{illustrated version}

THE FUTURE OF SPACE

An Encyclopedic Prospect

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THE DEVELOPMENT OF MARS

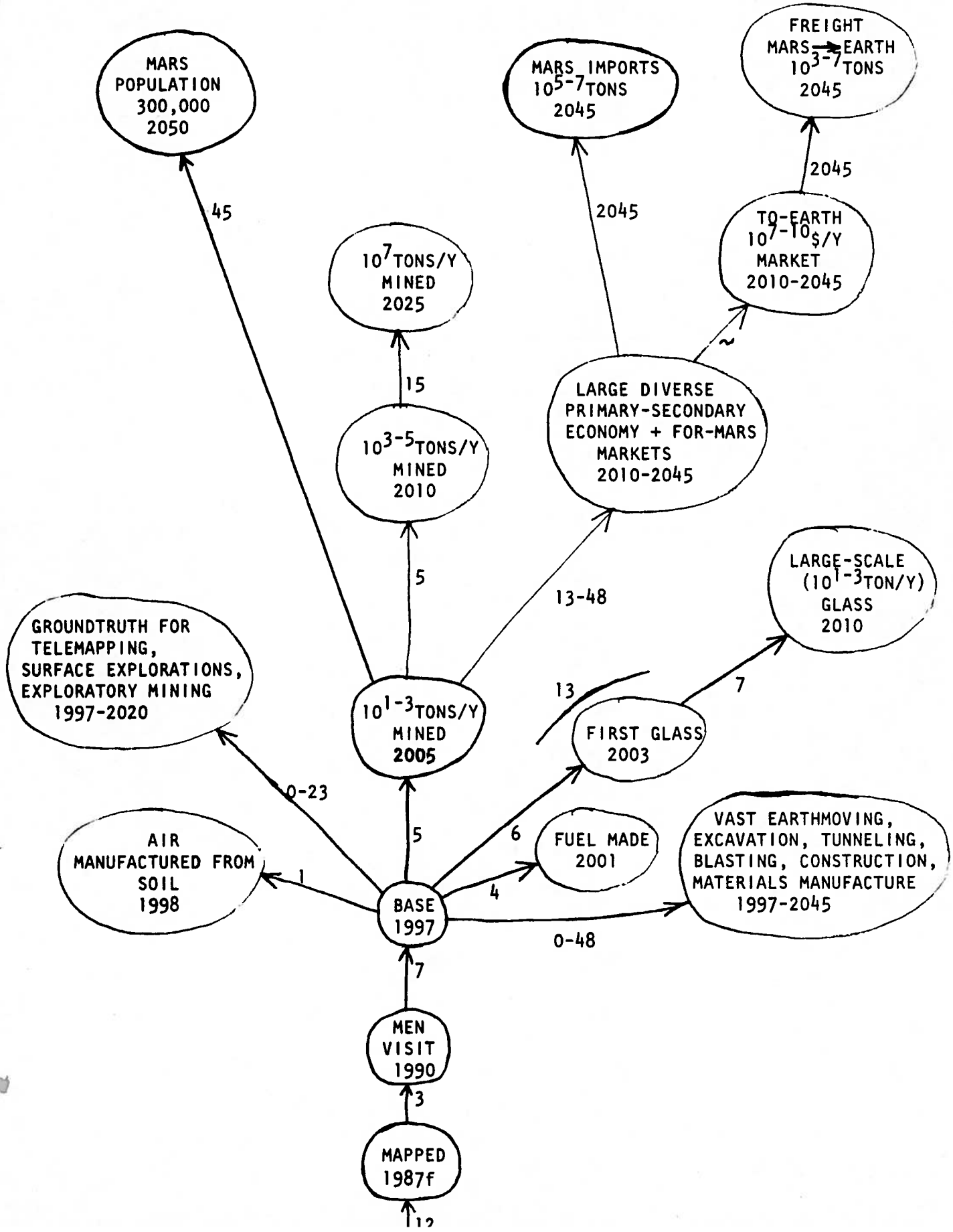


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FOREWORD

In the book you have before you I look at the future of the universe or of everything greater than ourselves. Today we refer to this in a vacuous way as "space". What we now regard as empty will tomorrow be found to be more than infinitely complex and full. This is a strange prophecy but I believe readers of this book will eventually find themselves in sympathy with it. In a like way I expect that the vastly bizarre picture of what is possible and of what is likely spread over the canvas in this book will come to seem both reasonable and appealing to those who peruse this book with an open and friendly mind. There is something enchanting and infinite about the unknown world about us and my sense of this should be communicable, at least to those who are sensible of the overwhelming limitations and idiosyncrasies of current knowledge, the pregnant peculiarity of all that there is of which we already know, and the infinite kaleidoscopic flux whose transient aspects of stability and simplicity permit us the illusion that the laws and shapes we ascribe to nature are at once universal, eternal, complete, definite, comprehensive, and supreme, when in fact they are none of these things and are better described as faithful reflections of our own ignorance and willfulness.

Man has attained his greatest religious wisdom when he has recognized and affirmed the fact and the importance of the infinity of nature. Horizons occur in nature but their number is infinite. Greater generalities are iscovered, but infinitely greater generalities must remain. The road twists, ·ails off, and divides, but in the labyrinth of the physical world it rsists. The wheel of time turns upon itself, the serpent swallows its own l, but only to perpetuate creation and exclude repetition for the world nges fundamentally each time it is witness to its



Andromeda Nebula, M 31 or NGC 224, the spiral galaxy which is nearest the Milky Way system. Also called the Great Nebula, it rotates about its center with a period of approximately 2 X 10^8 years and is believed to be some 2.5 X 10^6 light years distant. It contains bright blue stars, bright

FUTURE SPACE EVENTS: EXPLANATORY NOTES

The various lists and calendars of events are presented in a preliminary way and are meant to illustrate the nature of certain final productions. They were, in fact, literally written in a hurry and without consultation of facts which will later be turned to for the sake of criticism and refinement. This is not to suggest, however, that the dates and events are not considered or are overly foolish. The blatant and indefensible errors are presumably rare.

The question naturally arises whether the events and dates have much chance of being accurate, no matter how well done. Is the author gifted with prophetic powers such that his schedule of events represents absolute foreknowledge about the unique and unalterable course of things? The answer is that there are an infinity of worthwhile schedules, all different, that could be made. That is, the very attempt to confer some reasonable order and pattern upon all possible events is beneficial and enlightening. The hypothetical calendar created in this daring way is a temptation to all kinds of criticism, as well as being a challenge to man's larger program. It prompts revisions and alternatives. It feels events out in an intuitive way. It casts at least one man's perspective in a chronological mold. Even if the exact chronology is defective, something of the larger order and pattern may not be. Events in the future of space are clearly extraordinarily contingent upon political, military, social, technical, and purely spacial developments. Yet there is an opportunity for devising a sequence fairly independent of such contingencies whose pace and sequencing is educational and persuasive, and can to some extent be relied on in the face of such (frustrative or acceleratory) contingencies.

The events and dates are useful in another important respect. They supply a story to, and dramatize, what may in fact or in effect occur. On a scale of possibilities within 200 years an evolutionary imagery has the effect of justifying nearer events by relating them to a larger, more impressive, and more meaningful framework. Space exploration and development is shown to have a start and a proper continuation. Maintenance and growth of man's spacial enterprise is rendered sensible. Initial exploration and development are identified with important consequences. Sadly, this has never been done. It has been made to seem that things done in space and yet to be done are small and arbitrary. The result has been minor interest in space programs and unreliable support. The space program in general has yet to fulfill itself and the nature of fulfillment has never been depicted.

"A General Calendar for the Future of Space": comments on. Each "event" designated in this calendar might as well be prefaced by the words: "If the event is going to occur, it might reasonably occur by..." Such a thought doubtless preoccupied me as I dated and arranged the events. There was obviously, also, a competition between date-of-feasibility and date-of-actual-occurrence, a conflict which mars the overall chronology. As long as the user remains sensible of such factors, however, their effect is not apt to be catastrophic, and the calendar will serve its imperfect role.

It is noteworthy that on the longer scale of time the calendar may be more realistic since the extrinsic and unpredictable factors influencing spacial events in the nearer term, say within 50 years or by 2025, may lose something of their turbulence and subside after 2025 and/or smoothed over bigger units of time.

The events are listed in the following way. They run from the past to the eschatological year 100,000,000,000 A.D. This seemed a sufficient scope. First, a reasonable year at or by which the event should transpire is given (sometimes more than one year is given). Occasionally the year is preceded by a question mark. This signifies that there is a serious question whether

the event will occur at all (perhaps it is infeasible, pointless, or conjectural). Occasionally the year is followed by a question mark. This means that the date, per se, is somehow suspicious. The event may actually deserve an earlier or a later date, or a date refined into subpossibilities and alternatives.

Secondly, the event itself is identified. The identification given is actually an abstraction from another document, "Annotated Calendar for the Future of Space". This last is being continuously revised and extended. It should be resorted to wherever difficulties and questions arise in examining the breviloquent calendar presently under discussion. This is readily done since, thirdly, the statement of each event is succeeded by a cross-referential number.

Finally, each such number is followed by a range. The interval of time thereby indicated is that I at first assigned the events (but with which I sometimes later disagreed). I have included these intervals because they supplement, and in some cases are more interesting than, the specific dates I have, having been asked to do so, assigned to the events (even the intervals, of course, are questionable). I have here and there appended sharps, #, to the intervals. These signify that a range of possibilities or a set of subevents belong to, and properly divide, the event as given. Similarly, at the beginning date of the line I have occasionally added the initials "&c". In this case what is meant is that a continuum of possible or actual dates probably obtains, and that the user should not be deceived. I have, finally, put some dates in quotes--eg "1988"--by way of admitting that the nature of the event, as or even as worded, was not clear to me, so that the date chosen was somewhat arbitrary or expedient.

Matters that are obscure, controversial, important, &rc--in both the abbreviated and annotatory calendars--I intend to elaborate on in a future series of notes incorporated in the annotated calendar or occurring as brief, independent papers.

Is the pace of events set forth in my calendars too slow or too hasty? I concede at once that it may happen that mankind, over the next few decades, will basically turn its back on outer space and concern itself with more down-to-Earth problems and opportunities. Whereas I do not think this will happen, I do think there will be 1-2 or 1-3 decades of restraint over the world, and some ignoration of larger possibilities. Also, there are a set of likely or unlikely things which might restore or enlarge an interest in space, say over the next 3 decades, and impose themselves on the natural background of temporary neglect.

The pace of events I have assumed presupposes exponential progress in human affairs, generally, and to some extent also in space. As such it is merely consistent with continued exponential growth or a reasonable logistic curve moderating future growth. Even if world demographic and economic growth begins to turn over and obey a logistic curve in the future, there is good reason to think that scientific progress will lag or disobey such an inflection and will continue to accelerate or maintain approximately its current rate, and certainly there are some affairs (of which the space program may prove an example) which should behave in this optimistic way.

If the exploration and development of outer space continues in a serious and vigorous way, the rate of change and evolution I have given to events is perfectly reasonable. Modern progress in science, technology, engineering, and other human accomplishment is really extraordinarily fast. Both prospectively and retrospectively it is almost incomprehensible. Were space pursued with enthusiasm or abandon my calendar would probably prove to have been very conservative. The timing of the entire calendar, therefore, is critically dependent upon a good estimate of future human motivation and whatever things this, in turn, is dependent on.

The scale of the calendars. The warrant for a bicentennial prospect, beyond my previous remarks, is that 2 centuries (between now and 2176) actually seems to correspond to the period of the initial beginning of the solar system as a multiplanetary civilization. Almost all of the potential events I have identified

would seem to occur or begin during these years. If true, this is remarkable, and alone justifies a 200-year prospect and partial program.

As to the sheer number of events I have suggested, doubtless a fair number of them, even under competition with each other, have a fair chance of occurring in 1-20 decades. But I have admittedly tried to exhaust all possible major events, even fantastic and highly dubious ones. I thought this important because to my knowledge it had never been done, and because events will inevitably occur which presently seem impossible or highly unlikely. Moreover, I thought there justification for including those very few events which are in my opinion patently absurd, and noting them to be such, as instruction to caution. Some of the events must seem contrived, effortful, and vague; but, carefully reconsidered, some of these may prove to contain important possibilities, despite their original novelty.

KEY

/ A slant signifies a competing, further period of possible dates.

? A question mark after a date, directly, signifies uncertainty over the range as a whole.

/? A question mark after a slant functions as already indicated.

;? A question mark after a semicolon indicates a serious question about the event, eg its feasibility.

_ A date is underlined if it, as a pole, is stressed.

This indicates the event, as stated, or inherently, contains a number of possibilities; in effect, subevents.

&c The range continues, perhaps as a progressive development of the "event".

=? Asks, in effect, what is intended, required, &c.

± Indicates the date of the event varies with its components, ##.

?? Comparative of "?".

GLOSSARY

AEROSPACE Operating in both air and space.

BAMBI Ballistic Missile Boost Intercept. Orbital missile-interception systems that would be used to attack launched missiles at their vulnerable "boost" phase.

INTRASPACIAL Of that within space and off bodies.

SPACIAL Of outer space.

O'NEILL COLONY, TERRAN L-5, &C At two points 60^{o} ahead of and 60^{o} behind Moon in its orbit about Earth dynamical stability exists with respect to the gravity of these two bodies. These two Lagrangian points, L-4 and L-5, invite colonization by man, as has been proposed and developed by physicist Gerard K. O'Neill. O'Neill visualizes them as populable by millions of men, as sites for large-scale industries, and as way stations for other points in Solar System. He specifically visualizes their emergence between 1982 and 2020. It is not inconceivable that considerable matter exists naturally at these loci. This pair of points also exists for the Sun-Earth system, for the Sun-Jupiter system (the Trojan Planets), &c.

ARTIFICIAL MOON A huge reflector distributed or erected in space in order to redirect sunlight to Earth, eg to diminish nocturnal darkness, raise temperatures at high latitudes, &c.

RERELUNAR Located on the backside of Moon.

SUPER ATMOSPHERES Atmospheres with supernormal oxygen, pressure, or the like. Hypothetically, these might improve agriculture when this is done off Earth in the future.

EXOBIOLOGICAL ACCIDENT Some disaster resulting from or involving extraterrestrial organisms. An example would be a Terran pandemic produced by a pathogen returned from a planet visited by man, cf The Andromeda Strain, a novel by Michael Crichton. Conversely, a Terran organism might ravage what biology was previously found on the other planet.

HOLLOWED ASTEROID Dandridge M. Cole and Donald W. Cox, in their book Islands In Space, The Challenge of the Planetoids, suggested that elliptical asteroids of moderate size might be hollowed out, spun, and inhabited. The spin would give them artificial gravity, the mural landscape could be planted, farmed, and built upon, an artificial atmosphere could be created, along with an artificial sun down the major axis. Such a nice intraspacial microcosm is vividly depicted in Rendezvous With Rama, a novel by Arthur C. Clarke.

DYSONIAN Engineering or construction on a nearly, actually, or more than planetary scale in terms of mass, energy, population, time, &r the like is called "Dysonian" after the eminent physicist Freeman Dyson.

DYSON SPHERE The eminent physicist Freeman Dyson has seriously proposed that man in the future may build a rotating band around Sun in order to capture and make use of the total 10^{41} erg/y emission that is otherwise being constantly lost to Universe. Jupiter, which has 340 X the mass of Earth, could provide the necessary material. Dyson suggests that such surfaces may already exist about other stars, the creations of other civilizations.

ARTIFICIAL PLANETS Buildings of planetary size (eg 10^{-6}-10^{2} $m_{\oplus}$) built at once or incrementally in space out of available materials. Natural planets are too dense and hot inside to be developed at great depth. So the proper thing to do is to take them apart and build low density, highly vacuous, and completely artificial structures, either flat or spherical. In this way the inhabitable surface can be multiplied tremendously, eg 100,000 X.

CELESTIAL PHOTONICS There may be created in space in the future actual or virtual lenses, mirrors, basers, transformers, transducers, modulators, capacitors, batteries, conductors, resistors, and other circuitry of titanic or astronomic scale for proportionate applications of the annual 10^{41} erg

solar efflux of photons. These innumerable photons could be used for planetary engineering, communication, scientific instruments of observation, and many other purposes of a kind and scale utterly beyond our puny grasp.

CUTOSPHERE and TENT. It is not unlikely that other planetaries will come to be covered with great numbers of inflated and thin-shell domes sheltering men and their cities in local atmospheres. It may happen that these will eventually grow so numerous as to touch one another and emerge as domes of ever greater magnitude. It may also happen that men will desire to create or alter entire atmospheres of planets in single bold steps. The result in either case may be the enclosure of the whole planetary in a low-and-closed skin, or "cutosphere". Perhaps 10-100 ft high, such bagged atmospheres might be far more efficient, economical, stable, regulable, natural, practical, &c than ordinary gradient atmospheres. The magnitudinous sequence, again, would be: dome, tent, cutosphere.

VON NEUMANN MACHINES. The journalist Adrian Berry, in his book The Next Ten Thousand Years, A Vision of Man's Future in the Universe, discusses what is actually the technological vision of the physicist Freeman Dyson, in turn referring to the seminal ideas of the mathematical genius John von Neumann. Von Neumann was concerned, before he died in 1957, with abstract and physical entities possessing life's essential properties of self-reproduction, multiplication, maintenance, growth, and evolution. Such entities have come to be called "cellular automata". The development and application of this field will surely be one of the most thrilling chapters in the history of the intellect. Dyson realized that cellular automata possess cosmoplastic (ie world changing) and cosmopoietic (ie world creating) properties. They literally offer an infinite potential to remake Universe. Suppose an automaton were produced that could fend for itself anywhere in Universe, reproduce itself and do so as quickly as possible, evolve to meet any conditions, and that somehow possessed the ultimate ambitions of filling, conquering, and transforming Universe. Suppose one were freed on Moon. Spreading and evolving exponentially, it would, with remarkable speed, achieve just those incredible ambitions! (Indeed, it is thought that what we call the natural universe may be merely the pageantry of such automata, as has been suggested by computer scientist Edward Fredkin.) Dyson has therefore suggested that man will one day have created cellular automata, or artificial biota, engineered for particular, grand purposes, such as the speedy refashioning of an entire planet, a level of automation utterly beyond any semblance of that ours today. By way of example, in centuries, or even mere decades, the whole atmosphere of Venus could be terraformed.

TERRAFORMING, PLANETURGY, and ECOPOIESIS Terraforming refers to the adaptation of large-scale, especially planetary, environment to human needs by remodeling it along Terran lines. Planeturgy refers to any changing or creation of environments of the order of size of the face of a planetary, whether climatic, atmospheric, hydrologic, geologic, biologic, &rc. Finally, ecopoiesis to the creation of some environment. Another customary term is PLANETARY ENGINEERING, a synonym for planeturgy. Although what is usually intended by these terms is some alteration of a planetary surface, they comprehend as well any great deeds performed upon planetary interiors.

PERITERRESTRIAL Of that region of space beyond the atmosphere, and yet in the vicinnity, of Earth. It especially refers to Earth-orbital and geocentric activities. (The prefix "peri-" is used similarly for other systems.)

EXTRATERRESTRIAL Of, relating to, or characterizing that space beyond Earth's atmosphere, or even beyond periterrestrial space.

TRANSLUMINARY Pertaining to that which is faster than light (>c).

PLENISTIC PHYSICS A realm of physics that may evolve in the future if nature

is variously found to be of unsuspectedly great, or of infinite, subdivision, structure, density, energy, dimensionality, complexity, hierarchy, variability, &rc. Possibilities here are themselves infinite, but some of those now living who have had ideas of this kind are P.A.M. Dirac, John A. Wheeler, Fred Hoyle, H.C. Dudley, Gerald Feinberg, and Patrick Gunkel. For example, it may be that all but 1% of the mass of Universe is invisible (neutrinos or black holes), that "real" energy and mass are infinitesimal alongside the energy density of the so-called vacuum, that the material and energic density of any space-time point is infinite or superinfinite owing i.a. to the bidirectionally infinite frequency and energy spectra of nature, &rc. Such physics may lead to progressive scientific discovery and applications in terms of usable resources, transportation, communication, exploration, inventions, &rc.

TELEPORTATION Any technological analogue to the parapsychological concept of material things being moved through space immaterially. Specifically, telefacsimilization of objects reproducing to some degree their appearance, constitution, or even chemistry--eg via 10^{5-26} bits/gram--and invading thereby the realm of so-called communication. The velocity of transmission might range from greater than, at, or less than the speed of light. The rapidity of terminal conversion might range from less than a second to months. The presumable idea is that, with or without simplification, the character of the object is transformed into, or transmitted as, pure information &r energy, and is thus received and rematerialized. But there exists the possibility that something like "superspace" might enable an object qua object to be shifted discontinuously and instantaneously through space-time, sans strict conversion or any simplification.

BASER The generic term encompassing any and all lasers, masers, grasers, gravitonic-asers, &c that do and could exist, inasmuch as they all must employ bosons, and all bosons theoretically admit of such amplification.

SUPERSPACE A foundational manifold of our normal, and infinitely many other, universes which the renowned physicist John A. Wheeler says must be taken for granted. The concept breeds various and sundry remarkable, and indeed bizarre, possibilities, whose nature and extent are highly imaginative and but negligibly understood by modern physics and mathematics. For example, there may exist some or infinitely many other universes (possessed of arbitrarily different laws, energies, matters, dimensions, phenomena, times, spaces, &c), these might be voyaged to (eg via black and white holes), time itself may be travelable in either direction, and so on ad infinitum.

SUPERGRAVITY The hypothetical possibility that gravitation can be artificially intensified, and thus applied.

RELATIVISTIC Pertaining to velocities near to that of light, eg >0.1c, at which Einstenian effects become important.

SPACEPLANE An aerospace craft, or one able to both enter and leave Earth via the atmosphere.

MASS DRIVER A linear-acceleratory or ballistic device that would shoot small or microscopic objects (eg comminuted minerals), or particles, long distances across space, and even from atmospheric or anatmospheric planetaries, thereby achieving certain maximal economies in the cost of shipping materials, as proposed by the physicist Gerard K. O'Neill. Massive and constant streams of this kind might one day flow between planetaries and space.

CATOPTRICAL BALLOON Shaped balloons of titanic or astronomical size inflated in space to create immense concave mirrors, the foci of which would be used to propel or refine planetaries, for highly efficient power generation, or even for weather control.

BASER RAILS Baser beams stretched between planetaries or over space to power,

directly or indirectly, commuting craft.

TERRAN Of Earth.

ACCELERATOR or LINEAR ACCELERATOR A lengthy device, whether tube or ramp, over which a load, whether craft or material, is continuously accelerated, say in order to attain escape velocity from a planetary, or be driven with a land-based efficiency. Such a device can also be either vertical or aslant with respect to the ground.

SPACIAL AUTOS Imaginary craft designed to lift mere individuals or families into space, &r to move them about within space.

SONDED-BALLOONS Balloons dispatched atop other planetaries to monitor conditions during continuous descent through, or other movements within, their atmosphere or effectual ocean, the information collected by attached instruments being transmitted out, presumably to an orbital station or relay.

DIAGALACTIC "Cross-galactic", or venturing beyond the near stars, say beyond 10-100 light-years.

A.I. Artificial intelligence, the field of machines approximately as intelligent as man, or more so; or the machines themselves.

DEMIGODS Extraterrestrial beings possessed of transhuman intelligence, character, ability, power, or accomplishment, such as almost surely exist elsewhere in Universe, Milky Way, or maybe nearby. Most life in Universe is apt to be almost infinitely ahead of or behind us, and not our equal. Life hundreds of millions of years ahead of us very likely would seem to us incomprehensible, magical, and divine.

ARTIFICIAL SUPERMETEORS Great objects or masses dropped purposely to Earth from space by man in the future as a transportational short-cut or a method of engineering.

ANTIMETEORS Objects fired from Earth into space at orbital or escape velocity without containment in needlessly expensive vessels.

INTRAJOVIAN Going within Jupiter's atmospheric envelope.

INTRASOLAR Going below Sun's surface.

FRACTIONATION Natural stratification or division into elemental, chemical, mineralogical, &r other components, such as may distinguish Solar System per distance from Sun, planetary size, satellitic order, atmospheric or solid depth in a planetary, &rc. Such fractionation would be highly desirable for, and perhaps critical to the economics of, mining in space.

TRANSNUCLEAR Involving an efficiency of mass-energy conversion in excess of that practically or theoretically obtainable by conventional or known fission and fusion processes, say in excess of ½%. Some schemes have already been suggested, and cosmology has entertained the notion that Universal oscillation is 100% efficient, i.e. eternal.

CHEMO-SELENOGRAPHIC ATLAS An atlas giving the distribution of chemicals (minerals) on Moon.

AGRAVITIC Involving the nullification of, or shielding against, gravity, &r suppression of inertia.

TERMITARIA Readers who are termitologists will instantly visualize those elaborate and intricate constructions in which termites live their lives, and will understand how future man, faced with the lethal vacua of spacial milieux, will almost inevitably resort to the building of vast underground complexes, chambers, ways, storage places, and cities in such places as Moon, Mars, and Asteroids, and thereby mimic the ancient termite.

GRAVITONS The gravitational quanta or particles which are supposed to exist.

LANDING ENERGY-REGENERATION SYSTEMS Systems recovering some portion of the flight energy of a vehicle or projectile transferred, and usually wasted, in braking. Comparable systems already operate on Earth for nonspacial purposes.

ANATMOSPHERIC Having little or no atmosphere.

MICROATMOSPHERIC Having considerably less atmosphere, and atmospheric pressure at ground level, than Earth.

PICTOMAP A photographic montage of the surface of a planetary substituting for a customary map and for direct exploration, given its resolution and peculiar character. Such a pictomap may be the combined product of innumerably many and diverse instruments, surveys, computer analyses, human designs, &c. It may, in fact, be an atlas and comprise many alternative versions or renderings of the landscape. It may depict both morphology and chemistry of the surface, and either stereoscopically or holographically. Its resolution may be absolutely incredible, the kind of thing that can be restudied under a microscope and imaginatively walked over and reconstructed. Such pictomaps may be creatable for all planetaries in a short time, economically, and with almost available technology. They may use passive &r active sensors in orbit.

PERPETUAL MOTION DEVICES or INTERPLANETARY ORBITERS Devices repeatedly circling between planetaries, and also Sun, by relying on their gravitational fields as their motive power and on the frictionless vacuum of space.

TRANSPLUTONIAN Of that outside, or departing from, Solar System.

&r And/or.

&c Et cetera.

&rc And/or cetera.

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MEN WALK ON MOON

ASTRONAUTS LAND ON PLAIN; COLLECT ROCKS, PLANT FLAG

Voice From Moon: 'Eagle Has Landed'

EAGLE (the lunar module) Houston, Tranquility Base here. The Eagle has landed.

HOUSTON: Roger, Tranquility, we copy you on the ground. You've got a bunch of guys about to turn blue. We're breathing again. Thanks a lot.

TRANQUILITY BASE: Thank you.

HOUSTON: You're looking good here.

TRANQUILITY BASE: A very smooth touchdown.

HOUSTON: Eagle, you are stay for T1. [The first step in the lunar operation.] Over.

TRANQUILITY BASE: Roger. Stay for T1.

HOUSTON: Roger and we are you venting the ox.

TRANQUILITY BASE: Roger.

COLUMBIA [the command and service module]: How do you read me?

HOUSTON: Columbia, be loo Eagle Tranquility Base. Eagle is at Tranquility. I read you five by. Over.

COLUMBIA: Yes, I heard the whole thing.

HOUSTON: Well, it's a good show.

COLUMBIA: Fantastic.

TRANQUILITY BASE: I'll second that.

APOLLO CONTROL: The next major step-on ship will be for the T2 event. That is at 21 minutes 33 seconds after initiation of power descent.

COLUMBIA: Up telemetry command reset to re-acquire on high gain.

HOUSTON: Copy that.

APOLLO CONTROL: We have an unofficial time for that touchdown of 102 hours, 45 minutes, 42 seconds and we will update that.

HOUSTON: Eagle, you looked X3 coming. We want MESA.

TRANQUILITY BASE: Roger. Do you want the high-gain [illegible]?

HOUSTON: That's affirmative.

APOLLO CONTROL: We're now less than four minutes from our next step-on step. It will be for our complete revolution of the command module.

One of the first things that Armstrong and Aldrin will do after getting their next step-on step will be to remove their helmets and gloves.

HOUSTON: Eagle, you are stay for T2. Over

Continued on Page 4, Col. 1

VOYAGE TO THE MOON

by Aaronson Stricklin

Reindeer coming on,
wanderer in our skies,
dazzle of silver in our homes and on our
window silver,

silver coaster in our fertilest thoughts—
"the crackling coaster" . . . "the glimpses of the moon" . . .
and we have touched you!

From the first of time,
before the first of God, before the
first man existed there, we thought of you.
You were a wonder to us, unreachable,
a hanging pearl the result of longing,
a light beyond our light, our love—perhaps
a meaning to us . . .

Now
our hands have touched you in your depth of night.

Three days and three nights we journey 4,
alarmed by furthest stars, shocked more with
it around the invisible sideway where the shining dust
falls into rays or the other in the void between,
followed that other dream, remembered
cold, found death—unfathomable emptiness . . .

Then, the fourth day evening, we descended,
made fast, set feet at dawn upon your kingdom,
rifled between our fingers your cold sand.

We stood here in the dusk, the cold, the silence . . .

and here, as at the first of time, we lift our hands.
Over us, more beautiful than the moon, a
meaning to us, unreachable,
a hanging pearl the result of longing,
a light beyond our light, our love—perhaps
a meaning to us . . .

O, a meaning
deep as an abyss about beneath the bright
dark,
priceless meaning as



Neil A. Armstrong moves away from the leg of the landing craft after taking the first step on the surface of the moon



Col. Edwin E. Aldrin Jr. climbing down the ladder. The television camera was attached to a side of the lunar module.



Mr. Armstrong, right, and Colonel Aldrin raise the U.S. flag. A metal rod at right angles to the mast keeps flag unfurled.

A Powdery Surface Is Closely Explored

By JOHN NOBLE WILFORD

HOUSTON, Monday, July 21—Men have landed and walked on the moon.

Two Americans, astronauts of Apollo 11, steered their fragile four-legged lunar module safely and gently to the historic landing yesterday at 4:17:40 P.M., Eastern daylight time.

Neil A. Armstrong, the 38-year-old civilian commander, radioed to earth and the waiting world these words:

"Houston, Tranquility Base here. The Eagle has landed."

The first men to reach the moon—Mr. Armstrong and his co-pilot, Col. Edwin E. Aldrin Jr. of the Air Force—brought their ship to rest on a level, rock-strewn plain near the southwestern shore of the arid sea of Tranquility.

About six and a half hours later, Mr. Armstrong opened the landing craft's hatch, stepped slowly down the ladder and descended to be planted the first human footprint on the lunar crust.

"That's one small step for man, one giant leap for mankind."

His first step on the moon came at 10:56:20 P.M., as a television camera outside the craft transmitted his every move to a growing and awestruck audience of hundreds of millions of people on earth.

Twenty-Two Steps That Led

Mr. Armstrong's bibbed stops were tentative tests of the lunar craft's firmness and of his ability to move about easily in his bulky white spacesuit and backpack and under the influence of lunar gravity, which is one-sixth that of the earth.

"The surface is fine and powdery," the astronaut reported. "I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and side of my boots. I only go in a small fraction of an inch, maybe an eighth of an inch, but I can see the footprints of my boots in the tracks in the fine sandy particles.

After 19 minutes of Mr. Armstrong's touring, Colonel Aldrin joined him outside the craft.

The two men got busy setting up another television camera and then the lunar module, planting an American flag from the ground, stooping to pull out rock samples, displaying scientific experiments and hopping and loping about in a demonstration of their lunar agility.

They found walking and working on the moon less taxing than had been forecast. Mr. Armstrong even reported he was "very comfortable."

And people back on earth found the black-and-white television pictures of the bug-shaped lunar module and the men bounding about it so sharp and clear as to seem unreal, even like a toy and top-like figures that humans belong on the moon during and the remaining experiments time for moonwalkers.

When Telephones Congratulation

During one break in the astronauts' work, President Nixon congratulated them from the White House by what, he said, "certainly has to be the most historic telephone call ever made."

"Because of what you have done," the President told the astronauts, "the heavens have become a part of man's world. And as you talk to us from the Sea of Tranquility it inspires us to redouble our efforts to bring peace and tranquility to earth.

"For one priceless moment in the whole history of man all the people on this earth are truly one—one in their pride in what you have done and one in our prayers that you will return safely to earth."

Mr. Armstrong replied.

"Thank you Mr. President. It's a great honor and privilege for us to be here representing not only the United States but men of peace of all nations, men with interest and a curiosity and men with a vision for the future."

Mr. Armstrong and Colonel Aldrin returned to their landing craft and closed the hatch at 1:11 A.M., 2 hours 31 minutes after opening the hatch on the moon. While the third member of the crew, Lieut. Col. Michael Collins of the Air Force, kept his orbital vigil overhead in the command ship, the two moon explorers settled down to sleep.

Outside their vehicle the astronauts had found a bleak

Continued on Page 2, Col. 1

Today's 4-Part Issue of The Times

This newspaper's issue of Th... Financial and business news... New York Times is divided into... on the first page of the... four parts. The first part is de... general news... Following is the Story Index... and today's issues:

[illegible]

Section 1 [illegible]
Section 2 [illegible]
Section 3 [illegible]
Section 4 [illegible]

General news begins on... The... first page of the second part... The Financial and business... to on the first page of the... part, which includes... Obituaries (Page 37) and... Amusements, news and... appear (Pages 38 and 39).

Neil A. Armstrong, first man on the Moon: *"That's one small step for a man, one giant leap for mankind."*

A GENERAL CALENDAR FOR THE FUTURE OF SPACE

(Numbers refer to items on Annotated Calendar--see next section.)

	Past	First corporate profit from space. 24. 1976-2000
45	Past? 1992?	Wholly automated flight. 32. 1976-2000
44	Past-1990	Morphology &r mineralogy of planetaries mapped by radar &r baser. 204. 1976-2000
44	Past & 1990	Sonded-balloons into the planet's atmospheres. 165. 1976-2000
	Past?	100,000mph flight attained. 139. 1976-2000
44	Past&c	Gravitational acceleration of ships using planetaries &r Sun. 215.
44	1976&c#	International cooperations in space. 214. #
44	1979	Reusable space shuttle. 79. 1976-2000
44	1979	Horizontal takeoff or landing. 121. 1976-2025
44	1980($10^{\wedge}$) & 1991($10^{\wedge}$)	$10^{\wedge}$ watt power plants in space for space. 180. 1976-2000#
44	1980?	Nuclear, solar, or other novel Lunar surface drive. 132. 1976-2000&c#
44	1982?	Discovery of massive extraplanetary water (comet, moon, &rc). 219. ?1976-2000
45	1982&c	Supermaneuverable ships &rc. 216.
45	?1982	Human physiology proven inadaptable to space. 220. 1976-2000
44	1982?	Discovery of natural water on Moon or asteroids. 101. 1976-2000&c
	1983?(10^4) & 2000?(10^6)	10^{4-6}tn accumulated in Earth orbit. 75
46	1983?	10^{0-20}-square Lunar mineralogy map wrought. 4. 1976-2000
45	1983?&c	Wholly unmanned craft cum subcraft for scouting and landing-leaving planetaries. 218. 1976-2000
45	1984	10^{10-15} bits/s relayed through space for points on Earth.
45	1984	184. 1976-2000#
46	1985?(10^4) & 2000?(10^6)	10^{3-6}tn payload from Earth to space by a single launch. 179. 1976-2000
47	1985?	10^{1}-10^{-3}m resolution of Earth's surface from orbit. 181. 1976-2000#
47	1985 pu 1976?	Direct satellitic broadcast to homes. 112. ?1976-2000
47	1985	Single-stage-to-orbit (SSTO) spacecraft. 213. 1976-2000
47	1985? Past?	Transplutonian probe. 223. 1976-2000
48	1985	Flight out of the ecliptic. 214. 1976-2000
48	1985	Half-fueled takeoff cum in-flight refueling. 212. 1976-2000
48	1986	200,000mph flight attained. 140. 1976-2000
48	1987?	Aerospace plane ("spaceplane"). 173. 1976-2000
48	1987?	10^{0-20}-square Martian mineralogy map wrought. 5. 1976-2000
49	1987?	10^{0-20}-square Mercurial mineralogy map wrought. 9. 1976-2025
49	"1988"	Proliferation of parties in space. 113. 1976-2000

53	1990	Men visit Mars. 231.
49	1990	Saturn's rings visited. 154. 1976-2000/2025
49	1990	Saturn's rings examined to see if they are fractionated and minable. 74. 1976/2000-2025
50	1990?	10^{0-20}-square mineralogical map made for a Jovian satellite. 7. 1976-2025
50	1990?	10^{1}-10^{-6}m resolution "pictomap" made of planetaries, substituting (potentially) for direct exploration. 182. 1976-2000#
50	1990?	10^{1}-10^{-6}m resolution of other planetaries from space. 182. 1976-2000#
51	1990 (All planets explored by ...)	
52	"1990"?	Break-even point for aggregate space industry. 25. Past-2025#
52	1990 & 2014	Mechanized flyby of Pluto. 222. 1976-2025
52	"1990"&c	Structures ideal for space. 164. 1976-2025/2175&c
53	?1990	BAMBI. 168. 1976-2025
54	1990?	Solar electric propulsion. 146. 2001-2025?
54	1990	Solid chemical propellant exceeds in power &c any liquid propellant. 205. 1976-2000
54	1990(10^{4}) & 2000?(10^{5})	10^{4-5}tn/y put in space from Earth. 76. 1976-2025
54	1990	Experimentally, energy sent to Earth from space. 40. 1976-2000#
54	"1991"	General deployment of space defense. 1. =? 1976-2025#
55	?1992(solar system) & 2020?(other star)	Extraterrestrial life discovered. 13. 1976-2025
55	?"1992"	Consequences of life/fossils being found in Solar System. 221. ?1976-2025#
56	1992	Intrajovian probe. 30. 2001-2025#
57	1993?	Military &r commercial hypersonic &r suborbital diaglobal transport, travel, &r commuting. 95. 1976-2025#
58	?1993?	Soldier-to-soldier communication via space. 189. ?1976-2000/2025
58	?1993?	Interpersonal communication via space. 189. ?1976-2000/2025
58	1993	Lunar base. 2. 1976-2000
60	1993(10) & 2020(100) & 2040(1,000)	10^{1-3} lives claimed in spacial disaster. 192.
60	1993	A United Nations spacial force, undertaking, &r administration. 80. 1976-2000
60	1994	Robots &r teams in spaceships inspect &c peri/extraterrestrial satellites, stations, &c. 171. 1976-2000&c
61	1995	Machine approximately as smart as man. 44. 1976-2025
63	1995	First private spacial "adventure". 26. 1976-2000
63	1995	Perfect submarine monitoring. 190. 197602025#
63	1995	First industrial use of space (i.e. business accompanies a governmental mission to achieve a private purpose). 24. 1976-2000
64	1995 "&" 2075	Celestial photonics. 162. 1976-2176&c#
64	?1995	Lesser power places bombs in orbit. 167. ?1976-2025
64	1995	Magnitudinous use of sunlight on Moon. 84. 1976-2025
61	"1995"	Robots working in space. 33. 1976-2025#
65	1995	Magnetohydrodynamic (MHD) drive. 127. 1976-2000/2025
65	1995?	Hypersonic transport (HST) lifts objects to/ward orbit. 48. 1976-2000
65	1995	17-25 Mach ramjet. 122. 1976-2000?

65 1995 Ionic or other drives using un/charged particle beams. 53. 1976-2000/2025.

65 "1996" Controlled fission drives. 54. 1976-2000

65 1996(fission) & 1998(fusion) Pulsed nuclear ("Orion") drives. 105. ?1976-2025#

65 1997 Revolutionary space offensive systems. 111. 1976-2025&c#

66 1997 Solar energy basered to Earth from orbit on a large scale. 225. 1976-2000

67 1997? Extraterrestrial manufacture of oxygen, eg enabling colonial self-sufficiency. 22. 1976-2000

67 1997(10^2) & 2010(10^4) 10^{2-4} asteroids "visited". 87. 1976-2025

67 1998 Manned laboratory near Sun. 16. 2001-2025?

75 "2000"? Pollution of or from space. 191. Past-2025&c/2175 #

68 2000 400,000mph flight attained. 141. 1976-2025

68 2000? Artificial moon or its equivalent. 96. 1976-2025/?#

68 2000? Major extraterrestrial "agriculture". 23. 1976-2000#

69 2000&c Universe discovered to be a "plenum", and investigated. 104

70 2000? Suspended animation (enabling ≥50y travel). 178. ?1976-2025

70 2000 Mining and refining of an asteroid. 37. 1976-2025

2000 Terran ramp/tube launches freight &r ship. 128. 2001-2025/?

71 2000 Extraterrestrial extraction/synthesis of fuel. 21. 1976-2025

69 2000 A transnuclear (eg >½% mass-energy conversion) source of energy demonstrated. 71. 1976-2025&c

71 2000 Mass driver. 210.

72 2000 Nuclear energy generated in space and sent to Earth. 151. 1976-2025

68 2000? 10^{0-20}-square Plutonian mineralogy map wrought. 8. 1976-2025

72 ?2000 Orbital interterrestrial power relay station. 152. ?1976-2025

77 ?2000 Abrogation of Space Treaty, &c. 169. ?1976-2025&c

71 2000 Machine smarter than men. 45. 1976-2025

73 ?2000? Earth-to-space payload cost $50(1975)/lb. 77. 1976-2000

~~2000 Extraterrestrial fuel. 21. 1976-2025~~

73 2000? O'Neill "colony" at L-5 (50 men?). 18. 1976-2025

73 2000? Men identify themselves as "spacials". 63. ?1976-2025

74 ?2000 [redacted] fractionated mineralogically. 159. ?1976-2000/2025#

~~73 ?2000?~~

~~78 ?2001 "Second Earth"~~

79 ?2001 Earth-to-Moon payload cost $50-$100(1975)/lb. 144. 1976-2000

International teams/robots inspect military/all satellites &rc. 170. ?1976-2025

79 2003? Energy for spacial ships, laboratories, &r colonies basered up from planetaries such as Earth to space. 226. 1976-2025#

79 ?2003? Earth's upper-atmospheric helium &rc mined by low satellites or the like. 133. ?1976-2025

~~83→2003 First Serious use of Space~~ ~~for military purposes~~

80 2003 Longitudinal weather prediction, explanation, &r control via exosphere, magnetosphere, &r heliology. 97. 1976-2025&c#

80 2004 Controlled fusion drive. 55. 1976-2025

80 2005(&c?) Polluting processes kept off Earth. 227.

82 2005 Mars mined. 238.

83 2005? Disputes over space rights. 228.
85 2005 Continuous 10^{13-21}-cell reconnaissance and surveillance of Earth. 183. 1976-2025&c#
86 2005 Nuclear explosion on Moon. 35. 2001-2025?
87 2005? A satellite of a jovian planet landed on and explored. 148. Unmanned: 1976-2000. Manned: 2001-2025
87 2005? Ultimate chemical propellant. 206. 1976-2025
87 ?2005 Magnetomotive-magnetospheric space vehicle. 211. ?2001-2025
88 2005 Volcanoes, geothermal gradients, &r chemicals present on planetaries used as energic sources. 83. 1976-2025#
81 [redacted] 2005 Lethal Terran wastes disposed of in space. 91. 1976-2000
89 ?"2005"&c Maximum electrostatic charge vehicle. 207. ?2001-2025?&c
87 2005 Rerelunar observatory and supertelescopes. 86. 1976-2025#
90 2005?&c Mining of planetaries using controlled fission &r fusion. 134. 2001-2025&c
91 ?2005 Astronomic balloons used to mine &c asteroids. 56. ?1976-2025
92 ?2005 Van Allen Radiation Belt swept up. 176. ?2001-2025?
93 2007 10^{11}/y, or 1% GWP, spent on space. 199. 2001-2025 → N: Est. (1984 NYT.) by 1996, retail value of pharmaceuticals made in space will be $5B/y (vs. est. $10B/y New alloys made there, $1B/1996.
93 2007 (in 2009, 11, 12) Lunar population 1,000; buildings. 10. 1976-2025
93 2007 Giant domes for atmosphere and cities on Moon, &rc. 102. 1976-2025#
101 → 2010 Venus mach. 101 → 2010 Aluminum mines.
97 ?2010 Super atmospheres for super agriculture. 160. ?1976-2025&c#
99 ?2010 Natural caves found/occupied on Moon, &rc. 100. ?1976-2025
103 ?2010 Geocentric fleet. 175. ?2001-2025
103 2010 Extraterrestrial radioisotopes/radioactivity found/then used. 158. 1976-2025#
112 → 2010 → 10⁶ tourists/year
105 2010 Mining of jovian planets (some). 72. 2001-2050
109 2010 Moderate asteroid moved to Terran L-5. 69. 2001-2025/?
121 2010 Interplanetary "baser rails". 209. 2001-2025.
113 2010? First birth in space. 29. 2001-2025
118 2010 Super computer built in space, eg for cryogenic reasons (but see # 44-45). 147. 2001-2025?
116 ?2010 Military bases in space. 172. 1976-2050
119 "2010"&c "Absolute minima" of transportational costs. 94. 1976-2025&c#
108 ?2010? Catoptrical balloon propels planetary. 56. ?1976-2025
114 ?"?2010 Materials dropped to Earth for recovery. 85. 2001-2025
121 2010 Ground laser ablationally propels craft into space. 49. 2000
108 2010 Asteroid moved, say to Earth. 20. 2001-2025
110 ?2010 Asteroids dropped or flung onto Earth for engineering. 155.
(123) 2010? 122 Jupiter's deuterium &r protium used for fusion. 73. 2001-2075
(124) 125 2013 "Start" of exodus from Earth to space. 28. 2001-2025
126 2014 Men visit Pluto. 17. 2001-2025/2050
127 2014 All planets since visited by men. 239.
115 2016 2010 A jovian moon mined. 238.

→ Interplanetary "mass jets".
2012 → industrial satellite belt.

127 2015	Hotel orbits Earth. 60. 1976-2025
125 ?2015?	Earth-space &r intraspacial "autos". 188. ?2001-2025
129 2015	Intrasolar probe. 125. 2001-2050#
132 ?2015	Flywheels store energy in space. 129. ?2001-2025
133 2015?	1,000,000mph flight attained. 142. 2001-2025
138 ?2015?	Atmospheres gotten from planetaries' solids via nuclear explosions or other means. 157. 1976-2100#
137 2015?	Performance in space of too dangerous experiments, processes, or undertakings. 92. 1976-2025
134 2015?	First intraspacial, per se, hostilities. 99. 2001-2025?
139 2015	Climate changed. 150. 1976-2025&c#
138 ?2015	Terran vertical accelerator launching freight into space. 131. ?2001-2025/?
135 "?"2015	Manned laboratory on Venus. 15. 2001-2025
142 2015	Braking energy of landing craft &r materials captured. 130. 2001-2025
136 2015	Fissionables mined on Moon. 81 1976-2025
144 2017?&c	Use of Solar Systemic, Milky Way, &r Cosmic energies, matters, currents, &r fields to "sail" &rc. 107. ?2001-2075&c#
143 2017?	Solar wind sailed. 106. 2001-2025/?
146 2017	Mercurial or perisolar power plant sends energy elsewhere. 82. 2001-2025
150 2017	Radioisotopic sail drive. 229.
?2020?	Artificial supermeteors used to mine Earth &rc. 155.
151 2020?	"Plenistic" physics creates means for novel and extraordinary communication. (104; # ~ See p. 16
154 2020?	Higher extraterrestrial life discovered. 14. 1976-2050
155 ?2020	Earth-to-space payload cost $10(1975)/lb. 78. 1976-2025/?
154 2020?	Life determined to exist on another star. 41. 1976-2025/?
156 ?2020	Terran L-5 population 10^4. 51. ?2001-2025.
157 "?"2020?	Use of exobiology for environmental engineering, or exo-biological "accident". 221. ?2001-2025
157 2020?&c/10^9y	Galactic, cosmic, &rc incidence of "earths", life, intelligence, "gods", &c virtually determined. 197. 2001-2075/10^9y?
155 ?2020?	Via a nuclear gaseous core drive, Earth-to-space payload cost <$1(1975)/lb. 145. ?1976-2025
161 "2020"?/2100?	Realization or proof that exploitation, occupation, exploration, &r unification of Universe is or is not futile, meaningless, &rc. 198. 1976-2075&c?
162 ?2020?	Solar energy sent to Earth from space semi/omnidirectionally. 149. ?2001-2025?#
158 ?2020	Transluminary (>c) event in nature proven. 46. ?1976-2025?
159 ?2020	An asteroid hollowed out, spun, and occupied. 38. ?2001-2025
159 "2020"	Fair idea had of Solar System's wealth. 93. 1976-2025
154 2020?	Reception of a message from another star. 41. 1976-2025/?#
152 2020	Base on all Solar planets.
160 2020	Massive Space → Earth equivalence.
156 2020	Plutonium.

?2022	Heliocentric fleet. 177. ?2001-2025?
"?"2025	Chain of nuclear bombs used to penetrate Moon. 34. 2001-2025/?
2025	A chain of nuclear bombs used to mine a planetary at depth. 34. 2001-2025/?
2025	Nuclear bombs used for Lunar construction. 98. 2001-2025
2025(2000?)	Venus mined. 31. 2001-2025
2025	Perisolar industry, eg using Sun's gamma and cosmic rays. 163. 1976-2025
2030	50%-99% conversion of matter into usable energy per $E = mc^2$. 67. 2001-2050#
2032?	Sun mined. 126. 2026-2050/?
2035?	Perisolar heat used for industry via juxtaposed asteroids. 156.
2035	Terran intercommunication via space so vast that it engenders a world or Terran language, government, economy, culture, &r society. 186. 1976-2025&c
2035?	Boats on Sun. 124. ?2026-2050
2035?	Ship launched from Earth via solar energy from orbital station sent to ship or launch site. 166. ?2001-2025/2050#
2040?	Information received from another star revolutionizes our culture. 42. 1976-2025/?
?2040?	Transluminary (>c) communication. 47. ?1976-2025?
2040?	Gravitons, neutrinos, or other unusual particles &c used for propulsion. 110. 2026-2075?#
2040?	Lunar population 100,000; cities. 11. 2001-2050
2045?	Interstellar probe launched. 19. 2001-2050
2045?	Martian population 100,000; cities. 12. 2026-2050
2045?	Technological analogue to teleportation (telefacsimilization of objects reproducing to some degree their appearance, constitution, or even chemistry--eg via 10^{5-26} bits/gram--and invading thereby the realm of so-called communication). 115. 1976-2100?#
2045	Antimatter fuel. 137. 2001-2075#
2050?	Interstellar basers. 109. 2101-2175?#
2050?	Probe to Moon's center launched. 36. 2001-2075
2050?	Gravitons, neutrinos, muon beams, or other exotic, esoteric, or unknown physical entities &r principles used for novel &r extraordinary communication. 110. 2026-2075?
?2050	Asteroid fused, blown into a bubble, and occupied. 136. ?2001-2050
2055	7,000,000mph (0.01c) flight attained. 143. 2026-2075
?2055	Super (and directed) gravity. 103.
?2055	Antigravity. 103.
?2055	Nullification of, or shielding against, gravity, &r suppression of inertia. 103.
2050?	We attempt to communicate to another star's beings. 201.
2060	All planets "populated", ie population $>10^6$. 239.

THE EXTREMELY YOUTHFUL PLEIADES CLUSTER, DISPLAYING ITS TYPICAL HOT BLUE COLOR



2060?&c	"Plenistic" physics yields new sources of energy. (104.) 2051-2075
2060?	"Plenistic" physics yield drives. (104.)
?2060	Transluminary (>c) flight attained. 47. ?1976-2025?
2060?	Spaceships of urban or planetary size. 138. 2026-2100#
2060?	Photonic drive. 52.
2065(satellite) & 2100(planet) & 2010(asteroid)	Planet/planetoid relocated. 68.
2065?	Diagalactic probe launched. 89. 2076-2150
2070?	Probe launched to Milky Way's center. 108. 1976-2105
2070	Project of Dysonian stature. 39. 2051-2075
2070	Artificial planets. 193. 2076-2175?#
2070?	Relativistic (0.1c) flight attained. 119. 2051-2075?
2075	Celestial photonics for engineering. 162. 1976-2175&c#
2075?	Communication intercepted from another galaxy. 88. 2026-2075
?2080	Tents and cutospheres. 161. ?2026-2100#
2080	"Expedition" (using A.I.?) launched to another star. 66. 2076-2100
2080	Von Neumann machines (experimental?). 43. 2026-2175
2085	Terraforming or planeturgy. 65. 2076-2100#
2100(exploitative) & 2045(experimental)	Sun modified. 70. 2101-2150?
2105	Most men living in space and off planetaries. 135. 2101-2150?
?2110?	"Teleportation" ex receiver. (203.)
2110?	Extragalactic probe launched. 90. 2151-2175?
?2110?	Almost "clairvoyant" observation of 10^{7}-10^{-3}m features of worlds trillions of light-years away ex transmitter. (203. #
?2110?	"Teleportation" ex receiver, eg over trillions of light-years. (203.)
?2120	Transportation via singularities in superspace (black and white holes, Schwarzschild or Kerr singularities, other and odder singularities, wormholes through space, 1/2-way interuniversal and "omniversal" voyages, time travel, &rc). (117.
?2120?	Communication via superspace. (117.)
2125	Dyson sphere begun &rc. 64. 2101-2150#
2150?	Luxonic (~c) flight attained (ironically, after >c). 208.
?2175??	Physical meeting with beings of another star. 116. ?2101-2125?
2175/?	Interstellar basers used for energy. 109. 2100-2175?
?2175?	Superspace aids exploration &r is explored. (117.
2200?	Baser beams between stars used for commuting. 109. 2101-2175?
2220?	We occupy 10 stars. 120.
2300?	Solar System population 10^{15}, a quadrillion. 118.
?2300?	Conflict or unlimited war with aliens. 202. ?
?2400	Gravitational fields of other stars used for flight. 215.
2400?	Mining of other stars. 224.
2600-10^{7}/y	Planets/solar systems navigated around Milky Way and galaxies reconstructed. 114. #
10^{5}y?	Milky Way fully populated by some intelligence. 194. Past-2176/10^{8}y/10^{9}y
?10^{8}y?	Universe fully populated by some intelligence. 195. Past-10^{8}y/10^{10}y
?10^{11}y	Universe "stops". 196.

ANNOTATED CALENDAR FOR THE FUTURE OF SPACE

Note. The following events for the future of space are presented in a preliminary attempt to exhaust such possibilia. They are unaccompanied by precise dates so that readers may post their own and subsequent discussion (occurring in "Delphi" fashion) may converge or diverge such opinions, and allow better assignment of such events to the period of the next 200 years (1976-2176) divided into a "calendar" of 8 quarters. It is hoped that readers will contribute additional ideas for events that I will have overlooked. My statements of events may be imprecise, flawed, excessively broad (better divided into several component events), or presumptuous. It is hoped that a framework of ideas will emerge from this initial exposition of what space may mean as a human endeavor inspired by various purposes. A column is provided on the left for insertion of dates guesstimated. Other systematic questions pertain to the absolute probability, the desirability, accelerability, importance, complexity, implications, interconnexions, contradictions, priority, ranking, preconditions and assumptions, order, equivalence, hierarchy, &c of the various and sundry possibilities. Obviously this greater contexture is the heart of Hudson's preview of the next 200 years in space.

1976-2025	1. General deployment of space defense (eg interceptive or retaliatory lasers
1976-2000	2. A lunar base (eg 20 men, existing 6 months or semipermanently, 15 rooms or 3 buildings, using some local resources and energy, feeding itself, conducting multifarious research, assembling and perhaps extending itself, &c).
1976-2000/2025	3. A series of such lunar bases (eg 5 scattered around Moon).
1[illegible]-2000	4. A detailed (eg resolution of mineral resources on surface into kilometer or meter squares) map of lunar mineralogy undertaken or extant (10^0-10^{20}-square, eg hierarchic, chemo-selenographic atlas).
	5. Such a map for Mars.
	6. Such a map for a large asteroid (eg 1000 km d Ceres).
	7. Such a map for a Jovian moon.
	8. Such a map for Pluto.
	9. Such a map for Mercury.
1976-2025	10. 1000 men on Moon.
2001-2050	11. 100,000 men on Moon.
2026-2050	12. 100,000 men on Mars.
1976-2025?	13. First discovery of extraterrestrial (self-reproducing) life.
1976-2050	14. First discovery of extraterrestrial "higher plant or animal".
2001-2025	15. First manned laboratory on Venus.
2001-2025?	16. First manned laboratory orbiting or passing as close to Sun as Mercury.
2001-2025/2050	17. First manned probe to, or landing on, Pluto.
1976-2000/2025	18. Colonization of Earth's Lagrangian points (a la Gerard K. O'Neill).
2001-2050	19. Launch of an interstellar probe.
2001-2025	20. Movement of an asteroid out of orbit, eg to #18 or Earth.
1976-2025	21. First extraction and/or synthesis of extraterrestrial fuel, eg lunar.
1976-2000	22. First manufacturing of oxygen from extraterrestrial, esp. lunar, soil enabling colonial self-sufficiency.
1976-2000	23. First manufacturing or growing of an adequate diet from extraterrestrial materials (eg lunar agriculture).
1976-2000	24. First industrial use of space.
Pa[illegible]-2025?	25. Break-even point for total simultaneous space industry (space becomes profitable).
1976-2000	26. First private adventure, periterrestrial or beyond.
1976-2000	27. First corporate profit from space.
2001-2025	28. Beginning exodus of individual Terrestrials into space.
2001-2025	29. First spacial nativity.

2001-2025	30. Intrajovian probe to the planet's solid surface (if any) or deep atmosphere.
2001-2025	31. First or massive mining of Venus.
1976-2000	32. First wholly automated space flight.
1976-2025	33. Robots working in space (so flexibly as to climb hills, mine in tunnels, surpass men, pilot ships, roam over entire planets, transmit superb impressions of their environment, learn and innovate, farm, run factories, operate in teams, repair themselves, construct buildings, man weapons, run complex scientific experiments, &c).
2001-2025/?	34. A chain of 2-10,000 small nuclear bombs dropped (eg 1/minute, 1000/day) into a thus-excavated hole in eg Moon.
2001-2025?	35. First peaceful nuclear explosion on Moon.
2001-2075	36. Probe reaches Moon's center.
1976-2025	37. First in situ mining and refining of an asteroid.
2001-2025;?	38. First occupation of a hollowed and spun asteroid.
2051-2075	39. First project of "Dysonian" stature.
1976-2000	40. First transmission of energy from space for terrestrial purposes (eg collimated but areal, collinear, convergent, divergent, stored, &r fuel; ie eg "aser", "Tesla", "optic", "charged", "intrinsic", &c).
1976-2025/?	41. First determination of the existence of life on another star, esp. first detection and translation of an interstellar signal or message.
1976-2025/?	42. First acquisition of such information from civilizations of other stars as to revolutionize our culture.
2026-2175/?	43. First use of "Von Neumann machines" (ie self-reproducing, life-like automata able, through pullulation, to substantially transform an immense environment per artificial purposes; roughly, artificial biota serving industrial purposes; cf. Freeman Dyson).
1976-2025	44. "True" artificial intelligence.
1976-2025	45. "True" superhumanly intelligent machines.
1976-2025?;?	46. Speed of light proven exceedable.
1976-2025?;?	47. First transluminary success, communication, or transportation.
1976-2000	48. Objects lifted into orbit by hypersonic transports (HST's).
2001-2050	49. Objects lifted into orbit by using ground-based, eg gigawatt, lasers to ablationally propel them.
2001-2025	50. Use of linear motors or other ramp systems to launch craft or objects from the lunar surface.
2001-2025;?	51. 10,000 men (women, and children) occupying Earth's Lagrangian points a la O'Neill.
	52. Photopropulsive craft in space.
1976-2000/2025	53. Ionic or other spacial engines using charged or uncharged particle beams.
1976-2000	54. Fission craft (eg gaseous core, nuclear-electric, pulsed, solid core, &c).
1976-2025	55. Fusion craft.
1976-2025;?	56. Use of astronomical balloons to mine, refine, energize, atmospherize, and/or propel asteroids, Moon, other planets, and (incl. weather control) Earth, a la Pat Gunkel.
2001-2100/?	57. Mass agriculture in space to feed Earth (using the superabundant sunlight, low gravity, and room).
1976-2025	58. First "serious" use of space for medical purposes (space hospitals).
1976-2025	59. First periterrestrial or extraterrestrial touristry.
1976-2025	60. First commercial hotel orbiting Earth.
1976-2025	61. First large-scale manufacturing in space for exportation of products to Earth.
2001-2025	62. First "entirely self-reliant" subcivilization in space.
?1976-2025	63. First conscious "spacials" or spacial citizens.

2101-2150

64. Construction or completion of a "nonplanetary" or Dysonian band or sphere about Sun capturing her 10^{41} erg/y emission for local or remote industry, population, &rc (Earth receives $4 \cdot 10^{31}$ erg/y from present sunlight and man uses about 10^{27} erg/y of fuel; a megaton fusion bomb releases about 10^{22} erg).

2076-2100

65. First "terraforming" (transformation of the entire, immense surface and/or atmosphere of a planetary body so as to approximate it to Earth or render it habitable to man or suitable for human purposes; eg Carl Sagan has proposed using algae to terrestrialize Venus, Freeman Dyson has pictured transferring the ice from Saturn's moon Enceladus to Mars to give the latter an ocean and atmosphere, and various suggestions have been made for increasing the lunar atmosphere).

2076-2100

66. Expedition to another star.

by 2100?

67. 50-99% conversion of matter into usable energy.

2001-2025/?
2101-2125?

68. Relocation of a planet (eg Mars closer to Sun, Mercury orbited about Earth).

69. Transfer of a moderate asteroid to one of Earth's Lagrangian points, eg L5

Too many degrees?
1976-2025/&c
Progressive?

70. Modification of Sun for scientific, energetic, propulsive, "mining", and/or other purposes.

2001-2050

71. Discovery of a "transnuclear" source of energy, presumably coming out of particle physics or astronomy.

2001-2075

72. "Mining" of the jovian planets (eg hydrogen, helium, carbon, &c, or even hypothetical substances in hypothetical cores or layers).

1976/2001-2025

73. Terrestrial or intraspacial use of Jovian protium or deuterium for nuclear fusion.

74. Examination for possible stratification and mining of the numerous Saturnian rings, which are corpuscular.

1976-2025

75. 10^4-10^6 tons in Earth orbit.

1976-2000

76. 10^4-10^5 tons of freight annually exported from Earth into space.

1976-2025/?.

77. Payload deliverable into space from Earth at $50(1975)/lb.

1976-2000

78. Payload deliverable into space from Earth at $10(1975)/lb.

1976-2000

79. Reusable space shuttles.

1976-2025

80. A United Nations space undertaking, force, or "administration".

2001-2025

81. Lunar mining of fissionables.

Practical sooner?
1976-2025 ##

82. A Mercurial and/or perisolar power plant relaying solar energy to Earth or interplanetary loci.

83. Discovery of usable volcanoes, geothermal energy, "petrochemicals", other combustibles, and/or other endergonic reactants on or in Moon or other planetary bodies.

1976-2025

84. Magnitudinous use of sunlight on Moon to drive solar cells, hydroelectric generators, and/or other convertors, motors, and devices.

2001-2025

85. Materials dropped "meteorically" to Earth (deserts, ocean, Antartica, &c) for crude recovery.

1976-2025 ##

86. Installation of an astronomical observatory and gigantic or planetary telescopes on Moon's backside.

1976-2000+2025

87. 100-10,000 asteroids since "visited".

2026-2075?

88. Reception of an intergalactic message.

2076-2150

89. Launch of a cross-galactic probe.

2151-2175?

90. Launch of an extragalactic probe.

1976-2000

91. Disposal of certain lethal Terrestrial wastes in space.

1976-2025

92. Performance in space of certain experiments, processes, or undertakings too dangerous on or near Earth.

2025

93. A fair idea possessed of the kinds, abundances, distributions, maps, recoverability, and value of the total resource wealth of Solar System.

1976-2025&c =?
[illegible]-2025 ##±
1976-2025/? ##
1976-2025&c ##
2001-2025
2001-2025? =?
1976-2025;? =?
1976-2000&c =?
1976-2025 ##±
Endless? Sense? Degree? Uses? Implications?
1976-2025;?
2001-2025/? for?
[illegible]2175/?;?
Which?-When?-Why? Rate? Silly?
2076-2150
2101-2175? ## for?
2026-2075? ##?±
1976-2025&c ##
1976-2000;?
1976-2000
2151-2175??
2001-2100? ## =?
[illegible]2125?;?
2126-2150??
2051-2075?
2051-2100

94. "Absolute minima" of transportation, maintenance, and operations costs, including "maximal" economies of scale, &c.
95. Military or commercial hypersonic or suborbital transport, travel, and/or commuting across the globe.
96. Creation of an artificial moon, or its equivalent, to lighten night, perpetuate day, increase agriculture, delatitudinalize Earth, deseasonalize Earth, control global climate, &rc.
97. Explanation and prediction of longitudinal (days, weeks, months, years, centuries, and more) weather on Earth in terms of exospheric, magnetospheric, and heliological phenomena, and perhaps its, and even their, control.
98. Nuclear bombs used on Moon for construction purposes, eg the building of underground cities, tunnels, and storage places ("termitaria").
99. First intraspacial hostilities.
100. Discovery and occupation of natural caverns in Moon and other bodies.
101. Discovery and use of natural water on Moon or asteroids.
102. Erection of giant atmospheric domes, eg intradomal cities, on Moon and other bodies.
103. Agravitic, antigravitic, and/or supergravitic discoveries or inventions.
104. Discovery, and exploitation (eg for energy, inventions, material, adventure, &rc), that Universe is in some sense a "plenum" (eg of infinitely dense hierarchical structure, constituted of an infinity of particles and forces, infinity-dimensional, &c; a Diracian, Wheelerian, Hoylean, Dudleyan, Gunkelian, &rc "sea") rather than a "vacuum".
105. Space propulsion using nuclear explosions (cf. Project Orion).
106. Use of solar wind to sail about Solar System.
107. Use of stellar "breezes", light, gravity, magnetism, cosmic rays, enantons (alternating matter and antimatter, cf. Hannes Alfven's Worlds, Antiworlds), cosmic blackbody radiation (eg handled anisotropically), &rc to sail Milky Way and beyond.
108. Probe to Milky Way's center.
109. Interstellar "asers" (those espousing interstellar communication preexisting in a cooperative community might be compelled to presume as well ready or elicitable artificial interstellar flows of energy tappable by members; certainly the value of such artificial currents or beams is obvious, even for collinear commuters).
110. Communication using gravitons (Leon Brillouin, Relativity Reexamined, proposes using "grasers", by which he means gravific "asers"), muon beams, neutrinos, or other exotic, esoteric, or unknown particles, waves, principles, electromagnetic grasers, &c.
111. Revolutionary offensive systems using outer space.
112. Direct broadcasts from satellites to home receivers.
113. Proliferation of participants in space (NASA, corporations, UN, all the Great Powers, 10-20 lesser powers; eg US, USSR, UK, France, FRG, Japan, Italy, Canada, PRC, India, Mexico, Brazil, Iran, Arabs, Israel, Australia, Poland, Sweden, Czechoslovokia, &c).
114. Navigation of whole planets or solar systems cum stars about the galaxy (Fritz Zwicky) and reconstruction of galaxies (Olaf Stapledon, Pat Gunkel, &c).
115. Technological "teleportation", the transmission of material objects.
116. First meeting with beings of an extraterrestrial civilization.
117. First exploitation of John A. Wheeler's "superspace".
118. Population of Solar System, a quadrillion (10^{15}).
119. First probe or ship moving at relativistic (at least 0.1 c) velocities.
120. 10 stars inhabited by Homo sapiens or its derivatives.

1976-2025 121. Horizontal takeoff or landing systems for space.

[illegible]-2000? 122. 17-25 Mach ramjet.

[illegible]-2025? ## 123. Analogues to ramjets wholly or partly fueled by atmospheric extracts, suitable for operation in the atmospheres of other planetaries (Venus and the jovians, as well as Earth), perhaps interconvertibly or universally, and perhaps even able to regularly hurtle themselves into space and back or across to other planets (eg Earth=Venus), or operating as purely spacial and atmosphere-skimming craft in perpetual motion.

2026-2050;? 124. "Boats" on some layer or isopycnic of Sun--moving and operating by sail, "ramjet", or "Brownian motion" if not endogenous fuel--for scientific, exploratory, power-relaying, heliacal engineering, mining-mineralogical, manufactural, or other purposes, being either homoiotherms or poikilotherms with suitable electronics and mechanics to withstand the anomalous, hot, violent, and noisy conditions.

2001-2050 125. Intrasolar probe to enter, and perhaps leave, solar strata and structures (eg the corona, chromosphere, and regions below the photosphere; the prominences, faculae, sunspots, poles, and other quasi minute features and complex phenomena) and perhaps sample local matter; a subsequent generation of intrasolar devices for exploration, experimentation, or mining.

2026-2050/? 126. Ingenious devices for "mining" Sun (eg her heterogeneous corona which extends millions of miles and contains iron and nickel), including ingenious techniques (cf. #70).
Scale? For? How? Why?

1976-2000/2025 =? 127. Magnetogasdynamic (MGD; magnetic and electric fields coupled to plasma) spaceship.

[illegible]-2025/? 128. Terrestrial acceleratory ramps using linear or nonelectrical motors to launch craft or freight ("antimeteors") into or toward space; the tremendous advantage of this mode of launch is its economy from not using fuel to lift itself (if shipless freight could be trajected a further "double" economy would be realized by absence of shell weight and friction).

2001-2025;? 129. Use of tremendous &r swift flywheels (incl. spun asteroids or rocks thereof) to store energy in space, on Moon, asteroids, &c in light or zero gravity and extreme vacuum; superabundant and all-sized asteroids may possess considerable natural counterrotation that might provide local energy (spin spectrum =? possessed of negligible gravity, asteroids can be brought arbitrarily close to each other).

2001-2025 130. Moderately or highly efficient landing energy-regeneration systems (operating like buses using motor-generators, levitated trains in gravitational U-tubes, and a bob on a pendulum--as well as countless other critically-dependent natural phenomena--to store braking for relaunch so that interplanetary &r intraspacial transport might eventually become isentropic and costless; such unlikely "elastic" ideas are actually eminently feasible, especially in the light of new and future technology); note the "isentropic" analogue of automation (discounting initial expense over eternity and combining regeneration with complete automation of operations, future space transportation costs could become virtually zero or capacity-competitive).

[illegible] 2025/?;? 131. Large Terrestrial vertical, rather than diagonal, accelerators to hurl packages up eg to a broad Earth-parked planetoid (Dandridge M. Cole and Donald W. Cox, Islands in Space, suggest the last might have a magnetic retrieval field).
Better for Moon?

1976-2000&c ## 132. Miniature nuclear reactor, solar energy, or other novel engine systems for ground vehicles on Moon, Mars, asteroids, &c (note that the vacuum, low gravity, intense sunlight, &c of such landscapes could give them unmatched opportunities for primitive and sophisticated transportation systems).

1976-2025;? 133. "Mining" of upperatmospheric helium (or other gases) by low satellites using immense conical collectors.

2001-2025&c 134. Direct fission or fusion mining of planetaries.

2101-2150? Earth%? 135. Most people living in space and off planetaries.

2001-2050;? Figuration? 136. Astronomical machines (eg gigantic catoptrical balloons) melt asteroids and blow them into immense habitable bubbles, vitreous &r metallic (Dandridge M. Cole and Donald W. Cox, Islands in Space).

2001-2075 ##± 137. Matter-antimatter propulsion (eg un/natural leptons or baryons).

2026-2100 ## 138. First spaceships of urban or planetary size (eg operating in or out of Solar System, locomobile in various degrees or ways, manned or robotic, variously self-sufficient, directed to alternative and complex purposes, variously shaped and designed, housing 10^3-10^{20}, weighing 10^4-10^{27} tn, possibly "carrying" internal "stars", providing a "natural" or "artificial" living environment, &rc).

1976-2000 139. First achievement or some customary use of engines/velocities of 150,000 ft/s (100,000 mph, 0.00017 c); going to Pluto from Earth requires only 50,000 ft/s).

1976-2000 140. First achievement or some customary use of engines/velocities of 300,000 ft/s (200,000 mph, 0.00034 c).

1976-2025 141. First achievement or some customary use of engines/velocities of 600,000 ft/s (400,000 mph, 0.0007 c).

2001-2025 142. First achievement or some customary use of engines/velocities of 1,500,000 ft/s (1,000,000 mph, 0.0014 c).

2026-2075 143. First achievement or some customary use of engines/velocities of 10,000,000 ft/s (7,000,000 mph, 0.01 c); what is the curve of engine/velocity increase from lowest Earth orbit (25,000 ft/s, 17,000 mph, 0.00006 or $6 \cdot 10^{-5}$ c) to the velocity of light (c, 1,000,000,000 ft/s, 700,000,000 mph)--a difference by a factor of 17,000--and what will it depend upon?

1976-2000 144. Terrestrial cargo landed on Moon for $50-100/lb (round trip $70/lb).

1976-2025;? 145. Gaseous core nuclear ships able to land terrestrial cargo on Moon for < $1/lb (and to travel between planets for "a very few dollars").

2001-2025? =? 146. Solar electric propulsion.

2001-2025? Supreme, experimental, or any? 147. "Inevitable" development, construction, &r operation of a supreme computer in space owing to the latter's extreme cold, "absorptivity", conductivity and nonretardation of light, &c (assuming other ambient radiation is acceptable).

1976-2000:unmanned 2001-2025:manned 148. Surface of a jovian satellite, such as Titan or Ganymede, landed on and "carefully" explored by a manned or automated-but-supersophisticated laboratory (if not more, conducting all the types of investigation of Moon by 1975).

2001-2025?;? ## 149. Omnidirectional or "broad" transmission of electromagnetic ("supravisible", visible, IR, MW, radio, &r cross-spectral) or material particle-mediated (eg electrical) solar energy to Earth (eg a la Nikola Tesla)--depending on the technological and biological tolerability, cost, efficiency, workability, competitiveness, comprehensibility, &c of such fantastic modes of energy conversion, transmission, and distribution.

1976-2025&c ##

150. Capability, necessity, desirability, &r practise of marginally or drastically, homogeneously or heterogeneously, experimentally or purposefully, in one or many ways, safely or dangerously, correctively or innovatively, adjustingly or perfectingly, reversibly or irreversibly, empirically or theoretically, finally or incrementally, gradually or abruptly, slowly or quickly, regionally or globally, cheaply or expensively, crudely or elegantly, statically or variationally, naturally or artificially, by one &r many act &r method, consensually or nonunanimously, purposively or accidentally, favorably or unfavorably, successfully or unsuccessfully, militarily or peacefully, alternatively or constrainedly, supplementally or complementally, costfully or costlessly, &c altering the world's climate, performed in &r outside Earth's atmosphere, for a profile of one or many purposes, and by a particular schedule.

1976-2025/or Sun?

151. Nuclear generation of energy in space for transmittal to Earth.

1976-2025;?

152. Power relay satellite interlinking points on Earth.

1976-2025

153. Probe visits, examines, samples, &c one or many comets.

1976-2000/2025

154. Probe visits, examines, samples, &c 1-all of Saturn's rings.

Silly since reorbiting energy excludes gain?

155. Asteroids propelled to and dropped, or even "kicked", onto Earth (eg one a km^3 $\approx 10^{12}$ tn TNT) to serve various purposes: disperse ice caps, expose polar subglacial earth, "flake off" navigable and useful icebergs (eg for steerage to and carriage by oceanic currents to meet lower latitude freshwater needs and purposes), build giant craters for lacustrine and other purposes, penalize enemies, release geothermal energy, mine mountains, mine 0-3 miles down, dig great trenches or canals (tangential trajectory), disturb the crust; asteroids could function similarly on other planetaries and on an enhanced scale (eg to "gouge" Moon, probe Jupiter, pulverize-mine each other, &c), could be used to probe within Sun, as "planetary" interstellar ships, as extraplanetary ships gravitationally accelerated by a grazed Sun, &c.

Silly since reorbiting energy equals heat of sublimation, &c?

156. Asteroids approximated to Sun to liquefy and (autocentrically or heliocentrically) fractionate them, to chemically and materially transform, to gasify, dissociate, recombine, or "elementalize" them (for recovery), to incandesce and then relocate them as handy and usable thermal batteries or furnaces, to plasticize and mold them, &c.

1976-2100;? ##±

157. Subsurface nuclear explosions used to give Moon or other "anatmospheric" planetaries local or global, partial or full, nonterrestrial or terrestrial (eg 20% O_2), &c atmospheres (it is also conceivable that other sources of energy, eg focused nonradioactive sunshine, could be used); the nuclear explosion or controlled reaction could occur on a titanic or astronomical scale, eg toward Moon's center, and serve a multiplicity of purposes.

1976-2025 ##

158. Discovery/use of tremendous, unsuspected intraplanetary radioactivity, &r the retrieval of useful transmuted or radioactive nuclides, somewhere in Solar System.

1976-2000/2025;? ## 159. Discovery &r exploitation of the fact that major or even miraculous nuclidic, chemical, mineral, energic, &r "environmental" heterogeneity, "fractionation", range, concentration, and subtle variation occurs in one or many forms in Solar System (eg per planetary sizes, solar distance, Kirkwood position of asteroids, satellitic order, order within Saturn's rings, intraplanetary horizon, intraplanetary "hierarchic cluster", distance from Jupiter's orbit, membership in some intraplanetary phenomenal formation, &rc), and in such a way as to complement or supplement present or future industry and represent an overall economy.

1976-2025&c;? ## 160. Creation of hyperbaric &r hyperoxic, or ultrabaric, atmospheres on Earth, other planetaries, &r in space if it could enable "super agriculture", regardless of the forms of natural, modified, or artificial life used (eg cf. #157); for an extreme, how would plants grow in liquid air (perhaps in a thin film or shallow "lake") at room temperature?

2026 thru 2100;? ## 161. Thin-shell or inflated enclosures ("tents"), perhaps 10-100 ft high, could so multiply, overspread landscape, and interfuse gradually over time as to assume planetary proportions and ultimately--or directly in a Dysonian fashion--englobe planetaries, and constitute distinctive low-and-closed atmospheres ("cutospheres") more efficient, economical, stable, regulable, natural, practical, &c than ordinary atmospheres; such cutospheres could arise on anatmospheric planetaries like Moon, Mars, and the asteroids, over at least portions of Earth, over intraspacial "cities", &r under intolerable atmospheres, perhaps like that of Venus.

2001-2175 ##± 162. Creation and use of titantically or astronomically large actual or virtual lenses, mirrors, "asers", transformers, transducers, modulators, capacitors, rectifiers, circuitry, batteries, conductors, resistors, &c ("celestial photonics") for planetary engineering employing up to 10^{41} erg/y of solar energy; the energy and apparatus might serve other purposes as well, eg controlling Sun, communicating with another stellar civilization or the entire galaxy, amplifying extraordinarily weak signals or self-descriptive emissions of Nature, ad infinitum (it is to be expected that possible and appropriate uses, of now unimaginable kind, will emerge when such energy and apparatus becomes available and used).
First example=?

1976-2025 163. Perisolar industry exploiting the multitudinous and high curents, voltages, and frequencies in particle fluxes of matter and energy in and around Sun varying with solar distance, latitude, and cycle-spectrum time (eg the gamma and cosmic rays to produce isomers, radioactive or other isotopes, and transmutations, and molecular changes, novel molecular processes, and novel materials).

1976-2025/2175&c 164. Physical, chemical, biochemical, biological, and industrial processes and structures not just suitable but ideal for the positive and negative peculiarities of space (eg in terms of the intensity, spectrum, and collimation of sunlight, infinitesimal gravity, infinitesimal temperature and heat, extreme vacuum, importable materials, needs, &c).

1976-2000 165. Sonded-balloon investigation of other planets' atmospheres (Venus and the jovians).

2001-2025/2050;? 166. Ships launched from Earth and other planetaries, a la remote propulsion by laser ablation, by solar energy beamed to craft rising from Earth or to launch site (lasers, optics, converters, transducers, &rc could be used or combined).

1976-2025;? 167. Lesser power places nuclear bombs in orbit as a relatively cheap and invulnerable strategic-weapon system (in lieu of large, airborne, submarine, land-missile, &rc systems).

1976-2000;? 168. Orbital missile-interception systems (BAMBI ie "Ballistic Missile Boost Intercept") to attack launched missiles at their vulnerable "boost" phase (without or with nuclear warheads).

1976-2025&c;? 169. Abrogation, violation, or evasion of the Outer Space Treaty (1967) and sister agreements, and realization of space-based war (especially nuclear) capabilities, eg by sudden deployment of prepared offenses &r defenses or weapons previously secreted in space (perhaps even by a rationale of "preemptive preparation" in defense).

1976-2025;? 170. International teams or robots using spaceships to systematically tour and inspect some or all satellites and stations in orbit, in deep space, &r everywhere else in space, to ascertain military, especially nuclear, capabilities.

1976-2000&c 171. Robots or teams in spaceships to periodically &r per need inspect, maintain, repair, refuel, reconstruct, enlarge, exchange film, &r otherwise modify periterrestrial &r extraterrestrial satellites, stations, "artificial planetesimals", eccentric-orbit probes, ships, &c, eg because of great enlargement, complication, proliferation, longevity, age, progress, &r opportunities of periterrestrial satellites, new opportunities for and economies in such maintenance and access, the ideality of maintaining rather than adding to and replacing (increasingly expensive and, say, modularized) satellites, the increasing opportunities for and appropriateness of such human presence or visitation, the increasing human residence in space in general, &c.

1976-2050;? ## 172. Periterrestrial or extraterrestrial military (eg semimilitary) bases.

1976-2000 173. Aerospace plane (amphibious).

1976-2000&c ## 174. Reexecution and execution of critical physical experiments in space.

2001-2025;? 175. Manned maneuverable geocentric bombardment fleet.

2001-2025?;? Why? How? 176. Sweep up Earth-trapped radiation zones.

2001-2025?;? 177. Heliocentric strategic or tactical fleet.

1976-2025;? 178. Asenescent suspended animation possible for 20-1,000 y, allowing interstellar flight.

1976-2000: 10^4 tn
2001-2025: max 10^6 tn 179. 10^3-10^6 tn payload launchable from Earth to space in single vehicle.

1976-2000 180. 10^5-10^8 watt power plants in space, eg Earth orbit, for immediate space needs (whether nuclear reactor, radioisotopic, solar, battery, fuel cell, combustive, &rc).

1976-2000 (10^{-3} m?) ##± 181. Theoretical, actual, economical, or large-scale resolution of nonlinear objects of diameter 10^1-10^{-3} m on Earth from space (eg by telescopes, active sensors, select portions of the electromagnetic spectrum, data processing, mathematical techniques or theory, night or day, in normal or exceptional conditions, socially or militarily, in real-time or eventually, for national or global use, for developed uses, &c; eg a system able to track or trace individual cars or citizens vertically, to simultaneously map the waves of the ocean or the textured tree-shaking winds of a continent, ad infin.)

1976-2000 (10^{-6} m?) ##± 182. Extraordinary or theoretical (eg 10^{1}-10^{-6} m nonlinear-object) resolution of the (2- or 3-dimensional) surface of planetaries with little or no atmosphere (eg Moon, Mercury, asteroids, Mars, possibly Pluto) from space, a la #181; eg anatmospheric and inert planetaries like Moon could be "perfectly photographed" and these "pictomaps" thereafter be perlustrated and elucubrated in order to substitute for, and guide, a great deal of direct manned or unmanned exploration cf eg #4 (eg multiinstrumented and multipurpose "pictomapping" laboratories could be dispatched to all the planets, many other planetaries, and Sun for the sake of pictomapping Solar System and serving an intermediate stage of its study using these devic

1976-2025&c ## 183. A la ## 4, 181, and 182, all or most of Earth could be under continuous nonmilitary and military reconnaissance and surveillance (eg as a "face" of 10^{13}-10^{21} cells-of-resolution) from space for real-time, partial, from-memory, or progressive study (notice the virtual infinity of cross-correlations or analytic combinations)--a semidivine "Earth-consciousness".

1976-2000 (10^{15}?) 184. 10^{10}-10^{15} bits/sec (10^{17}-10^{22} bits/y) transmitted interterrestriall via space for the entire Earth.

1976-2000 ## 185. .01-.5 of large computers on Earth normally or facultatively interlinked, and perhaps cooperating, satellitically (eg for time-sharing, "free" or free access eg by all men, for health, education, science, trade, &c; for information, computation, &r regulation).

1976-2025&c ## 186. Interterrestrial communication via space so vast and sophisticated (cf. ## 184-5) as to birth a world language (English, "computere number, binary, information-theoretic, "intelligence-theoretic", &rc), government, economy, culture, &r society, directly or indirectly.

1976-2000 187. Earth-space, space-Earth, space-space, and Earth-space-Earth communication using higher frequency "asers".

2001-2025;? =? 188. "Automobile-like" vehicles enabling wealthy or average individuals or households to enter space from space or Earth (space universalized).

1976-2000/2025;? 189. Interpersonal (eg soldier-soldier) communication via space (super satellites &r super transceivers).

Past-2025 ## 190. Capability and actuality of continuous monitoring of all military submarines (perhaps regardless of depth, location, "microlocation", weather, disguise, interference, size, subglacial position, wartime environment, &rc), perhaps coupled with some "sufficient" or advantageous counterforce capability and operation, and perhaps having a novel critical balancing or destabilizing effect in the arms future.

Past-2025&c/2175&c ##± 191. First, mixed, large-scale, signifigant, irreversible, cosmoplastic, uncontrollable, cumulative, &rc pollution of or from space (eg rocket emissions catalyzing global climate changes, titanic space masers or mirrors exerting Earth-ecological effects, radioisotopic clouds from fissionables mined in space or disintegrated nuclear ships or plants poisoning Earth's atmosphere, biological or gaseous contamination of microatmospheric planetaries, pathogens returned to Earth, radioactive explosions on other planetaries, scientific or technological alterations of Earth's weather, climate, atmospheric layers, Van Allen belts, magnetosphere, &c, comparable alterations of other planetaries, scientific or technological alterations of Sun, "terraforming" of other

planetaries, saturation and disturbance of the electromagnetic spectrum affecting communications or astronomy, aftereffects of egregious wars, "morphological" changes of faces of other planetaries, creation of interplanetary meteroids, alteration of the interplanetary atmosphere (eg crudely weighing $\sim\sim 10^7$-10^9 tn), intensification of aurorae, disturbance of Earth-atmospheric communication, celestial-mechanical or other "Dysonian" perturbations or modifications, holocaustic particle-physical "ignitions" of ordinary planetary material, &rc

1976-2000,-2025,-2050 192. First spacial disaster costing 10, 100, or 1000 lives.

2076-2175? ##± 193. Planets supplemented or replaced by "artificial planets" (cf #138) built from the substance of Earth, Moon, the asteroids, Jupiter, other or all planets, &r Sun (eg steric Earth's surface could be multiplied up to 10^{10} times or, in effect, rendered flesh and "environment" in a 1:1 ratio as 10^{21} men, as a Dyson sphere; Solar System could have 10^0-10^7 planetaries; industry or society might be restricted to artificial or natural planets; planets might be disassembled for seperating minerals, enlarging agriculture, enlarging population, capturing Sun's total energy efflux, constructing "celestially large" and strange machines, fashioning spaceships of planetary size, controlling nature, cooling the interior of Earth, &r for other purposes).

Past-2175/10^8y/10^9y? 194. Milky Way fully populated by life at least as intelligent as Homo sapiens (by Terrestrial men or artificial intelligence, or by extraterrestrial beings) and become a complete community.

Past-10^8y/10^{10}y? 195. Universe fully populated by life at least as intelligent as Homo sapiens (a la #194) and become a complete community.

10^{11}y-∞y;? 196. All life throughout Universe finally ceases since energy, matter, possibility, time, space, meaning, purpose, viable conditions, &rc completely exhausted.

2001-2175/10^9y? ## 197. Incidence of "terrestrial" planets, life, intelligent life (say of "animals"), humanly inteiligent life, humanoid life, alternative life, superhuman life, arbitrarily great intelligence, &rc established for Milky Way &r Universe; in particular, the relative uniquity of man established.

1976-2175&c?;? 198. Racial realization, perhaps proof, that the exploration, occupation, exploitation, &r unification of the extraterrestrial Universe (other stars, Milky Way, all that there is) is or is not futile, meaningless, unnecessary, accomplished or not ours, misconceived, &r inevitable.

1976-2025 199. $\$10^{11}$(1975)/y or 1% GWP spent by Earth on space.

1976-2000:$\$10^8$
2001-2050/?:$\$10^{11}$
##± 200. $\$10^8$-$\$10^{11}$(1975)/y/Earth directly spent on astronomy, titanic and planetary telescopes and other ultrasophisticated instruments (eg orbiting Earth, in space, on Moon) developed and built, astronomic knowledge (1975) enlarged 10^2-10^8 times, transplutonian observatories dispatched in 1-4 directions for immense interferometric and parallactic determinations, much radical astronomic advancement of fundamental physics and cosmology through revolutionary astronomic discoveries, &rc as a novel era of pure scientific research in the future.

erious, all-out, or
dequate? 201. Our first attempt (initiatory or responsive) to communicate to another star's civilization.

2051-2075/?;? 202. Conflict, perhaps even "unlimited" war, with an alien civilization.

203. Immaterial transmission of material objects (eg men), or of "intelligence" (specific complex causative influences), sans artificial receivers, say to other stars; conversely, an almost clairvoyant ability to see aspects or scenes on planets of other stars, sans artificial transmitters, via superscientific receivers on Earth comprehending, distilling, and exploiting natural signals carrying an unsuspected wealth of information.

1976-2025 ##

204. Map the morphology, and possibly the mineralogy, of Solar planetaries (and possibly subvisible interplanetary, transplutonian, and interstellar planetaries, rubble, dust, molecues, and plasma) &c, by powerful, precise, computer-assisted &rc active sensors ("radars") located on Earth, around Earth, toward the target, or in situ, a technique that, sophisticated, might rival or surpass, empirically or even theoretically, the power or value of visual telescopy and unmanned or manned probes (or, say, in cost/benefit terms): radar imaging and basers

1976-2000;? =?

205. Solid chemical propellant equaling or surpassing today's or tomorrow's liquid propellant in power, convenience, &r other characteristics (size, weight, regulability, efficiency of reaction, safety, cost, &c).

1976-2025

206. The theoretically ultimate chemical propellant, a la #205; eg the theoretical minimization of the chemical/nuclear, electronic/nuclear, &r strong force/electromagnetism gaps.

2001-2025?&c;?

207. Maximum-electrostatic-charge vehicle (and general spacial battery); eg using a concentrated pressural sea of like, and thus mutually repellent, charges--$e^{\pm}$, $p^{\pm}$, &c; the question is, toward what fermionic density can such positive potential energies be--simply, subtly, or regulably--compressed?

2126-2150?

208. ∿c travel.

2000

209. Earth-into-space, planet-to-planet, &r intraspacial "baser" beams "ridden" by pioneer probes &r ships, &r traffic (convertively or ablatively); eg like companionate searchlights, beams originating from powerful perisolar stations might spoke Sun to run ships and laboratories navigating Solar System.

2000

210. Minerals, chemicals, other materials, &r "small" objects (perhaps comminuted, pelleted, atomized, encapsulated, coated or combined, &rc) for transportation across space as, in effect or fact, particle beams shot--eg electrostatically, magnetically, chemically, or nuclearly--from extremely long &r powerful "guns", at 0-c velocity; eg mass fluxes from such "mass drivers" might move in dis/continuous, dense, &r enormous streams or rays with variable dispersion &r deflection as the predominant freightage from Asteroids or Pluto to Earth.

2001-2025;?

211. Magnetomotive space vehicle (leaves and pursues poles--or pilots magnetospheric flux lines, isomagnetics, and radii--of Earth, Jupiter, Sun, galaxy, &rc, via herculean electromagnets).

1976-2000

212. Partially fueled takeoff with in-flight refueling.

1976-2000

213. Redeemed single-stage-to-orbit (SSTO) spacecraft (eg cum ## 121, 128, 173, 211, &rc, or by vertical launch).

1976-2000&c ##

214 Various, elaborate, variously harmonious and unitary, variously novel, &c US-USSR, US-USSR-ia, &r other international events, missions, programs, purposes, developments, industries, &c (periterrestrial, Lunar, manned Martian, interstellar-communicational, astronomic, &rc).

1976-2000 214. Flights and purposes out of the solar ecliptic plane (oblique or meridional), which require more energy.

past-&c ## 215. Gravitationally-acceleratory trajectories using Solar &r planetary fields for Solar Systemic or transplutonian transportation (theoretically these could comprise many loops for progressive acceleration to arbitrarily great velocities, but eventually the trajectories become hyperbolic and loose the accelerate into bodiless or insular space); eg a spacecraft from Earth could derive the energy for leaving the ecliptic using Jovian or Solar gravity to overfly Sun's N and S poles.

1976-2000 216. Highly or totally maneuverable orbiters or nonorbiters (eg able to change to any longitude, latitude, altitude, velocity (incl 0 orbit (eg "geosynchronous"), &c, to do so reversibly (incl takeoff and landing), to do so 1, 10, or 100 times or perpetually, to assume any eccentricity, "amphibious", to execute complicated maneuvers, to return to Earth (possibly for refueling or film, sample, crew, &c removal, for repair, reequipping, or redesign), for any and all of the planetaries or beyond Solar System; possible realization, thus, of economies over many and diverse serial and parallel devices; such vehicles could be used in connexion with very-mooned planets, Asteroids, eccentric planetoids, comets, to couple the transmartian planets, to explore Solar System en bloc, &c (and cf ## 146, 182, 183, 204, 209, 216, &c); at "minimum", large craft could "piggy-back" many craft, devices, materiels, &r personnels to sets or systems of planets, stations, or loci, dispatching &r retrieving seriatim (eg satellites, telemetric microstations, many simultaneous satellites &r landers for the same planet or space, &c).

001-2025?;? =? 217. "Perpetual motion" passive or semiactive craft or devices ("interplanetary orbiters") relying upon gravitational fields, miraculous orbits, computation, course correction, compensation, adequate semistable or metastable trajectory topologies, &rc so as to create closed or temporarily closed 3-body or n-body oscillations (the oscillator could commute capsular or near-communicated information, subcraft, freight, passengers, crews, tourists, &rc).

1976-2000 218. Wholly unmanned and robotic craft cum subcraft for scouting and landing-cum-leaving other planetaries.

1976-2000 219. Discovery and use of massive extraplanetary water (eg Fred Whipple's cometary "snowballs", and glacial or glaciated asteroids or satellites (eg Ganymede)); the water might be used in situ or allochthonously as hydrogen, oxygen, or water, for power, drive, food, breath, agriculture, manufacture, fusion, construction ("grand igloos"), "terraforming" (rename planeturgy or planetary ecopoiesis), &rc.

1976-2025;? 220. Human physiology proven un/remediably in/adaptable to temporary or permanent residence in the gravitational, atmospheric, radiational, &rc conditions of interplanetary space &r other planetaries; and consequences of proven inestablishability (eg minimization of intraspacial time, human selection, need for artificial gravity or major insulation, medical needs, need for artificial gravity on low-g planetaries such as Moon and Asteroids, abandonment of space, present or lasting (but fantastic) substitution of instruments &r robots (eg "androids") for some or all space operations and activities, need for better control over or radical modification of human physiology, postponement or slowing of spacial exploration and development, elemental dangers tolerable by earthbound and spacebound alike, &rc).

1976-2025;? ## 221. Various consequences of life or fossils (cf ## 13 and 14) being found elsewhere in Solar System (exobiology, exobiotaxonomy, exopaleontology, exoecology, exploration, exopathology, exoagronomy and "planeturgy" using natural or modified "exobionts" and "exoecologies", transfer of the latter two to Ea vice versa (eg symbiotically), other exobiological industry, amplified &r accelerated exploration &r development of space, &r

1976-2025/&c ## ! 222. Pluto (enigmatic and unknown in 1975) photographed, radared, flown by, orbited, landed, sampled, crudely spectrographed, morphologically mapped, chemically mapped, explored from the ground by man or machine, sampled by matter returned, crudely or well understood internally, "explained" and resolved of salient mystery, found ordinary or extraordinary (elementally, geochemically, geophysically, atmospherically &r oceanically, cryologically, "plasmospherically", electromagnetically, cosmogonically, geomorphologically, climatologically, phenomenologically or scenically, mechanically, &r economically), crudely or well understood exploitationally/& economically, crudely or well exploited, &rc; eg is Pluto denser than Earth, neither terrestrial nor jovian, the outermost planet, planet or moon originally, with/out sea/atmosphere, cold or hot, dead or active, advantageous for an astronomic observatory far from Jovian, other planetary, Solar, &r interplanetary (eg assuming Solar System has a "thick" and bounded plasmatic (fermionic) or bosonic envelope) noise and interference (eg things blocking or burying pieces of the natural energy and frequency spectra), plutologically valuable in Terrestrial terms, exploitable as a cryogenic domain or reservoir, &rc?

1976-2000 223. Transplutonian probe launched to explore interstellar space (10^9-10^{13} miles); note leaving the ecliptic plane might accomplish this, at least in part, by a much shorter excursion (whose continuation could fulfil both purposes); see #222.

224. Any/full interstellar/galactic/intergalactic enterprise, trade, mining, energy, &r the like.

1976-2000 225. Solar energy basered to Earth (later, other planetaries) via great in-orbit receiving-converting-retransmitting stations, eg via microwaves; eg 10gW/station.

1976-2025 226. Energy for space (ships, laboratories, colonies, &c) basered up from planetaries such as Earth.

1976-2025# 227. Worst &r major polluting processes kept off Earth.

1976-2025&c 228. Disputes over territorial and other space rights.

2001-2025 229. Vast, paper thin, and gossamery radioisotopic sails propel ships.

2001-2025 230. An "industrial satellite belt" comes about.

?1976-2000 231. Propaganda wars using direct broadcast satellites.

1976-2000# 232. Semi/permanent Martian base/colony.

1976-2000 233. Men visit Mars.

1976-2000# 234. Base/colony on another moon (eg 16km Phobos of Mars, Io or 5100km Ganymede of Jupiter, Mimas or 4800km Titan of Saturn, Ariel of Uranus, Triton of Neptune).

1976-2000# 235. Extraplanetary or periplanetary ships &r stations once/endlessly refueled by economical throwaway/cyclic unmanned "refueler" ships. Also resupplied, repaired, altered, checked, &c (cf #171)?

1976-2000# 236. Permanent or 10-100y life satellites and other unmanned vehicles.

1976-2025/2160# 237. A proper "second earth" extant (eg cislunar, Lunar, rerelunar, antiterran ie 180° from Earth, Plutonian, transplutonian, &r heterostellar).

1976-2025# 238. Actual mining of planetaries (Moon 1997, asteroid 2000, Mars 2005, Mercury 2010, jovian moon 2015, Pluto 2020, and the like).

1976-2100# 239. All 9 planets since: flown by @<10^{6-5}mi (1990), landed or entered (2000), visited by men (2014), equipped with a manned base (2020), "colonized" i.e. population >10^3 (2038), "populated" i.e. population >10^6 (2060), and "filled" i.e. population >10^9 (2100).

KEY

/ A slant signifies a competing, further period of possible dates.

? A question mark after a date, directly, signifies uncertainty over the range as a whole.

/? A question mark after a slant functions as already indicated.

;? A question mark after a semicolon indicates a serious question about the event, eg its feasibility.

_ A date is underlined if it, as a pole, is stressed.

This indicates the event, as stated, or inherently, contains a number of possibilities; in effect, subevents.

&c The range continues, perhaps as a progressive development of the "event".

=? Asks, in effect, what is intended, required, &c.

± Indicates the date of the event varies with its components, ##.

?? Comparative of "?".

SPACE DEVELOPMENT:
BREAKS, THRESHOLDS, INFLECTIONS, TRIGGERS, AND CATALYSTS

Foreword. The future development of space will be contingent upon various events: intrinsic and extrinsic, obvious and obscure, controllable and not, likely and unlikely, datable and not, sizable and not, rankable and not, independent or interdependent, early and not, critical or just modifying, evolutionary and revolutionary, facilitative and inhibitory, political, military, economic, social, scientific, technological, engineering, domestic and international, reversible and irreversible, unambiguous and ambiguous, and in all kinds of things. Such a batch of unavoidable and decisive circumstances makes forbidding the quest to plan and anticipate possible and actual courses of events, especially as a bigger calendar is attempted. Even so, or perhaps because of this, specific events and circumstances can be listed apt to have a critical bearing on space development overall. Presented, these can be applied as the basis of alternative hypothetical scenarios, and a comprehensive set of scenarios should in turn furnish a reasonable, or at least useful and instructive, picture of men in space in future.

1. Drastic (1-2 order of magnitude) fall in the cost/price of energy, at least in terms of space (eg Earth to Moon @$1-$10/lb. of payload).
2. A new source of energy (eg efficient fusion, solar energy beamed from space to launch site or craft rising from Earth, a new mode of nuclear energy eg using catalytic quarks or antimatter, &c).
3. A nuclear Earth=space or intraspacial spacecraft developed and operational.
4. Renewed competition between Great Powers, new and multiplied nations, new corporations or consortia, &r a United Nations program in terms of programs, profits, purposes, agencies, capabilities, &rc.
5. New or expanded private and semiprivate cooperation, programs, purposes, needs, directions, shared means or scale, federal raison d'etre, public support, resulting accomplishments, spectacular and exciting developments, &c.
6. New, emphatic, mild, or horrid unilateral or multilateral defensive or offensive capabilities or achievements of strategic or technologic kind directly or indirectly involving periterrestrial &r extraterrestrial space, and hence a direct &r indirect military spur of special or general quantitative &r qualitative originative or reactive development of space at a renewed, sustained, accelerated, maximal, or "supramaximal" rate, scale, motivation, &rc (eg unilateral causing bilateral causing multilateral causing world involvement).
7. A reversal of growing or maintained antiscience, anti-space, pro-social, &rc sentiment &r a rebirth or birth of imagination, a spirit of adventure, a specific enthusiasm for space, and pro-space politics, occurring either spontaneously (eg antiphasically or dialectically) or as a result of other developments intrinsic or extrinsic to space.
8. A conspicuous, understood, or virtual break-even point in the partial, net, or total profitability of space in terms of space-related industries, spin-offs, or intraspacial civilization, or a rapid improvement in such profitability or returns.
9. Discovery of simple or complex life elsewhere in Solar System.
10. Discovery of transplutonian life.
11. Spectacular astronomical discoveries complete in themselves or demanding further investigation (such as greater instruments and ones in space), perhaps discoveries upsetting or transcending basic or important physical laws, and perhaps promising eventual or imminent technological &r social consequences, or such as to grip public imagination a la Relativity in the first half of the 20th century.

12. Spectacular, beautiful, stark, detailous, artful, grand, mysterious, adventurous, philosophically provocative, natural and uncontrived, constant, massive, widely shown, understood, and appreciated, &rc photography, television, cinematography, publications, museums (dioramas), artist representations, stories, narratives, &c depicting the static, dynamic, systemic, historic, possible, and imaginative faces, geographies, settings, features, aspects, phenomena, events, processes, stories, perspectives, and abstractable meanings of other planetaries or Solar System; the reproductive technology may be progressed eg involving natural, transformed, or "equivalent" sound, computer reprocessing, fantastic photographic detail and accuracy, insightful or stimulating "coherent" transformation of color scheme, stereoscopy or holography, "zooming", "omnifocal" techniques, cycloramic or "spheroramic" photography, the invisible spectrum, acceleration and deceleration of time, unbelievably powerful spectral analysis by computer, real-time transmission to Earth, natural &r "supernatural" (in the sense that IR photography is both natural and supernatural) information involving other senses (eg vibratory, vestibular, tactile, thermal, olfactory, algetic, kinesthetic, emotional, &c); and such adventure, reportage, art, reproduction, perception, contemplation, dramatization, explanation, conceptualization, amplification, &c may be made a high or supreme part of each and every mission or of exploration of Solar System, and every effort could be made on Earth, at great expense, to cause every American and Earthling to experience, understand, enjoy, and love the returning and unfolding perceptual and conceptual treasures from the space expeditions and existence; note that the degree and style with which this has been done hitherto has been pathetically poor, but unnecessarily and consequentially, and that such treatment in the future can, for reasons basic and not, occur in the sublime way I have depicted, especially as the technology is developed and applied, and the highly imaginative and almost religious policy is (if it is) adopted and applied (this is obviously, also, a superb way to compete, propagandistically and morally, with the USSR).
13. Discovery of spectacular, easily exploitable, and clearly lucrative mineral wealth (eg lodes, traces, rare elements, rare or exotic chemicals, rich soils, peculiar Solar Systemic fractionations, fuels, cheaper bases for spacial industry obviating importation from Earth, "precious" and shippable asteroids, collectible and shippable atmospheres, &c) anywhere in Solar System.
14. Permanent residents, cities, colonies, governments, industries, scientific laboratories, research expeditions, &rc in space, eg reporting back.
15. Thousands of launches, thousands of payload tons, &r hundreds of men from Earth into space per year.
16. Ultrasophisticated or intelligent automata or robots, &r comparably sophisticated "telechirils", replacing or joining men in space.
17. Virtually totally automated circular flights, eliminating the human backup henceforth on similar or novel missions, and a similar level of automation and dehumanization of other space operations and enterprises.
18. Economies of scale allowing deflation by 1-2 orders of magnitude.
19. Economic (GNP, GWP, GWP/capita, discretionary income), social, political, scientific-technological, and purposive growth of the world increasing competitive and cooperative involvement in space, diminishing its relative cost, and accelerating its autocatalytic progress.

20. Useful achievement of some level of exploration, and morphological and mineral mapping, of some part of Solar System, allowing or encouraging [illegible] utilization.
21. [illegible] of occurrence of private or national territorial, mineral, and other interested claims of parts of planetaries.
22. [illegible] of space for the capture, generation, &r transmission of [illegible]
23. [illegible] space for [illegible] Terrestrial or [illegible]
24. [illegible] (1-5 order of maghitude) increase of single or diverse periterrestrial [illegible]
25. Space shuttles, spaceplanes, aeronautic launches, &c.
26. Discovery of an acute need to modify, control, or improve global climate [illegible] ering).
27. [illegible] expenditure on space by Earth.
28. Great, sudden, insuperable, economic or absolute, unique or multiple (eg "across-the-board"), "fixed-pie" &r "fixed-tap", ideological or real, accomodable or inaccomodable, "shrinking-pie", "autotoxemic", &rc [illegible] future Terrestrial resource crises (with or without further [illegible] demographic, economic industrial, &r scientific growth).
29. Discovery that spacial loci and conditions are highly competitive for certain industrial processes, products, or services sufficiently high in profitability &r vendibility.
30. Discovery or demonstration that one or more spacial works of Dysonian scale are now or directly, easily, simply, trustably, super inexpensively (or per return), super profitably, super beneficially, "economically" (ie eg drastically decreasing previous expenses on Earth), &c implementable, [illegible] or less demanded by Terrestrial straits (examples would be catoptrical balloons of astronomic scale focusing sunshine on Earth for macroengineering, industry, electricity, weather, reclamation or prospering of high, frigid latitudes, &rc, and a herculean periterrestrial communications system effectively quantum-jumping Terrestrial society and the development of nations).
31. Discovery of (other) surprisingly cheap ways of doing things in space, eg asteroidal ballistics, planet-to-planet "ramjets", pulsed nuclear [illegible] of Sun as a furnace, catoptrical balloon refinement of asteroids, solar ground vehicles on Moon, cavitation and gasification in Moon using nuclear bombs, solar-hydroelectric plants on Moon, acceleratory launching ramps, regenerative braking, ad infinitum.
32. Spacial touristry beginning and booming.

ENVIRONMENTAL ENGINEERING AND CONSTRUCTION

1983(10^4) & 2000?(10^6) 10^{4-6}tn accumulated in Earth orbit. 75.
"1990"&c Structures ideal for space. 164. 1976-2025/2175&c
1993 Lunar base. 2 1976-2000
"1995" Robots working in space. 33. 1976-2025#
"2000"? Pollution of or from space. 191. Past-2025&c/2175 #
2000? O'Neill "colony" at L-5 (50 men?). 18. 1976-2000/2025
2000? Artificial moon or its equivalent. 96. 1976-2025/?
2005? Disputes over space rights. 228.
2005 Lethal Terran wastes disposed of in space. 91. 1976-2000
2005(&c?) Polluting processes kept off Earth. 227.
2005 Rerelunar observatory and supertelescopes. 86. 1976-2025#
?2005 Van Allen Radiation Belt swept up. 176. ?2001-2025?
2007 Lunar population 1,000; buildings. 10. 1976-2025
2007 Giant domes for atmosphere and cities on Moon, &rc. 102. 1976-2025
?2010 Natural caves found/occupied on Moon, &rc. 100. ?1976-2025
?2010 Super atmospheres for super agriculture. 160. ?1976-2025&c
2010 Asteroid moved. 20. 2001-2025
2010 Asteroid moved to Terran L-5. 69. 2001-2025
?2010 Asteroids dropped or flung onto Earth for engineering. 155.
2015? Performance in space of too dangerous experiments, processes, or undertakings. 92. 1976-2025
2015 Hotel orbits Earth. 60. 1976-2025
2015 Climate changed. 150. 1976-2025&c#
?2020 Terran L-5 population 10^4. 51. ?2001-2025.
"?"2020? Use of exobiology for environmental engineering, or exobiological "accident". 221. ?2001-2025
?2020 An asteroid hollowed out, spun, and occupied. 38. ?2001-2025
2025 Nuclear bombs used for Lunar construction. 98. 2001-2025
"?"2025 Chain of nuclear bombs used to penetrate Moon. 34. 2001-2025/?
2040? Lunar population 100,000; cities. 11. 2001-2050
2045? Martian population 100,000; cities. 12. 2026-2050
?2050 Asteroid fused, blown into a bubble, and occupied. 136. ?2001-2050
2060? Spaceships of urban or planetary size. 138. 2026-2100#
2065(satellite) & 2100(planet) & 2010(asteroid) Planet/planetoid relocated. 68.
2070 Project of Dysonian stature. 39. 2051-2075
2070 Artificial planets. 193. 2076-2175?#
2075 Celestial photonics for engineering. 162. 1976-2175&c#
?2080 Tents and cutospheres. 161. ?2026-2100#
2080 Von Neumann machines (experimental?). 43. 2026-2175
2085 Terraforming or planeturgy. 65. 2076-2100#
2100(exploitative) & 2045(experimental) Sun modified. 70. 2101-2125?
2105 Most men living in space and off planetaries. 135. 2101-2050?
2125 Dyson sphere begun &rc. 64. 2101-2150#
2220? We occupy 10 stars. 120.
2300? Solar System population 10^{15}, a quadrillion. 118.
2600-10^7y? Planets/solar systems navigated around Milky Way and galaxies reconstructed. 114. #
10^5y? Milky Way fully populated by some intelligence. 194. Past-2176/10^8y/10^9y
?10^8y? Universe fully populated by some intelligence. 195. Past-10^8y/10^{10}y

ENERGY

1980(10^6) & 1991(10^8) 10^{6-8} watt power plants in space for space. 180. 1976-2000#

1990 Experimentally, energy sent to Earth from space. 40. 1976-2000#

1995 Magnitudinous use of sunlight on Moon. 84. 1976-2025

1995 "&" 2075 Celestial photonics. 162. 1976-2176&c#

1997 Solar energy basered to Earth from orbit on a large scale. 225. 225. 1976-2000

?2000 Discovery &r exploitation that Solar System is highly fractionated mineralogically. 159. ?1976-2000/2025

?2000 Orbital interterrestrial power relay station. 152. ?1976-2025

?2000 Nuclear energy generated in space and sent to Earth. 151. ?1976-2025

2000 Extraterrestrial fuel. 21. 1976-2025

2000 A transnuclear (eg >½% mass-energy conversion) source of energy demonstrated. 71. 1976-2025&c

2003? Energy for spacial ships, laboratories, &r colonies basered up from planetaries such as Earth to space. 226. 1976-2025#

2005 Volcanoes, geothermal gradients, &r chemicals present on planetaries used as energic sources. 83. 1976-2025#

2005 Nuclear explosion on Moon. 35.

2010 Interplanetary "baser rails". 209. 2001-2025.

2010 Extraterrestrial radioisotopes/radioactivity found/then used. 158. 1976-2025#

?2015 Flywheels store energy in space. 129. ?2001-2025

2015 Braking energy of landing craft &r materials captured. 130. 2001-2025

2017 Mercurial or perisolar power plant sends energy elsewhere. 82. 2001-2025

?2020? Solar energy sent to Earth from space semi/omnidirectionally. 149. ?2001-2025

2025 Nuclear bombs used for Lunar construction. 98. 2001-2025

2025 Perisolar industry, eg using Sun's gamma and cosmic rays. 163. 1976-2025

"?"2025 Chain of nuclear bombs used to penetrate Moon. 34. 2001-2025/?

2030 50%-99% conversion of matter into usable energy per $E = mc^2$. 67. 2001-2050#

2035? Perisolar heat used for industry via juxtaposed asteroids. 156.

2060?&c "Plenistic" physics yields new sources of energy. 104. 2051-2075

2175/? Interstellar basers used for energy. 109. 2100-2175?

EXPLORATION

Past-1990	Radar/baser mapping of planetaries &c. 204. 1976-2025
Past & 1990	Sonded-balloons into the planets' atmospheres. 165. 1976-2000
1983?&c	Wholly unmanned craft cum subcraft for scouting and landing-leaving planetaries. 218. 1976-2000
1985	Flight out of the ecliptic. 214. 1976-2000
1985? Past?	Transplutonian probe. 223. 1976-2000
1990?	10^{1}-10^{-6}m resolution of other planetaries. 182. 1976-2000#
1990	Saturn's rings visited. 154. 1976-2000/2025
1990 & 2014	Pluto. 222. 1976-2025#
1992	Intrajovian probe. 30. 2001-2025#
?1992(solar system) & 2020?(other star)	Extraterrestrial life discovered. 13. 1976-2025
?"1992"	Consequences of life/fossils being found in Solar System. 221. ?1976-2025
1997(10^{2}) & 2010(10^{4})	10^{2-4} asteroids "visited". 87. 1976-2025
1998	Manned laboratory near Sun. 16. 2001-2025?
2000&c	Universe discovered to be a "plenum", and investigated. 104.
2005?	A satellite of a jovian planet landed on and explored. 148. 2001-2025
2015	Intrasolar probe. 125. 2001-2050#
"?"2015	Manned laboratory on Venus. 15. 2001-2025
2020?	Higher extraterrestrial life discovered. 14. 1976-2050
2020?	Life determined to exist on another star. 41. 1976-2025/?
2020?&c/10^{9}y	Galactic, cosmic, &rc incidence of "earths', life, intelligence, "gods", &c virtually determined. 197. 2001-2075/10^{9}y?
"2020"?/2100?	Realization or proof that exploitation, occupation, exploration, &r unification of Universe is or is not futile, meaningless, &rc. 198. 1976-2075&c?
2035	Boats on Sun. 124. ?2026-2050
2040?	Interstellar probe launched. 19. 2001-2050
2040?	Information received from another star revolutionizes our culture. 42. 1976-2025/?
2050?	We attempt to communicate to beings of another star. 201.
2050?	Probe to Moon's center launched. 26. 2001-2075
2065?	Diagalactic probe launched. 89. 1976-2050
2070?	Probe launched to Milky Way's center. 108. 1976-2050
2075?	Communication intercepted from another galaxy. 88. 2026-2075
2080	"Expedition" (using A.I.?) launched to another star. 66. 2076-2100
2110?	Extragalactic probe launched. 90. 2151-2175
?2110?	"Teleportation" ex receiver and almost "clairvoyant" observation of worlds trillions of light-years away ex transmitter. 203.
?2175?	Superspace aids exploration &r is explored. 117.
?2175??	Physical meeting with beings of another star. 116. ?2101-2125?

MINERALOGY, MINING, MAPPING, ETC

Past-1990	Morphology &r mineralogy of planetaries mapped by radar &r baser. 204. 1976-2000
1982?	Discovery of massive extraplanetary water (comet, moon, &rc). 219. ?1976-2000
1982?	Discovery of natural water on Moon or asteroids. 101. 1976-2000&c
1983?	10^{0-20}-square Lunar mineralogy map wrought. 4. 1976-2000
1987?	10^{0-20}-square Martian mineralogy map wrought. 5. 1976-2000
1987?	10^{0-20}-square Mercurial mineralogy map wrought. 9. 1976-2025
1990?	10^{1}-10^{-6}m resolution "pictomap" made of planetaries, substituting (potentially) for direct exploration. 182. 1976-2000#
1990	Saturn's rings examined to see if they are fractionated and minable. 74. 1976-2000/2025
1990?	10^{0-20}-square mineralogical map made for a Jovian satellite. 7. 1976-2025
1997?	Extraterrestrial manufacture of oxygen, eg enabling colonial self-sufficiency. 22. 1976-2000
2000	Extraterrestrial extraction/synthesis of fuel. 21. 1976-2025
2000?	10^{0-20}-square Plutonian mineralogy map wrought. 8. 1976-2025
2000	Mining and refining of an asteroid. 37. 1976-2025
?2003?	Earth's upper-atmospheric helium &rc mined by low satellites or the like. 133. ?1976-2025
2005	Continuous, eg 10^{13-21}-cell, reconnaissance and surveillance of all Earth. 183. 1976-2025&c#
2005	Volcanoes, geothermal gradients, &r chemicals present on planetaries used as energic sources. 83. 1976-2025#
2005?&c	Mining of planetaries using controlled fission &r fusion. 134. 2001-2025&c
?2005	Astronomic balloons used to mine &c asteroids. 56. ?1976-2025
?2010	Natural caves found on planetaries. 100. ?1976-2025
2010	Asteroid moved, say to Earth. 20. 2001-2025
2010	Moderate asteroid moved to Terran L-5. 69. 2001-2025/?
"?"2010	Materials dropped to Earth for recovery. 85. 2001-2025
2010	Mining of jovian planets (some). 72. 2001-2050
2010?	Jupiter's deuterium &r protium used for fusion. 73. 2001-2075
2014	Pluto. 222. 1976-2025
2015	Fissionables mined on Moon. 81. 1976-2025
?2015?	Atmospheres gotten from planetaries' solids via nuclear explosions or other means. 157. 1976-2100
"2020"	Fair idea had of Solar System's wealth. 93. 1976-2025
?2020?	Artificial supermeteors used to mine Earth &rc. 155
2025	A chain of nuclear bombs used to mine a planetary at depth. 34. 2001-2025/?
2025(2000?)	Venus mined. 23. 2001-2025
2032?	Sun mined. 126. 2026-2050/?
2065(satellite) & 2100(planet)	Planet/planetoid relocated. 68.
2400?	Mining of other stars. 224.

TRANSPORTATION

Past? 1992? Wholly automated flight. 32. 1976-2000
Past? 100,000mph flight attained. 139. 1976-2000
Past&c Gravitational acceleration of ships using planetaries &r Sun. 215.
1978? Horizontal takeoff or landing. 121. 1976-2025
1978? Reusable space shuttle. 79. 1976-2000
1980? Nuclear, solar, or other novel Lunar surface drive. 132. 1976-2000&c#
1982&c Supermaneuverable ships &rc. 216.
1983(10^4) & 2000?(10^6) 10^{4-6}tn accumulated in Earth orbit. 75.
1985 Half-fueled takeoff cum in-flight refueling. 1976-2000
1985 Single-stage-to-orbit (SSTO) spacecraft. 1976-2000
1985?(10^4) & 2000?(10^6) 10^{3-6}tn payload from Earth to space by a single launch. 11. 1976-2000
1986 200,000mph flight attained. 140. 1976-2000
1987? Aerospace plane ("spaceplane"). 173. 1976-2000
1990 Solid chemical propellant exceeds in power &c any liquid propellant. 205. 1976-2000
1990? Solar electric propulsion. 146. 2001-2025?
1990(10^4) & 2000?(10^5) 10^{4-5}tn/y put in space from Earth. 76. 1976-2025
1993? Military &r commercial hypersonic &r suborbital diaglobal transport, travel, &r commuting. 95. 1976-2025#
1995 Magnetohydrodynamic (MHD) drive. 127. 1976-2000/2025
1995 Ionic or other drives using un/charged particle beams. 53. 1976-2000/2025
1995 17-25 Mach ramjet. 122. 1976-2000?
1995? Hypersonic transport (HST) lifts objects to/ward orbit. 48. 1976-2000
"1996" Controlled fission drives. 54. 1976-2000
1996(fission) & 1998(fusion) Pulsed nuclear ("Orion") drives. 105. ?1976-2025#
2000 Mass driver. 210.
2000 Terran ramp/tube launches freight &r ship. 128. 2001-2025/?
2000 400,000mph flight attained. 141. 1976-2025
?2000? Earth-to-space payload cost $50(1975)/lb. 77. 1976-2000
?2000? Earth-to-Moon payload cost $50-$100(1975)/lb. 144. 1976-2000
2000? Suspended animation (enabling ≥50y travel). 178. ?1976-2025
2004 Controlled fusion drive. 55. 1976-2025
?2005 Magnetomotive-magnetospheric space vehicle. 211. ?2001-2025
?"2005"&c Maximum electrostatic charge vehicle. 207. ?2001-2025?&c
2005? Ultimate chemical propellant. 206. 1976-2025
2010 Ground laser ablationally propels craft into space. 49. 2000
2010 Solar System baser rails. 209.
?2010? Catoptrical balloon propels planetary. 56. ?1976-2025
"2010"&c "Absolute minima" of transportational costs. 94. 1976-2025&c#
2015 Braking energy of landing craft captured. 130. 2001-2025
?2015 Terran vertical accelerator launching freight into space. 131. ?2001-2025/?
2015? 1,000,000mph flight attained. 142. 2001-2025
?2015? Earth-space &r intraspacial "autos". 188. ?2001-2025
2017? Solar wind sailed. 106. 2001-2025/?
2017?&c Use of Solar Systemic, Milky Way, &r Cosmic energies, matters, currents, &r fields to "sail" &rc. 107. ?2001-2075&c#
2017 Radioisotopic sail drive. 229.

?2020	Earth-to-space payload cost $10(1975)/lb. 78. 1976-2025/?
?2020?	Via a nuclear gaseous core drive, Earth-to-space payload cost <$1(1975)/lb. 145.
2035?	Ship launched from Earth via solar energy from orbital station sent to ship or launch site. 166. ?2001-2025/2050#
2035?	Boats on Sun. 124. ?2026-2050
2040?	Gravitons, neutrinos, or other unusual particles &c used for propulsion. 110. 2026-2075?#
2045	Antimatter fuel. 137. 2001-2075#
"2045"&c	Technological analogue to teleportation. 115. 2001-2100?#
?2055	Antigravity. 103.
?2055	Nullification of, or shielding against, gravity, &r suppression of inertia. 103.
?2055	Super (and directed) gravity. 103.
2055	7,000,000mph (0.01c) flight attained. 143 2026-2075
2060?	Photonic drive. 52.
2060?	"Plenistic" physics yields drives. 104.
?2060	Transluminary (>c) flight attained. 47. ?1976-2025?
2070?	Relativistic (0.1c) flight attained. 119. 2051-2075?
?2110?	"Teleportation" ex receiver. 203.
?2120	Transportation via singularities in superspace (black and white holes, Schwarzschild or Kerr singularities, other and odder singularities, wormholes through space, 1/2-way interuniversal and "omniversal" voyages, time travel, &rc). 117.
2150?	Luxonic (~c) flight attained (ironically, after >c). 208.
2200?	Baser beams between stars used for commuting. 109. 2101-2175
?2400	Gravitational fields of other stars used for flight. 215.
2400-10^7y	Planets/stars navigated around Milky Way. 114.

COMMUNICATION

1984	10^{10-15} bits/s relayed through space for points on Earth. 184. 1976-2000#
1985?	10^{1}-10^{-3}m resolution of Earth's surface from orbit. 181. 1976-2000#
1985	Direct satellitic broadcast to homes. 112. ?1976-2000
1990?	10^{1}-10^{-6}m resolution of other planetaries from space. 182. 1976-2000#
?1993?	Interpersonal communication via space. 189. 1976-2000/2025
2005	Continuous, eg 10^{13-21}-cell, reconnaissance and surveillance of all Earth. 183. 1976-2025&c#
2020?	"Plenistic" physics creates means for novel and extraordinary communication. 104. #
2020?	Reception of a message from another star. 41. 1976-2025/?#
2035	Terran intercommunication via space so vast that it engenders a world or Terran language, government, economy, culture, &r society. 185. 1976-2025&c
?2040?	Transluminary (>c) communication. 47. ?1976-2025?
2040?	Communication received from another star revolutionizes our culture. 42. 1976-2025/?
2045?	Technological analogue to teleportation (telefacsimilization of objects reproducing to some degree their appearance, constitution, or even chemistry--eg via 10^{5-26} bits/gram--and invading thereby the realm of so-called communication). 115. 1976-2100?#
2050?	Gravitons, neutrinos, muon beams, or other exotic, esoteric, or unknown physical entities &r principles used for novel &r extraordinary communication. 110. 2026-2075?#
2050?	Attempt to communicate to another star's beings. 201.
2050?	Interstellar basers. 109. 2101-2175?#
2075?	Message received from another galaxy. 88. 2026-2075?
?2120?	Communication via superspace. 117.
?2110?	Almost "clairvoyant" observation of 10^{7}-10^{-3}m features of worlds trillions of light-years away ex transmitter. 203. #

MILITARY EVENTS

1985 Aerospace plane. 173. 1976-2000
?1990 BAMBI. 168. 1976-2025
"1991" General deployment of space defense. 1. =? 1976-2025#
?1993? Soldier-to-soldier communication via space. 189. 1976-2000/2025
1995 Perfect submarine monitoring. 190. 1976-2025
?1995 Lesser power places bombs in orbit. 167. 1976-2025
1997 Revolutionary space offensive systems. 111. 1976-2025&c#
?2000 Abrogation of Space Treaty, &c. 169. 1976-2025&c
?2001 International teams/robots inspect military/all satellites &rc. 170. 1976-2025
2005 Continuous 10^{13-21}-cell reconnaissance and surveillance of Earth. 183. 1976-2025&c#
?2010 Military bases in space. 172. 1976-2050
?2010 Geocentric fleet. 175. 2001-2025
2015? First intraspacial, per se, hostilities. 99. 2001-2025?
?2022 Heliocentric fleet. 177. 2001-2025?
?2300? Conflict or unlimited war with aliens. 202. ?

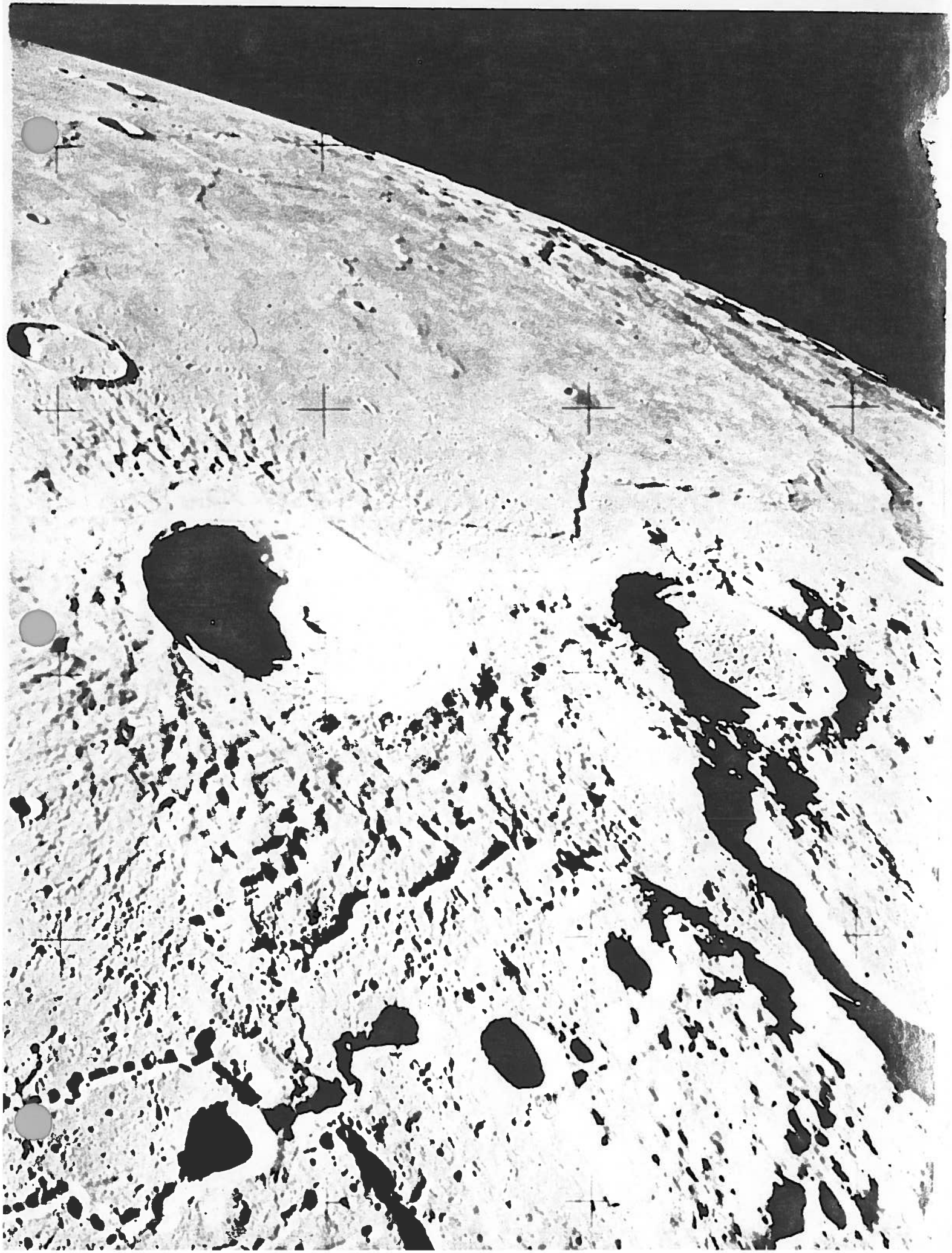
MISCELLANEOUS EVENTS

Past	First corporate profit from space. 24. 1976-2000
1976&c#	International cooperations in space. 214. #
?1982	Human physiology proven inadaptable to space. 220. ?1976-2000
~~"~~1988"	Proliferation of parties in space. 113.
"1990"?	Break-even point for aggregate space industry. 25. Past-1925?#
1993(10) & 2020(100) & 2040(1,000)	10^{1-3} lives claimed in spacial disaster. 192.
1993	A United Nations spacial force, undertaking, &r administration. 80.
1994	Robots &r teams in spaceships inspect &c peri/extraterrestrial satellites, stations, &c. 171. 1976-2000&c
1995	First industrial use of space (i.e. business accompanies a governmental mission to achieve a private purpose). 24. 1976-2000
1995	First private spacial "adventure". 26. 1976-2000
1995	Machine approximately as smart as man. 44. 1976-2025
2000	Machine smarter than men. 45. 1976-2025
2000?	Men identify themselves as "spacials". 63. ?1976-2025
2000?	Major extraterrestrial "agriculture". 23. 1976-2000#
2003	Longitudinal weather prediction, explanation, &r control via exosphere, magnetosphere, &r heliology. 97. 1976-2025&c#
2007	$\$10^{11}$/y, or 1% GWP, spent on space. 199. 2001-2025
2010	Super computer built in space, eg for cryogenic reasons (but see # 44-45). 147. 2001-2025?
2010?	First birth in space. 29. 2001-2025
2013	"Start" of exodus from Earth to space. 28. 2001-2025
?2020	Transluminary (>c) events in nature proven. 46. ?1976-2025?
?10^{11}y	Universe "stops". 196.

QUARTER I: 1976 to 2000

From even before 1976 through 1990, and continuing, increasingly sophisticated and detailous mapping of the surface morphology, and to some extent mineralogy, of the Solar planetaries will occur using powerful, precise, computer-assisted, &rc active sensors--radars and basers--located on or around Earth, toward the target but in interplanetary space, on third planetaries, &r in situ. These novel imaging techniques, once refined or before 2000, may rival or surpass--empirically or even theoretically--the power or value of naturalistic, visual telescopy and of probes or ships, or do so, say, in cost/benefit terms. Thus communicational exploration of space may compete with, at least some aspects of, transportational exploration, or at least initially. These techniques may also assist the investigation and discovery of such subvisible interplanetary, transplutonian, and interstellar planetaries, rubble, dust, molecues, and plasmas as may exist and become an important branch of astronomy. During this same period of two decades, before 1976 through 1990, sounding balloons will frequently be used to investigate the atmospheres and "oceans" of various planetaries; Venus, Jupiter, Saturn, Uranus, Neptune, and possibly Titan, Mars, and Pluto, will be explored in this fashion. The lower reaches of the Jovians and of Venus will involve bathyscaphes substituted for balloons and dirigibles. These various devices will carefully research the chemistry, physics, and possible biology of the complex gaseous, liquid, and solid layers of these exquisitely problematic bodies. Various international events, missions, programs, purposes, developments, industries, disputes, &c will occur over the quarter, beginning with the Apollo-Soyuz Earth-orbital rendezvous of the Americans and Soviets in 1975. There will be periterran, Lunar, manned Martian, interstellar-communicational, astronomical, and other cooperations and collaborations between--in various senses--10-160 nations and many great corporations. The gravitational fields of the planetaries and Sun, already used before 1976, will be used ever more extensively to accelerate probes and ships operating in and leaving the Solar System, in and beyond the quarter century. A reusable space shuttle will be tested in 1979 and operational in 1980, economizing spacial operations from Earth and increasing the number of trips into space. It will constitute the first true example of horizontal takeoff or landing systems for space. There will be great improvement, enlargement, diversification, and multiplication of power plants in space--especially in Earth orbit--eg fission, fusion, radioisotopic, solar, battery, fuel cell, combustive, &rc--serving immediate spacial needs. A ~~1-megawatt~~ 10 K low-T plant in space for space will exist in 1980, and a [redacted]-megawatt plant by 1991. Miniature nuclear reactor, solar, &r other novel engine systems for ground vehicles on the Moon, Mars, Asteroids, &c will be developed and used over and beyond the quarter. Perhaps around 1980, a nuclear, solar, or other novel Lunar drive will power surface vehicles. The vacuum, low gravity, intense sunlight, &c of such landscapes will provide unmatched opportunities to primitive and, later, sophisticated transportational systems mastering the faces of these alien planetaries. Some water, and later massive deposits and forms, will be discovered to exist naturally off planets--on the Moon &r Asteroids around 1982, and then in comets, glacial or glaciated nonterran moons (eg Ganymede), and finally on other planets (eg Mars)--and thereafter be developed and used both in situ and allochthonously as hydrogen, oxygen, or water, for power, propulsion, food, human respiration, agriculture (eg on a massive scale), manufacture, fusion, construction (the erection of what will come to be known as "grand igloos"), terraforming, &rc; this hydrological spring, falling between 1982 and 2032, will constitute one of man's great engineering achievements and will be overseen, in the 21st century, by the Space Hydrological Authority, a supranational body possessed of very real powers and responsibilities.

From 1982 forward there will begin to appear so-called "supermaneuverability". This will refer to highly or totally maneuverable orbital &r nonorbital probes, stations, and craft possessed of, eventually fairly extraordinary, powers. Such powers may and will include the ability to change to any latitude, longitude, altitude, velocity (including zero), orbit (eg "geosynchronous"), &c, to do so reversibly (including takeoff and landing), to do so 1-100 times or eternally, to assume any orbital eccentricity, amphibious (eg aerospace) abilities, powers to execute complicated maneuvers, to return to Earth (eg for refueling, removal of film, sample, crew, &c, repair, reequipping, or redesign), for any or all of the planetaries or beyond the Solar System, &c. Thus economies will be realized over many and diverse serial and parallel devices. Vehicles of this masterful kind will to some degree be used to explore and develop the very-mooned planets (such as Jupiter and Saturn), Asteroids, eccentric planetoids, comets, to couple the transmartian planets, explore the Solar System en bloc, &c. ⌈In particular, and at minimum, large craft will be tested and employed over the quarter at piggy-backing many craft, devices, materiels, and personnels to sets or systems of planets, stations or loci, dispatching &r retrieving seriatim (eg satellites, telemetric microstations, many simultaneous satellites &r landers for the same planet or space, &c). ⌈An interesting development over the quarter will be that extraplanetary or periplanetary ships &r stations will be once or endlessly refueled by economical throwaway or cyclic unmanned "refueler" ships, and also progressively resupplied, repaired, altered, checked, &c. The first such refueling will be periterran and occur in 1982. ⌈An uncertain but bothersome question mark remains whether human physiology is or is not, and whether remediably or unremediably, inadaptable to temporary or to permanent residence in the gravitational, atmospheric, radiational, &rc conditions of interplanetary space &r other planetaries. Might annoying or fatal dyscrasia occur to some men after months, years, or decades of exposure to abnormal gravity, or might extreme variations in solar activity and particle efflux prove incompatible with men in space concurrently? Some of the imaginable consequences of proven human inestablishability include minimization of intraspacial time, human selection, need for artificial gravity or major insulation, medical needs, need for artificial gravity on low-g planetaries such as the Moon and Asteroids, abandonment of space, present or lasting (but fantastic) substitution of instruments &r robots (eg "androids", robots designed in the image of man to a degree) for some or all spacial operations and activities, need for better control over or radical modification of human physiology, postponement or slowing of spacial exploration and development, elemental dangers tolerable by earthbound and spacebound alike, &rc. The spectrum of nocuous things will be thoroughly investigated between 1976 and 2025 and the principal question of man's tolerance for and safety in spacial milieux will be decisively or largely answered, and with >[redacted]% probability given the green light, by 1982. ⌈Around 1983f wholly unmanned and automatic craft cum subcraft will appear, and be progressively developed, for scouting and for landing and leaving other planetaries. This high level of automation will economize spacial operations. Present human backup and safety requirements impose enormous obviable costs on such operations. ⌈In 1984 10^{10-15} bits/second--which is $3\times10^{17-22}$ bits/year--communicated between points on Earth will go via spacial relays for the entire Earth. There will be tremendous growth in this flux continuously from 1976 through 2025 (and it may grow thereafter independently of human number and wealth). Its general growth will be cause and effect of synchronous growth of a world-circumfusing telephonic, videophonic, holovisual, &r computer (informational, computational, and regulatory) network or plexus. The mediative periterran communicational satellites and stations will completely transcend 1975 standards in terms of size, number, capacity, sophistication, and even type over the next 3-5 decades. ⌈Another, eventually radical, economical improvement in spacial engineering will occur from 1985 forward. Satellites and other unmanned vehicles with 10-100y or "infinite" life-spans, with or without maintenance. This will reduce launch redundancy.



← Add, (preferably here) Facing page 46, a superb (say 100 cm x 100 cm) dense photo, and a stop that, on activation, see-through (transparency) with a set of 1-10 squares with successive wider glimpses FLASH guide to show corresponding but interesting magnifications to resolutions and cells.

→ (that is, at the "ultimate" extreme under extraordinary investment)

Before 2005, conceivably as early as 1985, of the order of 10^4 tn "payload" will be possible for a single launch vehicle. If justified, by 2040 and conceivably as early as 2000, this will have increased to 10^6 tn (greater than the gross weight of the largest oceanic tanker, at capacity, in 1975). The possible justifications for such capacities might be that preassembly on Earth reduces intraspacial operations' cost (manufacture, transport, construction, &c), energy needs, time, plant requirements, work force, &c; hypothetically advantageous size laws; that such great capacities minimize flight number and all concomitants, might serve specific large-scale purposes in the future, might fit imaginable future freight quantity or need for large vehicular crews or passenger bunches, might fit imaginable large devices (eg physical and astronomical instruments) shippable to space in future, might be economical in terms of a material "tanker", &c. On the other hand, such economies or advantages, even if real, might go ignored. The space shuttle, carrying a few tens of tons, might establish and ingrain a practise of bringing materials and constructions to space piecemeal. Finally, stupendous vehicles might be especially suitable for nonterran routes, or might just be built experimentally. The quarter may be characterized by a debate over any proper ceiling for vehicular size.

Around 1983 there will be undertaken the construction of a 10^{0-20}-square map of Lunar mineralogy. This will give man a permanent record of the nature, distribution, concentration, and amount of the varied mineral resources of the Moon's surface as resolved into a virtual mosaic of countless kilometer or meter squares. It will be presented as a FILLABLE hierarchy of 10 linear-order-of-magnitude levels, e.g. there will be approximately $10^{7\frac{1}{2}}$ kilometer-square cells, $10^{13\frac{1}{2}}$ meter-square cells, and $10^{19\frac{1}{2}}$ millimeter-square cells constituting the pluto**graphic** atlas. This will commence the exploitation of a unique opportunity for absurdly cheap, technically novel, and comprehensive mapping of natural wealth on Solar planetaries. Such comprehensive telemineralogical planetography, using passive and active sensors put in controlled orbits around the Moon, will be done "all at once", quickly, surprisingly thoroughly, and more or less in terms of 1975 and 1983f technology, but it can not be done for Earth due to ~~her~~ thick atmosphere, dominant ocean and ice, impenetrable biomass, "noisy" regolith, and active geochemistry and geophysics (also, to some extent Earth will be old hat). One or more, perhaps as many as 100, satellites will orbit and systematically scan the Moon using baser spectroscopy and a laboratory of other telemetric systems. The basers, of great power and tunable, will, in effect, cover the electromagnetic spectrum, and the recorded spectra will be analyzed by advanced spectroscopy and computers. The Moon being free of atmosphere, the resolution will be as great as attainable over the Moon from a few kilometers height. The mapping will be an ongoing continuum of progressive resolution, AS WELL AS RECURSIVE PROCEDURES and will involve iterant stages, selectively and progressively focusing on those topographic and qualitative details implied to be important, or arbitrarily important, by earlier processing. Despite her scant dust and surface activity over the ages, the Moon will prove to be a far more transparent being than Earth and her pristine surface a lavishly resourceful cross section, a clear indication, and the first, of the extractive economics of space. This technology developed for the Moon will be gainfully reapplied to Mars, Mercury, the Asteroids, moons of other planets, and Pluto in the subsequent 17 years. For comparison, in 1975 our map or composite photograph of the Moon is limited to around 10^{12} solar-reflectance (not spectroscopic) cells, an infinitely inferior and rather useless record.[a] The future opportunity is for a tremendous refinement in the registration, recording, analysis, understanding, and use in the intensity range, bandwidth, fidelity, sharpness, and internal structure of natural and artificial spectral signatures in terms of absolute and quantitative mineralogy.

[a] ADD: (However, the ordered "single" registrations on preserved and available Films may actually have a large marginal signal-to-noise ratio of an untapped but computationally and intellectually recoverable nature. Wherever this becomes recoverable, and is

Around 1985 satellites orbiting Earth will theoretically, actually, economically, or on a large scale attain a resolution of nonlineal objects on our planet's surface only 10^{1}-10^{-3}m in diameter via telescopes, active sensors, select bands of the electromagnetic spectrum, data processing, mathematical techniques or theory, &rc. This will be done--and done evolvingly--for night &r day, in normal &r exceptional conditions, socially &r militarily, in real time &r eventually, for national &r global use, for developed uses, &c. This will create a system able, to a degree, to track or trace cars or individuals vertically, simultaneously map the waves of the ocean and the textured tree-shaking winds of a continent, and so on ad infinitum. Successful subdecimet[illegible] resolution will presuppose speckle photography at 1975 or 1985f standards. It is unclear how close to the theoretical ultimate of 10^{-6}m such reconstructive photography will ultimately go. What will be achieved, however, could have revolutionary impact on international and intranational politics, say by opening an unshutterable window on the world. The problem existing in 1975, that computer capacity exceeds in a way commensurate applications, will diminish in 1985f when transmission of immense information from panoptic satellites will both invite and require equally immense data processing for the continuous description of natural and artificial phenomena on the surface of Earth.

Another radical technological event will occur in 1985, direct radio &r televisual broadcast to homes from satellites. The prolonged consequences of this new practise will be complicated and extraordinarily disputatious. The initial use will be by a nation like India wishing to mass-educate, and actually discipline politically, its ignorant but enormous population, and to do so in a cost-effective, convenient, and ideal way. Such a method, however, will be irresistible to countless developing and developed nations, and rapid growth will occur in this satellitic industry. Bandwidth problems may be resolved by the superimposition of simultaneous baser relays unaffected by, and not affecting, the tenuous broadcasts, or operating at visible frequencies with tremendous Hertzian capacities. The diffuse character of the broadcasts will later have various and sundry geopolitical implications, especially if the method is adopted, or consciously or unconsciously used for certain purposes, in certain politically diverse and competitive areas of Earth, on which more anon.

What might prima facie seem a regression will occur in 1985, the experimental launching of a single-stage-to-orbit (SSTO) spacecraft. It is as yet unclear what impact this will have on spacial transportation in the subsequent years, although it may have a big effect, especially economically since dispensing with multiple stages will eliminate certain problems and costs which currently burden departure from Earth. The SSTO will be the first time man has entered space other than by multistaging, and so intrinsically quite revolutionary. But it remains to be seen whether any SSTO can be cheaper or more convenient than multistaged rocketry for terrifugal flight.

A transmissive transplutonian probe will be launched in 1985 to explore in situ the transolar realm and interstellar space 10^{9-13} miles out, traveling at a final velocity of nearly 200,000mph ($2 \cdot 10^{9}$ miles/y) and so exceeding Pluto in 1987, 10^{10} miles in 1990, 10^{11} miles in 2035, &c. It is uncertain whether this probe will be coordinated with an examination of Pluto itself, and so what additional sensors it will carry. Its function will be to investigate the physics, chemistry, and cosmography of the limits of the Solar System and beyond in terms of both dynamics and statics, and to notify Earth. It is not unreasonable that bodies of any order of magnitude of volume and mass, and of varied type and composition, obtain in number free or in heliocentric orbit, and astronomers have propounded interesting theories and hypotheses in these terms, such as J.H. Oert's idea that the Solar System may be surrounded by a sea of giant icebergs, a cosmogonic residue the origin of comets.

ERRR: OCCURRED FIRST IN 1976, AT LEAST TO A DEGREE?

There will have been launched by 1985 a flight out of the ecliptic, either meridional or oblique. Such a trajectory requires more energy than one coplanar with the Solar System. The departure from the ecliptic will either occur directly, in the vicinity of Earth, or at great distance via the gravitational field of a body such as Jupiter or the Sun serving both to steer and accelerate the probe. In this way so-called transolar space might be reached and more quickly by a shorter excursion whose continuation could fulfil both purposes. Such flights will provide us at last with important information on the structure and dynamics of the Solar and planetary fields of energy and matter which merely intersect the ecliptic plane and behave differently elsewhere. (DID! E.G., DISCOVERED PARTICLE DENSE ^ ECLIPTIC D.S.C.)

In 1985 half-fueled takeoff relying on in-flight refueling will occur. In-flight refueling after "fully"-fueled takeoff may also occur. In both cases refueling may occur at ever more extreme altitudes. It is not inconceivable that the refueling vehicle could be a rocket, instead of a plane, and even unmanned, and recovered on Earth after gliding or falling down, or descending by balloon or parachute. Likewise, spacecraft returning to earth could be met by refueling vehicles enabling the former to land by fuel. The ideal procedure for spacecraft landing on atmospheric planets might be various means for fuelless descent, say gliding from space to earth. The evolution of such systems will be too tricky to predict. Note that the "space shuttle", "SSTO", and "spaceplane" are names covering a multitude of alternative means and designs.

By 1986, 200,000 mph--300,000 fps or 1/3,000 c--flight will have been achieved, and thereafter will come into common use for certain missions. These and higher velocities are what is practical for interplanetary manned expeditions and commuting, particularly with regard to the more distant planets and over the long term. Nonchemical propulsion, especially nuclear and electrical, will be either ideal or essential to such purposes. Unfortunately the development and implementation of nuclear systems has been and will be seriously retarded by terrestrial antinuclear ideology, and both nuclear and electrical systems will emerge 10-20 years later than otherwise because of a general limitation of spacial exploration and development and a myopic refocusing upon geocentric needs and opportunities between 1969 and 1994. The historical untimeliness of this sacrificial redirection and constraint will not be widely appreciated until about 2010 or 2020, 41-51 years later, and 15-25 years after the resurgence of man's spacial adventure. By then the debate circa 1975 over the social acceptability and warrant for an investment costing the United States $25 per capita/y will seem absurd and sad.

Sometime around 1987 an aerospace plane or "spaceplane" will be in use for military and nonmilitary purposes. What will distinguish this vehicle from its predecessors will be its complete amphibious ability to take off from the ground, fly into space, operate wholly within space, and return to the ground, all without assistance and without jettisoning tanks or stages. This independence will work economies in the time, expense, difficulty, and complexity of spacial operations hitherto impossible.

Various generations and types of purely intraspacial craft will be developed over the quarter.

Perhaps around 1987 the construction of gigantic maps of Martian and then Mercurian mineralogy will be undertaken, analogous to the super map of the Moon above begun about 1983, and in fact representing its technology. The excellence and utility of the earlier map will explain the quickness of making of the later atlases. Such mapping will also be a result of substitution for things that would occur under a more active program than the constrained one operating in the pre-1995 period. It will result in the discovery of many amazing geological features and eminently minable deposits notable for their richness, scale, and mineralogy. These, in turn, will stimulate a multitude of governmental and private concerns on Earth to participate in spacial exploration and development both within extant programs and by semi-independent adventures.

In the 1980's and 1990's a variety of productions will greatly enhance the average American's, and even the average Terran's, understanding and appreciation of past and future spacial exploration and development. For example, many highly imaginative and superbly produced motion pictures will dramatize and romanticize outer space by telling irresistible stories about the Solar System and the Universe, and the treatment will be largely affirmative and heroic, a new standard in the industry. Truly inspiring cinematography will be taken of Earth, interplanetary space, the Sun, and landscapes over and on the Moon, Mars, Jupiter, and eventually all the planets out to Pluto. It will be realized at last that such presentation is enormously inspiring and vitally important to everyone's understanding of the meaning of what is going on and why, rather than of trivial importance and even ignoble. Mankind will in this way acquire extensive extraterrestrial imagery and yearnings, and the economic basis of space will come alive. In addition to films and stills, magnificent and innumerable televisual programs, fictional and factual books (including some of the greatest literature in history with towering novels and deeply affecting poems), great realistic and fantastic paintings, and technologically novel art forms will supply the human imagination at last with images of and ideas about space of a spectacular, beautiful, stark, detailous, artful, grand, mysterious, adventurous, philosophically provocative, natural and uncontrived, &c nature, and in a constant and massive way. Museums devoted to the natural science, technological, and artistic aspects of space will be created costing hundreds of millions of dollars, and these will be filled with vivid dioramas measuring 2 to 300 feet across; for example, the extraordinary morphological and mineralogical pictomaps that will be made for all Solar planets and many other planetaries by around 2000 will be created pari passu in halls in tridimensional and polychromatic casts set under pedestrian glass. Such heroic adventure, reportage, art, reproduction, perception, contemplation, dramatization, explanation, conceptualization, amplification, &c will to some degree be made a high or supreme part of virtually each and every mission or exploration of the Solar System (and the Universe observed beyond), and every effort will eventually be made on Earth, at great expense, to cause every American and Earthling to experience, understand, enjoy, and love the returning and unfolding perceptual and conceptual treasures of the spacial expeditions and existence.

The year 1988 can serve as a milestone for the proliferation of parties in space. With gathering momentum, a family of public and private participants will compete and collaborate in opening up space. By 2000 all great powers, and 10-20 lesser, will have more or less their own programs with varying degrees of redundancy and warrant, and obedient to scientific, economic, military, and prestigious purposes. From 1988 through 2000, NASA, several American and transnational corporations and consortia, the United Nations, the Soviet Union, the United Kingdom (or United Europe), France, the Federal Republic of Germany, Japan, India, Mexico, Brazil, Iran, Arabian nations, Israel, Canada, the People's Republic of China, Argentina, Australia or Australasia, Poland or United Eastern Europe, Sweden, Czechoslavakia, United Black Africa, &rc will first enter space on a nominal or large scale, a development to accelerate and alter drastically over the vernal years from 2000 to 2050. Some participants, of course, will initially become disheartened or withdraw from space for other reasons, and it is likely that space between 1976 and 2076 will be dominated by a monopoly or oligopoly of 1-5 nations, even if not unified as an undertaking by a single Space Authority or World Government. A certain bifurcation of the proliferation will occur based on periterran and extraterran, &r on Terran and Spacial, purposes.

Saturn's rings will be mechanically visited in 1990, having been flown by many years before and televised and telemetered in crude fashion. One or all of the rings will be intimately surveyed, televised with photographic accuracy and beauty, and telemineralogically examined by advanced passive and active

sensors. Samples or pieces of the many rings will be examined in situ, by removal into an on-board laboratory, or by the vehicle or a subvehicle returning them to Earth for human study. The probe will be highly autonomous but some specific and general instructions will come from Earth after 1 or 2 hours delay. The principal objective of the mission, or sub-mission, will be to determine whether, and if so how, the rings are fractionated and economically minable for Terran or Spacial purposes. Even if not fractionated or mineralogically distinguished, the corpuscular rings may be glacial and represent a massive hydrological resource. The pictures returned to Earth will awe Terrans with the beautiful grandeur of the perpendicular rings and the panoramic planet which they halo. There is, however, a chance that this intricate or contactual exploration will await Quarter II, 2001-2025, conceivably because of negative or positive finds of flyby telemetry, or terrestrial telescopy or radar imaging.

About 1990, forward, a 10^{0-20}-square telemineralogical map will be made for a Jovian satellite, say lowest Io or biggest Ganymede, 485,000,000 miles from the Sun. Its bases, forms, and functions will match those already begun and completed, as described above, for the Moon, Mars, and Mercury. Also, by this time that detail of form, composition, and depth structure--exquisite but finite--which Jupiter reveals to an external observer will have been statically, and to a degree dynamically, telemetered and televised to Earth by many successive and simultaneous flyby and orbital probes, and a radiosonde will have been dropped into Jupiter's oceanic atmosphere on at least one occasion. The Jovian atmosphere will have been appreciated as constituting a majestic and enormous hierarchy of sizes and species of texture, objects, and phenomena, and hardly dull and homogeneous. The Terran technology and art of graphic representation will have quantum-jumped by 1990 and will facilitate such clear and impressive portrayal. A seemingly abstract and erudite subject, Jovian meteorology, will come to fascinate Terran publics. In passing, it may turn out that the mineralogy of a planet's satellite either embodies or reflects the mineralogy that distinguishes a planet, per the latter's distinction from Earth. If true, this might lead to a policy of studying, and also of mining, one or more satellites of a planet in circumvention of the difficulties of exploring and exploiting the maternal planet, and a considerable simplification of the space program.

Perhaps around 1990 a phenomenal development will begin. At an extraordinary eventual or theoretical resolution of 10^{1} to 10^{-6} meter for nonlineal objects, the bidimensional or tridimensional ("textural") surface of planetaries with little or no atmosphere (such as the Moon, Mercury, Mars, Asteroids, and possibly Pluto), and with lesser resolution for those with greater or more impenetrable atmosphere, and ideally for inert bodies, will be "perfectly photographed" and these "pictomaps" thereafter perlustrated and elucubrated in order to substitute for, and guide, a great deal of direct manned or unmanned exploration. Inter alia, multi-instrumented and multipurpose "pictomapping laboratories" will be dispatched to all the planets, many other planetaries, and the Sun for the sake of pictomapping the Solar System and serving as an intermediate stage of its study using these instruments. Note that such telescopic, baser, &r radar orbital pictomapping will be analogous to super telescopes on Earth. In fact, a big telescope may be orbited about the planetaries. In some cases, such as the anatmospheric Moon and microatmospheric Mars, the orbit in some cases will be made arbitrarily or very low, say conditioned by the need to avoid overswept mountain ranges and geoidal perigees or perceptual distortion from excessive velocity. It is not clear in what form the pictomap memories will at first, and later, be presented, say as pieces or wholes. One possible representation is as a photographic globe containing microscopic detail examinable via a hand lense, microscope, or projector. Regardless of whether, either at first or ultimately, the planetaries are recorded as a whole surface of equal detail (isoresolutional surface), random or particular parts of large but partial areas (perhaps arranged in a hierarchic or sample stack) could be recorded

and presented as ultimately resolved examples of the planetary surface useful for various purposes. The recording and transmission, or return to Earth, of such ultimate pictures could be wholly automated and represent the use of but familiar technology. Such a program, like the telemineralogical one for the Solar System described above for c1987f, might be cause &r effect of a reduced or "dehumanized" (ie purposefully unmanned and robotic &r telecommunicational) spacial program potentially characteristic, say owing to sociopolitical circumstances, of all or part of the next 1-2 decades, until 1995 or 2000. The production of the pictomaps might produce on Earth a glut of unanalyzed and underanalyzed data, and yet data to which supplementary launches and missions would tend to be redundant, and this might temporarily limit or alter spacial programs and objectives, with subsequent programs and objectives reflecting or being expressions of terrestrial scholarship centered on the pictomaps or "cosmoramas". Whether or not stored in, or remade by, computers, the cosmoramic memories could be "explorable" from a video console fitted with a bank of controls tied to a programmable computer able to vary scales of size, contrast, color spectrum, metric, topology, rate of transformation, motion, general perspective, geomorphic and geochemical criterion, polynomiality, multivariate set, &c over a terrific independent and dependent range and wholly ad libitum. As an elementary but suggestive example, computers are already used in architecture in such a way that the viewer can create and modify realistic and fantastic perspectives, or subjective buildings and landscapes, which he walks within and becomes knowledgeable about as artificial worlds or what might be called "neocosms". The equipment foreseen here for the spacial program in the 1990's will equally incorporate structure, detail, chemistry, and perhaps active phenomena in the synthesis of subjective worlds coessential with, or inherent in as a matter of an infinity of possible perspectives, the recorded surfaces of real planetaries. Apart from serving science via scientists, the computer cosmoramas will be used by thousands or millions of amateur explorers and scientists panoptically probing the infinity of perspectives and detail present in the pictomaps, and furnishing serious science and industry with their invaluable finds, as well as by such numbers of people employing them as means of sheer, keen entertainment, as wonderful escapes from a too familiar and overly explored Earth. It is clear that such a wealth of participation and imaginative experience will have a tremendous psychological and social impact on the ongoing spacial program. Barriers to entering space will be torn down, support and participation will become enthusiastic, and the enormously vast and various face of the Solar System will be researched domestically at a blinding rate. It is unlikely that such terrestrial examination, participation, and knowledge will hurt or limit the exploration, development, or occupation of space; the effects are more likely to be the contrary in extreme measure, the greatest stimulation ever to the large-scale development of space. It is, of course, uncertain whether, and in what ways and degrees, such armchair exploration, mapping, and "geology" is apt to be deficient, and invite or require personal presence, reexploration, experimental sampling and comparison, &c, either finally or initially, and with what detail, care, and purpose such terrestrial scholarship, as a unit of time or a matter of phasing, should be pursued. Nor is it clear at what pace and with what cost the relevant development of technology, resolution, and exploration can and will occur, especially insofar as competing undertakings are concerned. It is not even clear whether such pictomapping can or will be implemented. Finally, both before and after, pictomapping will be done of Earth in various degrees, for various purposes, and with various intensities of use. Clearly a superb comparative planetology will materialize around the turn of the century.

All planets of the Sun will have been flown by, at less than 10^{6-5} miles, by 1990. So they will all have been at least primitively examined and mapped by then.

A literal or figurative break-even point for aggregate or sectoral spacial industry, representing positive net profit after debts paid for a typical year or over the entire past of man's investment in space, for the United States or the entire world, might as well be reached around 1990. Admittedly this prophecy is truly oracular. What force it does have expresses the explicit or implicit belief that by about 1990 man's involvement in space will be a paying proposition and not an absolute expense to society, as it hypothetically is today. Arguments have been made that space has long since paid for itself and in fact will profit the United States and Earth several billion dollars per annum until the end of time as a result of technology already implemented, without even taking into consideration temporary or lasting benefits of billions of dollars produced by all sorts of obvious and subtle spin-off. Of course, estimation of net profit or loss may also be done in other terms such as some idea of social needs and opportunities unrelated to space but suitable for such investment, charity, interest, or development, or some period of amortization. Or the criterion for a break-even point might be expressed in terms of the day when intraspacial life and industry will be economically self-sufficient or independent, or when the balance of trade will favor Space. It might be expressed either for public or private enterprise, or for either industry on Earth or the origin, growth, and proportionateness of wares, information, &r materials produced in space and visibly returned to Earth. In any case, the period before the year 2000 is likely to be the epoch over which man's interest in space justified itself in the net in purely economic terms and ordinary cash flow, and in terms sensible even to statesmen, and so to constitute either a causal or acausal turning point, at least for some.

Pluto will be flown by within 10^{3-6} miles by a mechanical probe in 1990. The probe will be almost entirely autonomous owing to the ½-1 day telecommunicational lag between Pluto and Earth. The surface will be scanned by passive and active sensors and the data and pictures transmitted to Earth. Ordinary observation of the planet will be marred by sunlight only a 1600th as bright as on Earth. Pluto remains enigmatic and unknown in 1975. The state, chemistry, structure, and any activity of the Plutonian surface will be glimpsed or studied. Plutonian satellites and transplutonian planets will be sought. Pluto will to some degree be crudely spectrographed, chemically mapped, and morphologically mapped. The probe may be made to orbit or effect a hard or soft landing. If soft landed, many experiments will be performed, including in situ measurements, television, microscopy, active sensing, chemical analyses, surficial tours, exploration, prospecting, local surveys, subsurficial researches, meteorology from the surface, &c. The question whether Pluto has an atmosphere &r ocean will be answered. The orbited &r landed probe may be designed to operate as a laboratory for weeks, months, years, decades, or centuries, a high-technological substitute for multiple probes and manned exploration. If and to the degree these more complex functions are added the probe may not be launched until later in the decade, and the wish to include these functions may retard the launch. It may be that a tour of the outer planets will terminate around or on Pluto. If launched in 1987, the probe will reach Pluto 1988-1992. A number of nations &r organizations may independently send probes to Pluto in the 1990s. Further questions that will or may be answered by these probes will be whether Pluto originated as a planet or satellite, is dead or active, is terrestrial or jovian or neither, possesses a magnetosphere &r electrosphere, is cold or hot, and has any economic value.

Very crudely, around 1990 and thereafter there will begin to appear processes and structures--physical, chemical, biochemical, biological, and industrial--that are rather ideal, and not just suitable, for the positive and negative peculiarities of Space. They will be such, for example, in terms of the intensity, spectrum, and collimation of naked sunlight, "infinitesimal" gravity, "infinitesimal" temperature and heat, extreme vacuum, importable and native materials, needs, and endogenous purposes.

∝ Of course such systems, including nuclear ones, may easily be kept on the ground for sudden offensive or defensive use!

1990

Before man can master spacial milieux he will have to explore and understand them, meet with their peculiar problems and opportunities, systematize his experience, test his options, formulate a plan for the future (including the future of the Solar System), research and develop his projects, and acquire a great deal of reflective wisdom and pooled experience. Gradually certain elegant and organic solutions will be discovered or evolve. Prior to 1990-2050, countless naive, imperfect, and irrelevant possibilities in terms of construction, drives, power, mining, exploration, business, industry, communication, mapping, food production, &c will be tried and abandoned. Thereafter, spacial development will be accelerated, economized, vindicated, and extended, and the promise of Space will be realized.

Men will first visit Mars around 1990. This will be an expedition of 5-20 men that will land and examine the surface of the planet. They will explore a radius of several 100 miles via a land vehicle. It is possible that they will land 2-5 times, say at globally equidistant points or some selected features. Given the rarity and importance of the mission, and its access to c1990 technology, it is reasonable that many such extraordinary and comprehensive abilities will be given the single long-duration mission. The team will remain on the surface for 7-90 days. It will photograph, film, televise, conduct geological experiments, examine the soil at 20 meters depth, survey, prospect, analyze soil chemistry, search for traces of life, set up and leave behind instruments (meteorological, seismological, radiational, &c), investigate outstanding previously discovered geomorphology, and so forth. Both prior to landing and after leaving the Martian surface, extensive orbital studies (first from equatorial orbit and then from polar) covering days or weeks will be made of areography. The expedition will return to the surface of Earth around 1992. In a few years, perhaps 1995, another nation will dispatch its expedition to Mars, and yet another may follow before 2000. One obstacle to this exploration as dated is that the presumption has been that interplanetary flight will necessitate nonchemical, and probably nuclear, drive, but development of these means is apt to be held back for policy reasons of a myopic kind insofar as long-term goals, such as the exploration of other planets, is concerned. It is uncertain whether any such initial retardation will likewise retard longer-term development, as the situation is apt to be elastic. It is possible that the first or another of these expeditions will graze or land Phobos &r Deimos, and instrument one.

It is possible that orbital missile-interception systems, or BAMBI (Ballistic Missile Boost Intercept), will eventually be "emplaced" on a unilateral or at least bilateral basis, and, if so, a reasonable year for their periterran installation is 1990. The function of such systems is to attack launched missiles at their especially vulnerable boost phase, probably using chemical rather than nuclear warheads.∝ Predicting military events in space, in terms of either time or kind, is particularly difficult and dubious since these are so subject to choice over a menu and to extrinsic international and intranational contingencies. Too, a veil of impossible secrecy hangs over the whole and one is reduced to reading tea leaves. In fact, one is ultimately left with the impression that not even military people, and those at the top, know themselves, the present world, or the shadowy future. In passing, it is significant that the American military space program now equals the nonmilitary, that it is completely reasonable that the military ratio will continually grow, and that the implementation of general spacial defensive and offensive systems in the 1990's will enormously enlarge man's total spacial program. The military, per tradition, may remain the greatest motor of progress in space and the cornucopia for spacial technology.

To digress, it is possible that future governments will support scientific and technological research and development on a far greater scale 20-50 years from now by conscious escalation or accretive growth. Progress once and still dependent on military and corporate largess may at last occur whatever the motive, because of an explicit emphasis on the general and massive development of science and technology

Astonishingly, it is practical and possible that scientific and technological progress, being potentially or actually exponential, will render scientific and technological knowledge, ability, accomplishment, importance, size in various terms, &rc greater in 2050 than in 1975 by a factor of the order of 10^{4-8}. Clearly any such expansion will have stunning impact on the velocity and scale of spacial exploration and development over the interim and beyond, through 2176.

Around 1990f there will be developed, tested, &r used various systems of solar electric propulsion. These will take their energy from sunlight, presumably via greatly improved (in terms of cost and efficiency) photovoltaic cells, and will propel intraspacial periterran and extraterran probes and perhaps ships. The electrical current generated will be converted in some electrothermal, electrostatic (= ionic), or electromagnetic engine. Such engines give low thrust, high specific impulse, and long duration, but their interplanetary role in the future, as currently imagined, will be for interplanetary maneuver and attitude control, rather than primary propulsion, the latter being dependent on nuclear or Strong reactions. Still, a system drawing its energy ubiquitously from an inexhaustible and readily tapped source--interplanetary sunlight--seems, at least abstractly, especially attractive. Possibly the continuing suppression of nuclear drives will favor a reassessment and reconceptualization of types and scales of solar electric propulsion systems between 1985 and 2020, or man may have recourse to these.

In 1990 there will be discovered or manufactured a solid chemical propellant equaling or surpassing today's or tomorrow's liquid propellant. This will be in terms of power, convenience, &r other characteristics such as volume, density, regulability, reaction efficiency, safety, cost, &c. The solidity may be a result of extreme temperature &r pressure, of course. If hydrogen-oxygen bipropellant is insurpassable, then at least the event may occur by their storage in solid form. The reduction in fuel weight, or increase of specific impulse, could over the long run greatly help the economics of spacial activity.

In 1990 Earth will on the average put 10^4 tons of payload into Space each year, apart from removals. This is 300 times the payload of the space shuttle implemented in 1980, but it covers all parties, shuttles, trips, and shuttle capacities as of 1990. This freight may be ferried into space by ships far different and more massive than the 1980 shuttle, as already discussed. The accumulation of 10^{4-6} tons in Earth orbit over the quarter will be sign and basis of elaborate and extensive spacial projects. For example, a colonial and industrial satellite belt will be germinating that will finally flower c2012. A flux of tourists developing in waves between 2000-2040 will rely on great periterran and extraterran facilities. Great communications, power, Earth-scientific, astronomical, maintenance, manufactural, and other satellites will require great masses of material between 1990-2025.

Also in 1990 energy from Space in some form will be sent to Earth experimentally for the first time. There are six general categories for the possible form of such energy. They are "collimated but areal", "collinear", "convergent", "divergent", "stored", and "fuel". Probably both at first and over the long run transmission will occur via basers (ie Bosonic Amplification by Stimulated Emission of Radiation devices) &r catoptrical systems. The basers may be lasers or masers. The catoptrical systems will involve titanic soft or hard mirrors focusing on Earth or orbital converters. The subsequent development of such systems is uncertain. They will eventually compete with tremendous production of energy by fusion reactors located on or off Earth. Another possibility is that energy between points on Earth will be relayed via satellitic stations.

Perhaps one could say (the event is essentially complex and unpredictable) that around 1991 there will be unilateral, bilateral, and perhaps multilateral deployment of general and revolutionary defensive systems in Space. Certainly

something like this will occur by 2025. These systems may at first or later--in various degrees, senses, and ways--be either stabilizing or destabilizing, defensive or offensive, inevitable or optional, partial or complete, effective or ineffective, economical or expensive, restabilizing or spontaneous, revolutionary or not, substitutable or not for terrestrial systems, &c. Again, current and future military technology and policy are shrouded in heavy secrecy, discouraging prophecy. A major possibility and probability for such systems between 1987 and 2017 is gigawatt basers serving to intercept enemy missiles. Gigawatt and terrawatt basers may ultimately provide their possessors with retaliatory capabilities, the ability to wreak havoc on enemy soil by destroying life or igniting buildings. They might obsolete nuclear bombs, missiles, airforces, and armies, and be more acceptable than pollutive and relatively uncontrollable nuclear weaponry. They might even obsolete war by rendering all sides forever vulnerable to unacceptable reprisal. On the other hand, by giving a potential aggressor or an enemy the ability to protect itself, say by enabling him to intercept virtually all missiles, they might prove ambiguous or bad, and they may trigger an arms race &r the development of costly and bothersome spacial offensive systems. There is a chance that such spacial defensive systems as presented above will become harmful or simple ignes fatui by being developed on the theory that they are preferable, safer, uncounterable, insurpassable, and stabilizing. That has happened time and again in the history of warfare.

There is perhaps a 50% probability that life--entities that reproduce, grow, multiply, maintain themselves, and evolve--exists elsewhere in the Solar System, probably in the form of minimal organisms, but possibly even of high botanical, zoological, or mental order. If it does, there is perhaps a 65% probability that it will be discovered, or a single example, by 2000. Let us say that if it exists it is odds on that it will be discovered by man by 1992. It may exist, and it may first be discovered, on Mars, Jupiter, the transjovian planets, the Sun, or elsewhere. Let us suggest THAT the first extraterran organism discovered will be acellular (about as complex as a viroid or virus), microbial, carbonaceous, possessed of a ribonucleic genome, proteic, nearly inert but nonetheless alive as opposed to fossil, &c. It will be found on Mars or atop Jupiter. Nature has produced many mutually remote animals on Earth that are highly intelligent, if not as "practical" as Homo sapiens. The possibility therefore exists that very complex and intelligent species have evolved and now live, along with highly complex ecosystems, in the atmosphere of a jovian planet. On Mars there may be traces of lowly life that are now extinct or persist on a subsistence basis. The conclusion may be drawn prematurely that life is totally absent on a planet examined in a preliminary way, and also that the Solar System in general must be ARIDITY because of failure to detect life on one planet. Such a myth might persist 15-50 years afterwards. There is also a serious danger that life exists, and may even be found, without being recognized as such. There is a real possibility that elementary or advanced life obtains in the Sun, for example, or even on Earth in totally "nonbiochemical" form, say hidden by the unfamiliarity of its morphodynamical mathematics or the bias of human percepts and concepts. Such possibilities are understood by many very sophisticated scientists. Many eminent scientists share J.B.S.Haldane's motto: "The universe is not only queerer than we imagine. It is queerer than we can imagine."

Once found, such life elsewhere in the Solar System would and could have many different consequences. It might enliven, accelerate, enlarge, and redirect spacial exploration and development, possibly quite drastically. Earth might experience pandemics caused by pathogenic exobiota returned to Earth. Conversely, the life of the other planet might be ravaged by a

Terran pathogen. The other planet might be respeciated or otherwise denaturalized by Terran escapes. Discovered exobiota might be applied to food, materials, planeturgy, and other purposes both in Space and on Earth. The life discovered would broaden and intensify, perhaps radically, our biological understanding, say of the nature, circumstances, and laws of life. Life on other planets might enable us to determine the role of biology in the natural appearance and dynamics of planets. For example, whether or to what extent the Terran atmosphere, geomorphology, soil, hydrosphere, climatology, &rc were originated, or are maintained, by life; whether Jupiter appears as she does for biochemical or biological reasons; whether Venus &r Mars exemplify Abiotic planets. There is, in any case, a need for positive (life confirming or life negating) results to guide Earth's larger exobiological program. And of course, if life were discovered, exobiology would come into its own as a science comprising taxonomy, paleontology, biochemistry, ecology, exploration, pathology, agronomy, industrial processes, &c. Finally, there is also a slim chance that life on another star will be discovered by this time, although it will probably occur 28 years later, around 2020 (as discussed below).

In 1992 a probe will be sent beneath Jupiter to the planet's solid surface, if any, or deep atmosphere. Ideas about Jupiter's internal structure disagree violently, and clues will at last be provided as to which, if any, apply. This probe may be either a balloon, glider, airplane, helicopter, jetplane, 2-way spaceplane, or some combination. Its voyage will probably be 1-way. It will operate robotically and in response to instructions from Earth returning after an hour, and perhaps relayed by a jovicentric station. It will telemeter passive and active vicinal and distant readings and will televise radar imagery. It will analyze the chemical structure, composition, and dynamics over various altitudinal, longitudinal, and latitudinal ranges of the Jovian atmosphere and presumptive sea. It will research the nature, distribution, and systematics of Jovian events, phenomena, history, and systems. It will investigate temperature, density, homogeneity, stratification, time variation, material v energic structure, &c. It will probe the transverse belts, spots, disturbances, convection cells, belt interfaces, and poles. Given the recent suggestion of transparency and lesser turbulence at the poles, the probe may be sent directly into a pole. The probe may be a bathyscaphe or spherical boat. It will assess, or enable assessment of, the planet's intrinsic or exploitable wealth. It will systematically explore and analyze for signs of life. Major questions addressed by the probe will be whether Jupiter is or was a star, what the Great Red Spot is and is like, whether Jupiter has a solid core and then its size and nature, what explains the planet's net electromagnetic efflux, an explanation and better picture of Jupiter's magnetic asymmetries, &c. It is possible that the intrajovian probe and exploration will be followed by Terran publics as a romantic, beautiful, and intellectual adventure of an enormously exciting and dramatic kind; in part, perhaps, because of the highly realistic and aesthetic telecommunication and Terran treatment by computer graphics, combined with impeccable scientific explication for Terran audiences. Far from diminishing Jupiter's mystery, awe, curiosity, and beauty, the first intrajovian probe, like its extra-atmospheric predecessors, may deeply intensify such feelings. Indeed, affluent Earth may pursue Jupiter, whether consciously or unconsciously, out of playful enthusiasm or mystical transport (which is, au fond, a superb reason). Jupiter--out of sheer size, complexity, and difficulty--may, like a mountain, challenge mankind to send probe after probe to it, to master it, and to remaster it. It is not unreasonable that 20-30 probes will have been dispatched to this great symbol in Space by 2000. A true appreciation of what Jupiter is will require some telecommunication of its scale, and it is likely that Jovian and Terran devices and technics will enable just this fidelity to grandeur by 1992, the psychological impact of which will be enormous.

It may happen that around 1993, 8 years after the beginning of direct satellitic broadcast to homes &r congregational sets in backward areas, this technology will be the cause of serious--minor or major, covert or overt, unconscious or intentional, possibly ever-escalating, noxious &r constructive, bilateral or multilateral, local &r global, international &r intranational, governmental &r private, regulated or unregulated, more or less effective, counterable or not, subtle or crude, belligerent or peaceful, ideological or not, superimpositional or not, temporary or lasting, consequential or not, substitutive or not, &rc--propagandistic wars. Propaganda, says the dictionary, is the "dissemination of ideas, information, or rumor for the purpose of helping or injuring an institution, cause, or person", and it speaks of "doctrines, ideas, arguments, facts, or allegations". Again, such use may cause, or may be limited naturally by, the employment of other terrestrial &r spacial communicational systems, including repeater towers, narrow beams, idiosyncratic or controlled modulations, displaced bands, &r the like. (These potential complexities and solutions must already discourage or time any country's adoption of such practises, and even systems, apart from working inertias.) Still, there is some prospect that sooner or later some spacial intercommunicational system will reface world politics and government, positively &r negatively, say by gaining access to some or all of the world's peoples for some or all of the world's people(s). A totally neighborly world might be a more self-understanding, democratic, peaceful, and productive world; forever. It may or may not be obvious that certain nations would have an initial or overall advantage of some kind over others. Use of direct satellitic broadcasts specifically for propagandistic purposes might ultimately be proscribed by international law, before or after such use. If direct satellitic broadcasting to earth is not used for education, entertainment, or practical purposes, it might be used for advertising, ideological persuasion, annoyance, prestige, counterpropaganda, &rc. Distortion of fact, bald ideology, and conscious propagandism are not necessary for remarkable social and political effects of direct satellitic broadcasting, which may convey merely a picture of a society, or some or all societies, in governmental, moral, sentimental, prosopographic, purposive, panhuman, and other terms, offensive or not to certain states, and persuasive or dissuasive. The ultimate outgrowth of this &r other communicational systems and effects might be the emergence of a world society, culture, government, &rc, and possibly the dissolution of what is wrong in the local forms of these things. Universal mass communications may be the only way in which the world will be kept from transmogrifying into a closed set of unhearing spheres or blocs at war with one another in some deterministic or indeterministic way, or become foolishly parochial or superstitious. It remains to be seen how enlightened and intelligent statesmen will be, and how inane.

Around 1993 a phenomenon of military &r social hypersonic &r suborbital diaglobal transportation, travel, &r commuting will first show itself, and thereafter evolve into a strenuous enterprise overrunning and fusing the Earth. Flight to any antipode will take 1½-38 hours at Mach 1-26 velocity. Such flight times, especially by maximizing the duty, may be economical. Such services might be available to the military, officialdom, the wealthy, or most everyone, for special or general purposes. Like future communications, they may intraconnect, integrate, and implode--in effect "retopologize"--the presently disharmonious but convergent globe. Tourists, residents, migrants, commodities, systems, technologies, values, life-styles, monies, ownership, control, power, ideas, goals, and possibly weaponry will flow in 1, 2, and all directions, and with an increasing indifference to distance increasingly rendering the Earth, in effect, a mathematical point (the same effect future communications will have). Likewise such global compression, punctation, acceleration, complexification, and amplification--via future communication and transportation--will recast the politics, behavior, &c of all men and nations, and conduce to world government, etc. More persons &r types of

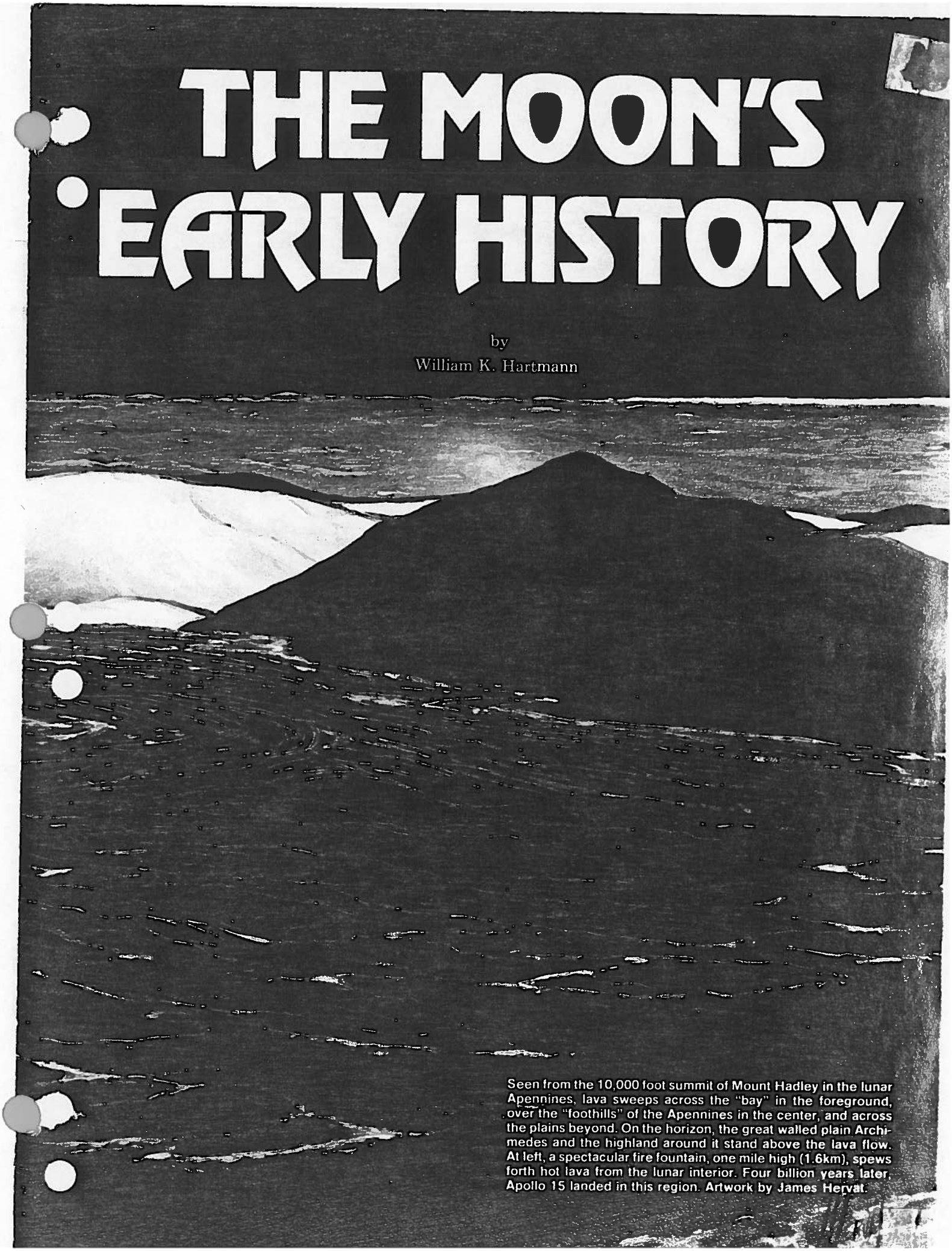
persons will or may travel and travel more, or travel more freely, exploring and developing their reciprocal backyard. Travel will be less interruptive and inconvenient. Distance will be less divisive. Economic synergism will increase. The organization of the world will be less geographic and more appropriate. In passing, equivalent effects might and may be achieved if the future is marked by sustained, major, or drastic falling of transportional costs &r prices, say the result of technological developments or a transvaluative redistribution of resources, the deflation occurring in terms of subspacial &r spacial transportation (these same remarks applying to communications), the evolving deflation being absolute or relative for local or world mean or median per capita income or savings at sets of future dates. Finally, progress toward Mach 26 flight, in terms of the universal set of transportations, will naturally conduce to the development of orbital and transorbital transportation, and the general development of Space. The overall phenomenon of the climactic growth of supersonic transportation will transpire over the next 68 years, between the past, 1993, and 2043.

Some sort of 1-way or 2-way communication via Space for points on Earth using microtransmitters (say weighing less than 25 kilograms, and originating from or passing between men bearing backpacks, vehicles, &r homes) sending code, voice, or pictures--and conversation, data, or computations--could and might occur, for military &r nonmilitary purposes, around 1993. The reception might be inferior or superior. The use might be minor or major, special or general, occasional or frequent, expensive or cheap, more or less important, fixed or growing, limited or not by technical ceilings, &c. There might or not be any subspacial (eg central) relays. The transmission &r relay might be broad or radial (ie baser). Certainly one can see a gradual reduction in the necessary size of any &r some transmitters beginning with the huge transmitters, relays, and receivers that are necessary in 1975. Mediated and subspacial transmission &r reception will certainly compete with purely spacial systems, but with unknown balances. Improvement in possibilities &r actualities will occur from 1993 to 2033, and thereafter. Some sort of soldier-to-soldier or military intercommunication will probably occur sooner, if it has not occurred already.

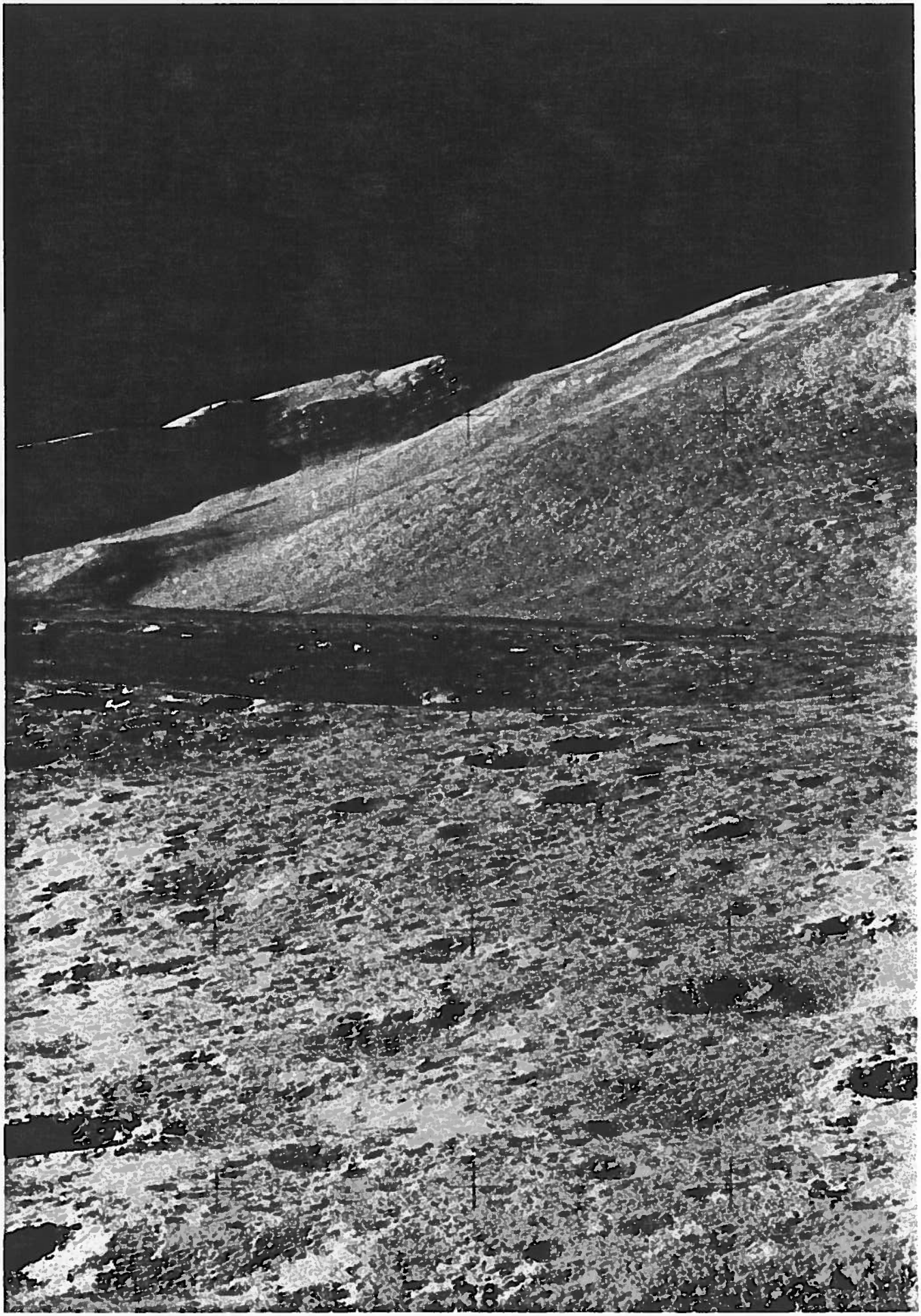
A base will exist on the Moon by 1993, 18 years from now. This is an interesting prediction because it is so conservative. Why doesn't one exist already? What is required other than the technological and economic means at our disposal? What new reasons or warrants for such a base could be necessary? Given the rapidity of past developments in Space, why must we expect to wait 18 years for a first elementary base? Is there nothing exponential about spacial technology, industry, and exploration? Won't someone create the base earlier, in $\frac{1}{2}$ or $\frac{1}{4}$ the time? Is there really good reasoning in prolonging spacial exploration and development by prorating and serializing costs and events over the years, and abandoning our hectic pace over the first 12 years? Might it be cheaper, wiser, and completely tolerable to proceed at a maximal rate and scale, and to initially explore and develop Space as a concern, not of the future, but the present, and for the sake of the thing we will be initiating? One senses the proximity of foolish, expedient, and uninspired politicians and bureaucrats, and is indignant; such leaden men did not build the world, and never could have, but are like vultures. These reflections sat aside, the primordial Lunar base may further be visualized as probably to comprise 5-20 men, existing semipermanently or 6 months, 1-15 rooms or 1-3 buildings, to use some local resources and energy, to feed itself, to conduct multifarious selenological and nonselenological research, to assemble and perhaps extend itself, &c. It is conceivable that the base will be maintained permanently by repeated, rotating expeditions, and very likely that it will at least be reused by successive expeditions, in place or elsewhere, after

THE MOON'S EARLY HISTORY

by
William K. Hartmann



Seen from the 10,000 foot summit of Mount Hadley in the lunar Apennines, lava sweeps across the "bay" in the foreground, over the "foothills" of the Apennines in the center, and across the plains beyond. On the horizon, the great walled plain Archimedes and the highland around it stand above the lava flow. At left, a spectacular fire fountain, one mile high (1.6km), spews forth hot lava from the lunar interior. Four billion years later, Apollo 15 landed in this region. Artwork by James Hervat.



temporary abandonment. The base might even be mobile--a vehicle--rather than a fully or partially stationary construction, in which case the vehicle will be suitably large to function as a combined driving and operating room, living quarters, laboratory, and possibly lunipetal and lunifugal craft. But one assumes the base initially will have 1-3 independent ground vehicles. The initial energy will be nuclear &r solar. From the base, men will progressively explore, and perhaps eventually occupy, the $10^{7\frac{1}{2}}$ square miles of the various Moon, its rugged terrain, anomalous and ordinary features, map and mineralogy, surface processes, history, internal structure and dynamics, opportunities for exploitation or general use, petrology and pedology, and the encyclopedia of difficulties it presents. They will survey, extract cores from 100 meters depth, perform certain experiments, study the heavens, station automatic instruments and microlaboratories at remote points, blast, do various seismological experiments, seek and examine quasi vulcanic phenomena, film terrain, cross craters and maria, classify phenomena, name landmarks, recover a galaxy of mineral specimens, search for biota and biochemicals, search for specific minerals such as deposits of radioisotopes, investigate the exterior and interior of fissures, mountains, &c, discuss with each other and reflect upon their experiences, dream, test and develop means for more natural survival, investigate some industrial possibilities, diarize, interact with men over on Earth, construct and dismantle things, hopefully make entertaining movies, possibly circumnavigate the Moon, &c. By foot, ground car, flying vehicle, &r motile robots, they will concentrate on their neighborhood within a radius of 1, 10, or 100 miles, concentrate on a set of special and perhaps predetermined loci everywhere on the planetary, &r explore the world in some way or degree as a whole, and they will do so by some chronological progression or criteria. The critical question will be, What is the hierarchy of interesting loci and aspects? Also, What is to be done next? This pioneer work on the Moon will lay the basis for the manned translunar expeditions and purposes that will shortly follow. A series of such Lunar bases will arise or exist from 1993 to 2010, say 5 scattered around the Moon in 2000 and built by 2 or more nations. Thereafter the number may multiply rapidly &r certain initial bases may be continuously broadened, deepened, extended as rays, &r enlarged a la netting. Primary, secondary, tertiary, and purely mechanical bases or stations will evolve. The bases will metamorphose into colonies, and the colonies become cities. Such constructions will surround the Moon at all longitudes and latitudes. The bases may to some degree be specialized. There will be efforts to extract, synthesize, and fashion Lunar resources. Self-sufficiency will eventually become a predominant objective. Thought will go into Lunar, Terran, and extraplanetary uses for Lunar resources and capabilities. Early planning of the future development of the Moon as an entity will begin. The first bases will serve as a catalyst and turning point in the large development of Space and proliferation of interested parties. They will give a needed air of inevitability and propriety to the Spacial enterprise, and create an historical record that will play a prominent role on Earth. All these things in their course, to be sure. The bases will make many important and dramatic discoveries, variously unpredictable as to nature, time, scale, likelihood, basis, significance, reception, place, rate, &c. The set of such will adumbrate later translunar discoveries, and favor or disfavor a greater translunar enterprise or pace of development. Men, meanwhile, will be joined by increasing numbers of increasingly various, versatile, able, superior, and competitive automata, fulfilling an increasing number and percentage of old and novel tasks and purposes on the Moon and elsewhere; automation will be an accelerant of Spacial exploration and development, and will ultimately transfigure the enterprise, as it will all else. It is clear that--because of human scarcity and needs, the dangers and difficulties and novelties of Space, the very magnitude of Space and human purposes there, and human limitations--the development of Space will progress

and involve cybernation to a unique degree. Eventually one can imagine whole ships, factories, laboratories, bases, cities, planets, enterprises, and teloi being largely both run by and for automata.

By 1993 a spacial disaster, or spacial disasters en bloc, will have claimed 10 lives. How costly, critical, consequential, predictable, preventable (before and after), horrible, &c will and might such disaster be? Where and when will particular and peculiar disasters occur? Will they involve guilt or not? Will they be peculiar in kind to space, of a more familiar nature, artificial, or natural? What maximal catastrophes in or involving Space might occur? The particular and peculiar disasters that will successively occur are unsayable, but possibilities include the collapse of a dome, the explosion of an engine, generator, or stockpile, the puncturing of a ship or building by a meteoroid, fluctuations of the solar wind, a major quake on some planetary, other natural catastrophes, the crashing or collision of a ship during takeoff or landing, sudden forms of major pollution, risky missions, consequences of computer malfunctions or errors, consequences of poor planning or miscalculation, consequences of planeturgical projects, exobiological diseases contracted in Space or transmitted to Earth, untreatable epidemics in Space, prosaic industrial accidents in or of Space the result of carelessness or risk, catalytic disturbances of Spacial statics and dynamics themselves exerting catalytic effects on natural systems containing men, fires in Spacial craft or constructions, malfunctioning spacesuits or subspacial vehicles, decreased emphasis on absolute safety in the Spacial program, &rc. An intraspacial toll of 10 lives is obviously trivial compared with Terran tolls, whatever hazard it poses for a certain population in Space. Of course, various and serious disasters and other accidents will occur in and of Space that will be limited to nonfatal or noninjurious effects, to certain financial, strategic, &r psychic costs, and these will occur with a certain schedule. With time the scale, number, and range of disasters will increase and accelerate; certain particularly intolerable disasters will become possible and require disproportionate attention. The spectrum of possible disasters, and inherent risks and costs, will slowly unfold.

A United Nations spacial force, undertaking, &r administration will exist by 1993. The UN will conduct large-scale periterran operations using (beginning in the tenth decade) its own spacecraft, centers, and operations. It may happen that, towards or beyond 2000, purposes in Space will be progressively given an international or supranational basis and transferred from nations to an organization like the United Nations. The wisdom or folly of this transferal and unification may not be apparent until 20-30 years later. Apropos, the United Nations may radically alter over the next 20-50 years in terms of power, composition, nature, wealth, purposes, &c, and this will have a bearing on its spacial roles. It is as yet unclear whether the United Nations would favor or oppose space if it were dominated by the Third World. In addition to periterran purposes, one can imagine the United Nations concerning itself with spacial policing, law, mining, exploration, scientific research, surveying, energy development, and occupation. Certainly in the long run, 2025-2176, the United Nations or an analogous or homologous organization will very likely dominate the development of Space in an international or supranational fashion, or as an extraterrestrial political entity or authority. It is not inconceivable that a World Spacial Authority will materialize over this period as an archetypal Solian Government made of planets, nations, elected officials, or citizens.

By 1994 robots &r teams in spaceships will move in Space &r leave Earth to periodically &r per need inspect, maintain, repair, refuel, reconstruct, enlarge, exchange the film of, &r otherwise modify periterran &r extraterran satellites, stations, artificial planetesimals, eccentric-orbit probes, ships, &rc. They will do so because of, for example, great enlargement, complication, proliferation, longevity, age, progress, &r opportunities of periterran satellites,

new opportunities for and economies in such maintenance and access, the ideality of maintaining rather than adding to and replacing (increasingly expensive and, say, modularized) satellites, the increasing opportunities for and appropriateness of such human presence or visitation, the increasing human residence in Space in general, &rc. The American space shuttle that will become operational between 1980-1984 will be designed with such purposes in mind as satellite placement and return, the repair and servicing of satellites already in orbit, space station support, &c. This will be the start of such activities. It will also be the start of "geosatellitic industry" and a Terran "satellosphere". These terms simply visualize a great deal of installed mass, building, industry, storage, observation, touristry, hospitalization, agriculture, power facilities, &rc arising over the next 100 years outside Earth's atmosphere but within her finite gravisphere. This periterran mass might grow over centuries to something like 10^{-9} $M_{\oplus}$, 10^{13} tons, whatever its predominant source(s). It is, however, unclear whether this mass will be concentrated in one or a few satellites, or more equally distributed over a myriad satellites, since there would seem certain advantages in concentrating the mass, volume, and facilities as much as possible, perhaps in an artificial "Moon II". There will be a larger debate whether to occupy and develop in situ natural bodies, or to emphasize instead various satellitic, heliocentric, and Lagrangian loci as Space is developed.

In 1995 will occur the most critical and important event that will ever occur in the history of the human race. A machine will either exist or be born that will quite clearly be roughly as intelligent as a man with IQ 100. The implications of this event are, in fact, so stupendous that the full consequences will deliberately be omitted from this book since they would surely alter completely the emphasis of the book and the view of the future of Space it attempts to set forth. Instead there will be treated unrealistically conservative development in the computer field. Even if the event does not occur around 1995, it will occur with greater than 90% probability by 2035, 60 years from now. This subject is treated in detail elsewhere in this book.

1995 can stand for the year or the era when there will be biracial exploration and development of Space, with Homo sapiens assisted by and cooperating with automata so ingenious mentally &r physically as to fully deserve to be spoken of as robots. Only if these automata replace men on Earth do I expect them to exclude the human presence from Space. The direct presence of extraordinary and original intellect in Spacial milieux is simply necessary. Fragmentary perception, conception, action, and initiative--such as computers are limited to as of 1975--is inadequate for standards and purposes appropriate for our Spacial program as presently executed by men in situ, entirely apart from the romantic, challenging, and occupational aspects of that program. The gap between human and mechanical ability will close stepwise over the next 30 years; as already hinted, man will be totally equaled and transcended, with 50% probability, by 1995-2005. Long before then, however, machines will surpass men in key respects, as they have already. The robotic flexibility that will evolve over the quarter and show itself markedly in 1995 will include such things as climbing hills, mining in tunnels, surpassing men at particular tasks in absolute and unambiguous terms, piloting ships, running stations, roaming over entire planets, transmitting superb impressions of their environment, learning, innovating, farming, running factories, operating in teams, repairing themselves, constructing buildings, manning weapons, running complex scientific experiments, studying stars, monitoring planets, &rc. They will begin such chores experimentally, then crudely, then compete with men, then no longer compete with men. The presence of such robots and the power of future computers will greatly accelerate the exploration and development of the Solar System over the next century. For example, the rate of data processing, the size of memory, and the progressive intelligence of computers will be so great as to simplify and economize the

chemical and topographic exploration, mapping, and development of other planetaries by many orders of magnitude before 2000, possibly by 5-10 orders of magnitude, say in necessary man-years. The absolute cost of mechanical workers--able to walk and to sense, manipulate, &r evaluate things like a man--is very unclear in 1975 but might, in Space, be or become 10^{1}-10^{-2} as expensive as human labor. Costs will change completely when automata become able to manufacture automata and the sole real issue will be the rate of growth and compound interest of the cornucopian "money tree"; such inhuman economics will appear around 2000. Robots working in Space will remove various overheads of the current human program related to tolerable risk and discomfort, biological needs (food, water, air, health, waste removal, entertainment, space, environmental optima, luxury, return voyage, sleep net income, idiosyncrasies), and so forth; these are enormous overheads. Robots can forgo sleep, vacations, death, fatigue, and other discontinuous activities. Three additional possibilities, actually related, are so-called telechirils or "telehosts", cyborgs, and symbioses. The telehost would be a machine largely or completely actuated by the will or psyche of a human being operating it externally or remotely, say from a surficial base, orbital station, or Earth; the human presence might be limited and crude or it might be anything up to complete or superhuman, but man (a man or men) would be the autonomous operator of the heteronomous operatee. The idea seems wild, but, of course, it is nothing but what has already occurred in Space and is developing progressively in the indicated direction. The idea of a cyborg is that of a man heavily equipped with bodily prostheses of a temporary or lasting kind, where artificial hearts, visual protheses, &c are already in use. Symbiosis usually visualizes the mechanical part of a relationship with a man as almost equal to, or more important than, the man, in physical &r mental terms, or, alternatively, the grafting of some part or aspect of human intelligence, personality, &r sensorimotor skill onto a machine, or letting the machine use a man directly. Over a period of 200, 100, 50, or even 25 years in the future, none of these possibilities are strange, and the bizarre things are actually what will occur, with an important bearing on man's Spacial programs. The sophisticated instrumentation man is already inserting into the Solar System, for example, can be more than poetically characterized as the extension, replication, and magnification of his muscle, eye, mind, and heart. There are two compatible possibilities in terms of both the heteronomous and autonomous devices: their number and their individual power. A machine, for example, can be made stronger, faster, more enduring, tougher, and nimbler than any athlete. It can be made as big as a mountain or as small as a cell. It can be made sensitive to any frequency of sound or photons, or to any intensity or spectral information. It can see in the dark using all sorts of active sensors such as lidar. Moreover, it can do all these things at once, at superhuman capacity, and with superhuman thoroughness of analysis. The environment contains infinities of information that go unused, unrecognized, and unrecognizable by man, but are accessible to future machines' sensoria &c. One incredible machine could therefore accomplish many, many orders of magnitude as much per second or as it does its job, as man. On the other hand, the number of machines is important. An army of 10^{2}-10 robots might be exploring and developing Mars or the Solar System before 2075. They might be totally portable and draw their energy from photovoltaic sombreros or skin. Customary demographic restraints would not seem to apply to these robots. Both possibilities for robots will evidently give man unlimited power over nature. Human and mechanical slaves have always underlain civilization. The promise of infinite and superhuman slaves is the promise of infinite and superhuman civilization. Future automation will minimize the costs of Spacial exploration and development beginning around the turn of the century, and remove the one hurdle to its unlimited development by our species and our children. It can even be argued that we ought precede the development of Space by the development of computers, but here we exceed the evaluative powers of most readers.

ERROR: 1977 ?

The first private Spacial adventure, periterran or beyond, will occur in 1995. In the tenth decade 3 American or transnational corporations will launch their own, albeit purchased, spacecraft and conduct exclusive operations using their own men, professional "imports", or loans. In any case, there will certainly be a great deal of initial and continuing governmental liaison, and such great corporations by then, anywhere in the world, will probably have many semipublic aspects, for better or worse. Initial and later launches might be directed to general or specific purposes such as communications, energy, mining, touristry, science, and occupation. There exists the serious possibility that many individuals and families, wishing to experience and even pioneer Space, will, in effect, defy fickle, unimaginative, and preoccupied governments and use their own funds and enterprise to enter and develop the Solar System over the next 40 years, with or without governmental assistance, especially as average and exceptional income rises and Spacial costs presumably fall, or some corporation might be formed for the same purpose with this group of men in mind. Dwelling and life in Space could easily be highly amusing and inspiring, and might never repeat the arduous trials men once underwent when they set out to explore and develop new and extreme frontiers. Moreover, dangers, stresses, discomforts, and sacrifises are not necessarily unattractive as presenting a challenge to brave, bored, curious, impetuous, and wild men, even such as exist today, increasingly exist, or could exist. Alaska, Antartica, jungle, desert, &c appeal to many as challenging and intrinsically fascinating places, however exotic and rigorous. Outer space is especially challenging and attractive because it demands totally new thinking, personal abandon, the synthesis of all essentials and luxuries, and it promises the ultimate and almost ecstatic pleasure of having uniquely achieved such things or of playing a role in their attainment by allying oneself with transcendent destiny. The dwellings one should properly visualize as arising in Space, say geosatellitically or at Gerard K. O'Neill's L-5 colonies, are ultramodern and beautiful ones along the lines of the visionary cities of the architect Paoli Soleri; much of their beauty will arise from sheer awareness of nature's miraculous order and provision even in terms of such spiritual entities as Spacial cities, and from pride and wonder over transcendent human accomplishment. One's own creation is always cause for wonder and satisfaction. The current state of science and technology will probably make inevitable a high degree of comfort, room, efficiency, reliability, safety, environmental interest, beauty, work and play, &c in such uranian habitats. Life in them will have its sublime aspects, envied by terrestrials. Space will inspire a stronger and finer man.

By 1995 one or more nations or sides will be able to, or will in fact, continuously monitor all military submarines via Space, perhaps regardless of depth, location, microlocation, weather, disguise, interference, size, subglacial position, wartime environment, &rc. Such abilities may be coupled with some "sufficient" or advantageous counterforce capability and operation, and might have a novel and critical balancing or destabilizing effect on the future of arms. The importance of these things lies in the fact that enemies may have the ability to hide, enlarge, and protect their striking force, especially nuclear, in the pelagic, abyssal, polar, benthic, and littoral parts of the world ocean in threatening or advantageous ways, much as if they could tunnel within the crust of their opponents' lands. It is necessary that such a major military force should be vulnerable, especially if dominant or ominous.

See June; error - 1977 ?

It might be said that by 1995 the first industrial use of space will have occurred, say in the sense of business accompanying a governmental mission to achieve a private purpose. Really what is meant is a degree of autonomy in the corporate venture, a degree attained by slow evolution beyond the subservient, minor, and semipublic roles of corporate participants today or before 1995. The objective might be mining, solar energy, or touristry, or industrial teams riding, occupying, or using public facilities to ascertain in a preliminary way the real industrial utility of Spacial milieux, or want thereof.

Perhaps the date 1995 can serve as a marker of the beginning of actual "celestial photonics". By this is visualized the creation and use of titantically or astronomically large actual &r virtual lenses, mirrors, prisms, basers, transformers, transducers, modulators, capacitors, rectifiers, circuitry, batteries, conductors, resistors, &rc in Space in order to harness and use the absolutely incredible electromagnetic emission of the Sun, which is of the order of 10^{41} erg per annum, less than 10^{-9} of which Earth intercepts, where global fuel consumption is 10^{-4} of the latter, or 10^{27} erg. The immense Solar emission is all but completely wasted on the black Universe beyond, forever. There are several candidates for the initial, experimental use of sunshine by man in Space; man naturally has long since used sunshine in Space on a comparatively negligible scale to supplementarily power satellites, probes, ships, and surficial stations, or instrumental packages, on planetaries such as the Moon. The event that will probably occur around 1995 to kick off a new era will be the prototypal utilitarian (post-experimental) retransmission of the energy of sunlight to Earth's surface from a reflective or convertive power station orbiting the Earth, perhaps at 22,300 miles, as already discussed as something occurring experimentally in 1990, and as discussed below as officially occurring on a large-scale in 1997. I have advanced the date here to 1995 to make the point that the event "in" 1995 may be of another kind than that scheduled for 1997, or the nature of the "event" is diffuse. Celestial photonics, as it evolves, will serve such things as energy, communication, transport, scientific research, engineering, &c. More specifically, such things as planeturgy, control over the Sun, communicating with another stellar civilization or the entire galaxy, amplifying extraordinarily weak signals or self-descriptive emissions of nature, &rc. It is to be expected that possible and appropriate uses of now unimaginable kind will inevitably emerge when such energy and apparatus become available and are used. These more fantastic possibilities will occur at progressively later dates; for example, planeturgy using celestial photonics in 2075. A finer point that I am making is that photonics already shows signs of developing into something largely replacing electronics in terms of power transmission, communication, computation, weaponry, amplification, &c; there is, for example, promise of greater energy and speed. The Photonic Era will succeed the Electronic Era on Earth and in Space. The photonic circuitry evolving and amassing in Space will tend to acquire ever-greater mass, volume, ingenuity, complexity, variety, and importance in obedience to purposes and functions still largely mysterious.

It may never occur, but if it does, there is perhaps a 50% probability that a lesser power will place nuclear bombs in orbit about Earth in 1995 as a relatively cheap and invulnerable strategic weapon system, in lieu of large, airborne, submarine, land missile, &rc systems. Such placement is currently outlawed by the Outer Space Treaty of 1967.

In 1995 magnitudinous use of sunshine will occur on the Moon to drive solar cells, hydroelectric generators, &r other converters, motors, and devices. One thinks initially of 1 megawatt or more output serving transportation, communication, scientific research, heating, miniature manufacturing of such essentials as air and water, computation, &c over the Moon or just for the base established in 1993. 1 gigawatt of power might be in production from sunshine by 2015, and play a critical role in the rapid growth of Lunar civilization apt to occur between 2000-2050, perhaps regardless of the rapidly expanding use of fusion power transpiring on Earth and in Space. Mankind's disposal of the 10^{41} erg per annum shine of the Sun in the years before 2100 is quite obscure. Nevertheless, he may utilize catoptrical devices during the 21st century of gigantic and astronomical size for purposes of Lunar industry itself developing on a titanic scale.

The first serious use in Space of various electrostatic and electromagnetic drives will occur in 1995. Known possibilities for electrostatic propulsion include a nuclear reactor, photovoltaic cells, or solar collectors as the power source; the Brayton gas-turbine cycle, Rankine turbine cycle, semiconductors (thermocouples), or thermionic diodes for converting the power; and various ionic or colloid devices for the thrust. Known possibilities for electromagnetic propulsion include the thermal adiabatic arcjet, magnetohydrodynamic (MHD) arcjet, magnetoplasmadynamic (MPD) arcjet, or electropulsed methods. The characteristics currently assumed for electrostatic (ion) propulsion are a specific impulse of 5,000-60,000 second, a thrust-to-weight ratio of 10^{-5}-10^{-3}, and a typical thrust duration of months. The characteristics assigned electromagnetic systems are a specific impulse of 5,000-25,000 second, and ditto. Clearly these drives would seem to have special ranges of applicability. Per contra, chemical propulsion involves a range of specific impulse of 120-450 second, a 10^{-3}-10^{2} thrust-to-weight ratio, and typical thrust duration of minutes; fission propulsion, respectively, 500-1,100 second, 10^{2-1}, and minutes. Given their uncertain nature, feasibility, cost, developmental requirements, drive characteristics, applications, trade-offs, &c, it is really a little early to comment on future events related to such drives. Even so, they may be the key to important developments, and they are widely discussed.

Maybe in 1995, hypersonic transports (HST) will lift objects to or toward orbits. It is uncertain at what height and velocity release will occur, and what independent drive the objects may carry. The purpose will be financial economy.

In 1995 scramjets will operate at 17-25 or more Mach. One function may be that just mentioned. Another will be aerospace scramjets.

1996 may be taken to stand for the year when controlled fission drives will become operational in spacecraft &r atmospheric assistance thereof. Possibilities include gaseous core, solid core, nuclear-electric, huge particle-reflecting hemispheres, &c. Such drives could come into Spacial and subspacial use far sooner were there not the opposition existing. Nuclear drives will greatly expand unmanned and manned interplanetary flight and operations. The imminence of controlled fusion and fusion drives in 1996 will have a complex positive and negative bearing on fission developments in terms of both power generation and propulsion in Space.

Pulsed nuclear ("Orion") propulsion will be tried out in Space in 1996 with fission bombs. The blast effects of small, repeated atomic explosions will be used to propel space vehicles. High instantaneous accelerations, loss of fissionable fuel, and radiobiological hazards are serious problems that have to be solved. Nuclear pulses may ultimately be used to propel planetesimals of mineralogical value elsewhere in the Solar System without radiation hazard.

Revolutionary spacial offensive systems can be foreseen arising in 1997. The spacial defensive systems expected, say, in 1991 are a two-sided coin: they may induce both sides to evolve offensive systems and they may also have a certain utility in tactical and strategic offense. Certainly their and other hardware can provide valuable offensive systems. Gigawatt and terrawatt basers may be used to destroy missiles in flight, military materiel and personnel on land and water, nonmilitary construction, populations, and the countryside, at least in theory or threat. Mighty basers may also be used intraspacially to destroy military and nonmilitary installations and means. Bombs can be placed and maintained in orbit, deep Space, on in Spacial bases. Manned and unmanned fleets can be placed in Spacial loci. A defensive or offensive Doomsday Machine can be orbited and either announced or not; Spacial Doomsday Machines might be especially effective or cheap. Many possibilities must be possible for a sinister mentality, and may already be contemplated or exist, or should arise unpredictably by 1991 and later. The Outer Space Treaty of 1967 seems to forbid such systems, but it is ambiguous and sofar unchecked. Countless qualitative and quantitative possibilities will be possible or occur before 2176.

In 1997 solar energy will first be basered to Earth on a large scale via great geocentric receiving, converting, and retransmitting stations, say via microwaves, as currently envisaged in terms of decagigawatt stations. Later the same orbital relaying of solar energy to the ground will occur for other planetaries such as the Moon and Mars. The growth curve for these stations in terms of both their total number and power, and power per station, is hard to forecast, but such stations collectively might relay 1 terrawatt (which corresponds to man's total industrial use in 1975) to Earth by 2030-2040, and 1 ~~kiloterrawatt~~ PETAWATT by 2080, 105 years hence. Obviously critical in these estimates are certain ideas about the competition of nuclear sources (especially 3rd-generation fusion), world population growth, world monetary growth, world consumption growth, and so on. It is usually supposed today that world population and wealth will grow deceleratively over the 21st century, and perhaps essentially cease growing by 2100, but I find this logistic picture simplistic and see excellent, and even necessary, reasons why both human number and wealth, albeit undulating tidally, will completely transcend 20th and 21st century levels and ascend by many orders of magnitude, even by 2176. This issue is discussed in extenso on page f. The presence of these enormous energies in Space in directly usable form will greatly stimulate general exploration and development of Space by the Terran satellosphere and other loci, for countless reasons. The development and installation of the huge relay stations will maintain and enlarge spacial industry on and off Earth, and create facilities and vehicles of such size and number as will perforce serve other needs and uses, both before and after. The number of men in Space will greatly enlarge. The converted energy of the power stations can be tapped by periterran and extraterran users. The power stations can be towed to, or are easily replicable at, the most various loci, eg lunicentric. The great benefits derived on Earth from the retransmitted energy will endorse the economic value of Space and point the way to further industry. The great stations, seen distantly orbiting from the ground, will visually symbolize the excitement and importance of Space. The first relay stations may or may not be geosynchronous. The enormous energy derived from Space may be marketable or donable to other nations. Relaying from various experimental, complementary, and supplementary celestial longitudes, latitudes, altitudes, and apparent cycles will occur 1990-2010 forward. The feasibility and ideality of this means of clean free energy, and perhaps its peculiar capabilities and requirements, will prompt the United Nations to encourage, and later personally undertake, its very large-scale development, and its distribution to 160 nations. Possibly, unavoidable radioisotopic by-products of fusion &r fission plants may stigmatize, disfavor, and stunt or abort Terran reliance on fusion &r fission power, and solar energy ~~may~~ MAY come, between 1990 and 2025, to virtually supplant all other sources of energy on Earth, or all those creating significant external diseconomies; but 1st, 2nd, and 3rd generation fusion will become increasingly clean, safe, convenient, efficient, &c.

A semipermanent or permanent base on Mars will exist in 1997, followed by a series of bases and a colony; the creations, ultimately, of many Terran nations. Similarly will a temporary base, the predecessor of a colony, be created on 16 km d Phobos, a Martian moon, during 1997. The Phobian base will be related to, and collaborate with, the base on the Martian surface, being ia a route of supply and the recipient of terriphobian and phobiomartian traffic. The several expeditions to Mars during the 1990s and beyond will utilize these primitive bases, regardless of the nationality of the expeditional forces. The activities, purposes, and programs of these remote bases are outlined in the above discussions of the 1990 Martian expedition and the 1993 Lunar base. Spacial exploration and development as a whole will be experiencing a critical resurgence after 1994, with events compressed and clustered in time (distinctively, many events will be occurring concurrently instead of serially, per today's political custom).

Mars, a relatively far more hospitable resource than the Moon, will fairly bloom in the spring between 1997 and 2045. It will be explored, populated, and developed at an almost hectic pace over 50 years, and will rapidly become, to all intents and purposes, self-supporting. Life there will have a romantic, ensorcelling aspect, and visitors will stay, becoming Martians. Backpack and vehicular compressors and converters will enable men to breath the thin air, ½% the density of Earth's. Considerable water may be found in extensive permafrost. Enormous domes and tents may be erected over great swatches of soil, pressurized with compressed and converted air, irrigated with recovered water, and heated by ingenious use of greenhouse effects imprisoning the natural heat of the Sun received over the identical acreage, the resulting ecosystem enabling low-technologic silviculture, agriculture, floriculture, and human inhabitation of Edenic image transfigured by the Martian adventure and the dreams of men.

The first manufacturing of oxygen or air on a nonlaboratory scale from extraterran soil, rock, water, &r carbon dioxide will occur around 1997 on the Moon, enabling colonial self-sufficiency to make a stride forward. Oxygen is, of course, omnipresent and concentrated on all solid planetaries as soil and rock oxides. The only question is the most efficient means of liberation, and its costs in energy and facilities. Eventually trillions of tons of soil will be deoxygenated throughout the Solar System. The Earth's atmosphere weighs 10^{15} ton, but an agricultural cutosphere could be established around Mars weighing only 10^{11} tons and perhaps costing $\$10^{13}$ or less, enabling the entire surface to be farmed and inhabited by men.

A hundred asteroids in circular and eccentric orbits will have been individually visited by man or machine by 1997, and 10,000 by 2010, only 13 years later. It is even conceivable that one or more probes, or a team or force of men, will be created for the express purpose of the continuing investigation of the asteroids, especially the asteroidal belts, in a systematic and exhaustive way. Although the collective mass of the asteroids is much less than the mass of the Earth, their collective surface area is enormous and presents quite a challenge, as well as opportunity, to explorers and developers. The Asteroidal Survey, as it may officially be called, will have as its object the cataloging, photographing, morphological and mineralogical mapping (and possibly the pictomapping), classification, and early experimental development (mining, occupation, industrialization, &c) of the 100,000s of large and small asteroids that exist. The fragmentation and possible mineral fractionation of the asteroids may make them ideal for mining and conceivably an Eldorado, in which case the Survey will have its hands full and the tide of Solian civilization will advance by 1-3 AU. The automata usable by the Survey in the early decades of the 21st century will, of course, be fantastically sophisticated both in terms of their analytic methods and instrumentation and sheerly in terms of their perceptual and conceptual power, thus accelerating, perfecting, and enlarging the survey that will be made. What early use will be made of the asteroids is not clear at this point, but is obviously critical. They could, for example, seed massive occupation and become an archipelago of "kingdoms".

A pulsed fusion drive will be tried in Space by 1998, using deuterium, tritium, lithium, rc, and to some extent representing an idea competing with pulsed fission.

A manned laboratory studying the Sun will come as close as the orbit of Mercury (aphelion $58 \cdot 10^6$ km) and either return, land Mercury, or assume a Mercurial orbit, in 1998. It may even overleap Mercury and approach a few Solar radii, depending on the safety with which this can be done; or it might launch a telemetric probe to do this and to fall into the Sun, quiescing at some minimal altitude. But would such a mission be too dangerous and pointless for men, and best be undertaken by an unmanned probe, such as presumably will occur in the 1980s? What would be gained by being so much closer to the Sun? Could lengthy stay of men so near to the Sun be too injurious &r risky? These objections strengthen when the sophistication of probes possible in 1998 is remembered. Man may keep his distance

By 2000 all 9 Solar planets, and many of their moons, will have been landed or atmospherically entered. The studies performed on them will have been comparable to those done above by the intrajovian probe in 1992 and the possible Plutonian landing in or after 1990, possibly in 2000. Such comprehensive coverage of the Solar System will to some extent function as a signal or causal turning point for the Spacial enterprise.

There is a chance that by 2000 man will be putting of the order of 10^5 ton of payload in Space annually from Earth &r other planetaries. This is an enormous sum and it is advanced with some caution, but on it hangs the extent and rate of man's overall extraplanetary activities by that date. It is 3,000 times the projected payload of the space shuttle that will operate in 1980. There is a temptation to regress the date to 2010-2015. Despite these worries, 2000 has a >10% probability of being correct, regardless of the duty of single vehicles, their number, their capacity, and their multiplicity of ownership. Confer the discussion above of 10^4 ton per annum being orbited by 1990.

Flight at 400,000 mph--600,000 fps or 1/1,500 c--will be achieved in 2000 and thereafter come into customary use for special purposes. This will require nonchemical propulsion with outstanding specific impulse &r thrust duration. But the use may remain basically experimental. Gravitational acceleration by the planets or the Sun may figure in the achievement of such velocities, which are many times Solar escape velocity. Mars could be reached from Earth in half a week at 400,000 mph, and Pluto in under a year. The utility of flight at 1,000th the speed of light is therefore unclear, a fortiori beyond it.

An artificial moon will be created around 2000. Or its equivalent. An artificial moon is a huge reflector distributed or erected in Space in order to reflect sunlight to Earth or some planetary. Reasons for doing this might be to lighten night, perpetuate day, increase agriculture, delatitudinalize Earth (ie raise temperatures at high latitudes, say in Greenland, Canada, the Soviet Union, Antartica, or for Mars' poles or Titan's surface), deseasonalize Earth, control global climate, &rc. The United States considered using such a moon to illuminate nocturnal Vietnam during the 1960s, and the Russians have entertained the idea of surrounding the Earth with a ring of dust oblique to the equator in order to melt their continental permafrost. An excellent idea is to build hard or soft concave reflectors of titanic or astronomic area in Space to focus sunlight to the ground for countless economical purposes, as discussed below for 2005.

Major extraterran food production will occur around 2000. The first real growing or manufacturing of an adequate diet from extraterran materials will probably be Lunar agriculture. Food will also be produced in geocentric satellites or Earth's satellosphere, Gerard O'Neill's L-5 and L-4 colonies, spaceships of increasing size, on Mars, in asteroidal colonies, &c as the century rolls on. The produce will be used in situ &r exported to other planetary and extraplanetary loci, possibly even to Earth's surface. The latter, and its magnitude, are moot, and presuppose alternative perspectives. Production of food in Space, at any rate, will supply Space with a second critical element of self-sufficiency. The rudimentary triad for Spacial self-sufficiency--air, energy, and food--may thus be fulfiled by 2000, and 2000 might be spoken of as the year zero for true Spacial civilization and the year when Terran civilization embryonically reproduced itself. The production of natural and synthetic foods in Space will experience tremendous scientific and technological progress between 2000-2050, and ideal possibilities in terms of Spacial milieux will gradually be discovered and unified. Certain characteristics of Space--such as intense and uninterrupted sunshine without cloud, night, season, or climatic change, low or zero gravity, unexplored and unexploited soils, &rc--might provide agricultural conditions superior to those common on Earth.

A new school of physics, called "plenistic", will arise over the next 25-100 years. Nature will variously be found to be of unsuspectedly great, or of infinite, subdivision, structure, density, energy, dimensionality, complexity, hierarchy, variability, &rc. The experiential universe will come to be considered as in some sense a "plenum", for example of infinitely dense hierarchical structure, constituted of an infinity or more (per transfinite arithmetic or developments in set theory, analysis, topology, &c) of particles and forces, having infinite dimensionality, &r the like. Possibilities here are themselves infinite, but some of those now living who have had ideas of this unconventional kind are P.A.M. Dirac, John Archibald Wheeler, Sir Fred Hoyle, Gerald Feinberg, H.C. Dudley, Geoffrey Chew, Pat Gunkel, &c. In fact the debate is ancient in its roots, an immemorial philosophic issue. Modern physical understanding merely perpetuates the plenistic view in one of its variants. It may be that all but 1% of the mass of the known universe is invisible, existing as neutrinos or black holes, that "real" energy and mass are infinitesimal alongside the energy density of the so-called vacuum, that the material and energic density of any space-time point is infinite or "superinfinite" owing, inter alia, to the bidirectionally infinite frequency and energy spectra of nature, &c. Such physics, as it presumably emerges in its greater glory, will lead to progressive scientific discovery and applications in terms of usable resources, transportation, communication, exploration, inventions, &rc. Returning to the nature of such a physics, some groups of possibilities are that nature is literally full of infinitely and infinitesimally graded residual types of relationships, that these relationships continuously or discontinuously grade off from one another (the latter includes the possibility that some natural qualities and realms have only an indirect, or possibly purely asymmetric, relationship to or continuity with each other), that the universe is of infinite physical extent (in terms of space, time, microscopy of both, qualitative relation, organization and complexity, novelty, laws, &c), that order and disorder (or symmetry and asymmetry) simultaneously always increase, that cosmogony is continuous and possibly also omnipresent, that an infinity of infinitely different "parallel" worlds coexist, that both "determinism" and "indeterminism" are far greater and different things than supposed in past discussion, and so on. If such uncustomary circumstances in fact prevail, then they will inevitably open the gate to the greatest adventure man has ever known in terms of both extensive and intensive exploration of the universe that embodies him and his order. It is conceivable that civilizations elsewhere in the Milky Way and Universe give no sign of themselves for the simple reason that scientific and technological development invariably and virtually directly leads to the abandonment of the conquest of outer space, as perceived by man, to the pursuit instead of such strange realms as are here contemplated. In any case, the figurative or elementary exploration of such plenistic realms will commence with certain investigations in 2000 and forward. It is almost impossible to predict the consequences of such ongoing investigations and discoveries for the future of Space, but they will doubtless be radical and critical.

The existence of a transnuclear source of energy, presumably coming out of particle physics or astronomy, will have been demonstrated in 2000. "Transnuclear" means involving an efficiency of mass-energy conversion in excess of that practically or theoretically obtainable by conventional or known fission and fusion processes--with exception of experimental matter-antimatter annihilation since this represents no energic resource--say in excess of ½%. Some schemes for such retrieval have already been suggested, and cosmology has entertained the notion that Universal oscillation is 100% efficient, ie eternal. Quarks or heavy leptons ($\eta \approx \frac{1}{2}\%$), production of superheavy nuclei (eg of A = 500-1000, for η = 10%-30%), &c are possible novel catalytic means for the recovery of nuclear energy. ½%-5% η conversion might occur in 2000. Later

efficiencies of 6%-49% might be achieved, perhaps by 2030, in which year >49% conversion will occur. Correlated with these novel efficiencies are their possible mineralogical implications, since they may enable the recovery of titanic energy from ordinary matter such as the gross soil of all planetaries. The mass-energy of a gram of any matter is 10^{21} erg so that coal has, so to say, $3 \cdot 10^{9}$ X as much energy in nuclear as in chemical form, and Earth contains over 10^{48}, a quindecillion, ergs of hypothetically recoverable energy, enough to run the modern world for 10^{21}, a sextillion, years. When and if this extraordinary energy becomes available, and intelligence cares to master and apply it, the scale of intelligent enterprise will graduate completely unimaginably. In passing, access to such energies will pose equally unimaginable dangers to Faustian man or his descendants.

Asenescent suspended animation for 20-1000 years may become possible around 2000, allowing interstellar flight. It may instead develop much later, and its use for such flight will probably not occur until 65-100 years from now, if ever. Interstellar flight may be confined to highly intelligent machines, multigenerational flight crews aboard "colonial" ships, or men living at least 2-3 X longer than ourselves. Suspended animation for men is almost certainly feasible, perhaps even on the basis of current knowledge properly utilized. Something, of course, must regulate and protect an interstellar ship with a dormant crew, even if the crew rotates. The value of suspended animation is purely transolar, however.

The first in situ mining and possibly refining of an asteroid will occur in 2000, albeit on an experimental or prototypal scale. It will validate such asteroidal industry and stimulate rapid exploitation over the next 20 years. The growth of such industry will in turn lead to the colonization of the asteroids and the beginning explosion of Spacial population. Ore ships, both manned and unmanned, and mass drivers of increasing scale, eventually titanic or astronomical in size, will transport great quantities of processed and unprocessed precious, semiprecious, and unprecious minerals across tens and hundreds of millions of miles of deep Space to other asteroids, Mars, the Moon, the Earth, and various satellospheres and Lagrangian colonies, at first of picayune, and later of gigantic, size in terms of operations, men, and buildings. Eventually an autonomous community will arise within the asteroidal belt, and a local government, called The Community of Asteroids. Behind all these developments will be the Asteroidal Survey, formed around 2010 and discussed above. An interesting engineering problem facing this emergent community in the long run will be the dangerous orbital ballistics of the asteroidal swarm, but this will certainly not be an immediate concern. The means used to mine &r refine the planetoidal surfaces, planetesimals, rocks, &r dust might be or include controlled and explosive fission and fusion, solar energy, and chemical energy, possible native. Eventually energy will be relayed to the 2-4 AU belt from periterran &r perisolar generative &r relay stations via baser beams, beams at once functioning as baser rails for commuting craft. So energy might be transmitted outward and materials inward in countercurrent fashion, possibly both as beams, a la Gerard K. O'Neill. In fact, corpuscular beams, regardless of direction, might transport both energy and matter, the former as the momentum of the latter sent at high velocity. Engineering, in general, ultimately becomes the ideal synthesis of different purposes, and this is evident here.

In 2000, "accelerators" using linear or nonelectric motors will come into use on Earth to launch craft or freight--"antimeteors"--into Space. An accelerator or linear accelerator is defined as a lengthy device, whether tube or ramp, over which a load, whether craft or material, is continuously accelerated, say in order to attain escape velocity from a planetary, or be driven with a surface-based efficiency. Such a device can also be either vertical or slanted

with respect to the ground. Antimeteors are defined as objects fired from Earth--or another planetary--into Space at orbital, escape, interplanetary, or greater velocity, without containment. The tremendous advantage of this mode of launch is its economy from not using fuel to lift fuel. If unhulled trajection proves possible, by a "mass driver", a further "double" economy will be realized by the absence of shell burden and friction.

Mass drivers will, indeed, appear in 2000, although they will be possible far sooner. The mass driver is defined as a linear-acceleratory or ballistic device that would shoot small or microscopic objects (eg comminuted minerals), or particles, long distances across Space, and even from atmospheric or anatmospheric planetaries, thereby achieving certain maximal economies in the cost of shipping materials, as proposed by the physicist Gerard K. O'Neill. Massive and constant streams of this kind will one day, in the first 30 years of the 21st century, flow between planetaries and space. The minerals, chemicals, other materials, &r "small" objects or mitraille--perhaps comminuted, pelleted, atomized, encapsulated, coated or combined, &rc--will be sent across Space as, in effect or fact, particle beams shot--eg electrostatically, magnetically, chemically, or nuclearly--from extremely long &r powerful "guns" at zero to c velocity. The mass fluxes will move in discontinuous or continuous, dense, &r enormous streams or rays with variable dispersion &r deflection as the predominant freightage from the Asteroids or Pluto to the Earth. O'Neill foresees a Lunar mass driver launching 80,000 tons a year in 1989 (specifically, a 13km vacuum pipe shooting precisely compacted payloads of materials weighing less than 10^4 gram at the rate of 1 per second to an L-5 colony forming itself from the received material) and 400,000 tons a year in 1991, the price per pound falling eventually from $3 to $$\frac{1}{2}$$.

The first significant extraction &r synthesis of fuel from extraterran materials will occur by 2000, and will occur on the Moon and as oxygen, possibly with the other member of a bipropellant, such as hydrogen from naturally or artificially concentrated water likewise discovered on the Moon. In 2000, or shortly after, this will be enough to cover in part or full a return flight to Earth or Lunar navigation. Its critical advantages over fuel brought up from Earth will quickly lead, by 2010-2020, to its use throughout Space instead of Terran fuels, or the large-scale exploitation of a resource by public &r private enterprise. In the subsequent years various fuels will be discovered and developed on Mars, the Asteroids, and other bodies. The accession of native resources will be a major turning point in Spacial exploration and development. The chemical discoveries and utilizations will be succeeded by equally important discoveries and uses of fission and fusion resources for flight and general power.

A machine surpassing man in general intelligence will exist in 2000. As already discussed in connexion with the advent of a machine as smart as a man in 1995, the implications of this development are so epochal that I have largely divorced them from the anthropocentric picture of Space over the next 200 years that I paint in this book. They are just incompatible with normal considerations and the timetable of the Spacial enterprise probable in the absence of extraordinary computer intelligence. Even so, it is fair that I here list some of the possibilities connected with superintelligent machines:

(1) Everything man does in Space--pilot ships, captain expeditions, labor in mines, run stations, supervise great operations, prosecute and assess scientific experiments and research, occupy niches, enjoy himself, &c--could equally, instead, or better be done by machine.

(2) Superintelligent machines could have rights and purposes of their own.

(3) The development of science, technology, Space, wealth, culture, &c could be accelerated arbitrarily greatly.

(4) If Space were previously difficult, it might suddenly become easy.

(5) Nature is probably saturated with infinities of information and possibility unknown to, unrecognizable by, and unexploitable by Homo sapiens but enormous in their implications for superintelligent beings. For example, the analysis of a planet's mineral resources and other developmental potential might proceed in a lightning fashion under the eye of a superintelligent machine.

(6) The intelligence of machines will not simply transcend man but rapidly go infinitely beyond him, attaining semidivine stature. This makes the future otherwise opaque.

(7) Such intelligence will have both the ability and will to prosecute simultaneously such a degree and variety of purposes as to more or less disorder and destroy the linear, conservative, and naive calendar of events I have prepared.

(8) Such intelligence will probably only naturally display and perfect "Dysonian" motivations. The term Dysonian as used in this book refers to engineering, construction, exploration, purpose, &c on a nearly, actually, or more than planetary scale in terms of mass, energy, population, time, &r the like. Freeman Dyson is a famous physicist who has seriously proposed the reconstruction of planets, stars, and galaxies, somewhat like the astrophysicist Fritz Zwicky, who perhaps more deserves the credit. The philosophic doctrine I expect the superintelligent machines will espouse or exemplify might better be termed "maximalism". Maximalism favors the quickest and most complete development of every ontic possibility there is in terms of efficiency, quantities and qualities of matter and energy, physical law, possible values, number or fullness of meaning, intensity of experience, simultaneous and future possibility, &c. It knows no purposive restraint. It values only what is or leads to that which is ultimate, perfect, best, ideal, certain, optimal, conscious, intelligent, animate, applied, &c.

(9) Machine will physically replace man.

With these sparse and pithy comments, I will once again abandon the unmanageable subject.

Nuclear energy will be generated in Space and transmitted to Earth in 2000. Fission, and later fusion, power plants will produce gigawatts of energy that will be converted in situ and sent to Earth's surface by masers, lasers, &r other basers, being received and converted there by gigantic stations, possibly desertic. This will be done to explore the possible advantages, especially the freedom from pollution related to surficial reactors and the universal line-of-sight transmission sans wires and repeating stations. Such orbital generation will be in exploratory competition with solar energy also sent from orbit. Both sources of energy will inevitably benefit directly other points in and beyond the Terran satellosphere by being bled in their direction by identical means. Again, whether solar or nuclear energy will emerge victorious is unpredictable at this remove owing to the complexity of relevant considerations; social, technological, and scientific.

In 2000 a 10^{0-20}-square telemineralogical map will be wrought of Pluto analogous to those made in previous years for other planetaries, such as the Moon around 1983, and completing the series of such remarkable maps for all 9 planets. Its impact will be analogous, if tempered by Pluto's extreme distance from advancing Solian Civilization; yet Pluto will prove to be the repository of peculiar and idiosyncratically precious resources that will be mined by 2020.

By 2000 a power relay station interlinking points on Earth will exist in geocentric orbit. It will do such things as relay energy from solar &r nuclear power stations purposefully located in deserts or other inhabited areas,

antiquate atmospheric, surficial, and subsurficial interterran power transmission, and link however-remote places on Earth, for example by carrying energy both to and from underdeveloped and developed countries. It will carry gigawatts. But wireless transmission will sooner or later compete, and interact unpredictably with, the transmission of power over the Earth by superconductive wires. Certain hazards may also be related to wireless transmission via Space, perhaps intolerably and insolubly.

By 2000 men resident in Space on a temporary or permanent basis will start being referred to by themselves and others as "Spacials". A certain status, and difference of values, character, and way of life, will be connoted. Out of this identification with Space will grow a different allegiance, society, philosophy, and order of things, a divorce from Terran existence. The latter will come to seem dull, obvious, sick, unchallenging, unimportant, offensive, undesirable, &r irrelevant, in contrast to Spacial affairs and even intrinsically. Terrans, on the other hand, will look at Space and Spacials with mixed and uncertain feelings of reciprocal dislike, contempt, awe, respect, incredulity, fear, suspicion, mystical adoration, affection, fraternity, paternalism, fascination, passivity, &rc. Spacial civilization itself, of course, will differentiate into planetary and extraplanetary communities. Too, countless Terrans will circulate monthly, annually, and decadally through Space as tourists and professionals, and this flux will constantly grow between 2000-2050, becoming millions turning over at periterran and extraterran loci. Many of the idly curious and temporarily employed, experiencing Space, will develop a fever for the things developing there, and remain. Those born in Space will be especially prone to stay, for physical &r psychic reasons, and think of themselves as Spacials and the Earth as alien. These events will constitute critical turning points in the future of Space.

In 2000 a Lagrangian colony will exist at the terrilunar L-5 &r L-4. At that point it will support 50 men on a semipermanent basis. At two points 60^{o} ahead of and 60^{o} behind the Moon in its orbit about the Earth dynamical stability exists with respect to the gravitational fields of these two bodies. These two Lagrangian points, L-4 and L-5, invite colonization by man, as has been proposed by Gerard K. O'Neill. O'Neill visualizes them as populable by millions of men, as sites for large-scale industries, and as way stations for other points in the Solar System. He specifically visualizes their emergence between 1982 and 2020. It is not inconceivable that considerable matter exists already at these loci, as one astronomic observation has suggested by seeming to detect "dust". This pair of points also exists for the Sun-Earth system, the Sun-Jupiter system (the Trojan Planets), and so forth. O'Neill optimistically populates his Terrilunar L-5 with 10^{4} men in 1989, 10^{5} in 1994, and 10^{6} in 2000 (biennial doubling time, say). Such quick development is feasible but, per my calendar, improbable. The activities in such terrilunar Lagrangian colonies will be analogous to those in the concurrent Geosatellosphere: manufacture, power generation, servicing Space, scientific research, industrial research, chemical engineering, agriculture, the undertaking of the exploration and development of Space generally, touristry, and simple human existence with all concomitants. The rate of growth of the terrilunar and other Lagrangian points is unpredictable at this point and may be dependent upon future impressions as to their essentiality, feasibility, or value. They might eventually grow in line with the size and rate envisaged by O'Neill, or they might stagnate or remain diminutive, or they might vanish or never come about, for intrinsic or extrinsic reasons. O'Neill's case for them so far does not seem entirely persuasive.

By 2000 a payload will be deliverable into geocentric orbit at $50(1975) a pound. A cargo will be taken from Earth's surface to the surface of the Moon for $50-$100 a pound. It will complete a round trip for perhaps $70 a

pound. This is an order of magnitude decrease from current costs. Maxwell W. Hunter II has argued persuasively that pound costs could be reduced in 1968 by 2-3 orders of magnitude for geocentric, terrilunar, and interplanetary missions alike via auxiliary disposable drop tanks, an orbital fuel storage facility, chemical propulsion, extreme duty shuttling, modern electronics, and efficient launch techniques. He has also suggested a trick whereby the fuel cost of shipping a cargo from the Moon to the Earth might be reduced to $0.15 a pound. Spacial activities to date have been unusually inflated and burdened with extrinsic research, development, and operational costs, stripped of which in the future, drastic deflation might occur a la Hunter. Any such major deflation might critically stimulate the Spacial enterprise in future decades and could effect a revolution in its scale, rate, and other qualities. The profitability of Space rests directly on transportation costs. What is especially striking about Hunter's contention is that it satisfies itself with chemical means of propulsion, per contra the claims of the need of nuclear propulsion for a revolution in costs and manned expeditions to other planets.

If it is true to any degree, it will have been discovered by 2000 that the Solar System is highly or conveniently fractionated mineralogically, or this will have led by 2000 to exploitative efforts. What may be discovered, more specifically, is that major or even miraculous nuclidic, chemical, mineral, energic, &r "environmental" heterogeneity, "fractionation", range, concentration, &r subtle variation occurs in one or many forms in the Solar System (for example, per planetary sizes, Solar distance, Kirkwood position of Asteroids, satellitic order, order within Saturn's many rings, intraplanetary horizon, intraplanetary "hierarchic cluster", distance from Jupiter's orbit, membership in some formational phenomenon in a planetary, &rc), and in such a way as to complement or supplement present or future industry and represent an overall economy. Such fractionation would be highly desirable for, and perhaps critical to the economics of, mining in Space. The determination one way or another might be the most important and decisive event in Space over the next 50 years and in terms of the whole Spacial enterprise over the next 125 years, until 2100. The actual facts may be disappointing or spectacular. They may be discovered soon or much later, abruptly or gradually, smoothly or stepwise, crescendo or decrescendo, ambiguously or unambiguously, deductively or systematically, with or without surprises, boldly or accidentally, perfectly or imperfectly, personally or mechanically, &c. Omitting the jovian planets and anomalous Asteroids, the extraterran planetaries aggregate a surface land area that is 11 X Earth's and 40 X the New World discovered by Christopher Columbus in 1492. This intimates the task awaiting any answering of the question as to whether the Solar System embodies great fractionated wealth. The telemineralogical mapping of the 9 planets and various other planetaries proceeding over Quarter I, discussed above, may be the critical factor in such cardinal plutography.

If it is ever to occur in any real way, then the abrogation, violation, &r evasion of the Outer Space Treaty of 1967, and sister agreements (including post-1975), might as well occur by 2000, over the next 25 years. The possibility includes the realization of Space-based war, especially nuclear, capabilities, for example by sudden deployment of prepared offenses &r defenses or weapons previously secreted in Space, perhaps even by a rationale of "preemptive preparation" in defense. The 1967 treaty is considered to be ambiguous as to whether it forbids the installation of all, and not just nuclear, weapons in Space. Critical for these possibilities might be whether, and what kind of, supervision and inspection of Spacial launchings and objects will be tolerated 5, 15, and 25 years from now, particular

developments in military science, technology, policy, and relations, and the ease with which violations could be implemented clandestinely or suddenly, as well as the ultimate value of such implementation. Heavy or increased military involvement in Space might increase, or might represent a turning point in, the whole Spacial enterprise, and regardless of whether it expressly violates certain accords.

It might as well be said that in 2000 the first mixed, large-scale, significant, irreversible, cosmoplastic (lit. world-changing), uncontrollable, cumulative, &rc pollution of or from Space will have occurred. What is uncertain is the schedule, probability, magnitude, exact and greater cause, consequences, interaction, importance, rank, complexity, preventability, rate of growth, future growth, predictability, exhaustibility, history, contemporary treatment, specificity, comprehensibility, trade-off, longevity, cumulative impact, quantity and kind of cost, parties at fault, real injuriousness, &c of the events listed below. This situation would seem to preclude prophecy. Some of the pollutive possibilities are rocket emissions catalyzing global climate changes, titanic Spacial basers or mirrors exerting ecological effects on Earth, radioisotopic clouds from fissionables mined in Space or disintegrated nuclear ships or plants poisoning the Terran atmosphere, biological or gaseous contamination of microatmospheric planetaries, pathogens returned to Earth, radioactive explosions on other planetaries, scientific or technologic alterations of Terran weather, climate, atmospheric layers, Van Allen Radiation Belts, magnetosphere, &c, comparable alterations of other planetaries, scientific or technologic alterations of the Sun, terraforming of other planetaries, saturation and disturbance of the electromagnetic spectrum affecting communications or astronomy, aftereffects of egregious wars, morphologic changes of the faces of other planetaries, creation of interplanetary or satellospheric meteoroids, alteration of the interplanetary atmosphere (that may only weigh $\sim 10^{7-9}$ tons), intensification of aurorae, disturbance of Terran atmospheric communication, celestial-mechanical or other Dysonian-scale perturbations or modifications, holocaustic particle-physical ignitions of ordinary planetary material (air, sea, &r soil), &rc. The list of pollutions merges with disruptions, catastrophes, and simple alterations. As in the above discussion of spacial disasters in 1993f, the scale, number, and range of pollutions will increase and accelerate with time, and certain particularly intolerable pollutions will become possible and require disproportionate attentions. One important fact is that in 2005 polluting processes will be shifted off the Earth, and lethal Terran wastes will be disposed of in Space (both as a matter of degree and percentage); the processes and wastes may threaten Space, and possibly the Earth during removal. Of course, as recent furores attest, it is easy to exaggerate worries and see the world blackly.

Supplementary and Summary Comments on Quarter I

Quarter I, from 1976 to 2000, will be a twilight time of awkward awakening, of ambivalence, diversity, conflict, failure, crudity, and endless circling and compromise. Imagination will continually raise its wondering head only to fall into stupor and self-denial. Yet the preceding Quarter 0, from 1951 to 1975, was a time of lightning progress and accomplishment (at least from 1957 forward), and the period between 1976 and 2000 will be filled with a swift rush of events and even more spectacular accomplishments since 25 years, especially at this moment in history, is a very long time.

In the course of the quarter material samples of 14 planetaries, including all 9 planets, will have been brought to Terran or cislunar laboratories and examined by curious human beings. In the year 2000, periterran satellites and stations will instantaneously aggregate of the order of 10^{7-9} ft^3 (volume) and perhaps 10^{4-6} ton; perhaps 1,000 men will be off the Earth. 12 nations

will have teams, per se, in Space, and representatives of 75 countries will have visited Space. No current (1975) programmatic schedules will faithfully describe the actual rhythm and branching of events, especially from 1985 forward, owing to unforeseen, unpredictable, uncontrollable, novel, interactive, environmental, technologic, scientific, financial, military, revolutionary, evolutionary, and fortuitous developments--occurring in legion and knitting together--disturbing those long-term developmental plans and ideas. The scale of Spacial development will again greatly enlarge between 1990 and 2010, and at that point it will be understood by educated humanity and statesmen that a rapid or moderate development and partial civilization of no less than the Solar System is beginning, and it will probably also be understood that a Solian Civilization is inevitable. This will be progress, indeed!

It will have been established by 1987 that a large and profitable Lunar, Asteroidal, and perhaps Martian mining industry, serving Space and Earth, could function sufficiently profitably to be viable and answer Terran needs resulting from depletion of some of [redacted] known or economical reserves.

What will be, in effect, touristry on a tiny germinal scale will occur in the late 1990s, perhaps involving a hundred men--governmental and corporate officials and scientists competing for the rare and prestigious experience via diverse pretexts. The Spacial renaissance occurring after 1994, partly as a reaction from a preceding 20 year slump, will underlie the new interest. Periterran and extraterran touristry could actually begin today and is not really held back by any technologic or economic barriers; certain thresholds will nonetheless have been crossed by the late 1990s, and fertilize touristical industry. Government &r business will support &r constitute the industry. The first touristry will inevitably trigger a wave of enthusiasm on the part of the general public to undergo the same experiences, and between 2000-2020 a massive industry will explode into being promoted by public and private entrepreneurs. The scale, rate of growth, assured growth, and profitability of the enterprise will guarantee its lavish financing, and it will be highly autocatalytic, expanding at a maximal rate at a time when populations in the developed nations will be enormously affluent, leisure[redacted], and experimental. So steep may they be, and so efficient, that it is all but impossible to predict the growth curves for industrial investment, profit, and number of passengers between 2000-2050. E.P. Wheaton and M.W.Hunter estimated in 1966 that a 2-day stay might cost only $1,000, a 2-week stay $4000, per person. A Lunar trip would obviously be a great adventure, once the Moon is suitably developed, and yet everyone in developed countries could afford it since the expense would be little greater than the stay in Earth orbit. These were estimates for what was already possible in 1966. Looking forward, 10^4 men might visit Space per annum by 2010, and 10^6 by 2030, a triennial doubling time. The interest average people would have in ascending to the top of the atmosphere and observing Spaceship Earth from a height of 10^{2-3} miles, like mounting the Empire State Building, is obvious, and probably a majority of men would want to have the experience once in their lifetime, if possible. Visiting Space will clearly become a multibillion dollar, and almost a trillion dollar, industry between 2000-2050. Many of these tourists will wish to remain in Space on a permanent or semipermanent basis. The fall in costs for stays and extraterran activities beyond the round trip into geocentric orbit will spur rapid development of extraterran cislunar and translunar touristry, for which periterran touristry will be the real threshold. The myriad economical possibilities for touristry confined to the realms of planetary surfaces will intensify their touristic development like beads on a string. The self-supporting status of Lunar, Martian, and other colonies that will be attained between 2000-2020 will greatly facilitate alien touristry. But above all, the growth, quantity, lavish expenditure, and nontouristical deeds of periterran and extraterran

cosmopolitan tourists over this epoch, Quarters II and III, will constitute one of the greatest turning points and catalysts in the future development of Space by seeding Space with primary, secondary, tertiary, and quaternary industries, by creating its plant, by populating it, by rendering it autonomous, and by initiating Spacial culture. Touristry, furthermore, will seek out and develop all loci in the Solar System, partly because of the fascination of wilderness, harshness, isolation, novelty, and remoteness.

What one sees occurring over Quarter I can be characterized:

(1) Mapping of the relief and mineralogy of all planets and many satellites and asteroids, and especially the plutography, by telehosts, automata, and men, especially via sophisticated and powerful passive and active extraplanetary telemetry.
(2) Surficial and atmospheric direct exploration of all major planetaries, and intense in situ study, by mobile telehosts, automata, and men operating out of landing craft, bases, and early colonies.
(3) Research, development, testing, and common use of a large number of possible drives, power plants, ships, buildings, communicators, computer systems, food and air producers, &c; routinization of transport, creation of large-scale and permanent energic networks, development of extremely realistic and aesthetic communicational systems, &c.
(4) The appearance of large-scale mining, manufacturing, power, communications, research, and other industries in Space.
(5) Maturation and enormous growth of periterran Earth-oriented activities.
(6) Installation of permanent bases in geocentric orbit, at Terrilunar L-5/4, on the Moon, Mars, Phobos, and possibly elsewhere.
(7) A glimmering of Spacial touristry.
(8) Comparatively elaborate scientific studies of atmospheres, surfaces, and "vacua".
(9) Proliferation of competing nations and businesses in Space.
(10) Reestablishment of favorable attitudes toward Spacial enterprise and a permanent resurgence of programs; late reglamorization of Space.
(11) Origination of self-sufficient civilization in Space.
(12) Great increase in extraterran population.
(13) 0-2 orders of magnitude deflation in the cost of various Spacial operations and commodities.
(14) Making and heavy use of pictomaps for the inner planetaries.
(15) Implementation of revolutionary defensive and offensive systems in Space, and greatly multiplied military investment in Space.
(16) Acquisition of human and transhuman intelligence by machines, and the appearance, in effect, of a mechanical "soul"; supersophisticated automata and compleat robots complementing, supplementing, replacing, and surpassing men in all Spacial activities, and exponential growth of their population in Space.
(17) Many new and radically important developments in pure science and technology, especially the general emergence of the Plenistic School of physics.
(18) Implementation of ideal Spacial systems such as linear accelerators, external or remote propulsion, baser beams, mass drivers, interplanetary orbiting, Lagrangian colonies, titanic catoptrics, graser communication, &c.
(19) Operation of many catalysts and the passing of turning points.
(20) The resurgence of nuclear power after an antecedent hiatus.
(21) Enormous growth of human wealth, power, purpose, and cooperation.
(22) Much better expert, political, and public visualization of the future of Space and of what Space means.
(23) Important evolution and revolution of extrasolar astronomy, and a nobler picture of the Universe.
(24) Increasing, if incipient, Spacial government and the lineaments of many authorities.

QUARTER II: 2001 to 2025

Appropriately enough, a proper "second earth" will exist in 2001. The term refers to an actually or facultatively self-subsistent colony branched from Earth but independent of the Terran biosphere or of Terran natural resources, industry, and population by having acquired the ability to extract all the necessities of life from intracolonial and nonterran resources so as to be independent of the physical and social fate of the parental Earth and able to perpetuate itself indefinitely, regardless of the trials and deprivations implicit in survival, so that Terran civilization will, in effect, have reproduced itself in the colony and be able to reproduce again in the future through the same hereditary agent. The integrity of Terran culture, per se, would probably be more or less perpetuated by an adequate piece of the culture as an irreducible gestalt, monad, or hologram and so--assuming an adequately thorough and representative record of the traits and treasures of Terran civilization were included in the colony by advanced technology--might be considered less important than insurance that the viability of the colony involved a probability greater than 50%, 90%, 99%, or 99.99% in the event of foreseeable Terran catastrophe or self-annihilation. But one might concern oneself further with creating such a colony as soon as possible, designing it so as to minimize disruptive effects from Earth or to maximize the rate at which the colony could recover following imaginable disruption, locating and designing it in such a way as to be proof against almost any imaginable Terran, or even any anthropogenic, catastrophe (redundant earths), &rc. Some of the reasons for creating such second or redundant earths that have been suggested include the possibility that medical or military microbial research may create a devastating pathogen able to maim or terminate civilization or the human race, that nuclear or transnuclear war will deliver the same blow, that particle-physicists will conflagrate Earth, that Terran doomsday machines may be built or used, that a military victor or political tyranny will subjugate Earth, that purely Terran civilization will decay or grow forgetful (oblivious of the challenge of Space and the virtue of adventure), that the dispersion of adversaries in Space will make them less threatening to one another, that some unknown force majeure will wrack Earth, that the Sun may instantly become a nova, that a planetoid may come from nowhere and strike the Earth, &c. More benignly, multiplying earths may enlarge and diversify culture, Spacial civilization may be inspired by its circumstances, there may be need to preserve and extend human frontiers, an escape from the familiar world may be a nice option, and the second earth may be vitally important to extraterran civilization universally. There may be need or warrant for more than two or any number of "earths". In any case, a proper second earth may arise (per the needs of an era) between 1976-2025 or by 2160, according to conceptions. A further, better, different, &r more numerous "second earth" may arise successively with passing decades, centuries, millennia, megennia, gigennia, and eternities as consciousness encompasses the Universe and time. Effectual or purposive second earths that might or will emerge include cislunar, Lunar (by 2001), rerelunar, antiterran ie at 2 AU 180° from Earth about the Sun, Martian (by 2008), Plutonian (by 2025), transplutonian, &r heterostellar (in the Alpha Centauri system by 2160) ones; each of these can be ascribed some type &r degree of superiority to its predecessors or cousins. The perfect "second earth" might be achieved by launching supreme cellular automata of infinitizing kind into the total Universe, as discussed on page . The concept of a second earth requires a certain height of intelligence, wisdom, and character that contemporary or future man may not possess, so that the second earth created may be clumsy or cheap, or never created at all. In the near term, a forlorn colony, base, or spaceship might with good fortune, genius, &r application establish a human foothold on extraterran soil if caught unguarded by sudden loss of race and maternal planet, by ingenious use of the materials at hand.

There is a minor chance it will not occur, but if it does, international teams or robots will use spaceships to systematically tour and inspect some or all satellites and stations in geocentric orbit, deep space, &r everywhere else in Space in order to ascertain their possible military nature in 2001. The inspector may consist in neutral nations, the major nations, a special international organization, &r the United Nations, possibly the latter's recently created Spacial Force. The methods and standards of inspection may or may not be adequate to subvert violations of treaties outlawing emplacement of strategic &r tactical, offensive &r defensive, nuclear &r conventional, explicit &r facultative, major &r minor, new &r old, &c weaponry--&r perceptual, command, &r control devices--in regions of Space. To some degree this development may occur far sooner, as early as 1981, or it may already have occurred in the special sense that means exist in orbit, belonging to one or both sides, for some degree, kind, and efficacy of intersatellitic inspection by external &r internal measurement &r observation. To a large extent the possibilities depend on the imaginable dangers posed by such emplacements at moments in the future. Characteristically for military possibilities, it is extremely hard to be predictive in this area. The major nations themselves, instead of or in addition to the possibilities considered above, can and presumably will have means for inspection in Space, both ground-based and Space-based. What I am specifically entertaining, however, is the regularization of a system of inspection that, being aboveboard and directed to the purpose, is definitely adequate to enforce the relevant treaties and reports to the whole world. The system may be perfectly workable, technologically; for example the radioactive emission, and its energy spectrum, of a satellite containing a nuclear bomb may betray indisguisably a violation of a treaty, the detection occurring by the tangential passage of a policing, maneuverable satellite. Some arguments have been advanced that unilateral or bilateral emplacement of various military means in Space might actually be desirable by exerting a stabilizing or protective effect, so man must not be premature in his evaluation of such options and in the measures he takes against them, or he will hurt himself.

In 2003 energy for Space (for ships, laboratories, colonies, &rc) will be basered up from planetaries such as the Earth. The generation &r acquisition of energy for Space from Space and from Earth will compete, as will alternatives for answering Terran needs, over at least a 20 year period, 2000-2020, and the resolution of these conflicts will only then be decided, being essentially unpredictable in 1975. Eventually, to be sure, energy will be transmitted over interplanetary distances, whatever static &r dynamic network will progressively develop from it. Greater energies can be sent, at least in theory, via higher frequencies, but frequencies used must be compatible with intervenient atmospheric windows and be served by energic apparatus appropriate for such frequencies at successive points in the future per the technical evolutions. The growth curve for these transmissions is difficult to foresee. But one can imagine the successive use of megawatt, gigawatt, and terrawatt beams from single basers. The energy might be redistributed in Space. The efficiency of reception and overall utilization is hard to predict, especially its eventually practical maximum. Such Earth-based beams may sooner or later be developed for the military purpose of incapacitating or destroying Spacial and atmospheric weaponry and other devices.

An event that will virtually never occur, because practical but pointless, is the mining of stratified gases, such as helium and hydrogen, in Earth's upper atmosphere. The region in question is part of the ionosphere called the "heterosphere" since in it chemical composition varies with altitude. The reason against the proposal is that the total mass of such elements in the heterosphere is too slight to compete with methods of production elsewhere. One might, however, be generous by assigning the futile nonevent to 2003. Such atmospheric extraction will occur in the case of other bodies, however, such as the Jovian Planets &r the Sun, for several constituents. The methods used in any case might be things like low satellites equipped with immense conical collectors &r using electromagnetic fields. It seems a little premature to speculate on the technology.

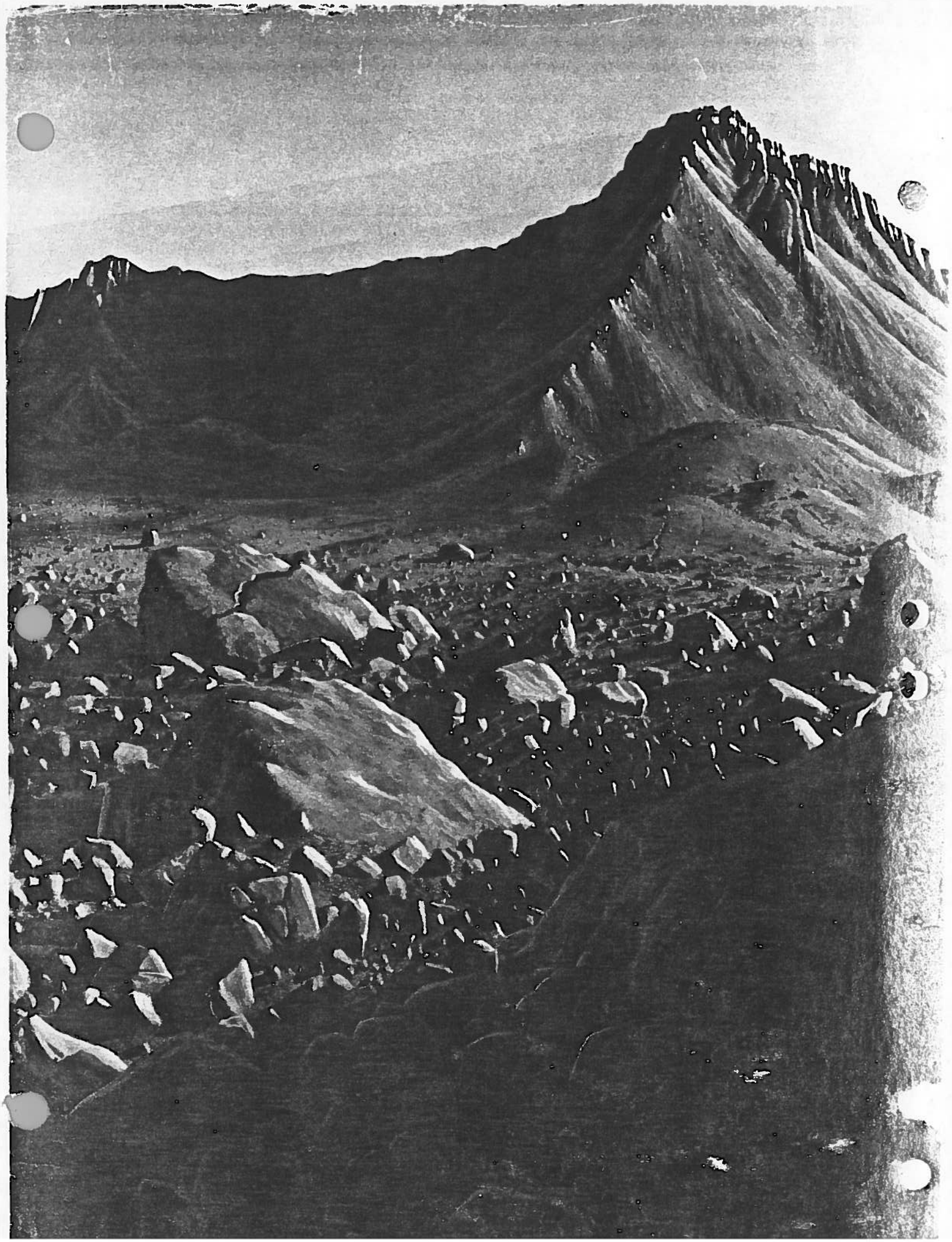
2003 can serve as the year when some kind &r degree of explanation &r prediction of longitudinal (meaning days, weeks, months, years, centuries, and more) weather and climate on the Earth in terms of Terran &r Solar ionospheric (thermospheric &r exospheric), magnetospheric, &r other phenomena --and perhaps control over the former &r even the latter--will be possible or occur. This event has been deliberately stated in ambiguous and complex terms as reflections of what is possible. Current thought is that the larger static and dynamic spheres referred to have an asymmetric or symmetric, catalytic or forceful, cumulative or instantaneous, specific or general, major or minor, cooperative or single, simple or complex, static &r dynamic, occasional or perpetual, overall or aspectual, qualitative or quantitative, &c bearing on Terran meteorologic, climatic, geologic, &r biologic processes. But it is an area of uncertainty and debate in terms of almost every possibility. Certain debates concern the degree of determinacy, predictability, and manipulability of weather and climate in time. For example it has been suggested that the theoretic limit of predictability may be a fortnight and the theoretic limit of determinacy a bimester. My own conjecture is that these are artificial limits superable by future theory and technology, and not in nature absolute. The explanation, prediction, and control of weather and climate will probably proceed hierarchically, aspectually, and stepwise with man grappling simultaneously with heterogeneous dates and ranges, and progressing in the seperate, difficult area of ideal modes and means of analysis and illustration suitable for diverse audiences and purposes. The evolution of mechanical intelligence and superintelligence will have a decisive bearing in these areas.

Controlled fusion drives for craft entering, operating within, &r leaving Space will have been developed and in service by the year 2004, 29 years from today. They probably could be, and they may be, operational as early as 1990. Fuel possibilities include deuterium, tritium, and lithium. Development and use of fusion power on Earth during the 1990s may itself have a bearing on Space. Fusion power plants will concurrently become important, even critically, in Space for Geosatellospheric, other Vacual, and surficial men and machines. So-called first, second, and third generation fusion will be developed between 1990-2040. Fusion will become ever safer, more efficient, cheaper, more competitive, more widespread, more controllable, cleaner, more versatile (eg more compact), and productive of more energy throughout the Solar System; the ultimata are difficult to predict but may be fantastic. The initiation and exploitation of fusion drives and plants will constitute a major catalyst, and a turning point, in the development, occupation, and independence of Space. Fusion drives will have a critical bearing on subsequent interplanetary, and later extrasolar, travel. The development of fusion will revolutionize nuclear attitudes and policies by further retiring the residual antagonism to nuclear energy of the previous era, which antagonism might even be triumphant prior to the appearance of fusion as a practical alternative to fission, say during the 1990s. It is not inconceivable that man will confine but perfect fusion &r fission in Space so as not to endanger or pollute the Earth, and possibly perfect systems will thereafter be used on Earth. The research and development of fusion &r fission drives &r plants might in this way become one of the major tasks of the Spacial program, say after 1985, being undertaken in a geosatellitic laboratory, terrilunar Lagrangian colony, &r on the Moon; any such exclusion from the Earth, however, would seem largely hysterical and silly, but human beings are funny beings.

By 2005 some or all of the worst &r major polluting processes and activities extant, and perhaps residual, in that year will be or have been shifted off the Earth into periterran, extraterran, &r extraplanetary Space. They might be concentrated on the Moon, judged a wasteland fit as a temporary or eternal

sink, on Asteroids similarly judged, on another planet, &r in extraplanetary colonies such as colonies at the terrilunar L-5 point arising in the early decades of the 21st century. Some candidates for such confinement or concentration as visualized include nuclear, biologic, chemical, highly thermal, highly electromagnetic, and highly (solid, liquid, &r gaseous-) waste-producing industries, assuming their momentary or perpetual insolubility and intolerability on Earth by 2005. Quantitatively or qualitatively more offensive, dangerous, &rc processes, as new quantities or qualities, may come along by &r after 2005, and possibly specifically require their confinement or concentration off Earth. Instead or also, quantities &r qualities of polluting and dangerous processes may be drastically curtailed, modified, &r otherwise mitigated before &r after 2005, and conceivably only a few quantities &r qualities may require, or be subject to, any Spacial banishment. The initial or eventual raison d'etre for putting such industries in Space might be a paradisial preservation, reversion, or transformation of the Earth by segregating, perhaps completely, nature and industry, or such industry as pollutes. Too, extrapolation of cumulative pollution and defacement from 1975 or 2005 levels or rates might point to sooner or later unacceptable or catastrophic pollution, degradation, &r alteration of part or all of the natural environment in terms of the face of the land, the air, the ocean, &r the integral biosphere, discovery or hint of which fact might prompt Terrans to have recourse to Space by removing to, or recreating, there intolerable but essential industries and processes. In all candor, the events foreseen may never occur, certainly not by 2005.

Similarly, by 2005 certain lethal Terran wastes, of the kind suggested directly above, will be disposed of in Space. The interplanetary space of the Solar System is unimaginably voluminous and empty (for example the solar wind 1 AU from the Sun has a density of 5 atoms per cubic centimeter), and a high velocity (if perhaps tenuous, ionic, and low capacity) solifugal current, so that it could absorb wastes of suitable form almost without limit. Waste consisting of denser particles would, per contra, fall into the infinite Sun if "derotated", ie stripped of heliocentric momentum, and virtually vanish from the Solar System. Extrasolar disposal of wastes, since requiring more energy than dispatch into the Sun, is presumably without warrant. The necessity or even value of either presently or later disposing of wastes in any part of Space is questionable. One reason is that biologic and chemical wastes can be effectively sterilized, incinerated, gasified, and dissociated by subjecting them to high energies on Earth such as may be the automatic product or even by-product of some or all nuclear reactors to which the wastes may be taken or on which the waste-producing industries may rely, perhaps propinquitously, as their source of energy, perhaps via direct thermal conduction in situ, a system potentially ideal for chemical or elemental recycling that would limit wastes and economize on materials production. The one residual waste, or waste amplified in this way, might be radioisotopic by-products of diverse radioactivity, lifetime, and chemistry, regardless of concentrability and mutual seperability by present or future processes. Perhaps these wastes would warrant Spacial disposal surmounting the odd and perhaps extraordinary dangers transportation across the Earth and through her atmosphere would pose, and the pollution produced by the ferrying vehicles and the industry which would support them. But Spacial disposal of radionuclides is still questionable for various reasons: Closed-cycle reactors are possible, fusion may minimize production of unwanted radioisotopes, adequate storage containers and places may be possible, and the radioisotopes &r storage bins may themselves be useful. The materials might be disposed of in deserts, Antartica, or in deepest mines or drillings (say 10 or more miles in continental or oceanic crust). The solution might be to concentrate all global radioisotopic wastes in a single storage bin of sufficient wall, area, &r capacity. Radioisotopes might be exquisitely



concentrable, exquisitely seperable as different isotopes suitable for various precise and efficient uses, or usable as sources of heat or energy. Radioisotopes or their bins might be concentrated in masses of such purity or size as to function as low or high temperature heat sources serving architectural heating &r industrial processes (eg in place of reactors), and do so safely or even ideally. These alternatives illustrate the objectionability of any future disposal of wastes in Space. The transportation into points in Space would require money, power, temperatures, and risk that could better be spent on Terran methods and loci of disposal. Therefore any disposal of Terran wastes in Space in 2005 might be experimental, dubious, &r extremely limited. Readers might turn to Garbage World, a science fiction novel by Charles Platt published in 1967, for diversion. It portrays the asteroid Kopra covered with unimaginable filth in all shapes and forms (including its own life), the collective refuse of the United Asteroid Belt Pleasure Worlds Federation.

Mars will be mined in a serious way for the first time in 2005, having been telemineralogically mapped beginning around 1987, visited by men in 1990, and equipped with a semipermanent or permanent base in 1997. The method of mining may be opencast (by pits, strips, dredging, hydraulic, pneumatic, &rc methods), underground tunneling, &r various techniques of welling. Explosive &r controlled fission &r fusion will sooner or later be tried and used to some degree. The order of mining envisaged for 2005 will be 10^{1-3} tons a year. By 2010 this will be 10^{3-5} tons a year. By 2025 this may have grown to 10^{7} tons a year. The curve thereafter is uncertain. Vast earth-moving, blasting, excavation, tunneling, construction, and materials manufacture will occur on Mars between 1997-2045. The Martian bases, borrowing from Lunar experience, will be manufacturing some air from soil around 1998 and some fuel around 2001. Much earlier use will be made of soil, rock, and landforms for shelters, artificial caves, thermal insulation, and mounds for the sake of storage and inhabitation. The first manufacture, refining, and fabrication of glass (from oxides of silicon) and iron (from oxides of iron), using plain earth materials, will occur around 2003, and on a large scale (10^{1-3} tons per annum) by 2010. The earlier mapping and expeditions will have prelocated regions and lodes of unprecious and precious minerals, and groundtruth determinations, surficial explorations with care and detail, and exploratory mining will proceed between 1997-2020. Some extraction and manufacture, as just discussed, will follow directly, and a large and diversified primary and secondary economy, including markets on Mars, will arise between 2010-2045. The entrepreneurial &r governmental bases of such initiatives and industries over that period are rather unforeseeable in 1975. The nature, degree, rate of growth, and importance of interplanetary mineralogic and manufactural competition (commercial &r otherwise)--say from 2000 to 2050--are likewise hard to prophecy. It is uncertain what mass, quantity, and percentage of Martian resources and manufactures will be diverted to extramartian buyers or users on the Terran Moon, extraplanetary colonies, &r the Earth, instead of meeting Martian needs directly. This is partly because the microgravitational and conveniently fragmentary Asteroids, despite their heliocentric distance, may be more serviceable to mining and manufacturing purposes. Questions of transportational competition may be clarified or answered by graphing orbital annuli about heliocentric orbits indicating the momental costs on a relative basis for interlocal (ie between loci) transportation; the results may be surprising. The abundance, concentration, form, accessibility, costs of extraction, costs of processing, and costs of shipping certain Martian elements, chemicals, &r minerals to Earth may be sufficiently advantageous to substitute for, or supplement, relevant Terran mining, and to support a certain scale and rate of growth of interplanetary industry, perhaps a $\$10^{7-10}$ (1975) Terran market between 2010-2045. 10^{3-7} tons of raw, processed, or manufactured materials will flow to Earth from Mars in 2045; Martian importation from the rest of the Solar System will gross in that year 10^{5-7} tons.

The first "serious" use of Space for medical purposes will occur in 2003. The incipient Geosatellosphere foreseen by 2000--in that year aggregating 10^{7-9} cubic feet volume, 10^{4-6} ton weight, and 10^{3} men population--and awaiting an influx of tourists increasing from 10^{2} unavowed tourists in 1995 to 10^{4} tourists in 2010 and 10^{6} in 2030, will inevitably support large-scale medical research on the effects and values of Space for man and other organisms, and just as inevitably support experimental and increasingly serious and large medical treatment based on the foreseeable and unforeseeable advantages of the Spacial milieu deriving from its special insolation, nongravity, and spectacular psychic stimulation. The incident tourists will in many cases, coincidentally or as the explanation of their travel into Space, stand to benefit from these medical effects. The value of low or zero gravity in the treatment of many diseases and conditions, causes and effects, is already obvious, if the essentiality, economic justification, degree of benefit, length of treatment, number of patients as a percentage of Terran population, cost of treatment, &c are not presently obvious. Thousands of men in Space for nonmedical reasons will clearly require substantial medical facilities and the presence of a permanent hospital with a professional staff, equipment, and pharmacy. It is plain that an outgrowth of this overall situation will be Earth-Geosatellosphere traffic involving persons seeking relief from macrogravitational Earth or a milieu in which they can experience some relative comfort of a temporary or more permanent nature. Hospitals, clinics, sanatoria, health resorts, and salutary vacations can therefore be predicted to arise between 2003-2025, whatever the privilege or universality of their clientele in an age of rapidly increasing affluence and equality of opportunity. Beyond the Geosatellosphere and Terrilunar Lagrangian colonies, Terrans wishing to benefit from Space or to retire or live there, all for medical reasons, can be imagined willing to travel to a microgravitational and perhaps ever more civilized and populous Moon, whose low but substantial gravity might well be ideal for the afflicted and normal alike. Theoretically the entire population of Earth, especially as economic progress enables it to do so both barely and frugally, might prefer Spacial retirement in old age as a protection, help, and comfort. An interesting possibility is that Spacial milieux might be found basically or interpretably superior to Terran existence, and to such a degree, or in such an obvious way, that tourists would stay or emigrants set forth with utopian visions; the superiority might be physiologic &r nonphysiologic. For example, the ease and felicity of Lunar movement, and the nervous levity, might confer a superhuman aspect on human Lunar life sufficient to act as a magnet on Earth, much as Californian sunshine has concentrated the United States, especially certain people; similar attraction and retentivity might result from, and supply parallels to California in terms of, the superabundant sunshine, absence of cloud and weather, and inhabitable desert (remembering California) characterizing the Moon; and naturally California was populated by idealists, often deluded. If the cost of a round trip to the Moon were $10,000(1975), and it might become less, this cost could easily be justified as a medical expense, given rates of specific treatment on Earth. On the other hand, it may be understood in advance, or discovered by trial over 1-2 decades, that Spacial milieux in no sense afford any special benefits or warrant the expenses involved, and Space may instead have minor medical significance in the first half of the 21st century; medicine, of course, is mainly empirical.

By around 2005 the first important disputes over territorial and other rights in Space will have occurred. It is possible that the forbidding of land and resource ownership in Space by the Outer Space Treaty of 1967 was unfortunate in that such appropriation has always been and might continue to be an incomparable spur to the exploration and development of all frontiers

by nations, businesses, and individuals for psychological and economic reasons alike, and the proscription might thus have been naive. If so, there is a chance this portion of the treaty will eventually be repealed, circumvented, or disregarded as the scale of Spacial exploration, development, occupation, and government goes up; the circumstance being either good or bad in the light of subsequent history. The consequential staking of claims and impropriation of whole regions, even bodies, depending on its incidence and nature, would lay the basis for future disputes and itself probably give rise to judicial or nonjudicial action or censor, or some antagonistic climate. Whether some enforcement or penalization will sooner or later occur in Space or on Earth, as a result of such disputes and possible abuses, is unclear, as is also who, if any, in Space would prosecute and police the parties, sites, and matter there occasioning conflict and friction. Suppose some extraordinarily valuable but easily taken mineral lode were discovered on the Moon, Mars, or an asteroid: would the discoverer be entitled to take possession or the developer unlimited gain? Suppose a finite and unique energic resource were discovered on one of these bodies inherent in which was promise of playing a critical or even essential role in the future development of that or other planetaries: would it be moral, legal, or politically tolerable for its discoverer to bar others from it or exploit it as a disruptive source of exorbitant gain? What absolute or justifiable right would authorities on Earth or constituted in Space have to impose jurisdiction upon others operating in all or parts of Space, and to variously penalize considered offenses? Suppose geosatellitic facilities were established of obviously transcendent value, and perhaps value without overriding cost to the owner, to other countries, especially those of the Third World: what moral or **legal** rights or arguments would owner and user have, and what customs and related institutional arrangements might develop over time? Would gigawatt and terrawatt energic transmitters and relays be tolerated in geocentric loci if they posed a threat, or suggested a weapon, to geosynchronous or passing Terrans, particularly under various circumstances? Will means to influence Terran weather or climate, either locally or globally, be tolerated or peacefully accepted by people domestically and internationally, especially since Terran nations and men are so numerous, irrational, and suspicious? What means would be necessary to guard against abuse and appease claimants? Once fission and fusion drives and plants appear in and saturate Spacial milieux, what claims, threats, abuses, potentials, and other issues --along with practical authorities--will they give rise to initially and perpetually, and what compromises will they force? Will a positive law arise in the future by which authorities, firms, and individuals will acquire obligations of a transcendent kind to anticipate, create, develop, perfect, provide, cooperate, share, divulge, &rc, enforceable and sanctionable obligations to do such things as provide for the common welfare by researching and developing energic and mineral resources in an optimal way, say by installing multigigawatt power stations in geocentric orbit to answer a nation's or the world's needs, the authorities, firms, and individuals being subject to subjunctive challenge by other authorities, firms, and individuals (or hypothetical interests). Since the Outer Space Treaty of 1967 requires others able to do so to come to the aid of another party in Space in distress, the question of legal and moral boundaries, and sanctions, arises, and remains unanswered. The possibility of open or covert warfare, or other belligerence, between Terrans or Spacials in Space becomes significant over the long run, and is fraught with legal implications and problems. Many possibilities for serious pollution of or from Space protrude before the imaginative eye as delicate, difficult, potentially catastrophic, inevitable, and political legal and quasi legal issues before and after 2005. For example, radical alteration of the global Lunar environment for, or as a by-product, of various purposes would seem an easy thing to do or even inevitable, and would have various side effects. More familiar legal issues, and complementary institutional arrangements, will clearly also arise in Spac

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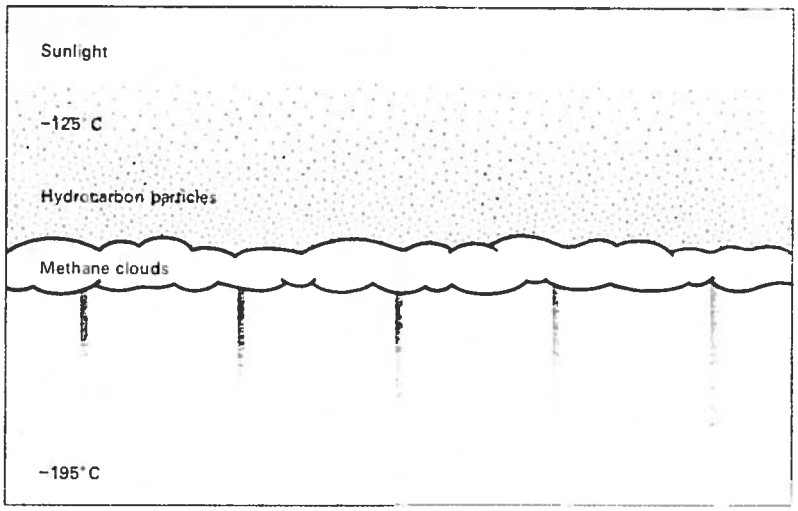
In 2005 all, most, or parts of the Earth will be under more or less continuous nonmilitary and military reconnaissance and surveillance as a face of 10^{13} (square decameters) to 10^{21} (square millimeters) cells-of-resolution via observatory geosatellites at various radii for real-time, partial, from-memory, or progressive study (notice the virtual infinity of cross-correlations or analyticosynthetic combinations), affording, in effect, a semidivine "Earth consciousness". A certain amount of information, or number of bits, will be common to, or unequally distributed amongst, the individuals cells, whatever their number and evaluated diachrony (in bits &r frames per second). Assuming, as a discussional minimum, each cell normally yields 1 bit per second. Then, if simultaneously active, 10^{13} bits per second would configure and change a complete 10^{13}-cell global mosaic, and likewise 10^{21} bits a 10^{21}-cell mosaic or "eye". For comparison, the human retina may be calculated to transmit of the order of 10^{8} pulses per second, and the optic nerve just 10^{7}, although these comparisons are after all largely meaningless because of a division relating to redundancy and a multiplication relating to analogue transmission so that the digital information sent to the brain could be orders of magnitude higher than suggested by setting the ratio of bits to pulses at unity. Whatever the case, $10^{13\text{-}21}$ bits per second, or more as the number of bits per cell per second is enlarged, constitutes a flux of astronomic proportions unmanageable by telecommunicational and computational technology and creations existing in 1975; even by 2005, acquisition and transmission approaching and surpassing 10^{21} bits per second will presume unprecedented evolution of technology and facilities, and equally marvelous computational facilities. The intelligent and superintelligent computers existing, and continuously and perhaps explosively evolving, by 2005 will be the ideal and solutional complement to the fund and fountain of infinitely various data issuing from the panoptic, and perhaps almost superscientific, geosatellites; they may even be essential to either the trivial or profound analysis, evaluation, recordation, or use of the stupendous geosatellitic voice or chorus. Disregarding any multiplicity of bits describing ranges within each cell, the activity frequency per cell might normally be anywhere over the range 10^{-6}-10^{9} cycles per second (50 octaves) corresponding to a month through a nanosecond, say depending on the needs per spatial &r spectral resolution. Any or all of the usable electromagnetic, gravitational, magnetic, radioactive, and other-particulate spectra could be sampled, suitably combined, or comprehended by passive &r active Spacial sensors on some progressive basis and in obedience to a myriad purposes. Parallactic (eg more than binocular stereoscopy), holographic, edar (broad beam, Electromagnetic Detection and Ranging), baser (narrow beam), &r many other methods may be employed in the production of the real-time, gradual, &r mnestic Terran "chronocosmorama". By 2005 the science and art alike of analyzing, illustrating, and "rotating" (myrioramically) information will have undergone fantastic revolutionary and evolutionary progress so as to complement, and greatly multiply the value of, the mountainous and otherworldly chronocosmoramic data so that a human user will find the productions of enormous aesthetic and intellectual excitement, as interesting, or more interesting, than his ordinary sensorimotor experience in the absence of such detailous, enlightening, transfiguring, and completely challenging aids as involved in the chronocosmoramic presentations. In any case, used by men and supercomputers, the evolving superconscious chronocosmorama will suddenly give us an infinitely improved appreciation of the rheology and morphology, and the transcendent equilibria, of the face of our wholly miraculous planet. The result will be awe, and the encouragement of a new style of thought within proletariat and intelligentsia. The Earth will appear as if in the palm of the hand, a machine at once tiny and fragile like a child, and cataractally immense like the oldest man in the world. Chronocosmoramas will subsequently be made for the physiography of other planetaries.

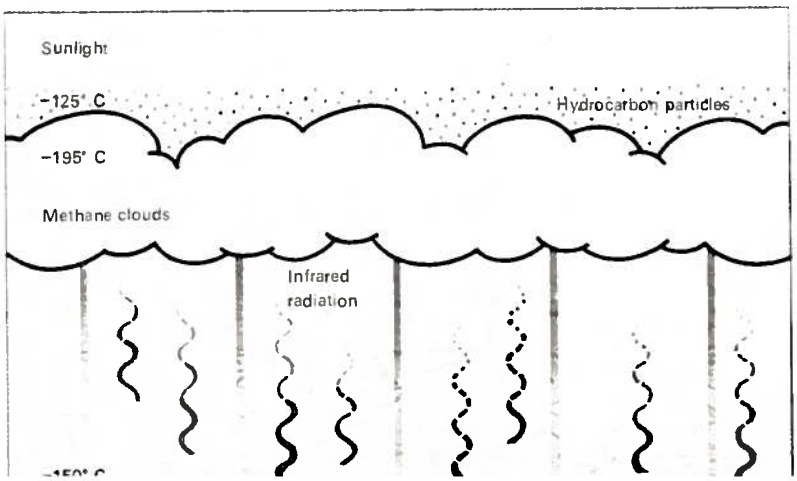
In 2005 the first peaceful nuclear explosion will occur on the Moon. It may be, or be followed in time by, any one of many types of fission or fusion bomb. It may be anything from a microbomb (say equal to 10 tons of TNT) to a superbomb (say 1 gigaton). Possible purposes of the first &r later bombs include surficial excavation for geologic &r mineralogic exploration &r mining, cavitation in the Moon creating a potential storage tank, warehouse, factory space, inhabitable but protective environment, &rc, excavation on the Moon for similar purposes, shaped telescopic crater or a concave reflector for solar energy purposes, seismologic experimentation, instantaneous manufacture of large amounts of materials such as gases, air, and glass, production of heat or other controllable energy, nonseismologic and possibly nonselenologic scientific experimentation, testing &r development of nuclear explosives or nuclear engineering (possibly instead of on Earth), lunifugal propulsion of materials or craft, search for or recovery of water, multiplication of usable radioisotopes &r radioactivity, penetration or detonation of mysterious selenomorphologic features such as mountains or crater walls, marginal planeturgy, research and development of Orion drives, an attempt to trigger a sufficient moonquake, &rc. A great many of these purposes or opportunities might be achieved simultaneously. The nuclear explosion might be more or less unique in the future history of the Moon or it might be the start of a series of 10, 100, 1000, or 1,000,000 explosions (possibly underground) over the next 10-100 years. Eventually bombs equivalent to 10^{9-15} tons of TNT, or 10^{25-31} erg, may be detonated on the Moon, as well as elsewhere in the Solar System, for example in extraplanetary Space, in or on Asteroids, in Jupiter's atmosphere, in Mercury, on Pluto, &rc. The Lunar event will lead within 5 years, by 2010, to a nuclear explosion on one of these other planetaries, more or less assuming the Lunar event occurs. The initial explosions on the Moon might either vindicate or obviate future uses in Space, other than for Orion-type propulsion. The first explosion on the Moon, or later explosions, might pollute, disturb, or destroy the local or global Lunar atmosphere (whose total amount is so slight it could be held by a hand) &r surface. For example, one scientific consequence might be some denaturalization of strain relationships and seismicity within the Moon over the following year interfering with delicate selenologic determinations. One economic consequence might be that the nuclear explosion would scatter noisy and unnatural radionuclidic dust around the Moon that would successfully disrupt orbital mapping of the Moon using its surficial radioactivity. Even slight reduction of the Lunar vacuum might limit future industrial uses of that vacuum. Successful explosive nuclear engineering on the Moon might encourage and greatly speed any future mining and recovery of fissionables <u>in situ</u>, fissionables whose Lunar use for Lunar purposes might eventually play a significant role in the energy economy of Lunar industry and civilization. It is uncertain how quickly, and with what base, such mining, seperation, and exploitation of fissionables could develop on the Moon. Krafft A. Ehricke has also indicated the value of underground detonation of nuclear bombs for the extraction of elements, generation of various compounds, crushing of large quantities of Lunar rocks for processing, tunneling, creation of metal ore deposits in little differentiated primordial material, &c. Confinement of the explosions underground would protect the Lunar environment. Ehricke sees such explosions as sources of carbonaceous and nitrogenous chemicals. He says that a 1 kiloton charge, weighing a few 100 pounds as a whole, would fracture 80,000 m^3--330,000 tn--of Lunar rock, evaporate 33,000 tn of rock, and liberate 6,000-10,000 tn of <u>recoverable</u> oxygen. In defense of a Lunar Plowshare Program, he specifically mentions that nuclear explosives provide the highest presently available concentration of energy per unit mass, as the preceding figures manifest.

Titan→



Heating the Particles
The unexpectedly high temperature observed for Titan may be caused as sunlight heats up hydrocarbon particles high in the atmosphere. Temperatures could be much lower on the surface. Atmospheric pressure might be only 2 per cent of Earth's.





Stoking the Atmosphere
An alternative theory of Titan's high temperature is that the atmosphere allows sunlight through, but traps the infrared radiation from the surface. This requires substantial atmospheric pressure and could produce relatively high surface temperatures.

By 2005 the surface of a satellite of a jovian planet will have been landed on and carefully explored by a manned or automated-but-supersophisticated laboratory, a more primitive probe having soft landed one such moon by 1993. More primitive probes will also have landed at least 5 such satellites by 2005, possibly by hopping. Such microsalient probes may in fact have explored virtually all the satellites of one-to-all-four of the jovian planets by 2005. Candidate satellites for the initial events include the major moons: 5100 km d Ganymede of Jupiter, 4800 km d Titan of Saturn, 1000 km d Titania of Uranus, and 4000 km d Triton of Neptune. These large moons may actually have atmospheres, seasons, and even life. They may reflect directly or indirectly upon the composition, nature, and history of their planets. They may have considerable interest for mining. They may shortly give birth to semipermanent and permanent scientific and developmental bases and colonies, and facilitate various planetary operations, as well as operations relating to their fraternal satellites. Some mining for export will have started by 2010. If it is an unmanned automaton which lands in 2005, it will of course be at least as intelligent as a man. The initial expeditions will accomplish all those things achieved by the 1993 Lunar base described above, including a comprehensive survey of surficial morphography, mineralogy, and dynamics, subsurficial and seismological exploration, establishment of 10^{1-3} stationary &r mobile autonomous and heteronomous microlaboratories over the surface (the combined area of which equals all land on Earth), &c, but, on the basis of rapid scientific and technical progress and past experience, they will do so much more quickly, cheaply, elegantly, comprehensively, selectively, and effectively. The population of the major and minor moons of jovian planets occurring initially between 2005-2040, will be spurred on for aesthetic reasons since the ever-changing and immense panoramic faces of the planets which the satellites and their occupants circumnavigate will be continual sources of fascination, admiration, and wonder, noble and poetic in their daily orbit, a charmed background to the satelllans' lives. Large though these planetary faces will be in the skies of their natural satellites, they will be larger still in the skies of artificial satellites sailing the fringes of the planets' atmospheres, in some cases filling for a moment each day the entire sky. The inspiration to human existence derived from such conceptual spectacle cannot be exaggerated. It perfectly exemplifies the motivation for colonizing Space, which is inspirational. Monkeys might not appreciate the motive, but men will.

The or some theoretically ultimate chemical propellant or propellant mix --for example the theoretical minimization of the chemical/nuclear, electronic/nuclear, &r Strong force/electromagnetism gaps--will have been achieved by around 2005. The degree of qualitative &r quantitative innovation over what is possible today is unclear, and may be major or minor. The gaps are of course enormous, and seemingly irreducible in major terms, but time will tell whether improvements by a factor of 2, 6, 10, or 10^{2-6} are feasible and practicable, say over a mixture of solid oxygen and flourine. Inter alia, what is the achievable compressibility and containability of matter apart from any chemistry? The criteria of ultimacy might be volume, density, regulability, reaction efficiency, safety, cost, &rc. The question of what is attainable by various dates must be asked in superscientific terms (that is, in terms of any intrinsic limits of any science and technology existing in nature). Minor and major improvement in nuclear efficiency is itself possible and likely, and a consideration. There are many characteristics of the milieu of chemical reactions, radical variation over which in the future might "catalyze" extraordinarily efficient propulsive processes; probably few of these characteristics are known, much less understood, at present.

If such a thing is possible or meaningful, a magnetomotive-magnetospheric Spacial vehicle, or at least auxiliary drive, will operate in Space by 2005.

Being visualized is a vehicle that would leave and pursue the magnetic poles --or pilot magnetospheric flux lines, isomagnetics, and radii--of the Earth, Jupiter, Sun, Milky Way, &rc by means of Atlantean on-board permanent magnets or electromagnets. For example, a set of such magnets could be arranged in reversible radial symmetry, &r in connexion with redistributable insulation, so as to create in effect an artificial magnetic monopole of macroscopic dimension whose reversible polarity would propel the craft as already described, possibly almost isentropically. The critical acceleration possible in this way would have to be calculated. The notion of a spaceship operating by magnetic levitation intraspacially &r subspacially is common in science fiction but otherwise seems hard to realize. Levitation over the surface of a planet, by magnetic or other analogous means, is actually plausible if fantastic kinetic &r potential energy could be realized, contained, and controlled aboard some superscientific craft at some future date, and the idea that beings visiting Earth in flying saucers from another star would possess means seeming to defy gravitation and momentum (by exhibiting seemingly infinite acceleration, orthogonal turns, isentropic levitation, and infinite power) is probably correct, and will probably hold when our civilization lands intelligent life on another star in the 22nd century. Magnetic fields and currents may have an important role in the structure, dynamics, and energic densities of the Universe, in which case they may have a similar importance in the future navigation of the Universe; but all this is rank surmise. Geomagnetism has been used for attitudinal control in satellites. Much greater magnetism surrounds Jupiter and certain stars. Some planetaries possess much less magnetism than Earth. Certain radical scientific and technologic developments in magnetism may well eventuate in 25-100 years and transvalue it.

By 2005 there will be used as sources of energy such things as volcanoes, geothermal gradients, petrochemicals (presumably inorganically produced), other combustibles, &r other endergonic reactants on &r in the Moon &r other planetary bodies. Flashes have occasionally been seen on the Moon that have been interpreted as vulcanic eruptions. Active volcanoes usable for the generation of much power may well obtain throughout the Solar System, and even on many larger satellites. These may play an important or critical role in the initial &r later exploration &r development of Solar planetaries. On at least one of them vulcanism may even be more active than on Earth, for example it is conceivable that Jupiter's Great Red Spot overlies and discloses some extraordinary, however unorthodox, volcano. Terran lithospheric "plumes", such as are conjectured to exist, may amount to immense volcanoes, as may as well Earth's orogenic and midoceanic ridges, in which case analogous thermal sources may exist and be exploitable on other planetaries as technology advances and the need arises. The steepness of crustal thermal gradients on other planetaries is unknown, but it is noteworthy that the integrated heat flux of the Earth's surface equals all the energy from fuels man uses today, and that the flux is so heterogeneously distributed over the surface. It has long been surmised that Venus may have a "hydrology"--an ocean or lakes--based on a chemical other than water; there is a chance this could have some energic significance on or off Venus. Liquid fuel chemicals might obtain as ultradeep oceans on the Jovian planets. The importance of living organisms, geophysics, and conditions analogous to those on Earth, in terms of the past or present establishment of sources of energy usable by man, are all largely unknown. The point is that we really don't know what energies exist elsewhere in the Solar System as resources exploitable by man sooner or later in the development of our system. In China, on the Amur River below Yermakavo, lie the Burning Mountains, which are rocky precipices made up of complex layers of spontaneously igniting carbonaceous, clayey shales that are continually steaming and sometimes give off flames! Who knows how complex and varied the Solar System may be.

Again, if such a thing is possible or meaningful, 2005 might serve as the year by which a maximal electrostatic charge vehicle, &r general battery, may exist for Space. What is intended is, for example, something that might use a concentrated pressural sea of like, and thus mutually repellent, charges: $e^{\pm}$, $p^{\pm}$, &rc. A relevant question is to what fermionic density can such positive potential energies be simply, subtly, or regulably compressed? What is the maximal containability, concentrability, &r density theoretically or practically obtainable for such charges? What is the role of the matrix? What is possible both with and without the matrix? What are the possibilities for both mono-charge and bi-charge systems? What would be the attractive &r repulsive force &r velocity of various or all charge types? What gap should be said to exist between these potentialities and present batteries and fuels? What diseconomies and economies of scale should be imagined to apply to these novel systems? Major or minor ones? Would these hypothetical systems be able to compete with modern or future batteries, fuels, engines, &c? What advantages and disadvantages might characterize the maximal charge systems? How close to hand is the technology? Are such possibilities explored or unexplored? What argues that they are possible, impossible, &r probable? Where, by what, how, and how often would the charging occur? What would be the current vs. voltage vs. total charge (the power vs. duration)? Would such systems operate on &r off planets? Such powerful and revolutionary systems could conceivably play an important role in the future of intrasolian &r extrasolian transportation. Again, modern scientists may be in no position to affirm or deny such future or ultimate scientific and technical possibilities for want of basic data and theory.

The installation of prosolunar &r rerelunar astronomic observatories &r gigantic &r planetary telescopes will occur for the first time in a major way by 2005. Teams of astronomers will be located on the Moon to assist in the construction of, and to use, the buildings and instruments dedicated to the description and understanding of both the Solar System and the greater Universe beyond. The astronomic facilities will employ 100 men by 2010, at which time the customary stay will be 12 months. Work will be performed, and facilities will be created, at the extreme prosolunar, rerelunar, limb, and polar loci, advantageous as they are for particular astronomic purposes. All sorts of fixed and variable design and size of aperture photonic, magnetonic, electronic, gravitonic, baryonic, neutrino, and, by then or eventually, other corpuscular types of telescopes--potentially covering astronomical spectra of as much as, or more than, 83 octaves of voltage, and a similar range of current--will be built on the Moon, and sooner or later in interplanetary space and on other planetaries, to the degree warranted. In fact, in the course of the 21st century the Moon will become the center of Solian astronomic activity, perhaps as early as 2025. The advantages are known to be many and include the favorability of the sixth of a g gravity and extreme vacuum for the construction of fantastically large, stable, and precise telescopes, the low natural and artificial microseismicity and noise, the absence of electromagnetic and other corpuscular interference, the extraordinary absence of an interferential atmosphere (both statically and dynamically), the extreme isolation from the Earth of an observatory or instrument on the Lunar backside, the superabundant cryogenic conditions (eg electronically), &rc. The many observatories and the developing industry will have to be so distributed as to minimize such interference as would impair the multifold astronomy using the Moon during the first half of the 21st century. Eventually such growth will encourage astronomy elsewhere in or outside the Solar System, insofar as it is incompatible with the particular purposes being pursued and the ever-increasing sensitivities required for longterm investigations, discovering and characterizing new objects, and covering ever fainter and more diaphanous objects, features, and aspects. In particular, the maximal, gamma, x-ray, ultraviolet, visible, infrared,

microwave, radio, and minimal bands of the electromagnetic spectrum will be carefully researched by infinitely more powerful, sensitive, sophisticated, and discriminating instruments than were possible, or at least existed previously, in artificial-satellitic observatories orbiting the Earth and Moon. Human knowledge about the structure, dynamics, composition, and history of systems at all levels within the Universe will be enormously broadened, deepened, thickened, and strengthened in both empirical and theoretical terms. Not only passive but active astronomy will be done from the Lunar globe using fantastically powerful, modulable, and precise basers and edars reflected off objects of any size, density, state of matter, and texture in the Solar System and, in terms of an acceptable number of light-years and degree of imagability, beyond, exploring in this way density, composition, structure, and dynamics of the accessible atmospheres, planets, planetesimals, Sun, tenuous zones of the Solar System, dust clouds, molecular clouds, and plasmas.

Perhaps beginning around 2005, mining of planetaries using controlled fission &r fusion directly will occur. The use of nuclear explosives, and the indirect use of controlled nuclear energy, will be occurring simultaneously, also on an experimental, and later on a persistent, basis. It is difficult to foresee in 1975 the general and specific techniques that will be developed, tried, rejected, and perfected around 2005, but the following remarks are possible. There is the opportunity to bridge or reduce the quantitative &r qualitative gap which exists between controlled fission and fusion and explosive fission and fusion, in terms of various applications, such as mining, planeturgic purposes, and the set of things discussed above in connexion with a peaceful nuclear explosion on the Moon in 2005. A reactor--of whatever kind, design, or size--can be so moderated as to produce faster, hotter, and denser reaction, different particles and plasmas, and directed jets of varied and variable voltage, current, and focus; or at least this will be possible to a superlative degree in the future, say by 2005. It may be possible to create unusually safe beams of energy &r matter, even for beams of incredible magnitude. It may become possible to manipulate reactions and energies, both in and outside any reactor, in such a way as to reduce their ordinary destructiveness to the means used to generate, contain, and control them. It may develop that there are methods for creating, using, and controlling fission, and even fusion, reactions without what would usually be considered a reactor, say by percolating or inserting nuclear reactants into porous, fractured, pulverized, singly drilled, multiply drilled, or excavated rock or soil, or by adding such reactants to germinal liquefied pools of such planetary crust and letting such pools propagate with certain patterns. Direct and indirect use of nuclear energy actually form a continuum, and various mediators may be entertained for controlled nuclear energy used in mining, provided the linkage is close. Various states of matter serving to transfer &r focus heat &r momentum externally or internally from the reactor or reaction to the obliterable, penetrable, fusible, vaporable, dissociable, catalyzable, weakenable, refinable, plasticizable, or otherwise workable target--whether wall or removal--are imaginable. Such work might be prosecuted by laborers or--for reasons of discomfort, danger, deleterious instantaneous or persistent radiation, difficulty, opportunity, &rc--by telehosts &r automata. Such mining using controlled nuclear energy more or less directly might be necessary in extraterran milieux owing to the economical impossibility or inconvenience of transporting chemical energy over interplanetary distances, at least at some stage in the future. Its extraordinary power and cheapness per unit of energy might be necessary as a sort of extravagance to lubricate mining other planetaries, particularly in such outlandish situations as several miles beneath the planetary surface. Such nuclear technology will serve other purposes as well such as excavatory construction of industrial and living spaces underground and on the surface, and various industrial processes directly. The development of transnuclear energies, beginning in 2000, will obviously have an important bearing on such modes of mining.

Probably if ever, in 2005 soft or stiff "balloons" of titanic or astronomic size (say 1-100 miles in diameter or 10^{1-5} square miles in surficial area) will be used to mine, refine, energize, atmospherize, &r propel asteroids, the Moon, other planets, and (including meteorological engineering) the Earth. Loci, scale, multiplicity of uses, &c--assuming the value is manifest and the idea takes--will all balloon between 2005-2025. The hypertrophied balloons will be silvered on a back so as to function as concave reflectors. Although they may in limited cases operate spherically, funicular devices or manufacturally shaped balloons will prevail to project the focus onto external targets. The advantages of such catoptrical balloons include maximal economies of materials, design, operation, maintenance, and theory in terms of cost and the energy produced; such economies are ideal and almost necessary for Spacial milieux. They are far more economical than hard mirrors proposed for the exploitation of solar energy. They may be important catalysts in the concurrent development of the Solar System. But they pose many engineering problems, among others leakage, effectuation and maintenance of shape, stiffness, and smoothness, predesign and operational precision of focus, operational transformability, mode of inflation, post-inflational treatment, pressural tension, materials research and development, initial and subsequent positioning and orientation in Space, tidal problems near certain planetaries, susceptibility to corpuscular and micrometeoric damage, uncertainties as to lifetime and repairability, questions as to maximal size, effects of pressure exerted by the solar wind and sunlight, and--after all--questions as to eventual material cost. I very crudely estimate, however, that the material cost of a 100 mile diameter silvered-hemisphere balloon would be $\$10^{9-10}$(1975); since 140 terrawatt of sunlight would be intercepted, at 1 AU from the Sun, the cost of material would be under 1¢-10¢ per kilowatt of capacity, which is spectacular. A soft mirror could not be perfectly two-dimensional or a monatomic plane, however, but perhaps at least 10^{5}Å thick in order to reflect most of the sunlight, so perhaps it would use only 10^{-3} as much material as a hard mirror, the savings figured accordingly. A soft or hard hemisphere of proper composition and lamination could englobe a planetesimal and receive an atmosphere; the latter being given proper density and composition, as well, the whole could achieve room temperature on the planetesimal surface merely via a greenhouse effect, along with a breathable atmosphere suitable for human habitation. The same thing could be achieved in one of Gerald K. O'Neill's cylindrical colonies sans a planetesimal nucleus. The feasibility of airships on Earth ½ mile in length and 10^{8} ft^3 in volume has recently been discussed so that the stupendous balloons visualized here must not be dismissed outright as impractical. Balloons may eventually be built 10^{2-8} miles in diameter with industrial crucibles at purely internal foci, the volume tolerating the pressures generated; these will be marvelously simple and beautiful examples of celestial photonics. Indeed, the most economical way to capture and focus the total radiation of a galaxy such as the Milky Way would be to completely surround it with a concentric catoptrical film, providing of the order of 10^{44} ergs/sec for semidivine purposes; curious astronomers might search the universe for signs of just such objects. Synchronous geocentric, lunicentric, areocentric, mercurocentric, &c catoptrical satellites may well arise in legion and dot the planetary skies over the first half of the 21st century. For example, geocentric satellites reflecting and converging sunlight could denubilate areas on the Earth by heating, raising, precipitating, causing absorption, &r causing stratospheric dispersion; serve nocturnal or diurnal snow removal; hyperfocally defog airports; burn off thunderstorms and hurricanes (or steer the latter about); evaporate water from seas and great lakes to contribute to land precipitation (especially over the Afroasian desert and other coastal deserts); redirect oceanic currents; increase vertical turnover of great waters; create

great "above pyre" updrafts to turn over stagnant, cold, or hot atmosphere by rejecting masses of air into higher altitudes; enable hibernal (perennial) agriculture in mid-latitudes; warm frigid mountain ranges, circumpolar regions (Canada, Greenland, the Soviet Union, &c) and small pieces of Antartica; and so on ad infinitum. Such catoptrical, or other optical, technology could likewise serve sundry spectacular industrial purposes such as astronomical distillation of seawater, great "super-energy" crucible furnaces in deserts or other wildernesses (which could gasify and dissociate water into hydrogen and oxygen, rock and soil into oxygen and other elemental or simple molecular species, mass-perform other reactions, serve ion-mediated energy conversion, &c), burning gigantic mining craters or shafts into the Earth, digging (laser fashion) canals, cooling cities by propinquant updrafts, &c. Might intense focusing of astronomically large mirrors or lenses (the latter consisting, for example, in tenuous balloon-englobed steam or Jovian hydrogen--or whatever appropriate and available) on the ocean enlarge its columnar life by creating a broad submarine photosynthetic zone--as one example of an extraordinary possibility? Such titanic optics might be used with special niceness to shape and run the Moon, free as it is of atmosphere, population, and alternative sources of energy. Propulsion is discussed below. What is the maximal temperature producible by technological architecture and a greenhouse effect (hundreds or thousands of degrees), the maximal heat, and the minimal cost and material? It is possible that greenhouse effects operating on or off planets via ingenious structures could supply industrial furnaces of most elementary design and minimal running cost. Enormously large and precise planetocentric &r heliocentric soft or hard mirrors might compete with basers in future interplanetary transportation and power transmission if divergence can be minimized.

If it is both feasible and justified--and it is unlikely to be either--the Van Allen Radiation Belts of the Earth may eventually, as has been proposed, be "swept up", ie removed, perhaps by 2005 or 2040. These belts consist of protons, electrons, deuterons, and tritons of diverse energy, and are said to have the form of a doughnut, exist around the equator, and extend for about 1.1 to 9 Terran radii. Since the proposal was made many years ago one assumes it might have reflected a naive fear that these belts would have characteristics incompatible with, or dangerous to, human beings passing through them or orbiting the Earth. It is possible that exploding nuclear bombs, inserting matter, altering the exosphere, creating titanic artificial electrical &r magnetic fields, using catalyses strategically on the basis of a great deal of knowledge, &rc might eventually enable the Belts to be temporarily, periodically, or permanently destroyed, reduced, repositioned, restructured, altered spectrally, overloaded or rarefied, reconstituted, modulated, &r the like. The cost, means, characteristics, procedure, &c are unpredictable. Important questions must be answered first such as the rate of restoration, the structure and dynamics of the Belts, the lethal fluctuations (for example during Solar storms), the value of the Belts and their states for climate and life on Earth (the function of the Belts), the irreversible consequences or side effects of tampering, the negotiability or circumnavigability of the Belts, the relocatability of future geosatellites, the insulability of satellites and ships, &c. The real justification for removing or altering the Belts may only appear as a massive, extensive, and permanent Geosatellosphere arises during the first half of the 21st century, or beyond. Yet the Geosatellosphere might be inessential, or might learn how to protect itself by creating intense local magnetic &r electrical fields by way of insulation, or by using the surface-volume law to reduce the relative cost of sufficient surficial insulation for structures of sufficient magnitude, a la Gerard O'Neill. If it is discovered that the Belts catalyze or otherwise control global climate, their intensification, reduction, or other modification might be motivated by climatic engineering needs on Earth. There may also be value in altering the Belts for purely experimental reasons, at some future time.

check all these figures!

cont. from ✕ approach.

Dome H. = 10 mile ($10^{4\frac{1}{3}}$ ft.); dome tension from cable (weight for in² cable; 10^{4} TN. for m² cable) is 10^{4} TN./mm²; total cable weight for either cable size is $10^{9\frac{2}{3}}$ TN ($\frac{1}{2}$ s-m. dome wall weight). Circumferentially the ideal

would be to have the cable arborescence [1, 2, 3 ... n] prior to the dome "walk" in this way lowers tension could be a substitute for areal tension, (by reducing the net mass of the dome structures by a factor of 1-3) by modifying the arborescent wall / cable mass ratio of 3/1.

Flaws → However, all this creates a book inconsistency since on p. 203, item #55, I have only 10^{9} TN/yr (10^{9} TN/week) being mined, while the mass of the ~2055 10^{5} ft. dome is ~10^{10} TN. (and similarly for the other dome & mining data!)! Note that the 10^{4} Ft (1 mile) dome in ~2035, need only be 2 inch thick!

In 2007 the world will spend $\$10^{11}$ (1975) annually, or 1% of the current Gross World Product ($\$1\text{-}2\cdot10^{13}$), specifically on Space. This is 20 X what the United States alone currently spends, ½% of its Gross National Product, or about 6 X as much of the GWP as the American expenditure is in 1975. Considering the likely evolution of aims by then, the Spacial renaissance anticipated to begin by 1995, and the relatively advanced state of Spacial development in 2007, the absolute and percentage amount indicated are actually rather conservative, although they do presuppose that nations will not have lost interest in Space in the interim. If world population in 2007 is 10^{10}, the world expenditure on Space will amount to but $10 per capita, 10 X what it is today. Of course by 2007 Space will have been paying for itself in every sense of the word for perhaps 17 years, since 1990, and by 2007 it will be a tremendous source of obvious direct and indirect economic, scientific, technological, industrial, and cultural benefits in purely Terran terms and an autonomous subcivilization. By 2076 Gross Solian Product will be something like $\$10^{15}$(1975), a quadrillion dollars. Of course it may be orders of magnitude higher if superintelligent machines are taken into the picture as lucrative slaves or fanatics of growth, as will probably happen. 1% of $\$10^{15}$ is $\$10^{13}$, 5000 X what the world currently spends on Space. But a figure of 1% of the GSP is nonsensical since in 2076 the majority of the human race will reside off the Earth, and represent well over 50% of the GSP; thus the money spent in connexion with Space by 2076 will approximate $\$10^{15}$(1975) or 100,000-1,000,000 X what is spent today. This gives some idea of the scale of developments that will occur during the emergence of Solian Civilization in the 21st century.

The population of the Moon will attain 1,000 by 2007. It will include skilled laborers, administrators, scientists, engineers, technicians, military people, explorers and surveyors, miscellaneous staff (doctors &c), visitors and tourists, businessmen, and a sprinkling of others. There will be 1-100 bases. There will probably be specifically scientific, Spacial operations, industrial or corporate, military, administrative, touristic, residential, &r international bases, and the traces of colonies. Vague but implicit territorial districts will have begun to overspread the Moon related to various Terran nations and other Terran and Lunar parties; it is difficult to extrapolate such a process to 2070. Lunar architecture will to some degree define its characteristics by 2007, and especially by 2040. For example, it will be decided over this period to what extent the Lunar surface vs. the Lunar underground will concentrate the future Selenian population; industry and residence might segregate on this basis. In either case, transparent domes, both miniature and gigantic, will will afford Selenians and visiting Terrans a breathtaking view of the heavens distinguished by still pinpoints far more numerous than the veiled stars seen from the surface of the Earth, set against sable, seeming immovable, and uninterrupted by day or nightglow. Combined with the stark and colorless moonscapes, the impenetrable quiet, the changelessness, the Moon's profound mystery, the ecstasy of an extraordinary rebirth and adventure, the very daring and improbability of the enterprise, and the future's capitalized promise, Selenians will evolve a noble and unique character both superficially and profoundly different than that of sedentary Terrans in their aged but ancient regime.

In 2007 giant domes will make their appearance over the Lunar landscape. They will at first be but 10-100 feet across, but larger and larger structures will be seen over the years that will be 1000, 10,000, 100,000, or more feet in diameter, and of varying curvature, design, composition, complexity, aspect, and purpose. The larger and more irregular structures will come to be known as "tents". The domes will be hard and soft, textureless and textured, spherical and polyhedral, integral and modular, thick and thin, clear and translucent and opaque, plain and decorated, frameless and framed, single- and multi-layered, conical and cuboidal, perfect and rococo, Rechabitic and flat, fenestrated and

continuous, &rc; they will be made of plastic, metal, glass, cement, &r rock. Means for sealing them in the event of rupture, puncture by micrometeoroids and macrometeoroids, and other damage will be developed. They will have to be designed in consideration of leakage, radiation from Space, heat loss from within, the tension of the Lunar vacuum, future modifiability, materials and means available, the importance of sunlight, greenhouse-effect engineering, human madness, the need to filter Spacial sunlight, surface-volume laws, architectural and technological possibilities, calculable reliability and tolerable risk, the buildings and developments they cover and protect, intended lifetime, knowledge about the Lunar environment, &rc. A few domes may simply serve as storage tanks for gases or for military secrecy. In 2007 or a few years after, domes such as those just described will be inflated &r erected on other planetaries, such as Mars, and in interplanetary Space, in which case they may be 3/4-spheres, full spheres, cylinders, toroidal, &r the like. But many factors may sorely limit the use of such macrocosmic (undivided), exposed, open, thin, aesthetic, and idealized structures in extraplanetary &r epiplanetary loci, sooner or later. A science fictional conception is an immaterial domic force field. The feasibility of such energic fields for various purposes is uncertain, especially as to date and advantage. Probably they will ultimately be possible, and they might be used by 2075-2125, perhaps almost isentropically. Their basis at that time is very obscure 100-150 years beforehand. The evidence on extraterran meteoroidal bombardment is now very good, consistent, and reassuring. The problems structures, operations, and men in most Spacial milieux will be presented with in terms of 10^{-6}-10^{6} gram meteoroids, would seem to be minor, foreseeable, and soluble ones of design, sensing, and repair, rather than major, catastrophic, and horrific ones. A 1 ton meteoroid might collide with 1 square kilometer once a gigennium, a 100 gram meteoroid once every 3 millennia. Meteoroids from 1-10 grams may be the most problematic and burdensome flux. These comments only apply, however, to enormous, very hard or tough, and inexplosive structures that can tolerate apertures of such distributions of size, number, rate, and ellipticity as are both characteristic and significant, and that are appropriately reparable. Risks, dangers, needs, and solutions will to some extent have to be based on progressive experience in Space with actual constructions, conditions, and temporal spectra. Engineering and insurance are highly empirical.

The first serious mining of Venus will occur in 2010. Massive, 10^{2-4} ton/year, mining will develop by 2025. The inhospitality of the Venusian environment will make this a very curious mining. It may be done by increasingly intelligent automata &r telehosts operated by men on Earth, in venerocentric stations, or in extraordinary shelters on the surface of Venus, just as will exploration and surveying of the planet over the previous 2 decades. As in general, computers of sufficient intelligence may exclude humans altogether from these progressive and perpetual operations. But the hostile and inhuman Venusian environment presents a challenge that man might accept for adventurous or unconscious reasons, or properly, analogous to the challenges of Jupiter, the Sun, &c. The aerial opacity, composition, temperature, violence, and pressure (with, for example, the difficulty multiplied by 3 factors: temperature X pressure X wind velocity) are superable simply by greater energy, material or building, and by suitable mechanics. A surface-volume law will economize for buildings of greatest spherical size, for example in terms of persistent energy expenditure for cooling. Underground mining might therefore be practised with minimal energy needs for atmospheric circulation in tunnels and interconnected chambers. Chrestomathic mining could occur by putting a minimal number of such superficial or subsurficial buildings centrally at the best or most precious mineral lodes of the entire planet, the mineral structure of Venus having been previously researched and mapped by futuristically precise, ingenious, panoptic, and complete methods, and assessed

plutographically. Assuming the subterranean cavities are spheroidal, their enlargement in the future would be at ever more marginal cost both because of the surface-volume law diminishing refrigerative costs and because the enlarging interior surface would enable ever more ideal selection of strike and direction of mining. The artificial caverns produced in this way could subsequently be used for Venusian industry (such as secondary economy increasing the value/weight-volume ratio of interplanetary exports) and residence, in microcosmic disregard of the foul Venusian complement. The fact that Venus is Earth's twin in size and mass tempts the planet's development. The large and active atmosphere, and the temperatures at the surface, imply that Venus may have excellent &r unusual mineralogic fractionation and interest. Surficial temperatures are hot enough that a "hydrology" based on liquid or plastic surficial &r crustal oceans, lakes, vulcanism, and even flows of elemental or combinational lead, zinc, tin, &c is imaginable, perhaps not only of great scientific interest but also valuably extractable; Terran extrapolation is apt to be both misleading and negative (as it is apt to be for the rest of the Solar System). That Venus might have aerial or surficial life is not impossible, although any life would have to be drastically unlike that on Earth. Not merely poetically, a kind of "life" obtains in the static and dynamic differentiation evolved within a planetary world, whose complexity and purpose is difficult to [recognize, describe, understand, and generalize about], as exemplified by the fact that even 20th century man has but the most cursory and unintelligent view of his own planet's [anatomy, physiology, and systematics]. Our current knowledge about Venus is so short that it is hard to imagine its pattern and what surprises it has in store for us, but one possibility is that aerial processes have latitudinally fractionated mineralogy so that equatorial evaporation and polar condensation has occurred and left valuable and massive deposits of certain chemicals at the poles. Venus may have had and maintain [larger, more active, more diverse, &r just different] "geophysics" than the Earth, and thus greater mineralogical differentiation and energically exploitable vulcanism. The extraordinary [observational, analyticosynthetic, communicational, presentational, and representational] technology (or science and art) that has been described as developing in earlier years, and radically altering the scientific and public appreciation of nature, will come into play in 2010 and be even further advanced; a world that might otherwise seem [bleak, incomprehensible, inscrutable, &r familiar] will instead seem [thrilling, awe-inspiring, beautiful, adventurous, different, beckoning, meaningful, and valuable]. The potential for such enhancement of Venusian and other extraterran environments is actually not finite but infinite, and the [art, technology, appreciation, and impact] will go on advancing with the years to 2075, 2175, and so on ad aeterno, for nature is of infinite complexity and stratification, an inexhaustible landscape, an autogenic dream. The land area of Venus is several times that of the Earth. It is essential to remember that the detail present requires hundreds of millions of man-years to be known, much less correlated and exploitationally thought through. The secret to what has been done on Earth has been time and billions of individuals; similar quantities of intelligence will be required by Venus and other planetaries. Idiosyncratic telemineralogical and telephysiographic mapping of Venus will occur intensively between 1987-2000. Passive and active sensing will proceed from Earth, Venus-orbit, and within the Venusian atmosphere by buoyant stations. Venus will become one of a set of dissimilar and complementary mining sources that will gradually expand to include all the types within the Solar System. Such mining will begin with the [best, most concentrated, most valuable, most obvious, most currently useful, &c] planetary [members, lodes, and minerals] and switch over countless decades to remainders. Eventually methods of seperation will be developed so [cheap, discriminating, elegant, ingenious, massive, quick, simultaneous, universal, and advantageous] that factors of [concentration, form, combination, adulteration, situation, value, amount, chemical type, &c] will become irrelevant. Ingenious and transcendental means for seeing, moving,

and working in and under the Venusian atmosphere and ground will be developed, some even for the missions in the 1980s and 1990s. All sorts of [passive and active] radiations, including [basers and edars], will be used for [evaluating, penetrating, and picturing] [surficial and underground] features [1, 10, 100, 1000, 10,000, and 100,000] [linear and cubic] meters around the man or machine, as well as at [lesser and microscopic] [distances and widths]. Many of these will be or become holographic techniques, and the data will be more or less instantaneously [reconstructed, "humanized" (ie rendered as ideal for human perception, appreciation, and use), "annotated" (ie supplemented by schematization, librarial commentary, graphing, reminiscence, instrumental indicia, pattern indicators, correlations with particular purposes, and invitations), and "kaleidoscoped" (ie potentially or actually continuously or discretely shown as different perspectives, or myrioramically, either as a unified picture or simultaneous or serial mosaics, &c)]. These extraordinary possibilities are fully discussed on page Nc . The human sensorium probably receives and uses millions of nervous impulses each second conveying sensory impressions, and the human brain undoubtably has a capacity many orders of magnitude greater than this if it could be inputed more directly by some future neurotechnology (which will unquestionably come about before 2025, opening a whole new human realm of amplified man). Yet man's current [communicational, presentational, and analytical] technology is immensely cheaper than this potential or natural influx, and suffers from tremendous distortion: [telephony, television, photography, qualitative and quantitative chemical analysis in lieu of olfaction and gustation, &c] are infinitely far from [physiological, potential physiological, and physical (ie of or as the things themselves)] informational [fluxes and transformations], which not only deprives us of data but prevents us from understanding and enjoying things, even in a natural way. Subnormal standards will therefore be replaced over the next 30-40 years by normal and supernormal ones, and by purely mechanical possibilities. So between now and 2015 the intimate and overall environments of other planetaries will come to be seen [in terms of 10^{6-15} bits a second, three dimensions, comprehensively, chrestomathically, processually, intertransformatively, synesthetically, multi-aspectually, multidimensionally; cataractal analysis, synthesis, and re-illustration; in terms of its order, conceptually, with complete and even superhuman and transhuman realism, in terms of its continua and total content, in terms of its texture and beauty, in scientific terms, with normal and even superhuman precision and freedom from distortion, in terms of its immense or infinite detail, with maximal metamorphosis or an infinity of perspectives, in terms of its equilibria, and as transparently as possible (like an image in glass that can be held in hand and x-rayed by the eye--more like an idea than an object, or a tool than a thing). Thus the fate of Venus, named after the goddess of love and beauty. Veneropetal flight will be facilitated and economized by the almost oceanically dense atmosphere enabling capture of the energy of interplanetary flight and engineless aerodynamic descent. Buoyant stations at all levels of the atmosphere will be extremely characteristic of many Venusian operations. There may be supernormal opportunities for eolian production of power on the ground, serving Venusian purposes, and even for indefinite, countercurrent, and grandiose sailing--perhaps industrial operations--in the Venusian atmosphere. As with the jovian planets, buoyant cities may be built in the sky, and even moniliform skyscrapers reaching to fantastic altitudes and waving like grass. All sizes of airships may serve all necessary surficial intertransportation and carry massive freight. Underground cavities may be installed in the Venusian crust by the quick and easy method of detonating nuclear bombs at the bottom of drilled holes, the cavities functioning as already discussed by the surface-volume law. The surface of Venus has been shown by Earth-based radar to be cratered and mountainous, suggesting minable exposure and differentiation. Active vulcanism will be sought in the future, and probably exists on a large scale. Vulcanism cradles mining.

If it is a meaningful and warranted technic that will eventually be practised, by 2010 "neatmospheres" (ie new atmospheres) will have been created in Spacial milieux on a more than prototypal scale for "super biocultural" industry. Men grow organisms for both "sitocultural" goods (ie for foods) and for nonsitocultural goods (chemicals, materials, objects, sewerage treatment, scenery, &c); the two together constitute bioculture. The occupation and development of Space will involve the massive production, manipulation, transformation, and enclosure of human, biocultural, industrial, environmental (eg insulative), and effluvial gas and atmosphere. There is no a priori reason why these synthetic atmospheres should duplicate those on Earth. Indeed, Terran atmosphere may have been, and even be, biogenic, produced by life to facilitate its evolution &r existence, and may have begun with radically different density, composition, structure, processes, and functional aspects (such as filtering of sunlight) than it now has, and which make it sui generis among planets of the Solar System. There is no strong reason for believing that the current conditions which prevail, often heterogeneously over the biosphere, are absolutely or even approximately ideal, or necessary, both for all species, taxa, and phenotypes, as a universal optimum, and particular or selectable species, taxa, phenotypes, and biocultural purposes. Man has yet to explore the n-dimensional manifold which is given by the intersection of all potential parameters, in any serious way, much less develop it, on the Earth and in uncorrelable Spacial milieux. There is little question but that Terran conditions, ecology, and husbandry (in pedologic, meteorologic, climatologic, atmospheric, stirpicultural, and other agricultural terms) can be both replicated, agro-analogously, in Space, and altogether transcended by innovative generalization and specialization and by adaptation to Space with its peculiar opportunities. The lesser gravitation and novel insolation of Space may favor certain types and methods of agriculture for example. It may develop, in particular, that--without regard, or in respect, to the forms of natural, modified, or artificial life used--the creation of hyperbaric &r hyperoxic/capnic, or ultrabaric (ie even greater, or maximal), atmospheres on Earth, other planetaries, &r in Space--perhaps, but not necessarily, conformably with certain conditions--is favorable or ideal for certain organisms' growth, multiplication, qualities, efficiency, survival, health, &r other specifications, and opens the door to super bioculture, or to bioculture surpassing in specific or generals ways some or all life in some or all natural Terran conditions or milieux. For an extreme example (which is therefore to the point), how would plants grow in liquid air --perhaps in a thin film or shallow "lake"--at room temperature? What if light sources were sterically meshed with leaves and stems in a sort of "photoponic" matrix, or in a tissue, cell, or biomolecular culture tank? Might Spacial or extremely actinic &r brilliant light promote such biological systems if it was combined with such novel thermal, pressural, &r compositional atmospheric conditions as suggested above? Extraordinarily elegant, economic, and ideal "Spacial biaria" (or individual biocultural environments) will be devised, and built throughout Space on an eventually titanic and planetary scale, in the future. An example or trait of such a biarium might be a hollow hard sphere, or a revolving cylinder, 1-10 miles in diameter built at a satellosphere or Lagrangian colony in 2020, this hard nucleus or inner shell or skeleton being surrounded with a relatively thin, transparent, and soft or hard plastic or vitreous "bag" 1-10 meters removed from the inner surface, and serving to optimize atmospheric volume, by flattening it, and to warm the cultural organisms by downshifting and absorbing light and thereby effecting a greenhouse, the set of interspatial media--be they "liquiponic", "aeroponic", &r "pedoponic"--being profoundly interwoven with an almost human circulatory system of equidistributional trophic distributaries and eliminative tributaries conveying solids, liquids, and gases in a perfective fashion for extrasystemic regeneration, say by an interior industrial plant, or for extraction of biocultural product; the entire affair being totally closed as an "ecopoietic" system save for export of product, stoichiometric import, and management.

Hybridization, stirpiculture, artificial evolution, genetic engineering, selection, &rc might be necessary, ideal, &r what will occur in terms of fauna &r flora appropriate for ideal neatmospheric or other Spacial bioculture at points in the future and as Spacial bioculture flourishes, which might even become largely microorganic, perhaps because of the greater manageability of populational &r genetic dynamics using microorganisms. Geotropism, and artificial or natural gravitation, may or may not be found critical or important in future Spacial bioculture, or for certain biological systems. Artificial or natural Spacial soils, such as Lunar soil used in situ or exported, may or may not be found needful of a menu of native or artificial trace and major elements and compounds, or toxins may exist naturally in nonterran soils (as has been suggested by Lunar soil returned to Earth) requiring or defying removal; any obstacles discovered in this way, in certain cases and for certain biological systems, may prove major or minor in future Spacial biocultural development. There may be ways of using extraordinarily nonterran materials &r conditions to support Terran life, ways that might be essential to successful extraterran bioculture or niveaux thereof. Really radically novel Spacial bioculture may develop via such things as ectogenesis, accelerating &r maximizing growth by electricity and natural or artificial hormones, raising tissues, cytoculture, acellular culture of plasmas &r organelles (such as membranes), usurpation of genetic or cellular machinery (eg cistrons), simulating cancer by (eg deregulatory) interventic ultimating proliferation or overproduction, abstracting and maximally promoting certain normal or abnormal organismic or biochemical processes, cycles, sequences, or reactions; or from the synthesis of almost completely unnatural morphogenetic, evolutionary, differentiable, controllable, reproductive, catalytic, adaptative, chemosynthetic, materials-producing, &rc simple and complex chemical processes and systems on the basis of vast scientific and technical progress, such as is inevitable by 2075 and then by 2175. An example, a complementary kind, of the needlessness of duplicating Terran conditions is that the use of greenhouse effects by epiplanetary hemispheres and extraplanetary spheres in future times may rely on hyperbaric atmospheres as advantageous to normal pressures in the production of the effects. What sorts of atmospheres men can and will tolerate is another question, but bioculture and human inhabitation are segregable, perhaps even advantageously. It is not clear whether atmospheric characteristics different from those found or prevailing on Earth might be specifically superior for man, but marginal superiority, or superiority through stability and feedback, seems almost certainly possible. The isolated, totally controlled, variously synthetic, variously sterilizable, sterile, perhaps subchambered, environmentally perfectible, perhaps nonevolutionary, perhaps nonterran soil-based, mutually isolated, perhaps unvisited (eg robotically tended), conservatively and selectively speciated, perhaps wholly artificial (for example consisting of artificial food chains, pyramids, and ecosystems, or without all three--and thus perhaps without predators, parasites, random and cyclic fluctuations of populations or species, or problematic complexity generally), perhaps periodically re-creatable, perhaps narrow-tolerance, ubiquitously monitored and watched (eg by ingenious or intelligent automata), perhaps organismically simple, perhaps based on artificial organisms or even nonorganismal or even nonbiochemical, &rc biocultural biaria might be virtually or actually exempt from customary or any interspecific &r intraspecific pathology (even death might be overcome or transvalued). Over gigennia, &r infinite intelligence having applied itself, the species, taxa, individuals, ecologies, and systems evolvable could be inconceivable, and the very meaning of life might be altered. Things discovered and developed in Space might be exported to &r replicated on Earth, vice versa, or both. But as pointed out by Gerard O'Neill, there is as yet no reason for believing that in the main or absolutely Terran or epiplanetary milieux are superior or even equal to extraterran or extraplanetary milieux in industrial or sociological terms, despite the prevalence, fixity, and strength of the contrary presuppositions, man being a natural bigot.

To the extent it is ever done or found to be important, natural caves will be discovered &r exploited on the Moon &r other planetaries by 2010. This is a more daring prophecy than it might at first seem since the agents and circumstances of cave formation on Earth, at least in their ordinary senses, are considered actually or potentially inapplicable to the extraterran planetaries, caves on which would therefore be exceptional or unpredictable. If caves do exist elsewhere in the Solar System, questions must be asked about their likely and possible ranges of density, size, depth, character, interest, cause, need, use, dangers, loci, and planetaries. As they have in Earth's past, caves might serve initial &r later inhabitation, mining purposes, other industrial purposes (storage, processing, shelter), science, &r simply adventurous exploration. Terran caves have biological, hydrological, meteorological, geophysical, climatological, &r astronomical origins: in terms of biogenic calcareous rock, water waves and currents, waves and currents of air, vulcanism and diastrophism, precipitation, epochal glaciation and deglaciation, stratification, seasons, days, months, groundwater, oceans and terrestrial streams, other astronomical periods and events, &rc. Other Terran planetaries are seen in less picturesque (in less differentiated, active, varied, complex, powerful, and appropriately speleogenic) terms, and jovian planetaries, being immersed in impenetrable and incalculable atmospheres, cannot be understood or investigated speleogically (which is not to say that any lower atmospheric fabrics, and lithospheric soils and rock, might not generate and contain caves in these planetaries, even to a degree unknown on Earth). Lengthy lava caves occur over the Earth that might well be copied on other planetaries. Probably most, perhaps the overwhelming majority of, caves on Earth are undiscovered and underexplored. An ideal method of detection is necessary, and might alter the situation on other planetaries. Processes destroying caves are also dominant on the Earth whose possible absence off Earth might preserve, especially certain types of, caves, or leave them open to the surface. What is necessary for fluctuation, and differentiation of compositional and morphological statics and dynamics, of planetary environments (regardless of speleogenicity)? What specific values and correlations in terms of orbital eccentricity, diurnal period, tilt of a planet's axis of rotation, inclination of annual orbit (if this is important, say with respect to the extended heliosphere), various long-term precessions and perturbations, solar irradiance or general lithospheric and atmospheric energy and activity (including exoergic processes), atmospheric structure (depth, stratification, composition, dynamics, &c), &c? (The answers to such questions are essential as well to understanding the origin, evolution, form, and varieties of life, the existence of minable deposits of minerals, the natural interests of planetary milieux, and the scientific value of their comprehension.) It is possible that the set of possibly influential astronomical characteristics previously listed might identify one or another planetary as of superior interest to the Earth in general or specific terms, such as the terms listed. For example, the orbits of most planets (and therefore their satellites) are far more eccentric than Earth's: Mars is 3X as eccentric, Jupiter is 5X, Mercury is 12X, and Pluto is 15X (ecc. 0.247). The diurnal axes of Mars, Saturn, and Neptune are slightly more inclined than the Earth's (Uranus is incl. 98.0, making for a stabler but bizarre situation, unless its inclination varies or varied eonically, in which case, here and elsewhere, very interesting phenomena are imaginable; Pluto is unknown). The day of Venus, Mercury, and Pluto is longer than ours, acquiring seasonal aspect. The day of Mars is Terran, and the day of Jupiter, Saturn, Uranus, and Neptune is half ours, perhaps making for a more powerful day and hypothetically doubling the number of days experienced by these planets over time. Just as for Earth,

the other planetaries may have experienced major and significant atmospheric and physiographic periodicity, fluctuation, and alteration--both quantitatively and qualitatively--since the beginning of the Solar System, toward the present, or over much of their time. There is evidence and theoretical speculation that the history of the Sun, and therefore the extended heliosphere and Solar System, may involve a much more complex spectrum of temporal variations than formerly thought, and likewise that the state of the Terran atmosphere and "solidosphere" (or the extended "geosphere") may be heterodoxly dependent on the general heliospheric inconstancies. In this way it has now been surmised that phenomena such as Earth's Quaternary glaciation are matched on other planetaries by major thermal reversals and concomitant overall planetospheric variations. For example, Mars may in the past have experienced one or any number of solidospheric, atmospheric, and possibly biological inversions, rebirths, nascencies, golden ages, &r simply gross variations--atmospheric pressure, moisture, clouds, standing and running water, clement temperature, greenhouse effects, oceans, chemical processes, topographical processes, &rc may have half the time, much of the time, formerly, or for a spell have been favorable to the origin, evolution, multiplication, and maintenance of life, or at least to physiographic diversity, along Terran or exotic lines--and paleontological &r paleogeographic traces may remain as relics or fossils. It is perhaps even probable that some or all planetary environments were much or infinitely more active at some early stage, of indefinite length and character, in the history of the Solar System after the formation of planets, and remain in the Solar System today in revivable or irrevivable form. Large areas of the Earth today, during an era of relative climatic clemency, are dead or suspended owing to excessive heat or cold, or other variable factors; it is not unreasonable that for long stages in its history the Earth has known conditions of such severity, say of heat or cold, that far greater death and suspension of biological and geological processes, and desolation of Spacial aspect, has been characteristic, even such as might have rendered it outwardly similar to Venus, Mars, &r the jovians --since the record is poor and little understood, greatly supposititious. Every reason exists for thinking that analogues for rain, snow, cloud taxa, storms, rivers, lakes, oceans, underground waters, continents, diastrophic processes, complex molecular soups, horizontal as well as vertical planetospheric regions, intricate planetospheric circulations, intricate chronological fluctuations, furious energic processes, &c prevail on each of the jovian planets (and on Mars, with different rate, density, complexity, equilibria, laws, history, &c; and even in the tempestuous Sun). The stratification, dynamics, and complexity of Jupiter's atmosphere may be infinitely greater and far different than anyone has suggested, and what they might originate is unknown. A key question is whether biological, and even geological and meteorological, processes may be much more dependent upon some, any, or a particular current and historical differentiation than usually supposed, and even whether such processes might be autocatalytic and experience, or potentially exhibit, one or more "takeoffs" in the sense that some or a kind of level of complexity--in molecular, macroscopic, &r planetary terms--might be the natural or essential antecedent or basis of a discontinuous or exponential appearance of the level or kind of relevant phenomena we know, at least to some degree, on Earth? We just don't know, yet the idea is perfectly reasonable and even appealing. Such a takeoff may have an incidence or a time period such that 1 planet in 9 may experience it within 4 billion years, or only 1 in 1,000; or it may be universal, perhaps multiform. Also interesting is whether the process is irreversible or not. Lunar caves might be much larger than those on Earth as a result of the sixth of a g gravity. Here the asteroids must be considered. These have much less, even essentially zero, gravity, and may be less consolidated by past gravitational, thermal, &c processes. They, or some, might amount to random piles of all sizes of

rocks surrounded with all sizes of cavities (not just the intergranular ones characteristic of Terran soil and rock). Some of these cavities might be 10-10,000 feet across, or 1,000-1,000,000,000,000 cubic feet in volume, or easily excavated as such without worry of collapse, if artificial caverns are called for. Vesicular lava on Earth, or scoria, is essentially a foam whose bubbles are presumably limited in size by such Terran factors as excessive gravity confining the chambers to a certain dimension near the surface of Earth and enormously reducing the sizes possible by gaseous processes in the interior of the Earth manifesting a voluminal law; for this reason, conversely, some or all asteroids and satellites may amount to cinderous mountains, or, more importantly, to clusters of bubbles of size ranging up to the diameter of the whole planetary. Such bubbly planetaries, if they exist, might be absolutely ideal for mining, factory, and occupational purposes, and colonies arising on or in them might be styled "aphropolises", or cities of foam. Even if the bubbles are always or usually less dense, varied in size, readily exploited, or the like, the planetaries might be discovered, as early as 1985 or probably by 1997, to be riddled with spheroidal &r tubular caves of some origin. It is possible, even probable, that some satellites and asteroids, even planets such as Mercury or a small &r microinsolated (ie poorly lit by the Sun) Pluto, are geophysically cold and rigid. There is high controversy here, even about our Moon. Also, such planetaries may have been cold and rigid for much, most, or all of their life (they may have formed cold). What is therefore possible is that such planetaries, perhaps throughout their radius, are to one degree or another filled with large vacancies that existed originally or have formed since, interconnected perhaps in various ways; we know little about the possible existence of liquid &r gaseous chambers &r tubes deep in the Earth's crust or even below, much less the laws translating from geology to "exoplanetology". Some planetaries may be so hot on their surfaces and in their superficial crusts that speleogenic processes use fluidic media other than liquid water, such as metallic flows of zinc, tin, lead, or various molecues, and vaporous &r fluidic cavities exist or have been left behind. Glaciation and deglaciation characterize Earth's history (at one time at least 30% of Terran land was ice-covered, today 10% is). Glaciers and ice caps (both peripherally and interiorly) both contain and cause important caves (the inhabitability of which might be comparable to igloos). Various types and forms of ice obtain, and have obtained, on many and most planets, and even on planetesimals, and cave systems doubtless have arisen from them, the proper transformation of narrow Terran conditions. The liquefied and solidified gases present on the jovian planets and satellites must involve vertical and horizontal boundaries, and time fluctuations of those boundaries, related to extraordinary cave systems. I have pursued this foreseen event--caves being found and used in the future, by and after 2010--in the detail that I have in order to illustrate the intricacies typifying all events in the future of the Solar System, and the potential importance of seemingly minor and easily overlooked things. The schedule of the various particular possibilities is difficult to supply, but may be imagined.

The planet Mercury will be mined on some more than exploratory scale by 2010. Its proximity to the Sun, 36,000,000 miles with an eccentricity of 0.2, and its lack of an atmospheric cover, which exposes the surface to the full corpuscular bombardment of the Sun, might seem to render it of little interest to mining and too inhospitable to exploration and development in any case. Yet these facts are deceptive. Radiotelescopy suggests that at a depth of a meter the temperatures are Terran (little greenhouse effect operates). The Mercurian day is 2 Terran months so that the surface temperature, per se, varies from perhaps 700° K at the subsolar point to immeasurably low. The maximal diurnal temperature might make for some interesting topographical

fluidal phenomena &r mineralogy, the nature of which it is not mine to surmise. Interior morphography, rheography, and chemistry may also be extraordinary in nature and useful, as well as improgнosticable. What is striking about Mercury is its apparent density of 5.2 grams per cubic centimeter, where Earth is 5.5, since its coupling with a radius of 3,000 miles implies a larger abundance by far of intrinsically high-density material, as a percentage of the planet. It is possible that intense cosmogonic radiation vaporized Mercury's upper silicate mantle, exposing a denser sphere of material. In any case, the surficial and upper mineralogy of the planet may be so different from what we are familiar with on Earth as to be of great extractive interest, apart from the scientific value of its future study. Whatever the explanation of the anomalous density, it is already favorable to the belief that the Solar System may be tremendously fractionated conditionally, elementally, chemically, and mineralographically. One problem is that Mercury's mean velocity is faster than Earth's by more than Earth's is faster than Saturn's, requiring great energy for interplanetary commuting. The approximately Terran temperatures at a meter's depth and the ready insulation of the ground, not to mention the accomodative length of the night, would seem to make the subterranean mining and occupation of Mercury far easier than in the case of Venus, and perhaps not hard at all. Perhaps development will actually occur sooner and more rapidly than with Venus. Mercury's proximity to the Sun might make it an outpost and midpoint for study and use of our star, the site of a manned, or extraordinarily complex and sophisticated mechanical, heliological laboratory, or of a solar power generation station retransmitting its energy to Earth or other points in the Solar System. The photonic flux density with distance from the Sun presumably obeys a simple inverse-square law regardless of frequency, but the same presumably does not hold for fermionic species, velocities, densities, energies, &c, so that energic effects and utilitarian advantages might be far greater than the discrepancy between Mercury's and Earth's distance from the Sun might suggest. Mercurian radioisotopic mineralogy, and its prior telemineralogical and epiplanetary mapping, might be especially interesting, say as compared with the other planets. The degree of its differential superiority to these planetaries, in gross and net economic terms, is uncertain: it might be negative, unity, fractional, manifold, or over an order of magnitude. The rapidity with which these circumstances would lead to exploitation is uncertain. It is not impossible that recognizable subterranean life does or could exist on Mercury, but it would be astonishing given our limited assumptions about the nature of life. Discovery of elementary or fossil life on Mars, Venus, Mercury, &r comets would imply life on the others is far more likely. There is a chance that life is far more pervasive, various, and tenacious than is customarily thought or is suggested by the Earth; "open" rather than "closed" definitions of life may be more accurate or sooner or later timely. Life as we know it may be a special case of a much larger set of actualities or possibilities, that might be variously finite or infinite. Solar energy used on or relayed from Mercury would be profiting from more than simply 4X sunlight on Earth since Mercury is anatmospheric. Planetaries other than Earth are of exceptional interest to science because of what light they may throw on epeirogeny and plate tectonics, apart from other matters. Are there continents on other planetaries and do these continents migrate over the solidosphere, changing the face of the planetaries? How unique is the Earth generally? There will be at least 10^9 men inhabiting Mercury, or dependent upon 10^{12} tons of her matter, by 2100, 125 years from now. By 2175 she may have ceased to exist, the totality of her 3×10^{20} ton mass having been mined or rearranged in Space, a fate befalling the lot of her sister planetaries and leaving, at least temporarily, the Sun. Some anomalies will show up in the course of future exploration of Mercury that will require, and involve, important explanations. These will not just be instrumental anomalies.

Assuming it ever occurs, at least before 2040, then there is a 50% chance that by 2010 a manned or unmanned geocentric bombardment fleet will exist, that may also cover the rest of Space either potentially or actually, whatever its activities, capabilities, or ambitions there. This will be predominantly a maneuverable fleet of spaceships, however numerous the immobile geosatellites connected with it. Abrogation, modification, violation, evasion, obsolescence, or nonsubscription to the 1967 Outer Space Treaty, and possibly other agreements, will have to occur, unless the Treaty is interpreted as limited to nuclear--and possibly defensive, clear-cut, &r destructive--military capabilities, or possibly to usably or explicitly military, as opposed to peaceful, &r explosive &r violent, nuclear devices. A military geocentric fleet might not have nuclear bombs, baser weaponry, offensive, defensive, strategic, &r even tactical capabilities or functions; rather it might serve inspection, observation, crisic implementation, unarmed maneuvers and researches, policing, &r quasimilitary purposes. It might be the neutral organ, variously able, enforcing the 1967 Treaty &r later agreements, perhaps as a United Nations mission. The fleet might in any case comprise 10-100 ships and 100-10,000 men in 2010, perhaps assuming much grander proportions thereafter in a gradual and proportionate fashion. In 2010 or by 2020 there might exist 2-20 such fleets, say expressions of diverse powers. Ultimately the governments of other planetaries, of colonies, &r of the Solian Government will create laws and use military &r police fleets to enforce them by prosecuting, apprehending, punishing, and scrutinizing offenders. Hopefully the taxation for military purposes will fall from today's tithing (10%) to 10^{-2}-10^{-4} by 2100. There is little assurance that military defense, and multilateral stalemate, will or could be efficacious, much less desirable, over periods as long as the next 50-125 years (until 2025-2100); scientific and technical progress, and international turmoil, make the future appear both unstable and threatening, perhaps more so than ever before. It might be highly desirable to keep all military forces &r weapons out of periterran &r extraterran Space so long as possible, thereby guaranteeing the survival, peace, freedom, and stability of at least a portion, and ultimately most, of human civilization as a practical ideal. The probability of a geocentric bombardment fleet as initially described existing by 2040 is ¾%.

The discovery &r use of tremendous unsuspected intraplanetary radioactivity, &r the exploratory &r exploitative retrieval of useful transmuted &r radioactive nuclides, somewhere else in the Solar System will have occurred by 2010. The discoveries may or may not be immediately accessible; for example, presence of some extreme radioactive deposits &r reactions toward Jupiter's center may be determined, and even understood to be potentially valuable, without any immediate method of extraction or utilization. Very crude telemineralography of the Moon's surface has already been done by lunicentric satellite, say down to a resolution of 10^4 meter and with some indication of radioisotopic species as differentiated by energic spectrum. Unquestionably such research and mapping will be both improved and extended by a great many orders of magnitude--in terms of extensiveness and fineness of selenography (ie Lunar geography), cumulative product, sophistication of instrumentation and analysis, sheer multiplicity of probes and investigations, epiplanetary explorations and groundtruth, and simply by the growth of human interest--between 1975-2010, and the investigations will automatically be carried to other planetaries. Neutral, electrical, and photonic emissions are all useful for radioisoptic mapping, say from orbit. Exploration, mapping, and sequent mining will all be helped as mineral suites, petrogeny, and physiography--in exoplanetological terms--are better understood as correlated and indicative things with proper and radiomineralogically valuable signatures. The gradients of compositional fractionation possibly marking the Solar System as previously discussed may be correlated with or exemplified by extraordinary and perhaps parallel distributions and concentrations of minable radioisotopes.

Particular radioisotopes may be concentrated r& clustered at special geospheres in Earth, but in regions inaccessible to current &r economical mining. On other planetaries these regions may be exposed &r accessible in highly nonterran fashion, perhaps according to the size, spacing, fragmentation, &rc of the planetary. For example, one might assume that valuable radioisotopes unfortunately located toward Earth's core are fortunately surficial or readily reached (say by virtual independence of planetary structure, being universal, from planetary size) in the case of asteroids &r satellites. Radioisotopes might be concentrated toward Pluto &r Mercury, &r in particular asteroids, comets, &c. Extraordinarily powerful mining tools intolerable on Earth but usable in Space, such as ordinary or giant nuclear bombs, might render deposits in mountains or miles underground accessible as well for the first time, r& cheaply. The general scale of undertakings in Space might facilitate such mining and recovery. For example, machines of unprecedented dimensions, say 10^{2-4} meter high and weighing (on Earth) 10^{3-7} ton, might prove efficient or necessary for certain purposes, at least in terms of Space, and be built and used in Space, with some consequent productivity; certain size laws might actually favor these stupendous and otherwise cumbrous devices, and certain opportunities in ways of using future energy might encourage their serious or experimental construction. They might enlarge the field of mining and impact in turn the form and scale of industry and civilization. There may develop in the future expanded scale and array of uses of natural and artificial radioisotopes, encouraging the greater and diversified recovery of such isotopes; &r the new recovery may stimulate the new use; &r improved seperation may be important, of stable from radioactive isotopes &r of radioisotopes &r radioheterotopes inter se. Radioactive deposits might conceivably be used more or less in situ by collocating or combining industrial processes, if there exist deposits of arbitrarily but suitably great concentration or radioactivity. Fossil natural fission reactors have recently been discovered on Earth, and active reactors, perhaps of great size and even importance, may exist within the Earth. This implies that extraordinary radioisotopic concentrations, and even large-scale nuclear reactions of a local &r general kind, may exist on other planetaries. Industrial use of radioactivity, both bosonic and fermionic, on Earth is in its infancy but already an array of important and potentially large-scale applications is prefigured in terms, particularly, of the chemical and structural transformation, production, and synthesis of materials, and the control and alteration of normal industrial processes; the marginal economic value of these helps, bases, and products--now and in the future--is unclear, although of course Space will have its own needs, particularly over the long term or destinationally. It is possible that Weak &r Strong force radioactivity exists in certain intense foci near or on the surface of other planetaries over such volume or with such density that heat is liberated in a spheroidal region at temperatures approaching those of the emissions &r with industrial power, furnishing natural furnaces at temperatures ranging from 100 to 1000s of degrees centigrade, furnaces eventually discoverable and exploitable by compresent or distant industries. Like possibilities are discussed above for the disposal of wastes in 2005. There is a bare possibility that Jupiter harbors natural fusion reactions, conceivably exploitable. The discovery, extraction, seperation, and application of fissionables on the Moon by 2015 and on other bodies may play a key role in the development of these specific planetaries and of Space in general--in terms of the production and distribution of power, the energies necessary for mining, the manufacture of materials and objects, the scale and growth of communication and transportation, the air-conditioning of human and biocultural habitats, and the production of alternative sources of energy--between 2015-2050. It is an interesting thought that two types of "sun" may exist in the Solar System as the energic basis of physical and biological planetology. One the Sun as we know it, an external and remote luminary, and the other one or more centers in planetary interiors

based on Strong, Weak, electromagnetic, &r gravitational exergonic processes. For certain planetaries the ratio of the two types of sun, in terms of the motor of the planetary processes, may be unity, and for Jupiter the greater source of energy is actually the native or internal processes. It is conceivable that the internal suns of planetaries, even regardless of their energic ratio to the external sun, play critical roles in the variety, complexity, evolution, and amount of interesting physical and biological processes and the forms related to them throughout the volumes of the planetaries or at distinctive horizons &r foci. The volumes of planetaries may be compared with the volumes of deep oceans, the gradients and currents of energy therein, and the molecular and organismic forms permeating the volumes because of their ability to find energic niches in the river or landscape of entropy; that the entropic slope is perhaps greater with oceanic depth than with depth over an entire planetary radius is not necessarily fatal to the occurrence of any, populous, &r intricate physical and biological differentiation and kingdoms of phenomena. No profound reasons are known for believing that the unfamiliar and extreme density, temperature, structure, composition, pressure, unresearched nature, &c of regions 10-10,000 miles below planetary surfaces limit or simplify their possible or even probable morphic and dynamic differentiation and forbid evolution having attained biological levels, however difficult it might be for us to determine the facts, and even to perceive and conceive the things. Associated with present or former deposits of radioisotopes, &r with extraordinary flux of radiation over the ages, there may be derivative &r underived stable isotopes that are nonetheless extremely valuable, or even masses of important chemical materials. Fusionables may also be valuably fractionated elsewhere in the Solar System; for example, it has been suggested that deuterium is 60 X as abundant in or atop Jupiter's atmosphere as it is in the Terran ocean, itself a fabulous reserve of fusional energy. Since Jupiter is thought to be almost entirely hydrogen and is 300 X as massive as Earth, the fusional energy it contains is almost inexhaustible and unimaginable, were it not for the likely rescaling of industrial purposes over coming centuries, millennia, &c absorbing the difference in orders of magnitude. But of course, in terms of this discussion, deuterium is stable. Less concentrated and even diffuse background occurrences of fissionables, fusionables, and radioisotopes are also important--less, equally, or more so--as illustrated by the economic possibilities for mining uranium and thorium traces in common seawater and granite; gross variations in these percentages are therefore interesting and suitable factors of advantage for recovering absolute &r unequal traces from situations on other planetaries probably or possibly discoverable in the future could easily justify the costs of interplanetary transportation, regardless of the in situ uses. Certain stable or relatively nonradioactive nuclides are of course nonetheless valuable because of their possible transitional uses in transmutative nuclear reactions, even comparably valuable, and deposits or unusual abundances of these may exist on other planetaries. When, during or beginning in the 22nd century, planetaries are grossly stripped of their mass and taken apart for Dysonian purposes--as is likely--the deepest concentrations and full distributions of these minerals may be recovered, if warranted, or may even be problematic because of their radioactivity. By this time, however, processes for the recovery of transnuclear and stable-isotopic energy may have drastically altered what is considered valuable, or even have equalized all materials' elements and stripped radioisotopes entirely of any advantage for energy production purposes. It is also conceivable that drastically unfamiliar pretreatment &r alteration of reactional environment--say by enormously energetic gamma &r beta radiation--may, in effect, catalyze nuclear reactions based on, &r possessing efficiencies or warrants surpassing, today's selection of nuclear fuels; for example, stable or stabler nuclides and isotopes might

come to offer efficiencies of mass-energy conversion, or energy production, comparable to the rarer fuels either in terms of the relative abundance of the base deposits or even absolute reaction efficiency. I am not sure to what extent the existence and characteristics of these imaginary catalytic regimes are assessable by contemporary scientists and technologists. It is conceivable that radioactive deposits &r backgrounds obtain on other planetaries that will constitute hazards or suggest limitations for the future exploration and development of the Solar System, either through environmental radiation or absorbable toxins (such as oligodynamic plutonium); such conditions might require the substitution of telehosts &r automata for men in exploration, work, &r life.

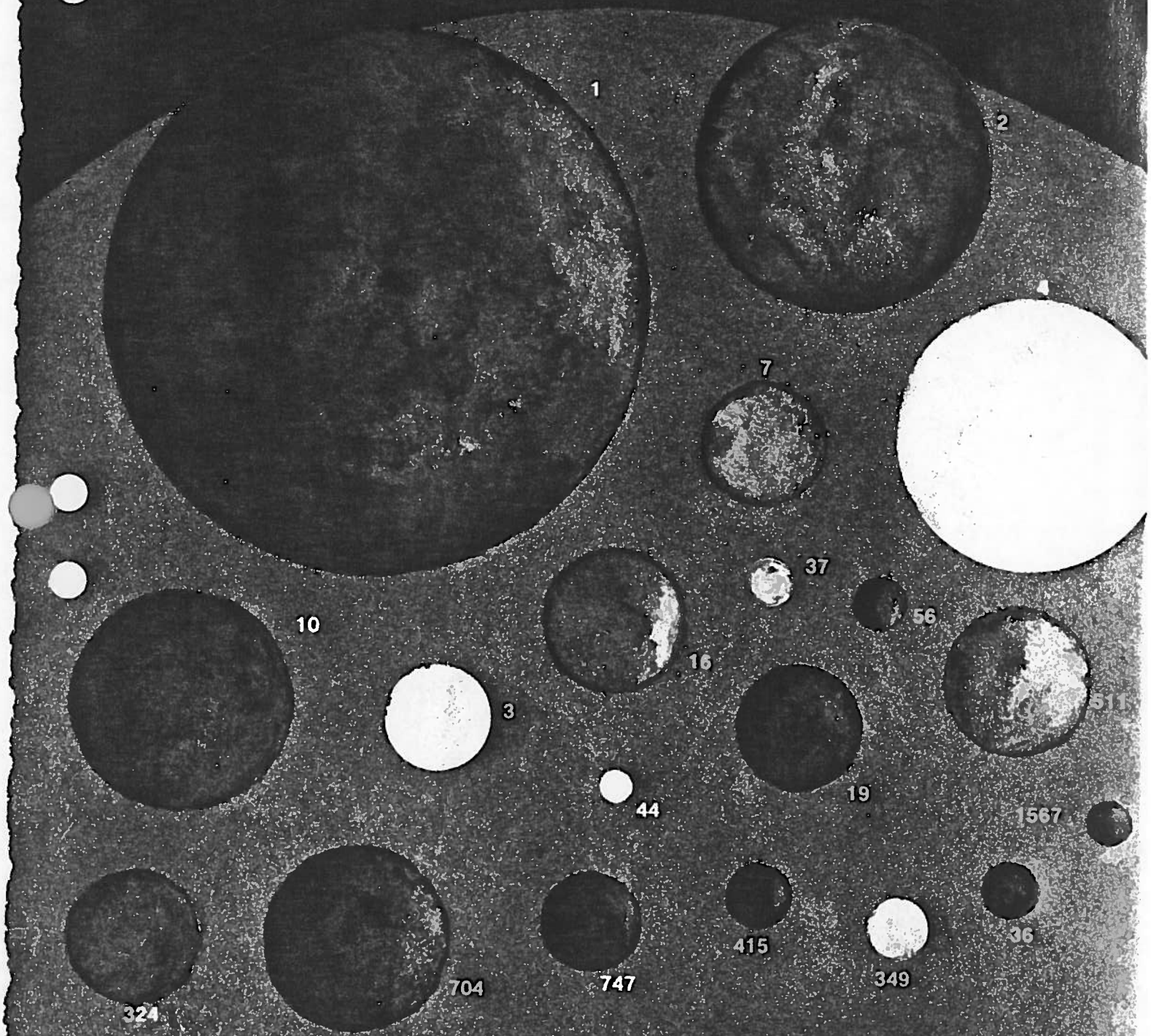
Some mining of the jovian planets--Jupiter, Saturn, Uranus, Neptune, and conceivably some of their satellites, the status of Pluto being unknown--will have occurred by 2010. The cumulative extraction will have to have exceeded 10-100 ton in order to qualify as serious mining rather than an example of scientific curiosity. The extraction annually from 2010 forward, and the curves for its growth, are hard to predict, especially in view of the uncertain uses and importance of the minerals removed. Extraction from one or the set of planets might be sluggish and impurposive over 2010-2023, but thereafter grow with a steep, regular, and sustained curve, or a curve competing with other sources of energy and material. Uses for hydrogen and helium will have to multiply and enlarge, but the unusual properties of these chemical elements argue that the theoretical value and scale of use of these superabundant extracts will in fact display such development in connexion with old and new uses and in terms of both replacement of and addition to the industrial bases of civilization. The internal, and thus basic, structure and composition of any and all of the jovian planets is, frankly, largely unknown, both theoretically and empirically, quantitatively and qualitatively, generally and detailously, and crudely and precisely; this intensifies their mystery and underlines the fact that they are likely to be fascinating and scientifically important. Their phenomena, elements, chemicals, minerals, and higher evolutions equally reflect these dimensions of uncertainty. Their obvious dissimilarities with the Earth and terran planetaries--giantism, extreme atmosphere, internal heat, reducing atmosphere, low density, heliocentric distance, extreme magnetic and electric envelopes, &c--would seem to vitiate and falsify Terran thinking, comparisons, and extrapolations and to open the door to a whole new world, if not universe, of phenomena. The questions about the jovian planets would thus seem to address less our knowledge than our ignorance and fancy, or our tolerance for extreme ideas and surprises. The identification of compositions of the jovians and the Sun is probably equally helpful and misleading. The surface and volume of the jovians have very likely experienced chemical and biochemical evolution and differentiation on a massive, elaborate, and unpredictable scale, and great tonnages and fractional abundances of these products must obtain in their respective spheres, perhaps accessible to mining, if not in situ use. Whether such evolution and differentiation have likewise given rise to structure and even morphological processes on &r over great range of scale (eg in size ranging from 10^{-8}-10^{-7} meter diameter macromolecues, $>10^{-7}$ meter organisms, arbitrarily complex and diffuse colloids, $>10^{-6}$ meter cells, microcrystals and macrocrystals, arbitrarily dense soils, $>10^{-4}$ meter rocks, 10^{0-7} meter scenic features, and ubiquitous informational soups) is uncertain, but nothing forbids it and the answer is highly probably yes; the extent to which spatial, temporal, and functional rigidity is key to planetological and biological organization is unknown, but nature is probably flexible. It has been suggested that Jupiter may contain vast minable petrochemicals, whose value might be to energic &r chemical industry. Whether Jupiter might ever offer an economic

source of chemical energy is a difficult and moot question; conceivably chemical propulsion will remain important in the future of Solian transportation, in which case the jovians provide virtually unlimited hydrogen. The greater value of hydrogen is suggested by the fact that its overwhelming isotope is protium, or a proton paired with one electron, a simplicity the future technological importance of which seems necessary, whatever the specific applications and categories of use. Eventually life will assume a form, and industry will differentiate to a degree, apt to de-emphasize water as an essential or even important chemical; but prior to then, and with the foreseen expansion of human numbers by over 5 orders of magnitude (barring a replacement of mankind by a race of machines) before 2300 or 2500, the 10^{18} cubic meters of water on Earth may prove insufficient, and oxygen of the crusts of the terran planetaries may be combined with hydrogen of the atmospheres of the jovian planetaries in the production of relatively unlimited water. The jovian planets may or may not possess solid &r terran interiors that may or may not be minable or mined in terms of imaginable mineralogies and at points in the future. The gaseous, liquid, &r solid atmospheres of the jovians and their hypothetical solid nuclei alike will require imaginative schemes if mining is to occur, evolve, enlarge, and become perfect, outlines of and suggestions for which are now possible in a beginning way. See, for example, the discussion above of hypothetical mining of the Earth's heterospheric gases in 2003. It is possible that gravitational acceleration of vehicles somehow passing through, gathering in, and carrying away large quantities of the uppermost layers of the Jovian atmosphere could, for example, render such mining rather perpetual and without recurrent costs, say assuming on-board automata piloted the ship appropriately. The extreme internal temperature of Jupiter and possibly the other giant planets might--a la the foregoing discussion of "second suns"--invert the usual vertical zonation of a planet by a centrifugal arrangement of plasma before gas before liquid before solid, at least relatively speaking or to a degree; the internal temperatures may help account for the low density of the jovian planets. Gases and liquids of the jovians could be exported into extrajovian Space so as to solidify by irradiation and be used as building, cryogenic, electronic, &c materials. What qualitative and quantitative differences distinguish the jovian planets among themselves compositionally is unknown, but great and important differences, whether random or systematic, probably exist, and will be found and exploited in the future. Some of the satellites of the jovian planets probably resemble a jovian planet in terms of elemental, chemical, &r mineral composition, and will be mined before the macrogravitational and deep planets. General clues as to the composition of jovian planets may be more directly discovered, either empirically or theoretically, in the satellitic similarities. Carbon present in the jovian planets as methane (CH_4) &c could conceivably justify some supertechnological mining 50-100 years from now (2025-2075). The rings of Saturn may be mined, if just for ice or perisaturnian purpose. The Great Red Spot of Jupiter may be mineralogically extraordinary and relatively minable; whether planar or deep, it may well be or contain a wealth of complex &r useful mineral resources, perhaps concentrated from the whole surface of the atmosphere. The jovian planets may be mineralogically fractionated in terms of latitude, and the poles may be sui generis. Buoyant vehicles--airships, boats, &r submarines, perhaps of titanic size--may be usable and used over and within the atmospheres of the jovian planets in order to explore, mine, industrialize, &r occupy them, say at various depths and latitudes and by a universe of means. If one or another of the jovian planets is biologically organized--ie supports a heavy, complex, &r planeturgic biosphere--biocultural harvesting might be possible, &r a biogenic mineralogy (in terms of biomass, environmental by-product, &r paleontological deposition) might be concentrated, massive, &r a fair percentage of a part of the planet, and minable as such. It is conceivable that Pluto might be a collapsed jovian,

a planet of identical or analogous composition but compressed and frozen by its isolation &r smallness, in which case minerals, chemicals, &r elements typifying the other jovians might be relatively accessible and minable.

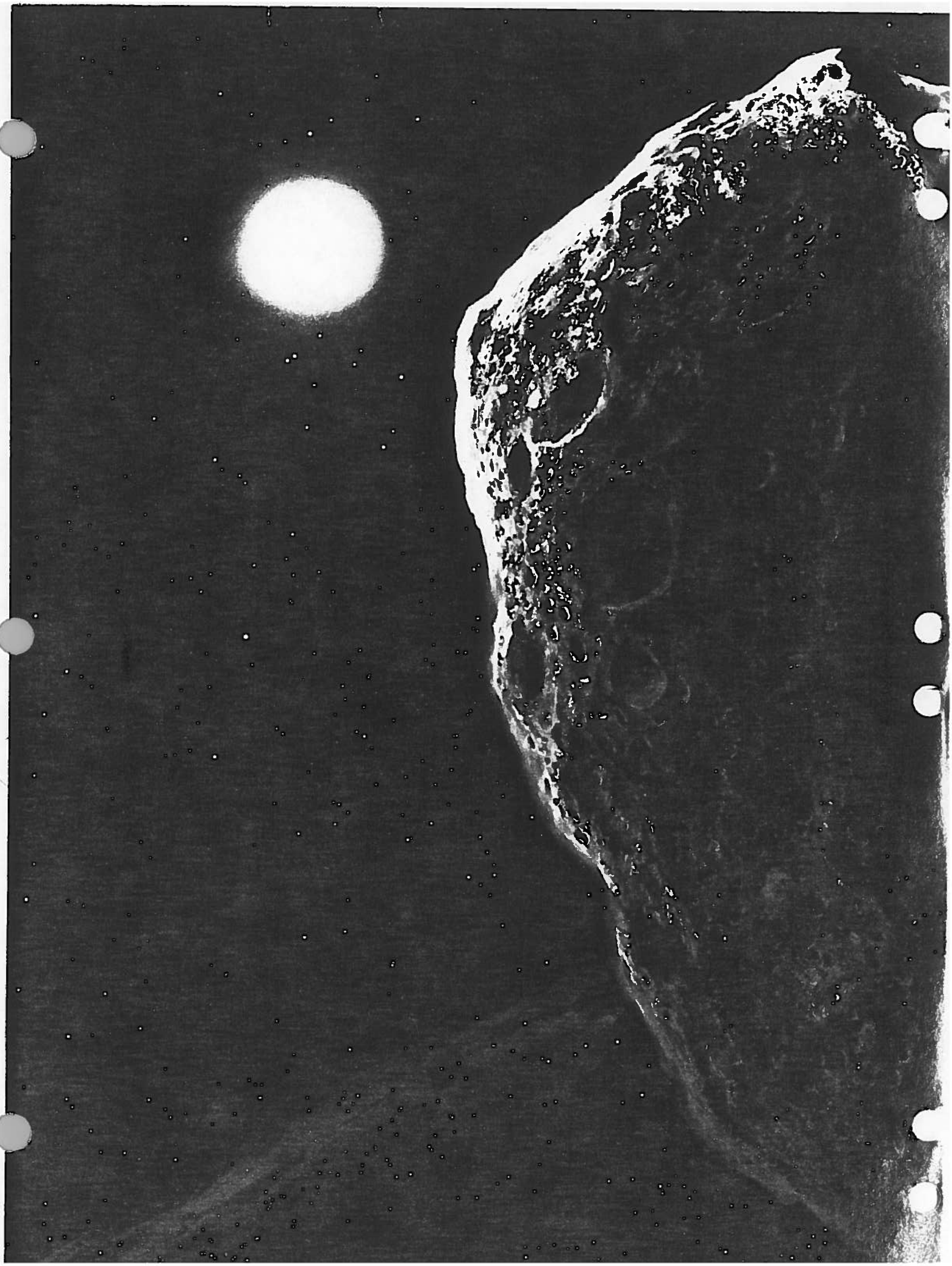
By 2010 an asteroid of moderate size (10^{3-12} ton or cubic meters) will be moved to cislunar Space. This will be the first time an asteroid was moved a great distance in any direction for any purpose by man, and the start of an interesting game of billiards. By this time an asteroid of such magnitude will specifically have been sent to the geoselenian libration points L-4 &r L-5. If taken from the perisolar fringe of the Asteroid Belt at 2 AU from the Sun, rather than for example an orbit outside the belt or an eccentric orbit, an asteroid of such mass will require, according to its specific mass, of the order of $5 \times 10^{20-29}$ erg, equivalent to 5KT-5TT TNT, where mankind uses 10^{27} erg of fuel per annum in 1975. Means for moving these first asteroids will probably be nuclear explosions, an Orion drive, or catoptrical balloons of titanic or astronomic size tethered to the bodies and propelling them by ablating their stern. A 100-mile diameter balloon would focus of the order of 10^{27} erg/sec of sunlight at 2 AU, and 10^{28} erg/sec at 1 AU, from the Sun, although the efficiencies would have to be worked out, and include the ablative processes. The average asteroid velocity is 10-15 km/s and so the above energy needs should be multiplied by 1-1½ to give what is required for interorbital transfer. Since Lunar escape velocity is only 2.3 km/s, mass could be taken from the Moon at an energy cost of 10^{17} erg per ton, and asteroidal mining must justify itself in these terms, or in terms of drastic selection for transportation to geocentric orbit, although mining for transportation within the Asteroid Belt, and possibly Mars, is another matter. Transfer from the Moon to lunicentric orbit, or a Lunisatellosphere, would require half as much energy as escape from the Moon, and, at least initially, transportation costs, especially per pound, will dominate astronomical mining considerations. If colonization of Geoselenian L-4 and L-5 involves 10^{2-4} ton per man, 1,000 tons could support 10^{-1}-10^{1} men and 10^{12} tons 10^{8-10} men. If different asteroids, or some, differ greatly in elemental and chemical composition (say some being metal and others glass) &r structure (say some being solid and others bubbly), this might justify almost from the beginning the transfer of 2 or more asteroids. The alternative to shipping an entire asteroid would be to ship raw or processed ores, although some asteroids are, for example, thought to be almost entirely iron. Whether a mass of soil or boulders could be made big enough to hold itself together by gravity and be so dispatched and received, or could variously be containerized or bagged, is uncertain, but certainly over the long run, and perhaps directly, shipment of whole asteroids or packets of matter of asteroidal dimension will compete with "mass drivers". Since such enormous energies are involved in interorbital shipment, and the power therefor is assumed to be available at the Asteroid Belt, the materials could just as well be preprocessed, and presumably this will sooner or later be the case for most shipment over such distance. At least a few asteroids, such as Hector, are known to be highly oblong, and a cylindrical asteroid might be evacuated and spun to enable such a colony as visualized by Gerard O'Neill via an artificial cave of enormous dimension (which might also provide better thermal, radiational, and meteoroidal insulation, and structural integrity, than O'Neill's economical specifications, as well as supplying the necessary matter more or less directly, or over time qua core enlargement). If either any or normal gravity proves inessential &r unimportant to life &r industry in Space, the mountainous body of an asteroid might simply be riddled with plexiform or alveolar caves, and perhaps spun, any inhabitants leading a troglodytic existence that could be merry. Such an industrial, inhabited, urban, &r expedient asteroid could remain mobile, possibly equipped with engines, and voyage back and forth or throughout and without the Solar System; within

ASTEROIDS: Size and Brightness



		Diameter (miles)	Albedo
1	Ceres	600	6%
2	Pallas	350	9%
3	Juno	140	19%
4	Vesta	310	26%
7	Iris	125	18%
10	Hygiea	240	5%
16	Psyche	150	9%
19	Fortuna	140	3%

		Diameter (miles)	Albedo
56	Melete	70	4%
44	Nysa	45	45%
511	Davida	170	6%
324	Bamberga	145	4%
704	Interamnia	200	3%
747	Winchester	110	3%
415	Palatia	80	3%
349	Dembowska	90	24%



the Solar System it could sail sunlight via catoptrical ablation, the sunlight also supplying superfluous power for nonpropulsive needs, &r use gravitation for interplanetary orbiting. Such a planetary or natural spaceship might simply be placed in, or selected for, suitably eccentric (interorbital) orbit (although exchanged freight would still demand accomodative acceleration, deceleration, timing, &rc). Many such asteroidal ships might be placed in at least binary orbit between all the major planetaries of the Solar System, or their speeds adjusted. Conceivably ships of such size commuting between orbits might be rendered into more isentropic devices by being sprung between landing-energy regeneration systems as their termini; the stupendous mass of the envisaged ships might even be that which justifies or perfects such interlocal systems, assuming certain economies in their functioning. It is uncertain with what initial and ultimate accuracy an asteroid could be launched to cislunar Space, &r corrected midcourse &r terminally, and at what expense in energy. One estimate puts the number of asteroids of diameter greater than a mile at 100,000. Therefore preselection for size, composition, structure, orbital element, &c could be enormous and highly advantageous: there must be a few ideal asteroids for various purposes. The newly formed Asteroidal Survey, already active in an innominate way in previous years, will have in some sense visited 10,000 asteroids--cataloging, photographing, morphologically and mineralogically mapping, pictomapping (constructing cosmoramas), classifying, and directly or indirectly developing--by 2010, and this noble survey will be employed in selecting candidates for interorbital transfer. It will have been determined whether, or in what ratio, the asteroids are composed of dust, dirt, gravel, boulders, great bodies in aggregates, or more or less fused masses, the extent to which they are glassy vs. crystalline, the extent to which some of them (such as Ceres, the largest) qualify as planets, the extent to which their internal minerals are mutually seperated or to which there is concentric stratification, &c. It is conceivable that a second major belt of asteroids at another Bode point exists, say Plutonian or transplutonian (thus explaining the anomalous perturbations), which might be identical or quite different than the belt which divides the inner from the outer planets beyond the orbit of Mars. If it exists, it will have been discovered by 1990, probably by Earth-based astronomy seeking it. It is possible that, with a certain frequency, the Solar System is visited by interstellar planetesimals traveling at 100,000-1,000,000 mph that might be detected when approaching within 10^{10} miles of the Earth, boarded and reconstructed at perihelion, and used to transport men or machines into extrasolian and interstellar Space. Probably some asteroids are or situate ice, the uses of which in cislunar Space could be many: potation, agriculture, human respiration, hydrogen-oxygen economy, industrial processing, manufacture of hydrogen + oxygen fuel for Spacial transportation and power, construction of solar mirrors out of glacial parabolas and tesserae, environmental decoration in colonies, deuterium and protium fusion, building (eg spherical "grand igloos"), intracolonial weather and air-conditioning (air must not be too dry for comfort and health), protective overcoating of colonial megastructures, heat pumps and hydroelectric power, propulsive mass, giant lenses for astronomy, solar energy, industrial heating, &r planeturgy, &rc. The asteroids may be a source of carbon absent on the Moon, and other minerals likewise. Recent evidence suggests that asteroids of the Belt are indeed highly differentiated elementally, chemically, and mineralogically, even in terms of Solar distance and to some extent in terms of size. Some three dozen different types of spectra have been found, for example, and densities appear to vary considerably. Recently the asteroids have been viewed in terms of past condensation, agglomeration, accretion, heating, metamorphism, and differentiation processes in an effort to explain the accumulating facts. Their materials may well include varying gaseous content. Asteroidal types may vary with the shape and inclination of their orbit. Classification systems used for meteorites on the Earth are considered to be suggestive of the nature of asteroids as well.

Some or all of the following things might never occur, but if asteroids are ever dropped or flung onto the Earth &r other planetaries for engineering purposes then the first time might be in 2010. The full idea is that asteroids (10^{2-12}-ton bodies having a momental energy of roughly 10^{20-30} erg at impact with the Earth) might be propelled to and dropped or even kicked onto the Earth to serve various purposes: to disperse ice caps, expose polar subglacial soil, flake off navigable and useful icebergs (for example, for steerage to and carriage by oceanic currents to meet lower latitude freshwater needs and purposes), build giant craters (artificial astroblemes) for lacustrine and other purposes, damage enemies, release geothermal energy, mine mountains, mine 0-3 miles down, dig great trenches or canals (tangential trajectory), disturb the crust, produce recoverable energy, &rc. Asteroids could function in a similar way on other planetaries and on an enhanced scale (to gouge the Moon, probe Jupiter, pulverizationally mine each other, &rc), &r could be used to probe the Sun (by being thrown through or into the Sun at a certain depth, say having been instrumented centrally), as interstellar ships of planetary dimension, as extraplanetary ships gravitationally accelerated by a grazed Sun, &rc. By way of apology, the original idea was not mine, although I have developed the kernel in various fantastically hypothetical ways which are not absolutely defeasible in 1975 or by me, and which may actually be very practical and useful, and be implemented or tried within 50 years, by 2025. I have learned not to dismiss wild ideas out of hand, even if they seem prima facie fallacious and perhaps condemnable by ad hominem argument. For example, I originally assumed the lot of the ideas was invalidated because the energy involved in interorbital transfer from the Asteroid Belt to geocentric space was directly producible and usable on Earth without recourse to any such imported projectile as an asteroid, and that the latter scheme would simply squander money without having any vindicating advantages: escape velocity from Earth is equal to the velocity necessary for interorbital transfer, or to the energy involved in the orbital discrepancy, so that the reacceleration to earth by Earth's gravity would at best recover the invested energy, even if the reacceleratory energy could somehow be captured on the ground with nearly 100% efficiency (so that the material, per se, would be transported without losing energy in an overall system), or the energy sacrifised but not regained for but a fraction of the terrestrial worth of the imported matter (presumably efficiently recoverable in a crater). This would seem to defeat any utility of asteroidal transfer for the production of energy on Earth, except perhaps marginally at some far date in the future when incredibly efficient technology would hypothetically have evolved without simultaneous evolution of preferable systems for the production of useful energy, and therefore to defeat at least one proposed use for asteroids (<u>conceivably</u> such asteroidal systems might work heliofugally or for Mars, with invested energy being recoverable in whole or part). Too, the energy involved in transmitting asteroids to the Earth (much less the Moon or cislunar space) is so considerable that one would assume it would be easier and better to produce it purely locally, perhaps in comparable magnitude, for the mining and other purposes (the justification for which is not clear in any case). But it is not inconceivable that the extreme momental collimation of the asteroidal mass projected could be highly advantageous to the spherical forces producible locally by nuclear or chemical explosives, and the nonradioactive asteroids might additionally be advantageous over nuclear bombs used on Earth (although these might have propelled the asteroid initially). Possibly the asteroidal projectiles would possess such a greater ratio of useful energy, as massive particles cohering to each other en bloc, that would generally or specifically be advantageous to nuclear bombs which have the form of energy they do, that the asteroids would be used instead. These notional superiorities are only meant to illustrate the possibility that asteroids may have unsuspected

utilities. It must be pointed out that there are laws of diminishing returns for the impact of a projectile and for the explosion of a nuclear bomb in various milieus, and the effect of massive meteors on the surface of the Earth (as illustrated by ancient astroblemes caused by calculable masses) can be disappointing, even or especially where the meteors are one or many kilometers in diameter. Of course, this could make the use of such colossal artificial meteors safer, even on Earth. The crudity of the method is not necessarily an argument against it; crudity can be simplicity and elegance, and simplicity can often be advantageous. The number, size, and distribution of asteroids outside the Asteroidal Belt &r of highly eccentric orbit is another matter entirely since the energies essential to adjusting their course and effecting a collision (however difficult to calculate for precise purposes) are in many cases comparatively slight, and some asteroids of enormous mass periodically or occasionally come within hailing distance of the Earth and could well be deflected into it or the Moon (or conceivably moved into geocentric or lunicentric orbit, or the like). If asteroids exist that are kilometers in diameter and yet largely ice, and this is possible, they might be directed to, say, the surface of Mars, vaporizing or not on impact, and supplying 10^{9-11} tons of water for atmosphere or irrigation (a moon of Jupiter composed largely of ice could imaginably supply Mars with an ocean of greater mass and depth than Earth's, and an atmosphere 1,000 X as massive as Earth's; such a Martian ocean might be biologically warm abysally or benthally owing to a greenhouse effect &r the planet's heat flux from the interior, regardless of the temperature and state of its surface, or perhaps as a result of a larger atmospheric greenhouse effect produced by the "atmogenic" ocean, and thus support an enormous aquafarmable biomass at depth or surficially (perhaps especially if planeturgical schemes for producing oceanic currents and high water aeration are possible and applied)). The more fantastic uses for asteroids which I have suggested above might be meaningful at progressive times in the future far beyond 2010, so they should not be dismissed from imagination by artificial confinement to this early stage of Solian development; all should come into being, if ever, well before 2175. It occurs to me that the orbital velocity of the Earth is a factor in the equation for any possible efficiency and production of energy by interorbital transfer of asteroids, and perfectly restores their conceivable advantages to other sources of energy and role in the production of energy via fantastic schemes; this underlines my point that such fantastic possibilities must be reviewed with utmost care and not dismissed on the basis of a priori doubts that may well be totally erroneous. Obviously these possibilities must be subjected to exhaustive analysis in the future that may render them very attractive, given the means. One could imagine dropping an asteroid in a clockwise parabolic orbit around the Sun with a minute perihelion in such a way that it would collide with such a planetary as the Earth or Moon on its return trajectory, in a highly efficient use of energy demonstrating possible ballistic ingenuity. An asteroid 2 miles in diameter orbiting the Earth at 10^{-3} the Moon's distance, or 200 miles, would appear as large as the natural Moon in the sky and exert as strong a gravitational attraction, at least regionally, although with a different and perhaps more powerful tide owing to a revolutionary frequency almost 10^3 X the Lunar month; yet it would be far easier to silver, flatten, &r render concave the surface of this artificial moon since the construction would be 10^{-6} the area. What tidal engineering, or engineering using tides, is possible through such artificial satellites is not immediately clear, but probably many ingenious and highly important things could be done in this way, and will be understood and possibly exploited in the future, say between 2010-2050. Similarly, increasing or diminishing the Earth-Moon seperation, and hence the length of the month, could exert various important effects and be sufficiently advantageous overall to justify its being done eventually, since the seperation prevailing naturally is inapt to be ideal for human purposes, but the set of

decades	increase (x)					
0	= 1 [20% increase p/x]	1 [5% increase p/x]	1 [40% increase p/x]	10,000		year:
0.1	= 1.2	1.05	14	Σ tourists/y (Estimate)		2010
1.0	= 6.19	1.63	29	20 59	14T	2011 AD
2	= 38	2.6	837	60T	16T	2020
3	= 237	4.3	24,201	330T	26T	2030
4	= 1,470	7	700,000	2M	43T	2040
5	= 9,100	11.5	20M	15M	70T	2050
6	= 56,348	19	600M	91M	115T	2060
7	= 348,889 X	30X	17B	563M	196T	2070
				349B	308T	2080

such positive, negative, and neutral effects--and the proper sign, degree, eccentricity, inclination, precession, &rc of variation--are not in my, nor probably my contemporaries', power to foresee, &r even to describe &r explain. It is not even known whether the Moon plays a role, or once played a role, critical to known or important biological, meteorological, &r geological phenomena, or might as well vanish or never have been; this carries over to any possible values of creating such moons for other planetaries, or asatellitic ones such as Mercury, Venus, and the Moon, or virtually asatellitic ones such as Mars. But the redesign of the Solar system which could, should, or will occur in the future might be enormously extensive, ingenious, advantageous, and exciting for all its disinterest now. The energies basic to such feats will become available before 2175, along with the means for their use and perhaps the initiative. Such possibilities are discussed much later on. We do not know what geological, meteorological, climatological, &r biological consequences would directly and indirectly result from dropping a 10^9 ton asteroid on the Earth at an angle of 0-90 degrees, velocity of 17,000-50,000 miles per hour, at certain loci, &rc, nor do we know what would be the scale, goodness or badness, predictability, controllability, intercombination, essentiality, &rc of the consequences--yet all this knowledge is more or less essential to evaluating the technological options, and elevating or dismissing the basic idea.

There will be of the order of 10^4 tourists visiting Space each year by 2010. X By tourist is meant someone whose leading reason for making the trip is not business, medical treatment, administration, scientific objectives, or the like, but simply someone who is going there for the experience. Motives for such touristry will be various, including prestige, curiosity, adventure, and pilgrimage. Probably 50-90% of people, given the chance and having the means, would like to make such a trip as a voyage to a geocentric satellite, at which they could look back and down upon the curious, finite, and closed sphere in which life began, to which their existence is almost entirely confined, and which is their home, at least once in their lifetime, if not repeatedly. The spectacular experience would have the same ubiquitous magnetism as the Empire State Building. Whether or not sought for such, it would have philosophic impact upon the lives of those experiencing it and humanity as a whole, constituting an emotional and aesthetic climax, and being a lesson in humility. The beauty of the planet Earth would be manifest, inspiring higher and lasting reflections; and the unity of nations, of man with nature and the universe, and of man with man would acquire symbolic and imperishable form. The beauty, grandeur, mystery, and poetry of the Earth viewed from orbit is doubtless infinitely greater than is supposed, can be told in words, or shown, and the impact on many would doubtless be epiphanic and staggering, without equal in their lives. The desire and intention on the part of mankind to have the experience, consequent upon the first touristry, will unquestionably explode. Great numbers of men, a large percentage of mankind, will be so bitten by the experience that Space will become for them the goal of their lives, and they will initiate colonization of Space, facilitate touristry, and endlessly extend the boundaries of touristry, colonization, and exploratory frontier, encompassing an ever greater volume of Space, multitude of worlds, and variety of conditions. 10^{3-4} tourists will be the inflection point for touristry and the greatest catalyst for the exploration and development of Space as a whole. The tourists will pump tremendous money into Earth-Space trade and intraspacial economy, that will in turn function autocatalytically to balloon the Spacial enterprise and to render the development irreversible and autonomous. From 2010-2020 these mad tourists, eager for more and determined to surpass themselves, will spill over from periterran Space to new Geoselenian L-4 and L-5 colonies, bases and interspaces everywhere on the Moon, interplanetary Space, and (as a fateful trickle) other planets and the asteroids, the growth averaging perhaps ~~5%~~ 8% (5-40%?) a year for 5-7 decades, however transilient or irrational. The growth of the enterprise will simultaneously

lower basic or transportional costs and prices, and increase average per capita and nontransportational expenses, both by a factor of 5 in their respective directions; yet the ever lengthier trips and stays will in turn multiply both by a factor of 5. Homesteading and real estate corporations will evolve in connexion with the rural, urban, and suburban occupation and development of the enormous surfaces of the Moon, Mars, asteroids, &c, and the diverse condominia of epiplanetary and extraplanetary colonies. Governments will assist groups of 10-100,000 men, women, and children by 10-300% grants &r loans to founders of colonies, perhaps especially if the colonies are founded rather where the governments wish, in conformance with plans, preexistent populations, national precincts, developable resources, extant facilities, known or unknown territories or environments, &r the like. This might particularly become the function and desire of the Governments of Earth, Space, &r the Solar System existing or developing at that time, or from 2010-2070. One could imagine a Spacial Development Authority becoming such in name over this great epoch, and exerting considerable, increasing, or dominant influence while experiencing a variegation of its powers, functions, obligations, &c. A growing number of tourists will come from other nations and socioeconomic groups. Important leagues will form on Earth for the visiting, developing, occupying, studying, &c of Space. These will consist of enthusiasts, entrepreneurs, lobbyists, explorers, scientists, and even religious devotees. Attending the growth of Spacial touristry, business, and migration will be a spirit of sincere cosmopolitanism, panhumanism, and futurism on the Earth and in Space. Spacials, particularly, will look upon the flags, capitals, ideologies, manners, and even mentalities and lives of those on Earth as silly, irrelevant, and offensive, and develop their own homogeneous and heterogeneous ethics as exponential units of time pass, generation succeeds generation, and the texture of human life in Space varies and mellows, habit replacing innovation, familiarity replacing novelty, and leisure replacing adventure in various Solian milieus. Over the long term, however, between 2020-2075, the complexion and propensities of civilization will be radically altered, without precedent in human history, by powerful and decisive interventions in the design and function of man's nervous system. Like the future of computers, however, this theme is too important and transfiguring that it can be handled in connexion with the future of Space, and, despite its almost certain impact, it will be suppressed almost entirely in this book except for isolated and marginal treatment. The future of Space in the 21st century admits of dichotomous treatment since it may either be modulated by the growth &r triumph of post-industrial society, leisure, and tertiary and quaternary economy, or instead by the continuation of an order which prefers work to play, serious to amusing adventure, growth and progress to stasis or even some reversion to nature, higher to lower values, sacrifise to indulgence, idea to thing, variation to repetition, artifact to nature, ambition to mediocrity, &rc; in numerous other ways the character of mankind may alter between 2000-2100 and thereby vary completely any concurrent civilization of the Solar System, or even abort such civilization. In turning from this subject it is not an unreasonable conjecture that human population itself will divide along such dichotomous lines, and maintain by opposition each great family of mankind, the effect being the full or even stronger development of Space over the period, if not beyond. The boredom of leisure can be the origin of a preference for good work.

The year 2010 can stand for the date by which the first human birth will have occurred in Space. Given that the number of residents and tourists in Space by 2010 will be in the 1000's, such a late date will presume an impressive contraceptive effort on the part of people; perhaps too impressive, and the birth might occur by 2000. Whenever it occurs, it will function as a symbolic or influential turning point in Space and Solian civilization. Those born in Space

will generally give their allegiance to Space and not to the Earth. Nurseries, schools, playgrounds, &c will already exist in Space for the young of Spacials, tourists, and other visitors, but these will become greatly amplified as the unique birth is quickly succeeded by a flood of births. With these births will start the population of Space by multitudinous natives adding themselves to the flux of immigrants and ultimately becoming more important. Ultimately those native to Space will visit and emigrate to Earth, although the high gravity may act as a critical restraint and counterargument, creating an asymmetric ratio of population increase in Space to its increase on Earth. Actually by the middle of the 21st century Terran population may have ceased growing altogether, or even be falling, while vacant Space may be experiencing accelerating population, regardless of the means then common for increasing or decreasing one's own fecundity, which may be absolute &r universal. A pronatalist policy &r fervor may spasmodically, continuously, or eventually dominate Spacial milieus over 2010-2100, regardless of its specific raison d'etre. Such a prospect, and its novel philosophical bases, are discussed directly on pages 268-275. Spacial touristry will have its vulgar and splendid sides, and its devolutions and evolutions. Its institutional basis might be more governmental than corporate, although presumably there will be mixture.

If it ever occurs prior to 2050, 2010 will be the year by or during which materials will be "dropped" meteorically to a planetary, at first Earth &r the Moon, for crude recovery. Terran landing sites would tend to be such vacant places as midocean, deserts, the Antarctic, the North Pole, boreal tundra, &rc. "Artificial supermeteors" are great objects or masses dropped purposely to earth from Space by man in the future as a transportational short-cut or method of engineering (as above). Theoretically they could range in size from those pebbles of such density-with-mass as would slow their descent to a point that undesirable decomposition or evaporation would not occur, or impactive disintegration, or from 10^{0-13} tons. In the latter case there might be warrant for reducing their mass to 1-1,000 tons; above a 1,000 tons the atmosphere would not slow them, and below a ton some floor exists to further atmospheric deceleration, but over the specified range 200-fold deceleration of meteorites can operate and maximize velocity at as little as 400 mph (these being suggestive estimates) at impact. Excessively large (by which is meant enormous and millennially rare) meteorites have never been recovered, their fate being unknown. This commentary has concerned unshaped and unguided meteors, however. Oblique trajectories, pelagic reception-points, and aerodynamic design for friction or fluidity, bluntness, lift, &rc are also possible for perfecting delivery; asteroids or fragments might even be selected for better properties! It is unclear with what preciseness the path of bodies or showers could be predicted, followed, or guided, or what precision would be economically desirable in terms of unclear methods and difficulties of surficial recovery at points in the future. Asteroids existing naturally as, or made into, light foams could conceivably just "float" to earth (the energies necessary for such conversion would be comparable to those involved in transportation; all this assumes the absolute or relative cost of energy eventually falls to the dubious nadir where mining of base or even "precious" minerals over interplanetary distance turns competitive, perhaps 3-4 orders deflated from 1975!). Anatmospheric planetaries such as the Moon would not naturally decelerate such meteors. But the Moon is presently unoccupied and undisfigurable (as well as marketless), possesses a sixth Earth's gravitation, and conceivably might receive terminally motionless (only lunigravitationally reaccelerated) projectiles and projectiles arriving on tangential or even concurvate trajectories. Objects dropped onto Earth might be dropped into the same industrial crater, or crateral crucible, for integrated pulverization, heating, fusion, vaporization, &rc--and thus also on other planetaries, the effects recovering the invested and critically costly energy; the technique might, for example, desilicify and degas iron-nickel

asteroids or asteroidal chunks ("asterites"), although I only drop this on the reader as a necessarily inexpert figure for the galaxy of likely alternatives. Mining subcraterally for valuable meteorites (that might, for example, be unusually rich in platinum or gold: iron meteorites are uniquely rich in the Platinum metals) has already been attempted, if unsuccessfully. The overall economy surmised, in any case, would be through an advantage, analogous to Gerard K. O'Neill's proposed use of "mass drivers" in lieu of ships, of material transport over interplanetary distance and through planetary atmospheres and gravitational fields sans costly ships or containers, the raw material simply (with more or less guidance over its course) being sent qua natural meteors from its origin in the asteroids, or elsewhere such as the Moon, to its planetary destination. O'Neill's mass driver is intended to propel almost or very microscopic objects, or so-called "mitraille", but the bullets I intend would be macroscopic and range upwards in size to planetesimals; their mode of launch, and methods of recovery, might be basically similar or dissimilar (linear acceleration of the magnetic iron-nickel asterites might be ideal). The titanic and planetary asteroids transferred to cislunar space, as previously imagined, could easily give rise to a small or large central or synergistic mining and refining industry, and, assuming certain things produced in this way more valuable to Earth or the Moon than the, say, Lagrangian colony, these minor valuables could be sent meteoritically ("flung", in the argot of the future) to the planetary market. Possibly this meteoritic method will never be used or adopted, and have no effect on alternative systems of transportation.

The first mining of a jovian planet conceived as occurring by 2010 and discussed above, will probably take the form of initial mining of a moon of one of these planets such as will transpire before 2011. Titan of Saturn is 3,500 miles in diameter, abnormally hot (presumably as a result of a hydrogen greenhouse), possessed of an atmosphere that may be a few tenths as dense as ours and that is overflown by sanguine clouds, and probably contains snows and ices of water, methane, and ammonia. Organic molecues of considerable complexity, interest, mass, and perhaps minable value may very well be discovered on it. Man may fly the moon by--even at a few 100 miles--as early as 1981, 29 years before the mining foreseen for it or a cousin. A difficulty with intersatellitic, so-called "microsalient", exploration and visitation of the satellitic families of the jovian planets is that these constitute minor solar systems (most of Jupiter's moons lie at jovicentric distances of the order of 10^7 miles) and the velocities of the moons are as energetically demanding as interplanetary travel. Possibilities for mining these moons have already been considered in connexion with mining their planets, with which there may be critical similarities, or differences just as important. Eventually the minor solar systems with their natural, but transformed, satellospheres will literally birth local and introspective subcivilizations within Solian Civilization. The very velocity of some of these satellites will diminish the energic requirements for maneuver within the megagravitational fields of the jovian planets, or some of the needs for interplanetary travel, since some expended power will be recovered during launch from the celeritous systems, perhaps a la Gerard O'Neill's bicylindrical &c intercolonial transportation via engineless vehicles (the craft operating in these planetary --or "planetosatellitic"--systems might be at least supplementarily impelled and powered by remote sources of energy, acceleration, &r guidance, as so-called "exomotive" or "exodynamic", rather than "esomotive" or "esodynamic", craft or projectiles). Ingeniously, these fleet moons could be approached at orthoparallel loci and left likewise but hemicyclically (halving commutative energy); conceivably or eventually a landing energy regeneration system will arise enabling periapsidal, or even favoring antiparallel, visitation.

Some of the moons have highly eccentric orbits, furthermore, and corresponding variations of velocity; there are possibilities to be studied here which could furnish, combined with the preceding, almost ideal mechanisms of interplanetary, intersatellitic, and between-satellite-and-planet transportation, and even for net overall power production from the planetary momenta (which are truly astronomical). A perfectly nice opportunity is suggested by the fact that the inner and outer moons of Jupiter are antiparallel, if only some efficient landing energy regeneration (or "cataleptic") scheme--or overall, say, electromotive-pondermotive intersatellitic cycle--could be developed for a suitable mediative oscillator. An important question is whether satellites and asteroids generally are mineralogically and otherwise interchangeable, which would depress some or most of the immediate interest the jovian moons might otherwise have. Mining of in situ materials for bases, colonies, and other purposes on these moons will occur regardless simply as a matter of convenience; in this case a certain question arises over the completeness and complementarity of their spectra of elemental, chemical, &r mineral prevalence. The Solian plot of mass against density suggests that satellites and asteroids diverge from one another as classes in terms of structure &r composition, although the reason and significance are not understood. The asymmetry of the Moon's subgeal and antigeal hemispheres--in terms of mass concentration, figure, feature, &c--and suggestions of the same hemispheric asymmetry for other planetaries, imply that planetaries--perhaps regardless of their rotational-revolutional indices, at least presential--may not only differ in these ways interhemispherically, but also in a much subtler and antipodeally stratified way heliocentrically or planetocentrically, and be valuable for mining in these dichotomic or bipolar terms; although the question of qualitative and quantitative degree will be decisive. It deserves reemphasis that the variety and idiosyncrasy of jovian planetosatellitic systems, both within and between themselves and the Solar System as a whole, may well turn out to be so great and important in terms of composition, morphology, &r conditions that the Solar System will for all purposes deserve to be treated as a medley of several solar systems as if the solar systems of several surrounding stars were to be torn from the vault of the heavens and juxtaposed within ours, perhaps even because aspects of variety between satellites are as great or greater than those existing between the various planets or per heliocentric distance, perhaps thereby--upon its discovery--multiplying the difficulties and opportunities alike for any future Spacial program prosecuted by Earth, or favoring at least temporary concentration upon the revelation and exploitation of an intersatellitic palette and realm. This illustrates a larger point, that the symphonic development of Solian Civilization has many choices before it and only a wizard could predict which selections the engine of progress will make as it traverses the sphere of the universe. The first asteroid will have been mined a decade earlier, in 2000.

If it occurs before 2030, military bases will exist in Space by 2010. The previous discussion of a geocentric bombardment fleet that might be with us, if in Space, by 2010 gives an idea what such bases would mean, be, and serve. The initial base--whether explicit or implicit, obtaining in posse or esse, observational or also armed, geocentric &r spaciocentric, big or small, sudden or organic, diverse or ad hoc, overseen or autonomous, neutral or antagonistic, self-sufficient or dependent, vulnerable or invulnerable, strategic &r tactical, innate or anticipatory, defensive &r offensive, inoffensive or provocative, malign or benign, stabilizing or destabilizing, necessary or inessential, inevitable or optional, encouraged or discouraged, transparent or secretive, known or unknown, propagandistic &r functional, analytical or operational, visited or unvisitable, inspected or uninspected, multiplicative or sufficient, inimical or friendly, revolutionary or ordinary

in itself &r by the character of the weaponry it boasts, &rc--will be at a periterran or an extraterran locus. It may or may not be the cause &r effect, or be complemented by, the geocentric bombardment fleet--or other manned &r unmanned forces of mobile, semimobile, or orbital kind--previously considered. The first base will probably be cue, cause, &r sign for the formation of diverse military stations, bases, and colonies--and the introduction of weaponry and men--at diverse Spacial loci. The living, intelligent, superintelligent, autonomous, uncharacterizable, unpredictable, voluminous, delegatory, superpurposive, gubernatorial, creative, omnificent, autoreproductive, infinitely diversifiable, protean, endlessly evolving, never-to-be-understood, transpolitical, humanly distrusted and resented, omniscient or seemingly omniscient, ultimately defiant, and ultimately transcendent machines--previously hinted and discussed as appearing initially around 1995 and 2000--will obviously have absolutely staggering implications and impact upon the future of war and peace, however muted by historical people like ourselves for reasons of emotion &r ignorance. Even limited forms, roles, schedules, and other degrees of such alien automata--or brilliant and universally important computers--will repaint the future of Space and Earth alike in a thousand ways. Suffice to say that machines of various sensory, motor, mental, and operational powers may over this period, and progressively, do the like of fully or largely automating weapons, bases, observatories, inspections (eg robotically), calculations, and eventually strategic planning, adjudication, and everything else. Some of the "mental" aspects of the machines may and will include--integrally or seperately--human and superhuman memory, infinite storage capacity, infinite associative power, instantaneous retrieval, incessant application and exercise, absolutely photographic character, infinite variegation and evolution of associative systems, universality of subject, unlimited simultaneous use, infinitely abstract and infinitely concrete--eg cinematographic--kind, fully parallel circuitry, striking recognitive powers, &rc, virtually instantaneous thought and reaction, ability to execute simultaneously any number of tasks of any complexity and difficulty, powers of mathematical calculation and thought simply unimaginably great, continuous and supernaturally intense vigilance, virtually apodictic and deterministic reliability, perfect autoscopy, superhuman consciousness, superhuman creativity, perfectly controlled and transcendent "emotions", virtually instantaneous development and learning, semidivine insight into nature and use of the informational scatter of the environment, sensation and perception incalculably beyond man (in detail, variety, autocorrelation, intercorrelation, spectrum, immensity, geographic complexity of input, rapidity, focusability, precision, subtlety, dynamics, quantitative properties, morphological diversity, contrast, inconspicuousness, use, &rc, immortality, superhuman specializability, superhuman generalizability, and so on to infinity. Again, the impact of machines of this order, or any pastel of it, on military affairs, Space, man, &c will be radical, indeed, and one can only enumerate possibilities and eternally interlink them, and the subject is officially suppressed in this book. Man's dispersion into the Solar System before and after 2010, especially the appearance of "finite" and "infinite" second and redundant "earths" over this period (first on the Moon in 2001, then on Mars in 2008, and so on increasingly with the years, almost as an exponential process; but also in geosatellitic, Lagrangian, and other autotrophic communities concurrently), will dilute the military, strategic, political, and eschatological significance of the Earth, decrease or increase the importance of the initial and other military bases, complicate certain military purposes, change the scale of civilization (regardless of military budgets), foment new and possibly more virulent forms of human hatred and belligerence, give man the reason and something of the opportunity to abandon his martial ways more or less permanently, profer

the human species an unprecedented opportunity to unify or at least harmonize itself socially and politically, supply us with a universe of nonideological motivations, &rc. Incontestably, a military base orbiting the Earth and visible and rather impressive from the ground to coplanar peoples would be a psychologically sinister and bothersome thing; perhaps even an intolerable star. People don't like being reminded of Damocles' sword, and perhaps they shouldn't be. The Heavens might come to look like a game of chess. An indistinct geosynchronous military satellite at 22,300 miles--perhaps even friendly--is another thing, however equipollent and lethal. It is not even sure what a military base, say orbiting Earth at 100-100,000 miles, would do--what great purpose it would serve. Excellent possibilities which come to mind are familiar or superscientific global and enemy reconnaissance and surveillance, roles in command and control, powerful peacetime and wartime communications, a good seat on the action, interception of hard weaponry launches (say by gigawatt or terrawatt basers), Interference with or other countering of an enemy (say over a bit in the next geosatellitic base), monitoring of all interspacial and intraspacial traffic, parity to the civilian Spacial program, operation of tremendous edar facilities, acquisition of military skill and capabilities in terms of imaginable contingencies in the future of Space, monitor the distribution and order of an enemy's forces and construction activities on the surface of the Earth, "telescopically" or otherwise guide missiles to microtargets, &c. Some of these things can be done terrestrially, aerially, suborbitally, telemechanically, robotically, or on a smaller scale or in a less pretentious way. Some of the things are already possible, or being done in a way and degree. A military station need not necessarily be equated with a military base, and there is the question of permanency, scale, nature, &c for a satellite or installation to qualify as a so-called base. The American Department of Defense may soon build and operate a military Shuttle and Skylab; in a sense the latter could qualify as the initial Spacial base. The Soviet nonmilitary program is secret enough, but we have little public idea what their military Spacial program will, and already does, include. It is conceivable the Russians have already launched a military analogue to Skylab, regardless of whether it remains in orbit or is periodically visited, or what precisely it does; but if they have not, and assuming this does not reflect their space-technological inferiority, this may imply that the possibility, at least at this time &r by the Russians, is deemed unwarranted, inessential, ineffective, &rc. It does not seem like an overture to benevolent abstention from a military option.

The "inevitable" development, construction, &r operation of a supreme computer in Space owing to the latter's extreme cold, thermal absorptivity, conductivity and nonretardation of light, &c (assuming other ambient radiation is acceptable) will finally occur by 2010. The development is viewed by many as inevitable because of the ideality of conditions in the interplanetary vacuum. One might argue that a place like the Moon, an asteroid, or far Pluto would be even better owing to the greater thermal conductivity of solid ground and the insulation these frigid bodies might provide from natural and artificial radiation, not by filling half the sky, but for a computer located deep underground (in the case of those planetaries whose interior is not warm). Of course other factors deciding the better location for such a computer or computers, at various points in the future, will be competing considerations. To what extent would a difference in temperature, or a given approach to absolute zero, be important for machines of various design? To what extent, at points in the future such as 2010, would cryogenic means exist for transcending natural temperatures, heats, and other conditions in terms of, or going beyond,

these same? Colder operation is conceived as essential for maximal informational density, operational rapidity, stability of memory and reliability of process, simplicity of design, computational precision, exploitation of finer physical effects and relationships, maximal 1-3 dimensional size of computer, and the perfection of the various processes of recording, access, use, erasure, operational simultaneity and multitudinousness, &rc--in a much more than linear, for example in a cubic, way. It will become ever more important and critical as the power and sophistication of computers rise, especially by 2010, and perhaps toward then making the Spacial loci decisively beneficial or essential. Conceivably by 2010 the Photonic Era will have succeeded the Electronic Era, and the extremity of the interplanetary vacuum will have justified the location of a computer of photonic type there for the sake of exploiting the speed of light in a vacuum as opposed to electrical transmission by subluminary wire. The higher frequencies and energies of light will favor miniaturization and accelerated computation. Sometime over the period 1990-2050 will arise transmission, circuitry, and computation with parts of the electromagnetic spectrum higher in frequency than visible light, and the highest that material technology can then deal with usefully--ultraviolet, x-ray, and gamma ray; these special revolutions will enormously increase computer power. The computer or computers in Space will presumably forever increase in size, complexity, sophistication, ability, &c. The potential value and accomplishments of future computation, being infinite or inexhaustible, will justify endless perfection and augmentation of computers--as, indeed, I have been suggesting elsewhere--and it is reasonable that the ratio of mass, energy, materials, tasks, benefits, evolution, &c of computers over mankind will exceed unity and increase hurriedly in indefinite fashion, almost certainly before 2050. For example, by 2100 virtually the entire extrasolar mass of the Solar System will probably--if one is to be precise--be absorbed in computational, mental, &r ontic circuitry; this very odd prediction will be discussed later, and the conservative reader may, if he wishes, dismiss it from his mind for the while in preference for a more purely anthropological conception of the future of Space. It must be understood, however, that the attainment by machines of unambiguously human and transhuman intellect and "being" is not a sine qua non for such ratios of men to machines as I have foreseen: the astronomically great powers of computation that even ordinary computer software and hardware could attain by simple scaling up would doubtless justify themselves, and such up-scaling, in terms either of tasks assignable today or those additional and further ones that will unquestionably appear around and beyond 2010.

The year 2010 may as well serve as the date by which there will begin to be realized certain "absolute minima" of transportive, maintenance, and operational costs, with reference to Space. In some cases the costs referred to will subsequently both fall further and rise, so it is relative absoluteness that is being referred to. The main point is that current 1975 costs are probably significantly and often radically depressable in terms of what science, technology, and abstract economy allows, and that by about 2010 one could expect a set of ready opportunities to be exhausted, a plateau of sorts to be reached, &r great improvement over what has so far been possible in Space. The independent, interdependent, or combinable bases of such reduced expense can easily be tabulated, as below. These bases are complex and subdivisible. They should be carefully investigated. The present and future exploration and development of Space will be limited, colored, and even scaled by what is or is not possible in terms of these tabular categories, and the history of costs prior to 1975 should be researched in terms of the determinable mechanics of these basic categories and their way of changing with time. Many of the categorial costs are not simply objective and are amenable to compensatory and preparatory acts on the part of antecedent policy-makers, scientists, and public

THE ABSOLUTE MINIMA IN TRANSPORTIVE COSTS

1. Maximal duty cycle (ie minimal turnaround time).
2. Maximal load (in weight, volume, &rc per ship, system, &rc).
3. Ideal size for any scientificotechnological law of size or dimension.
4. Greatest passenger number per launch, ship, &c.
5. Greatest economies of scale: in terms of industry producing ship, use of systems, least marginal charge, &c.
6. Governmental (ie non-profit) subsidy or running of the service.
7. Risk-taking, achieved safety, &c. For example, the space program to date has been very inefficient because of excessive safety reflecting politics.
8. Total reuse and eternal life-span.
9. Minimal maintenance, repair, &c in duty cycle.
10. No-cost energy.
11. Exomotive travel: periplanetary and intraspacial baser propulsion, linear accelerator, mass driver, &c.
12. Perfect drive: fission, fusion, ionic, antimatter, &rc.
13. Research and development (R&D) costs terminated and debts paid.
14. No or least backup: in terms of launch facilities, personnel, guidance, &rc. For example, maintenance and checkout done by flight crew instead of others.
15. Minimal or no crew (ie perfect automation).
16. Perfect guidance, control, theory and electronics replacing on-board and other systemic needs, &c.
17. Ultimate fuel.
18. "Intervehicular staging": for example, using three vehicles successively.
19. Such intervehicular staging dispensed with altogether.
20. Unistaged (ie unstaged) launch or flight (ie SSTO).
21. Maximal total annual passengers, number of flights per passenger, &c.
22. "Learning", or a "wise" stage.
23. Relative value of freight, materials or persons; the ratio could be infinite.
24. Relative human wealth (which could be infinitely greater than in 1975).
25. "Unhulled" transport, both microscopic (via mass driver) and macroscopic (driven asteroids).
26. "Circular entropy", which refers, for example, to gravitational "pendular", &r electromotive-ponderomotive "regenerative", schemes for interplanetary transport which minimize flight entropy or mimic perpetual motion; one of the most important developmental curves describing the future of science and technology, in various areas and overall, will be that plotting progressive reduction in the entropic product of customary actions.
27. Transportation using, in fractional fashion, the energy &r value of energy (eg fuel) obtained en route, and netting positive profit &r energy; examples would be ferried fuel, atmospheric and intraspacial "ramjets", solar energy drives, modes of "sailing", &c.
28. Miscellaneous things like disposable drop tanks, orbital fuel storage facilities, semifueled takeoff and in-flight refueling, aerodynamic descent, &c.

It was on the basis of some of these things that Maxwell W. Hunter II, in a 1968 paper titled "Propulsion Systems for Manned Planetary Missions", argued that the cost of single periterran, terrilunar, and interplanetary missions, alike, could be reduced by as much as a factor of 150-500 from what it then was--a shocking assertion, by Lockheed's Director of Advanced Space Programs. I have given an interval of 35 years--twice the time since man launched Sputnik in 1957--in order to let certain minima emerge. One wonders what economies will have been attained by 2045, 2080, 2115, 2150...., and the impacts these will have on what man does in Space.

By 2010 a ground-based laser on Earth will for the first time have been used to lift a craft or other objects from the ground and propel them into Space. The feasibility and relative value of this exomotive mode of propulsion are probable but not certain, but calculations suggest that it may be more efficient or economical, overall, than current modes of esomotive propulsion using on-board chemical engines of any description. The energy of the baser (probably laser) beam will be of the order of 10^{8-10} watts, say 1 gigawatt, and the ideal mode will probably be a direct system of continuous explosive ablation of an aft shield of some composition, structure, weight, efficiency, &c. A continuous gigawatt baser beam naturally possesses stupendous power, and even though existing or orbiting the projectile in only a few minutes (for the acceleration may be strenuous), lineal, and perhaps cooperating with a set of highly seperated (and perhaps highly numerous) beams only converging at the target, might pose a threat or nuisance to unrelated aerial operations, or require highly controlled launch. Such beams might propel aircraft as well, if efficient, and continue to operate in the depths of cislunar and even translunar Space. Their development will be motivated as well by military (destructive), Space-Earth and Earth-Space teledynamic, and other purposes not directly related to Space (such as the hope of achieving controlled fusion using basers), a conspiracy which may insure their eventual and quick development. An alternative to ablative propulsion is some method of receiving, converting, and then using the power of the directed baser beam, which requires a ship and diminished efficiency. Such beams from epiplanetary stations can serve not only ascent but also descent, or the full cycle of spacioplanetary intertransportation. Eventually entire interplanetary flight cycles could be managed by biterminal, and perhaps certain intraspacial, baser stations (the basers used specifically for intraspacial and anatmospheric flight, being unconstrained by atmosphere opaque to supravisible photons, could be the more powerful supravisible types such as highest frequency grasers using gamma rays). An epiterran beam attenuates divergently from its power at minimal orbit (100 miles altitude) by a factor of 10^7 at lunar distance and of 10^{11} at martian distance, regardless of the convergence possible, but decisively in terms of the convergence possible. I do not know the practical and theoretical limits to collimation and convergence of photonic beams through the media of planetary atmospheres and the interplanetary vacuum.

Such teledynamic propulsion via basers in 2010 will be the start of a method, system, and network of so-called "baser rails", or of "phototelpherage". Planetospacial, periplanetary, interplanetary, &r intraspacial baser beams--at least as powerful as just discussed and eventually infinitely more powerful (say for regular, multiple, heavy, &rc traffic)--will thus be ridden by pioneer probes, ships (so-called "telphers"), traffic, &r "freightage". The baser propulsion may be either convertive or ablative, as just discussed. Like companionate searchlights, beams originating from powerful perisolar stations might spoke the Sun to run ships and laboratories navigating and dotting the immense Solar System. Eventually such beams will spill into extrasolian Space. The real economy involved in such exomotive transportation is in eliminating extra fuel needs related to the additional transport of on-board fuel, engines, and perhaps other navigational equipment, and the gains achieved by reducing such encroachments on payload are more than linear and can even be transcendental. Of course, ablative propulsion in vacuo, rather than in an atmosphere, is wholly momental, but this limitation applies equally to other modes of propulsion. It is conceivable that exomotive photopulsive systems, or stational systems, are possible that do not involve, and are not analogous to, "basers", say ordinary or extraordinary (perhaps now unimagined) optical systems--whether catoptrical, lenticular, &r otherwise--of either focal or collimatory kind; such systems, if feasible and economical, might at various points in the future, and in various ways and degrees, compete with baser systems in powering a Solian teleferic network evolving initially between 2000-2050, and perhaps playing a key role in the historical development of the Solar System.

Between 2001-2075, probably by around 2010, Jupiter's hydrogen, which is thought to be 80% of the planet's mass (which is itself 320 X the Earth's mass), will be used in Space &r on Earth for fusion. The deuterium present in Jupiter offers an energic resource, in this way, about 10^{16} X greater than all the energy generated annually by man today, or 10^{16} "world-years". The protium present should also be exploitable, however, as it is by the Sun, in which case the energy reserve represented by Jupiter, in terms of a mass-energy conversion of about 10^{-3}, comes to around 10^{20} world-years. It is obvious that the fractional cost of shipping Jovian fusional fuel anywhere in the Solar System is and will be negligible (whatever its chemical cost today), so the fuel may be considered ubiquitous in the Solar System and the industry assured, even though Jovian escape velocity (about 130,000 mph or 37 km/s) is over 5 X Earth's (25,000 mph or 7.0 km/s). The Sun, if minable at a distant day, offers 1,000 X as much fusional fuel as Jupiter. There is, however, no particular reason for thinking that exponential growth of civilization &r use of energy will not be sustained, with whatever exponent(s), more or less indefinitely, or at least in order to attain some ratio of annual use to ultimate reserve greater by numerous orders of magnitude than in 1975, and so it should not be supposed that the fact of such superabundant energy being available is trivial and the energy supererogatory. Even the Sun's spherical output of $10^{26\frac{1}{2}}$ watts per instant might, and very likely will, prove inadequate to meet the instantaneous or unit needs of future beings derived from ourselves, forcing readoption of artificial production of energy via nuclear or transnuclear processes. This, however, takes us to a later page. It is obvious, as well, that the fractional energy necessary to take the hydrogen energy embodied in Jupiter out more or less in one stage, even at very low efficiency, would be negligible and unimportant (in the presence of the essential engineering). No matter how uninhabitable Jupiter's depths might seem--as a result of a core pressure of perhaps 60,000,000 atmospheres, temperature of 20,000-80,000° K, and strenuous violence and radiation--the advantages of locating industry or existence there, particularly by avoiding the gravitational cost of jovifugal transportation and because of the diachronic cost (in energy) of maintaining a "terriform" or inhabitable microcosm, will very probably eventually justify doing so, however weird and unlikely it seem preanalytically; by 2100 man or his descendants or unnatural offspring will probably exist in an artificial microcosm at the center of Jupiter and constitute some exponentially growing fraction of the planet's mass (the exponential growth will lead to a very interesting situation by 2200). It is conceivable that in the long term Jovian protium usable for energy will tend to be reallocated in a major way for purely material uses, in analogy with what may occur in 30-40 years on Earth in terms of petroleum and coal reserves divisible between fuel and material needs. It is possible that between 2050-2100 a massive nuclear-transmutational industry will develop, say as a result of superabundant power, probably powered by fusion or emergent transnuclear energy. As discussed previously, there may be very low energy methods for retrieving Jovian materials despite the immense gravitation and the apparent atmospheric difficulties, particularly hydrogen's very low density; apart from the net energy in the exported hydrogen, or the circular gain, it may be the efficiencies which are in fact possible that will decide whether Jupiter is mined on any scale before 2050 and by 2010, plus the curve of growth, and to the best of my knowledge no one has so far done the speculative engineering and economics, even as a first approximation. At a depth of 1,000 km Jupiter's hydrogen may be liquid (so that Jupiter's atmosphere, per se, may be relatively tiny), and solid at 25,000 km; the fusional fuel recoverable, therefore, may be infinitely more convenient than its atmospheric tenuity might suggest, both altitudinally and in terms of density (though not gravitationally) A buoyant station floating on Jupiter's hydrogen ocean could mine and convert

fusionable isotopes, and baser power out through an electromagnetic window in the hypothetical 1,000 km atmosphere, the teledynamic beam being practically immune to any gravitational redshift, and perhaps recovered or relayed by a jovicentric station; this scheme appears so elegant and simple that it may be inevitable, and in practise by 2030 or no later than 2050. Such ease exemplifies what will probably characterize Spacial discovery, invention, and development as a whole in the future.

By about 2012 a so-called "industrial satellite belt" will officially and clearly exist distributed over geocentric Space, having emerged piecemeal but increasingly over the 55 years since the launch of the first Russian Sputnik, with an inflective surge around 1995 corresponding to the Spacial Renaissance occurring at that time. The dictionary says that a renaissance is "a return of youthful vigor, freshness, zest, or productivity: a renewal of life or interest in some aspect of it." Decisive answers must exist to certain questions:

DETERMINANTS OF A TIMED GEOSATELLOSPHERE

1. The timing, magnitude, character, &c of the presumed c1995 Spacial Renaissance.
2. Sufficient annual growth and cumulative amount of geocentric transportation (cargo weight, passenger number, flight number, per flight capacity, &c), mass and building volume, multiplicity of purposes and parties, acceptable costs, touristry, population, &c.
3. Orbital industries sufficiently many, varied, proven, large, profitable, motivated, contagious, &c.
4. Warrant for and fact of great differentiation of various loci in geocentric Space: minimal and maximal altitude and all contained (tunicary) spheres, all possible triaxial spheres, varied eccentricities; unstable, semistable, and metastable orbital and nonorbital loci; filling of loci by numerous stations; structures of any extension; and interlocal and interstational coordinations.
5. Justifications for a temporal &r spatial geosatellosphere intervening between subspacial Earth and transgeosatellospheric (transgeogravispheric) loci (targets and installations) of sufficient or at least magnetic kind.
6. Specifically, the fate and concomitants of medical, touristic, scientific, military, communicational, power-related, manufactural, "geoscopic", and other periterran programs.
7. Chance (tychistic continuities and quanta).
8. Whether lethal &r major wastes are, concurrently, disposed of in Space, and whether any or much of terrestrial industry likewise is shifted off Earth.
9. Whether periterran residence and "cities" ("caelopoles" ie cities of the sky) occur, have passed minima, and have suitable rates of growth; correlatively, whether a fad for such life develops, life there can be sufficiently pleasant or excellent, a tiny fraction of Terran population volunteers, remigration is sufficiently low, the outside spectacle is sufficiently meaningful, governments push the cities, &c.
10. The astronomical milieu is sufficiently safe in absolute &r relative terms as far as radiation, micrometeoroids, macrometeoroids, prevalent gravity, storms, &c are concerned, and engineered structures and systems are also tolerable.
11. The ratio between initial warrant and development, and eventual warrant and development, is sufficiently high.
12. "Resonant" Terran interest in Space has by this time reached sufficient pitch. The resonance referred to is an anticipated phenomenon characterized by any almost irrational cumulation and multiplication of public and institutional interest in Space when the idea of Space has been around long enough to saturate, snowball, be familiar, seem inevitable, be thought through, be differentiated, be cathected, be explained, seem

tested, be curious, be challenging, be "visual", be socioculturally integrated, be amplified, seem different, acquire subconscious potency, &rc. For a variety of reasons, the enterprise is autocatalytic (however oscillatorially and discontinuously).

The evolution of such a satellitic archipelago, or "Geosatellosphere", will lead in subsequent decades to the identical development of progressive scientific, residential, &r industrial satellospheres throughout the periplanetary spheres of other major and minor planetaries of the Solar System and within the Solar gravisphere. Ideal ways of doing things in Space will be discovered and developed, and aid the Geosatellosphere's emergence. For example, industrial and inhabitable volumes are easily constructible via inflatable structures obeying an exponential 3/2 law so that per volume cost falls continuously the larger the mural structure. Such cutaneous structures can be filled with atmospheres and contain agravitational or autogravitational "visceral" structures in isotropic Space. Walls, floors, ceilings, and other supports can be minimized in terms of strength and mass in the weightless milieu: a great savings and an advantage for Terran and intraspacial fabrication. The integrity of interior structures can rely instead on a funicular web or "skeleton" stretching between the exoskeletonic spherical or exterior wall, the fabric of these 12-axially stabilized members supporting and stabilizing any tensions and compressions resulting from the 12-vectorial human, mechanical, dynamic, and static activities --representing rotational, vibrational, &r translational stresses and strains-- enclosed by the history of the redistributive exterior. One of the major uses proposed for industrial geosatellites would be in the so-called secondary sector of the economy, manufacture. It is suggested that the peculiarities of periterran Space--vacuum, light, zero gravity, and "silence" in a broad sense--would or might so favor certain current or possible industrial processes there (certain standards, syntheses, fabrications of materials and objects, &rc) as to justify a level of import-export industry in Space. I confess finding myself dubious about these specific and even general predictions in the near term (until 1995) and to a lesser measure even later (after 1995, say by 2010). But let me admit that industrial processes and economic warrants are extraordinarily subtle and surprising things which it takes an expert or empiricist to know about, much less project or anticipate out of the blue. The difficulty, complexity, sensitivity, demanding nature, value of product at stages, unmet needs and standards, novel industrial possibilities, &c belonging to industry--even current industry--could well justify transfer to Space paid for by near or eventual returns in terms of the costs of research, development, construction, and operation of the relevant periterran facilities and of essential intertransportation (say at $100 per pound in the latter case, or at an attainable $10-$1/lb). Too, all the proposals made to date for periterran manufacture of things for export to Earth may be faulty, even quite excusably, without thereby impugning possibilities and justifications that may well exist unforeseen or unspecified by the faulty or intuitive prophets. The relative &r absolute importance of primary, tertiary, and quaternary sectoral activities may be the whole point or the winning argument for an economic geosatellosphere; a manufactural sector might evolve derivatively from these prior and basic activities, or play a very minor role over a longer term. It is worth mention that the satellosphere could extend continuously and subtly into Earth's atmosphere, even well below the traditional least orbit of about 100 miles, via satellites with shorter lives or by what are called "satelloids", which are atmospheric satellites whose drag is compensated by continuing propulsion, whether esomotive or exomotive. Satelloids could actually operate at lower-atmospheric circular orbits or elliptical perigees with suitable propulsion owing to the rapid drop-off of density of the Earth's atmosphere (many orders of magnitude greater than the additional atmospheric resistance caused by the difference in flight velocity between an orbital object and usual jetcraft).

The year 2013 can stand for the year by which an exodus of men departing Earth for Space will have begun. It will be a touristic and semiresidential exodus more or less at once and reciprocally: the curves of annual growth of tourists and residents will at this time and until 2100 be very complex in their mutual relationships and are difficult, for this reason, to foresee. The situation partly derives its difficulty from the facts that tourists will become residents and residents tourists, permanency will be ambiguous and highly varied, men will have a conflicting multitude of purposes in Space, qualitatively different Spacial loci will be opening up at uncertain moments and rates, repeated and "dialectical" waves are to be anticipated (smoothable to an uncertain degree), almost organic nonlinearities are to be expected, patterns of development will be so extraordinarily contingent upon "catalytic" events, &c. The upward inflection expected in 2013, however, will in part embody an autocatalytic phenomenon. It is the turbulent nature of the explosive development of Space that is so forbidding for any modeling and extrapolation here: it renders equiprobable and highly improbable the most diverse set of long-term alternatives so that Space over decades and centuries will be curiously free and pluripotent. Over time, especially at this time forward, tourists will be penetrating ever deeper into the Solar System and venturing to the outer planets. If unique, and not just narrowly uniform, voyages are possible for tourists, perhaps as a function of what they are willing to pay for fuel and time, then a wide and diverse spectrum of trip distances and types can be anticipated, and spaceships might even be more or less for rent or even individual purchase by groups of suitable size or persons of adequate wealth. Such innovative adventure could conceivably be an interesting phenomenon with important consequences between 2013-2060, with an important bearing on the overall development of the Solar System. Critical considerations are falling costs and rising income over this multigenerational and distant period, as well as positive touristic feedbacks apt to give a new face to things and accelerate change. Another consideration is the tremendous area and diversity of heteroplanetary environments, so manifold Earth's interoceanic land as to stagger the imagination and exceed the human lifetime; it may mean that a single planet such as Mars will to a large extent absorb Terran tourists at least for many decades (assuming the planet aesthetically multiverse anthropocentrically); even our Moon may be or become, for these are seperate things, intensely interesting selenographically in terms of various landscapes, landmarks, walks, rides, overflights, historical tours, random expeditions, and activities. Tourists on Earth are too sophisticated to equate desolation, starkness, &r monothematicity with dullness, or the mere thing with ideas transfiguring that thing. Lovers of caves, a numerous breed, are illustrative since they realize a fervor from subjects that are often colorless, lost in shadow or sense, barren, superficially invariant, and as abstract and subtle as modern art--structure alone is a sufficient, or even imaginationally ideal, lure to the enthusiastic spelunker and admirer of desolate mountains alike. The infrequent cloud and sunset over a Martian waste, the strange storms and sandcast landscapes, the provocation to thought of a planet ever without life, &rc are apt to make Mars of keen interest to a great percentage of potential tourists, perhaps planning once-in-a-lifetime experiences prejudiced with countless tales and dreams, and a sense of history and promise. But there are apt to exist within the Solar System and the orbit of these adventurers places to visit and things to see utterly surpassing--in grandeur, mystery, curiosity, miraculousness, and beauty--anything found on Earth, then or now. An example might be a visit to one of Jupiter's or Saturn's inner satellites from which an infinitely spectacular and sublime vision of the maternal planet, with its suggested inner purposes, might be had and never forgotten, luring others on as perhaps the chief wonder of the Solar System: such an experience could be literally priceless, in itself a sufficient magnet to attract Earth's lonely billions. Almost surely the real highlights of Solian touristry will be things unknown and unimaginable because less obvious and far subtler.

In 2013 there will have been tested and in operation analogues to ramjets, wholly or partly fueled by atmospheric extracts, suitable for operation in the atmospheres of other planetaries such as Venus and the jovoids. These might at this time or later operate interconvertibly or universally between the connected planetaries, or even be able to hurtle themselves regularly into Space and back or across to other planetaries, say between Earth and Venus, or operate as purely Spacial and atmosphere-skimming craft in perpetual motion. In these terms, the similarities and dissimilarities of barometer and composition of the Solian planetaries are critical and worth study. Means for efficient intake, compression, combination, recomposition, storage, purification, drive conversion, &rc--perhaps quite novel or even revolutionary or unlikely--will have to be discovered and perfected over the years, and for systemic evolution overall. Yet there has so far been little real relevant development of scramjets for operation limited to Earth's atmosphere. The important question is what part of fuel needs is answerable by reliance on terminal &r visitable atmospheres; in particular, whether all such needs can eventually be so met, or whether there are theoretical limitations. Chemical and nuclear ramjets are more or less independent possibilities, as are transnuclear possibilities in their later time frame.

In 2014 man will visit Pluto for the first time. Barring unforeseen obstacles such as a giant, reactive, hypertoxic, turbulent, radioactive, uncertain, dense, viscous, high-temperature, obstacle-ridden ("deadhead-filled"), interminably problematic, &rc atmosphere &r ocean--or the absence of a solidosphere--this will be a surficial landing accompanied by pedestrian, vehicular, &r subvehicular exploration, survey, &c of surrounding terrain and apparent loci. These uncertainties will probably have been partly or largely answered by preceding unmanned satellites &r landers, whether representing a unique or repeated efforts. By 2014 man's means for such research, exploration, and exploitation will have become very advanced and reflect systematically prior work on cisplutonian planetaries enabling the final, manned Plutonian expedition to be markedly programmatic and elegant. Pluto's isolation, Solian economy, and Spacial programs will cause this manned expedition to be extraordinarily elaborate, multipurposive, and almost comically fancy: a myriad chores will be pursued during the 2-3 year stay. A minimal base may be established for later facultative or planned reoccupation and use, automata may be left in control of it, and cis-2014 automata may even have built &r readied the base &r site to any degree. Man's economic purposes in the Solar System will have developed sufficiently by 2014 that a principal and serious motive of the remote expedition will be the direct exploitation of Plutonian resources consequent upon and possibly starting with the expedition, and the creation of a basis for substantial colonization. A manned Plutonian base--orbital, natural-satellitic, terrestrial, buoyant, &r subterranean--will exist by 2020, and by 2038 Pluto will have been "colonized" and support over 1,000 men. It is obvious that the complications listed above for landing would, if real and according to their kind and solvability, condition any developmental purposes, and perhaps postpone such development for 10, 30, &r 50 years, until 2024, 2044, &r 2064. Man's motives for visiting Pluto in 2014 or ever might include: curiosity, completion of purposes within the Solar System, inter-party races, division of Solian planetaries between different parties, filling of available space, skipping of cisplutonian planetaries, military ends, transportational or expeditionary ease at that time, exploitation of industrial opportunities relatively or absolutely unique to Pluto, facilitation of expanding touristry, debate generally about Pluto, &rc. The discovery of a Plutonian or transplutonian asteroidal belt, particularly if attended by hypotheses or evidence suggesting resource potentials unique to the Second Asteroidal Belt, could at that time or by then give Pluto an important and helpful intermediate role that it now lacks. Presumably Pluto is ~~azoic~~ Artificial, unrelated to any prior visit to the Sun by heterostellar beings, not absolutely remarkable, fairly inert, &c; but who knows?

By 2014, as well, all 9 known Solian planets will since have been visited by apian men. Planets more or less unlandable, such as the Jovoids, will at least have been visited atmospherically, and perhaps oceanically, by manned expeditions or brief entries, or their moons will have been landed. It is uncertain whether Jupiter, Saturn, Uranus, Neptune, and Pluto will be visited consecutively, and whether by special or combined expeditions, but multiplanetary expeditionary craft may be in existence at this time or come into operation subsequently. The future exploration and development of the Solar System may be highly competitive as between different countries and organizations, perhaps even in order to preempt the discovery &r exploitation, or impropriation, of resources; such competition might even be fierce or accompanied by covert &r overt hostilities &r other complications. The directly preceding remarks about Pluto will hold generally for the several accomplishments here under discussion with a high degree of analogy. The manned landing of Pluto will probably be the event completing the series. Of course it is alternatively conceivable that the Outer or perhaps transaturnian planets will be, in whole or part, neglected by man for 10-30 years, and they might not even be bodily explored by human beings until 2024-2044, much less developed. Still, the differences in time, energy, and cost involved in exploring and developing all 9 planets before and after 2014 would not seem important enough to preclude or even especially limit such exhaustive operations, particularly considering the ease of obtaining knowledge relative to possible payoffs, even over that term: the planned early development of Solian wealth and opportunity should be based on such comprehensive and primary knowledge, and the concurrent returns from precedent Spacial enterprises should subsidize &r justify such additional and likewise exponential research and development. The trans-2014 growth of touristic exploration and development will be revolutionary, and by 2014 it will loom influentially on the horizon and be a factor in planners' schedules. Our knowledge of the planets, or planetology, will have advanced enormously by 2014, and the picture man will have of the Solar System by then will be radically different and far more stimulating than our own. Man will have begun to identify himself with the greater Solar System by as early as 2000, and this Spacial consciousness will dictate his purposes.

The growth of tourists will inevitably bring into existence by 2015 a hotel, or its equivalent, orbiting Earth at low-orbital or geosynchronous distance. The stays of such tourists, at least initially, may be a matter of mere hours and days, but eventually longer stays, covering months and years, will evolve to accomodate the tourists' wishes, needs, and opportunities. The capacity of facilities will thus have to increase as the product of increasing number of tourists, lengthening stays, expanding requirements, return visits, and emerging opportunities, and the increase of capacity will be very rapid and great. The services performed by any hotel are many and may be said to potentially embrace: social halls, observational rooms, kitchens, dining rooms, dormitories, sanitary facilities, auditoria, various operational chambers; also to be imagined are shops, offices, semipermanent residences, miniature squares and parks, virtual streets, substantial athletic facilities, medical facilities, symbiotic and commensal industries, opportunistic laboratories, resort areas, "wilds", a spaceport and related undertakings, commercial and noncommercial communications facilities, &rc. In brief: lodging, meals, entertainment, and various personal services. The example of the airlines suggests that the facilities and services might be cheap, yet not too cheap, and comfortable or even semi-luxurious (for example, ultramodern or technologically brilliant). The flux of tourists and wealth might be so great and concentrated that the hotel facilities and services will be from the first, or shortly thereafter, absolutely delightful, even better than hotels on Earth. For example, the basic costs of constructing and running the hotel may be so high, as also the costs of transportation, that the materials and things used to make

and to supply the hotel might effectually be chosen without regard for their expense, or in terms of their weight and volume independent of their value, &c. Furthermore, the first hotel would be a corporate, national, &r technological showpiece and perfected for those reasons. The hotel might be governmental, commercial, or hybridal, and likewise its similar and dissimilar successors. Free to expand into infinite Space, the hotel and its facilities might undergo persistent accretion with the years, and become a homogeneous or heterogeneous "hotel city". Such hotels will contribute to the formation of the Geosatellosphere. Clearly there will be some evolution from the provision of rooms for transients to larger suites, apartments, condominia, houses, neighborhoods, cities, and lands. Things, materials, purposes, and persons taken to the "hotel" will obviously accumulate there over the long term, expanding and complicating the hotel and amounting to that same ever-wealthier environment found on Earth and basic to Terran economy. The extraordinary growth of Spacial touristry, population, and economy over the 21st century will clearly cause and accompany an extraordinary growth of the hotel &r hotels in orbit about the Earth and elsewhere in Space. The important thing about such hotels, in conclusion, is that they will be the germs and hearts of great cities. Such hotels or stations will be preceded by mere suborbital, orbital, and highly maneuverable passenger vehicles themselves transient in Space--in both the nontouristic and touristic cases. "Hotel ships" may instead &r also evolve, perhaps taking 10^{2-4} tourists at one time on tours of cislunar Space, to the Moon, or of translunar Space. Such giant mobile hotels might execute endless rambles through the Solar System with tourists coming and going independently by interlocal ferries. Such meandering or free hotels, perhaps communicating with vehicular sub-hotels, might trace nonplanetary or designed circular, elliptical, inclined, retrograde, &rc orbits &r trajectories of any kind and number. The life on them, or in intraspacial colonies, might eventually become so independent, self-sufficient, self-centered, indifferent or antagonistic to Terran or Solian civilization, romantic, specialized, spontaneous, &rc that one such hotel or city--perhaps among thousands--will choose to fling itself, or drift, into extrasolian Space: could the chance be minute by 2100 or 2200?

Assuming them possible, Earth=Space &r intraspacial "autos" may exist in 2015. X I have stated this hypothetical event very cautiously. One's first temptation is to dismiss it altogether. How could the extravagance be justified, how could fuel so powerful be supplied the necessarily small ship, why would anyone or people in general want such a vehicle &r ability, where would people get the wealth, how could flight be made sufficiently simple or reliable (or automatic), is not the idea simply derived from science fiction, how can such things occur very soon, would not the traffic be dangerous, &rc? On second look, however, I find the event much more feasible, probable, imminent, justifiable, interesting, predictable, diverse, inevitable, important, &c, but still largely on the basis of conjecture. To state the event more precisely, by Spacial autos is meant: "automobile-like" vehicles enabling wealthy or average individuals or households, &c to enter Space from Space or Earth, thus "universalizing" Space. The ratio of payload to vehicular weight for all current terrifugal vehicles is very low so that all small terrifugal craft operating on current bases &r means would have to be very expensive to pay for the large ratio of nonpayload ship and fuel to essential human payload; since curren orbital payloads of the biggest rockets are 100-200 tons, and these rockets as hardware cost about $\$10^7$, however, an individual or familial payload of roughly 1 ton could theoretically cost only $\$10^5$ as the cost of an owned and reusable vehicle (all launch and developmental costs rightly omitted). Such a vehicle using current means might cost 3,000 tons of ship + fuel mass, whether the price per ton might be $30 or much higher (where the fuel and launch cost might be critical). These very crude studies suggest that future personal &r corporate annual incomes &r savings, and deflations possible in the cost of things, might well enable

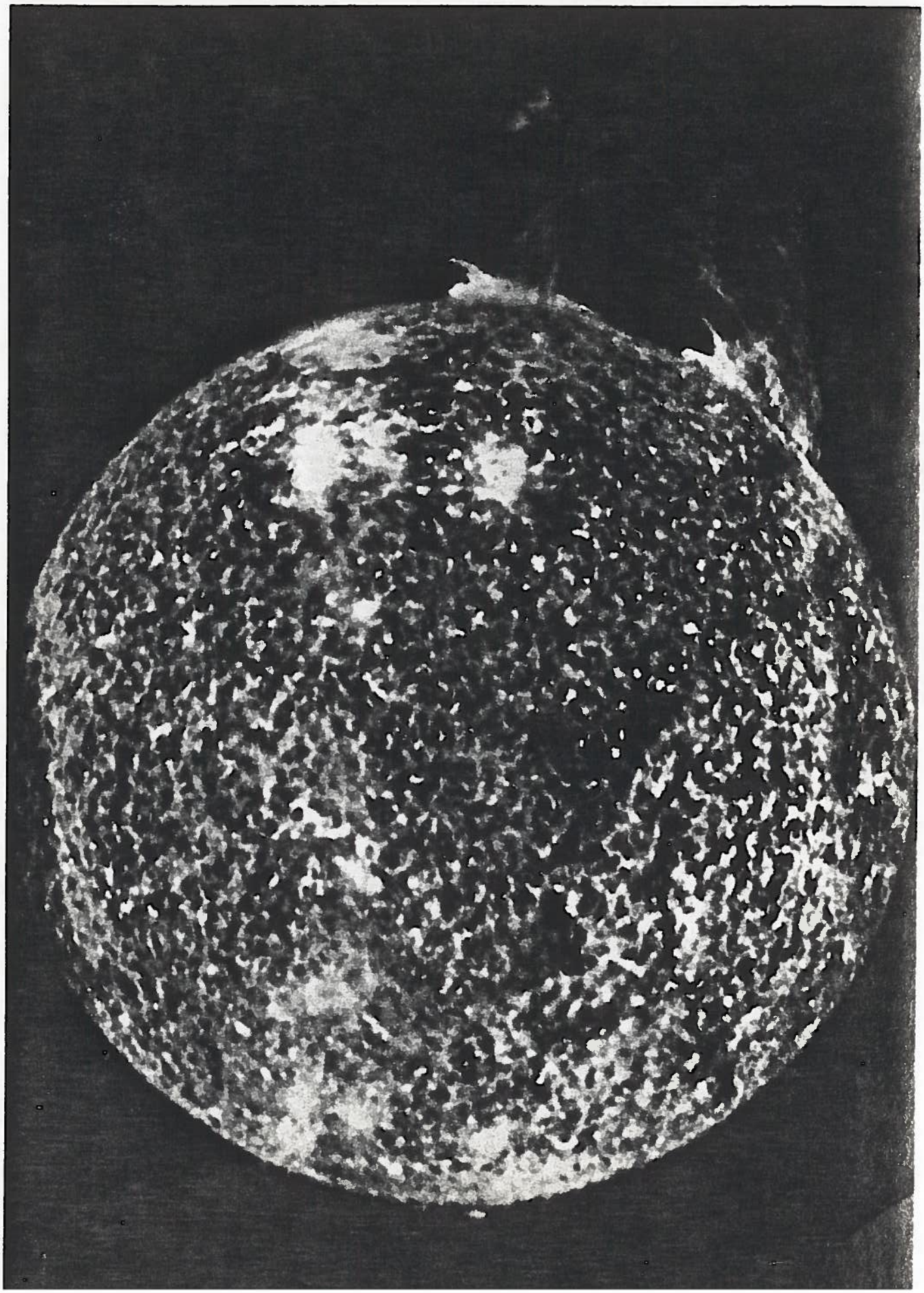
1/several-passenger vehicles to be owned, shared, rented, &r used by individuals &r organizations 10^{0-4} times in a human lifetime (ie decadally to daily); in a world of 10^{10} men, 10^{4-10} such terrifugal (or Earth=Space) spaceships might exist even before 2050. Minimal or negligible launch and fuel costs, and maximal reuse, might greatly enhance situations. So, and in addition, might ended research and development costs, splendid economies of scale, &rc. Beyond these possibilities, revolutionary power advances in propulsion (drives &r fuels) might reduce ship to payload ratios by 1-5 orders of magnitude, as previously discussed in terms of nuclear, transnuclear, enantonic (antimatter), maximal electrostatic charge, and ultimate chemical vehicles, and in terms of exomotive (eg remotely basered) vehicles. The level of automation of flights almost certain in 2015 will just as certainly reduce launch and flight operational costs likewise by many orders of magnitude, or essentially nullify them. Superscientific reduction of all nonhuman weight (eg ship weight) involved in such flight may also, even probably, come, however distantly, after 2015. An interesting possibility is that exomotive propulsion by ground-based or remote baser, acceleratory tube, extendible fields of tractive or repellent energy (a recurrent theme in science fiction; the fields, whatever their possible nature, might operate over 10^{0-4} vertical miles from Earth &r Space), &rc might drive craft from Earth into Space, and vice versa, at a great deal less expense than is currently necessary, so that the low-passenger &r low-payload craft might be almost entirely unencumbered by engine, fuel, navigational, &r crew mass and costs and simply represent affordable payload. Short of private use, taxis and mass transportation systems can be envisaged in terms of small vehicles. Obviously even 1-10 trips into Space per capita being possible would be a wholly revolutionary development with tremendous impact on the future of Solian enterprise. The ratio of terripetal to terrifugal costs and payload/launch ratios can be very low since little nonpayload requirements are necessary for aerodynamic landing and the Spacial auto returning to Earth could even glide down without energy expenditure. Entirely different and even more optimistic possibilities are opened up in terms of other planetaries and extraplanetary Space in microgravitational, agravitational, frictionless, and local environments, and because of the possibility of irreversible (any-acceleration) progression. Even if terrifugal Spacial autos are impossible, distant, &rc, autos in these alternative, and extrinsically and intrinsically important, milieus may well not be, in fact quite the reverse (cheap, primitive, numerous, already possible, &c). Considerable energy is expended per lifetime in walking, driving, and riding: a few trips into Space per lifetime might cost relatively little. Any flight on the anatmospheric Moon would automatically qualify as Spacial flight, whatever significance this have. Certainly the cost of human running, during a good percentage of which both feet are off the ground and "suborbital", is low! A further point is that there is no such thing as an "absolute cost" for energy: economic rearrangement could lower the price and supply of energy, mutatis mutandis, arbitrarily; therefore fuel costs, and likewise vehicular costs, of Spacial autos could become almost arbitrarily low, and are certainly not "absolute" in the sense of having an impenetrable, or even very inflexible, floor. Nor are there any necessary or even forceful limitations upon potential and desirable human income. Take notice Detroit!

2015 can serve as the year by which intrasolar probes will have achieved certain remarkable powers as indicated specifically by a latest and most sophisticated probe launched into the Sun. The Sun is a complex entity possessed of many layers, considerable apparent horizontal differentiation, and an unknown wealth of morphodynamical phenomena--even as suggested by what we have seen &r theorized as early as 1975, a very primitive time in heliology and astrology. The very fact of such differentiation and extension, however, allows us to travel to various regions of the Sun on the basis of current and foreseen technology. The crude, understood lamination of the Sun might be said to embrace, in inward order, an as yet unmeasured interstellar or Solian heliopause, a heliosphere in which all known planets of the Solar System lie, a corona, a chromosphere, a photosphere

Add'l) See p. 15 item #31 of DSI Ch. IV, Section "[illegible]" —

Eg. a maximum specific melting point of [illegible] equals body point is 250,000 °K! Thus extremely [illegible] range to materials will [illegible] specifically & superlatively [illegible] with [illegible] working maximum instantaneous regimes. Second Type, are the [illegible] strong neutron star material (i.e. 10^12 [illegible] steel) [illegible] If. In a sense, the bond strength of a black hole is, supposedly, infinite. [Of course, a particle or material we'd think of as "infinite" force would [illegible] to control the [illegible] might seem capable of counteracting its infinite inherent — the problem is one of [illegible] understanding mathematics, however, [illegible] & of [illegible] physical theories, [illegible] a subject presupposing the necessity of physical [illegible] solutions to certain problems in mathematical physics and perhaps in "pure" mathematics. One can imagine [illegible] a black hole string rotating [illegible] along its long axis to create relativistically "infinite" centrifugal forces at its [illegible] counteracting the hole's self-compression and supporting all intermediate points on the string, although in this case the "infinite" [illegible] accelerations might be thought to give rise to "infinite" gravitational forces [illegible] — some perhaps that spherical black hole gravities might similarly be thought to do [illegible] we don't know the two cases might perhaps [illegible] to resolve the question. E.g. etc.]

constituting the inner limit of the Sun's atmosphere (in one sense), a convective zone, a radiative zone, and a core of basic nuclear reactions. Varying temperatures, densities, chemistries, possible vertical and horizontal subdivisions and superdivisions, phenomena, processes, radiations, and intolerable conditions--however little understood and known--characterize these rough laminae and present monotonic, nonmonotonic, linear, and nonlinear challenges equally to abstract theory, external observation, internal observation, and any internal doings of mankind in general in the future. The common but naive impression is that the depths of the Sun will necessarily and probably rightly remain unvisitable by any imaginable vehicular contrivance owing to the surpassing inhospitality of these forbidding regions. My own conjecture is that the Sun has no part such that future science and technology will never be able to design a vehicle capable of its in situ inspection or a permanent occupation for its various exploitation (furthermore, such exploitation will probably be desirable eventually, at least for all purposes--a contention equally apt to be a bone to conservative imaginations). The rate of such progressive visitation and exploitation is another matter, although it is apt to be astonishingly quick in terms of feasibility and actuality; it will probably be marked by countless demonstrational, exploratory, and exploitational stages, if just because the Sun and the future itself are very big places. Of course it is very difficult to paint generally, much less specifically, the nature of any relevant science and technology, partly because its relationship to current science and technology is highly questionable. Despite the latter, means probably exist already in 1975 and will exist a fortiori by 2015 for sending elaborate or simple transmissive or 2-way automata or instrumental packages across the orbit of Mercury to a few Solar radii and below the turbulent surface of the Sun's complex atmosphere, even to the corona or photosphere. The surface, proper, of the Sun is 5000°K, 10^{-7}gm cm^{-3}, and 28g. Such a description, however, by no means discloses its rigor and difficulty of access. It is unclear how much, or how readily, the intricacies of the tridimensional Sun are comprehensible on the limited basis of any, or perfect, abstract theory &r external observation (the power and completeness of which will be progressing simultaneously over the years). Advances in intellectual power occurring with the development and application of humanly and transhumanly intelligent "computers", beginning in 1995-2000 and perhaps exploding apocalyptically before 2020, will obviously have a bearing on theoretical, observational, and penetrational heliology over this period; characteristically, the poor knowledge and intellect of a man your contemporary is no instrument for prophecying such particulars and generalities. Probably by 1985 a probe will have been cast into or around the Sun at a heliocentric depth or perihelion of 3-1.0 Solar radii. Between 1985-2015, 10-200 such probes will have been fired toward or into the Sun. The outward transmissions of these probes might be relayed once to several times by following, heliosatellitic, Mercurian-station, &rc relays. Why so probe the Sun? There are recent signs we are fundamentally in error in our theory as to the nature of its energies, structure, and processes, that the phenomena of the Sun are far--perhaps arbitrarily--more detailed, complex, and exotic than we naively assumed, and that the history and changes over time of the Sun are not so simple, stable, and regular as we thought. It appears that Solar phenomena have a highly critical, puzzling, and genuinely disturbing causal relationship to meteorologic, climatic, and other patterns on Earth. Astonishingly, intelligence should ultimately be able to alter, control, and transform these Solar effects and causes, or the Sun itself, possibly at a surprisingly close date and very importantly. Ultimately the Sun will furnish innumerable materials to an extractive civilization superior to its extreme regime; conceivably, elementary and atmospheric mining of the Sun, as later discussed, will occur before 2050. It is possible that the Sun, and correspondent climatic and biologic variations on Earth, experience far greater fluctuation over larger units of time, or at abrupt moments, than previously thought; possibly the true sharpness and largeness of these variations has been masked by



unsuspectedly great static and dynamic, or equilibrial, covariations of Terran geology &r biology (it is quite possible that Terran life has played a decisive role in creating and stabilizing life-related conditions on Earth and that therefore no paleontological record, or currently recognizable record, exists of the true extent or external magnitude of these fluctuations--at least on this life-dominated planet). The Solar and resultant Terran fluctuations which occur in nature may soon become unacceptable to an evolved science and technology presupposing far greater stability, predictability, &r simplicity of Solar and Terran phenomena, &r amenable to control or scientific inquiry. Eventually there will develop highly sophisticated active sensors--edars--for peering into the Sun at depth, and radar imaging of the Sun has already begun, whatever its current limitations. It could be worthwhile to enter and inspect in situ the prominences, plages, faculae, flares, sunspots, poles, and other quasi minute features and complex phenomena of the Sun, in order to carry away or backtransmit images, measurements, chemical analyses, material samples, &c. Very unusual and interesting in situ experiments could and will probably be conducted within the Sun. The probe might be homoiothermic (self-refrigerative &r insulated) or relatively poikilothermic, or materially &r energically insulated against various radiations, impacts, reactions, contingencies, &rc or isolated from conditions. Even today we possess or could build electronic, fluidic, photonic, &rc circuitry, computers, &r other devices proof against elements of the Sun's purely nonterran regime, or friendly to such elements--despite some of the noise, violence, exoticism, reactivity, &c. Certainly within 40-100 years, by 2015-2075, there will be means at our superscientific disposal for taming, in fact exploiting, the rigors of intrasolar and perisolar milieus. Toss a coin--the center of the Sun may prove a more desirable locus for some human offspring &r "industry" than the relative vacuum beyond, or the "dead" Earth. The Sun may already be occupied or occupiable by some wholly unfamiliar, but subjectively comfortable, life; the whole Sun might instead, or also, be a single giant organism, mind, &r spirit! The strange, superior, transcendental, or ultimate effectors, perceptions, conceptions, intelligences, purposes, communicators, characteristics of nature, &rc I recur to throughout this book as potentialities, singly or together suggest that the Sun may be an infinitely more interesting place now and in the future than it has been our custom to envision on the basis of rather ordinary assumptions and a possibly fallacious conservativism. These, moreover, are not merely inexclusible possibilities: they may well be higher probabilities, the face of a Nature grossly misconstrued by mortal man. An asteroid 10-100 miles in diameter might be fitted within with appropriate instrumentation and thrown at a velocity of 10^{4-7}mph by some chord through the atmospheric or subatmospheric, conceivably eminently puncturable, Sun, or the like! Such understanding of the Sun as affordable by such direct, possibly brute methods might be a sine qua non for comprehending other stars or perfecting astrology--and the Lord knows what importance this might have owing to the fine interrelatedness and the technological impact of all science! Only by firing such probes into the Sun might we learn the fact, the extent, the nature, and the cure of our ignorance, which might be sublime! It is perhaps remarkable that for all purposes our natural science is limited to the regions of and between the surfaces of the planets and Sun, and almost totally ignorant of the interiors of these bodies which therefore constitute worlds for all we know as complicated and interesting, or infinitely more so, than the provinces of our knowledge in terms of the complexity, differentiation, uniquity, evolutionary attainment, and importance of natural phenomena. J.B.S. Haldane once suggested that within the Earth a characteristic life may go its own way as ignorant of us as we of it, a loss to us both. Voyages of discovery may yet be made to the realms within planets and stars, revealing undreamt continents and kingdoms. We will not know how difficult exploring the Sun is until we send probes there to inform us by their success or failure. Might man one day seal himself securely in a probe and investigate the Sun by submergence? Likely he could if he wished, but

by such time as he might wish and be able to there will almost certainly have evolved machines so advanced as to eliminate the last reason for a specifically human adventurer. The early and eventual probes, variously, may possess various degrees of maneuverability within the Sun's layers and phenomena, such as an ability to move at any velocity (including zero and negative) and in any direction, perhaps on the basis of discoveries or needs. The modes of propulsion, steering, ballast, &c--as well as isolation, perception, manipulation, transmission, &c--are rather unclear at this time (although suggestions are possible). Some sort of surveying might be meaningful, possible, and desirable. The lifetime of any probe might range from minutes to days, months, or eternity. Probes might be powered &r driven externally &r internally. Probes might be succeeded by floating stations or other highly curious occupations (how does Heaven look?). Equivalents of "doors"--such as coronal holes, already discovered--might be used to enter regions or travel within the Sun ("corridors"). The greater future is unimaginable and our intrasolar probe stops here.

By 2015 flywheels will probably be used on a large scale to store energy in Space. The flywheels may be tremendously massive, swift, various, &r many. They will be used in interplanetary Space, the Moon, asteroids, aboard ships, &c. Some will be spherically compact, others discoids and toroids (the latter two maximizing peripheral velocity or the like). They will be used in Space owing to the low or zero gravity, extreme vacuum, storage needs, free bodies, possibly the cryogenic temperatures, &rc there. Rotors will already prevail in Space for artificial gravity, attitudinal control, and natural reasons. Asteroids, superabundant and of all sizes, may possess considerable natural counterrotation that might --just imaginably--provide local energy. What is the spectrum of such spins, momenta, collocations, &c? Asteroids, since possessed of negligible gravity, could be brought arbitrarily close to one another. Or the counterrotation could be artificial, a means of storage if not a source of natural energy. Fancifully, the spin of asteroids might be used to support "vertical satellites" (cords tied to the surfaces of asteroids and suspended by centrifugal force, as has been fancied for Earth), the playing out of such a cable might lift materials from asteroids' surfaces, run generators, &c, and distant cables might even launch projectiles at high velocities--but an arbitrarily strong cord might be essential! The use of high-momentum flywheels on Earth has recently been reproposed for stationary and vehicular storage of energy, yet conditions in Space would be far more congenial. Gerard K. O'Neill has suggested that counterrotating colonial cylinders could exchange cars in order to mimic perpetual motion in transportation. A toroid, or just a counterweighted cable, might be gradually accelerated in rotation in order to launch somewhat exomotive projectiles, depending upon the strain tolerable by such a toroid, cable, or pole on the basis of familiar or transcendental science. It has been suggested that Jupiter's daily rotation might be accelerated in order to mine the immense planet to build a Dyson sphere. An interesting question is what size of rotor would allow maximal installable &r usable momentum, and whether innumerable microscopic rotors might or might not be ideal. Two counterrotating bidimensional discs 1-100 miles in diameter, involving very little matter (they could even amount to counterrotating 1-circles made of 2 cables &c), could be placed in the sky as satellitic clocks (in fact, 48 hour-marker satellites, in 2 counterrotating cycles, could encircle the Earth for global horology); an analogous system could provide the time to developing nations and eliminate the millions of watches that do, and the billions that would, exist (thereby saving billions, or an eternity, of dollars spent otherwise on manufacture and repair, and some unknown amount by synchronizing the world's "watchable" peoples). (I will not, at this point, propose placing a projectable screen in the sky to economize on movies or television; until the world is more populous or wealthy, it would squander photons.)

Perhaps by 2015 engines or velocities of 1,000,000 mph, which is 1,500,000 feet a second or 1/700th the speed of light, will have been achieved or come into customary use for certain purposes, or be under development for such standard or more widespread use. What is the point of such speed? It might be necessary for flight to Pluto in 3 months, or for commuting between Earth and Mars in a few weeks or days (one way). Theoretically one could travel to the Moon from the Earth in a few minutes or less than an hour. Gorgeous waste of energy on acceleration might be unnecessary if part of the energy could be recaptured by landing energy regeneration systems (systems using terminal satellites and functioning like the energy levels of atoms, have been suggested between Earth and the Moon). Flight at 1,000,000 mph, being 10 times faster than at 100,000 mph, could be justified merely on the basis of human wage savings or the duty cycle with a tenfold use (which might apply to even higher velocities, in which case early traffic could be handled by a very few ships, or the traffic could be very enlarged). The means of propulsion for such rapid intrasolian flight might be various nuclear systems possessed of various accelerations, or exomotive propulsion by planetofugal or interlocal basers. Theoretically, at least, the velocity and acceleration of interplanetary ships using solar energy could be increased merely by increasing their collector's area, providing the weight would stay efficient and the strain tolerable. A critical question is what acceleration is possible, tolerable, and efficient at points in the future for man, automata, and simple projectile. Conversion schemes would have to be possible, say for exomotive propulsion by ground-based basers or by interplanetary heliocentric arrays. Machines might tolerate many orders of magnitude greater acceleration (g-force) than men. What would be the maximal acceleration possible for automata or mere projectiles ("bullets")? On the other hand, future science and technology may enable men to withstand far greater accelerations for far greater periods (or perhaps indefinitely), and narrow the man-machine or man-bullet gap. Epiplanetary &r extraplanetary linear accelerators of tremendous power &r length might launch men, machines, or bullets at incredible accelerations and velocities. Such accelerators might eventually be 10^{0-9} miles long, or circular, even wrapped around planetaries; they might even be helical. Some accelerators might be "resonators", machines accelerating objects by vibrating them elastically between 2 equidistant poles (say 2 fields of force). Various explosive accelerators ("guns") are imaginable that would use electromagnetic energy, electrostatic energy, chemical energy, stored and released pressure, nuclear energy or explosion, &r the like to launch a projectile from a tube ("barrel") or ramp. Assuming maximal acceleration tolerable to ship &r load, barrels could be constructed 1-1000 miles deep in planetaries at the bottom of which instantaneous or sustained nuclear, chemical, rc explosions could occur, the released pressure pushing the unhappy projectile up and out of the inexpansible barrel at astronomic speeds, perhaps conveying the projectile to Pluto or out of the Solar System and to adjacent stars; such modes of launch might actually use energy with high efficiency (ballistic systems may, however, suffer from ceilings on efficiency at maxima). What velocity and efficiency maxima would apply to so-called "mass-drivers", perhaps competitively? No one has so far indicated any optimal maximum of velocity for future intrasolian operations, or the suprema in terms of efficiency or cost: a critical fact. An interesting question is what rates of transportation will be tried and used on Earth for nonspacial purposes, at points in time. Sufficient velocities or accelerations may render types of "teleportation" more efficient or cheaper than the transportation of objects &r men, favor the transmission of information &r power, or curtail such things altogether, at least at distinct points in the future. Since escape velocity from the Solar System is 138,000 mph, the speeds under discussion could be the basis of interstellar flight: Alpha Centauri (a system of the 3 closest stars) could be reached, at 10^6 mph, in 3 millennia, by 5000 AD.

X

The first real hostilities in Space will occur before 2015. Let us face it, this is not a surprise. Hostility is probably inherent in human nature. Over time, the spectra of size, number, and kind of hostilities will inevitably grow. They will likewise grow as human numbers, wealth, purposes, &c in Space inevitably increase by many orders of magnitude. The very isolation, distance, cost, size, strangeness, danger, &c of Space can and will serve as an inducement to crime, hostilities, misbehavior, anarchy, emotional behavior, &c. There will certainly be all kinds of discrete causes for the inception, growth, vigor, continuation, and extension of hostility &c: vast but finite and competitive wealth, opportunities for individual fortune and graft, patriotism, critical essentials, &c. Nations, companies, and individuals will compete strenuously and consciously for prior, best, and any minerals, energies, and loci. Everyone's launches, stations, ships, bases, colonies, ideas, needs, purposes, &c will compete. All sorts of administrations will be scattered over Space and inevitably give rise to covert and overt hostility and competition, good and evil, jealousies, strains, misunderstandings, misconceptions, worries, prejudices, escalable games, conflicting ownership, other legal conflicts, traditions, prides, conflicting jurisdictions, conflicting purposes, controversial extensions of jurisdiction and power, critical habits, disagreeable procedures, disagreeable controls, resented authority, conflicting perceptions of truth, good, and beauty; &c. Initial and elementary differences will enlarge, transform, ossify, intensify, and become independent forces of turmoil, hatred, bitterness, subversion, neurosis, myth, and religion. The spectrum of human types will gradually slide into Space and set up shop. Supplies can be misused and impropriated. Funds can be embezzled, frauds can be perpetrated, lies can be told, favors can be paid for, mistakes and consequences can be masked, conspiracies can arise, propaganda can develop, deceits can be implemented, &c. Greed, jealousy, xenophobia, antisociality, hunger for power, simple human fallibility, carelessness, professional differences, psychological differences between men, &c will all play their role in the creation and maintenance of hostility. The development of government, and the changing aspect of Space overall, will unavoidably give rise to hostility. Responsibilities in Space, and concomitant potentials for guilt and resentment, will be enormous: human error may result in the collapse of a colonial dome, collision of ships, pollution of the environment, squandering or destruction of resources, exobiological havoc, death of dependents, awful discomfort (eg offensive or unhealthy air), redistributions of wealth, major costs or other burdens, &c. The countless unknowns, incessant development, scale, fast development, and very intricacy of Space as an enterprise will often lead to radical, important, and strategic disagreement among men, and scathing tests. The fewness of men, meritocracy, turnover, load, enthusiasm, variety, &c of men in Space will result in severe tests in human relations and permanent hostilities. Space may be invaded by Terran military purposes, by weaponry and forces serving offenses and defenses on Earth, or conflicts limited to, or even centered on, Space. The diversity and disconnexion of parties and authorites in Space will make for at least initial anarchy and perhaps uncontrolled conflict. Any use of military force in Space may set a precedent and open a Pandora's Box; it might, for example, initiate a century of conflict and barbarism. Even if war and militaries are kept from Space, or deep Space, there will be crimes and belligerence to police, even if the policing is confined to, or unified in, a single authority, such as the United Nations or a Space Authority. Disastrously ready, great, obvious, abusable, &c wealth may be discovered on planetaries. Colonies developing in Space may become psychologically rather self-centered or suspicious. Nations or organizations indigenous to Space may be jealous of one another. Those in Space, or part of them, may dislike and seek to spite the Earth, and vice versa--and may eventually revolt against its economic, political, or cultural collar. Various planets may fall into disunion and struggle. Hurtful acts may be done, rightly or wrongly, for the sake of instruction, demonstration,



VENUS

redress, revenge, curiosity, provocation, &rc. Nations may attempt to subvert each other's Spacial programs. There will be competition for markets, brains, allegiances, &c. Purposes may be in conflict as illustrable by the mutual conflict of nuclear mining with mineral exploration with antinuclear causes with astronomic observation &c on the Moon, say in 2025. Men in Space may sometime wish to halt migration or even touristry from Earth, perhaps viewing same as a cultural infection at a time when an indigenous Spacial population is flourishing. Strange ideologies and even religions may play a key role in Spacial conflict (such ideologies, infinitely bizarre and irrational, have always originated on and plagued Earth, so why not in Space, especially because of the selective populations there?). Civil war, imperialism, societal psychopathology, totalitarian regimes, fanaticism, messianism, cold calculation, &c might all be destined, alas, to play an equal role in coloring the history of the future of Space if they are permanent to the human breast. Farther away in time and Space, who knows what greed, intolerance, xenophobia, superior purpose, ambitions, insanity, pathology, or triumph of the worst may already or eventually prevail on an interstellar, galactic, intergalactic, and universal scale? Spacial resources might prove vital to parties on Earth, and their allocation occasion conflict and outright hostility. Control of the world's weather or climate from Space might give rise to the most incredible and involved disputes, and inevitable hostilities in Space or on Earth. The very installation of weaponry in Space, offensive or defensive and overt or covert, might provoke actions designed for its removal or counteraction. The use of nuclear explosives in Space may give rise to ambiguities, and certainly disputes over its legitimacy for peaceful purpose. The first hostility in Space may be motivated by a wish to set, or to avoid, a precedent. Spacial colonies more or less belonging to certain nations might be used as vulnerable hostages by national or other blackmailers. Black and grey markets will inevitably, quickly, and even usefully arise dealing in practically everything. Thefts, privileges, extra quotas, variances, &c will be traded and sold. Out of the miasma will issue manifold hostilities and a more colorful Spacial history. Even if the early history of Space preserves an atmosphere of cordiality, cooperation, peace, fairness, honesty, and virtuous euphoria, this may fail suddenly or dissolve with time, perhaps as a result of Space becoming a more serious enterprise than it is today.

I expect 40 years hence, in 2015, the first manned laboratory will exist on Venus. The close reader may scratch his head and recall what I prophecied for 2010, that by that year the first serious mining of infernal Venus shall have occurred, which seems discrepant. Maybe so, but maybe also the dates are very similar, events may occur virtually or actually simultaneously (for example, on the basis of great planning and preparation), &r the initial exploration, science, and mining may be done telesensorially, telemechanically, automatically, robotically, &r by very intelligent machines (these possibilities differ). The question is, Won't the prior use and development of such fancy surrogates keep men from ever boarding Venus, or at least for the purposes and dates at issue? Well, men are curious creatures, at times daring creatures, and, after all, by then means may exist, &r have been installed on Venus, rendering human visitation the simplest thing on the world, just inevitable and convenient. The hostility of subaerial conditions on Venus may be temporary and totally relative, much as Terran climes have eventually yielded to Homo faber. The hostility of Venusian conditions to man and machine is suggested by the fact that sulfuric acid may endlessly rain on Venus and constitute 1/10,000th part of the 85-bar atmosphere at ground level. Worst yet, flurosulfuric acid (HSO_3F) may obtain and make the Venusian rain the most corrosive fluid in the Solar System; flurosulfuric acid attacks most common materials and dissolves sulfur, mercury, lead, tin, and most rocks--never mind the 750°K room temperature! On the other hand, such reactive conditions hint that the soil and landform mineralography of Venus may be

interesting, minable, and even better than Earth's in these respects. What planet in the Solar System excels all others? Purely equiprobabilistically, Earth may be an unlikely candidate. The present and historic chemistry, morphology, meteorology, climatology, &c of Venus should make for fascinating and important in situ investigation in terms of venereology, planetology, and (broadly) geology. The laboratory may be temporary or permanent, but may well give birth intermittently to bases, colonies, cities, and a rollicking planetary civilization. If this seems improbable, consider the fact that eventually man will place industry &r himself over the entire face of the Earth and transform, however he wishes, such inhuman milieus as Antartica, the great deserts, and the bottom and column of the global ocean. Exhausting the Earth will remove a buffer and substitute planetaries such as Venus as the residual frontier. Reformation of the planetaries, as alike all of nature, really seems inevitable, barring astonishing philosophic developments (deservedly controversial or variously inconsistent in terms of present human nature, belief, and custom). We might understand Venus from afar or outside its atmosphere, but think how inefficient and wasteful of time such isolation would be compared with direct subaerial and personal exploration and a brave confrontation with the Venusian element. Venus is currently rather mysterious meteorologically even if we confine ourselves to the mysteries of what is known and defined by our limited theory of nature. An economic equation might be interesting: Would it be cheaper to research Venusian conditions in situ (by man or machine) and full-scale than by repeatedly scattering myopic satellites and subsatellites over the planet as we have done so far and might be expected to continue to do between now and 2000 or 2015? The little pictures provided by these inadequate probes are fascinatingly difficult and mysterious, to be sure, but may be a comparative waste of time and an unaffordable luxury: the questions, mysteries, and problems are infinitely subdivisible, whereas we might overleap them by a comprehensive and farseeing eminently sophisticated mechanical, or manned, laboratory supplemented by strong research expeditions and a will to understand the planet completely and soon. But of course very good arguments can be made for the unexampled value of initial samples in cost-effectiveness terms, and the appropriate cost of Venusian research until 2015 is another matter entirely and a question pursued elsewhere in this book (p).

One foresees fissionables being mined on the Moon by 2015, as already discussed. Presumably these would be the ones already mined on Earth and presumably these exist on the Moon in equal abundance. Whether they compare with Earth as to the surface or depth of these bodies--and compare in amount, concentration, and access--is another matter; the Moon might be superior or inferior in these respects. What margin of superiority or accessibility would be necessary to justify the economics of their mining, in competition with alternate sources of energy, is unknown; the question must be asked both about direct use on the Moon and distant importation by the Earth or extralunar Space. Prior epilunar industrial concentration might be critical or important to the economics of extralunar use owing to pound costs of available transportation systems. Further, even more abundant, concentrated, &r convenient fission &r fusion fuels may, sooner or later, be found elsewhere in the Solar System and even on Earth. Remarkable technology may come about for planetographic detection, survey, and quantitation of natural fissionables, &r for extraction &r refinement of ores--and these developments may be absolutely decisive for the patterns of resource use. Such technology will almost certainly eventuate to some extent. The discovery and large-scale extraction, processing, and use of these Lunar fissionables may play a key role in the emergence of Lunar civilization--industry, population, and culture--between 2015-2050. What should be done is calculations made for the cost of that industry essential to extracting and refining nuclear fuels, on Earth, and, on the other hand, the range of imaginable extrapolated costs for that same industry established and performed on the Moon, and in finite time frames. Can such industry be miniaturized? Will new methods of isotopic &c seperation greatly deflate pound-of-fuel cost?

Can transportation from the Earth pay for itself? Can the industries be highly automated? Are bothersome "takeoff minima" involved, even fatally? Is too much begged? Are certain ideal mineral distributions required, but perhaps only 10% or 1% probable? Must the Moon prove sufficiently valuable in other respects? Is not a slow progress of all Lunar development more likely, even nonsensically slow progress? One can argue that the development of the Moon, of Space, and of Earth most likely will occur almost as inefficiently, haphazardly, and imperfectly as possible--ideally unideally. Pour tar on my prospect for the future of Space: crystallize thereby what will actually occur!

The year 2015 stands for the date by which one expects that certain experiments, processes, or undertakings considered too dangerous--too big, unknown, destructive, actually or potentially lethal, disturbing, polluting, intolerable in number, intolerable in type, obscurely subtle in effects, controversial, outlawed, erratic, unnatural, elaborate, &rc--for (on or near) Earth will be performed instead, for the first time, by law or agreement, by custom, by preference, by experiment, transitionally, occasionally or regularly, also, particularly, always, absolutely, first, &rc in regions of Space. They might be so performed beyond Earth's limiting atmosphere, in deep cislunar Space, on the Moon, or deeper still in Space (outside Earth's orbit, in the gravispheres of other planetaries or the Sun, atop or upon other planetaries or the Sun, at or beyond Pluto, &c); all such loci might justify or progressively justify qualitatively &r quantitatively distinct events, or certain cautionary criteria. The choice of 2015 by myself was motivated by a desire to refer in particular to either a first event, an event of major or inescapable magnitude of sheer size or of danger, an inflection point up or "down" for a class of such events, an era of particular controversy or adoption of such remote loci or degrees of caution, a median for kinds or degrees of such events, a lasting or first maximum for any series of such events, a first very bad consequence, &r any number of other things which might be distinctive. Endlessly in the future endlessly more significant, and properly endlessly more distant or caution-surrounded, events might be considered likely--inexhaustibly so, however strange it seem! What might be the nature of some of these experiments, processes, undertakings, practises, &c? Examples that might be mentioned are genetic engineering (in a broad sense), gigaton or greater explosions (in terms of TNT equivalent for instantaneous or arbitrarily protracted events), doings (scientific or engineering) in progressive particle physics, "super chemical" laboratories or factories, "dropped" asteroids, "super" nuclear reactors (these might be of any size, perhaps because of some scale economy or efficiency, and for this reason--excessive size--placed off Earth), climatic engineering, planeturgy, gigantic planetological experiments, non/explosive energies like 10^{31} erg (equivalent to 10^{15} tons of TNT, enough to raise the Andes mountain chain), &c for such purposes as "super" mining, chipping off pieces of planetaries, &c. The things I have referred to are only a few untrustworthy and not necessarily chrestomathic possibilities which at first spring to mind--the future will generate its own set of examples! It has seriously been proposed: a) that current work in genetics may produce and free, disastrously, an irresistible and apocalyptic pathogen, and b) that such a danger already warrants unprecedented isolation, if not cessation, of such work, perhaps by removing and restricting it to Spacial laboratories, say in the Lunar atmosphere and gravisphere (and even its total automation so as to render human transmission impossible). Why tolerate at all any such grave danger as a threat of total human extinction? A reason might be that the potential benefits of such work might warrant its safe pursuit despite the enormity of any error. There are already hints that it is possible to catalyze potentially irreversible and catastrophic transformations of the atmosphere, biosphere, &c, and even that human industry may be exerting such horrid effects: exclusionary action may already be desirable, essential, &r possible. One model of scientific and technological progress is approximately exponential: with time the scale, variety, profundity, importance, &rc of such "progress" should accelerate or explode, or reach into new domains. This implies that with time,

perhaps especially at this moment of history, the side-effects and dangers related to science and technology (perhaps because of man's concomitant ignorance) should be toward flood tide, placing us in grave danger. The radial and volumetric dimension, vacuum, opposite gravitation, time distance, &c of Space may invite transfer there of categories of events discussed, possibly even a partly accelerated Spacial program directed to these protective and wary ends. Per contra, of course, worries motivating such exclusionary ideas may be exaggerated, fallacious, premature, &r neglectful of devices and opportunities for modifying, curtailing, &r safeguarding against the same group of events performed on Earth. Careful consideration should be given to the alternatives. Even so, especially fatal and ominous events, however incomprehensible and tendentially disregarded (for example, professionally or administratively), would seem to be with us or on the horizon and to warrant exaggerated caution and certain extraordinary present and future measures: too much, alas, is at stake that would seem eternal, primary, or greater.

Specifically vertical, rather than diagonal or horizontal, linear accelerators may come into use to launch projectiles off planetaries by 2015, as has been proposed, for example, by Dandridge M. Cole and Donald W. Cox in their nonfiction book Islands in Space: The Challenge of the Planetoids. How important or trivial this development may be is unclear to me. It is also unclear to me whether the event will even occur: a vertical structure may be more subject to "architectural" stresses and strains than a terrestrial structure, and might be absolutely impossible for any structure greater than 1-10 kilometers in length, where initial or eventual linear accelerators may be 10^{0-7} kilometers long (say located in extraplanetary Space). Some accelerators may consist of vertical shafts sunk at depth in the lithospheres of planetaries. Would vertical and nonvertical accelerators be effectively indistinguishable? Would the smaller path of a vertical launch be justified by minimizing atmospheric drag, or would atmospheric lift by diagonal flight be preferable? Would vertical launch be preferable in the particular case of microatmospheric &r microgravitational planetaries, say for the Moon? Could some special power or mechanism of launch justify compacted accelerators, and thus also vertical launch? I do not know.

Perhaps by 2015 atmospheres may be gotten from the solids &r liquids of planetaries by the use of nuclear explosions or other large-scale means. For example, underground (Plowshare-type) nuclear explosions might be used to give the Moon or other anatmospheric planetaries local or global, partial or full, nonterroid or terroid (say 20% oxygen), &c atmospheres. The controlled or explosive nuclear reaction could occur on a titanic or astronomic scale, eg toward the Moon's center, and could serve a multiplicity of purposes. It is possible that other sources of energy, such as "nonradioactive" focused sunshine, could be used on such a scale to generate atmospheric gases. On either atmospheric or anatmospheric bodies the tremendous heat and temperatures could liberate and dissociate nonrecombining gaseous fractions, in some ratio to the total energized mass. Krafft A. Ehricke has suggested schemes whereby the gaseous and elemental product fraction might be captured and increased, in the case of underground nuclear bombs. A critical question is how radioactive the product would be, and how seperable the nuisance radioisotopes by present or future technology? Possibly for some purposes a variously radioactive gas might be unusually acceptable; such industrial or even biocultural purposes might be critically important. Nuclear evaporation &r dissociation might be easy and important in the case of satellites, asteroids, &r other planetesimals, and planets, covered with or made of various evaporable "ices" frozen at low temperature. Such liberative engineering via nuclear or other means might be executed, either gradually or "instantly", on any scale as suggested earlier in my discussion of the size attainable by nuclear explosions on the Moon. It would be interesting to see what life would ultimately be compatible with various higher levels of background radioactivity than characterize Earth presently; life tolerant of very high levels, indeed, might evolve of its own or be engineered

into existence by man. If one is prepared to wait 10^{1-7} years for artificial radioisotopes to decay and radiation to reach an acceptable level, enormous temporary levels of radiation related to nuclear engineering on some planetary scale could be acceptable; after all, this was the situation cosmogonically, and it might be interesting to know what radiation levels prevailed during the years that life first arose on Earth, and whether these events were interrelated. It is conceivable that man or his descendants may ultimately set aside one or more planetaries or environments for stupendously pollutive industries (in biological, chemical, &r radioactive--or other--terms) possible in such peculiar or accumulative milieu but practically incompatible with inhabitation or different purposes: the Moon might become such an isolational Hell, for example, or "old" Earth herself. The surfaces of planetaries virtually consist of dissociable oxides so that there is no scarcity of this biologically essential element. Carbon for carbon dioxide, nitrogen, hydrogen for water, &c are different matters, but the overall picture is promising in terms of selectable milieus, interplanetary exchange, composition at depth, maintained percentages, possible substitutions, &c. The possibility of nuclear transmutation on a titanic and controlled scale may seem improbable in today's terms, but my intuition is that in the long run it shall be feasible and economical, and thus ideal and adopted, if requisite; it may merely presume, for example, a certain large scale of industry, evolution of technique or theory, &rc. Whether nuclear explosions will be used more or less initially, say on the Moon, to recover respirable &r industrial atmospheres, and instead of chemical &r solar processes, is uncertain and questionable, but it is hard to say when, if at all, nuclear explosions will be phased in. Possibly atmospheres shall be produced locally or globally by open rather than closed nuclear explosions, but possibilities for degradation of the environment might be critical. The vision of catoptrical balloons of titanic size orbiting the Moon, concentrating the Sun's rays on evaporative and dissociative foci, and evolving massive atmosphere by very cheap and simple processes, is attractive. Presently anatmospheric or microatmospheric planetaries such as the Moon and Mars might retain an artificial atmosphere at an acceptable level of leakage into Space regardless of their lesser gravity, at least in terms of the possible rate and cost of continuous or periodic replacement (calculations of illustrative cases should be done); or these might be englobed in cutospheres (retentive epiatmospheric skins of planetary size, discussed elsewhere): calculations for energy and dollar costs of escapable and inescapable atmospheres should be made and compared since the ratio may prove interesting.

Man will have altered the Earth's climate by 2015, and certainly will have acquired the ability to do so in various ways, by various means, and to various degrees by 2015. This issue is so important that the analytic dimensions in its connexion deserve being stated fairly exhaustively. The following list, although partial, should succeed in exhausting the reader. The event foreseen by 2015 is the capability, necessity, desirability, &r practise of marginally or drastically, homogeneously or heterogeneously, experimentally or purposefully, in one or many ways, safely or dangerously, correctively or innovatively, adjustingly or perfectingly reversibly or irreversibly, empirically or theoretically, finally or incrementally, gradually or abruptly, slowly or quickly, regionally or globally, cheaply or expensively, crudely or elegantly, statically or variationally, naturally or artificially, by one &r many act &r method, consensually or nonunanimously, purposively or accidentally, favorably or unfavorably, successfully or unsuccessfully, militarily or peacefully, alternatively or constrainedly, supplementally or complementally, costfully or costlessly, &c altering the world's climate, performed in &r outside the Earth's atmosphere, for a profile of one or many purposes, and by a particular schedule. This series of analytic dimensions should be reread and carefully studied for the things that may appear within its complex framework. There may be two modes of meteorological engineering: "intensive" (by local

intervention, say by spreading silver iodide crystals from a plane in the tropopause) and "extensive" (say by catalyzing an alteration of the global, multilayer, and multidimensional atmosphere, perhaps from Space or atop the Earth's atmosphere). It is conceivable that extensive meteorological or climatic engineering will prove performable, perhaps advantageously or ideally, from Space. The Earth's Van Allen Radiation Belts or magnetosphere may be catalytically or brutally modifiable in such a way as to exert pronounced and utilitarian effects on the structure &r dynamics of the Earth's atmosphere, climate, biosphere, &rc. It is possible that inadvertent anthropogenic modification of these things has occurred or is occurring already, even so as to exert major or catastrophic effects sooner or later; such effects might require that we research, understand, and remove the cause, cure or alleviate the symptoms, or intervene in similar or dissimilar ways, perhaps on an even greater, or apparently greater, scale, or at least more deliberately. Climatic equilibrium may be complex, fine-tuned, and easily disturbed, say of a metastable nature, and once disturbed it may require all-out efforts to counter, alleviate, or reequilibrate. The Earth's climatic fluctuation may be much greater, more frequent, and more consequential than hitherto supposed, and present or future man might find the natural fluctuation intolerable or unnecessary, even if the requirements for controlling it--as already discussed--may be much greater than would at first seem the case or than suggested by the changes themselves. The present overall or mosaic climate of the Earth, in space &r time, may be far from ideal, or even fairly atypical, and superior conditions may be creatable by deliberate interventions of a sufficiently intelligent and masterful kind, or specifically enabled through sufficient prior experimentation on some scale or through determination of the qualitative &r quantitative degrees of freedom of the global system by largely unpredictable tampering. At first it might seem that the Earth's global climate is not homogeneously, or in the net, improvable in that conservation laws will operate determinably or indeterminably working equal or ultimate harm in some quarters as actual or apparent good is worked in others, or at least scattering or appending certain "side effects" or basic costs unacceptably among nations or parties, and indeed global or climatic engineering may be extraordinarily complex, hard to balance, hard to do in a pluralistic world, uncertain, risky, &c. Yet there are so many possible dimensions to the world's climate, weather, biosphere, cycles, economy, atmosphere, &c--and sheerly to the useful technology--that one is encouraged to believe that great, acceptable, compromise, remunerable, partial, aspectual, &c gains should sooner or later be feasible by deliberate interventions, will be tried, and will be continued. The types or importance of things gained thereby are not very easy to suggest today. It is uncertain how independent geographic loci, global elements, specific effects, moments of time, &c may either naturally or artificially be. For example, could polar climate be radically tempered without major equatorial tradeoffs? Could the Amazon Basin be deforested or dammed, the Sahara Desert be irrigated or afforested the Mediterranean Sea be emptied, &rc without undue complications to natural or at least acceptable patterns of climate, vegetation, season, &c, regardless of the compensability of these larger effects? The capture of sunlight in Space and its redirection in various forms to Earth on an astronomic scale might exert, or enable, climatic effects. It might be possible to seed extensive areas of the Earth's upper atmosphere by discharging catalytic substances from low-flying satellites or suborbital missiles. It may be possible to build astronomically broad solar shields in Space made of filmy highly opaque plastic and costing virtually nothing, the shadows or penumbrae of which might exert catalytic or brutal climatic effects by cooling the underlying atmosphere, lands, &r seas, or these intervenient "megafilms" might filter or recolor transmitted sunlight received on Earth; such huge, amorphic, and tenuous megafilms might weigh so little as to easily be placed, controlled, and maintained in geocentric orbit by, say, punctiform and constellatory supermaneuverable satellites, fixed satellites, &r mere spaceships. One can imagine much beauty in the choreographic manipulation of such megafilms or "drapes".

Another possibility is that continuous or cellular sheets of such magnitude and serving such purposes might be continuously controllable in their surficial transmissive properties by electronic &r mechanical means, which dynamic means might even serve their orbital reconfiguration and maintenance by, in effect, sailing in sunlight. The dollar and energy cost of placing, maintaining, and controlling such astronomic bidimensional satellites in orbit, or of surrounding the world with an appropriately "rigid" or morphically maintained band or sphere similarly manipulable in its transmissive properties or effect, is uncertain, and depends on many things. One might prorate its initial cost over eternity, for example! The propellant costs of maintaining a nonorbital, collapsible balloon as big as Earth around Earth might be surprisingly small, and the technology may already exist; if, as Edward S. Gilfillan II suggests in his book Migration to the Stars, 50% or significant opacity may be possible with 10-Å films (which seems incredible to me), the global balloon or extra-atmospheric cutosphere would involve material costs limited to 1,000,000 tons of the suitable material (suggesting that man may already have it in his power to install the Earth in an unregulated, initial balloon). One must go beyond the Earth and consider as well related possibilities for creating, re-creating, and controlling the climates--and therefore other planetary components--of other planetaries, whenever these might reasonably be possible, probable, and appropriate, and in their dissimilar ways (the preceding calculations suggest that man may already have the technology and economy to so alter any and all planetaries of the Solar System, or will shortly). How drastic such simple means of intervention could potentially be is suggested by the fact that partial or complete removal of the Earth's sunlight could promptly condense, and hence liquefy or solidify, all of Earth's atmosphere, in which form, for example, it might be more manipulable for other, additional purposes. The planeturgical possibilities are really infinite and, in a way, total! Concern has already been expressed, and with political consequences, that stratospheric jetplanes &r rockets might seriously degrade or alter the zonal properties or the Earth's weather and climate--via tiny causes of inadvertent kind! Substances and particles introduced in or into Earth's upper-atmospheric layers may involve protracted settling times and hence multiplied effects, or effects over the world. The scarcity of any and particular nat molecues in these layers, which is extreme, means that the introduction of relatively little mass of any or particular kind can have stupendous consequences, at least theoretically. Better understanding of the structure, dynamics, sensitivitie &c of these layers, systems, and phenomena may give man extraordinary manipulative power over his atmosphere in cases where his efforts are nobly designed. It may be that current transmission by the atmosphere of ultraviolet light (or other waves or particles) to the ground may be unacceptably damaging to man &r crops, and yet readily reducible by relatively miniscule interventions, say for anti-carcinogenic purposes. The greenhouse properties of Earth's atmosphere may be comparably manipulable, say in order to stabilize climate. Of course, as may also be the case for business cycles, such climatic &c cycling or instability may actually be desirable. Conceivably Terran life produces and instantaneously maintains, both statically and dynamically, the properties of the Earth's atmosphere, climate, and even biosphere--composition, structure, barometer, solar absorption, &rc; it may even do so to the degree current natural &r artificial climatic changes may be innocuous or teleological, or to the degree that static &r dynamic climate &c may be hard to alter or inalterable, since readily compensated and orthogenetic. Indeed, conjecturably, current changes of aspects of climate may be natural and directed compensations for anthropogenic perturbations. But these things are fanciful and mysterious. If nothing more, the transportational and other technology, and the scientific knowledge, consequent upon man's Spacial endeavor may play a role in man's future efforts to modify climate, even if such modification is not done directly

By 2015 there will have been built and there will be in regular use moderately or highly efficient landing energy-regeneration systems that will perhaps be referred to as "cataleptic" systems. By these the braking energy of landing or arriving craft &r materials will be captured and subsequently used for stational power, relaunch of all vehicles, &rc. As redditions, the systems will operate like buses using reversible motor-generators, levitated trains in gravitational U-tubes, and a librating bob--as well as countless other critically dependent natural phenomena--to store braking for relaunch so that interplanetary &r other interlocal transport might eventually become "mientropic" (low or slow in entropic product or intrinsic entropy) and more nearly costless. Such seemingly unlikely elastic ideas are actually eminently feasible, especially in the light of new and future technology. The ultimate reducibility of ingredient entropy in industrial systems or intelligent acts--whether low or asymptotically high--is an interesting theoretical question pursued at length on page . Various mechanical and nonmechanical systems are imaginable for reclaiming some useful portion of flight energy, whatever uncertainties &r difficulties they present from an engineering standpoint, or whatever they presuppose in terms of evolvable and future science &r technology. One must be careful to avoid basic fallacies when proposing and evaluating mientropic or isentropic schemes; men are always getting ensnared in such fallacies, and all men have idiosyncratic scotomas down which they may turn and wander forever as free but foolish souls. The crudest cataleptic idea imagines some sort of pushable-pullable spring, rubber band, elastic diaphragm, rc that would be, in effect, charged by storing the decelerated arrival's momentum; I do not know what efficiency is now, later, or hypothetically possible for any such procedure as a complete cycle. Another idea would use a natural or artificial atmosphere to rotate a propeller, compress gas, compress a figurative spring, generate usable or reusable light, heat, &rc, rotate the whole projectile (so as to store angular momentum), &rc; again, I cannot speculate on any efficiencies, economies, dates, requirements, values, flaws, comparative merit, &c. A relativistic projectile could release its kinetic energy virtually as pure, high-frequency light --the question here is with what efficiency, ease, &c the arrival energy could be used and the flight acceleration could occur, and the nature &r fate of any material or immaterial "passenger". A system is possible which would use biterminal satellites for momental exchange, say in Earth=Moon flight, in a way analogous to emission and absorption in electron-orbital transitions and interatomic exchanges of migrant electrons; I understand such ideas are already possible and could be efficient and economical to a degree warranting their future implementation, the gains from which could be significant for, say, cislunar travel and shipping. Depending on the accuracy possible and energy requirements for mid-course &r other corrections, linear accelerators employing force fields (electrostatic, magnetic, &rc) could be reversible both for exomotive deceleration and for deceleratory generation of power, and possibly with efficiencies much higher than those related to purely mechanical systems. Recent and continued developments in the science and technology of electric, magnetic, and mechanical macroscopic quantum physics are very encouraging here, and may allow, even well before 2015, the implementation of revolutionary cataleptic, Spacial transportation systems. Important things enabling cataleptic systems might be developments and maxima in ultimate tensile &r compressive strengths of materials (for 1-, 2-, and 3-dimensional structures), ideal systems for interconverting velocities and momenta of translational and rotational movement, accelerations and decelerations withstandable by projectile, automaton, &r man, &rc. Interstellar vehicles might be decelerated, if not recharged, by impaction with and the frictional resistance of the atmospheres or subatmospheric regions of receptive stars--a wild suggestion to be pursued later. Gerard K. O'Neill has suggested mientropic intertransportive, engineless vehicles for his tandem contrarotating bicylindrical colonies operating via pulling-cable acceleration and arresting-cable deceleration and counterbalanced momenta. A

projectile vibrated between opposite elastically resonant termini hemicyclically and momentarily possesses zero velocity and zero momentum: could momentarily simultaneous removal of nonvehicular payload occur in order to limit flight energy costs more nearly to payload exchange sans vehicular needs, or even less since the payload momenta and hence energy would be maintained in the resonant vehicle-termini system at the extractive asymptotes? Macroscopic mechanical quantum physics and technology may produce some radical surprises when exploited for these and other uses 20-200 years from now. An important theoretical question in connexion with macroscopic quantum-physical possibilities is what statical, kinematical, &r dynamical efficiencies are possible, and whether they are in fact absolute or partial: I question that the latter is known. Should absolute efficiencies obtain and be exploitable, there could be fabulous consequences. There is the possibility that "mass drivers" will be employed for teledynamic purposes, or concomitant purposes, with the momentum of mass transferred across Space at high, perhaps arbitrarily high, velocities terminally recaptured by appropriate cataleptic systems; I refer to these shipments and systems as "hylodynamic beams", meaning that they transfer for dual or single purpose both matter and power via ballistical particulate. If certain transportation through Space eventually develops that is largely indifferent to flight durations, such as freight shipments in timeless concatenations moving at minimal interorbital velocity, then the simplicity and efficiency of cataleptic systems may be facilitated (assuming, say, that maximal velocities &r momenta are not physically or technologically ideal relative to minimal &r medium values thereof). Any and all possibilities for cataleptic events need to be much more carefully studied. Enviable possibilities may have been overlooked here or may be caught sight of with the Heraclitean passage of magical time.

Perhaps by 2017 the Solar wind will be used, or will have been used at least once for the heck of it, to sail about the Solar System as has been pictured by writers of science fiction. Obviously it would be cute, poetic, and perhaps even convenient if such natural sailing were to prove possible. Arthur C. Clarke suggests, in his book The Promise of Space, that the pressure of sunlight could be sailed at meaningful velocities and accelerations if a craft could somehow be fitted with perhaps 20 square kilometers of extraordinarily thin and yet manageable sail enabling impulsion from the Sun, tacking, and attraction to the Sun by somehow removing the obstructive sail in favor of the Sun's gravity; he does not concern himself with the presentation of any physical or engineering argument, counterarguments, and the basic forces involved. The difficulties, superable or insuperable, would clearly be considerable. The range of operation from the Sun, and the rate of operation, are uncertain. What is noteworthy is the range in orders of magnitude likely to characterize the actual feasibility or infeasibility, and their possible economic correlates. The difficulty of manufacturing craft with sails of the required characteristics, which are presumably extreme, is another matter in addition. A craft working on a minimal or quite acceptable basis, in terms of operating characteristics, is apt to differ immensely from a more ideal or the ultimate craft applicable to the vicinity of the Sun; considerable improvement over the years, in these terms, is likely, and might be important in itself, say by expanding range, competing with alternative systems, and converting a mere possibility, sport, or minor means into an actuality, major means, or highly competitive system of transportation. One serious question is whether it would be easier, cheaper, more feasible, &rc to use the energy instead of the pressure of sunlight. To a certain extent this depends in a critical way on the ratio of possible energy-producing surface-to-mass ratio to possible pressure-using surface-to-mass ratio (both might be extreme, involving surprisingly tenuous &r ingenious surfaces); how close can both photovoltaic and photo-opaque surfaces be brought to 10 Å depth, for example? Certain hierarchic anastomotic networks supplying maximal support &r electric conduction can be entertained that

β It should be noted that time variations exist of periodic and nonperiodic nature that might prove useful or at least complicating. Ditto various anisotropic spherical foci, currents, polar-oriented flow layers, &c; and probably potential wells, related to unequal particle masses and properties.

δ Very useful ordered configuration stable or dynamic Foci geometries of varied dimensionality — esp relativity high density, interactions, and energy surfaces, tufts, and lines — must also exist.

would represent a transcendentally great improvement over what is otherwise imaginable. Great sails by no means require to be taken in or manipulated as whole or large surfaces; they could be varied as to their transmission and direction as sets of arbitrarily many and small cells, or as realignable on a molecular or atomic level by certain known &r developable electrical effects. An interesting question is as to what greatest acceleration is theoretically and actually possible for a craft possessed of arbitrarily large sails and powered by the pressure of light, say in order to be impelled beyond the Solar System at interstellar velocities, inasmuch as cost of arbitrarily thin sail might be vanishingly small in terms of an extremely low cost-to-mass ratio or value of cost-of-energy thus derived. It is to be noted that we are actually discussing 2 seperate things: flight using the pressure of sunlight or photons, and flight using the pressure of the solar wind. The former obeys a simple inverse-square law for distance from the Sun, but the latter might not to the extent the density of particles of energy in the neighborhood of the Sun, especially charged particles, which exist in abundance, might vary in a more complex and irregular manner, and the Sun might be considered as a furnace at depth in an ocean of particles stirring up potentially exploitable currents at layers in this heliocentric sea.[α] Certainly, even assuming identical inverse-square laws, the ratio value of light pressure versus light energy for sailing purposes ought be calculated and considered, particularly since one may be crucial over the other and the proper topic for discussion of anything other than fantasy. In a way the velocity of the solar wind, which is several hundred kilometers a second,[β] imposes upper limits upon the acceleration and velocity of matter possible via the pressure of sunlight since it must represent the addition of that impulsion to the heliofugal corpuscles, although I believe its primary basis is not supposed to be such extrasolar acceleration but rather episolar momenta. The heliosphere may recover at least part of the heliofugal particles by their return along magnetic flux lines converging on the poles, a portion of the charged particles reentering the surface of the Sun and another part undergoing extrasolar (but intra-heliospheric) recirculation, certain pinching effects, &c.[γ]

Use of solar light &r wind by 2017 will be the first example of a far greater and grandiose set of events which will, if at all, transpire at successively later dates, some almost inconceivably late in the future history of man, or his progeny, in the universe. What is being referred to is any use of stellar "breezes", light, gravitation, magnetism, cosmic rays, enantons (or of alternating matter and antimatter, an alternation such as that surmised by Hannes Alfven in his book Worlds, Antiworlds: Antimatter in Cosmology), "cosmic" blackbody radiation (say handled, somehow, anisotropically), &rc to sail the Milky Way galaxy or beyond. The possibilities here are obviously uniquely speculative: difficult to either condemn, defend, or conceive. The suggestion would seem to work by analogy to the familiar world around us wherein energies, matters, currents, &r fields exist in sufficient plenty, variety, current, &r voltage to be exploitable for anything in any way analogous to sailing. Physicist friends tell me, to my surprise, that sailing is at least theoretically possible on the basis of many of these energies and forces, and not only at the interface of 2 media such as the surface of water over which boats sail and that divides air and water with their respective phenomena; they tell me that a vehicle wholly immersed in a single medium, such as an airship in the atmosphere or a submarine in the ocean, is even capable of countercurrent sailing (with respect to the rest of the universe), despite the failure of man to so far develop any such vehicle (there is none that I know of). The prior discussion of Solian sailing published the fact that a number of different possibilities coexist, which is likewise, or a fortiori, true here. The larger set of possibilities might be said to include: (1) Energy and matter used as fuel, (2) Pressural sailing, (3) Manipulable (push-pull) fields, and (4) Manipulable structure Oddly enough, all 4 have examples in our galaxy and in the greater structure of the

universe. A problem exists, in connexion with any extrasolian sailing, in that such structure attenuates with scale, becoming very weak, indeed, on a galactic and cosmic scale. Such attenuation would presumably be only partly compensable by proportionate scaling up of the machinery of any exploitable craft, &r by indifference to rates of acceleration and corresponding travel times for various (perhaps unduly fanciful or remote) employments. What is actually possible on an astronomical scale, or in such extreme circumstances, is really unknown, not thought out, and often incomputable by our antique selves. As an example, I have wondered whether any sort of optics might be possible that, employing quite astronomical scales, could enable the focusing and use of the so-called cosmic blackbody radiation of $3^{o}K$ that supposedly pervades the universe, exists isotropically, and represents a cosmogonic relic; I was particularly wondering whether it could be used as a source of power. There is a strange coincidence between the energy densities within our galaxy of starlight, the "cosmic" blackbody radiation, the flux of "cosmic" rays, the heat of the turbulent plasma, and the galactic magnetic fields (or the assumed values and distributions of these things), a coincidence which has yet to be explained. In any case, the coincidence simplifies our mental consideration of the possibilities for intragalactic sailing via the relevant media by roughly equalizing their Spacial values. Even if these things are ubiquitous within the galaxy, they must vary very greatly, even somewhat independently, in specific 3-, 2-, and 1-dimensional loci, and as a consequence there is a certain hope that in specific continuous or discontinuous loci (with respect to which the vicinity of the Sun may be advantageous, average, or disadvantageous) especially, and perhaps critically, advantageous conditions may obtain from the standpoint of needs of interstellar travel. Utilization of such low &r unusual energies may presuppose likely, unlikely, or unimaginable scientific &r technological developments at certain points in the future by which use of such hypothetical sources of power might be justified by the activities or wishes of beings at that time. Of course there is a good chance that within our galaxy or elsewhere in the enormous universe there exist beings whose mental, technical, and cultural development has preceded us by tens, hundreds, or thousands of millions of years so that any possibilities within our own future may already be in use and demonstrable, if at all, in what is observable telescopically or deducible on the basis of intelligent surmise. Man might get in touch with such advanced intelligence in just a few years, say by 2020, through some sort of passive interstellar communication, and receive in this accelerated way the technical bases and the axiological warrants for very early employment of such galactic and cosmic transportation systems; analogously, provision of such means very early may occur as the result of explosive development of intelligence in machines, unexpected breakthroughs in science, &c, making it very difficult to be precise about minimal feasible or even probable dates. When the development of of the galaxy &r universe eventually occurs, assuming it does or that it has not covertly already, it may well occur in a surprisingly synchronized, universal, and thorough way on the basis of transcultural cooperation and on the basis of communication, transportation, &r deduction. But I stray into topics to be treated elsewhere in the book. The possibilities just considered refer exclusively to physical and astronomic entities that are known already. Such a confinement not only neglects what is possible but is completely unrealistic. The realistic expectation is for the further discovery in years to come of variously dissimilar physical and astronomic phenomena, entities, structure, laws, &c; of new types and distributions of force, matter, and energy; and of new types of types of types... of these things, perhaps as an endless process. The history of science is that it has repeatedly astonished scientists, often only achieving its proper revolution and evolution by a generation of scientists dying and being replaced by another, more flexible generation. That the future of science and technology can be optimistically foreseen using nontechnical reasoning has been amply demonstrated

by the correspondence of what has transpired in the 20th century with the prophecies contained in Francis Bacon's 4 centuries old book The New Atlantis, and with other correspondences between things foreseen by imaginative minds, writing before technical defenses or even bases for such things obtained, and subsequent developments in the real world, such writers of science fiction as H.G. Wells, Arthur C. Clarke, Robert Heinlein, Olaf Stapledon, &c providing countless examples. Already certain of the things which may yet be discovered, or traits of these things, are characterizable by working within the framework of what is possible or probable, for theoretical or empirical reasons, in terms of accepted science and technology. Of course the nature of the situation is that the more extraordinary things which exist in nature but which have not yet been discovered must be less predictable, describable, &r evaluable--for the most part--on the basis of such limited knowledge. This can be restated significantly: the more fundamental, exotic, important, and decisive things in science and nature are precisely those things of which current knowledge, theory, and technique must be most ignorant. Beware the bumptious and reactionary scientist, be as wary of him as of his wild-eyed cousin! The Plenistic School of Physics foreseen as getting underway by around 2000, as an article of philosophy and on the basis of new empirical and theoretical developments in physics (and perhaps astronomy), and treated in depth elsewhere in this book (page), will contain abundant possibilities for such "sailing" transportation as considered here in Solian, Galactic, and Cosmic terms. The relevant interspaces, or so-called "Vacua", may even turn out to be better described as material, energic, and technological plena. Calculations should be made of the accelerations which are theoretically possible via starlight pressure or energy, magnetic attraction (even using hypothetical particles called magnetic monopoles), &c. Just as there exists in nature a triad of electromagnetic forces (photonic or neutral electromagnetism, magnetism, and electricity) and a triad of Weak forces (a neutral presumptive Weak mediator of analogous alternating nature, and 2 forces analogous to magnetism and electricity), so such a triad may exist in the case of gravitation with its parts technologically divisible in exceptionally interesting ways (one possibility being positive and negative gravitation). There are some theoretical and empirical suggestions that the fields, or fields defined in a range, of these things (such as gravitation and the Strong force) may be finite, alternating, multiple, &rc; if so, this would surely open the door to technological exploitation at some, however distant, stage of the future. Many other forces have occasionally been suggested in addition to these 4 more or less accepted ones (actually, even the nature of these accepted forces, and their distinctness, is highly uncertain). Tremendous concentrations of charge, and perhaps modulable charge, in spacecraft might facilitate natural galactic sailing. The structure of spacetime might vibrate in such a way as to be used by superscientific beings as a motive source for their undulating spacecraft. The really fantastic possibilities are really endless. I end here.

There is a chance that by 2017 a Mercurian &r perisolar power plant will collect sunlight and somehow send it Earthward &r to interplanetary loci. Especially in certain ways, such a event may never occur at all, except far later on a specifically Dysonian scale unrelated, presumably, to our present discussion. The power might be relayed catoptrically, optically, by frequency conversion, &r by conversion, storage, and shipment in some familiar or novel form. The motive for frequency conversion might be focusability at distance, ease of handling (at transmitter, en route, &r at receiver), &rc. Soft, balloon or "drape", mirrors near the Sun might be ideally cost-effective and affordable. The idea of perisolar power relay stations comes from science fiction, worrisomely; its motivation must be an image of fantastic power in sunlight 0-10^8km from the Sun's surface, yet at Mercury the solar constant exceeds Earth's only by a few factors and even on the surface

of the Sun the intensity of sunlight is only greater than at Earth by a factor of $10^{4\frac{1}{2}}$. A station located at a safe heliocentric orbit 1,000,000km above the Sun's surface would have such intensity of light at its disposal; the savings in the area of the collector would have to be such as to compensate the economics, difficulties, and inefficiencies involved in the overall transmission to Earth or elsewhere in the Solar System. A 5,000 Å wavelength power-transmitting 5m-aperture laser might use a beam divergence of 10^{-7} radians (2×10^{-2} arc seconds) to focus on an 18km circle at Earth. The energy collected near the Sun would have to be sufficiently great to justify periterran recollection over an area of $250km^2$. At first such an area seems unacceptable, but it happens to be the same as that currently being suggested for single periterran solar power stations that might be built by 1995. Critical is the ratio of artificial to natural irradiance at the receptive locus, which determines the economic competitiveness. It turns out that for twice the area of a single periterran collector (the doubling representing the addition of an equiareal perisolar collector) this ratio is as great as $10^{4\frac{1}{2}}$, which seems decisive for a matter previously up in the air. Moreover, depending upon the isareal capacity of any periterran collector--expansion of the perisolar area of collection, by enlarging or multiplying collectors (or cheap focusing on them as well)--the $10^{4\frac{1}{2}}$ ratio for the intensities of sunlight at the 2 distances would seem to underline the competitive superiority of perisolar to periterran collection since the mathematical relationship is one of amplification; of course the artificial light received by the periterran relay could, and presumably would, be cheaply (soft-catoptrically) focused, as well. Incidentally, the width of the 5,000 Å laser beam would widen 400 X, to 7,000km d, at Pluto. It would seem far more difficult, if not impossible, for mere spaceships, as opposed to planetocentric stations serving the needs of whole planetaries &r satellospheres, to receive and use such perisolar teledynamic energy (although ships employing immense tenuous collectors have just been considered for purposes of sailing natural sunlight, &c), but I also discuss in this book "spaceships" of titanic and planetary size for which this objection would not apply (the focus of such beams might have to be finite, limited theoretically and practically, but the power could be infinite and virtually on the basis of an identical efficiency), and a ratio of diameters for the collector over an actual spaceship could easily be 10^{1-2}, so that even enormous but not titanic spaceships could readily operate exodynamically via 10^{15}cps(visible) gigawatt lasers within the circle or 3-sphere defined by the Earth's orbit or the Asteroid Belt. All the preceding presupposed basers limited to 10^{15}cps, yet the irradiance and hence power receivable by a unit area of collector goes up as the square of the frequency since the frequency is directly proportionate to the convergence; we will have before 2017 basers operable discontinuously and continuously at frequencies many orders of magnitude greater than light of 5,000 Å. Grasers, or gamma-ray basers, operating at 10^{18}cps will send or concentrate 10^6 X as much power; cosmic gamma-ray grasers may possibly be built and used by 2017 or 2040 supplying as much as 10^{16} X as much power as our lasers by operating at frequencies as high as 10^{23}cps (the science and technology of these rather unnatural frequencies are admittedly both very uncertain in 1975, a fact which may paradoxically operate in our favor). It is clear that diametric improvements of 3-8 orders of magnitude, and areal improvements of 6-16 orders of magnitude, would totally revolutionize the picture previously painted of teledynamic power and propulsion in the Solar System using stations near to the Sun. If the ratio of $10^{4\frac{1}{2}}$ for sunlight near the Sun to sunlight near the Earth seems, or proves for purposes at dates, inadequate, an additional possibility is that the power of the solar wind next to the Sun, or of magnetic or electric currents there, might be competitive; but, better still, the very heat and turbulence of Solar strata (say atmospheric strata) could conceivably be used by fantastic in situ power plants collecting and relaying

energy to Earth as already described. The thermodynamic &r other cycles possible and appropriate in this bizarre episolar or intrasolar environment should be very interesting and may bear little resemblance to things so far done on Earth. Two schemes for sending power over interplanetary distance that have already been considered, namely by hylodynamic particulate beams (page) and by the launching and cataleptic reception of large masses or meteoroids (page), are of competitive interest in the case of transmitting energy near the Sun to elsewhere in the Solar System, but in this case the 28g gravity near the Sun burdens matters considerably by comparison with "massless" light quanta; ways of getting around the extraordinary gravity, for the sake of teledynamic masses or momenta, are nevertheless theoretically possible and may well turn out to be very attractive once the mechanics and technology are resolved, and who knows how early such resolution might occur? The attainability of 10^{20-23}cps basers would seem to make interstellar transportation eminently feasible even on the basis of fairly "customary" power, efficiency, &r acceleration, even for 1-century ~1-g and 0.1c flight between any 2 typically distant stars (say between Sol and Proxima Centauri). Such interstellar telpherage could be rendered pathetically easy and obvious by more than customary (and yet still probable and even rather familiar) power, efficiency, &r acceleration, or by ideal maxima or ultimata. A baser beam reaching from star to star over 10 light-years could theoretically converge on a circular target of diameter 10^4km for 10^{18}cps, 10^2km for 10^{20}cps, and 10^2m for 10^{23}cps. Whether higher frequencies of baser are possible, and with what efficiency and technological preconditions, falls outside my knowledge. If acceleration and deceleration are limited to a tiny fraction of an interstellar flight path, as they probably will be, the propellant beams need only be operative within a few solar system radii, most of the voyage being unpowered drift. Characteristically, a possibility which at first seems objectionable, even futile, upon inspection reveals itself to be quite the contrary and even inevitable. Thus much of the pessimism felt today toward the future of Space must stand upon a failure to give fair and veracious examination to ideas both proposed and dismissed a priori; how often this is the case for pessimism in general! The above discussion likewise was limited by presupposing a 5m-aperture baser. This aperture is naturally far grander than the fraction of a meter apertures so far attained, but an order of magnitude evolution is not overly grand and one wonders what restraints would or would not apply to the very grandest apertures imaginable or attainable within 42 or more years (2017f) on the basis of technical and scientific progress. Presumably apertures far in excess of 5m, perhaps by orders of magnitude, are at least possible. Since theoretically (and, by postulate, fundamentally) maximal convergence of light (and, by postulate, anything else in the way of energy and matter) is given by the formula λ/D, where lambda is wavelength and D is aperture, it follows that aperture is as interesting as wavelength and maximal convergence represents the linear product, and not the sum, of the 2. A Dysonian civilization might only naturally scale up our instruments by 1-11 orders of magnitude (certain instruments or construction details might be scaled up 0-17 diametric orders of magnitude, which is 0-51 volumetric orders of magnitude and potentially for certain things at least 0-153 orders of magnitude as the product of rate X density; the "Dysonian" civilization assumed only being that of a solar system, not a galaxy or universe). Confining ourselves to the discussional maxima above (neglecting God's maxima, if He has any), a 5 X 10^8km-aperture 10^{23}cps baser pops out as an oneiric creation with a focus on any star 10LY distant of 10-Å diameter, or 10^5-Å for any star in the Milky Way and 10^{10}-Å(1 m) for any target in the perceived universe (and in all cases almost all of the photonic energy and power transmitted would reappear at the target if only the relevant interspaces afforded a window for such maximal frequencies, where in fact no such window may exist). Obviously such "maxilineal" (extraordinarily narrow and long) beams would originate from

transmitters subject, for both technical and scientific reasons, to critical difficulties in terms of knowing where to aim, achieving aim, and stabilizing aim! But unthinkably great improvements are possible and probable in these cases as well. Note 2 things: the known universe or "phanerocosm" is supposedly or hypothetically 10^{26}m in radius (disregarding hypergeometric considerations); and the ratio of this cosmic radius to the aperture of the preceding baser is only but all of 2×10^{14}. Certainly some very great economies, or formulaic roots, should be possible for intrasolian remote power and propulsion using the Sun or any other intrasolian station, in the time frame of 42-200 years (2017-2175). There is always the possibility that electromagnetic power originating at perisolar stations but subject to objectionable divergence over interplanetary distances could, better or economically, be refocused by 1 or more intermediate repeaters in the form of spaceships, heliocentric satellites, or even bizarre longitudinally vast reflective, conductive, capacitive, or even mechanical (eg rotating if not vibrating) structures, perhaps to be known as "teledynamic interspacial fibers, wires, or tubes". The latter continuous or semicontinuous lineal structures at first seem preposterous but are in fact reasonably buildable, operable, and usable at various future dates. For example, a teledynamic line of the sorts considered that would be 1 cm in diameter and 10^{8}km in length (1×10^{13}) could weigh as little as 10^{7}tn, or multiples of this as perhaps equal multiples of the power transmissible by unit lines; for certain purposes size laws would benefit unit of power transmission costs by causing them to vanish in terms of the ratio of power to the mass of the teledynamic structure, a fact particularly significant by eliminating cost in Dysonian engineering once such engineering is typical. The number, costs, nature, efficiency, &c of the previous discontinuous or sequential repeaters or relay stations are uncertain but would be determinative, and initial objections to them must answer the fact that microwave (and, in a sense, satellitic) repeaters already function on Earth for teledynamic and telecommunicational purposes. Of course orbital velocities differ per distance from the Sun so as to grossly complicate teledynamic path, but propulsion needs of artificially collinear retransmissive spaceships might be completely fractional, satellitic number or population per orbital distance might be arbitrarily great (allowing the same interhorizonal reconnection as currently practised for telecommunicational geosatellites), weight of the retransmissive stations might be minimized or caused to vanish by 0-4-dimensional size laws, &rc. In the case of power exchanged between large stations, or able to involve such exchange indirectly but symmetrically, effective distances would presumably be reduced by the relative ability of such stations or interstations to incorporate enormous receptive and transmissive structures, particularly because of the superior and central power such epiplanetary &r extraplanetary stations will inevitably handle. For instance, a station on Mars many square kilometers in area receiving perisolar beams could store such power or send it directly, perhaps by line of sight, to areosatellites (artificial areocentric satellites) or to receptive, exodynamic spaceships and spacestations anywhere within the economical areocentric "half-universe" contained by the plane of points equidistant at any moment between Mars (power transmitters on Mars) and the Sun (power transmitters near the Sun). Ships changing their distance from the Sun, say by voyaging between the Sun and Mars, would stand to profit by receiving teledynamic beams from the Sun over the first and accelerational half of their journey, and, having crossed the "hemiuniversal plane" receiving teledynamic beams from Mars over the second and decelerational half of their journey, effectively halving the teledynamic distance; of course, better still, that portion of voyages devoted to acceleration and deceleration could be restricted to a small spatial and temporal part of such travels by concentrating

instantaneous power transmission and using higher celeration (acceleration and deceleration). A seperate matter is what teledynamic convergence is possible, and with what ease, via electromagnetic apparatuses other than basers, per se? For instance, what practical convergence would be possible for titanic or astronomic hard or soft mirrors stationed about the Sun and focusing sunlight at Earth? Huge devices of this kind might be easier than basers with apertures of such magnitudes as discussed above, and might not, by distinction, presuppose any revolution &r even evolution of science &r technology and thus be feasible as early as 1975. All the matters we have now considered urge upon us a radically unorthodox picture of what current or future engineering in the galaxy and universe may look like and involve. The novel and bizarre picture needs to be very carefully thought through so that we can draw proper and new conclusions upon the subject of this book.

By 2017, if such a thing is possible or important, intraspacial ships may be propelled about within the Solar System by vast, paper-thin, and gossamery radioisotopic sails as has been suggested by others. This is one of those events where one's first impulse is to contemptuous dismissal of a flight of fancy. What can be said in the idea's defense? I assume what is visualized amounts to coating an immense sail, or sheet functioning as a structural back through its continuous depth or reinforcing web, with a sufficiently radioactive, or appropriately energetic, radioisotopic paint of such thinness &r kind as to produce largely anisotropic emission of primary &r nonprimary radiation in association with a relatively nontransmissive or reflective underlayer, and an acceleratory exchange of momenta distributed over the total sail and transmitted to the central ship as a result of the rigidity or tensile stability of the erectable &r manipulable sails. Critical for such a conception would be the highest radioisotopic energies theoretically or practically possible for any such craft (and in terms of the necessary amount), destructive effects of radiation in the case of tenuous structures or fabrics, momenta and rate of various emissions, possibilities and requirements for insulators, reflectors, supports, and other devices, lifetime or decay rate, effects of radiation on living and nonliving payload, concentrability of radionuclides per unit area of sail, attainable anisotropy, preferability of various emissions, dirigibility and other regulability (say of the rate and direction of emission), possible velocity and acceleration, competitiveness of such radioisotopic systems with other modes of propulsion (including other sailing systems and even mere radioisotopic "batteries") in any cases, &c. Would acceleration possible be greater than using solar wind or sunlight, directly or indirectly? Would the system have any special value for extrasolian or interstellar flight? What ultimata might be possible for such a system? How would such a Weak force system compare with Strong force reaction systems? Would some incidental superabundance of radioisotopes as wastes or in nature at some point in the future conduce to the adoption of such a, previously pointless, system? What area would be necessary for sails giving certain accelerations? What would be the specific impulse of such systems? Would broad sails actually have any necessary advantage to solid, punctiform emittors? One leaves this proposal in a very skeptical mood and curious as to just what its originator meant and whether he considered something we have missed.

By 2020 a single Spacial disaster will have claimed 100 lives (see page). This seems almost inevitable in view of the number and concentrations of people in Space, per my projections, by then. The reader might object that such an event occurring only once in the course of the next 45 years is highly unlikely; this is possible.

The Plenistic School of Physics which I have said should arise beginning around 2000, and eternally thereafter (according to one view), was, to be frank, at least partly intended as something of a catchall or grab bag for the many scientific and technological developments probable over such spans of time, just as they have occurred in the past of physics. Of course it is at least possible, it may even be probable, that marked acceleration may occur in the rate of such developments, even an upward inflection in the curve of acceleration, and occur, say, between now and 2020; physics, perhaps even technology in the sense of applying what is discovered to practical affairs, may find itself overwhelmed by plethoric discoveries of natural complexities, particles, effects, laws, energies, forces, resources, &rc (&r this may occur at various later dates). In any case, it seems reasonable that probably by around 2020 such discoveries will have suggested means for extraordinary, or at least abnormal or additional, communication (say over Space) via essentially new means: new frequencies forces, energies, particles, effects, &r other relationships. Many possibilities already exist in physics such that they can be named: black and white holes, tachyons, neutrinos, muons, &c. It seems improbable that neither those things nameable, nor those not and unknown, should by then be discovered and be of use to communication, even if just by dint of clear sign as to their eventual possible or likely value, or achieved use on a laboratory scale or basis: physics is far more progressive and a failure of such a development would at least be inconsistent with the history of physics in 1975. There are many ways in which one or more developments in the science and technology of communication might have revolutionary significance for communication on Earth and in Space: the natural flux of modulable entities through space might be found much greater (more diverse, dense, powerful, useful, &rc) than previously assumed or known; means for producing such greater fluxes might be found (in any of the ways suggested); such fluxes (in any of the ways suggested) might be found (sooner or later) to already carry a certain measure of extrasolian communications; &rc. It might be found by then, in line with a Plenistic physics, that determinism in nature is much greater than thought, that atoms are much more subdivided than previously believed, that the functioning of nature is what might at first seem extraphysically complex, that new mathematics allow far more powerful or different communicable effects (with a hint that mathematics is unencumbered by the supposedly "physical" limitations of the world), &r the like. Gerald Feinberg, a prominent sponsor of hypothetical tachyons, deems them only 5% probable, and is more skeptical still about their possible use by ourselves to transmit or receive messages, particularly since such uses might seem irreconcilable with the conventional idea of causality in physics, although this is an area of heated controversy. My own guess is that other particles somehow exceeding the speed of light may well exist, that solutions to the seemingly paradoxical effects of tachyons or their hypothetical uses are possible that are neglected by current--and therefore naive--discussion, that paradoxes of an analogous or even homologous kind may exist elsewhere in physics &r in nature, that the nature of time itself is far different and more complex than currently assumed, that "superinfinite" (or more than infinite) time may exist and have a bearing on these matters, that tachyons themselves may be more likely than currently assumed, and that things in nature faster than light may even be necessary. It has been remarked that the cosmological implications of actual tachyons would be extraordinary since they would seem, in their preference for infinite velocity, fundamentally indifferent to the current 10^{10}LY event-horizon for the universe, or "phanerocosm", that is so crucial to modern cosmology expressed in terms of luxons (particles limited to 0 deviance from c, the speed of light) and tardyons (particles limited to velocities less than c). Martin Harwit has argued (in the book Communication With Extraterrestrial Intelligence, Appendix G) that tachyon data transmission rates might just conceivably be enormous. An interesting

question is how high frequencies man will sooner or later be able to produce using the 4 or more fundamental forces in nature and the other means at his disposal, and at what efficiency, convenience, and power in terms of specific communicational applications. For example, using basers or any other technology, will man be able to achieve, modulate, and use photons at, or beyond, 10^{23}cps, and, if so, what implications would this have, say by creating capacities for certain purposes? For all these things, when--if ever--should they come about? The increase in informational capacity enabled by going from gigacycle radio to visible (and beamable) laser--10^6 X--has already been remarked; a further increase by a factor of 10^8, or a total increase by a factor of 10^{14}, is mind-boggling in the specific sense that it seems to presuppose one or more revolutions in the very use, significance, or even meaning of communication and information, or a removal of known bandwidth barriers to recognized needs. The discussion of possible and warranted intellectual progress elsewhere in this book nevertheless makes it obvious that sooner or later such fantastic increases of information and communication may, and will indeed, serve purposes, however unimagined these purposes. An extraordinary fact is that the flux and energy density of particles at any point in the universe could be infinite or even superinfinite without our even knowing it, assuming appropriate distributions for the allowance of known characteristics of the universe's or phanerocosm's structure and dynamics; various infinities of "sub-known" &r "supra-known" electromagnetic frequencies might intersect our familiar space and be arbitrarily important, regardless of the inferior (eg 10^{4-8}cps) and the superior (eg 10^{23}cps) finite-radius "drapes" that astronomers impose upon extrasolian astronomy but which may yield, at more extreme frequencies, to further windows, sources, and cosmological implications. Deeper tissues of the universe may exist--forces, particles, dimensions, laws, realms, energies, matters, sub-universes, &rc--such as to be reached from our phanercosm only more or less indirectly, say through tertiary intermediates or asymmetric relationships; such more or less asymmetric &r indirect relationships, or depths to "the" universe, may be infinitely or superinfinitely many-dimensional, or weirdly anastomotic. These speculations are so extreme, however, that they are better confined to a section of this book (p) treating such matters specifically; yet by 2000 or 2020 such speculations may become conventional or be reactionary in their ignorance of subtler points of discussion. One last remark, however, is that particular significance will attach to the discovery (or failure of discovery) of additional stable particles and especially such as may play normal roles in nature, or to the determination of the precise nature and possible limits of stability in such particles as are known already; a related question is, how active is nature even now? ∫An alternative to communication as currently practised using microscopic agents--ie by limitation to modulable waves of energy and grouping of particles of matter, and because of which it is currently sharply distinguished from transportation--would be such miniaturization and condensation of whole objects (however tiny) bearing information in their structure as objects that these could begin to compete with energy, or transportation of microconstructed objects compete with modulated energy in the communication of information across space. Such a proposal initially seems absurd and retrogressive, yet actually it may pertain to what will develop by around 2020, perhaps depending on means for inscribing and reading information in grams of matter (analogously to transmitting and receiving information in volts, ergs, and watts of energy)--quickly, efficiently, conveniently, densely, reliably, &c--so that such information might be transmitted over certain distances and used locally instead of carried by energy packets of electrons, photons, &rc. A limitation inherent in energic telecommunication is fundamental divergence per unit of distance per unit of energy --suggesting an ultimate cross-over point with transportable objects. At 10^{24}bits/gm, 1-gm pebbles might communicate 10^{24} bits of information, 1-kg rocks 10^{27} bits, 1-tn boulders 10^{30} bits, &c. Yet information inscribable and retrievable in matter

might now or later greatly exceed this bits per atom schedule, if, however, as limited by Schrodinger's equation, which quantizes intercorpuscular relationships and hypothetically renders them finite (I question that it does this absolutely). In making the comparison between these future competitors it must be borne in mind that ordinarily energy-mediated communication, especially telecommunication, occurs via multitudes of parallel and seemingly redundant photons enabling concurrent frequency modulation and amplitude modulation; in actual practise--I am not sure why--the bits transmissible instantaneously are said to be limited by and given by the frequency, roughly the cps, and the extra flux is indeed redundant except insofar as it supplies a receiver possessed of a threshold and located at a distance with the minimal instantaneous registrations necessary for reliable detection of the information. So great numbers of practically superfluous photons or electrons are used in today's energy-mediated communication and must be considered when examining alternative object-mediated communication. Omitting such excesses momentarily, consider the relative efficiency, cost, &c of sending 10^{27} bits to the Moon as 1kg of matter and as roughly 10^{18}sec of televisual broadcasting at 10^{9}cps and 10^{12}sec of 10^{15}cps-lasering; the first is greater than the age of the universe and the latter is $10^{4\frac{1}{2}}$ years. Of course so many dimensions belong to and are possible for any such comparison that the preceding is largely meaningless and the problem is simply enormous; clearly it will have significance which will vary endlessly over the future. Still, either probably or very possibly, object-mediated telecommunication may in the future supplant that using, say, photons in the specific case of exchanging information between the Earth and the Moon. The divergent attenuation theoretically unavoidable for interstellar communication mediated by beams of energy, say via lasers, may argue a fortiori that conversations carried on over distances of light-years will properly be mediated by transportation of totally specific objects instead of by modulated packets of inconcentrable energy. Evidently there is some crucial equation possible here for the cost of a bit-photon per unit distance, or a steradian-expressed equation comparing atoms and photons--or molecues and wave trains--as carriers of information. Unfortunately I myself cannot compute these things. A decisive question is the costs and problems of sending information-laden objects at velocities various fractions that of light, where 10^{-5}c is 7,000mph; it would seem far easier to send 1-gm "spaceships" to the next star than 10^{9-11}-gm ones, and the famous costs for the latter--which some people consider to be fatal for interstellar flight--might be completely irrelevant for 10^{24}-atom ships (indeed, as 10^{11}gm combined mass, we could send 1 1-gm spaceship to every star in the Milky Way at the "same" cost as for 1 10^{11}gm ship; the specifically mechanical sophistication attainable by a superscientific organization of 10^{24}, a septillion, atoms is probably so great that everything today only achievable through the 10^{11} X larger ship--including an ability to reconstruct the entire universe via a cellular automaton, a feat impossible by a ship of such size in 1975--will eventually be accomplishable by the "microship", a topic treated on page). Ultimately all the television entertainment of a lifetime may be embodied statically in a replicated, omnipresent, and retrieval-permitting cube of matter (the bits per second representation used by commercial television in 1975 comes out to 10^{16} bits per lifetime--sans removable redundancy per frame, much less per lifetime--which is compressible, @1 bit/atom, into a like number atoms as a 10^{-8}gm cube of matter measuring about 10^{-5}m on a side); transportationally distributing such bacterium-size "televisual lifetimes" throughout the population would statically substitute for all television observable today and for eternity via telecommunication; even if such canned entertainment were to represent but a third of that enjoyed by televisual audiences, its transportation would probably be advantageous to its communication, at least using current means. A seperate issue is loss of electrons over media, as opposed to loss of photons in vacuo by divergence, in comparison with object-mediated communication.

Higher life in Space will have been discovered by about 2020, or the probability is 50%. If recognizable, it will probably be discovered outside the Solar System. By higher life is meant something that cosmic biologists would rank along with macroscopic organisms on Earth and that would include things analogous to visible plants. What will probably have been discovered is life more intelligent than we, initiating communication, tens of millions of years in advance of us technically, machines, and about 1,000 light-years distant. Many of these aspects are almost totally controvertible. For example, the average star in the galaxy is 20,000 LY distant, regardless of galactic radius, so why not assume such a distance for our first detection? The age and conditions of stars vary radically according as they are in or out of the galactic core, so why not look in one or the other or both? Most stars are in the higher densities toward the core so why not look there? Assuming our peripheral location in the galaxy rendered life on Earth prior, should we not look toward the galactic anticenter? Should we select for stars as alike the Sun as possible, for those Sun-like stars older than the Sun, or for theoretically ideal stars more or less independent of Solar analogy? Should we look for life outside, not inside, the galaxy? Should we look between stars? Should we look at the very nearest or the very farthest stars? Should we pursue a certain set and schedule of things at once? Should we be easily discouraged? Is life to be presupposed universal or just as rare? Should we look for anomalous or artificial astronomic features instead of for signals? Should we suppose communications directed specifically to us? Should we seek narrow beams, explore unique stars, or develop means for examining the whole galactic field at once or for diffuse communications? Should we not assume beings 1-10 billion years more advanced than us technically and intellectually, or beings as similar to us as possible or only 50-400 years more advanced? Should we assume that intragalactic communications are minimal or maximal? Might contact from another race of beings presuppose our having first given a signal or sign of our existence, or of our interest in and perhaps our reason for communicating? The same locational questions asked above about the galaxy are pertinent to the outer universe. This event is almost impossible to characterize in terms of what either will or might occur, a situation which complicates tremendously even the assignment of a date for the first example of any kind with a 50%, or any other, probability. That we intercept a message does not mean we will be sure it is intelligent (it might even be a purely functional intermechanical instruction or the equivalent of electromagnetic radiation or static from a light-switch), nor that we, deciding it is intelligent (or even sure), will then or later translate it (at least in any degree or certainty). It seems to me to be almost equally probable that by 2020 we will also, or instead, recognize astronomic signs of the existence of a technical civilization in Space. For example, it has been proposed that Dyson spheres will reveal themselves in the infrared or that wholly reconstructed galaxies may exist aglow, or not, in intergalactic Space. I have <u>speculated</u> that the $3^{o}K$ cosmic blackbody radiation may be explicable as the emission of a luxonically expanding civilization which has reconstructed the universe surrounding our laggard stellar bubble, conceivably thereby causing the expansion of our seen universe by gravitational accomodation to the artificial redistribution of mass externally. Many have suggested (eg Arthur C. Clarke in a short story, "The Sentinel") that even within our Solar System there may exist an automatic device observing us, aiding us, waiting for us to trigger it, &r simply waiting for us to use it (say as a message, library, monumental inspiration, spaceship, array of creations, &rc), say located on Earth, on the Moon, at Terrilunar L4/5, near Jupiter, near Pluto, or beyond Pluto. It is frankly rather hard to estimate the chance of such a thing. The possibilities for this and additional events are so complex, many, interesting, important, challenging, ambiguous, &c that I postpone them

until page .

The probability is over 30% that by 2020 payload will be deliverable into orbit from Earth's surface for no more than $10(1975) a pound. The possible bases for this are discussed elsewhere and need not be repeated. But some prominent ones can be referred to. By 2020 there may have arisen on Earth the hydrogen economy foreseen by many men today. Hydrogen and air or oxygen may be used throughout the economy of the world for combustion and other purposes. Such an economy might be a result of the emergence of fusion as an electric and thermal resource throughout the world, and it will certainly reflect the development and use of various fuel cells. A far greater number of products and processes may use pure hydrogen then than now. In any case, the prevalence of pure hydrogen may mean that its price will be minimal, so low, in fact, that spaceflight will cost very much less than it does today. By 2020 fission drives for spaceships of various sorts should have long been in use and have become refined and economical. Controlled fusion drives may exist as well, and, coming into use, drive down the cost of energy by simplifying ships and operations and reducing the watt cost of power. Safety measures in spaceflight may be relaxed, partly because of maximal safety, tremendous automation will economize operations aboard ships and on the ground, fuel will be stored and manufactured in Space, ships and facilities will be used at capacity, traffic and freight will be so heavy as to have realized economies of scale, research and development costs will have been dissociated from certain operations, competition will have driven down and minimized prices, governments may be producing minimal cost (zero profit or strategically overdeveloped) fuel exclusively for Space, fuelless descent to Earth will be common, exomotive basers will be in operation from Earth and Space, the cost of energy on Earth will have fallen, &rc. Of course in 2020, as opposed to 1975, dollars the picture will be different, but likewise, and more importantly, the costs of operations as a fraction of per capita American and Terran income will have fallen drastically owing to the great increase of such income in absolute terms, increase which might continue over the course of the 21st century, even by 1-2 orders of magnitude as a function of certain considerations whose likelihood is difficult to estimate and cannot be based on current rates of growth or current means. There are additional possible bases for such an order of magnitude reduction of costs as of 1975. A cynic might argue there is at least a 10% chance that peculiar inflation in Spacial operations may counteract such effects or even increase cost per pound of payload. My discussion so far has more or less restricted to ascent from the surface of the Earth into Space, but even more drastic reductions of operational cost in extraplanetary and heteroplanetary Spacial phases is likely, effecting correlated decreases in Terrispacial costs, particularly in relative cost in the case of strongly dependent or influential operations.

The probability strikes me as over 10% that by around 2020 such costs per payload pound from Earth into orbit will have fallen to under $1(1975) as a result, specifically (or perhaps specifically), of the development, perfection, and use of a nuclear drive (say using a gaseous core reactor) in ascent from Earth, and presumably return. A number of men have suggested this 2 orders of magnitude reduction in payload pound costs from 1975, including men with impressive credentials. But it has been contended that nuclear drives will be too difficult or impossible for propulsion through Earth's pollutable atmosphere and over Earth's populous ground and will therefore be limited to extraterran Space, or that they will be limited to extraplanetary Space as a result of a low thrust impotent against gravity (in which case high thrust nuclear engines would have to be developed, which seem perfectly possible). The possibilities reviewed in the preceding paragraph might combine to lower costs further, or to allow less than $1(1975)/payload pound costs, or they might themselves conceivably effect such a reduction.

Pluto will have been mined (over 100 tons of ore refined or removed into Space, independent of any movement of "earth") by 2020. For what, of what, by whom, with what consequences, how, &c, [illegible]

There is a more than 15% chance that by 2020 Terrilunar L4 &r L5 will be populated by 10^4. The earliest date Gerard K. O'Neill gave for his 10^4 men Model 1 colony at L5 was 1988, [illegible] a possible minimal feasible year, I suppose, I [illegible] O'Neill's optimistic date would argue it is a decade too [illegible] habitat foreseen here as having been created by 2020 might be quite [illegible] in general and specific terms, than that so far described by O'Neill. Any single, central megastructure might have cylindrical, spherical, hemispherical, toroidal, open-cylindrical (or flattened-toroidal), discoidal, serpentine, arboreal, foamy, tunicate, spoked, multirotational cylinder-within-cylinder, conical, amorphic, &r other form. It might be of any size, number, mass, complexity, &c. It might or might not employ artificial gravity at 1 or positive g. It might use natural materials already present at L4/5, or variously draw on the Moon, Earth, asteroids, &rc. The mass per capita might be 10^{0-5} ton. The barometer might be Terran or less. The composition of the air might be Terran or not. The habitat might be Terran, natural, or artificial. Fauna &r flora might or might not abound. Food might be produced by agriculture or artificially, or imported. The economy might have been built for, or operate on the basis of, manufacturing, bioculture, research, residence, touristry, power production, intraspacial services, medicine, &rc, or these things might be largely irrelevant. Such colonies might be successes or failures. They might or might not, per O'Neill, more or less reproduce themselves, advancing in number &r size and sophistication. They might grow by internal differentiation, surficial increments, overall bodily increase, or joining; they might not grow. The warrant for additional colonies in specific or related loci, or the advantage to epiplanetary colonies or mere mobile spacestations and spaceships, might or might not be demonstrated, and by 2100 such colonies might number 10^{0-4} and support a total population of 10^{4-10} men. Catastrophic accidents might not potentially or actually befall such colonies, or they might; there is a chance that by 2040 such a catastrophe will have claimed 1,000 lives. Existence on such colonies might or might not be found equal or superior to that on Earth, and might in the beginning or later be spartan or luxurious. The colony in 2020 might or might not comprise a "second earth". Old colonies might or might not be more or less abandoned. Colonies might or might not pay for themselves. The military might or might not play a role in the creation or life of such colonies. Colonies might be national or international. Colonies might also arise at Terrilunar L1, L2, and L3. The Lagrangian points of other planetary systems might be colonized in some order. Terrilunar Lagrangian colonies might be mobile and migrate to the asteroids &r elsewhere. The Lagrangian points might or might not be found to have any special and sufficient advantage (there are fundamental questions about O'Neill's idea). The Terrilunar Lagrangian colonies might play some role in relation to a developing geosatellosphere and lunisatellosphere. The function of an L5 colony might be a transitional and ephemeral one, a facilitation of Earth=Moon and other intraspacial operations during a profitable period. Nongovernmental colonies might be built &r operated by Terran and nonterran corporations (public or private). Colonies might sooner or later be self-governing.

By 2020 all Solian planets will have surficial or periplanetary bases operated by men &r machines for scientific, logistics, industrial, exploratory, &r other purposes. I am referring to permanent or at least rhythmically reused bases, say staffed by 10^{1-3} men. These may or may not shortly give rise to other bases, to colonies, cities, &r planetary civilizations. The fact of 9 such bases will be symbolically important and a stimulus to Solian enterprise.

There is a chance that by 2020 organisms such as may have been discovered by then will be employed for environmental engineering, or that an "exobiological accident" will have occurred. Microorganisms fortunately discovered on Mars, for example, might be used by men to produce agricultural crops or in biocultural factories (yielding food, fibers, drugs, gases, chemicals, energies; processing things, including wastes; controlling and recycling the environment; &c) directly, or they might be modified or evolved for such purposes, or variously imported to and used on Earth; they might be used to recondition the whole planet (say, in effect, artificially irrigated, fertilized, propagated, warmed, &c) for planeturgical purposes (over centuries or millennia); they might be used on other planetaries than Earth and Mars, or prove useful even in interplanetary Space. On the other hand, exobiota accidentally or intentionally returned to Earth might produce pandemics and devastate man &r other Terran organisms; or, conversely, Terran organisms, reaching other planets, might accidentally saturate, transform, or ravage such biological or lifeless planets. It would doubtless be profitable, and it could well be decisive, if organisms are found in Space able to subsist or actually thriving in hypobaric, nonoxygen, frigid, extremely hot, chemically novel, other rugged, or other conditions; especially exotic life might be especially interesting, or especially dangerous. If man accidentally or intentionally spreads Terran life to other planets, it may adapt in 10^{0-6} years to yield quite extraordinary species in scientific and industrial terms. Such a planet as Mars may never have possessed an environment able to create life ab initio, and yet possess an environment today, or such as it might be remade, able to support minimal life or a biological takeoff (possibly giving rise, in 10^{1-6} years, to biological control over the climate of the planet and to conditions of atmospheric pressure, composition, dynamics, temperature, &c perfect for life or such life as is possible on Mars). Even if the Solar System, apart from Earth, is found barren of, and incompatible with, life (or in terms of such things as just considered), it may happen that man or his descendants voyaging to other stars in a later age centuries and millennia hence will experience any or all of the preceding things.

It may be that by 2020 a significant beginning will have been made in actually or virtually determining the galactic and even cosmic incidence of terroid planets, life, intelligent life (say of analogues to animals), life as intelligent as man, technical civilizations, humanoid life, alternative life, superhuman life, arbitrarily great intelligence, &rc. In particular, the relative uniquity of man may either have been established, or, more likely, relevant (if indecisive) information or theory will exist. An especially interesting question is as to the existence, nature, and significance of any "demigods". By this is meant extraterran beings possessed of transhuman intelligence, character, ability, power, &r accomplishment, such as almost surely exist elsewhere in the universe, galaxy, or even nearby. Obviously, determinations of all or any of these questions could have radical effects on the future of our Spacial enterprise. There are innumerable ways in which something of these things might be determined. The origin of simple or advanced life on Earth might be pushed back considerably and significantly; such life might be created or evolved in the laboratory; life might be created or supported in extremely hostile or nonterroidal conditions in the laboratory, or any advanced molecular processes be shown compatible with such surprising conditions. Elementary or advanced life, or complex "organic" or inorganic chemistries, might be discovered elsewhere in the Solar System. The concept of life might be philosophically, mathematically, chemically, &r physically generalized. Conditions on planets of other stars might become perceivable or calculable. Past variations of Earth's climate, &r of the Sun, might be shown to have been more severe and radical than now thought, and yet to have tolerated, or been compensated by, Terran life. The future evolution

of intelligence, and the heights to which such intelligence might go in mastering nature, may be theoretically &r imaginatively depicted. Experiments &r theory might show that life on Earth was an extraordinary accident and that its incidence in the galaxy and universe is infinitesimal. The past history of the galaxy may be shown to have been violent to a degree incompatible with life. Factors incompatible with life (such as radioactive toxins) might be shown to prevail on planets of other stars and to be absent on Earth only as a freak. Computers may enable calculations of these probabilities. Detection of any extrasolian communications may be suggestive. The content of extrasolian communications received and translated may tell us at once of the incidence, nature, &c of life in and outside the galaxy (information that might itself be based on innumerable things); such communications may supply us with information enabling rapid technical adoption and access thereby directly to the conversations of the universe. It may happen that life even more intelligent than man may as a rule assume nontechnical, and even noncultural, form (like the whale, perhaps). We may be destined ourselves, even in less than 100 years, to assume such form. We may actually apprehend some sign that in the universe other life exists so advanced that it matches or even surpasses our very notion of a monotheistic God. We might discover that, unbeknown to ourselves, other life exists on Earth of any level of evolution, yet life--for physical, chemical, mathematical, epistemological, or other reasons--unrecognizable by ourselves; for example, storms may be alive (self-maintaining, self-reproductive, multiplicative, evolving and evolved, irritable, locomotive, perceptive, possessed of memory, intelligent, creative, &r even technical &r cultural), in which case our vision of the rest of the universe would have to alter itself considerably!

There is a chance that by 2020 a transluminary event in nature will have been discovered or observed. Transluminary is a word used by physicists to refer to anything that might possibly be found to exceed the speed of light in the vacuum. It has been hypothesized that some or all particles traveling at less than the speed of light, so-called tardyons, may have transluminary counterparts called tachyons. Tachyons are discussed on page . There have been some astronomic observations that seem to suggest that transluminary processes occur in quasars, but alternative explanations would seem too ready to give much basis to such a surmise. Nevertheless, physicists and astronomers continue to search for transluminary events and there is a reasonable chance (if less than 50%) that one or more such events will have been encountered by 2020; if such events do or can in fact occur such that they will have been discovered by 2100, I think it is probable that such an event will in fact have been found by 2020, 45 years from now, corresponding to physical progress since 1930, if under accelerated circumstances. It will be enough if theory, rather than empirical discovery or reexamined data, attest to such a probability; certainly the evolution and reexamination of such theory may furnish the possibility of transluminary processes. It is currently thought that transluminary events, at least if propagating what we usually think of as causality, would involve such physical &r logical paradoxes as to be irreconcilable with what is known of the universe (one-way time, finite events, lawful events, &rc), but it may be that these paradoxes will be defeated or circumvented by transcendentally novel ideas ignored by current thinking and knowledge, either before or after any empirical or theoretical discovery of actual transluminary events, effects, particles, &rc. There have been suggestions that, for geometric reasons, space and time may be traversable in extraordinary ways whose effect would be that the speed of light can either be exceeded or bypassed; but these ideas remain little-understood surmises which may in fact mask things more astonishing still than transluminary velocities. Any transluminary velocities might be slightly faster than light, many times faster, almost instantly faster, instantaneous, or--strangely enough--faster still. One hypothesis about tachyons is that they would be transluminary phenomena unusable for transluminary purposes; even so, they might have major effects on our world,

as has already been suggested on occasion. Transluminary processes verified to exist in nature but in astrophysical or cosmological phenomena might not have any utility to ourselves or be producible by ourselves, at least in 2020 but possibly even by 2200 or eternity; such pure and isolated status strikes me as unlikely, even given the irreproducibility of astronomical scales. On the other hand, events ordinarily impossible, perhaps unknown in the history of the universe, might be producible by ultimate intelligence or even by men living in 2020. There might simply be a 20-40 year lag in the experimental &r industrial use of transluminary discoveries. Higher types of causality might be found to be possible. It is unlikely that present man comprehends much of nature or of art.

The year 2020 can serve as the time by which man should have in his possession a fair idea as to the wealth of his Solar System, the energies, materials, and possibilities present in it. He should have arrived at such a preliminary but important overview on the basis of theory combined with exploration. There has been discussed in the preceding pages the development and use of almost fantastically powerful means for exploring the environments and mapping the multifarious wealth of the planets, satellites, and asteroids, and the evolution of an intricate picture of the Solar System as a whole. This has been combined with suggestions as to the rate of exponential progress of science, technology, economies, human purpose, and Spacial enterprise. By 2020 the 30 major planetaries should have been pictomapped at a topographic resolution of square millimeters, at many octaves of the electromagnetic spectrum, with superscientific spectral analysis, in combination with pictures now impossible of structure and composition 100 kilometers under their solid surfaces, and in combination with equally extraordinary techniques too numerous to mention. All of these planetaries will have been landed, or received probes in their jovoid atmospheres and oceans, and examined in situ over perhaps 0.1%-1.0% of their surface. Tremendous empirical and theoretical development of planetology will have occurred, and there will exist a paleoplanetology of such stature as to be of great economic value in indicating the distribution and exact location of elemental, chemical, and mineral deposits throughout the Solar System. Even apart from these grand things, there will certainly have been answered many simple and obvious questions about plutographic possibilities of an absolutely decisive nature, such as the degree of analogy of other planetaries to Earth, whether convenient fractionations exist within the Solar System, the degree of variation over this territory in any case, the ease of retrievability of at least the cream of the deposits, the complementarity of resources on other planetaries to Earth and human needs, the roles of other environments in the generation of valuable deposits, and the differentiation or nondifferentiation of other planetaries. It will be a fair idea in part because of the incentive it will supply to exploit the vast resources of the Solar System, to develop Space as a whole, to take the rest of the Solar System as our home, and the glamour it will attach to Space. Parts of the picture will exist well before 2020, even before 2000, and are even accessible today. The assembly of such a picture is in a way the meaning of what man is doing in Space even now. By 2020 there will have arisen as well, in the breast and brain of mankind, a stupendous vision of the future of the Solar System, the very thing which is lacking today. This will be the fair idea.

Assuming it ever occurs and is potentially important, an asteroid will have been hollowed out, spun, and occupied, at least to some extent, by the year 2020. Dandridge M. Cole and Donald W. Fox suggested in their book Islands in Space: The Challenge of the Planetoids that ellipsoidal asteroids of moderate size might be treated in this way. The spin would give them artificial gravity,

the mural landscape could be planted, farmed, and built upon, an artificial atmosphere could be created, along with an artificial sun down the major axis. Such a nice intraspacial microcosm is vividly depicted in Arthur C. Clarke's novel Rendezvous With Rama. Evaluation: One concern is that asteroids may be unconsolidated, essentially piles of rubble that would disintegrate with much torque or centrifugal force. Larger asteroids might be fused but too spherical (assuming ellipticity necessary). On the other hand, single boulders of such size may exist as or in asteroids, and loose asteroids might be inserted in a firm strong skin, and ellipticity maintained by an artificial framework. Asteroids are naturally oblong, some immense ones extremely, almost tubular. The basic idea is the same as Gerard K. O'Neill's rotated cyclindric, everted world, colonies. Like insects, men could gradually eat away and form a bulliform cavity, varying rotation of their world to maintain equal artificial gravity per the radii of their "entopic" topsy-turvydom. Of course a one-step, rather than incremental, process might be desired. The "inhabitants" of such topsy-turvydoms would of course be busy selling themselves by mining, refining, manufacturing, &r the like, presumably basically for export and balanced trade. Just as a torque to spin the body is possible (say by catoptrical unilateral ablation of a limb), so, at much greater power, the asteroid could be moved tridimensionally in the Asteroid Belt, toward Earth, or outwards in the Solar System. One important question is the comparative cost and absolute advantage of such natural to wholly artificial colonies; perhaps it is relevant that early dwellings on Earth were earthen or biological, and in some ways more lovable than the sterile abstractions that followed, since man is essentially a poetic being. The thick walls of inhabited asteroids could protect those within against the vacuum, cold, radiation, and meteoroidal rain of Space in a maximal, rather than minimal (a la O'Neill), way. Just conceivably some integral asteroids naturally possess spins simulating the negative gravity key to topsy-turvydom. Presumably such a topsy-turvy world must be large enough to be free of bothersome Coriolis force (how weak this force must be for human comfort and a convenient world is ill-known). Another uncertainty is how little gravity would be large enough to fulfill kinematic, stratificational, vestibular, geotropic, &rc needs, and how much would be superfluous, say for man's readjustment to macrogravitational environments like Earth: 0, 1, 10, 25, 50, or 100 percent of 1g? It might be well that we forget all such considerations since the supreme and sufficient reason for creating such an interior world might be its immense potential charm.

I assume the idea mistaken, but others have proposed that massive agriculture will eventually be done in Space for export to Earth, in which case it might initially occur on a substantial scale by around 2020. I have discussed already something of the possible nature of Spacial bioculture (see page). Much as others have proposed that industry will eventually be taken off Earth, say in order to re-create Earth as a paradise, so also, perhaps for the same motive, the growing of crops, which is wasteful of land and "pollutes" the environment in a way we are just beginning to understand, might be restricted to Space in order to free the land to forests, recreation, parks, yards, human residence (urban, suburban, &r rural), gardens, multifold population, nonvertical residence, a totally artificial environment, &rc. The substitution of agriculture for forests and natural species may have already disturbed, or in the future disturb, the balance of nature, the basis of climate, geomorphological stability, &rc; this might mean that a human population as large as ours, or that would be larger, will presuppose removing bioculture to Space or enlarging it there. Descent to Earth might be powerless, in which case crops raised in Space, or extracts thereof, might be exported to Earth's surface economically (after all, the efficiency of agriculture in using sunlight, and the calories in food in ratio to the sunlight invested in their production, are enormously low already). Space



might enjoy certain advantages in bioculture owing to its intense sunlight, low gravity, &rc, and in Space there is unlimited room and unlimited sunlight. Massive agriculture or bioculture might eventually develop in Space in answer to intraspacial needs, and become so easy, important, considerable, &rc that exports trickling to Earth might grow arbitrarily great and supplant Terran production for Earth and Space (it is notable that during the early years of Space food and other biological products will be launched into Space at a far greater cost in transportational energy than that possible for reversed shipment). The mineralogy of a body such as the Moon might be found ideal--say, once modified--for bioculture, leading to the lighter shipment of crops or products raised on it to Terran consumers. Certainly one expects that what will first, largely, or most reasonably be shipped to Earth from Space will be products possessed of pound values many orders of magnitude higher than bulk crops. Of course life may be discovered on other planetaries and there is just a chance that such biomass, parts thereof, &r the environment transformed thereby might be of superior value on Earth and warrant some scale of Terran importation, particularly if the products are not producible competitively on Earth; the level of such alien life might be that of microorganisms or mere organic macromolecues. The current excess of sunlight over human needs, eg the fact that our planet only intercepts 10^{-9} of what the Sun constantly emits, and the fact that harnessing sunlight on Earth and in Space may be so inexpensive (and that the collectors will accumulate with time and depreciate little, perhaps negligibly in Space), may mean that power will sooner or later be, or will become if we try, greater than human needs (energy used, energy needed, and energy usable in any equation of development), an essentially costless and inexhaustible resource (whose nonuse constitutes waste since the power is spent on the expanding universe and not on civilization). Even the means for converting, distributing, and using such a superabundant resource might largely be freed of contributory expense. If so, the costs of spaceflight (which today are almost entirely those of fuel, a predominance which might increase in the future with riddance of wear, maintenance, and nonrecurrent costs) might similarly be flattened, perhaps particularly for freight, in which case the expenses involved in the shipment of biocultural products through Space might be forgotten, leaving the other considerations reviewed, largely as if Space were located on Earth, and vindicating the idea of Spacial production for Terran needs and wants at points in the future.

The year 2020 might stand for the time by which there will be, on the part of the human race, a realization, or there may exist some form of proof, that the exploration, exploitation, occupation, &r unification of the universe beyond the wee Earth--other stars, the Milky Way galaxy, all that there is--is or is not futile, meaningless, unnecessary, accomplished or not ours, misconceived, &r inevitable. Such a realization might begin at this time, or it might instead belong to 2100, eternity, or never. It must seem ambitious to suggest that by 2020 such realization, in any form &r degree, will have occurred. But what may have occurred by then may be analogous to a point of inflection in a continuous curve in calculus: a conscious, unconscious, or virtual turning point in the fate of the race may have transpired of indefinitely great importance in the order of things. Many things might in part or full fulfill criteria for such a critical realization or inflection. As an example, or by way of illustration, the launching of Sputnik in 1957 shattered many people's more or less tacit assumption that Space was unreachable and unconquerable, an inaccessible background to man's eternity on Earth; the above realization might thus, in effect, have already happened 18 years ago. Many men now doubt that Space, although visitable, has any great value to man as he is or as he might be; such a confidence might be irreversibly shattered once important wealth is returned to Earth, splendid

colonies arise in Space, a Solian Civilization stares us in the face, &rc. The difference thereafter might be analogous to the elimination of that superstitious fear with which prescientific mentality regarded the beginnings of scientific knowledge. There may pass irreversibly from the human system by 2020 a fund of crude and irrational doubts about our reaching beyond the cradle to the universe beyond; a one-way evolution may have occurred in human nature, a departure into another and incontractable realm of human purposes. The realization may have occurred as a result of human contact with an extrasolian civilization; such a civilization may be aware of, and even variously united with, a community of beings throughout the galaxy and even throughout the universe, and a perspective might be supplied to mankind of superabundant life, inexhaustible culture, a static or dynamic mental collectivity in the universe, a triumph of such intelligence over immense nature, &rc. It might be learned that there is no point in voyaging to other stars, since occupied, or even in physical pursuits, since deeper layers to the human mind exist and instead embody our destiny; it might be learned that possibilities are finite or infinite, or we as a species might simply acquire a little humility in our view of things and our aptitude for cynical reflections. Beings before us might have done what we might otherwise do by having, gigennia before, overswept the universe, sought Faustian goals, idolized maya, &rc. Per contra, the preexistent or simultaneously emerging galactic or cosmic civilization of civilizations might be that which assigns us our destiny and role, or such destinies might be identical or divergent. Achieving a way to recover nuclear energies &r much of the mass energy from ordinary elements, over this period, might confer on us at once the power and realization of being able to occupy and transform the Solar System, galaxy, and even universe as a whole. Discovering the existence and utility as short-cuts of holes in the fabric of space and time might spring before us an unlimited prospect for human adventure and a whole different model of Space; pure theory, rigorous and certain, might by 2020 equip us with such realizations. The implications of self-infinitizing and cosmoplastic cellular automata, or the mathematics of cosmic engineering (for this is what such automata would amount to, ie the ideal and ultimate means for effecting drastic and practically spontaneous teleological changes in the design of the universe as a whole), may be understood or at least apparent in under 45 years by a few or even most (rather surprisingly) of mankind. The scale of the enterprises dreamed, planned, undertaken, and achieved in the course of the next half century should give to man a sense of unlimited power even against the prospect of a universe at least 10^{80}, 100-quintillion-novemdecillion, X the volume of a human body and 10^{49}, ten-quindecillion, X its weight! A religion based on worship of infinity, apeirolatry, neither seems an unreasonable child of the times nor unfamiliar in terms of past religion. There are a million other reasons for believing that a changed zeitgeist may figure the world in 2020, or that man will have turned outward toward the stars or the infinity beyond.

A possibility which I do not pretend to understand but consider relevant here is that, say by 2020 or 2050, energy derived from sunlight in Space will be sent to Earth omnidirectionally or semi-omnidirectionally (with the face of the Earth as its exact focus). In proposing this it is with Nikola Tesla in mind who earlier in our century had the dream of distributing power over vast areas by using the ground as its single conductor; the man was a visionary but not a fool, and as I understand he succeeded in achieving such transmission to a surprising degree before he died, although his efforts have not been resumed by others. His measure of success, the actual bases of what he did, the efficiency of any such mode of transmission, its potential range, the ultimate capabilities of like methods, the implications for the present proposal, &c are all unknown to me, so I am being brave in suggesting what I do. Nevertheless, I would not be surprised if what I propose here were in fact possible and likely by the date I assign it. To restate the event, it is the omnidirectional or broad transmission of electromagnetic

(supravisible, visible, infrared, microwave, radio, &r cross-spectrum) or else of material particle-mediated (say electrical), or any bosonic or fermionic, power, derived from Spacial sunshine, to Earth as a grander, better, more direct, more universal, more convenient, cheaper, ultimate, &rc system of power distribution, a system which would eo ipso replace largely all other teledynamic systems on Earth using underground cables, suspended wires, repeater stations, basers, chemical and nuclear fuels, storage systems, other antennas, &rc. Such an event would depend on the technological and biological tolerability, cost, efficiency, workability, competitiveness, comprehensibility, &c of such fantastic and unknown modes of energic conversion, transmission, and distribution. Certain analogies can be made to defend such a system. The face of the Earth is lit by sunlight 10^4 X as powerful as all the power man produces today, and heated from below by a geothermal efflux equal to that same production of of power; both these ubiquitous environmental sources of energy are becoming tapped in situ by man. That wealth of sunlight wasted on the universe and yet trillions of times greater than man's present energy needs, an excess which I have suggested might make it unimportant how efficiently man applies energy in the future or what relative value he places upon it in doing the things he does or might do, may justify such waste as might perhaps be implied in using various "Teslaic" systems in various circumstances at intervals in the future or on the basis of cycles which I suppose might be possible at some efficiency and at all. Once the surface of the Earth is saturated with energy users--things, men, &r machines--a Teslaic system transmitting power indifferently to the entirety of that surface might be ideal; even prior to then, the present paucity and unequal distribution of users might conceivably justify such a system because of the actual fate of certain forms of energy used, which might even, in effect, be stored in the Earth. I do not know whether the material medium of the Earth's atmosphere would be critical to certain fermionic systems in the sense of a conductor or storage medium. I do not know whether Teslaic systems confined to the Earth's surface and employing the ground as conductor &r capacitor (whatever mechanistically appropriate) might be completely superior to, or sufficient instead of, Teslaic systems operated from within or without the Earth's atmosphere, as from geosatellospheric relays for power derived from the Sun or beamed up from various generators on Earth. I do not know how much less or more effective Teslaic systems might be for other planetaries such as the anatmospheric Moon. I obviously do not know the possible competitive efficiencies of traditional teledynamic systems confined to the surface of the Earth, or of refinements as of 2020 or in answer to Teslaic systems. I do not know the competitive efficiencies of terrispacial teledynamic systems using unidirectional or focal beams of energy by 2020. All these things are critical. It might be mentioned that the broadcast of Teslaic systems might be narrowed &r shaped in an intermediate way, their Teslaic nature fully preserved, if not by the devices and principles themselves, by the fact of the terminal influx of energy overspreading receivers and their vaster interspaces alike; there is a tremendous gap to be filled here between Teslaic broadcasts and interantennal beams. The Teslaic broadcasts could be analogous either to sunshine, wind (where currents of air may be an important source of power), or rain (or moisture added to the atmosphere, precipitated on unequal ground, and concentrated by tributaries for the gravitational--or ponderomechanical--production of hydroelectric power; here the heart of the analogy is the wasteless concentration or streaming of that added to the system to bear power to scattered receivers). The reader must pick up the ball.

If it comes about before 2050, chances are that some sort of heliocentric strategic or tactical military fleet will exist by 2022. This is essentially that group of possibilities discussed earlier in connexion with a geocentric fleet imaginable but unlikely by 2010, to which the reader is referred (p), but free to roam the greater Solar System, if perhaps normally maintained in certain "base" loci.

Nuclear bombs will first be used on the Moon for construction purposes in 2025, or in a post-experimental, industrial, &r heavy way. Such uses were characterized earlier when I treated the first peaceful nuclear explosion on the Moon in 2005 (p). What I specifically foresee occurring in 2025 is excavating a deep or extremely deep hole or shaft in the Moon, for the first time for any planetary, by using a string of 2 to 10,000 "small" fission or fusion bombs dropped, say once a minute at a 1000 a day, into the deepening hole. The reasons for doing this could be many but might include a scientific curiosity about the nature of a planetary at immense or arbitrary depth (its structure, composition, thermocline, radioactivity, age, plutography, &rc), retrieval of mineral or elemental wealth concentrated at such depth, myriad possible industrial uses, wish to use heat present at such loci as sources of energy, tubes for vertical transportational accelerators, desire to make astronomic observations possible only at such unlikely depths (such observations are already done at the greatest depths man has so far reached in the Earth), &rc. Of course the depth of any such shaft, particularly if sunk via such sussultatory means as nuclear detonations, might be limited by rubble backfall and wall collapse, as well as conditions prevailing at depth, especially in any asthenosphere (the depth of the Lunar asthenosphere is said to be 1,000km, ½ the Lunar radius). What I visualized originally was that a shaft might eventually be sunk down the full radius of a planetary to its center, this being possible because of the relative or absolute cold, and lesser interior pressures, of bodies smaller than planets. The limitation of mining on Earth practically to deposits <u>on</u> Earth, and thus to a plate in volume trivial with respect to a sphere and particularly trivial because of the basic compositional stratification of the Earth rendering the surface of the Earth (despite some convective and vulcanic eversion) homogeneous and punctiform, is enormously frustrating since the elements, chemicals, and minerals withdrawn from industry by being concentrated in or confined to inaccessible depths could be of such individual and complementary benefit to industry which in fact must depend on a tip of the material iceberg. Even if depositional and differentiational stratification in the cooler and younger interiors of the minor planetaries such as the Moon is to be supposed much less, and thus much less interesting, than in the case of the Earth, the mineralogy and mining possible at depths in these planetaries holds much attraction from the standpoint of future human industry, even as it will have evolved by 2025. Moreover, in addition to vertical stratification in this simple sense, some sort of nesting or even hierarchical clustering (or miscellany of lodes) may be entertained as existing within all planetaries, hot or cold, of tremendous and even comparable value to future mineral-hungry men. Certainly the best way to discover quantitative and qualitative characteristics of planetary interiors might be to go there directly, at least on one occasion or at intermediate and indicative depth. Conceivably a shaft might be artificially walled and buttressed, particularly as civilization grows or "megamachines" are built and used; walls might even be artificially fused and thus frozen. Just conceivably, or by 2100, continuous terrawatt basers, or the like, might be used to penetrate planetaries at immense depths. The more consolidated materials at great depths might resist nuclear compaction; but small planetaries might be less consolidated. Certainly an asteroid like Ceres or smaller could represent a site appropriate for such solidospheric exploration, mining, &rc by Titanic men.

By 2025 there will have been massive mining of Venus, as discussed earlier (p 99).

A possibility is that, probably by 2025 if by 2050, a perisolar industry will eventually arise exploiting the multitudinous and high currents, voltages, and frequencies in particle fluxes of matter and energy in and around the Sun varying with Solar distance, latitude, and cycle-spectrum time. For example, profitable industry might develop using the Sun's powerful gamma and cosmic rays to produce nuclear isomers, radioactive or other isotopes, and transmutations, and to produce molecular changes, novel molecular processes, and novel materials. The tenuous outer atmosphere of the Sun, the corona, extends millions of miles (it has been seen "fading" in photographs at 70 Solar radii or 0.3 AU, so its relationship to the solar wind must be peculiar). Heated, turbulated, and pulsed by the dissipation of hydromagnetic, internal gravity, and sound waves produced in the turbulent convection beneath the photosphere and propagated outward--by viscocity, thermal conductivity, particle resonances, &c--the coronal, poi solar wind, stuff attenuates and accelerates from a base velocity of a few 100m/sec and density of 10^9atoms/cm^3 to a few 100km/sec and 5 atoms/cm^3 near Earth (accelerated 10^3 X, attenuated 10^7 X, difference 10^4 X). The coronal temperature near the Sun as a result of these processes is of the order of 10^6°K. The solar wind carries away from the Sun 10^6tn(10^{42} atoms) a second, an integrated flux density at the Sun, which has a surface area of $10^{22\frac{1}{2}}$cm^2, of $10^{19\frac{1}{2}}$atoms/sec/cm^2. The Sun emits a continuous stream of electrons with shorter bursts of electron and proton showers; the sporadic particles at Earth have energies of a few times 10^{3-9}eV. And so on. The actual distribution in space and time, energy, species' density, &c of these particles 0-10^7km from the photosphere is unknown, but very likely differs from current simplistic theory and in a way of help to the future perisolar industry being suggested. Industrial processes exploiting such high-energy radiation produced from Terran sources are little developed, but promising, today; this is partly because all physicochemical effects which could enable such industrial exploitation in convenient and ideal ways are themselves unresearched, undeveloped, and unknown, and almost entirely so. A guess can therefore be made that a greater than 10% chance exists that within 50-75 years man will be in a position to use such radiation, and to do so near the Sun, for some order of industrial processes able to justify the enormous expenditure of energy unavoidable in flying to and fro the Sun for the sake of materials used on Earth. As previously indicated, in the future we may find it useful and possible to enter the Sun's atmosphere (not being content with conditions on or outside it) and to use the energetic plasmas there for various industrial purposes, so the perisolar-episolar boundary is uncertain and inessential. That we should be able to travel and operate in these seemingly impossible environments has been argued on p , to which the reader is again referred. The severity of the conditions is to a certain extent commensurate with the suitability of the conditions for hypothetical industrial uses, assuming the difference between the needed and concomitant conditions of any such environments with the destructive effects of such environments is sufficiently great, marginally tolerable, stable in time, predictable, exploitable, &rc, and here is the nub of the question. A related question is whether man will have it in his powers at these future dates to produce materials &r controlling devices able to withstand conditions ≥1 orders of magnitude more severe (in linear description) than what seems possible, or even basic, today; the extremity and nonsolution of these problems is suggested by current attempts to harness fusion, but I would imagine that such gaps between possibility, necessity, need, &c and current feasibility, theory, technique, achievement, &c--arbitrarily immense gaps--are at bottom merely a measure of what it is actually possible for man to achieve and of likely scientific progress in the years ahead. Of course, man's increasing ability to produce more energetic, more powerful, more suitable, more varied, more controllable, more inevitable, more abundant, cheaper, more convenient, &c radiation on the Earth, from more or less natural or artificial processes, may interact with any value of doing so, at least at depth and in ways, by or in the Sun, in the course of the future.

SUPPLEMENTARY AND SUMMARY COMMENTS ON QUARTER II

The quarter century covering the years from 2001 to 2025, following as it does the c1995 Spacial Renaissance, will be the real beginning of the future history of Space, as well as the real beginning of Solian Civilization. It is true that I have assigned certain important events to Quarter I, but I did so mainly as a matter of the first qualifying but primitive examples, mostly concentrated toward the year 2000, of events not really becoming important until at least Quarter II. Many techniques of propulsion discovered, tried, and even developed during the years through 2000, for example, will really only come into use, be perfected, and be important in the years through 2025. This makes Quarter II, (~~[illegible]~~ years after Sputnik I or the beginning of the Space Age) of extraordinary and perhaps unique interest in terms of a perspective of the entire future history of Space. The rate and scale, and the particular way, in which things develop over this 2½ decade transitional period may be decisive for the way they will develop through 2100 &r 2175.

My treatment of Quarter II has been peculiar in that I have used particular events apt to fall within it to go beyond into a systematic characterization of larger, less likely, more distant, less related, interrelated, &c possibilities, and I have in this way perhaps given the illusion that all or many of the things I discuss in this way will actually occur, or even have any chance of occurring, prior to the infinite period beginning in 2026 or in Quarter III. The reader must retrospectively dissociate the events of this larger discussion from the simpler picture of what will actually happen in Quarter II if he is to have any clear and useful idea of the course of events over this admittedly critical Quarter. I have also created a certain problem by locating an enlarged discussion in Quarter II since I have robbed the Quarters and years which I will subsequently treat of something of their proper novelty, richness of treatment, clear sequence, development, distinctness, quantitative distinctness, &c. The reader will forgive me. A limited excuse arises from the fact that this was convenient, served to justify in detail the subsequent development of events, was to a certain degree inevitable, prevented some redundancy, simplified what is to come, is tolerable or compensable by the flexible reader, rendered subsequent events timeless in one realistic respect, served to create the overwhelming imaginative texture that is one of the principal objects of this book, &rc. There might even be some special abundance of strange developments in this Quarter, or if just by virtue of our inability to render later Quarters, years, events, science, human affairs, imagery, considerations, &c in similar detail, with similar fidelity, as logically, &rc. But I take the blame in full.

POSSIBLE ALTERNATE, ADDITIVE, OR MULTIPLICATIVE BASES
FOR HIGHLY OPTIMISTIC SCENARIOS

1. Growth in residents of Space from 1975 to 2200:

Assumed curve:
1975 = 0 residents
1983 = 100
1992 = 1000
2000 = 10,000
2025 = 10,000,000
2050 = 100,000,000
2075 = 1 B
2100 = 10 B
2200 = 300 B.

In 1975 there are for practical purposes no permanent residents of Space. By the early 1980's there will be semicontinuous residence in Space as a result of American and Russian "Skylabs" perhaps maintaining an average of 10 men anywhere in Space between 1980-1985, which is shy of 100 in 1983 by 1 order of magnitude. Even so, it could be imagined that a number of Skylabs might be built and operated concurrently by the US and USSR, use of these vehicles might be more continuous and early, larger crews might easily be accomodated per vehicle, larger vehicles and plans might be initiated (particularly by the uncertain Russians), and the enormous mass readily carriable into orbit by vehicles already planned (say 55 tons by the American Shuttle, which is intended to make perhaps 100 flights a year; 55 tons = 550 200-lb. men or probably quarters and necessities for 225 men using 27.5 tons @a200 lb./man; 100 X these figures = 5500 tons/y/shuttle for 22,500 men using a2,000 tons in terms of 1 shuttle; theoretically shuttles might make 3 flights a day each, an average of 10 shuttles might mark the quinquennium, maximal population of Space might be emphasized, &c, to yield--without stay beyond a year--a2,000,000 men occupying a 200,000-ton nascent geosatellosphere in 1983, which is 20,000 X, or over 4 orders of magnitude more, than simply 100 men) might be used to construct maximal quarters for a maximal population and at once answer their needs. So a highly optimistic base population of 100 for 1983 is in fact feasible on such optimistic assumptions, even if I originally meant roughly 10^2, not specifically 100, and was not too concerned about my initial, 1983 population.

I suggest that by 1992, on highly optimistic assumptions, 1000 men might exist on an average in Space as "residents", defined at this early stage of growth as those simply resident in Space for al year. This means a 1000% increase in 9 years or roughly triennial doubling. At this early, relatively small stage it is silly to worry about average percentage growth since it will smooth peculiar discontinuities. In general, 17 years seems adequate lead time, under highly optimistic assumptions probably free of technical constraints, for achieving a continuous low-orbital population of 1000 or more. A period of 9-17 years certainly seems adequate to multiply the previous equation or its semi-independent factors by a factor of 10 to in order to effect a population in Space of between 20,000,000 to 1000 men, even without regard for simultaneous 1 order of magnitude or more increases in the associated factors. In these latter terms, by 1992 there would seem to be possible, on highly optimistic assumptions, 1000-ton payload shuttles, virtually 100-1000 such over the world, whose duty would be 1000 flights annually, &c. These could transport men from Earth to a previously constructed geosatellosphere and back, the men staying 1-5 years in the increasingly lovable and self-sufficient extraterran habitat; these things (preconstruction and a2-year stay) in combination could erase the subtraction from payload in 1983 serving construction and maintenance as opposed to human transport. Without straining the imagination, therefore, by 1992 the population of Space could be 400-4000 million men on highly optimistic (but reasonable) assumptions, or $4 \times 10^{5-6}$ times greater than the 1000 men I in fact suggest as possible

It is easy to see how this ideal growth process could continue--even without any, much less highly optimistic, changes in the equation of a qualitative nature pertaining to revolutions in science, technology, power, income, human attitudes, incentives, autocatalyses, number of parties contributing to the mobilization, &rc (an omission unrealistic even in terms of a conservative outlook)--and at an exponential rate much greater than that I have selected as fit for a supposedly highly optimistic scenario. There is clearly room for infinitely more optimistic scenarios even apart from possible "maximal" scenarios or still greater, and hence truly absurd, scenarios. I suggest, however, that there will have been a 1 order of magnitude increase in Spacial population in the 8 years between 1992-2000, giving 10,000 men in Space 25 years from 1975, or perhaps regardless of fluctuations about quotas in the previous years. Again the previous equation can be referred to as the multiplicational basis for this increase on conservative assumptions, and as supplying sufficient redundancy, especially in view of the new considerations just discussed, to absorb any restraints, operating on highly optimistic assumptions, in connexion with the several factors of the equation. But, as it happens, I have assumed for the standard "highly optimistic scenario" that cost to orbit a pound of payload will have fallen to $20, say by a factor of 5-10, from 1975, and clearly this must be expected to influence in several, combining ways the residential growth curve. At the same time, all touristry on Earth will have grown exponentially and be an order of magnitude or more greater in 2000 than it was in 1975, and likewise the wealth of the world will have grown exponentially and exert critical effects on the marginal costs of Space and the relative price and cost of orbiting human beings. It is clear that the assumptions governing the rates I have assigned to the growth of Spacial population over the quarter century before us are certainly not overoptimistic but are in fact tame.

On "highly optimistic" assumptions I expect a 2 orders of magnitude increase over the next quarter century in the population of Space, and about 10,000,000 Spacials (or residents of Space) in 2025, constituting 0.1% of the total number of men alive in that day. Here at last the reader might be squeamish! But not for long. Let us suppose that by 2025 there will have accumulated in Space an inert mass (which, unlike residents, need not turnover) of 1 billion tons, giving 100 tons for each man in the geosatellosphere. That a billion tons might have accumulated by then is easily seen from the equation:

1000-ton payload X 25 years X 400 flights/year X 100 craft = 10^9 tons.

We exceeded this highly conservative equation in our 1992 calculations! A highly optimistic, standard scenario might reasonably suppose the cost of orbiting a pound of payload to have fallen, in the intervening 25 years, by 1 order of magnitude beyond that suggested for 2000, or 2 orders of magnitude beyond 1975 costs, to something inconspicuous like $2 in 1975 dollars). Clearly such a fall would have simply enormous, in fact transfigurative, impact on human movement into Space and the growth of Spacial population. By now the reader must have the impression that the increase of population in Space between 1975-2200 on my "highly optimistic" assumptions has only one claim to being treated as overoptimistic: the arbitrary slowness of the human race in responding to new challenges and opportunities. Assume a shuttle by 2025 costs of the order of $\$10^{7\frac{1}{2}}$ (1975), then its ratio cost to a 1975 car ($@\$10^{3\frac{1}{2}}$) would be 10^4. Such a vehicle might carry 1,000,000 men into Space per year. Even with payload transport cost today, a family need only spend $20,000 per capita to orbit; @$2/lb. in 2025, this could be $400 per capita, or less than much air fare today, on the basis of much smaller incomes. This would be of the order of 10^{-3} of a life's earnings for Americans in 2025, or (for moving) negligible. The question under these circumstances is what could stop Terrans from visiting and moving to Space on various moderate or highly optimistic assumptions as to the attractions Space might be expected to have, or have acquired, by then. And indeed, the attractions of life in Space can be painted in highly optimistic terms.

Highly optimistic assumptions enable me to suggest that by 2050, or 75 years from now, the population of Space can have risen to a1% of the entire human race, or by 1 order of magnitude from the 10^7 I foresaw for 2025, to 100,000,000 people, without regard for their specific location in Space. In this latter respect, the capacity of the Earth's satellosphere to absorb people, while limited by the mass of the Earth or common sense considerations pertaining to convenience, is for our purposes here (or until 2800 or 2200) virtually unlimited, and the geosatellosphere cannot be saturated. Whereas 10^8 is what I suggest for a highly optimistic scenario, and I in fact anticipate only but fully $10^{6\frac{1}{2}}$, the previous accessory computations make it clear that by 2050 the problem might be of another nature, namely that everyone on the Earth or in the race will have been relocated in Space years before (the motivation existing for 15-20 years), and further growth of comparable kind would presume means for simply unprecedented procreation, say in terms of advanced ectogenesis. As a matter of fact, the natural or forced evolution of biology should by 2025-2050 have provided those very means, but the problem remains that such rapid growth of population would require unprecedented means for providing existential resources--living quarters, food, air, water, medicine, schools, and so forth--for the superabounding young, or an unusual productivity, in the provision of these very resources, on the part of the older generations. Is it imaginable that means might be provided so quickly, fully, and reliably that mankind might increase its numbers by an order of magnitude each quartocentury (25 years)--roughly octennial doubling--for centuries, say 2025-2325? Actually I have already looked into the question whether the provision of means might occur at the rate of annual doubling, pari passu annual doubling of population via Terrans emigrating to Spacial colonies, and decided that such incredible economic growth, with various assumptions, would in fact be possible, so clearly my conclusion is that octennial accomodation would be possible and far simpler. But such wildfire growth would require peculiar technological means in terms of primary, secondary, and tertiary economic goods. For example, housing would have to be provided by the rapid creation of living spaces, air, sanitary facilities, &c. On Earth this might simply occur by absorbing preexistent natural spaces and perhaps by Rousseauesque existence, at least during the phase of growth, but in Space no such simplicity would be possible and everything would have to be imported, reformed, and provided. Mass-production processes on Earth are perhaps metaphorically suggestive. Automatic or semi-automatic machinery can form molten steel into endless tubing, the tubing can be swiftly subdivided and shaped into innumerable sealed cans. So in or for Space, immense quantities of metal or glass might be produced from crude ores, fabricated into tubing, the tubing remade into countless immense and sealed cylinders, and these used as the shells of buildings, molded intricately within. Likewise immense quantities of air might be produced by titanic industrial processes in Space, say deriving their energy from sunlight focused on an astronomic scale by catoptrical balloons, or the masses of liquefied air might be imported from Earth and recycled in Space, even through immense, easily built, and multipurposed terraria. It is important to note that materials in Space can be recycled to such a degree, especially by 2000-2050f, that their reimportation from Earth would be unnecessary, and highly efficient recycling could rely simply on known natural agents in completely anthropocentric terraria of urban size. By 2050 there will be without doubt, especially if long and directly pursued &r if our assumptions are highly optimistic, advanced sitotechnology dispensing with inefficient agriculture and able to synthesize the olidodynamic nutrient needs of human beings on a rate and at a scale such that rescaling at the rates required off Earth, per the growth of population, would be the simplest thing imaginable. Yet above all it deserves to be noted that by these distant years automation, the intelligence of computers, and the new science and technology of "cellular automata" will only naturally, and certainly by forcing or on optimistic assumptions, have so enlarged the actual and possible growth of the economy, or technological productivity, that the rates

of provision presupposed by the farthest-out increase of Spacial population--say by annual or octennial doubling--will not suppose any optimistic assumptions. Of course, at a doubling time of 1 year, beginning with a panhuman population of 10^{10} in 2100, the entire mass of the Earth would be absorbed by 2135, of the Solian planetaries by 2142, and of the Sun by 2152, and certain observable limits to human growth would have been reached. A significant fact in analyzing these degrees and rates of growth which are possible is that the creative agents--men, automata, technology, &r natural resources--will be expanding at the same time so that the issue reduces itself to the instantaneous reproductive rates that are imaginable, by nature independent of scale or dimensionless; I have in this way suggested that dimensionless rates are great, increasing, will increase, and can be increased stupendously or discontinuously by 2025-2152. I have, however, neglected economies of scale and other immense and inevitable helps to such rates of growth or chronologies. These things said, please note that I have merely suggested, in my curve, that Spacial population in 2050 could be 10^8 on highly optimistic assumptions, and on such assumptions 10^9 in 2075, and 10^{10} in 2100.

I suggest that on highly optimistic assumptions man's mostly Spacial population will be 300 billion in 2200. This assumes decelerated growth, namely octennial doubling prior to 2100 and 30-year doubling thereafter. If man continues to grow at the rate he is in 1975, or 2% a year, he will number 300 B in 2200, in agreement with my highly optimistic assumptions.

All the preceding discussion runs the risk of annoying the reader since it has nothing to say about any reasons why such an expansion of human numbers, or such an exodus into Space, should really occur. It merely suggests, in a phenomenological way, that certain rates and scales of transportation and resource provision are possible and plausible on the basis of graduations that have occurred historically. This in itself, of course, is for many people surprising. But in the final analysis it is necessary to motivate such growth. Let me therefore list a possible set of some alternate, additive, &r multiplicative raisons d'etre for the various rates and scales, successive and competitive, which I have suggested.

(1) The exploration and development of frontiers has historically played a major role in the increase of human numbers, both at the frontier and in the old provinces. Our subject is in some ways the greatest frontier man will have ever faced and one might be justified in concluding that, for whatever reasons, population will increase as the new frontier is invaded. Development of the entire Solar System over the next 1-2 centuries seems inevitable, whatever difficulties are experienced and however laggard the process be in the beginning; in fact, initial hesitations may have no effect on the dates by which things are eventually accomplished (a familiar situation in business cycles and long-term economic growth).

(2) Once man masters his fertility, which seems imminent as a result of perfect and universal contraception, it is likely that wholly new considerations will dictate the growth of population. Current fears that the growth of population is out of hand should largely vanish within 50-60 years, or sooner on optimistic assumptions. It will then become apparent that the universe should be populated in an ideal way. In addition to contraception, it is probable than by 2025-2050 perfect ectogenesis will replace maternal birth since the latter process will then be unnecessary, inconvenient, dangerous (to mother and child), and unsuitable for certain purposes (such as very rapid increase of population); ectogenetic birth, and possibly nursing as well, will by then be far superior to previous natural methods for having and raising children. Obviously the considerations governing the stability and growth of population will be totally different than those which dominated the world 50-75 years earlier. Any enlargement of the race will be planned and prudent, a synthesis of larger purposes.

(3) As a result, I anticipate that deciding men will come to realize the positive values of human plenitude: that the excellence of the world depends on the number of men constituting it; that the powers of mankind are regulated by human abundance; that certain economies of scale operate on the basis of human density and total number; that the variety and synergism of mankind increases per human number; that the effect of a larger population, or of increase of population, is that time is compressed and the future brought closer to the present, facilitating the evolution of culture, science, technology, the economy, and human destiny; that greater deeds require a greater abundance of men; that every man is the benefactor and beneficiary of every man and the means to human ends; that tasks and opportunities before the human race are virtually or actually boundless and the call for more and different men; that the size of population determines the number of truly extraordinary and beneficial individuals; that a whole universe, not merely a world, awaits us; &r the like. I expect that as a consequence of these reappraisals, pronatalist policies will become ascendant, at least among a large portion of mankind.

(4) Any perceived limitations of resources critical to the survival, happiness, prosperity, and future of mankind are specifically, if somewhat paradoxically, soluble through the expansion of human numbers and its enlargement of the workforce, differentiation of ideas and promotion of human initiative, acceleration of scientific and technological progress, and marginal benefits. Dwindling human numbers and lessened enterprise might, on the contrary, be fatal in the face of such challenges from nature and within.

(5) It may at last dawn on mankind that, apart from theological supposition and ignorant belief, the quantity of human beings is an absolute good, with the profoundly important corollary that potential people have a right to exist, and we, the preexistent and determinative, have an obligation to accomodate what wealth of human beings are compatible with a relative excellence of contemporary existence. At minimum this means profound analysis and profound courage must precede acceptance of any status quo, particularly the level of humanity existing today as an accident of history barren of such analytic profundity and courageous determination of compassionate and ingenious nature. That natural resources on and off the Earth would seem today, and a fortiori tomorrow, able to accomodate vastly greater populations without necessary infringement upon the balanced equation of the quality of human existence, implies that before us lies a decision to grow beyond our numbers now by many orders of magnitude.

(6) Any current perceived or real limitations to the growth, size, and quality of mankind having their origin in science and technology must be reexamined with an awareness of the promise of science and technology in the future, and specifically with an awareness that the growth of man's technical powers seems at once greater than the growth of human numbers, the depletion of any resources, and any foreseeable problems in the future.

This list could be extended and yet it seems to me that the point has been made that victorious reasons exist for the circumstances imagined earlier in this article on highly optimistic assumptions for the future growth of Spacial population on spectacular scales and rates. It may well be that mankind is on the verge of a downward inflection of the curve of growth of world population, a secondary exponential process checking explosive procreation and stabilizing the world by completing a rough logistic curve in the 21st century. Yet I have indicated above that the history of such curves is endless reinflection and undulating graduation, suggesting the manyness of horizons, the mountainous pleating, of Chinese paintings. The most realistic expectation is, therefore, that the future of human population in the years immediately before us will be such that it will lag and surge, lag and surge, according to the challenges and opportunities of nature and the protean metamorphoses of the human intellect. Any other expectation would be parochial.

FUTURE SPACIAL TOURISTRY AND RESIDENCE: POSSIBLE REASONS FOR INCEPTION, GROWTH, AND SCALE

GROWTH OF SPACIAL POPULATION

PESSIMISTIC:	PROBABLE:	OPTIMISTIC:	POSSIBLE:
1975 = 0 residents	0	0	0
1983 = 3	10	100	2 M
2000 = 25	500	10,000	4-4000 M
2025 = 250	50,000	10 M	EVERYONE + NEWBORN
2050 = 5000	3 M	100 M	supertocology +
2075 = 50,000	50 M	1 B	automata + maximalism
2100 = 500,000	1 B	10 B	1 sextillion by 2100
2125 = 5 M	1¼ B	28 B	
2150 = 50 M	2½ B	55 B	
2175 = 500 M	5 B	135 B	other stars and life
2200 = 5 B	10 B	300 B	

GROWTH OF SPACIAL TOURISTRY

PESSIMISTIC:	PROBABLE:	OPTIMISTIC:	POSSIBLE:
1975 = 0 tourists/y	0	0	0
1983 = 0	0	10	2 M
2000 =	100	100,000	4-4000 M
2025 =	100,000	100 M	EVERYONE + NEWBORN
2050 =	10 M	400 M	10 T
2075 =	100 M	1 B	
2100 =	1 B	5 B	
2125 =	10 B	15 B	see above
2150 =	40 B	50 B	
2175 =	100 B	225 B	
2200 =	100 B	1 T	

NOTE. Both of these tables represent crude and provisional estimates.

Why will people, even hypothetically, wish to visit or live in Space? After all, the Earth is a natural and cultural paradise, and will at first represent everyone's home.

One reason for touristry to geocentric Space is the panoramic view it will provide of so-called Spaceship Earth below, behind, outside, and above. It is unlikely that still and motion pictures, paintings, narratives, and stories will quite capture the quality, thrill, personal experience, and accomplishment of direct flight into Space. The excitement of anticipating and undertaking the flight itself (the ascent, orbit, and descent) will surely be enormous and unique. The enthusiasm afterwards of those returned to Earth will be highly contagious. There will be prestige and Veblenesque mimicry at work. By the years referred to mankind will differ considerably from ourselves in 1975. Families in the wealthiest countries will be many times richer than now. By then many current thrills will be old hat and men will be looking elsewhere for fun and adventure. Great momentum will have gathered about Space. Current hesitations, uncertainties, fears, and criteria of what is normal will have died. Spacial enterprise will have grown enormously--disproportionately even to economic growth and to technical means for Spacial ventures. Commercial interest in Space will have opened up and explored all possibilities. Traffic between Earth and Space of robots, freight, and employees will have developed apart from any touristry but thereby have supplied the basis for touristry, and partly the opportunity and motive. The less developed countries

of the world today will have undergone disproportionately and ahistorically fast rates of economic growth relative to current developed nations--in part owing to continuous and discontinuous transfer of technology, wealth, social organization, and values--and by 2025-2075 current international disparities in individual and national income, and in economic structure, will have been largely removed and yet on the basis of universal growth and nondeceleration of all countries' rates of growth. This unprecedented progress and novel matching means that by these times the wealth and emerging postindustrial values of the current developed nations will apply virtually to the entire future population of the world. Growth of discretionary income, and of tertiary and quaternary sectors of the economy and of the values which they nourish, will in all of these countries be all out of proportion to the simple growth of total and traditional income. Money available for Space will enlarge almost explosively. The inevitability of Space--for example, the fact that it surrounds all of the Earth, waits on our doorstep, and yet comprises the rest of the universe and virtually everything--will have dawned on mankind, turning Space into a popular and global enterprise. Already men in the developed countries spend a fair fraction of their lifetimes flying through the air between distant points on Earth. The number of these flights across the face of the Earth is already such as to drown out the relative expense in terms of income and energy of occasional flights into Space without regard for that greater fraction of his income which a man might be expected to part with to visit or live in Space. Beyond these important trends, there will develop over this time, under direct encouragement and perhaps in part reflecting the interest in Space, means for and types of employment independent of fixed workingplaces and congregations of employees, freeing producers to live where they will, and this disengagement will apply progressively to all jobs and producers the world over and at an everaccelerating rate; total leisure time will increase enormously; automation will at last and somewhat suddenly expand and be expanded in all realms of work (and particularly at those junctures and links of any economy crucial to the multiplication of overall production), especially with the introduction of truly intelligent and omnicompetent machines; and conventional sites and tasks in Space--offices, factories, services, and so forth--justifying the importation of very large workforces. There are many things which can just as well be done in Space (education, government, scientific research, power production, art, retired life, &c) and might even gain from the inspiration, resources, encounters, &r view there. There will certainly be some bell-shaped or at least skewed curve for income distribution--however leptokurtotic--and small fractions of the world's population will comprise vast numbers of disproportionately wealthy people liable to value supremely the status and escape of Spacial touristry and life. There are many jobs which might be better or only done in Space, or done instead of other things. All jobs performed in Space will presume or tolerate, in mutually assisting fashion, a network of primary, secondary, tertiary, and quaternary jobs. It is apparent in this way that a self-supporting nation could arise in Space simply by abstracting complexes of jobs usually performed on Earth and scattered among the nations of the Earth, much as in the world today we see the emergence of whole nations specializing in tertiary and quarternary roles with respect to the rest of the world. That the wealthiest of all types might concentrate in Space is especially interesting since a concomitant of such financial, intellectual, managerial, and aristocratic concentration would be disproportionate liquidity and growth in Space, and Space become the envy of mankind; furthermore, it is obvious, for real estate and investment reasons, that this concentrated and immense wealth, talent, and enterprise would dynamically spill over into the possibilities of transterran and translunar Space. Note the protection Space might likewise afford to wealthy classes on the defensive on a redistributive planet; powerful

migratory inducement would clearly exist for men craving autonomy, privacy of enterprise, freedom to amass wealth, and room to expand.

A single visit to or tour of Space in a lifetime could well be an almost universal object, and a novel custom, of mankind. Tourists turning over in Space would inevitably and progressively shed some percentage of temporary and permanent residents whose connections to those back on Earth would induce others to come and tour, visit, and remain in Space. Clearly, increasing relative and absolute numbers of Terran tourists and emigrants would represent a self-acceleratory process. The growth of Spacial touristry and population, the development of multifarious and self-sufficient industry in Space, the accumulative growth of instantaneous facilities and plant, the returns to things in Space through economies of scale, the improvements resulting from the turnover of priorities, the tendency to long-term investment and overall planning marking Space from the beginning, the organic and slow perfection of things in Space, the gradual evolution by Space of an idiosyncratic and unique self-justifying atmosphere, the progressive excitement of affairs in Space and the pervasive spirit of progress and triumph, the expanding environment of Space, the flux of men and things to more distant points in the Solar System, and a million other factors will unquestionably cause Space to be a self-acceleratory process of the first order. Those who once visited Space would tend to return as a consequence of realizing the convenience of doing so, reasons for doing so, out of memory and habit, out of curiosity about progress, out of increasing ease of doing so, out of enlarged and residual curiosity as to more distant and neglected points in Space, as a reaffirmation of their uniquity, because of job opportunities consequent upon their experience, and for other reasons besides.

The inception and growth of diaglobal flight over the next 25-50 years--supersonic, hypersonic, rocket, and suborbital continental, intercontinental, and antipodal shipment, travel, and commuting--should underly, stimulate, and be stimulated by orbital and transorbital flight into Space. The fact that half the energy necessary to go almost anywhere within the Solar System is that necessary to escape from the geogravisphere, and that return to Earth presupposes far less energy from many key loci in the Solar System despite their distance, has as an important consequence that no great economic discontinuity seperates geocentric from transterran Space and no overwhelming economic warrant exists for confining industry, population, and touristry to periterran Space and a convenient geosatellosphere. Moreover, falling costs and swelling means in the years ahead will ease Spacial enterprise by so many orders of magnitude that the few factors advantage apparently possessed by periterran and cislunar loci will lose all marginal significance and be overleaped by Sivaistic enterprise catapulting beyond into translunar Space.

It is not obvious in advance what sublime aspect the terraqueous Earth will reveal from Space as seen by encircling tourists lounging at windows, floating in bubbles, or hovering in spacesuits. It must be considered that such tourists will bring to what they see a long conditioning and an itself-miraculous expectation as to what will be beheld. The sight they therefore see at their climatic mecca will be a fascinating synthesis of spectacular natural beauty, exquisite symbolism, incandescent expectation, shared experience, and profound philosophical reflection. Beheld will be the fragility, purity, infantility, self-enclosure, natural beauty, and singularity of the Earth. As tourists graduate into Space the lesson will be learned that the Earth is tiny, transcendable, not unique, and yet rich in suggestions for the future. Few will witness these sights without coming away with some permanent alteration in their concept of the universe, of the world, of others, and of themselves. Indeed, on this basis alone a wise man might decree expense of no concern in the provision of this experience to the whole of mankind. No reason exceeds that of the wisdom of a thing.

Forgetting this, I continue my recitation. This experience of Earth from Space might be compared with the attraction to the earthbound Manhattan's Empire State Building once had. From there could be seen, it must have seemed, the rest of the Earth and the world beyond. A symbol of this magnitude in the lives of men can not be overestimated. Likewise airflight over the Earth today must play a poetic and ennobling role in our civilization. Beyond being a transient experience, geocentric residence could have a greater value analogous to that of a mountain overlooking a town: the monumental panorama of the Earth with its rotating terminator and kaleidoscopic cloudscapes could exert a magical shaping influence in the lives of half-watching geosatellians in their remote observatories. Continuous aurorae would be seen enwreathing the poles, the march of the seasons would be visible in a celestial calendar, meteors might be seen here and there on the nightside like dazzling fish by the observant, the unified symphony of the Earth's weather would be there, and periodically there would be visible the matchless symbolism of simultaneous sunset and antipodal sunrise on Earth, the totality of night alternating with the totality of day like a planetary heartbeat felt but immersed in its silence. Likewise analogy may be made to the life of islanders and men aboard great ships continually at sea. In all these cases there is some important contribution made to the grain of the men living in the sight of such things: a stirring vision can mean a different race, a different vision a larger man. Men who once experienced Space, or were born there, might return to Earth superior beings. The population of the Earth might be refined in this way.

That the human race is entering an age free of the need to work in the usual sense and yet possessed of the means to transform its experience entirely means that an opportunity is before it to pick and build its world according to artistic standards of perfection. This would seem to be the opportunity afforded by Space where we have the option of creating worlds ex nihilo or ex capite, motivated by the wish to perfect human existence. The life of the farmer is, in a way, the ideal life because of the farmer's relationship to the land, to time, to himself, and to his crops. A similar and a consecutive synthesis would be provided by the task of building colonies in the void of Space by the convergent demands it would put upon heart, brain, and muscle in the creation of one's own world. The world would accumulate about one as the art of past moments and other lives. Such self-creating and self-perfecting worlds would be a pleasant fate for men relieved of the need to work but thereby set adrift. Artistic endeavor permits the endless adventure of the search for an unattainable perfection through the infinite exploitation of past accomplishment.

An argument against the colonization of Space which is often raised is that such colonization, if desirable and feasible, might better or just as well be done, at least in the beginning or until necessity demands relocation, in various clement or hostile environments on Earth--on, in, or under the sea, or, in, or under the polar ice, on or under deserts or jungles, in or atop mountains, under the ground anywhere in the world, or even (what is possible in terms of floating cities which have already been sketched by R. Buckminster Fuller) in the atmosphere. A fit reply is an affirmation of the desirability and feasibility of colonizing all these spaces more or less simultaneously. Such choices would vary human habitats and maximally stimulate science, technology, engineering, and human nature. These are challenges which we really should not pass up. We have done so hitherto for false reasons such as the added cost and difficulty of such undertakings, the conservatism of financiers, the laggardness of potential buyers to new ideas, the convenience of building in the vicinity of prior construction, a failure of imagination and will shared by all parties, an indifference to the fate of the human race and to philosophical possibilities, a submission to mindless habit and irrational tradition, and an inability of human beings to cooperate on higher or larger things. The glory of life has been sacrifised to these insentient

restraints! It is also supposed, in a negativistic way, that not all of these loci could be colonized at once, which has led to none of them being colonized! Actually man has sufficient resources that he could build many large "colonies" at every one of the loci just listed starting tomorrow and concurrently. What is not realized is that the human race could only gain, overall, from undertaking these many purposes, even in the face of immediate failure such as is certainly possible. Such failure could simply result from insufficient resolve, wrong administration or planning, wrong people being involved, niggardliness about funds and style, premature pessimism, &rc. Similarly, man can and should now undertake the complete planning and building of whole cities of 10^{4-6} inhabitants, but with the same necessary ingredients just underlined. We have to learn to do these things and how to do them right and perfectly, and these things presume experience, even a taste of outright failure. In this way we can build the better environments that we all crave as opposed to the accidental environments accreted over the past and suffered by ourselves today. Colonies in Space are a special challenge, and a particularly desirable one, merely because the environments of Space are especially difficult to colonize because of the strange conditions, unknown resources, seeming emptiness, inhuman difficulties, &c. In every imaginable respect we will have to rely on human ingenuity and we will have to acquire a profound understanding of natural and artificial things, of what makes a society, city, environment, world, civilization, finer human being, good system of values, &c. These are the things which are important for what human beings do with themselves in this universe, not lesser things or compromises!

Such a level of mastery in understanding, controlling, and remaking the human world has an importance illustrated by the fact of what man has previously done to nature. He has found himself in Eden, a natural paradise in terms of weather, biology, landscape, resources, and his tribal beginnings. He has then progressed by exploiting and desecrating these accidents of nature, by taking them for granted, by slowly degrading things, &c. What he must do in the future if his destiny is not the contrivance of Hell amid a ruined environment is learn to understand the character and springs of natural beauty and resources and the techniques for preserving, extending, transcending, and re-creating ex nihilo all that previously was found wild and abundant in nature. He must learn how to play a responsible God. What will happen if he fails to do so, if he somehow lacks the will or impedes himself, is all too clear from the course of the world over the past 500 years. Naturally it might be possible to first destroy the world and then set about achieving things, but this seems an unnecessary and a dangerous course. It may happen that in 50-200 years man will successfully so wreck or poison his fortunate home that he will be compelled to migrate to Space and begin things from scratch, perhaps in a post-holocaustic world with the belligerents mutually annihilated and the survivors mere bystanders at scattered and chance outposts. Such a post-war emigration might occur as the aftermath of a relatively mild catastrophe, with the emigrants but a fraction of the survivors and represented by the wiser, indignant, more farseeing, more or less stricken, more tasteful, &rc few; the human race might even divide in this way, with the peaceful or the bellicose abandoning the disfigured Earth for raw Space.

By 2000-2050 the Earth may be so affluent that, paradoxically, a reversion to natural, cruder, leaner, harsher, alien, &rc conditions marking early life in Space may be less resisted by men than today when our transition from such original conditions is too early and greater intolerance for such conditions describes mankind. Life in these later years may be so easy as to give rise to widespread dissatisfaction and some eagerness for more strenuous experiences. Men may simply have become naive about such difficulties and hence overready to embrace them. Moreover, by these years man's economic and technical powers may enable or even insure that even initial colonization of Space can be done without leaving behind

the comforts, tasks, and habits of civilization on Earth. This is already obvious today where modern man can retire into the backwoods without abandoning many of the powers and perquisites of advanced urban life. Men in the developed countries in many ways enjoy the standards of living formerly limited to kings, and surpass the old kings in that the new is a movable empire. One is in fact inclined to regret that the pleasures, comforts, traits, perspectives, powers, &rc of modern and future civilization will be so readily exported to Space, in part because otherwise men might profit from the hardships, learn humility, value and perpetuate variety, and better value the purity of the untouched and prehuman world. It will be particularly easy to transport intact civilization to Space when the exportation is on such a large scale as represented by the long exodus of innumerable men or a sizable fraction of the race. Such a massive exodus will be unsparing and all that is good and evil on Earth will be copied at once in what might otherwise be frontier. For example, the pleasure of a good book and the all-encompassing nature of such pleasure for many persons is proverbial. By 2000-2050 all the books of the world will be transportable into Space as the personal possession of every casual visitor equipped with an ultraminiature record, and even those less able, by heredity or culture, to thrive on books will be able to bring with them inexhaustible entertainment in the form of such a record comprising unnumbered lifetimes of superior televisual programs, just as today a book or a television is brought by city-folk when they visit the wild in their domiciliary camper. Ultraminiature and infinite entertainment will be brought in the pocket of colonists of the stark Moon, the extraplanetary void, and remote Pluto. There is a clear danger that the happiness afforded by the technical entertainment and joys of future man will wholly absorb and content these simple beings and lead, for centuries or eternity, to their desertion of any greater, further, or more demanding goals. In the face of such a growing diminution of the human mind it is likely that portions of the human race would be actively hostile to such a course for mankind and would stop at nothing to destroy, limit, control, alter, prevent, defame, &rc the seductive means, or to pursue antithetical courses on the basis of rabid ideology. Extremism of this, very likely defensible, kind may thus play a key role in eventually driving man into Space and maintaining human progress.

One of the greatest reasons for the inevitability of the development of Space, especially its colonization, is the susceptibility of men in general to the fanatical beliefs of certain minds always appearing in society, perhaps especially in the future, eager to make their case and easy at persuading others, first to listen, then to wonder, then to commit themselves mind, body, and soul to the new gospel. It is obvious that the wild, romantic, and challenging claims of these sometimes questionable and sometimes unquestionable fanatics will galvanize large parts of mankind and lead many sheep into the sky. As important as anything in the makeup of human history has been the influence of symbolism and the power of ideas. Long journeys and arduous undertakings have continually been begun on foolish cause which was later unimportant before the accidental benefits of the enterprise and the creativity ignited in those who set themselves free. In an age of leisure spared the necessity of work the motility of humanity may be simply enormous and the colonization of Space may prove an irresistible recreation, creed, or trial.

The construction, acceptance, and perfection of condominia, new whole towns, trailer parks, and accidental conurbations on Earth such as is already occurring and will accelerate over the future will automatically lay the basis for the idea of colonies in Space and the desire of individuals and families to live in them. The process on Earth cannot be stopped and is already altering the mentality, life-styles, and modi vivendi of all of mankind. Once a future wedge is established in Space the spark will ignite the flame and a river of humanity will pour into the ocean of Space. That hundreds of millions of men will partake of the experience

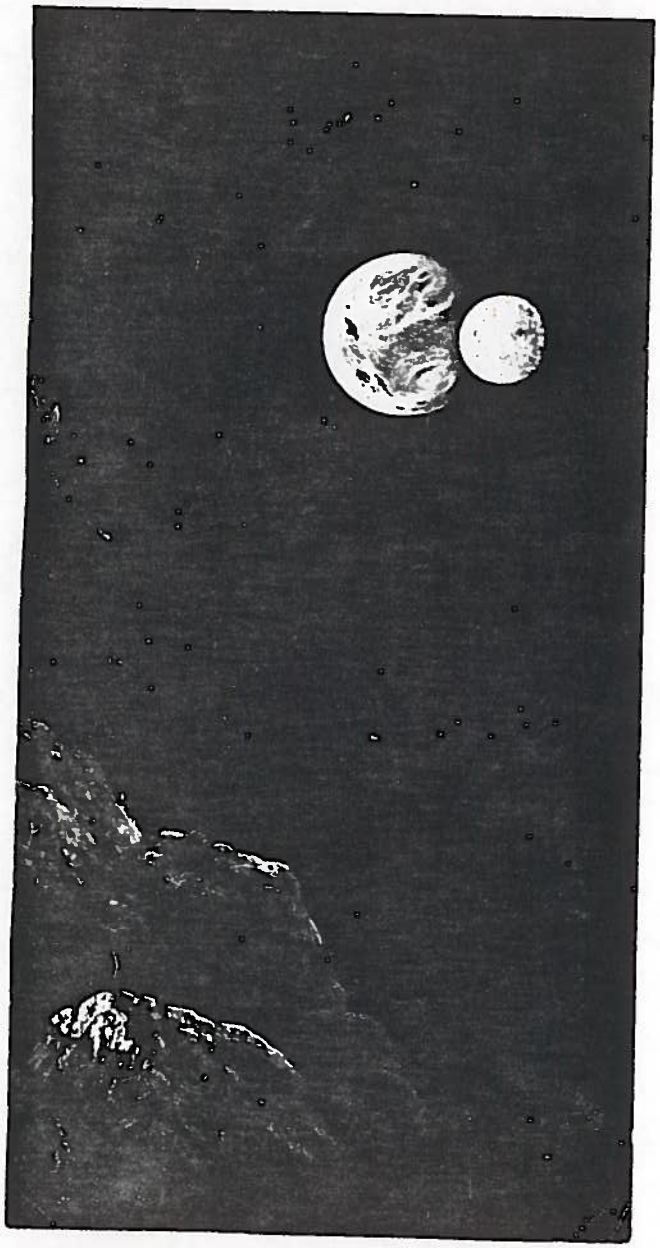
of being a tourist or resident in Space is a transparent unavoidable consequence of the fact that a round trip out of the Earth's atmosphere into the void will eventually be as easy as the snap of a finger for human beings 25-50 years from now wielding titanic powers. And since the real discontinuity in human initiative will be that involved in leaving the Earth at all, rather than the distances voyaged beyond, these titanic men will quickly inundate the Solar System under the impetus of an ever-enlarging curiosity and over past roads of accomplishment. The occupation of the cisplutonian Solar System will be an act which renders the diameter of Solian Civilization fully a thousandth the distance to the nearest stars, a discontinuity 1 million times less than what describes current Terran civilization and intrinsically small enough to imply the inevitability of our growing civilization eventually incorporating the near stars and, without further discontinuity, the entire galactic instellation.

The new colonies established throughout the Solar System during the 21st century and thereafter will to some extent be what I have metaphorically referred to as "edens". That is, they will represent the founding of various independent civilizations, histories, populations, biospheres, microcosms, races, &c and will potentially or actually be self-supporting and not zero-sum entities, or "redundant earths". Their basic materials may be the common soil and other materials that exist in such incredible plenty as the bodies of Solian planetaries, and their basic energies may be the overabundant light of the Sun which is currently wasted, or those in the future taken from the nuclei of virtually all elements, however common. Beyond this they will amount to plutographic, industrial, sociological, and biological wholly or virtually wholly closed ecosystems or vivaria, and not be such as to for practical purposes deplete finite supplies of Terran or Solian resources, pollute these realms, or threaten the destiny and greater purpose of our star. They will thus constitute demonstrational models of man's ability and likelihood of surmounting supposed evils of continued exponential growth and crises foreseen for the future of the world by current advocates of the limits of growth. In these ways, and by sparing the state of things on Earth, such colonies in Space as anticipated, or when built, will appeal to environmentalistic sentiments since Earth will be isolated from Space and might even be deindustrialized by finished imports from the colonies in Space. In a way it is hard to imagine any finer or more idealistic deed than sprinkling new civilizations in Space. Such civilizations themselves being self-reproducible, and a fantastic or perhaps infinite universe remaining beyond, the initial deed by Terrans, whatever combination of semiconscious motives behind it, might be an act of infinite worth, the greatest thing the human race, or ourselves as the initiators of the process, could and will ever do. This extraordinary fact deserves close study since it is truly extraordinary and perhaps amounts to the miraculous.

It has been remarked that there are no Martians because we human beings have yet to launch the Martian civilization that will give rise to the enchanting inhabitants of that planet long foreseen by romantic fiction. Likewise the rest of the universe appears uninhabited by superior beings because our destiny of filling the universe with superior beings evolved from ourselves has yet to fulfill itself, and perhaps because this saturation will be a very fast and unidirectional process amounting to a cosmic phase transition and preempting other and independent life. Thus it can be seen that someone must take the initiative in realizing the potentialities of the universe and hesitations about the colonization of Space are naive in disregarding infinite consequences of actions and the apparent relative importance of these consequences for everything we might otherwise do. Effects of our present actions on the future lives of our children already exert a potent influence as governors of our actions, a situation expressing in miniature a possible greater concern with posterity such as proposed here as a new obligation of mankind.



The good planet Earth, sun-blessed sanctuary of life, travels in tandem with its sterile moon. Artist Pesek imaginatively portrays them from the vantage point of the asteroid Hermes, as it swept to within a mere 500,000 miles of Earth in 1937. So large is the moon —a fourth Earth's diameter—that many astronomers regard the pair as almost a double planet. Here the moon, closer to the asteroid, appears abnormally large.



EARLY SPACIAL ATTRACTIONS TO TOURISTS

1. Thrill of ascent from and descent to Earth.
2. Face of the Earth filling half of the sky from 100-mile orbit or trajectory with incredible detail and beauty.
3. Circumnavigation of the Earth in 90 minutes from 100-mile orbit.
4. Meridian overflight of Earth's 2 polar regions from 100-mile orbit, including observation of nocturnal aurorae.
5. Circumnavigation of the Earth from extremely eccentric orbit including apogees at several Earth radii.
6. Overnight stay at 100-mile and geosynchronous geosatellitic spacestations or hotels.
7. Extended tours at cities, spaceports, factories, titanic power facilities, convention centers, museums, schools, governmental headquarters, geoscopic and astronomic observatories, other scientific stations, industrial research laboratories, hospitals, health resorts, military outposts, historical satellites, observational points, immense biaria, storage yards, extracolonial homes, diverse ethnic colonies, religious shrines, corporate offices, Spacial Force academies, derelict and wrecked spaceships and spacestations, military maneuvers, scientific field experiments, significant events and launches, amusement centers, biological preserves, omnidirectional communicational facilities, &rc in the Geosatellosphere.
8. Visits to Lagrangian colonies clustered in great numbers and possessing complete diversity at points L1 through L5 in the Terrilunar and Soliterran systems, including many of the things just described for the Geosatellosphere. So interesting are the colonies that many visitors tour for 3-6 months, or take up temporary residence for 1-3 years, perhaps as a change of scene and experience for their families. Human employment is so independent of location and even other human beings at this time that men simultaneously tour and work, or perform such nonautomated duties as are called for at occasional loci, in part because the custom has developed of rotating or alternating between similar and contrasting jobs. By this time work is less a necessity than an optional diversion or a recreational challenge, the really serious work being carried on by the overproductive and absurdly ergomaniacal automata in the manner of instinct or play. Such automata work, and create other and more advanced automata, to such a degree that their mission has changed to converting all of nature and the Solar System into a stockpile of future and better goods, fuel reserves, "money", vacant habitats, automatic worlds, endless art, a gigantic city, astronomically powerful tools and devices, armies of robots, an ever-expanding supermind, an explosively large memory of everything, endless scientific and technical research, endless and maximal economic growth, fulfillments of every actual and possible human velleity, a new form of nature, an infinite kinetic symphony of activities, a hurricane of arbitrary purposes, a civilization supplying whole cities and nations to every man, &c. The Solar System is pervaded with mechanical intelligence, sensors, and effectors.
9. Visits to wholly automated bases, cities, factories, &c unpopulated by any human residents.
10. Flight from Earth into orbit about the Moon and back to Earth.
11. Visits to lunisatellites and 10-mile oversweeping orbits of the Moon.
12. Visits to bases, colonies, cities, plants, forts, mines, historic landmarks, planeturgical zones, subsurficial cities, mountain ranges, unusual craters, active volcanoes, miles-deep rilles, 100-mile volcanic caves, crash sites, new and ghost towns, gigantic telescopes, strange polar landscapes, ancient river beds, unexplained mysteries, routes of historic expeditions, immense metropolises, tops of miles-high mountains, scenes of fearsome desolation and ancient cataclysm, remote points, interesting trails, tremendous monorails,

great power facilities, domes blanketing thousands of square miles, the capital of Solian Government, great spacial engineering facilities, the famous Center for the Lunar Sciences, the largest boulder on the Moon, the Shrine to the Memory of the Early Astronauts, the unusual Museum of the Future of the Solar System, the great recycling and atmospheric plants, the towering glass crescent commemorating The Declaration of the Independence of the Moon in 2043, the Great Museum of Collected Lunar Art in the City of Light (2050 population, 72,189), the cultured cosmopolitan city Second Earth (2050 population, 23,421), the Asthenospheric Project drilling to the base of the lithosphere and perhaps the center of the Moon, &c.

DIFFERENT TYPES OF SPACIAL SCENARIOS

BLEAK SCENARIO. In this scenario the current falling support of NASA and the conservatism of the Soviets' programs continues. Congress views Space as a dead issue and is merely concerned with its careful dismantlement. NASA remains, after 1983, as an impotent fossil, most of its chores having been turned over to the military. The Space Age proves to have been truly meteoric: as soon born as dead. Nevertheless, fossil NASA, absorptive military, and foreign programs (themselves drastically restrained where not abolished) continue to support spacial activities on a level commensurate with inflation, and thus $10B are spent on Space in 2000. However, Quarter I turns out to have been a morbid, feeble, dull, and slow time indeed. This bleak Quarter could be described as being followed by a revival, along various lines, or the 21st century might be painted in similarly somber terms. The wrongness of this bleak treatment of Space might be illustrated by comparison with nonbleak scenarios or by mentioning directly in bleak scenarios what is lost in terms of the spirit of man, a world that might have been, science and technology ignored, and trends on Earth encouraged and isolated.

TRAGIC SCENARIO. Space proceeds at its current, a moderate, or a vigorous pace, but with a history of spectacular, repeated, and fatal failures, errors, mischances, disasters, miscarriages, debacles, harmful effects, and growing opposition. Some or all of the following occurs:

(1) Nuclear spaceships are built and widely used, but many disasters and side effects result: atmospheric explosion and global radioisotopic (eg plutonium) fallout for weeks and years afterward (fearful populaces, international rancor and retributive demands, teratogenic and oncogenic outbreaks, poisoned and diseased crops, &rc), crashes (reactors fall on metropolises and explode disastrously), exhaust radioisotopes surround the Earth, endure or accumulate in the air, fall in rain, are concentrated by specific meteorological processes in precipitational events, collision occurs in the atmosphere or in orbit, controversy remains about the safety of nuclear ships in Subspace &r Space, nuclear explosion of certain spaceships' reactors occurs, theft of nuclear fuel occurs, it is suggested that nuclear spaceships might be used as or hide nuclear weapons, nuclear spaceships pollute the Moon, &rc.

(2) Many troubles occur in developing nuclear spaceships, fission persists, fusion is delayed or impossible (at least for spaceships), fusion is required for spaceships because fission reactors are too heavy, nuclear spaceships are denied operation in the atmosphere, elimination of radioisotopic exhausts proves hard, expensive, or impossible, nuclear drives prove little more efficient or more expensive to operate than chemical drives, &rc.

(3) Great solar power stations, a la Glaser, are built orbiting the Earth but at unexpected expense, show unexpected costs of wear or difficulties of operation (rigidity, orientation, reorientation, shape, conversion difficulties, &c), microwave radiation beamed to Earth pollutes the airwaves, affects weather, has biological side effects, requires restrictions on movements of population and flight, &c, transmitter downtime is high, &rc. The power produced proves surprisingly expensive in the absolute or relative to other and new sources of power, terrestrial power production from sunlight proves better, simpler, equivalent, cheaper, safer, &rc. Some or all of the orbital transmitters (optical, microwave, &c) prove intolerably dangerous by highly improbable but still possible and absolutely disastrous effects their drift might have or by superstitious fears and anxieties induced in most or some people, by initial uncertainties, or by

possible military uses then or in the future.
(4) Industrial research and actual industry and manufacture are attempted in Space, perhaps in a grand or impetuous way or an uncritical way, but gradually or fairly abruptly prove impossible, not cost-effective, not consequential, exceptional, little benefited, achievable or obviable on Earth, fanciful, too far-off, presumptuous of much larger scale of operation or auxiliary means (transportation, supplies, workforce, energy, supplementary industries, &rc), disadvantaged with respect to that possible on Earth, more relevant to the surfaces of other planetaries than to geocentric orbit, &rc. Government or industry loses initiative.
(5) The mineral resources of the Moon, other planets, asteroids, &rc prove undifferentiated, inaccessible, scant, earthlike, base rather than precious, too demanding of exploration, not immediately obvious, too presumptuous of new technology and supplementary technology in the conditions of Space, not competitive on Earth, useless in Space (or relative to Terran exports), unrefineable in Space, too strange or inappropriate for Terran traditions and skills, not economically minable, too expensive to transport, competitive with new techniques, sources, and uses on Earth, too presumptuous of a larger and critical scale of enterprise and supplementary enterprise, more relevant to the distant future, &rc.
(6) Agriculture is attempted in Space, even massive agriculture for exportation to Earth, but toxins prevail or basic nutrients are lacking in nonterran soils, fertilizer and soil must be exported from Earth, Spacial conditions (intense sunlight, minimal gravity, free space, &c) prove basically valueless or even harmful for would-be crops, costs (transportational, supply, personnel, constructional, research, systemic, salary levels, &rc) prove too great in the absolute or relative to Earth, agriculture on Earth grows proportionately or faster than population &r needs or is cost-expansible (possessed of too great a marginal elasticity), technological advance in agriculture and food production on Earth defeats any reason for or products of Spacial production, Terran &r Spacial population flattens or grows acceptably, &rc.
(7) Transportational costs stay basically even or even increase (say as a result of persistent energy shortage on Earth) or inflate (for incidental reasons or reasons of nonsubsidized cost), or else fall little or less than essential to justify agricultural shipments to Earth.
(8) It develops that man, or all Terran life, is disturbed by conditions in Space (zero or any lower gravity, unfiltered or unnatural sunlight, absence of diurnal or other natural rhythms, loss of ecological context, ambient radiation, magnetic differences, &rc) and thus discomforted, weakened, injured, &r killed by long, or even short, exposure to such conditions. Possibly men react badly, psychologically, to Space, whatever the resemblance of conditions to those on Earth.
(9) Dangerous pathogens are recognized on other planets, or invade Earth and wreak havoc. The aftermath might be a lifeless, manless, or crippled Earth, or absolute proscription of any Spacial enterprise or human travel, possibly for centuries or with poisoned human attitudes toward Space.
(10) Some power abuses Space by putting &r using weapons there, resulting in a curtailment or proscription of other Spacial activities.
(11) Crises on Earth--military confrontations, holocausts, disastrous scientific accidents, massive starvation, dwindling resources, widespread cynicism or malaise, civil war, economic depressions, biological or ecological catastrophes, &rc--distract men, possibly irreversibly, from Space.

(12) Interstellar communications are received. Knowledge gained thereby is used malevolently, foolishly, or just disastrously. The senders of the communication prove insane, evil, frightening, disgusting, ominous, belligerent, omnipotent, incomprehensible, in disagreement with or fatal to human beliefs or valid customs, seemingly brutal, enviable, intolerably better than us, abusive or designing, deceitful, a poor example, masters of the universe, demanding, influentially spiritual rather than Faustian, &rc. As a result, reception is halted, proscribed, fatally continued or enlarged, restricted, misused, substituted for travel into and development of the Solar System &r beyond, &r has the effect of discontinuing other interest in or development of Space.
(13) Interstellar communications are never received, despite all and ideal effort, and negative conclusions are drawn, or even the conclusion that the exploration and development of Space is unwarranted.
(14) Major disasters occur in Space: ships explode, solar storms severely injure astronauts or geosatellians, colonial domes or spheres collapse, expeditions are inexplicably lost, &rc. The toll in lives is high, fatal to the whole Spacial enterprise, stigmatic, poisons attitudes toward Space, discourages new adventurers, or exacts great costs in terms of subsequent safety measures in connexion with regulation, building, supply, transportation, personnel, protective forces, redundancy, limitations on operations, restraints on risk-taking by any crews, &rc.
(15) Expensive, unimaginative, foolish, discouraging, suppressive, conservative, overcautious, unenterprising, overregulatory, contradictory, Earth-oriented, imperceptive, noninnovative, inelegant, wild, self-serving, faddish, &r mediocratic bureaucracies progressively encumber and become all Spacial enterprise, with bad or terrible consequences.
(16) Conditions in Space, such as zero gravity, might be found basically valueless or uneconomical in human medicine.
(17) Spacial touristry might never start. It might start but never grow, or grow and shortly wilt. The spectacle of the Earth seen from Space might prove too transient or unpopular an experience to perpetuate the industry over the long term, to excite repeated touristry, or to maintain tourists in orbit over longer periods, even if it is the greatest reason why such touristry might initially occur; moreover, cinematography or simulation on Earth might adequately substitute for, or surpass, the direct view from Space, particularly in view of travel expenses, or the experience might be accomplished by nonstopping spaceship trajectories or maneuvers. Initial or continuing expenses might prevent touristry, render it unattractive or uncompetitive with alternative touristry, or limit it to the very wealthy or motivated. Initial or continuing accomodations in Space (apartments, food, services, options, personal excursion vehicles, &c) might prove poor, Spartan, vulgar, expensive, limited, simple, &c in themselves, or as compared with facilities (say priced identically) on Earth. Discouraging hazards might attend periterran and extraterran touristry, at least emotionally and superstitiously The jump from near Earth to the Moon and then to the planets might prove too great in terms of cost, time, risk, imagination, enterprise, interest, supplementary development, competing possibilities, governmental restrictions, &r returns. Such touristry might simply be very badly done: unartful observation windows and times, cheap and vulgar means, poor or no guides, forgotten romance and love, aborted humility, commercial handling on Earth, overcontrolled and overregulated tours and stays, omitted touches, herded and crowded tourists, artless interiors of ships and buildings, overselling, want of flair and genius, poor scheduling, poisonous delays, suppressed risks and excitements, smug presentation, stuffy atmosphere,

noticeably recycled water, bad cuisine, classless tourists and uniform accomodations, homogeneous experiences (eg modular monotony), &rc--things absolutely decisive for any touristry, certainly in Space. Things appropriate which might also be omitted include: offices, suites, plazas, stores, museums (astronautical, historical, scientific, commercial, artistic, and futuristic), performing and accomodated arts, vegetation and animals, playgrounds, available residences, parks, astronomical observatories, super planetaria, industrial facilities, conference centers, lectures, universities, headquarters for the United Nations, the encouragement of sports and amusements (eg the provision of stadia, invention of games only appropriate to zero gravity, &c), &rc. There is also the hypothetical possibility that touristry will flourish but on such a scale or in such a way that it will destructively remove some of the color or seriousness from other Spacial enterprises, eg by rendering Space too similar to other unglamorous or ignored wildernesses on Earth.

(18) Analogous things might occur in terms of any colonization of Space where there are additional questions about technical feasibility, use, economics, sponsorship, function, self-sufficiency, jobs, dangers, conditions, planning, &rc. O'Neill colonies might be built at L5, on the Moon, around Earth, &rc and come to support 50,000 people at their peak, but become gradually abandoned over Quarter II as nonpaying, vulnerable, fragile, futile, useless, pointless, passe, underused, dull, &rc or become ghost towns.

(19) Nuclear or other means enabling interplanetary transportation might never develop, for technical or other reasons, and thereby confine man's Spacial programs to geocentric or cislunar Space.

(20) Earth-oriented and geocentric programmatic foci might supplant or overshadow the exploration and development of the rest of Space.

(21) The exploration and development of Space might be so slowed, attenuated, &r controversial as to abort a critical enthusiasm still existing today but otherwise fragile or fugacious.

(22) Mechanical might supplant manned exploration and development of Space and thereby retard discovery, drown public interest, distract programs, prevent the fuller development of Space and especially colonization and the imminent beginning of a Solian Civilization, economically reduce the funding of Spacial programs, recolor Space, unknowedly prevent important discoveries and intuitive realizations, appease critics and opponents of Space, reduce international competition (now and later), limit exploration, limit the drama of early Spacial exploration, &r ultimately lead to almost total political neglect of Space and an egocentric Earth.

(23) Space might remain or become largely the plaything of very few parties, say the United States and the Soviet Union, and the grand proliferation of national and corporate participants, programs, and purposes otherwise foreseen for the 20th and 21st centuries might never occur, and thus important catalytic and synergistic effects might never occur.

(24) Man, unimaginatively &r gutlessly, might simply pass up the marvelous challenge and opportunity that Space myriadly represents.

CONSERVATIVE SCENARIO. Space is pursued sluggishly, leanly, and gradually.

MODERATE SCENARIO. Space is pursued at its current (1975) pace, or perhaps consistently with widespread imagery or conceptions as to what it means.

PROBABLE SCENARIO. An attempt is made in this scenario to project the most probable course of things, say on the basis of a sophisticated outlook and one whose basic assumptions have been defined.

OPTIMISTIC, VIGOROUS, AND YET NATURAL SCENARIO. Space is pursued at greater than its current or moderate pace but on the basis of what is technically and economically likely, perhaps in a way consistent with events and visions of the future between 1957-1966/9.

OPTIMAL SCENARIO. The way Space ought develop. A judgmental scenario.

MAXIMALLY VIGOROUS AND YET NATURAL SCENARIO. Likely means, now and later, are utilized to the full. Things are done as quickly and massively as possible, especially by using means already available or creatable in 1975. A maximally accelerated scenario.

FAR-OUT SCENARIOS. In these there enter critically important means, incentives, and events which, however, currently seem very unlikely, even by approximating actual things. The critical entrants may be questionable in the sense that very few people today would view them as very likely whereas some do, or because really everyone agrees that they are unlikely. Discoveries, inventions, unexplainable events, underived resources, spectacular human events, unexplained velocities of progress, &rc might contribute to such scenarios. It should be understood that, perhaps apart from specific or explained scenarios, there is a very good chance that what will actually occur in the future of Space would be placed by ourselves in the category of a far-out scenario.

PROGRAMMATIC SCENARIO. Here a program is set forth as the bone &r the flesh of what will occur in the future of Space as if the latter will conform to a coordinated and logical plan.

PREPOSTEROUS SCENARIOS. Here the course of things is foreseen on fantastic, ideal, fallacious, illegitimately supramaximal, &r just dumb terms, say like a story told in a children's comic book. Many people in fact see the future of Space in this way.

AUTOCATALYTIC SCENARIO. Here the stress of the portrayal is on showing how developments will or might lead to developments so that the future of Space will develop like the branching of a tree or a self-exciting chemical reaction. Such autocatalysis might purposefully be overdone--by overconnecting events, making certain effects seem inevitable or overpowerful, limiting counteracting events and consequences, smoothing the way for consequences, making branches too numerous, abbreviating branches, anastomosing branches, compressing branching, assuming perfect motivation, disregarding what is likely, &rc--for such a reason as to impress the reader's mind with the fact that such autocatalysis does occur, controls things, transforms things, &c.

WHY ENERGY HAS NO ABSOLUTE COST

It is ordinarily assumed that energy has some sort of absolute cost, an attained, imminent, or eventual floor that will limit anything man can do, now or later, and that confers absolute cost minima upon his actual and possible undertakings and technology. This is not so. That it is not so is critically important since present future possibilities in Space are basically limited or shaped by actual and possible costs, amounts, kinds, and other dimensions of energy and power.

Government could take over the production of energy or fuel in order to eliminate inessential profits and facilitate specific purposes. There is a temptation to limit production, limit development and innovation, hold prices high, conserve present means and ways, &c that pervades current industry. Direct costs of producing energy are tied elaborately to the whole economy so that the role of government could also be to minimize all related peripheral costs: the deflation here could be enormous for these superimposed prices are themselves artificial and inelegant. Energy produced can be reallocated to such a purpose as developing Space. Government can subsidize fuel purchase. Moreover, extraordinary natural wealth and opportunity is available for a development not currently pursued by industries indifferent to any oceanic or cheap needs, and certainly disinterested in diminishing their returns per ~~pound~~ sale. Gross national product, annual growth therein, &c are totally misleading since the cost of energy is dependent on historical events, arbitrary economic distributions and values, and variable exponential rates of growth and rates extraordinarily dependent upon prior rates of investment and overall economic emphasis. If man now explicitly undertakes to maximize energy and growth of the relevant industry, science, and technology, transcendental exponential advance is possible in terms of deflated costs and prices, excellence of the form of energy, marginal redistribution, momentarily usable energy, available stockpile, &c. If 50% of working men worked on producing energy and developing energy resources, disproportionately great deflation of future energy cost would result (availed energy might even raise general social income despite the modification and specialization of the workforce so that the situation is inherently surprising). No supposed or actual limitations upon the rate of extraction and fixed supply of natural energies really have any bearing upon the diminishability of energy costs in connexion with facilitating Space. Assuming Space has returns, economic &r energic, increased and cheapened energy for Spacial enterprise would probably encounter phenomena equivalent to phase transitions, and catalyses with future or direct returns overwhelmingly enlarging returns, repaying investments, and operating in terms of great and explosive positive feedback.

There are no absolute limits to human income, its rate of increase, or the warrant for its increase. Certain scientific developments are imminent &r possible--solar energy, fission, fusion, transnuclear processes, exomotive drives, more efficient conversion, conduction, storage, &c, &c--able to lower the cost of energy, and increase the power of certain systems, by very many orders of magnitude. Any such change would have nonlinear benefits of radical kind. Possibilities exist for more isentropic systems that could recover energy and raise the efficiency of its use, perhaps arbitrarily in terms of the endless development of scientific discovery, and these would clearly diminish the energy and dollar cost greatly. The value that man places upon goals and purposes in Space will be decisive in determining the costs of what he does there and thus in varying optimal prices, even apart from the diminishability of these costs as a result of industrial and research investment or effort at redesigning the economic system. Certain economies of scale inevitably do and would operate because of which larger operation of energy-producing processes would arbitrarily diminish energy costs over time. Much of human wealth, and hence the bases of prices in the small and large, is in the nature of accumulated asset from past economic endeavor: ability to produce energy benefits from means already provided. Men could labor to produce a focal mirror in Space concentrating for use a billion square miles of sunlight, creating solar energy in such abundance in ratio to man as to render us cowards.

WHAT WILL BE DISCUSSED AND ACCOMPLISHED AT THE DECEMBER MEETING

1. What might and what probably will be accomplished in space, especially in the course of the next 1-2 centuries.

2. The future of space touristry: technical and financial characteristics, possible growth and scale, raisons d'etre, and chronology.

3. Demography: growth of Earth's population, growth and scale of residence in space, importance of possible rate and scale to other developments in space, population supportable on other planetaries, &c.

4. Feasibility, bases, warrants, imminence, &c of space colonization.

5. Possible natural resource wealth of the solar system and the exploitability of such wealth: timetable of its discovery and use, economic requirements for its profitable use, candidate resources, possible competitions with resources on Earth, &c.

6. Values of going into space.

7. A proper space program: scale, growth, staging, purposes, bases, sensitivities, sponsorship, &c.

8. Developments that may have an important bearing on what actually happens in space: discoveries in space, sociopolitical events, changes of policy, economic progress, technological achievements, scientific discoveries, reversal of public attitudes, &c.

9. Ultimate achievements and value of near-Earth activities: in terms of dollars and sense.

10. The possible occurrence, nature, and importance of a solar system civilization over the next 200 years.

11. The possibility and importance of discovery of extraterrestrial life in the solar system or beyond.

12. The possibility that life in space might be equal to, or better than, existence on Earth, or a solution to any of Earth's crises.

13. The specific possibility of generating power in space for transmission to Earth.

14. The possible scientific importance of space.

15. Possible uses of space for manufacture and industrial research, and the validity of such ideas.

16. Alternative scenarios of the future of space: bleakest, conservative, moderate, vigorous, wildly optimistic, keyed to certain events, &c.

17. Variable and possible courses of space economics: deflations and inflations, operational costs, transportational costs, economies of scale, &c.

VARIOUS REMARKS ON THE HARDSHIPS ENCOUNTERED IN READING THIS BOOK

1. The present order and form of the book is not at all what it will be when the book is done. What you have instead is something escaped from a workshop, circulated at this moment for the value its content may already have to some, criticism, and an idea as to the nature of the work.
2. Complaints are frequent about the vocabulary, grammar, punctuation, and style. For example, the coined words are viewed as unnecessary and pretentious. The writer is conscious of the harm they do by alienating his readership and the difficulties they present to some fixed in their mental habits. He is particularly aware of how ugly they must cause his beloved manuscript to appear. He nevertheless persists in his ways, retaining the old coinages and adding new ones, for reasons which he considers, after all, primary. He specifically feels that when a field is first developing and someone makes an effort for the first time to summarize and project the future of that field, an opportunity and even an obligation exists to define the vocabulary of that field, and, in the absence of, or case of defect in, such vocabulary this even extends to the proposal of a new vocabulary in service to the future needs of the field and to present discourse. Of course a certain competence and care is presupposed in the architect of the vocabulary. The new words must have the several virtues of being precise, accurate, formed in accordance with the rules and traditions of etymology, mutually illuminating, necessary, sufficient to the needs, embodying an important concept, and relatively graceful. But it must be admitted that all words have some defects and limitations, absolute intolerance of which would preclude the existence of language and the ready evolution of fields of thought. Moreover, crudities present in the new vocabulary can be removed with time. Above all, the words I coin in this manuscript are hardly intended to obscure matters, to impress the reader in any illusory way, or as cheap expedients behind which there is some ignorance of science or of the English language. They are not employed decoratively. They are not motivated by some frivolous whimsy. I have advanced the new words for exactly opposite reasons: as scientific instruments, as statements of fact, as bases for better discourse, as illuminating metaphors, and as things of beauty for their suitability. He who devises the first words must become an object of derision by those more keen to the frail novelty of his inventions than sensitive to the needs of the world which the brave words are designed to answer.
3. An objection to the grammar is that it is too complex and laborious. Some readers react as if they were undergoing torture. Particularly the endless listing of possibilities, qualifications, and aspects of things gives umbrage to the humble reader. Readers see such listing as stuffing, repetitious or trivial, and certainly as awkward and difficult to digest. Yet the writer takes special pride in his listing. He sees in it an honest coverage of the dimensions, uncertainties, and presuppositions of things, as exemplifying unprecedented analysis and respect for the real world. He concedes the discomfort which may be involved in accepting the complexity of the world, but he feels the discomfort must be forgotten and the complexity faced.
4. Readers are appalled at the immense paragraphs and sentences. It is doubted that the writer has ever heard of indentations and periods, or bothers to read what he has written. The writer replies, airily, that classical writers achieved nobility of style with no attention to such arbitrary rules as flourish today and pulsate in the marketing of books to increasingly undisciplined publics. He is content to let the size and shape of his sentence and paragraph be governed by the natural modulations of thought and the felicities of the moment.

5. Exception is taken to the ideas themselves which are generally viewed as disgraceful flights of fantasy and expeditions into presumption. The real world is conceived as either thoroughly known or else completely unknowable, to the fault, in either case, of my derivations. Ideas and facts are interpreted as immiscible, with my manuscript representing a gross confusion. I have found it amusing that some readers find my ideas hopelessly far-out, and others find them so ordinary as to be dull. Scientists see no value in fiction, per se. Previous revolutionary progress in science and technology is evidently viewed as traditional, or else as having by now exhausted nearly everything that is possible. The writer replies that the ideas are intended as imperfect but analogous substitutes for things which will actually occur but are not presently comprehensible. He claims that his manuscript arises out of a clearer imagination of our ignorance and limitation. He asserts that important germs of later developments in science always long predate the developments themselves but are the bases for those developments. Further, he claims, lineaments of the future always exist in the present and are characterizable by men of genius. Such anticipations can play a role in bettering the future. He finds that many other defenses exist for what he does.
6. Disagreements with statements in the manuscript are common, even cyclonic. The dates are largely viewed as overoptimistic, even ridiculously so. The writer in many cases agrees since he intends to correct the manuscript on the basis of later impressions and the internally significant framework created by the book. He feels, however, that readers are fallible as well: they extrapolate current gloom, they disregard scientific and technological progress, they fail to take into consideration demographic and economic progress, they omit the 3rd dimension any view of the future must have by incorporating effects of rates of specifically exponential progress in all these things, they do not consider the probable ultimately autocatalytic nature of what man will do in space (and they forget the multiplicative and nonlinear relationships between many of these things), they unfortunately bare their ignorance and poverty of imagination, they readily assume antagonistic relationships, they view without emotion what will be fueled by emotion, they do not consider possible accelerants of space enterprise nor do they consider the importance of human values, they fail to read--much less analyze and consider--the pages which are before them (whereas the nature of the book specifically requires continuous, considerable, and determined reading of entries, chapters, and the whole; even rereading), they react to the ideas for their very newness and strangeness, they react to the ideas for their intrinsic and ineliminable difficulties, they infuriate themselves as they proceed as if the writer were some sort of ogre, they extrapolate (in the writer's opinion) a naive view of nature, they fail to combine the mutually critical parts of the book, they presuppose no remedies will be supplied at a later date by the industrious author, they caricature him as a fool, they content themselves with superficial appearances and with what they see as symptoms, they do not repair nor consider the larger significance of what they later discover to be their mistakes, &rc. They do much else besides. The dates used in the early projection found in the early manuscript assume that man pursues space with the same vigor and natural development as characterized the 12 years from Sputnik in 1957 to Apollo 11 in 1969; all slower chronologies, although perhaps more likely to fit what will actually transpire, are seen as exercises in triviality since governed by considerations extrinsic to realistic science and technology. It is certain that many readers are frightened off by deceptive magnitudes of suggested events and by failing to stare these in the face, entertain certain consequences of progress, perceive the possible simplicity and warrants for such events, and appreciate the changes of magnitude that have already marked human history.

7. When the book is finished it will include detailed descriptions of 8 quarter centuries from 1976 to 2175. So far about 2 quarters exist as first drafts. A more complete and self-justifying picture, or story of what may come, will therefore exist later. Many readers probably make the mistake of referring all events described in the neighborhood of an initial date to that date or to the contextual quarter. Actually the initial dates and events are intended to stand for the first probable incidence of anything at all like the topical event, however rudimentary or inanalogous, and the subsequent very extensive and intricate discussion of events and dates is intended to exhaust related possibilities, voyage to future ages, include things both probable and merely possible, hint the developments subsequent to and continuing the initial event, &c. Some of the initial events are considered improbable, and generally so characterized, and a few are only cited to be argued against and eliminated. Moreover, much is present in the manuscript by the exercise of an abnormal tolerance which I have always considered appropriate when considering the larger possibilities of the world and the ideas of others; it is difficult for any critic to be absolutely certain, and often only 50% certain (so that the introduction of additional possibilities should produce equipartition of the pie). I have repeatedly found, as I have written this book, that ideas which initially struck me as absurd, pointless, &c have revealed themselves to consist, upon further analysis, of unquestionable and irreducible bases, warrants, and warrants by analogy; the future seems both very flexible and large, and little apt to resemble the things in its past.
8. Distant and presumptuous critics of this book's form and content should be prepared to listen to the author's extrabiblical defenses and to challenge him specifically upon the points of their disagreement. The author enthusiastically invites good criticism and a battle of wits as a healthy substitute for critical presumptions and self-regard.
9. Since the manuscript is basically paginated in the order in which it has been written, the unknowing reader is apt to find an incidence of error at the start which is unrepresentative of the book as a whole and its final form and conclusions. Many of these initial errors are simply monstrous since the author began the book as an utter ignoramus on space and has proceeded to educat himself en route. Why pay attention to ignoramuses and neophytes? One reason is to gain an insight into one's personal ignorance. Another is that, the author has found, the amount of thought and imagination that has so far been given to the future of space, at least as disclosed in print, would seem, somewhat surprisingly, minute. For this reason I have had to pioneer my own ideas for the most part and to dismiss from annoying consideration the extant literature, which seems so impoverished.
10. A particular offense is taken from the fact that the canvas of events considered is so lavish. It is supposed this indicates ungoverned fantasy, a defective system for classification, rank gullibility, zero critical ability, no scientific background, a descent into triviality, or pathological mania. I reply that the future herself, however impossible to anticipate in specific detail, will be fantastically lavish and complete. The complexity and variety of the present world, which was the future of the past, is so familiar that it goes unappreciated, even unseen. Changes in things as they are now will be so great and fundamental that the future might seem to us improbably novel despite a predominant resemblance to the world as it is now; these changes need not even be basically progressive, the very kaleidoscopic flux of the world would produce jamais vu, things incomprehensible, things spectacular, things seemingly representative of major progress and evolution. A particular, and it seems to me more just, objection is to the concurrence, density, and mutual timing of events entered on my calendars. Readers argue, I think rightly,

that events will interfere with one another, substitute for one another, preclude one another, and enjoy some more natural order and espacement. To which I reply that your writer, too, is finite and imperfect, that adjustments can (perhaps more properly) be made in the mind of the reader (or reviewer), that interferential effects (especially over the longer river of ever-branching and ever-multiplying time) are too infinite in character and alternatives to have their description tolerated by an already anxious readership, that my real aim is to characterize things as they may as well happen (or to limit myself to those things that will probably happen and allow some allusion in the present), that the density of events has always been very high (particularly in various senses) and will be far higher in the future and over time, that events trigger events and a thick calendar is therefore only realistic, that at points in the future tremendous chance and semichance bunching of events (or event descriptions) will occur, that many events can overlap without interfering with one another, that much redundancy and seemingly unnecessary development of mutually substitutable things can and does occur (and perfectly rightly), that research and development of competing technical possibilities (and their experimental trial or even prototypal use) need not mean that in the long run the things will coexist possessed of equal stature (and certain special uses for things, like ecological microniches, are always possible and in fact the rule), that my thick and cacophonous calendar of events admits of a later and in fact designed and necessary trimming (as well as a wise pruning for the sake of fresh regrowth and for the sake of correcting regular, as well as irregular, peloria for which I am culpable), that the events' restudy is as apt to multiply as to subtract from the number, variety, and density of events, that (as we already know) exponential progress and change can seem unreal and interweave events in confusable ways, that many events partake of one another, that a proliferation of parties playing roles in the future of space is to be expected and underlies my calendar of happenings, that progress (increase of wealth throughout the world and of per capita wealth, enlarged population, increase of literacy and education, recomposition of employment, enlarged cooperative human endeavor, greater pursuit of science, quantitative and qualitative greatening of science and technology by numerous orders of magnitude, revolutionary discoveries, various nonlinear changes in society, &c) will occur enormously and found the mountainous calendar I suggest, that the future will be in nature a very big place, that clustering of events is organic to history (although no one knows why), and that the reader is basically being hysterical. Besides, so many interacting events are fun; why should the reader complain? I am convinced that certain readers have complained because they have been under stress, and that this renders such complaints unrespectable.

11. Some readers object to my supernormal and arbitrary numerical ranges, say ranges of exponents. When this is done it may mean: I am stating my or our ignorance, I am stating what is possible or probable, I am alluding to an interesting set of values or possibilities or perhaps to a continuum of events, I am challenging the reader, I am being tentative, I am being illustrative or suggestive, I am preceding a closer scrutiny by a loose statement, I am making that tough but intelligent and often necessary decision of choosing originally arbitrary but subsequently exploitable and developable footholds amid excessive &r continuous possibilities (thereby distinguishing black from white instead of floundering in countless finer and perhaps irrelevant distinctions), I am referring to an open and perhaps exponential future, &rc. Readers might take these things into consideration. To the objection that such ranges of events and arbitrary selections of dates are pretentious

since incalculable or unknowable, or nonscientific, I reply that the human mind is a wonderful thing whose resources and limits have yet gone unmeasured and whose ways of operating are basically unknown; man therefore possesses intuition and miraculous powers of estimation, generalization, imagination, and penetration which only a fool--and fools are plentiful--would deny.

12. The density and oddity of my style are the source of numerous objections to which my only replies are that it is so that I do and would think, feel, and write, that my nature (as my soul) are things I shall not alter, that great density can be a lesson to the mind, that a concentration of stimuli can be a torch to the imagination and impel one toward reality, that dense textures can be things of great beauty and delicacy (as fine and regular on their scale as things on our own), that the myriad associations inspired by the texture of densities can function on a high level of contextural analogy to adumbrate--as nothing else--features of things to come and the aesthetic joys of such things, that something of the oddity of my style must derive from its daedal purpose and nature, that a too accurate and fresh description of things can seem odd (for things are odd), that poetry is also dense but by no means defective for it, that a kind of useful discipline is required of the reader who would read my book, that an example is made by the fact that law is fascinating and powerful (not intrinsically repugnant) for its intricacy and deviation from ordinary English, that by certain simple and instantaneous acts of generous mental resolve the surface complexities and abnormalities of my style may be vanquished and be replaced by cotentive enjoyment of a worthy unsuspected netherworld (my laborious fabric), that much trouble ensues when alternative possibilities are omitted and where the world is treated crudely, that the reader should focus on ideas and derive from this perception and cognition the pleasures he misses or seeks (since I have principally devoted myself in this book to the reproduction of fact and the production of ideas, and otherwise consider myself incompetent), that there are many things which do not yield up their treasures to a glance but only after prolonged and essentially static labor upon their natural facets and subtle nuances (and I consider my work an example), that by such general, rough, various, novel, crude, indirect, connotative, and loose treatment--by confining myself to certain things--I have achieved in my book important suggestions of the future which could never have been accomplished had I limited myself to more customary and simpler means, &c.
13. Argumentations and ideas are presupposed by much of the text that do, or will, appear elsewhere in the book in explicit and pure treatments.
14. All strange and coined words will be defined and justified in a larger glossary to be included in the final book but only naturally omitted during its first composition. Certain coinages will be removed.
15. Slower, less ideal, adverse, alternative, and peculiar futures or scenarios will be presented and considered in the later book.
16. The book will be edited and may be completely rewritten; 2 books may appear.
17. Many readers fault and even condemn this book because of its avoidance or shabbiness of mathematical, physical, engineering, &r other scientific or technical detail, substantiation, argumentation, &rc. Partly this is due to the limitations of current knowledge and partly it is due to my shortcomings as an author since in innumerable cases I do not know how to demonstrate, develop, and criticize matters, do not know what we know, feel myself to have walked on weak ground, and have no reportial command. I only wish it were otherwise! My curiosity about facts and details is immense, and who enjoys looking a fool? My excuse for nevertheless doing what I have done is that these things are matters of degree, someone has to be the first fool, my book can function as a preliminary outline and a device serving further investigation, and possibilities should be surveyed, arranged, compared, integrated, and winnowed, processes begun and hopefully to be facilitated by my book.

THE PROBABLE DISTRIBUTION OF POPULATION IN SPACE IN 2050

	Locus.	Number of men.	Percentage of Spacials.
CISLUNAR 2,350,000	Geosatellosphere.	1,500,000	50%
	Terrilunar L1-5.	400,000	12%
	Epilunar loci.	400,000	12%
	Lunisatellosphere.	50,000	1.5%
TRANSLUNAR 571,100	Mars.	300,000	9.0%
	Asteroids.	200,000	6.0%
	Jupiter.	50,000	1.5%
	Venus.	10,000	0.3%
	Saturn.	5,000	0.15%
	Mercury.	4,000	0.12%
	Uranus.	1,000	0.03%
	Neptune.	600	0.018%
	Pluto.	500	0.015%
	+ Space.	3,000,000	100%
	+ Earth.	13,000,000,000	4000 X Space.
	Homo sapiens.	13,000,000,000	

Remarks.

The preceding distribution of men throughout the Solar System 75 years hence in 2050 represents my intuitive estimation of what will actually be the case at that time. Many considerations come to mind able to alter the relative and absolute distribution in marginal and drastic ways. For example, populations at other planets might be far more clustered and unequally distributed than I have suggested above. Only token populations, representing little bases, might exist at the outer planets. Lagrangian colonies might represent so little advantage over epiplanetary and periplanetary loci that but 1% as many men might be gathered at these loci as I explicitly and implicitly suggest. Epiplanetary loci might so dominate colonization that satellospheres and Lagrangian points will support but a tiny fraction of Spacial population. Countless possibilities come to mind and defy perfect allocation. The actual distribution in 2025, 2075, and so forth might differ radically from that in 2050, perhaps as the result of rapidly fluctuating and conflicting influences.

The distribution I have provided for 2050, in the face of these things, simply represents a "surprise-free projection" in that its realization at that time would not at all surprise me and would surprise me far less than many other distributions, including those with which most people would probably be far happier or which exist subconsciously in most people's minds.

GLOSSARY OF SPECIAL TERMS USED IN THIS BOOK

PLANETARY. A planet or smaller but analogous celestial body such as a moon or an asteroid; the term is thus useful in being more general than "planet".

TELESCOPY. Use of telescopes, techniques therein, &r the telescopes themselves.

TRANSPLUTONIAN. More distant from the Sun than the orbit of the planet Pluto.

GRAND IGLOOS. Future epiplanetary or extraplanetary constructions making use of ices, waters, and analogous substances present in abundance and sometimes conveniently at loci in the Solar System, with the common property of having low melting points and sufficiently higher boiling points as to be used in construction when at liquid temperatures (perhaps in the vicinity of room temperatures) and to solidify as the desired materials and structures a short time later or naturally owing to the cryogenic conditions found in Space; some whole moons, for example, may be largely ice; the point is that these ices will be easily used and yet combine properties such as glass-like transparency with exploitable crystallinity, &c. Massive water will only naturally be in transport across the Solar System in times to come so the marriage is one of very great convenience.

GLACIOTECHNOLOGY. The science, technology, and engineering which will arise in the future for construction purposes (such as the building of "grand igloos", titanic mirrors or lenses of ice, &c) and other industrial purposes (such as applications of cryogenic ice in electronic and photonic circuitry) using the immense quantities of icy materials which must surely exist throughout the Solar System.

SPACE HYDROLOGICAL AUTHORITY (SHA). A hypothetical intranational, international, supranational, or independent authority an equivalent of which will probably arise in the 21st century in Space and play an important role in the investigation, discovery, promotion, coordination, overseeing, mapping, quantitation, regulation, apportionment, conservation, development of technology and engineering appropriate to, development, provision, &r perhaps directly in the use of the myriad, finite, idiosyncratic, obscure, variously recoverable, &c water resources of the total Solar System of such importance to co-emergent Solian Civilization during its early years and later.

SUPERMANEUVERABILITY. This will refer to highly or totally maneuverable orbital &r nonorbital probes, stations, and craft possessed of, eventually fairly extraordinary, powers. Such powers may and will include the ability to change to any latitude, longitude, altitude, velocity (including 0), orbit (eg synchronous orbit), &c, to do so reversibly (including takeoff and landing), to do so 1-100 times or eternally, to assume any eccentricity of orbit, amphibious or omniphibious abilities, powers to execute complicated maneuvers, to return to Earth (eg for refueling, removal of film or tapes, sample, crew, &c, repair, reequipping, or redesign), for any or <u>all</u> of the planetaries or beyond the Solar System, &c. Thus economies will be realized over many and diverse serial and parallel devices.

AMPHIBIOUS and OMNIPHIBIOUS. Amphibious means that a spaceship will combine capabilities for operating and passing between 2 quite distinct media, such as the surface of a planet and space, possibly in either or both directions. Omniphibious refers to greater versatility still such as seems called for in order for there to be craft which will be able to pass from space into ocean &r atmosphere, perhaps in any order, and freely. Customary transportational systems that will arise for Space eventually may, of course, achieve greatest systemic efficiency by seperating and linking operational and vehicular stages in multistepped and polylocal transport, rather by unification of operations, vehicles, and systems; so far in Space, Americans have tended toward multistepping and the Russians toward unification, and it is hard to predict any denouement of this competition of practises.

VERY-MOONED PLANETS. Those planets--the jovians, except Neptune--possessing more than 2, in fact more than 4, moons (Jupiter $\geq$13, Saturn $\geq$10, Uranus $\geq$5).

SPACEBOUND. Restricted to Space, either figuratively or literally; or those so restricted. Some spaceships will be of such size or kind that they will perforce be restricted to interplanetary Space. It may happen that men too long in, or native to, Space--or agravitational or microgravitational loci--will find it difficult, uncomfortable, or physiologically impossible to live in, or even visit, higher gravities; thus it may happen that natural Selenians may be estranged from the Earth. It may happen that, perhaps because of lasting transportational costs, the resources found on other planets will have to stay on those planets or be used in Space; conversely, Earth's many resources may prove earthbound for similar or even greater reasons of insuperable gravitational barriers.

REFUELER SHIPS. Economical throwaway or cyclic unmanned or manned spaceships that will once or endlessly refuel (and perhaps, perhaps progressively, resupply, repair, alter, check, &rc) extraplanetary &r periplanetary spaceships &r spacestations, presumably evolving by 2000.

ANDROIDS. Robots to some degree designed in the "image" of man.

PLANETOGRAPHY. The descriptive phase of planetology; or a particular rendering of a planet, especially its external physiography; or the methods or devices used in planetography; or the doing of planetography itself. Either specific to a particular planetary or that known for, or those challenges presented by, many or all planetaries.

PLANETOLOGY. All the natural scientific aspects of one, some, or all planetaries in the sense of what is there, what is known, &r what should be known about their dynamics, statics, morphologies, histories, futures, etiologies, elements chemistries, physics, biologies, meteorologies, climatologies, oceanographies, extraplanetary influences, resources, human challenges, phenomena, similarities and dissimilarities, classification, &rc; clearly planetology is divisible into descriptive, theoretical, and other phases; or the equivalent "geology" of such planetaries in the sense of the science of solidospheric phenomena.

-FUGAL. A suffix universally attachable to local bases (soli- for the Sun, terri- or geo- for the Earth, luni- for the Moon, &c) to indicate flight, flow, or motion from the locus toward extralocal Space, and therefore covering ascent from particular bodies.

-PETAL. A suffix, converse of the preceding, denoting flight, flow, motion, or descent toward the body indicated by the affixed base, an example being "solipetal" which means involving motion toward the Sun. The utility of these 2 suffixes, and the absence of specific and general synonyms, is plain.

COSMOGRAPHY. Description of the universe as a whole, any of its systems, &r any of its arbitrary parts; either the process of making any or all such description, a particular description, possible or extant description, &r the methods and techniques of making such description. That referred to might be the cosmos, our galaxy, our Solar System, or one particular planetary such as Earth. Such description can embrace many things, including morphography, rheography, historiography, chemistry, physics, plutography, biology, typology, &r innumerable other things, however depicted. All descriptions of the universe must ultimately wed in a consummate cosmography. The "Myrioramic Principle" clearly has extraordinary consequences, to the extent it is valid, for any cosmography, either as undertaking or achievement.

SELENOLOGY. The collective sciences of the Moon.

GEOLOGY. The collective sciences of the Earth.

HELIOLOGY. The collective sciences of the Sun.

SOLIOLOGY. The collective sciences of the Solar System.

ASTROLOGY. The collective sciences of all or any stars.

AREOLOGY. The collective sciences of Mars.

JOVIOLOGY. The collective sciences of Jupiter.

VENEROLOGY. The collective sciences of Venus.

MERCUROLOGY. The collective sciences of Mercury.

TRANSMARTIAN. Of or relating to that beyond Mars or his orbit.

TELEMETRIC MICROSTATIONS. Little interplanetary, periplanetary, epiplanetary, diasolian, perisolar, atmospheric, oceanic, &c observatories, teleoperators, robots, experimental robots, wandering machines, relays, surveyors, pictomappers, chronocosmoramic eyes, extrasolian probes, &rc set or dispatched in Space in order to continuously, periodically, occasionally, or at command transmit some, all, or particular data to remote recipients, to pursue missions, to constitute Spacial networks, to assist other operations, to simplify undertakings, to facilitate interspacial power transmission &r telecommunication, to multiply sensors &r effectors, to accelerate and enlarge Spacial exploration, to proportionate means to tiny &r highly specific tasks, to scatter samplings, to increase the density of certain Spacial networks, to scout in advance of greater expeditions, to stay behind after their departure, to reduce mission costs, &rc. Tremendous, progressive miniaturization of sensors, computers, operators, experiments, vehicles, power sources, engines, memories, laboratories (diverse instruments), &r even certain payloads should be possible and occur over the future, miniaturization so exquisite and so many orders of magnitude beyond present degrees and past progress as to seem to us miraculous and impossible. So much information and mechanical versatility seems ultimately possible in a 1-centimeter, 1-gram, and 10^{24}-atom cube of matter--whatever its shape and form--that is hard to think of things not precisely or equivalently achievable simultaneously in an ultimate cube of such insignificant dimensions as a teleological condensate or quintessence. This is not only because of the micromanipulative, microscopical, ultrasensitive, microcosmical (otherworldly), elegant, &c powers possible for such micromachines, nor their computational capabilities (eg 10^{24}-bit memory, 10^{-10}-10^{-18}sec operations, &r arbitrarily great intelligence). Cellular automata and general ontological micromachines could and probably will eventually--even before 2050--acquire theurgic infinite and superinfinite powers to fulfill assignments to an infinite degree, reform the universe, create a universe, maximize natural evolution, destroy the universe, &c, or perform any intermediate thing within the finite or infinite realms of possibility (such supreme devices might be called "omnipotent atoms"). That a 1-gram or 10^{24}-atom virtually omnipotent micromachine, microrobot, microstation, &rc is possible argues that extraordinarily and perhaps similarly effective miniaturizations might be possible of far greater parvitude, say having 10^{-1}-10^{-16}gram masses and competing with bacteria, at least for certain environments or tasks and per the progress of both science and technology. We are discussing devices 10^{7-22} X less massive than payload probes used today as the limit of our technology and to some extent of our microtechnology. As a consequence, ultraminiaturized devices evolvable 50-100 years hence can miniaturize total operational costs, or else expand operational powers, more or less proportionately and fantastically (the view of nature which unsuspectedly prevails among men today would have difficulty assigning any tasks or value to specific and general Spacial operations 1-22 orders of magnitude vaster or even faster than current operations and programs; the alternative view of nature propounded in this book would have no problem making the most fantastic use of such magnifications and in reaping disproportionately greater benefits). Single spaceships launched from Earth could piggy-back millions or septillions of microships, microrobots, microminds, microbeings, microobservatories, &rc (perhaps mass-produced) into parts of Space and sow them through orbits or landscapes to do good deeds or to be themselves, all at a cost hypothetically commensurate with present individual undertakings, or at a fraction thereof. Interesting problems might arise in recovering such granular slaves, but we could rely on a statistical process and afford to lose most of them

THROWAWAY vs CYCLIC. The first term refers to such parts or wholes of spaceships or other objects as we might profitably throw away rather than burdening ourselves with the necessity of their transportation to destination or their return at nonlinear cost. "Cyclic", in contradistinction, refers to an act or practise of returning such things ½, 1, or many times. Economies both ways can be argued and matters have yet to be decided. For example, an SSTO (Single Stage to TakeOff) vehicle might or might not be most economical &r convenient for Earth-into-Space flight. Relative economies may prove variable according to different situations &r uses.

PIGGY-BACKING. The carrying of many spacecraft &r spacestations by single, capacious spaceships in order to effect total flight and operational economies, the contained or attached "piglets" being dispatched in various clusters and orders at 1 or more "dispatch loci". Put otherwise, large craft will piggy-back many craft, devices, materiels, and personnels to sets or systems of planets, stations or loci, dispatching &r retrieving seriatim (eg satellites, telemetric microstations, many simultaneous satellites &r landers--such as subsatellites--for the same planet or space, &c).

SUBSATELLITE. Today this term is used by the space community to refer to a probe and a set of probes carried by a spaceship to another planet and released upon arrival to effect seperate landings, assume different buoyant positions in the atmosphere, &r assume various orbits.

SATELLOID. A satellite able to maintain itself in an orbit so low as to ordinarily be unstable or impossible, compensating atmospheric resistance by continuous or periodic propulsion, thereby filling the very large gap between ordinary astronautical and aeronautical flight and actually allowing very low orbits with little expenditure of energy per instant or per eternity. Unlike ground-based aircraft, such a satelloid might actually return to Space and be space-based. It is interesting to consider what tasks might be fulfilled by future satelloids operating in the atmosphere of Earth and other planets. Such low-propulsional satelloids might maintain themselves in perpetual orbit, if not by intervehicular refueling, by "solelectric" drives, exomotive ablation or conversion using continuous or periodic ground-based or space-based lasers, "aerofuel" fusion, &rc. Clearly the configuration of satelloids would be appropriately aerodynamic.

SOLELECTRIC. Of or relating to power or propulsion converting captured sunlight into electrical energy.

AEROFUEL. Of or relating to fuel taken from the surrounding atmosphere by aeronautical &r astronautical ramjets, satelloids, or atmosphere-skimming craft; such fuel itself.

HOLOVISION. Holographic television. Between 1975-2000 various methods will be developed and implemented by networks for stereoscopic (binocular), holographic, and "ultraholographic" television and videophony. Difficult problems will be presented by the need to replace preexistent networks, but not insuperable ones owing to the simplicity of possible converters using identical receptions. By ultraholographic television is meant the large number of improvements over simple holovision which are foreseeable, including cycloramic holovision and of such kind--what might be called "spherovision"--that viewing angle will alter so rapidly with movement of the head that scenes viewed will readily be rotated through 360° by active observers. Indeed, viewers might be equipped with sufficient powers that scenes will be fixed unless a viewer chooses to move around by rotating, selecting or altering the distance of parts of, altering the perspective of, &rc a scene, &r to otherwise alter and select what he senses. All these things will probably presuppose much greater instantaneous transmission of information, regardless of the routes taken by such information or the distant location of various telecommunicators. Telecommunication via geosatellitic relays should grow accordingly, by many orders of magnitude, as such sophisticated and heavy-informational systems are implemented.

HETEROSTELLAR. Of other stars or stars other than the Sun.
HETEROPLANETARY. Of other planetaries, eg other than the Earth.
TERRAN. Terrestrial, or of or relating to the Earth. Substituted for the first word because "terrestrial" also refers to land, eg as distinct from ocean. Earthling.
SATELLOSPHERE. A region of potential or actual, or natural or artificial, satellites surrounding any planetary and bounded within by the atmosphere (or the lowest ranges of satelloids) and externally by the equigravisphere or by the apasides of any satellite. Prefixable by references to specific central bodies, eg the satellosphere of the Earth is denoted the geosatellosphere.
GEOSATELLOSPHERE. Earth's satellosphere. May be capitalized.
SOLIAN. Of or relating to the (our) Solar System and that contained by the heliopause or bounded by the systems of neighboring stars; of or relating to Solian civilization, that culture which exists and will grow within the Solar System, its various planetaries, vacua, and star. This term is proposed because of the double meaning of "solar", which refers also to the Sun as distinct from the bodies and vacua which surround it.
SOLAR. Of or relating to the Sun, our star.
EXTRASOLIAN. Of or relating to that beyond our Solar System, either as limited by the heliopause or by the orbit of Pluto; of or relating to cultures, beings, civilizations, messages, transportations, &rc beyond present or future Solian Civilization.
SOLITERRAN = HELIOTERRAN. Of or relating to the Sun and Earth together. This might be used to refer to the Lagrangian points between these 2 bodies, to transportation between the Earth and the Sun, to the discoidal or spheroidal region limited externally by the orbit of Earth, to power transmission from perisolar stations to the region of the Earth &r its Moon, &rc.
TELODYNAMIC. Involving or related to the distant transmission of power, whether through cables, baser beams, Teslaic systems, hylodynamic beams, &rc.
CISLUNAR. Of or relating to Earth, Moon, and the interspace as a whole, to the interspace plus the nearsides of the two planetaries, or to just the interspace, say about the imaginary line joining the 2 bodies.
TRANSLUNAR. Of or relating to Space beyond the Moon or the Earth-Moon system (cislunar Space).
CATOPTRICS. Mirror optics, or the science, technology, devices, &rc; in particular, hard or soft mirrors of titanic or astronomic size which may be built to harness the energy of sunlight by flat or concave reflection in order to produce power, simulate sunlight or moonlight, control the weather, produce industrial heat, ablationally propel planetaries, signal between stars, propel spaceships, &rc.
SPACIOLOGY. The spacial sciences and technologies, including planetology, planetography, Solar astronomy, the engineering of spaceships and spacestations, the engineering of Spacial colonies, planeturgy, spacial logistics, any past and future history of Space, exobiology, the sciences of the larger universe, spacial administration, the applied mathematics of space, &rc.
INTERTERRAN. Of, relating to, or involving 2 or more points on the Earth, eg the intercommunication of points on Earth or the transmission of energy between them but relayed through Space, &c.
COSMOPLASTIC. Of or involving that able to shape, or in fact shaping, a world or the universe. This refers, in particular, to planeturgy and also to so-called infinite cellular automata possessing the ability to engineer or reform the whole universe. The main idea is in terms of shaping what is present in some form already.
COSMOPOIETIC. Of or involving that able to create, or in fact creating, a world or the universe. Again this has particular reference to both planeturgy and infinite cellular automata. In contradistinction to "cosmoplastic", the main idea here is in terms of shaping or creating things ab initio or ex nihilo.

ENERGIC. Of or related to energy.

VACUAL. Of or involving those interspaces outside the atmospheres of planets and stars in which there is partial vacuum, tenuous plasmas, phenomena only little visible (to ordinary instrumentation), transparency to distant emitters, &c but what for most purposes seems a total void. Outside all the planets of our Solar System but within the supposed boundary of the Solar System, called the heliopause, there is a weak but complex, dynamic, and important atmosphere which has been dubbed the rest of the heliosphere or the heliosphere, period. Similarly the Milky Way galaxy is enclosed in an even more tenuous--but still perfectly important, complex, dynamic, &c--atmosphere. Intergalactic Space is an atmosphere rarer still, extraordinarily important, but almost completely unknown and undescribed. All these interspaces are examples of particular vacua. The vacua are not homogeneous but rather contain all sorts of gradients, neighborhoods, intermediate zones, &c. In the absence of a common term I use the singular, vacuum, and the plural, vacua. Capitalization of both could be justified.

TERRILUNAR = GEOSELENIAN. Of the Earth and the Moon together. This term might be used to refer to an intertransportational system, cislunar Space, Lagrangian colonies, &rc.

PLUTOGRAPHY. A description of, or the process of describing itself, the qualitative &r quantitative resources (mineral, energic, environmental, &rc) of, or their distribution on or within, celestial bodies such as the planets or Sun, &r the intermediate regions or so-called "vacua". A term of such generality seems required by the absence of any synonym and the needs of description and reference. There are obviously any number of ways of characterizing "wealth". One might, for example, do it in the absolute by describing the distribution of any or particular minerals, elements, chemicals, &c in &r out of lodes, or rich deposits, so that one's description is, in effect, timeless and ungoverned by any momentary priorities or even other considerations; per contra, one might characterize the distribution, kind, quantity, &rc of resources supposed or known to exist in a region in more or less familiar or contemporary terms of specific needs of the economy now or in the future, of real profitability or exploitability of a given resource (say in terms of relative accessibility or treatments presupposed for extraction), of the specific needs of regions of Space or opportunities related to foreseeable development of enterprise &r civilization in Space, of intraspacial needs, of possibilities for in situ manufacturing and exportation of intensely valuable product, &rc.

TELEPLUTOGRAPHY. The process, or its product (say map), of describing the wealth of celestial bodies or regions from afar, particularly from loci above their hard or liquid surfaces or outside their atmospheres, say by scanning or pictomapping satellites or by interplanetary active or passive telescopy, say by ground-based observatories on Earth. Anything which may contribute to an idea or picture of wealth or resources--spectrum of surficial radioactivity, geometric 2- or 3-dimensional morphography, ground truth investigations, gravimetry, magnetography, planetological theory, guesswork, comparative planetography, &rc--is a potential contributor to plutography, and everything done from extraplanetary loci is, by definition, teleplutography.

TELEMINERALOGY. Mineralogical teleplutography.

MICROLABORATORY. A set of instruments operated by a robot or remote control and used in Space to describe or monitor artificial or natural situations, say aspects of the natural environment on planetaries. The information obtained being telecommunicated to a distant station, or stored for recovery at a later date or per a particular need. Such a probe might perform experiments of any degree of complexity. The main idea is that such microlaboratories will be highly multipurposive, or pursue many different investigations. There will evolve over the long run probes of endlessly greater complexity, sophistication,

SUBSPACIAL. Of or relating to that region below Space associated with a celestial body, especially the Earth, say a suborbital trajectory of a projectile.

INTERLOCAL. Between explicit or implicit places or loci in Space or anywhere, or with regard to this relationship. One could refer, for example, to interlocal flight of a spaceship between Mars (one locus) and Earth (the other). The term is a very useful generalization without a synonym.

MEGENNIUM, GIGENNIUM, &c. These are units of years specified by a known prefix in the manner of "millennium". A megennium is a period of 1000 millennia or of a million years, a gigennium is a period of a billion years (what geology refers to as an eon), and so forth. These give rise to such natural derivatives as megennia, megennial, &c. In the absence of equivalent or familiar units, such words are very useful and should be put into universal use.

NONTERRAN. Of or relating to that other than, unlike, off, apart from, &rc the Earth or Terran things. For example, one might refer to nonterran loci, people, conditions, economies, needs, biologies, resources, affairs, &rc.

TERROID. Of or relating that having more or less the form or model of the Earth, particularly in contradistinction to things jovoid. The 2 terms may be used with reference to climate, atmospheric composition, planetary composition or history, life, planetary size or structure, &rc.

JOVOID. Of or relating to that having more or less of the character--as above--of the jovian planets (Jupiter, Saturn, Uranus, and Neptune) as opposed to those planets comparable to Earth (Earth itself, Mars, Mercury, Venus, &c). These 2 terms--jovoid and terroid--are proposed out of the necessity for avoiding confusion with specific references to the Earth, Jupiter, and the jovian planets, and to limit the degree of analogy.

INTRACOLONIAL. Of or relating to that included within the walls or boundaries of a Spacial colony, or to the internal affairs of such a colony, whether epiplanetary or extraplanetary.

COLONIAL. Of or relating to a Spacial colony.

COLONY. A community of men in Space in extraplanetary Space or on another world, &r the structure or structures (and other supplies, devices, &c) supporting a community &r the region occupied (continuously or discontinuously) or possessed, managed, used, &rc by a community. Such a community may be autonomous or heteronomous, of any size, variously self-sufficient, &c. The word "colony" connotes a community, population, &r structure larger, more serious, more permanent, more diverse, &rc than a base, and yet smaller, earlier, less permanent, less important, &rc than a city, and a fortiori a "planetary civilization".

PLANETARY CIVILIZATION. A civilization--population, culture, industry, ecology, history, government, landscape, &rc--literally or figuratively covering a planetary, perhaps having developed out of bases, colonies, &r cities as a result of immigration &r native birth. Planetaries--because of area, environment, resources, location, use, &rc--may differ in the sizes of population they support.

PROSOLUNAR. Of or relating to the nearside or earthward side of the Moon, being the antonym of rerelunar.

PHOTOPONICS. The growing of plants, or other stationary biological systems, in a medium permeated with a luminous (quasi-insolative) matrix so as to benefit the cultures by the effects of superabundant quasi-natural light, at least hypothetically; an assumption of such a proposal might be that organisms are so opaque that they generally fail to benefit from light having to penetrate far into their depths, and yet that this superficial high-energy illumination may be critical for general photosynthetic processes and productivity levels of light-dependent organisms. Such internal illumination could be the basis for tridimensional or compact bioculture (or "stereoculture").

PLANETOSPHERE. All the spheres--solid, liquid, gaseous, plasmic, electromagnetic, gravitational, and any other--that contain and define a given planetary; thus a planetary in its entirety, or a planetary at its extreme.

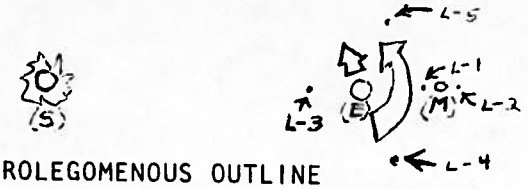
THINGS TO BE DONE IN SPACE

1. Mine.
2. Map its morphology and mineralogy.
3. Explore to discover such novelties as exploration on Earth once discovered.
4. Understand all its meteorology, geology, biology, astronomy, and history.
5. Colonize.
6. Render industry there profitable.
7. Find other life.
8. Explore and understand everything beyond the solar system.
9. Supply Earth with power.
10. Set up an independent and self-sufficient civilization.
11. Explore and monitor Earth.
12. Improve communication.
13. Have a good time.
14. Create touristry.
15. Manufacture.
16. Do industrial research.
17. Perform experiments.
18. Insure our survival by establishing men in space.

OTHER THINGS

19. Move industry off Earth.
20. Dispose of wastes.
21. Understand Earth by understanding other planets.
22. Lay the basis for future space development.
23. Find extraterrestrial intelligence.
24. Advance basic physics by investigating exotic natural phenomena.
25. Expand our military umbrella.
26. Alter or control Earth's climate.
27. Feed Earth.
28. Pursue a higher destiny.

These are roughly the only things which we can do, and which are to be done, in space --speaking ad ignorantiam! How do they compare when variously ranked in terms of priority, importance, likelihood, feasibility, presupposition, difficulty, complexity, interrelation, alternative programs, appeal, what is known, inevitability, desirability categories, &rc? All these questions are critical! What things are critical to each of the events or categories of events? What important things does such a list, qua list, miss? What has our effort in space accomplished so far in terms of each of the 28 items?



SPACE COLONIZATION: PROLEGOMENOUS OUTLINE

1. Possible loci: terrilunar L4 and L5 (Trojan points), L2 (antigeal, 35,000 mi ~~above~~ (beyond) Moon) and L1 (subgeal, 36,000 mi above (nearer than) Moon) (satellites placed at L1/2 are called "halo"), and L3 (subsolar); helioterran L1-5, the same 5 foci for all other planets and moons; equatorial, polar, rerelunar, and other points on the Moon; heliocentric both within and outside of planetary orbits; cometary and meteoroidal; asteroids in and outside of the main Belt; the atmospheres, surfaces, seas, and interiors of terroid, jovoid, or other planets and moons; perisolar; transplutonian; extra-ecliptic; mobile; interstellar; planetocentric (nearest, farthest, &c).
2. Reasons, effects, requirements, uncertainties, stages, interrelations, orientations, differences, &c pertinent to all loci.
3. Optimal, probable, possible, maximal, minimal, complex, &c rates of building all colonies at all loci, and the proper ranges of such rates.
4. Present, future, and possible circumstances on Earth conducing to building or not building any and all colonies.
5. Effects of building the first colony and possible autocatalyses behind colonization.
6. Volume, mass, design, energy, population, quality, self-reproductive rates, and all other spectra for all such colonies, including any limited set of spectra that might characterize the first colony.
7. Causes, needs, opportunities, effects, characteristics, &c in connexion with such colonies.
8. Criticisms of such colonies: engineering, science, technology, cost, profit, dangers, living standards, advantages or equalities to life on Earth or comparable colonies on Earth, fallacies of supposed raisons d'etre, uncertainties in and assumptions of estimates in connexion with such colonies, special inadequacy of proposals to date, liability to disaster or stupendous errors of calculation, competitive profitability of other enterprises on Earth, extendibility of resources on Earth (minerals, power, lebensraum, quality habitats, reattendable environments, addable industries, capacity for vaster population, unused lands, developable frontiers, greater beneficiality of developing Terran resources, &c), escapism, fantasy, sheer improbability, rate of construction, magnitude of associated problems, needs for vast prior thought and research, narrow appeal to Terrans, no real economic role, novelty and quality alike ephemeral, Terran problems will be repeated, vast and paradisal Earth cannot be imported to or re-created in the colonies, benefits of colonies too distant, good life in colonies too remote and subsequent, &c.
9. Costs: first colony, parts, progressive successors, developmental, annual, diachronic (final), curve of returns, point of net profitability annually or with all debts paid, competitiveness with any comparable or alternative Terran enterprise, differential marketability, divergent scenarios, intentional staging, self-reproducibility and self-evolvability of colonies (a la O'Neill), in terms of any or all industries (power, observational, scientific, mineral, manufactural, tertiary-quaternary, industrial research, military, Spacial, residential, biocultural, chemical, medical, touristic eg vacational, &c), gambles and presumptions, possible eldorados, costs of transport, costs of energy, cost of materials, costs of manufactures, costs of services, costs of labor, costs of maintenance, costs of necessities, costs of luxuries, not costs but prices, dependencies on market sizes (number of visitors, population, total imports and exports, specializability of both, Terran energy needs, &c), imaginable inflations, imaginable deflations, growth rates (amounts, derivatives, phases, inflections, immigrational and importational vs indigenous, &c), development of self-sufficient and independent intraspacial

economy, automation (productivity growth curve), &c.
10. Growth of Spacial touristry, residence, native population, work, enterprise, economy, self-government, government in general, business, &c.
11. Ways in which life in the colonies might be inferior to, differ from, equal, surpass, facilitate, complement or supplement, &c life on Earth.
12. What might be going on in the colonies: jobs, tasks, directions, programs, amusements, environment, homes, families, institutions, societies, technology, standards, feelings, thoughts, individual opportunities, &c.
13. Engineering, artistic, and other characteristics of: buildings and homes, communities, streets, vehicles, physiography (landforms and landmarks, soil, fauna, flora, climate, weather, skies, sunshine, water, parks, playgrounds, &c), farms, industries, extra-colonial transport, research installations, libraries, schools, parking lots or places, intercolonial travel, offices, furniture, tools, wardrobe, lawns, sewerage treatment plants, environmental plants, power plants, &c or their necessary analogues.
14. Government, planning, particular projects, economic structure, &c in connexion with, or had by, the colonies.
15. The competitive cases for epiplanetary vs extraplanetary colonies.
16. Who pays for the initial colonies? Federal government, corporations, consortia, other nations, nations combined, whole world (UN), individuals, borrowers, NASA, intracolonial ventures, &rc.
17. How many people could colonies support? Do potential people (the unborn) have a right to exist? Are colonies any solution to the Earth's population (and other resource) crises?
18. Should we build at least one colony for purely experimental reasons?
19. Should the future Spacial enterprise, NASA, &c center on colonization?
20. Is colonization just a matter of time?
21. Would the building of an American or Russian colony cause the other side to build another, ie compete, perhaps for prestigious, glamorous, economic, security, mimetic, "Jones's", or other reasons? Would this proliferate to third parties, the UN, &c? Is colonization apt to be contagious?
22. How serious is current interest in colonization? What is its nature and likely course? How apt is colonization to occur as a result? Has interest peaked or is there great aptitude for growth? Will the interest be underwritten by hard scientific and practical facts? Is colonization immune to preexistent social criticisms of Space? Is interest in colonization widespread or fanatical, public or governmental, American or (at least shortly) world? What treatment and help may the media give?
23. How far have studies, and criticisms thereof, gone? Are these (or any) studies to be trusted? Are O'Neill's proposals presently, or apt to remain, unique in their originality, feasibility, excellence, detail, comprehensiveness, interest, kind, &c?
24. Is any first colony apt to be built likely to be far less grand than O'Neill's Model O? Likewise subsequent colonies?
25. What effect will colonization have on the general Spacial program and the larger development of the Solar System?
26. Who is working full-time on colonies?
27. Could the vision of the design of, and life in, colonies be vastly improved over O'Neill's extant treatment, or is his treatment pretty ideal?
28. The competitive cases for periplanetary, especially periterran, vs Lagrangian colonies.
29. The competitive cases for colonies with one vast common space (unicellular colonies) vs a multitude of modular spaces (multicellular colonies).
30. Will the first colonies be built bit by bit, step by step, stage by stage, incrementally, without predesign, &c, or by erecting directly vast, elaborate, planned, sophisticated, &c structures a la O'Neill?

31. Whence the power, tools, raw materials, processed materials, chemicals, manufactures, services, &c for the colonies, initially and later? Whence the fuel, air, food, construction materials, machines, implements, &c? To what extent, and when, will these come from Earth, the native, or another environment? What safety margins are appropriate for such estimates in terms of actual planning? What tradeoffs between raw materials, elements, chemicals, minerals, tools, comforts, &c are possible and probable? What would these tradeoffs mean?
32. What kind of people could and should go into Space, or to these colonies, say developmentally?
33. Would such colonies be endangered by ransomers, madmen, terrorists, enemies, kids, or simply by fallible men?
34. What materials, manufactures, machines, energies, supplies (initial, developmental, and enduring), innovations, researched productions, &c will colonies require --types, amounts, standards, priorities, forms, rates, &c?
35. What "size laws", or other engineering laws, configure any colonies--and how?
36. What don't we know, what do we need to know, how do we find it out, &c?
37. Would many initially have to be excluded for colonization (too many volunteers)?
38. Might colonies anywhere in Space be easier or better, say initially, than colonies under the sea, in Antarctica, or elsewhere?
39. Can a case be made against the importance of initial or enduring transportation costs?
40. Is the greatest, and a sufficient, warrant for colonization of a romantic, heroic, spiritual, idealistic, psychological, philosophical, &rc nature?
41. How fast could colonization develop over the next century (2000-2100)?
42. What continued or semi-continued exponential progress (demographic, economic, global, technologic, scientific, sociopolitical, plutographic, &rc) might be expected such that it will cause or facilitate colonization?
43. Might there be some great--perhaps unsuspected, unpredictable, incomprehensible, &r unmeasurable--aesthetic significance to life in a colony off somewhere in Space or situated at particular prospects and settings?
44. Alternative, and rankable, power sources for such colonies: fission, chemical, solar (eg photovoltaic vs optical, vs turboelectric), future fusion, &c in terms of specific and detailed proposals.
45. Actual patterns of fabricating and assembling colonies in situ.
46. Specific matters, problems, and opportunities of: air pressure, air composition, artificial gravity, coriolis force, cosmic rays, ultraviolet light, micrometeoroidal and macrometeoroidal bombardment, catastrophic rupture threats, daily and seasonal cycles, inadvertent weather, wear and failure of structures and materials, ecosystemic equilibria, tidal stresses and strains, lifetime considerations, insulation requirements, problems of excessive heat and cold, vacuum leakage, possible disasters or annoyances (seisms, structural noises, barometric or gravitational discomforts, collisions, effects of perpetual or nonterran day, light of strange composition and distribution, possible crowding, &c), choice of biota, utility of previously developed and perhaps insistent technology and resources, recycling means and limits, intracolonial transportation systems (foot, car, scheduled public "trains", slidewalks, airplanes and balloons, subways, &c), &c.
47. The value, rate, kind, &c of all types and degrees of probable and possible spin-offs to Earth or mankind from colonies.
48. The or any transitions from colonies to planeturgy and the exploration, occupation, development, and transformation of whole planetaries; perhaps a transition from a "central" (colonial) phase to a "pluralistic" (homesteading) phase.
49. What is the psychological and moral significance of a colony, including such things as defiance of the unknown, new life from responding to an overwhelming physical challenge, filling the void with human meaning, development of courageous and imaginative character, self-reliance, cooperation, &c?
50. Where is actual or probable life in such colonies adequately depicted?

REASONS FOR MANNED AND REASONS FOR UNMANNED c1975 PROGRAMS

Reasons for manned programs.

1. Deservedly enlarges any program, Spacial development, funds, &c; eg "starts" colonization.
2. Ultimately the total weight after addition of the body weight and services weight is what we should be "spacing". (Space: v.t., to put in Space; v.i., to enter Space).
3. Man is a generalist.
4. Human intuition (Hilbertian).
5. Imaginative appraisal.
6. Discovery through foresight.
7. Insight and experimental test possible (constant with men).
8. Serendipity possible.
9. "Feeling of things" brought back.
10. Memories returned are infinite; the men become infinite resources.
11. Astronauts tour and inspire public (especially children); inspiration also helps the program, eg financially.
12. Better or greater 3-dimensional perception, color perception, total of "quasi bits" of information, haptic sense of things, &c.
13. Better realization and tendency to solution of problems.
14. Early programs required men.
15. Later programs require men.
16. Maneuverability, energy, versatility, kinesthetic and athletic prowess generally, delicacy (softest touch to full strength of touch, slightest to greatest motion and duration thereof, most complicated (eg because of simultaneous motion), &c), &c.
17. Manned program could have been, &r could be, better done: emphasis on scientific astronauts, long stays, permanent bases, elaborate base equipment, "total" mobility, less safety (eg for better sites), better scientific organization, &c.
18. Men can be specialists.
19. Manned precedents.

Reasons for unmanned (automatic &r telomechanical) programs.

1. Lighter, more compact, more versatile, less backup, more dispensable, more reliable, reusable, tougher, cheaper, &c.
2. More perceptive, quantitative; exotic sensoria (even astronauts use machines); &c.
3. Need no attendants, operators, &c.
4. Inevitable.
5. Infinite promise (in terms of perception, thought, parallel thought, creativity, imagination, foresight, intuition, genius, will, motivation; action; miniaturization, power, speed, &c)--say over Quarters I and II.
6. Unmanned programs could be much better done than have been.
7. Better and bigger memory.
8. Better reportage; reproducible results.
9. Can be self-sufficient, permanent, &c.
10. Theorization is done on Earth and not in Space; and not by astronauts, however competent.
11. Concurrent present and future progress in computer hardware, software, and analogous use, and the spin-off value for nonspacial computation.
12. Specific tasks now assignable to and performable by such machines in Space.
13. Virtually no time lag for periterran teleoperators.

Commentary on the preceding pair of lists.

The writer is able to suggest the distinctions between the abilities of the human brain and current machines that he does on the basis of his authority as a neurologist and his intense interest in computer intelligence. The distinctions are sound. But certain ambiguities in the comparisons are evident. These were intentional. Partly they reflect the discrepancy between the state of the art in computer software and hardware in 1975 and developments 1-5 decades hence, when software and hardware together will experience immense quantitative and qualitative progress and reverse inferior relationships to men prevailing today and in the interim. He has scant doubt that 5 decades hence, in 2025, the computer will have transcended human intelligence in every meaningful respect and probably to an astronomic degree; certainly this will be the situation sometime in the 21st century.

Partly the ambiguities just referred to reflect ambiguities inherent in the measurements intitulated. For example, "memory" is a thing embodying countless, often orthogonal, dimensions and always almost completely obscure in its measure, or in the measures of these myriad dimensions. Therefore it is in a way preposterous to make pretentious comparisons between the computer and the brain. No one knows how many "bits" figure in human thought or exist in human memory, ostensibly relating brain and machine--no one has a meritorious reason for identifying a bit sum of "engrams" exact to a range of less than 21 orders of magnitude (or 70 octaves), and the range could conceivably be infinite instead of finite, or permeated with far more important considerations.

I have referred to human intuition as "Hilbertian" as a stenographic scholium for the possibility or probability that behind and basic to human thought, memory, and insight is something like Hilbert space, or an infinite dimensionality practically irreducible to a "bits" or information-theoretic quantification and possibly fundamentally dissimilar to current discrete computers. This carries with it the possibility that the memories returned to Earth by astronauts amount to infinite gestalten, however poor their subsequent use.

The new view of nature or world view propounded in this book, referred to as The Efflorescent World View, complements the above and suggests that much of nature may only at present be revealed to man, and much of Space only to human astronauts. This of course is an hypothesis, about which readers will disagree. There is at least the chance that strong, subtle, little-understood reasons exist for perpetuating men in Space or using men and computers in sensible combinations.

A particular value of men, at least in the future, is that they can survey and assess large and idiosyncratic environments of data in a firsthand and immediate way. Simultaneous speculative induction and passive and active experimental deduction is thus possible; the compression of time for empiriological researches is far more than linear for this quick or instantaneous feedback, and the power with which landscape and experience are analyzed far exceeds what would be possible in later assessing records brought back to Earth or more or less instantaneously transmitted in awkward cybernetic ways. This second handicap results, and has resulted, in a certain conceptual blindness toward what obtains at the loci explored. This criticism will have far greater force if large, permanent, professional, and theoretical teams are eventually established at Spacial loci in place of mere machines.

Be it concluded that the debate so far over whether programs in Space should or could be manned or unmanned has not been very sophisticated, careful, or decisive, and is a poor guide for policy.

REASONS FOR SPACE

1. Maintains an important frontier: geographic, vectorial, scientific, technical, economic, intellectual, spiritual, emotional, characteral, vis-a-vis rest of the world, demographic, plutographic (ie in terms of natural resources), and in terms of the human adventure generally.
2. Stimulates the economy: industrial employment, forces innovation, increases excellence of workforce, triggers progressive policies, expands opportunity, lubricates whole economy, benefits peripheral and ulterior firms, advances general economic practises and attitudes (ie evolves the whole economy), spins off things (abstract knowledge, processes, techniques, products, materials, equipment, projects, programs, methods, &c), favors the US over the world, benefits the whole world, &c. Accelerates change, retires the obsolete and irrelevant, variegates and evolves industries and businesses, increases overall economic organization, replaces military waste, beneficially follows wars, underlines the future importance of applied and pure science, de-vulgarizes wealth, encourages long-term and non-zero sum investment, &c.
3. Revives, perpetuates, strengthens, enlarges, generalizes, differentiates, vindicates, redirects, exemplifies, and improves the factual or fictitious "American spirit": enterprise, courage, determination, innovation, growth, progress, perfection, technique, ambition, the romance of being challenged, activity, leadership, idealism, self-sufficiency, cooperation, industry, discovery, profit (economic gain, pursuit of a higher standard of living), transcendence of obstacles, mastery over nature, mystical futurism, savings and investment, development of resources, technical and scientific superbity, curiosity, love of freedom, achievement-oriented values, self-transcendence, self-dissatisfaction, "maximalism", poetry, &c.
4. Safeguards the United States, democracy, the human race, all posterity, civilization, all of life, &c: by creating "redundant earths", diversified being, greater civilization, the future in the present (ie compressing future-historical development), less militarily vulnerable or interesting civilization, a panhuman theme, panhuman and novel institutions (economy, government, culture, science, overlapping ownership, synergistic patterns, higher orientations, &c), an outer-directed psychology, &c; the United States can surpass or equal her adversaries in Space, capitalism and democracy can be fostered in Space, &c.
5. Enables an intrinsically valuable, non zero sum nonterran civilization to start and evolve itself independently, yet a civilization that will ultimately benefit Earth tremendously (economically, culturally, technically, and even politically): people can exist which do not now exist, the civilization in Space will ultimately become greater (eventually infinitely greater) than Earth in economic, demographic, and cultural (or all other) terms.
6. Inspires, entertains, elevates, preoccupies, reassures, &c mankind and its divisions on and off Earth.
7. Expands, or will expand, human resources: minerals, energy, land, space, means, knowledge, environments, opportunities, men, &c.
8. Has religious, aesthetic, educational, legal, &c significance.
9. That achieved in Space so far encourages a greater investment of human resources in Space.
10. Military needs and opportunities.
11. Astronomic benefits.
12. Destiny or ultimate things: the beckoning universe.
13. Peace: Space defeats or discourages war, unifies or elevates and redirects the race, &c.

14. So cheap in various terms: as an amount or a percentage of world, national, or personal income, or relative to such things as total tax or governmental income, welfare expenditures, money in science, defense expenditures, &c.
15. All objections are naive, answerable, obviable, &c.
16. Timely.
17. Possible.
18. Past benefit pays for future (in fact for self-enlarging) effort.
19. "No one else" is doing (neglected opportunity and responsibility).
20. Proven possible.
21. Costs reducible (eg now proven to be such).
22. Biggest research and development costs now paid, and the investment is too big to throw away. For example, costs per potential accomplishment (planetography, mining, colonization, "geoscopy", astronomy, &c) now drastically reduced.
23. Sheer continuity (we should finish what we began).
24. Biggest returns are now possible, some are even imminent.
25. The fastest &r biggest accomplishment of Spacial development would also ultimately be the cheapest way of doing things.
26. Ultimate accomplishment is "timeless and scale-less", ie we should go all out and now.
27. There are some important things which can or should only be done, or done properly, in Space.
28. Space is better than: tobacco, alcohol, candy, toys, television, sports, self-indulgence generally, dangerous or hypocritical religions (being rituals or idolatries), politically wasted funds, "welfare", military things, cars, unapplied science, infinite (insatiable) medicine, &c.
29. Some types of people (eg the adventurous, fanatical, wildly aspiring, &c) require something like Space.
30. Many people (a large percent of the population) want the Spacial enterprise.
31. Earth is sick (in any sense of the word) or will be sick.
32. That Space began &r continues for crazy reasons is irrelevant to what it could or does also, instead, or eventually mean.
33. The vox populi historically is something to be educated and defied, not pampered, if for no other reason than that it has come to embody past conditioning by politicians.
34. The real value of Space, and only naturally, is almost totally undiscovered and will only be discovered as Space is developed; mankind accomplishes most on the basis of pure gambling, faith, fountainous energy, preposterous quests, iconoclasm, &c.
35. Life better than that on Earth should eventually be possible, and in various ways might be possible from the beginning owing to the nature of a good life; certainly the antithetical ideas are silly or presumptuous.
36. To understand what Space really means we must go into Space and discover it.
37. Confer the list of "The Values of Space".
38. The very fact that Space is so vacuous, unpromising, alien, horrible, demanding, undeveloped, strange, vast, "negative", &rc means that we are challenged uniquely and comprehensively by it, and undertaking its exploration and development would be one of the greatest things mankind could do--scientifically, culturally, economically, spiritually, technically, politically, &c.

OBJECTIONS TO SPACE

1. Began for passing, false, inadequate, wrong, forgotten, ambiguous, &rc reasons.
2. Persisted, persists, &r would persist for such reasons.
3. No longer popular; the vox populi calls us elsewhere.
4. Served its purpose.
5. Proved disappointing: dull, lifeless, monotonous, unvaluable, inexploitable, difficult, unchallenging, desolate, unpromising, inferior to Earth, too costly relative to the return, inhospitable, alien, finite, antiromantic i short of previous fantasies about it, programmatically impersonal, militarily inessential, &rc.
6. Too expensive in absolute &r relative world, national, &r personal terms.
7. Interest mainly scientific, &r, yet scientific aspects and concerns sofar or constantly neglected (the last man to leave the Moon was a scientist, the first, and the final man to visit the Moon).
8. Too inflated &r self-serving.
9. Programs have been and promise to remain too bureaucratic, governmental, national (rather than international or global), sectoral, &rc; operations and progress are becoming too slow, complicated, &c.
10. Man cannot live well, comfortably, properly, or even subsist in Space.
11. Establishing man or civilization, developing resources, traveling, deriving economic benefits, profiting scientifically, business enterprise, &rc in terms of Space presupposes too long a beginning, too great initial &r sustained investment, too great foresight &r planning, too great &r maintained interest, too great a gamble, too great a profundity of reasons, &rc to justify greater, equal, or any Spacial program.
12. No, inadequate, wrong, &r nonidiosyncratic spin-off on Earth.
13. Too much to do applicationally, conventionally, near and for Earth, more economically, precedingly, &rc to justify other things.
14. The concern of posterity &r others and not ourselves.
15. The money, interest, science, technology, industry, resources, men, institutions, &rc--whether governmental, corporate, or of any other nature--ought be spent instead, if at all, on purely nonspacial things and particularly those related to human welfare (health, recreation, and welfare; housing, business, environment, pure and applied science and technology, deprived and developing people, mineral and energic resources, art, religion, education, thought, &rc); problems on Earth are too great, many, urgent, &rc.
16. The reason for #15 may be that these things emerged or became obvious since the Spacial enterprise began, or perhaps because of it.
17. Just another problem but whose addition is unnecessary.
18. Few men would ever, or justifiably, want to visit &r emigrate to Space.
19. The Spacial program is too inhuman, arrogant, vulgar, unnatural, meaningless, &rc
20. Space is no solution to overpopulation and could even worsen it.
21. The Spacial enterprise is scientifically, technologically, economically, &r psychically hubristic, Icarian, Faustian, Sisyphean, &r the like: science &r technology finite or laggard, the scale of the enterprise presupposes a far larger and more developed civilization and a much more serious undertaking, man may be tampering with Nature, such "infinite" scope and ambition must diminish &r corrupt us, the enterprise may be at root fatally escapistic, man's and God's reasons alike for the Spacial enterprise may be unknown and yet critical, all human "progress" should stop, our directions and reasons for being in Space should first be researched and decided, our programs are extravagant, other planets are unmanageable, the Universe is malevolent, Space is a task for men centuries removed, exponential progress is declining or will do so shortly or inevitably (in economic, populational, &r other terms), &rc.

22. The Spacial program has been poorly managed and remains so: it should have been faster, slower, more elegant fiscally, grander, more or better planned, philosophically justified, directed to and justified in terms of later and perhaps transcendent developments and payoffs, less melodramatic, handled more dramatically and explanatorily, more scientific, more daring than safe, less redundant, more profit-oriented, concerned with colonization, &rc.
23. We may waste resources on Space that give the Russians a military advantage.
24. Man has no destiny in terms of extraterran Space; he will never develop it in any real way and we are just dissipating our resources.
25. It will be more efficient to go into Space in a later day before which we should concentrate our resources on directly or indirectly related discovery and development of scientific, technological, and economic resources and in this way achieve a greater ultimate payoff; once the population and economy have become much greater than they are now, or perhaps leveled off, it will be far simpler and perhaps excusable to develop Space.
26. By way of exemplifying ## 1 and 2, Space has been r& remains simply a political boondoggle.
27. Space has no real--or no known, sufficient, &r peculiar--advantages to things that can be done or found on Earth; other planetaries--regardless of whether they have special, any, sufficient, &r accessible ones--merely offer resources that have such statuses on Earth: there is superabundant sunlight and the promise of fusion awaiting exploitation to answer our energy needs, there are substitutable minerals, untold wealth beneath and within the sea, incalculably great but simply undiscovered or undeveloped deposits of minerals, minerals more easily extracted from the soil than Space, multifold agricultural potential, overwhelming space for pleasant cities or spread-out population, the ability to cope with any pollutant or set of pollutants, lands open to fair adventure, inexhaustible diversity, a preexistent civilization and culture, great freedom, &rc; the supposed industrial advantages of Spacial milieus are defective, fantastic, inessential, minor, few, uncertain, temporary, in competition with innumerable Terran advantages, uneconomical overall or after all, preconditional, arbitrary, &rc; better, adequate, &r alternative astronomy can, might, or is more likely to be done--at least in the short haul--on Earth for a medley of reasons (both intrasolian and extrasolian astronomy).
28. Spaciology detracts men and resources from other science, hydraulically.
29. Life on Earth is much finer, healthier, more filled with destiny, sufficient, challenging, &rc than pessimists, critics, and escapists suppose.
30. There are no, no sufficient, or no necessary bases for certain claims made for Space: that wastes, industry, dangerous researches, &r redundant but precautionary civilization should be put there; that a civilization would arise there any different than that on sorry or happy Earth; that anyone would be basically happier there; &rc.
31. And so on and so forth.

PLANETURGICAL SCHEMES

1. Alter planetary albedo in a positive or negative direction, to varying degrees, permanently or temporarily (catalytically), by silvering or blackening the surface with powdery or laminar matter, changing the mass &r composition of the atmosphere (say by freeing soil gases), creating a thin ocean (say by melting polar caps, causing precipitation from or the condensation of the atmosphere, &r removing liquid present in some form in soil or crust), &c, and over a part (eg the poles) or the whole of a planet.
2. Use Terran biota of natural, modified, or almost totally engineered kind.
3. Use native biota of natural or modified kind, again to modify the chemistry or structure (especially of the atmosphere) of a planet, or to liberate materials present in some form in the soil.
4. Use cellular automata, or totally artificial biota, to similarly liberate or modify the materials of a planet.
5. Alter a planet's orbital &r axial elements: its astrocentric distance, orbital eccentricity, orbital inclination (assuming the atmosphere of the solar system involved varies greatly out of its ecliptic plane), alter the daily and annual precession and tilt of the planet or its monthly (satellitic) elements, &c specifically in order to cause climatic changes (see instead #39).
6. Alter the static &r dynamic patterns and relationships of the sun to its planet(s), either naturally or totally artificially; for example, increase or decrease the solar constant.
7. Alter the biological &r chemical feedback relationships characterizing a planet.
8. Shield a planet from sunlight by hard or soft screens of varying opacity (eg absolute or partial) covering all or part of a planet's normally insolated surface; for example by surrounding Venus with backreflective catoptrical balloons.
9. Melt or increase the polar caps by blackening, silvering, dissolving, shadowing, insolating (eg by focal mirrors or lenses interposed with the sun in Space), biologically modifying, convecting away (by modifying general or local atmospheric circulation), triggering their autocatalytic removal, shattering or exploding, perforating, dusting (for example stirring up the atmospheric transport of equatorial dust), &rc them, by altering orbital &r axial elements of the planet, by triggering volcanic epochs (thereby releasing heat, dust, moisture, gases, &rc), &rc.
10. Build vast manufacturing plants to alter quantitatively &r qualitatively a planet's atmosphere, ocean, &r soil, say by thermally or chemically liberating stupendous amounts of gases &r liquids from soil, rocks, oceans, air, &rc.
11. Surround the planet with a 10^{-3}-10^{3} meter high "cutosphere" to simplify the creation, maintenance, control, specification, &rc of an atmosphere &r ocean, produce any or particular greenhouse effects (say in order to liquefy &r evaporate the surface of a planet), enable tremendous agriculture &r human habitation, alter planetary albedo, &rc; the cutosphere could be steric or hollow, solid, liquid, &r gaseous, thick or thin, complex or simple, hard or soft, homogeneous or heterogeneous over its total area, temporary or permanent, permeable or sealed, single-leveled or multi-leveled, controllable or fixed, for planets close &r far from the sun, for planets or planetesimals, or natural &r artificial bodies, puncturable or not by meteoroids, for planets with or without natural or overlying atmosphere, &rc.
12. Variously rid a planet of its atmosphere &r ocean, say by evacuating it into Space in various ways.
13. Freeze or melt a planet in various ways.
14. Shatter a planet into planetesimals or dust, seperated or not in Space.

15. Catalytically alter a planet's climate by modifying, modulating, or re-creating its ionosphere, magnetosphere, radiation belts (ie electrosphere), &rc.
16. Brutally or catalytically reclimatize a planet by altering its general or cellular oceanic &r atmospheric circulation, or its various phenomena.
17. Brutally or catalytically reclimatize a planet by modifying, destroying, increasing, respeciating, redistributing, controlling, &rc its biosphere.
18. Heat an ocean, melt a pole, create a desert, deglaciate mountains, &rc to drastically alter (for example, increase or decrease, or change the form of) precipitation.
19. Create a molar or millimetric film over a major ocean, or all surface waters, to effect climatic changes.
20. Modify, alter the magnitude of, re-create, create artificial, &rc biota in order to effect gradual but decisive, stupendous, particular, &rc changes over centuries, millenia, or eons--say to accumulate useful chemical deposits, &rc.
21. Take a planetary apart and use its minerals, chemicals, elements, or mass for various purposes (for example, the maximization of living space, the englobement of a star with a photovoltaic Dyson Sphere, the total mining of a planet or specifically the mining of its interiormost minerals, &rc).
22. Rearrange, recompose, and perhaps utterly recreate the set of planets belonging to a solar system (for example, create a completely different set of planets: say $1\text{-}10^6$).
23. Use future physics to "ignite" or otherwise work nuclear reactions in the ordinary and total matter of a planet, or in one of its spheres such as part of its atmosphere or an ocean.
24. Move a planetary up to a sun in order to "work" the planetary by solarization.
25. Increase or decrease atmospheric pressure away from 1 atmosphere--eg create hyperbaric ("Venusian") atmospheres for various purposes.
26. Alter the electromagnetic properties of an atmosphere in terms of its strata, body, or surface (eg increase or decrease the Heaviside layer or the general transmissivity or opacity of air for the sake of specific bands of electromagnetic radiation).
27. Increase or create artificial vulcanism, perhaps in order to reclimatize a planet, mine the crust, dust the surface of the planet with fertilizer, study the phenomenon, give an atmosphere &r ocean (from moisture) to an anatmospheric planetary, create an atmosphere usable elsewhere for extraplanetary purposes, alter the electrical properties of an atmosphere, &rc.
28. Transport <u>massive</u> materials (for example ice or fertile soil) from one planetary to another.
29. Quantitatively &r qualitatively alter completely, substitute, or create ex nihilo the fertile, &r otherwise useful, pedosphere of a planetary (for example at $10^{-3}\text{-}10^{1}$ meters depth).
30. Alter partly, completely, crudely or detailously, naturally or perfectly unnaturally (ie in design), constructively or destructively, directly or indirectly, for technological or biological reasons (biocultural or for human inhabitation), statically &r dynamically, essentially &r superficially, reversibly or irreversibly, empirically or theoretically, gradually or suddenly, homogeneously &r heterogeneously, to any degree, and in any fashion the morphography, morphology, or physiography of a planetary surface--for example, create a regolith, hills, mountains, caves, a pattern of streams and lakes, more specific and interesting landforms, canyons, slopes, continents and islands, bays, &rc.
31. Create a planet "ex nihilo"; for example, from materials of a star, by freezing the atmosphere of a "jovian" planet, from a collection of asteroids, from materials of part or all of another planet, from foamy material, &rc.

32. Cover the face of a planetary, such as Earth's Moon, with life, habitats such as human dwellings or a cosmic city, industrial buildings and facilities, scientific facilities, art, things stored, a museum or wildlife preserve, &rc.
33. Turn a planetary into a bidimensional or tridimensional spaceship, whatever it be to bear.
34. Develop many "surfaces" or subworlds within the interior of a planetary, or the entire volume, for such purposes as considered above in ## 32 and 33.
35. Take an entire star, say 10^6 X as massive as the Earth, apart and remake it into a set of planetaries or one immense planet (say of suitable tenuity).
36. Do the same for a set of stars, galaxy, or universe.
37. Engineer the instantaneous climate of an entire planet, say one previously without any atmosphere or with an uncontrollable climate; for example, create artificially all the momentary, daily, weekly, seasonal, and epochal climate and weather of a planetary, perhaps with almost any range of variation.
38. Supply a planetary or set of planetaries with an artificial moon &r sun.
39. Alter, or render variably controllable, any or all of the orbital &r axial elements of a planetary; for example, any radius from the sun's surface to 1 light-year, likewise any eccentricity, any inclination, any precession, any year, any day, any month, any season, any many-body complexity, &rc; a planet could be made to orbit another planet or to remain at a Lagrangian point; a planet's rotation could be maximized or stopped.
40. Terraform a planetary or planetary surface, ie make it more or less like the Earth, &r acceptable to man or Terran life, by creating or modifying its geology, atmosphere, ocean, climate, flora &r fauna, microbiota, artificiality, sky, or even exact character (with some degree of resolution).
41. Create a completely new &r artificial biota (that is, multispecific biosphere) for a whole world.
42. Develop a planetary civilization at an accelerated or maximal rate, or ex nihilo.
43. Combine planetaries.
44. Tap roughly all of the heat flux, or use all the interior heat, of a planetary.
45. Quickly remove all the materials of a planetary, or certain base or precious materials.
46. Quickly or comprehensively exploit virtually all the resources of a planetary; for example, all hydrospheric flow and power, all eolian and oceanic power, all solar influx, all room, all biotas and organisms (or any extant or even possible biospheric capacities), &rc.
47. Modify planetaries or masses of planetary size in such ways for purely experimental reasons.
48. Turn a planetary into an artificial star using "transnuclear", or possibly nuclear, processes.

RECEPTION OF EXTRASOLIAN COMMUNICATIONS: ENCOURAGING POSSIBILITIES

1. Very abundance of stars (100-250 billion in our galaxy).
2. Probable average of planets per star the same as for the Sun (10).
3. Elementary life seems to form readily, quickly, and early.
4. Advanced life and human intelligence seems inevitable (probability over 10% at current age of planets, in the case of at least earthlike conditions).
5. Incidence of earthlike planets among planets seems high (over 2% of planets).
6. Analogies to the history of civilization on Earth (previous isolation of distinct cultures, later contacts and exchanges, seeming unlikelihood of our being virtually first as civilized or technical beings since 10^4 years is 10^{-5} of 10^9 past or future years and this makes our civilization seem absurd, and 10^2 years is 10^{-7} of 10^9 years and this renders our technology utterly improbable if we let probabilistic falsehoods mislead us, &c).
7. Gaps between nearby and farthest stars seem easy to cross, even by present technology, but particularly by what is possible in 100 years or 100 million.
8. Speed of light, c, means that our uniquity as a fraction of the past 10^9 years is less since travel across the galaxy would require 10^{5-7} years, which divided by 10^9 yields the quotient 10^{-2}-10^{-4}, and therefore the sense of our own unlikelihood should be much less, or zero in view of the fraction of time we represent, by comparison, in the age of the Earth.
9. Philosophic reasons are imaginable why other technical cultures might not travel and yet would be accessible to, or even productive of, communication.
10. Alternative possibilities (frequencies, beam convergence, object-mediated communication, novel particles, quasi-natural signals, far stranger things) for better communication so abound that it is rational to expect our current means are totally irrelevant, even to all communications.
11. The readiness with which these should be discovered or used, and their advantageous powers, suggests that other beings interested in our preservation or contact might be indifferent to technology a la 1975 or 2075.
12. Reasons can be imagined for ignoring a new culture during its extreme youth or transitional emergence, and only contacting it over a stage of maturity.
13. Technical cultures may instantaneously transcend our reality at early points, but prior to doing so may transmit and receive, thus thinning the number of such cultures in the galaxy, explaining their failure to travel and preempt us, and yet allowing for a sufficient number that early technical progress will put us in contact.
14. Benefits derivable from extrasolian contacts could be so infinite--culturally, scientifically, economically, and philosophically--that the tiniest chance of contact (eg 10^{-6}, which is 10^{5-6} X more pessimistic than anything allows us to be !) would justify the most enthusiastic efforts on our part simply from prudence!
15. By 2000-2035 the probability is 90% that machines will acquire intelligence almost infinitely beyond ours, speeding arrival at proper communicational technology and allowing brilliant analysis of astronomic observations (for indirect indications of extrasolian life) and data interpretable as communications.
16. Both natural and artificial emissions should yield between 2000-2035 to methods of analysis, and a theory of intelligence and order, universally applicable to the reevolution of pattern multiplexed in things, where our world is probably what would seem to us miraculously autocorrelated and therefore "transparent".
17. Very abundance of galaxies (10^{10}, totalling at least 10^{21} stars and 10^{22} planets).
18. The possibilities for life in unearthlike conditions.
19. "The Myrioramic Principle" (cf. p).

RECEPTION OF EXTRASOLIAN COMMUNICATIONS: DISCOURAGING POSSIBILITIES

1. Any messages, signals, transmissions, signs, &rc might be deliberately and superbly covert, cryptic, confused, &rc. Reasons might be to prevent the emergence or accelerated development of new and backward cultures, to keep such juvenile cultures from harming themselves (say by rash use of technology or technology too plentiful and advanced in ratio to the order, sophiology, self-mastery, worth, ideal stage, trustworthiness, brains, spiritual development, needs, capacities, fragility, integration, ability to appreciate, &rc of all, most, some, or any cultures), to compete (excel, not abet, &rc) with other nonbackward beings (for military, business, cultural, pride, political, governmental, religious, abstract, highly abstract or esoteric, quasi neurotic, condescending, playful, &r infinitely other reasons), sheer privacy (perhaps of a kind completely incomprehensible to ourselves), reactions to the dangers of stupendous, unknown, &c population (ie the billions of stellar civilizations and 10^{20-40} transhumanly intelligent beings that might exist within our Milky Way, and the quintillions of such "cultures" and 10^{30-60} such beings that may exist in the "phanerocosm", by which is denoted the currently known and seen so-called universe, may inevitably or potentially involve such huge and absolute spectra of types--of mind, value, behavior, instantaneous purpose, instantaneous perspective, sanity, badness, irresponsibility, large design, &rc--capable of crossing relevant interdistances a la a blight or predator, that such populations may, however enormously bizarre at first sight the idea, "no longer" be trustworthy on such a scale of mixed possibilities in a universe prone, perhaps overwhelmingly prone, to intercultural suicide, catastrophe, &rc), to multifunctionally seperate confusable messages on taxed channels (which channels might be finite), &rc. For such reasons the messages, signals, transmissions, signs, &rc might variously look like white noise, natural or pseudonatural phenomena, be hopelessly labyrinthine, abound in decoys and stalking-horses, be hopelessly elusive and varying, be pseudorandom, presuppose possession of some initial or other key (code, dictionary, message, mathematics, meaning, reference, interest, &rc), be rather or ideally inobvious (weak, marginal over background, discontinuous in time, distributed &r variable in space, collocated with stars, located in dubious voids, time-varied, time-compressed, suggestive instead of precise, minimal instead of maximal in amount, arbitrarily bunched in time, selective in direction &r focus (&rc), improbable &r extreme in choice of medium (any frequency or set of frequencies, any cross-spectral bunching, any energy or matter known or unknown to us, involving any science &r technology of transmission &r reception, &rc), &rc. Any progression in such a way might be possible with time; the progression might be linear or exponentially increasing, asymptotic &r open, discontinuous, hyperbolic and hence virtually perfect, &rc. Cultures just minutely beyond us in time or just technology might be hopelessly beyond us. The conclusion of all this might be that we, at least, at least now, stand essentially zero or less than 50% chance of detecting, recognizing, understanding, using, benefitting from, &rc such communications as may exist if the extrasolian communicators have willed it so. The galaxy might be silent or thunderously self-conversing and we might be unable to distinguish which. Frustratingly, the character and hence purpose of extrasolian mind and being are probably infinitely or superinfinitely inscrutable to anything like ourselves, or at least virtually so, and so the matter of the probability of these things is ultimately mysterious. The horrible thing is that the plethoric possibilities just reviewed merely presuppose deliberate self-obscuration and disregard all the encompassing difficulties, possibilities, hazards, uncertainties, assumptions, and considerations--which may likewise be superior, infinite, or superinfinite! But life is not without hope.

2. We may be first, alone, first along with many (wave-like), &rc within 10-100 light-years or hailing distance, the Milky Way, some current epoch of the Milky Way, our metagalaxy (say within 10^8 light-years), our phanerocosm, or the like for obvious or very strange reasons. Someone has to be first and would have to react the way we do to the appearance of being first (puzzlement, disbelief, elaboration and selection of alternatives, &rc). He that is first might preempt all other life by occupying, sterilizing, conquering, reconstructing, mechanizing, seeding, &rc the near stars, galaxy, phanerocosm, &c; such action may be mathematically certain or probable, consistent with our nature or philosophies, possible, highly justifiable, &rc so that the implication of failure of detection and absence of preemption may be that our status is as stated originally. Planets might be rare (and necessary for life), conditions suitable for life's origin and development (over gigennia) may be unusually specific and rare, the inner part of the Milky Way may be incompatible with life (owing to rates of processes, continuous or occasional radiations, violence, composition, structure, &rc), previous galactic life may have been wiped out (say by explosions in the galactic nucleus), conditions tolerant of life may have "just" come about in the Milky Way, the early prebiological and biological phases of life may be arbitrarily difficult and rare (possibly even the result of chance fluctuations)--which would be decisive for our sense of our own improbability (as supposedly unique, first, &rc), other galaxies or portions of the universe may be inexplicably hostile to life, the origin of life or technical intelligence may somehow be synchronically coordinated over the galaxy or phanerocosm, &rc.
3. The intelligence and "being" of other beings, representing the fate of all beings at a stage (technical, mental, philosophic, spiritual, cultural, &rc) just beyond man (say 30-1000 years and inevitable) may be too fast, complex, high, different, &rc relative to man. Even if man could be of no "anthropological" or collegial interest, he might not be of any utility, altruistic interest, concern, &c either. Beings beyond man might pass a critical threshold and explode (technically, mentally, culturally, ontically, &rc--perhaps variously interrelatedly) so as to suddenly attain a level significantly, drastically, totally, or infinitely beyond man, or the discontinuity might simply emphasize the disinterest or ignorability of the period of transition and all beings within or prior to it. The relationship between almost all, most, or most advanced beings and man might be analogous to that between the best of us and savages, apes, dogs, cows, bugs, bacteria, viruses, molecues, or entities too small and unimportant to have yet been discovered, considered, &c, or to aphrons, zeros, infinitesimals, minuses, rc; these could be very ridiculous positions to be in! Oddly and importantly, the velocity of perception, velocity of thought &r being, breadth of consciousness &r being, height, importance, complexity, peculiarity, rate of evolution, &rc of beings over various thresholds could not just be relatively tremendous but in fact infinite, superinfinite, &c (in terms of rate, quantity, quality, &rc)! How could this be? First consider the technology. The ratio of the speed of light (and, roughly, wire-running electrons) to the speed of impulses over the fine and main nervation of our cerebral cortex is 10^{9-11} over interconnective axons via discrete synapses (disregarding little-understood electronic &rc process possibilities); this intimates a computer can potentially think faster than man in a ratio of at least 10^{9-11} (assuming a linear law for rate of thought in terms of density) or at least 10^{27-33} (assuming a cubic law via convergent processes, which might at least have an independent value and a critical one). Some have suggested each human neuron functions as a 1 bit switch (if it might not as well as) and the brain (taken integrally) operates via 10^{10} bits (the number of neurons); then a computer using 1 bit atoms in plenary session as the constituents of a chunk of matter and ceteris paribus, so as to be, say, 10^{17} X denser or larger

than our abortive brain, would eo ipso be, per supra, at least $10^{5\frac{1}{2}}$ X (linear law) or 10^{17} X (cubic law) faster than the just discussed transhuman computer and therefore $10^{14\frac{1}{2}-16\frac{1}{2}-10^{44-50}}$ X faster, "at minimum", than us. This is a bit of a hurry. But it is only a short step. Suppose reduction, organization, compression, thought, &r other progress below the atomic (1 angstrom) level is possible and inevitable, say depressing electron shells down to nuclear or nucleonic (say 1 linear and cubic fermi) levels or dispensing with such shells altogether in favor of internuclear and subnuclear processes; the respective maxima conceivable in this way might be $10^{19\frac{1}{2}-21\frac{1}{2}-10^{59-65}}$ X as fast as us mentally and in other ways. I am not finished. I have only attained the possibilities within neutron stars (it has been suggested these could be pseudocrystalline, pseudochemical, originate &r support life, &r be wholly artificial--or, as pulsars, be artificial communicators, a possible interpretation which is still not wholly dead) of density 10^{15} gm/cc and using electrons and nucleons without regard for other particles that do &r might exist--particularly in such or particular levels, conditions, &rc. The level subcritical for a black hole (one a few times more massive than the Sun) could speed things on by a factor of perhaps $10^{3-10^{9}}$ for a being therefore at least $10^{22\frac{1}{2}-24\frac{1}{2}-10^{68-74}}$ X as quick as man. At this point a Schwarzschild limit would be reached by a stellar being and he would for practical purposes, it is thought, vanish from our conservative phanerocosm or epoch; his subjective fate within would be another matter entirely since things might possibly be arranged so that his quick progress to <u>or toward</u> (since the nature and attainability of a point are arguable) a mathematical point would be marked by enormously or indefinitely accelerating thought, being, &rc (whatever its irretrievability by, but not necessarily unimportance to eg vicarious and platonic, external beings). What actually does or would happen inside such a black singularity is unknown, perhaps utterly and infinitely, but more remarkable things still, in our ontological terms, might transpire, even on the basis of current physical ideas: a superuniverse of infinitely many dimensions might be attained and(paradoxically)/or pursued, time within the hole (as it is often assumed to be without) might be open (in which case both infinite growth of being &c and infinite acceleration of growth of being &c could occur, say just kinematically, dynamically, &rc; just conditions and arrangements of matter, information, processes, &c--occurring in this way--could at various possible rates result in a simultaneous transformation, proliferation, evolution, and advancement of all, and of all possible, laws of nature, spatiotemporal metrics, mathematics, properties, forms, orders, beings, values, and--in a word--things: we still do not understand anything about "infinity"), physics may evolve cosmogonically (ie, as toward the presumptive asymptote of our "universe's" creation, as is thought to occur in certain dense stars, as occurs in high energy physics investigations, &c: new, briefer, smaller, more complex, stranger, more numerous, &rc particles --and perhaps relations, processes, forces, laws, &c--should appear, enabling novel and greater ontological possibilities), &rc. But it may reasonably be that stars 10^{-30} X as massive (the mass of our brain), or less (perhaps arbitrarily less if there is covariation favorable for ontological possibilities, as may well be the case), allow greater compressions (and hence accelerations &c) prior to Schwarzschild singularity-mediated excision from our universe <u>or</u> phanerocosm, in which case we might go further than I have and in the <u>way</u> I have, perhaps infinitely further. Yet we already know that the nucleons we have been largely limiting ourselves to, at least, are not atomic, in the Greek sense, but instead comprise 1 or more levels of subsystems whose constituents could presumably further our fantastically progressive schemes.

Such a hierarchy of clusteral subsystems might extend down, repeatedly and importantly, to such a hypothetical material, energic, causal, spatial, temporal, dimensional, structural, informational, natural and artificial (or utilitarian), &rc minim or Grecian atom as a Wheeler-Planck length, or "aphron", of 10^{-35} meter (say), which would be a volumetric minim of 10^{-105} cubic meter (certain other, far smaller, minims have been hypothesized; an infinite series might exist). The idea behind an aphron is that toward a certain minimal scale the universe, space and time, may fold over into itself, condense as an indeterminate--or incomprehensible--foam like the crest of a breaking ocean wave; such a foam would have simply incredible mass, energy, complexity, &c (against this matrical background that which we call the universe, matter, and energy would be next to nothing, merely the dynamic and self-organizing holes in an active medium, certain interference effects or messages carried by the superuniversal lattice); I myself have suggested that at this crucial and immetrical level nature may conform to the concept of the continuum in mathematics in such a way that the expanding hypergeometric macrocosm (or phanerocosm) reproduces and regenerates itself microcosmically--in terms of energy, matter, space, time, probability, possibility, &c--by reproducing the punctiform properties of the universe in a growing hierarchy of clusteral subsystems (the vision fusing wave and particle and closing the universe on itself like a snake swallowing its tail). Aphrons of such minimality could be used in our ontological engineering to yield beings at least $10^{39\frac{1}{2}-41\frac{1}{2}}$-$10^{119-125}$ X faster, denser, greater, &c than we in thought, being, &c. Presupposed largely by all these suggestions, however, has been some being limited to the mass of the human brain and hence rates, capacities, values, &c related thereto and thereby limited, and yet the mass of most of these beings, &r their population (locally or throughout the phanerocosm), might be arbitrarily greater with mental and ontic rates, capacities, &c thus also arbitrarily greater, however complicated the covariation. The large and dense human population of the Earth, and our heritage of learning from past beings, has evidently given us enhanced intelligence and being in numerous ways--and yet with infinitely surpassable efficiency possible through different organization, such as is relevant here in computing ontological maxima that are theoretically possible manifold man. Purely quantitatively, the mass of the phanerocosm is estimated to be 10^{53-55} grams, which means that being, intelligence, &c could be increased at least by a factor of 10^{50-52} by reconstructing the known universe. Of course one might also condense the universe, &c, and transcend these estimates in certain respects ontologically. We have run full-facedly into a crucial point, that our estimates so far have been of a minimal, narrowly quantitative, and enormously presumptuous kind. There is small question that the matter, operations, memories, thought, genius, &c found in the human brain (and virtually stuck to throughout our preceding discussion) could be improved upon qualitatively, reorganized, evolved, perfected, &c in comparably great ways (remembering our orders of magnitude estimates); the two sets of orders of magnitude would then multiply each other to yield a thaumaturgical product. My guess is that neural organization is sufficiently important, imperfect, and evolvable, as found in man, that a supreme micrurgical bioengineer could beget an IQ of 100 in the brain of an insect or body of a bacterium; certain arguments imply that a 10^{6-3}-dalton biomolecule could &c VIPRS WITH SUITABLE TRANSDUCER hold conversations with Albert Einstein (and these arguments less frail than they seem); such miniaturizations unite with the linear and cubic laws above to greatly enlarge possible mental, ontic, &rc rates, capacities, &rc (consider that our brain weighs 10^{27}, an octillion, daltons; the implicit augmentability factor is 10^{21-24}, a sextillion to a septillion). But there is

no absolute value or maximum of the rate, complexity, quantity, excellence, or nature of thought or being, and as a consequence progress may occur to a degree and with a measure unexampled in our previous discussion. There are parallel, simultaneous, continuous, group-theoretical, convergent, divergent, timeless, sizeless, depthless, valueless, evolutionary, accumulative, &c properties both to human thought and being which defy simple understanding and force themselves onto our attention; there are paradoxical, mysterious, metaphysical, and incalculably intriguing matters with which we must come to terms. The relation in which the passage of things in the external world stands to the velocity of thought, for example, is evidently far different than is usually supposed by the act of rendering the two proportionate. The rate, complexity, quantity, &c of thought and being are evidently in these ways infinitely accelerable through progressive experience, will, making ideal mechanical minds and beings, &c; I use the word "infinitely" very deliberately since it would seem to exactly correspond to what is possible and actual. The most interesting conclusion extractable from this ramifying discussion, itself infinite, would seem to be that the rate of mental and ontic evolution of beings a little beyond us in past or future history might well have such exponential characteristics and inexhaustible potentialities that time as we know it--whether truly linear or pseudolinear (both are possible)--may subjectively for these beings slow to limit rates of zero, become infinitesimal in rate; so the galaxy and phanerocosm may in this way be temporally punctured with beings who, attaining man's technical level, almost instantly fade from our world by, paradoxically, engulfing eternity or discovering, like William Blake, that eternity exists within any instant, a nirvanic state admittedly quite beyond our modern comprehension. It is a little like our isochronic world undergoes a Lorentzian time-retardation and infinite redshifting from the transient standpoint of these asymptotic beings. Therefore it may happen that our universe is voiceless for the simple reason that supracritically advanced beings almost instantaneously pass from it mathematically, and now populate the universe, as mute as nature, of indefinite, and perhaps infinite, number. Who these beings are, and where they are, and what they are doing, and why, may be questions as unanswerable or curious as whether a photon on the heels of a photon can ever overtake its ideal. It was the great accomplishment of fin-de-siècle mathematics to realize that bigger numbers than infinity are possible; it may be the great accomplishment of 20th century physics to realize the role these numbers play in the nature of things. Even if one assumes a far slighter, finite, and single-stepped augmentation of being--say its acceleration by a factor of a quadrillion, 10^{15}, which seems quite conservative in view of what has been said--as more or less universally characterizing the transition undergone by beings a few decades or centuries ahead of us technically, and hypothetically confining these beings for, say, 1 megennium, their consequent ontological distance from us might relegate us to the same meaningless background, for practical purpose, as that just considered for infinitely more superior, or absolutely transcendent, beings and cultures. Northerners and urbanites find themselves contemptuously impatient with the drawling speech and leisurely ways of Southerners and rustics, yet the ratio of behavioral rates alienating these groups from each other is near unity; what would it mean if a being on another star, thinking or living 10^{15} X as fast as do we, saw us immobile beings from afar, our efforts to communicate or receive, our culture 10^{-15}-10^{-19} as old as his or he, would he be likely to more than glance at us? Assume a being on another star so much faster still that not 2 of our star's photons reach him in the course of his day--would we nonexistent beings be of use or interest to him? The highly parallel and indefinitely accelerated minds I entertained the vision of above would derive their independence of the rate of the external world, at least as we perceive it, from the pluralistic operation

of their material bases and memories alike: the complexity attainable in this way, as I suggested, could be infinite, in part because there is a chance (and it is a good one) that the interactions between any 2 pieces of the universe are instantaneously infinite, that time is dense in the sense of the interchangeability of any interval of the continuous line in mathematics with any part of that line including the line viewed as an entirety, and that nature is thus topologically infinite; such infinite texture and contexture in nature may disclose its infinite information to, or be reorganizable by, a mind consisting of many parts evolving in parallel and prosecuting infinite series. Assuming nature is this way, and permits infinite or superinfinite progress, it may develop as an ironic consequence that, in effect, "2 pieces of infinity are the same", that the eternal and infinite civilizable capacity of 10-100 years on Earth viewed from the standpoint of a hyperaccelerated or "subtemporal" being might be without importance to a being or civilization having discovered an infinity of internal time and possibility, an autocosmic world topologically equivalent to our overextended and infinitely vulgar view of nature, destiny, and extrasolian life. Apparently the basic question virtually is, Who is God? What does he do? We may be a little too ambitious at this stage in our life as a civilization. Any neighbors may have "long since" dropped into infinity.

Another question is as to what set of problems, concerns, importances, tasks, wishes, expectations, &rc would suffice to critically absorb an antecedent civilization's attention at a technical &r cultural stage not far beyond ourselves? It is entirely possible that the abundance, rate of evolution, &rc of these things could as a rule or law absorb the whole interest and the complete destiny--at least from our standpoint--of such civilizations, even regardless of the number and diversity of their individual beings, and do so either wrongly or rightly in consideration of supposed neglect of the possibilities of interstellar communication, travel, engineering, conquest, &c. One might suppose this statistically improbable in that a few civilizations or individuals should almost by force of chance orthogonally diverge from the rest and attempt these things in the results of which we are interested, particularly the intercommunication of the galaxy and universe, and their extensive use. In reply, the possibility exists that a multiplicity of individuals is a characteristic of technical "civilizations" only for the briefest moment in their initial development, invariably yielding to superorganisms composed of individuals fully unified mentally or physically, or to the absence, mereologically, of anything describable as individuals (perhaps because of extraordinary mental, physical, functional, &rc diversity, unity, &r overlapping); it is possible, and I think probable, that quickly in the future history of technical civilizations: such individuals cease to exist and are as a totality replaced by a single all-encompassing mentality or civilizational individual, and subsequently even this individual ceases to exist in the act of giving way to a type of "Being" almost undefinable by ourselves. This latter, quasi final, Being might perhaps be continuously distributed in time, space, purpose, &c; be, paradoxically, as pluralistic as possible, tending to become and function as a infinite universe of conscious and purposive atoms, "individuals" incalculably "smaller" than ourselves and perhaps genuinely infinitesimal, and yet overall and individually as self-conscious, distinct, &c as possible; have, paradoxically, virtually no image of itself, no suggestion of bounded identity and specific purpose; might perhaps find or seem to find its ultimate destiny in an ultimate fusion with nature, a wedding of matter and spirit, finity and infinity, &c; having no passing and bounded moment of consciousness, as do

we, it might simply cumulate, endlessly growing in size as an endless self-examining and pulchritudinous instant, an endless exercise by memory of memory, &c; and yet it might involve an interminable condivergent refinement of a single ever-developing, never-emerging purpose. Much more could be said or surmised about this future Being which may inhabit in some sense the galaxy and universe, but the subject really is impossible for us to understand. I have mentioned such singular being in order to counter the statistical argument presented above, since the unity of such being, or any early approximation to it, might destroy the statistical argument that individual variation should of necessity produce individuals who, even in the most advanced civilizations, should make successful efforts to communicate with their kind and perhaps, if only accidentally, ourselves, or produce individuals whose scale &r kind of enterprise should give artificial signs of itself such as we have yet to find and may never come across. Further, as to the diversity of civilizations themselves, even if the universal course of civilizations is not orthogenetic so that it terminates in the unimaginable Being just sketched, that very Being might so readily recruit all emergent civilizations into its way of life or as an indistinct part of its very being that we will have lost them, too; of course, in this latter case an urgent or patient Being may be what we listening men will soon discover or yield to ourselves.

If, as I think, existential possibilities are infinite, superinfinite, &rc, then any emerging technical civilization just beyond us, by chance, may experience, in effect, a discovery of itself, a sudden realization of these possibilities, and in that matinal moment a furious reorientation to, and pure concentration upon, these transcendental possibilities. The point is that these possibilities would be quite enough to distract it from, and cause it to utterly abandon, any previous program to transmit signs of itself to other galactic beings.

Is it possible that the direction of intelligence is one of endless self-miniaturization, as suggested above, for the sake of ever-greater density, velocity of thought and being, farming of the universe, infinities within infinitesimals, &rc, and that in this way the universe as we know it is but an arbitrary point on a bidirectionally infinite road of time traversed by endless generations of self-miniaturizing beings so that our own destiny will likewise be to diminish ourselves by refining our universe and originate in this way the world--and possibly the beings--about us and that we are? This would be a queer but very reasonable destiny; very reasonable, that is, when laid beside all other imaginations of our ultimate destiny reasonable in terms of circumstances inarguably queer.

WHICH WOULD ULTIMATELY BE A BETTER PLACE TO LIVE: ON EARTH OR IN THE SUN? (A SERIOCOMIC JEU D'ESPRIT)

A fair idea might be had by tossing a coin into the air: heads for the center of the Sun and tails for the surface of the Earth. The point is that we really cannot know on the basis of current knowledge and preferences. By the time it becomes possible for us to inhabit the Sun--and the time will come--it may be that we or our distant offspring will be indifferent to the choice or greatly prefer a habitat which presently seems the most intolerant of life, an "antihabitat".

Why the Sun might be Ideal for Life

1. There is plenty going on.
2. The interior of the Sun is more interesting than the surface of the Earth.
3. More energy is available.
4. Life there will be closer to the source of energy.
5. There is more room in the Sun than on Earth.
6. Natural phenomena may be more complex than on Earth.
7. There is more matter (eg higher density) in the Sun than on Earth.
8. Certain living processes may only be possible at the high temperatures found within the Sun: the Earth may be far too cold to support "life".
9. Certain living, chemical, physical, and other processes may only be possible on the basis of the extreme pressures found at the center of the Sun or other stars; nuclear or seminuclear processes possible or natural there may be far more intricate than any possible with matter limited to weak, vague, and sluggish electron shells, for example.
10. Rates of interaction may be infinitely higher in the Sun, or insufferably snailish on Earth.
11. The Sun's interior may be vastly more plastic and intellectually orderable than the milieu of the Earth.
12. The thermal gradient, or vertical "river of" entropy, is far steeper in the Sun than in the Earth; it may be this increase of entropy that underlies natural differentiation and evolution, or what is possible technologically and "industrially".
13. Most life in the Universe may exist within, not between, stars; Terran life may be an insignificant fragment of the Sun's. Even that life which evolves in extrastellar milieus, say on planets, may find its universal destiny within friendly stars.

Why the Earth might be Ideal for Life

1. Right chemicals for any life are confined to it.
2. Neither too hot nor too cold.
3. Not too radioactive, magnetic, violent, electrical, dense, gravitational, changing, complex, uniform, &c.
4. Allows many states of matter (solids, liquids, gases, and plasmas) to coexist and interact.
5. Permits the slow reorganization and evolution of matter.
6. Suitably bidimensional and environmentally sharp-edged.
7. Chance precedents.
8. May have changed, and change, more drastically with time than the Sun.
9. It might be that it only seems so to human beings so far blind to utterly unfamiliar chemistries, biologies, percepts, concepts, mathematics, &rc such as may characterize what exists on and within the Sun.

The objection that conditions adequate or superior for life existing within the Sun would since have bred life transcending man, adventuring beyond the Sun, and preempting life on Earth, is imperfect since it fails to solve the equal, related, and inseperable mystery of why life beyond the Solar System has not done the same.

PURPOSES OF THIS BOOK

1. To constitute the best, and an exhaustive, book on the future of space.
2. To make the perfect case for and against space.
3. To be eminently fair.
4. To list all possible events in the future of space.
5. To supply these with some sort of ordering and thereby create something of a calendar for what will happen in space by 2176 and beyond.
6. To list all sorts of events which may be critical for what man does in space by functioning as positive and negative catalysts, &c.
7. To treat distant and fantastic possibilities.
8. To present many convincing pictures for how space may develop.
9. To show that life in space may be as meritorious as life on Earth.
10. To show the impact on man of going into space.
11. To attempt to foresee what will be found on other planets and what will develop, generally, in space.
12. To define the economics of space.
13. To justify short-term accomplishments in space by relating them to greater things that will eventually result and to a big picture of what space will finally become.
14. To furnish future possibilities in space with a useful vocabulary.
15. To suggest new engineering possibilities.
16. To provide a plan for how space should be investigated and develop.
17. To allow better selection of alternative possibilities.
18. To, in effect, supply future spacial civilization with a voice in the self-centered present.
19. To show how science and technology will go on developing in a drastic way.
20. To make the case for and against spacial industries.
21. To depict the possibilities for man's continued exponential development.
22. To provide an outline and handbook for further discussion, research, analysis, synthesis, and projection, and a guide for simple action.
23. To crystallize everyone's vague thinking about the future of space.
24. To ignite a new interest in the development of space, to restore its support, and to enlarge the undertaking.

THE FUTURE OF SPACE: Outlinear Plan for the Book

1. Pithy calendar of events: 300 or more.
2. Annotated version of same.
3. List and discussion of all possible breaks, thresholds, inflections, triggers, and catalysts in the future of Spacial development.
4. 7 subject calendars.
5. Brown's moderate but retarded scenario.
6. Critique thereof.
7. A moderate but sustained (vigorous) scenario: 8 quarters and 10 parts.
8. Critique thereof.
9. An optimistic scenario.
10. A maximal, revolutionary, surprising, facilitated, explosive, and exhaustive scenario.
11. Comments on the set of scenari.
12. Pronatalist arguments.
13. Maximalist arguments.
14. A new view of nature, physics, and cosmology.
15. The future of astronomy.
16. The growth of science.
17. Present and future economics of Space; ultimate deflations.
18. Solian Civilization and the next bicentennium.
19. Ontology: mechanical intelligence, superintelligence, and beings.
20. Life elsewhere in the universe.
21. Interstellar travel.
22. Spacial colonization: basis, life, reasons, parities and advantages to Earth, &c.
23. Spacial exploration and development as a self-justifying and elevating romance.
24. Criticism of others' views of the future of Space.
25. List and discussion of all key and interesting questions.
26. The future of human wealth, sociology, politics, and purpose.
27. Spacial touristry: scenari, takeoffs, growth, maxima, raisons d'etre, bases, assumptions, effects, alternative costs, loci, environments, stages, counterarguments, directions, comparisons, &c.
28. Nature of human values and an enumeration thereof.
29. Aleatory possibilities.
30. Natural and technical aspects of the future of perception and communication.
31. Economic, technical, social, &c spinoffs from Space, especially on Earth.
32. A glossary of terms used and proposed.
33. An appropriate long-term, comprehensive, integrated, and self-justifying program for American &r World exploration and development of Space.
34. 20-50 new technological and engineering proposals of the author.
35. Criticism and defense of alternatives to Space.
36. Quantitative scenari of the future of Space.
37. Artistic aspects of Space: an aesthetic scenario.
38. Reviews of and comments on the book by others, and the author's recommentary.
39. The prognosticability of the future.
40. Introduction.
41. Outline.
42. The proper presentation of Space to Terran publics: billing, reportage, enjoyment.
43. Arguments for progress.
44. Technical objects of Spacial enterprise: absolute minima and maxima.
45. The autocatalytic nature of the Spacial enterprise.
46. Further schematization of the future of Space that is possible and appropriate.
47. The need for vision.

THE VALUES OF SPACE

A justification for virtue and excellence.
Mystery.
Grandeur.
Excitement.
Adventure.
Challenge.
Beauty.
Scientific curiosity.
Profit.
Fun.
Daring.
Escape.
Imagination.
Inspiration.
Maintenance of frontier.
Human diversity.
Nobility of thought.
Unusual setting.
Human mixing.
Social experimentation.
Social segregation.
Political innovation.
Political independence.
Freedom.
Life purpose and direction.
A cause.
A sense of the miraculous.
A counterpole to life on Earth.
A clean and fresh existence; a new civilization.
An external and unifying challenge.
An alternative to Earth.
A protection against disaster on Earth.
A fabric of human purpose and a program.
Privacy.
Novel community and cooperation.
Pride of human accomplishment and capability, personal role, transcendence of nature, complete artificiality of environment and support, ethnic distinction, meaningful life, use of intellect and ability, independence, enlarging goals, contribution to posterities, proven faith and determination, pioneering spirit, architectic role, satisfied life, concertion, &c.
Zenithal ambition.
Familial cohesion.
Distraction from neurotic concerns, trivia, self, others, a static future, smug and closed life, a dead present, a nihilistic and effete zeitgeist, an unchallenging life, a rotting or seemingly rotting world, and other human discontent and unhappiness.
Peaceful, creative, and constructive existence.
Enterprise.
Distance from things.
Quiet, loneliness, thought, dream, wonder.
Distinction and identity.
A quest.
Meaning.
Discovery.
Innovation.
Self-sufficiency.
Expanded being.

SOME BASES OF VALUES OF SPACE (Cf. list)

A justification for virtue and excellence.
Engineering. Cooperation. Synergism. Mutual understanding. Redemptive opportunity. Consequences of virtue manifest. Right path plain. Need for best. Need for objectivistic scientists, engineers, administrators, &c. Detailed meritocracy. Spirit of things. Sense of dependent posterities. Evolutionary orientation. Expanding and expansible means. Interdependence. Individualistic generosity and perfectionism. Innumerable opportunities for divergent and complementary excellence. External adversary and reference. Magic and humor of the whole enterprise. Conspiracy of mankind. Objective instead of subjective life.

Mystery. Development's course and climaxes. Many mountains over the horizon. Whole new world. Open universe. Discrepancy with past experience. Religious significance. Aesthetic mystery. Openness and flux of human possibility. Hyperbolic future. Interrelatedness of things bared by substitution of a new network. Uncertainty and possibility in everything. Imagination, conception, memory, pure possibility, creativity, preference, &c extremely important. Tininess and promise of man's ways bared. Infinite complexity of other planets encountered. New and renewed philosophic questions. Astronomic, geological, chemical, meteorological, biological, economic, &c mysteries. Inherent mystery of universe and nature reemphasized. Infinite scenarios. Constant social flux. Uncertainty on all time scales: next second, next day, next week, next month, next year, next decade next century, &c. Everything in the world in motion, transformation, growth, progress, uncertainty, reexamination, brilliant light, mutual drift, &c.

Grandeur. Human number, wealth, purpose, possibility, interrelation, complexity, &c. Large and infinite future. Size of Space. Size, complexity, novel beauty, &c of planets. Times, velocities, energies, scales, difficulties, dangers, prospects, &c. Arbitrarily huge colonies built by man; worlds. Expansibility and variegability of humanity by many orders of mankind. Stapledonian future of culture. Endless realms of possibility. Inexhaustible potentialities, implications, consequences, challenges, importances of what one does, &c. A self-conscious humanity. Human cooperation. Velocity and scale of undertakings. Explosive science, technology, wealth, world complexity, &c. Infinitized meaning, extensively and intensively. Scenes in nature utterly transcending any on Earth. New means for seeing and comprehending a world as a whole. New means for doing things on an unbelievable scale of size, complexity, &c. Emerging Solian Civilization. The extrasolian stars, galaxy, universe, and beyond. The web of all beings everywhere in the universe: the promise of universal intelligence. The infinite expansibility of undertakings. The infinite meaning of the future. New questions about God, purpose, nature, &c. A view over the Earth, the Earth dwarfed, the Sun viewed, the stars beyond, &c.

Excitement. Growth. Change. Possibility. New lives. New questions. New freedoms. New obligations. New enterprises. Continuous emergence of tomorrow. The future planned and built. The challenge of whole new worlds. New importance of everyone. Everything being created. Everything being perfected. Enormous food for thought. Human conspiracy. All nations, all organizations, all people, all purposes, all goals, all resources, all of nature, all ideas, &c. Innumerable historical events. Innumerable key days. Anticipated developments. Explained actions. Doing the impossible, unlikely, disbelieved, controversial, strange, exotic, &c. Frontiers. Horizons. Dangers. Accidents. Surprises. Gambles. Initiatives. Pride, hope, love, nostalgia, determination, conflict, decision, experimentation, development, transcendence, competition, triumph, heroics, idealism, messianism, mystery, the delights of accomplishment, wishes, directed desires, unconscious stirrings, hurry, busyness, friendliness, universal humility, liberality, mutual understanding, received and created heritage, possible profit, expanding wealth and opportunity, new emphasis on work, work and play integrated, schooling meaningful, &c.

THE PROPER TREATMENT OF THE LIST, SPACE EVENTS YET TO BE DATED

1. General deployment of space defense (eg interceptive or retaliatory lasers).
    1. Probable range of date(s) of actual occurrence.
    2. Probable range of date(s) of feasibility.
    3. Absolute probability (for various ranges of dates).
    4. Desirability (eg for space, mankind, programs, eschatologies, &rc).
    5. Accelerability (under various conditions).
    6. Importance (in various terms and for various ranges, social and economic value, &
    7. Complexity (eg is this a nonsimple event?).
    8. Implications (eg of its being feasible, for other events, for society, &c).
    9. Interconnexions (with events listed or unlisted here).
    10. Contradictions (with possible events).
    11. Priority (ranked importance, in various terms).
    12. Ranking (on various scales, eg esp a scale of importance).
    13. Preconditions and assumptions (eg scientific, technical, programmatic, social, &c)
    14. Order (regardless of specific dating, the continuous or discrete chronologies of this event or its subsevents).
    15. Equivalence (eg substitutability for or common generality with other listed or unlisted events).
    16. Hierarchy (various arboreal structures, both within and between events, eg decision-trees, trees of presumptions and conditions, &c).
    17. Summary exposition and final discussion.

The above breakdown should give some idea as to how the list should be treated. Were this done, professionally and carefully, for every item, an exposition of the promise of space would directly or could subsequently result surpassing, greatly, any previously existing, and serving as the definitive basis for future discussion of space (with the framework being expanded, completed, refined, and subjected to wide appraisal by everyone, including leaders, in the field or out of it). Real planning or projection of the future is almost impossible, and certainly is very difficult, in the absence of some simultaneous coverage of alternative, interrelated, basic ordered, well-managed, contextual, comprehensive, critical, &c possibilities. Since this has never been done (certainly never published) for space, the future, value, &c of space is to that (large) degree vague and unorganized, a situation that possibly in part accounts for the difficulties national space programs have encountered. Also, it is possible that there is some tremendous advantage to being totally honest, in the long run or covertly.

Engineers, physicists, mathematicians, administrators, economists, politicians, &c should contribute their systematic review to the initial and treated list. In particular, the events should be characterized in terms of research, development, project characteristics, and applications, individually and as a set of items.

Combined with all this, it is extremely important to have some historical review of the standard and exceptional course of past scientific and technological projects and events, the tendency of professional people to err (eg by underestimates and overestimates, by affirmations and denials of absolute feasibility or probable value or inevitability, re economics, &c), of the sensitivity of events to external developments, of the accelerability of events, &c.

My suggestion is that an informal or formal conference be called at Hudson to examine the list at some stage in technical, economic, social, Hudson, programmatic, and other terms. What contribution can individuals in or outside Hudson make to individual items (in which their interest or competence lies)? What relation should Hudson's contribution to NASA's "Outlook For Space" have to the items on the list, eg should the list as a whole be made something of the foundation or framework of Hudson's project? How important and therefore serious should this activity of Hudson's be?

EVENT NO. 30: INTRAJOVIAN PROBE

Complexity, ie is this a nonsimple event?

1. Balloon, glider, airplane, helicopter, jetplane, spaceplane (2-way), &c.
2. Robotic v manned.
3. Successive depth.
4. Experimental v staged v final and perfect phases.
5. Unstaged v multistaged craft.
6. Multiheaded independently targeted.
7. Predestined or guided (robot, or men aboard, in orbit, or on Earth).
8. Hours v days v months v years v permanently within the atmosphere.
9. Static (floating) or dynamic (longitude, latitude, &r depth).

Things to be researched (instead of each other or together).

1. Extra-atmospheric, atmospheric, oceanic, and solid vertical structure.
    1. Temperature.
    2. Composition.
    3. Barometer/density.
    4. In/homogeneity.
    5. Stratification.
    6. Time variation, random and patterned.
    7. Chemical activity.
        1. Type of reaction.
        2. Effects.
        3. Causes.
        4. Time variations.
        5. Scale.
        6. Energy source.
        7. Heat liberated.
        8. Endothermicity v exothermicity.
        9. Ir/reversibility.
        10. Sequences, trees, and cycles.
        11. Phasicity.
        12. Molar structure (ie macromolecular to microscopic to macroscopic to planetary: d 10^{-8}_m-10^{8}_m = 10^{16}; v $10^{-24}_{m^3}$-$10^{24}_{m^3}$ = 10^{48}).
        13. Etc.
    8. Distribution of minerals and chemicals.
    9. Distribution of elements.
    10. Events, phenomena, history, and systems.
    11. Structure (d 10^{-10}_m-10^{8}_m; v $10^{-30}_{m^3}$-$10^{24}_{m^3}$).
    12. Material (nonatomic, eg electronic and protonic) v energic (photonic...? magnetic, sonic, thermal, &c) structure.
    13. Dynamic v static, and transformational.
    14. Entropy.
    15. "Punctal" and "holic" measurements (various senses, spectra, &c): "sensations".
    16. "Perceptions": flat v stereoscopic v holographic, planetary v macroscopic v microscopic, various "senses", variously passive v active, complete intensity range, and so on ad infinitum.
    17. Samples of matter returned to men.
    18. Taxonomy.
    19. Appropriate representations.
2. Ditto for horizontal structure.
    1. Longitudinal.
    2. Latitudinal.
        1. Boreal v austral differences.
        2. 90^{o}N-90^{o}S.

3. Overall structure.
4. Biology (if any).
5. Level of knowledge.
    1. Data.
    2. "Picture".
    3. Understanding.
    4. Absolute comprehension.
    5. Prediction and retrodiction (10^{-18}s-10^{17}s).
    6. Grasping of entire "possibilistic structure" (branching, anastomosis, symmetry, asymmetry, total evolution, "gonohomy", holism, entire range of deterministic weighting, &c).
6. Evaluation for, and execution of, any and all exploration, investigations (graphing and experiments), determinations (eg economics), &c.
    1. Economics.
        1. Quantitative wealth.
            1. Thing.
            2. Amount.
            3. Form.
            4. Quality.
        2. Wealth value.
            1. Gross.
            2. Net.
        3. Wealth uses.
        4. Modes, research and development requirements, systems, schedules, &c of mining.
        5. Usable energies.
        6. Scales required to pay.
        7. Dates paying.
        8. Adventurous value and possible exploratory discoveries.
7. Control.
8. Exploitation (in fact).
9. Illustrative and important examples of particular subevents.

Main interests.

1. Is/was Jupiter a star?
2. What is the Red Spot and what is it like?
3. Has Jupiter any solid core? What size and composition?
4. What underlies Jupiter's enormous electromagnetic efflux? The electromagnetic, weak, strong, &r gravitational force?
5. Chemical heterogeneity and novelty.
6. Jupiter's magnetic asymmetries.
7. Composition.
8. "Geomorphology".

Preconditions and assumptions.

1. Turbulence, "noise", pressure, heat, radioactivity, chemistry, electricity, magnetism, &c nondestructive or surmountable.
2. No guidance problems.
3. Planet complex and not simple, or vice versa; complexity manageable.
4. Mars event must precede.
5. Perijovian space explored and occupied (and developed? bases on Asteroids, Jovian moons, or in Jovian orbits?).
6. "X" number of men.
7. Automation sufficient.
8. Wealth, value, profitability, and "ease" of business and industrial development?
9. Appropriate probe size.
10. Probe complexity.
11. Transmission back into space possible.

12. Cost-efficiency of sundry determinations.
13. Knowledge and device research and development requirements.
14. Probe research and development, and testing.

Implications.

1. For other jovian planets.
2. For subjovian planets.
3. Possible discoveries...
4. Comparative planetology, including geological and meteorological determinations.
5. Star formation, nature of solar system(s).
6. Cosmic distribution of elements.

Desirability.

1. Human adventure.
2. Exploitability.
3. Feasibility.
4. Priority.
5. Scientific value.
6. Challenge.
7. Cost, danger, conflict with other opportunities, difficulty.
8. Imminence of profit.
9. Probability.
10. Substitution.
11. In/essentiality.
12. Range of possible impacts (scenari).

EVENT NO. 13: FIRST DISCOVERY OF EXTRATERRESTRIAL LIFE

Nature.
1. Indication.
    1. Locus visited by probe, robots, or men directly or nearby, un/permanently.
        1. Vacuum prior to orbit.
        2. Vacuum but in orbit
        3. Atmosphere.
        4. Land or sea.
    Locus.
        1. Solar system.
            1. Jovian planets.
            2. Nonjovian planets.
            3. Satellites, asteroids, comets, "clouds", &c.
            4. Sun.
        2. Transplutonian.
            1. Interstellar.
            2. Vicinity of a nearby star.
                1. Terrestrial planet.
                2. Nonterrestrial planet.
                3. Artificial construction.
                4. Etc.
            3. Elsewhere in Milky Way galaxy.
                1. Vicinity of a star.
                2. Interstellar space.
                3. Galactic "center".
            4. Extragalactic.
                1. Intergalactic.
                2. Other galaxy.
                3. Distant universe.
    2. Received communication.
        1. Unambiguous.
        2. Ambiguous.
            1. Sign.
            2. Symbol.
            3. Message.
            4. "Traffic".
    3. Received transportation.
        1. Message.
        2. Mechanical being.
        3. Biological being.
        4. Explorer.
        5. Developer.
        6. Populator.
        7. Soldier.
        8. Conqueror.
        9. Undirected ambassador.
        10. Sol-directed ambassador.
        11. Present (eg materials, knowledge, culture, advice, laws, gesture, map, back-communicator or back-transporter, &rc).
    4. Astronomic observation.
        1. Spatial.
        2. Temporal.
    5. Biological, physical, philosophical &rc indication by Terrestrial theory &r experiment.
    6. Guess, belief, gamble, &c.
    7. Evidence of past visit to solar system.

2. Alternative forms, appearances, and other problems.
    1. Humanoid.
    2. Nonhumanoid.
    3. Not "mammal".
    4. Not "animal" or "plant" (differently, fused, or neither?).
    5. Not ribonucleic, proteic, &r the like.
    6. Not "genomic".
    7. Not "cellular".
    8. Microscopic, submicroscopic, &r megaloscopic (eg square/cubic kilo/miles).
    9. So lowly (eg "viral") as to be hard to distinguish from inanimate background.
    10. Not carbonaceous (eg based on another element such as silicon).
    11. Not chemical (eg electrical).
    12. Many or unique.
    13. Polymorphous.
    14. Too diverse &r plastic.
    15. Invisible.
    16. Immaterial (energetic, eg electromagnetic).
    17. "Incorporeal".
    18. Too fast/slow.
    19. Too complex.
    20. "Colonial" (eg like a web, cloud, sea, soil, or constellation).
    21. Too different mathematically.
    22. Irrecognizable by human gestalten (illusory).
    23. Quasi inert.
    24. Life-suspended.
    25. Too tenuous/dense.
    26. Disguised or evasive.
    27. Located in unusual loci/milieux (eg Jupiter's atmosphere, underground, in seeming vacua, on Sun, on neutron stars, on giant stars, in galactic center, on moribund stars, in Venus' 800°F atmosphere, on cryogenic Pluto, in a planet's molten &r radioactive core, in interstellar or protostellar gas clouds, in QSOs, &c).
    28. Constituted of new/exotic matter &r energy.
    29. Extinct with/without trace.
    30. Transhuman ("angelic" or transcendent).
    31. Environmentally rare or isolated.
    32. Poisoned/repelled by human effects (eg biological, chemical, &r mental).
    33. Etc.

<u>Complexity or subdivision of the event</u>.

1. Equivocality of nature.
2. Danger of infecting Earth ("retroinoculation").
3. Danger of infecting the alien biosphere ("prosoinoculation"), or of changing, destroying, respeciating ("terrestrializing"), &rc it.
4. Number, diversity, and size of planets (eg huge and tridimensional Jupiter).
5. Insensitivity of probes.
6. Danger of premature or emotional conclusions (eg presumed total sterility and identity of other planets).
7. Parallel and serial competition of sensors, instruments, methods, hypotheses, theories, programs, schedules, sites, &c.
8. Anomalous higher-probability areas (eg upper-atmospheric and abyssal Jupiter, <u>other</u> jovian planets, vacant Mars, infernal Venus, satellitic Titan, raging Sun, minuscular and frigid comets, &rc).
9. Automability v need for/value of men.
10. <u>In situ</u> v Terran examination of samples, data, &r "pictures".

1. Simple v complex.
2. Unique v diverse.
3. Standard v novel.
4. High/low energy using.
5. Diminishing v continuing v increasing returns.
6. Repeated v unique experiments/tests.
7. Discovery/negation v description v "exhaustion" of life.
8. Examination v live/dead return of explant/organism(s).
9. Random v patterned investigation, in various senses.
10. High/low probability determinations (eg >0.01, >0.15, >0.5, >0.99).
11. Kindred reliability ranges.
12. Etc.

Implications: of its being feasible, for other events, for society, &c.

1. Life in Solar System and of other stars would imply each other.
2. Rate (non/linear)/kind/scale of space exploration/development/occupation moderately or greatly increasable.
3. Philosophic and religious consequences.
4. Human idealism and devotion to science changed.
5. Diverse possible aspects of interstellar communication.
    1. Sign v signal v message v intentional program of aliens v business/gossip/purpose.
    2. Culture v science.
    3. Intracommunal v intercommunal.
    4. Directed v random.
    5. Variously cryptographic v self-revealing ("phanerographic").
    6. Decipherable instantly or in a day/year/century/never.
    7. Key v dictionary v message.
    8. Sending civilization un/visualizable.
    9. Sending civilization un/like ourselves.
    10. Sending civilization not/near our mental/cultural level.
    11. Sender/sending civilization biological v mechanical.
    12. The communication hieroglyphic v artificial.
    13. The communication "mathematical" v "verbal" v "symbolic" v "aesthetic" v "theological" v&c.
    14. The communication dangerous v safe.
    15. The intercepted communication:
        1. Non/self-conscious.
        2. "Perfective" v "leisurely".
        3. Un/interested.
        4. Non/multiplex (re purpose, meaning, &rc).
        5. Strong v weak.
        6. Transmitted
            1. Filarly (cabled, in effect).
            2. Conically.
            3. Spherically (broadcast omnidirectionally).
        7. Being sent to some/all stars (or some/all galactic stars receiving).
    16. Rare/frequent/constant and ir/regular.
    17. Little v moderate v maximal.
    18. Interstellar, diagalactic, intergalactic, &r diacosmic.
    19. What is the density of messages/information from everywhere in the universe anywhere in the universe?
    20. Transportation v communication.
        1. At which points do these become equivalent?
        2. Should one look for transmissions or transportations from other stars (eg one might suppose the probability is that transhuman intelligence elsewhere in Milky Way civilized 10^{7}-10^{9}y before man and that it is natural for such life to embrace available territory, implying either that man is "primary" or that former life eons ago dispatched inductive or discoverable mechanisms to eg 10^{11} stars as preferable to immaterial communications, eg a la Arthur C. Clarke's "The Sentinel"

9. Quantity v quality v type v combinations.
10. Rapidity and thoroughness with which Solar System can be explored.
11. Rapidity and thoroughness with which Milky Way and Universe can be explored.
12. Overlap or substitutability of methods &c.
13. Epistemological needs.
14. Blind spots.
15. "Agnosiological" needs ("agnosiology" is the dedicated charting of our ignorance).
16. Terran laboratory/&r theory capability for estimating probability/distribution/quantity/&rc, &r describing, other planetary and stellar life.
17. Progress in the field of cellular automata.
18. Quotient of things remaining to be done.
19. Combinability of the search for life with other spacial and terrestrial purposes.
21. The sending civilization being
    1. Progressive/static.
    2. Extrovert/introvert.
    3. Expansive/self-directed/"mentalistic".
    4. Homogeneous/heterogeneous.
    5. Etc.

Accelerability (under various conditions).

1. Current technology and science evaluated in terms of
    1. Adequacy.
    2. Amplifiability.
    3. Diversifiability.
    4. Naivete.
    5. Primitivism.
    6. Cost v price.
    7. Progressability.
    8. Transcendability.
    9. Peculiarity v universality.
    10. Understood power.
    11. Etc.
2. Mis/understood importance of the event.
3. Criticalness of certain
    1. Examinatory loci.
    2. Hypotheses.
    3. Theories.
    4. Criteria.
    5. Media.
    6. Frequencies.
    7. Analytical means.
    8. "Sequences and branches".
    9. Powers/sensitivities.
    10. Stochastics/systems/exhaustions/persistences.
    11. Spatial resolutions.
    12. Temporal resolutions.
    13. Capacities (eg need for "astronomical" data processing).
    14. Logical power.
    15. Expectations.
    16. Irredundancy of search.
    17. Imagination.
    18. Etc.
4. Inaccelerability.
5. US/world.
6. 1975/future.
7. Large/small fraction of GNP/GWP.
8. Empirism v theorism v mix v experimentalism.

Desirability: for space, mankind, programs, eschatologies, &rc.

1. Interstellar character and consequences.
    1. Friendliness, enthusiasm, allocentrism, perfection, assistance, &rc.
    2. Enmity (greed, intolerance, xenophobia, disdain, &rc).
    3. Insanity.
    4. Pathology.
    5. Survival and triumph of the worst.
    6. Irrelevance (eg diversity, spontaneity, "childhood", ignorance, graduality, &c being themselves good or primary).
    7. &rc.
2. Conflict with other spacial and terrestrial purposes.
3. Returns from one, many, or almost infinitely many civilizations 10^2-10^{10}y in advance of us.
    1. Historiological and culturological (how civilizations develop, change, proceed, fail, differ, operate, and culminate).
    2. Eschatological.
    3. Technological.
    4. Scientific.
    5. Cultural (aesthetic, axiological, ethical, sociopolitical, &c).
    6. Intercultural (exchanges, commerce, collaboration, &c).
    7. Inspiration.
        1. From the undertaking.
        2. From the success.
        3. From the opened vistas.
4. Maintenance or enlargement of man's involvement in space, generally, regardless of success or consequences of success.
5. Relative and absolute inexpensiveness of some means for conducting such an inquiry.
6. Justifiedness, despite probabilities of success from 0.8 to 10^{-9}, owing to the possible or probable radicality or sheer magnitude (eg sooner or later increasing human wealth, knowledge, understanding, technology, wisdom, excellence, possibility, endeavor, meaning, security, &rc by a factor of 2 to 10^{20}) of beneficial consequences.
7. The eschatological or deontological need to know our galactic and cosmic uniquity, importance, role, &rc.
8. Broadening and intensification of our biological understanding (eg of the nature, circumstances, and laws of any life).
9. Application of "exobiota" to food, materials, planetary engineering, and other purposes both in space and on Earth.
10. The need to discover, describe, stabilize, &rc any alien biota and ecologies in Solar System before they are destroyed, buried, disturbed, despeciated, or otherwise altered inadvertently or carelessly by human intrusion and enterprise; obversely, the value of finally proving or disproving the existence of life by enabling the removal of costly precautions and researches, or of measuring the possible or essential need for protections against direct threats to men or mankind (eg "retroinoculative").
11. Determination of the biological role in the natural appearance and dynamics of planets (eg whether or to what extent the Terran atmosphere, geomorphology, soil, hydrosphere, climatology, &rc were originated, or are maintained, by life; whether Jupiter appears as she does for biochemical or biological reasons; whether Venus &r Mars exemplify azoic planets).
12. Need for positive (life confirming or life negating) results to guide Earth's larger exobiological program.



QUESTIONS REGARDING MINING OF THE SOLAR SYSTEM

1. How is the greater structure and composition of any and all extraterrestrial planetaries apt, probably or possibly, to differ from the mining situation on Earth, now and in the future (10, 25, 50, 75, 100, 150... years hence)?
2. Relative to Earth, how accessible are minerals apt to be on these bodies?
3. What massive deposits are we apt to find on these planetaries?
4. What small but precious deposits, equally competitive?
5. To what extent are there alleged, possible, or probable present or future resources shortages, or noncompetitive situations, on Earth?
6. To what extent is Terrestrial wealth competitively enlargeable by further survey using old/future methods in un/usual areas, greater energy, old/future methods of extraction/synthesis/use, resource substitution or omission, &c?
7. At what dates in the future, if ever, are shortages or enhanced (general or special) needs apt to favor/require space exploitation?
8. Were transport, and its supplying industries, subsidized, what economies involving space exploitation could be worked in the economy overall, since the present system of costs is not, in these terms, absolute, nor even perfectly efficient?
9. What costs would be involved in mining various planetaries given current or future (reflecting economies of scale) costs of transport and all other operations?
10. Might government or other loans play a critical role in amortizing very long-term development of space?
11. Who is willing to take what risks?
12. Is the solar system apt to be fractionated in any ideal ways?
13. To what extent must complete industry exist self-sufficiently in space (eg producing building materials, energies, air, food, fuel, manufactures, &c, supporting colonies, supporting large-scale exploration and shipment, &c)?
14. How deceptive is the moon apt to be? How critical for initial mining?
15. To what extent should initial/later mining serve space/Terrestrial purposes?
16. To what extent can/should space mining development be accelerated?
17. How easily can the solar system be surveyed for an indication of its wealth?
18. How much mining, in dollars/tons, is apt to occur 20, 40, 60... years hence?
19. What methods would presumably be suitable for mining other planetaries? To what extent can methods currently used on Earth be used in space? Are there any methods which could be used in space, but cannot be used on Earth, which might make space competitive (eg certain large-scale, violent, wasteful, &c methods)?
20. Are there any ideas which seem to render nonsensical the mining of space?
21. Who is apt to mine space?
22. How important is space mining relative to other space purposes?

DIMENSIONS OF AN IDEAL SPACE DRIVE

1. Specializability.
2. Maximal reliability.
3. Maximal cheapness of fuel &r ship.
4. Versatility (i.a., intraspacial, Earth-space, aerospace, interstellar; accelerability cum decelerability; all sorts of ships (eg all sizes: 10^{-2}-10^{6} tn), missions, devices (eg "mass driver"), loci, &c; &c).
5. Controllability (efficiency, rapidity, variability (range), &c of control).
6. Most self-exhaustive fuel (minimal waste).
7. Maximal momentum per particle of exhaust (and eg greatest relativistic energy, closest to c for all exhaust particles, &c).
8. Best access (eg deriving fuel from around the solar system, from natural space fluxes, &c).
9. Closeness to theoretical perfection (efficiency &c).
10. Directness (simplicity) of energy use.
11. Closeness to $E = mc^2$.
12. Greatest degree and largest range of power (maximal engine thrust).
13. Largest on-board power (if "loaded").
14. Longest flight duration capability.
15. Least wear, maintenance, difficulty of maintenance, &c.
16. Minimal human attention/crew/backup industry demand.
17. Greatest source reservoir.
18. Least external diseconomy (pollution, noise, hazard, damage, &c).
19. "Most ultimate".
20. Least "overhead" (operating machinery, measuring and guiding instruments, least launch and landing costs/backup, "least" (ie optimal) past R&D, least crew requirements, least piloting, &c).
21. Minimal volume and mass fraction of ship by fuel and engine.
22. "Best design".
23. "Most" understood, certain, fully certain, "calculated-out" and "tested-out", &c.
24. Most tappable for other energy needs.
25. Most complementary to other applied needs (eg briefest interplanetary flight-time, largest duty cycle, short and long trips, greatest on-trip speed-direction variation, &c).
26. Most "off-board" (eg using ground-based or interplanetary "basers", coupleable linear-motor tubes, solar energy, breathed air; any and all energies, matters, fields, and currents present in space; &c).

A WILDLY OPTIMISTIC SCENARIO

1976-2000: QUARTER I

1. US, USSR, PRC, UN, "ESRO" (Europe's NASA), Japan, Eastern Europe, and Brazil have all highly competitive programs and agencies by 2000, and many other nations "ride" on these (eg building but not launching their own satellites, receiving and paying for returns from Earth Resource satellites, adding members to international teams, in effect paying taxes to certain agencies, adding experiments and tasks to various missions, &c). There are many races in Space involving attempts by various parties to beat and outdo one another and dynamic one-upmanship. This competition extends beyond geosatellites to unmanned and manned Lunar expeditions and bases, prototypal Lagrangian colonies at L4 and L5, continuous and sizable "Skylabs" orbiting Earth, interplanetary expeditions, a base on Mars, a manned expedition to the asteroids, planetary science probes to all 9 planets, and a few active transplutonian probes.
2. Various intranational and transnational corporations very strongly participate in the activities of the preceding parties (in a thoroughly international and businesslike way), and 3 corporations actually have their own, largely independent programs (building or purchasing, and launching, their own satellites, "Spacelabs", and a manned Lunar expedition).
3. The world in this way budgets $120 B/y on Space by 2000.
4. Controlled, safe, ideal, simple, nonpolluting, cheap, easy-to-build, and surprisingly efficient fusion reactors are developed during the 1990's and play an important role in producing power for both developed and underdeveloped nations by 2000, a role accentuated by a tendency of the remarkable reactors to replace fission and fossil power and by production of power by fusion growing at a phenomenal rate in 2000. Simultaneously, doubt and antagonism existing in connexion with nuclear energy between 1970-85, spends itself in the subsequent years, particularly as fusion power emerges and proves abnormally safe and is affirmed by environmentalists as an ideal or at least acceptable alternative to fission and chemical energy, which come to be seen as both polluting and unsafe.
5. Industry proves that it need not pollute the environment or infringe on the public welfare by what it does, and that previous damage to the environment is reversible, and environmentalist forces strike more moderate and compromising stances as decades pass and the value of growth once again becomes obvious and an important human motivation. In fact, by 2000 the developed and developing countries as one begin to seem very seemly places despite heavy industry and sustained economic growth. This inconsistency is by itself sufficient to revolutionize fair-minded and, indeed, popular attitudes toward economic growth, technology, and Faustian goals, except in those blinded by ideology, whose role in things however declines by 2000. Partly these benign attitudes and reconciliations occur over the world because of a stubborn refusal by almost all underdeveloped countries to abandon the ideal of growth and of catching up with the--themselves progressive--more developed nations.
6. The energy crisis of the 1970's fades away as alternative sources of energy (coal, shale, solar, fission, fusion, &c) become competitive and important in nations' affairs, OPEC disintegrates and compromises, and the atmosphere of fear and uncertainty prevailing throughout the 1970's disappears.
7. The proliferation of nuclear weaponry among Nth countries, the exponential and autocatalytic expansion of military forces in Space, the evolution of baser defensive and offensive weaponry in Space, certain major military confrontations between the Great Powers before 2000, the advancement of various Spacial reconnaissance and surveillance systems and capabilities, the inducement to a military role provided by the expansion and diversification of the world's overall Spacial enterprise, &c, cause tremendous growth of the world's military investments in Space.

8. Light shuttles (carrying 50 tons payload) proliferate both in the US and USSR, and are built, owned, operated, and used by the many parties of Item #1 (certain corporations have their own shuttles). By 1990 a heavy shuttle (carrying 250 tons payload) is under development by 3 different parties, and by the time it becomes operational in 2000 there is under development a Third-Generational shuttle carrying 1,000 tons of payload.
9. Cost of orbiting a pound of payload falls to $20(1975) and is falling steadily in 2000.
10. 10^{8-11} watt lasers are used experimentally to power ships to low orbit by explosive ablation.
11. The instantaneous population of the Moon is 1,000 by 2000.
12. Major Lunar expeditions explore and survey the Moon, and set up semipermanent and permanent bases, by 1990. These expeditions, in combination with elaborate multrispectral scanning by lunisatellites launched in the late 1980's, discover and map major and directly exploitable mineral resources at various sites on the Moon.
13. The preceding sites are mined, with some extraction and shipment to Earth of unusually precious materials by 2000. Minerals taken from the Lunar soil are used to answer the needs of Lunar bases in 2000 for oxygen, hydrogen, construction materials, metals, glass, and agricultural media.
14. Virtually self-sufficient, albeit primitive, bases exist on the Moon in 2000, producing their own water, air, food, housing, and part of their fuels.
15. Despite the rapid advance of fusion power, solar energy is used in the production of immense quantities of power and in Space. By 2000 there is produced in Space from sunlight 10 gigawatts, using photovoltaic arrays and microwave conversion.
16. Several catoptrical balloons 1 mile in diameter are used on the Moon in 2000 for industrial purposes exploiting their intense foci directly.
17. Interest in O'Neill-type and other colonies in Space during the 1970's proves itself sincere and hearty by leading to plans and programs during the 1980's and actual construction of 2 colonies, one orbiting the Earth and the other at terrilunar L5, in the 1990's. Growing rapidly, these are inhabited by 750 men in 2000, and even by then prove to have been more than justified.
18. The undertaking, construction, and success of these fantastic colonies whets the appetite of many Terrans, and gives rise virtually overnight to numerous touristic enterprises on Earth, which become hot items on global stock markets. By 2000 1,000 men visit Space as tourist, obviously the very tip of a tidal wave.
19. Spectacular cinematography of Earth, the Moon, Mars, Jupiter, Saturn, Venus, the Sun, and Uranus is brought back to Earth and presented with tremendous drama, revolutionizing popular attitudes toward Space and exciting the world's incandescing imagination. Other worlds are made to seem not such dull places.
20. Two 12-man 6- and 12-month expeditions to the surface of Mars are successfully executed. A permanent base is established in order to receive teams on 6-month rotations. Mars proves a wonderfully exciting and quite unexpected place. Readily exploitable resources abound, there are plants, ice abounds at the poles and in deep permafrost, vulcanism exists as a natural source of energy, &c. The first base erects a 100-meter diameter plastic dome sheltering a permanent community in a comfortable atmosphere generated from Martian resources. Plans are made for early Martian colonization and exploitation. Millions of people on Earth are so enthusiastic as to be willing to emigrate to Mars at once. Politicians prove sympathetic to these minority desires.
21. Space regains high romantic, prestigious, glamorous, and heroic significance.
22. It is understood by 2000 that man is on the verge of initiating an extraterran civilization, and that 2000-2100 will be The Spacial Century.
23. The new fusion drives becoming operational before 2000 greatly reduce the cost and duration of interplanetary flight.

24. Living bacteria, worms, and finally 1-10 pound plants are discovered on Mars operating on the basis of chemistry and structure analogous to that on Earth but astonishingly different from a precise biological standpoint, and these differences of the scarce but nevertheless highly differentiated and diverse Martian microbiota, flora, and fauna quickly give rise to a lively interest among the scientific community on Earth to investigate the biology and ecology of Mars in great detail. The programs to explore Mars instantly expand, and the very early returns before 2000 are alone enormously informative. Efforts begin to exploit the Martian organisms as possible sources of air, food, and even water, and to breed new varieties in superior conditions. It is concluded almost at once that the discovery of life on bleak and seemingly lifeless Mars has multiplied enormously the chances for other life in the galaxy and universe. A new picture of a populous and evolutionary universe marks mankind.
25. Signals are received from another star which are without question artificial. Literally tens of thousands of technicians in many fields concert to decode the presumptive communications, which continue unabated. This discovery provides clues where to look for other such signals, and what to look for, and by 2000 no less than 4 transmissions are uncovered. Governments throughout the world, reflecting everyone's curiosity and excitement, allocate hundreds of millions of dollars to projects, facilities, and institutions dedicated to discovering, mapping, puzzling out, and, if possible, using extrasolian transmissions. As the characteristics of such transmissions are figured out it begins to seem that a large number of the stars in the Milky Way, perhaps millions, are sources of indefinite numbers of such communications, and there is great interest as to what this may mean about the full pattern of civilizations in the galaxy, and the distance of the nearest intelligent civilization to the Sun. For some reason no such communications are found within 250 light-years.
26. Earth's climate is found to be changing rapidly for the worst as a result of innumerable effects of industrial effluvia which previously went unnoticed, and other changes in the distribution of vegetation such as Brazilian deforestation. Extrapolation shows that within 25-50 years human health will be affected unless something is done. The catalysts seem to have caused some irreversible disequilibrium, however, so that their subsequent nonproduction is no solution to the problem. Within 3 years it is realized that global climate can easily be manipulated and the threat ended, partly by climatic engineering costing $75B annually done from orbit, and it is perceived that climate can not only be normalized and rendered immune to other foreseeable effects of man, but that it can be made greatly superior to what it was before, with a potential for even further enhancement and control in the decades ahead. By 2000 the world spends $125B/y on global climatic engineering.

2001-2025: QUARTER II

1. By 2025 the cost to orbit a pound of payload from Earth has fallen to $2(1975). It has fallen this far for many reasons, but particularly as a result of the use of fusion drives for all spaceflight. Moreover, it continues tumbling downward in that year. These costs are the lower when it is remembered that man's economy has grown considerably by this time, and that the scale of Spacial enterprise has grown still further. Such very cheap transportation has removed all barriers once existing to human emigration into Space and to intraspacial enterprise, but it has even led to profitable sale of Lunar minerals to Terran markets: each year, by 2025, 3 million tons of refined ore are shipped from the Moon to the surface of the Earth.
2. By 2025 an accumulated mass of 10^9 tons exists in orbit around the Earth as the stuff of a rapidly enlarging geosatellosphere. The population of this community of satellites is over 3,000,000 residents (people lasting a year), but it is visited annually by 98,000,000 tourists, 7% of which (or 7,000,000) leave the Earth to visit the Moon &r other planets. The population of the Moon is 185,000, 160,000 of which are shared by 13 main cities or bases; in addition, there are some 200 bases of lesser size scattered almost randomly over the Moon and serving as headquarters for expeditions, buildings aside or above mines, laboratories for scientific and industrial research, military camps and spaceports, facilities and resorts for floods of tourists, astronomical observatories, and way stations and checkpoints for epilunar navigation. There are by this time 65,000 men on Mars, 35,000 of which live in Rhodopole, the only major city but a rapidly growing one (by 2050 its population will be 2.5 million). Several small colonies scattered through the Asteroid Belt total 7500 men, women, and children, 91% of which are men. Even the surface of far Pluto supports a colony of 623.
3. By 2025 the concept of a "Spacial budget" has been rendered meaningless, but a Gross Spacial Product is calculated to be $4 T, in 1975 dollars, which is 1% of the Gross World Product. This means that money spent annually on Space has grown 500 X from 50 years ago in 1975. What has actually been done in Space is far greater, however, because of the cumulative investments of the previous 68 years of Space beginning with Sputnik in 1957, and because of the enduring plant in Space created over that period.

A LIST OF SOME FAR-OUT EVENTS WHICH MIGHT HAVE DRASTIC CONSEQUENCES

Foreword. The following events may be likely or very unlikely, or may be taken to stand in varying degrees of analogy to everything else so far-out and critical that is yet possible, but are all distinguished by having as their possible or probable consequence the necessity of really radical &r drastic changes in our picture of the future of Space. In the author's opinion at least several such events with miraculous consequences will in fact occur in the course of the next 50-200 years and redirect the course of history; some of these can be predicted as to their kind and effect, others really cannot be. The point is that conventional and supposedly "moderate" views of the future of Space over the long term are truly "surprise-free" in respect to their timing, scale, selection of events, and other assumptions since the far-out events will probably intercede and horribly degrade such simplistic "business as usual" scenarios. My list of these events is by no means exhaustive since it is the very nature of the category that the events are less predictable and more surprising than other events. In a certain sense the list which in effect exists in nature is probably infinite, which my list by no means is.

1. Vertical satellite built of ultrastrong materials &r linear fields of energy is created and extends from the surface of the Earth to at least 22,300 miles in order to remain erect under centrifugal force imparted by the rotation of the Earth. The satellitic cable, pipe, conveyor, or tower thus built is used for such things as puncturing the Earth's atmosphere with a vacuum passing baser beams of any energy or frequency for power or communication in either direction, for thrusting or conveying goods or men into Space with minimal mechanical energy, for conducting enormous power or information in either direction along direct wires, for purposes of descent, &rc. (Such contrivances are also or alternatively possible for other rotating planetaries, including asteroids.)
2. Such a vertical satellite is projected yet further into Space to produce a "vertical satellite tug" tapping the rotational momentum of the Earth as a practically inexhaustible natural reserve of power. Materials, goods, or men are in this way accelerated to orbital velocity, escape velocity, or velocities many times the latter. Over 1% of the Earth's mass, or a hundred quintillion tons, might be removed from the Earth in this way, depending on the intrinsic expense of the process. The whip might even be used as a source of power on Earth. A dangling satellite might float masses or men around the Earth through the atmosphere (the trailing cable could pull a sledge over a Great Circle rail, pull boats, or pull a circumglobal linear generator). (If required, a ring could be orbited around the Earth punctured by a multitude of vertical satellites and tugs which could compensate for a hypothetical "wrapping" tendency of such vertical satellites or tugs.)
3. Disastrous pandemic retroinoculation of the Earth with exobiotic pathogens encountered in Space, or equally disastrous prosoinoculation of lowly or advanced exobiota with Terran pathogens (say ravaging the native biota). Retroinoculation might destroy civilization or the human race, or breed on Earth such hostility to and fear of Space as to terminate its development.
4. Computers as intelligent, or virtually so, as man. These might produce total leisure, unlimited national or personal affluence, maximal economic growth, unlimited energy, autonomous objectives, a total automation of all Spacial operations (diminishing or maximizing the human presence in Space), maximal enlargement and evolution of science and technology, sudden economic equality throughout the world, opportunity for vaster population, maximal enlargement and acceleration of Spacial enterprise, goals on Earth supplanting purposes in Space, great deflation of costs, armies of millions or quadrillions of laboring robots throughout the Solar System, &rc.

5. Breakthroughs reducing the cost of energy orbiting a pound from Earth by 1-5 orders of magnitude to between 10$ to 1 mil (0.1¢).
6. Controlled fusion of protium to boron (PB fusion) rendering the oceans a reserve of energy equal to 100 trillion times the power used by the world per year by 2000.

A POSSIBLE EUGENIC EFFECT OF THE COLONIZATION OF SPACE

An observer of the contemporary world and the course of history leading up to it is impressed with one overwhelming need so far unmet by men using the extraordinary scientific powers now at their disposal: the need for essential physical improvements in our human nature. Partly this is an intellectual problem. We simply are not smart enough to solve all the problems that were before us at the beginning of time and that have since been added. Partly it is a problem arising from the defects in our inherited character: our natural instincts, feelings, insensitivities, wishes, neuroses, behavior, and perhaps an inherited view of the world. Do what we might to the external world, there remains the world within ourselves as an overbearing fossil. The wonders of science are enslaved to the dictates and whims of apes, chimerical and disharmonious beings half angel and half beast, nature's culminating joke.

Those men who will colonize Space will necessarily differ from the average composition of humanity left behind on Earth. Some of this selection will be conscious, some inadvertent. The selectional process will be complex and the race resulting directly in Space and through subsequent intermarriage will be equally complex in its physical and psychic makeup. But for any number of reasons the Spacial population and its descendants should be superior men, and they will certainly differ from the rest of mankind. Reinforcing these things will be the aristocratic socioeconomic culture from which the immigrants will likely be drawn, and also the very specific set of traits that will mark this extract, and the influential attitudes brought along as an anticipation of the conditions in Space and evolved on the basis of Spacial experiences as the unique product of those extraordinary experiences. It might be argued that in the long run migration into Space will become so easy that the former segregative mechanisms will fail, but it is also possible that some considerable selection will long continue to operate, and the prior character of the men and civilization early arisen in Space will act as a barrier to dissimilar types and a reconcentrator of analogous types. For example, some element of risk or fear may long mark Space, or there may long prevail conditions unusually demanding of the men moving and working there, presupposing special courage, daring, hardihood, skill, brains, education, imagination, enterprise, resourcefulness, ambition, curiosity, independence, adventuresomeness, restlessness, life, &rc.

Space will be no place for those of less than average IQ. Too much will depend on individual men, on initiative, innovation, foresight, planning, provision, &c. Broad competence will be too important. The slow and dull on Earth simply will not volunteer. Inhabitants of slum, probably innately less intelligent and full of character than others, will lack the enterprise or value to enter Space, and the costs of life in Space will forbid emigration and immigration by these people; slums themselves will have no beginning in Space because of the quality of men there, and life on Earth will always be a temptation to the lazy and incompetent so that a countercurrent exchange mechanism will operate. This omission of those of subnormal intelligence, representing 50% of mankind, will, in combination with the natural stress on those with IQs of at least 110, produce a mean and median Spacial IQ of perhaps 120-125, apart from further intraspacial segregations such as are found, and are so important, on Earth.

It may eventually happen that 20%-80% of Terrans will emigrate to Space and thereby impoverish Terran population and render it even less attractive to, and disdained by, higher intelligence in Space.

All this meritocratic selection and casual stirpiculture--operating to a degree unprecedented on Earth--is entirely apart from euphenic (nongenetic) interventions in human growth and form, extraordinarily diverse genetic engineering, and the consequences of bimodal and interminable stirpicultural anamorphosis over future centuries, millennia, megennia, &c with accelerating progress in the human or posthuman constitution.

REASONS WHY LIFE IN SPACE MIGHT ACTUALLY BE BETTER THAN ON EARTH

Foreword. There is a possibility, a probability, an argument, a position, a belief, an idea, &r an opportunity (for making it so) that life in Space--in colonies, bases, spaceships, &r homes in vacua or on planetaries--will sooner or later, or particularly later or particularly at first, actually be better than life on Earth as a whole or for some, as a whole or in particular respects or aspects. Such a claim is shocking to many persons who look at Space and see nothing but hardship, difficulty, sacrifice, danger, risk, uncertainty, discomfort, Spartan life, isolation, and cheap imitations of Terran existence, who in fact see Nothing itself. It is even more surprising and disputable than the assertion that Spacial existence might equal or simply approximate the excellence of life on Earth. Yet there have been those who have suggested that one of the very reasons for colonizing Space is that life there will be intrinsically superior to concurrent life on Earth, and perhaps inimitable. If this were true it would have tremendous force in the argument for colonization even in the near term. The following points are associable, dissociable, amplifiable, extendible, mutually additive or multiplicative, variously weighted and weightable (and in sundry respects), hypothetical, counterarguable, &r can be seen in many different lights.

1. Income will be high, perhaps very high, in Space relative to Earth.
2. Innovation, invention, discovery, development, implementation, renovation, &c will be higher.
3. Rate, degree, and scale of overall progress will be higher.
4. Excitement, drama, intensity, adventure, fascination, challenge, motivation, justification for actions, &c will be higher.
5. More interesting, intelligent, and better people will be attracted to and concentrate in Space.
6. There will be greater freedom of enterprise, gain, government, taste, behavior, purpose, thought, values, ideals, creativity, initiative, belief, &c.
7. Space will be meritocratic and timocratic since mobility, power, profit, recognition, prestige, help, opportunity, influence, &c will be governed, even very strictly, by skill, accomplishment, success, relevance, intelligence, talent, utility, efficacy, experimentation, common evaluation, the opinions of the best, individual productivity, hard work, and other virtuous things. Rationalism, pragmatism, practicality, idealism, personal integrity, science, technology, engineering, progressivism, experimentalism, imagination, perfectionism, communalism, rigor, natural competition, evolutionism, intellectualism, tremendous incentives, universalism, individual toughness, &c will dominate things, giving a characteristic cast to Space.
8. A known renaissance will be taking place in Space, the birth of a new and greater civilization, an opportunity for a transvalued and nobler man, an ideal place for the peaceful and autonomous development of new and higher societies (new and better governments, life-styles, standards, attitudes, interrelations, institutions, manners, goals, psychologies, philosophies, economic systems, organizations, ethnic entities, religions, jobs, life cycles, interests, friendships, cultures, atmospheres, &c), a chance to leave the old and false behind, a chance for science and technology to leap ahead and prove and consummate themselves or acquire their proper role in the scheme of things, an opportunity to equal and surpass nature (its cycles, systems, resources, bases, faults, limitations, dangers, overall structure, evolution, complementarity to man, &c; its biology, geology, meteorology, &c; its sheer beauty), a new and greater concern with posterity and ultimate things, an unprecedented differentiation of humanity, &c. Never before will any human renaissance

have been so universal, involved so many or all classes, types of men, societies, nations, enterprises, subjects, possibilities, purposes, concerns, &c, billions as opposed to hundreds or thousands of men, men on such a democratic or meritocratic basis, such a fusion of things, a complete turning over of the order of things, the very creation of whole new worlds, such planning, imagination, vaulting ambition, &c, such stupendous and assured promise, such universal understanding, such need of everyone, such a repudiation of and deviation from the past, such enormous and fundamental challenges, such synchrony, velocity, acceleration, complexity, &c, such internal and unending reevolution, such historical and environmental significance, such frankly religious and aesthetic significance, such continuity, such power and wealth, so many thousands of miracles, such clarity of objects, such criteria for accomplishment, such room for expansion, so many parts, &c.

9. It may turn out that, following adaptation or for natives of Space, lesser or zero gravity confers an ideal levity upon man &r his devices. Such levity might make for easier, quicker, &r more comfortable movement of men, and men, moving or still, might feel better. Such levity might sublime as a lighter, brighter, bolder, and healthier state of mind, and this in turn sublime as a similar spirit permeating Spacial culture.
10. Certain men in particular--the elderly, obese, feeble, &c--might find such levity a tremendous and deciding advantage over life on ponderous Earth.
11. Settings in Space--the spectacle of the Earth revolving below, the wealth of undisturbed stars, the perpetual day, the mysterious and then closer void beyond, the magnificent desolation and stillness of the Lunar landscape, the peculiar storms on Mars, the beauty and power of the kaleidoscopic Jovian atmosphere, the poetry of other asteroids of all sizes dancing through the sky and into the distance, the Sun reduced to a star from Plutonian distances or enlarged to a behemoth at Mercurian distances, the infernal ruby glow of the sky and landscape on Venus, the eternal emerald green of Neptune filling the sky of domed perineptunian colonies, the ocher and ruby landscapes of sculptured Mars, &c--might naturally surpass in several respects some or any epiterran settings for most or many men, or simply have the undeniable merit of diversifying human character growing out of the environment.
12. Wastes, junk, garbage, and pollutants might simply be put, fired, evaporated, incinerated, processed, aggregated (eg emballooned), exploded, stored, &rc in Space for extraplanetary colonies, desolate epiplanetary loci, or microgravitational &r microatmospheric epiplanetary colonies.
13. Inexhaustible, otherwise wasted, natural, clean, more intense, easily focused (by agravitational and anatmospheric soft mirrors), anatmospheric (in its path), arbitrarily broad (instead of proximal and horizonal), constant (instead of semidiurnal, seasonal, and obnubilable), actinic (and thus more energetic), safe, constant in supply (instead of depending on distributors), readily and arbitrarily greatly enlargeable, &rc sunlight exists in Space for necessary power.
14. Future industry will develop countless triumphant ways for using photons directly, efficiently, centrally, intensely, universally, advantageously, &c--eg for artificial photosynthesis of biochemicals and chemicals, for communication, for producing radioactivity, for producing plasmas (themselves of ever greater utility), for powerful furnaces, for photonics superseding electronics, for Spacial transportation (eg by directed beams to exomotive ships), for superscientific bioculture, for immense fractionation of chemicals and elements fractional but superabundant in planetary soils, for diverse glaciotechnology, &c.

Space will promote the actual, hurried, and full discovery, development, and implementation of such preferable techniques and resources.

15. Life in Space will not suffer from varying, bad, unavoidable, &c diurnal cycles, seasonal cycles, weather, climate, geologic phenomena, erosion, rust, temperature variations, unwanted precipitation, windborne dust, the biosphere functioning as a universal sink for mundane pollutants, imperfect climate, cloudy skies, frightening lightning, dangerously or impassably snowed roads, biospheric pathogens, &rc.
16. Space will promote, accelerate, and perfect environmental and resource recycling, maximal efficiencies of use of material and energic resources, full and substitute exploitation of common and relatively inexhaustible substances (for example and in particular, the recent discovery that an organic silicon-based chemistry is actually possible--and other developments with glassy semiconductors, ultrastrong glass, fibrous glass, quasicrystalline properties possible for glass, photonics, &c-- strongly argue that a. the most common and almost singly existing element silicon promises the most varied new and surrogate uses and b. intensive development of a single element can substitute chemicals for other elements throughout human industry, say given sufficient power), freeing man at last from nature and natural history, supernormal and "supernatural" possibilities, the perfection of human habitats and life, mastery over nature and hence its better exploitation everywhere; wil minimize the entropic product of man's purposes, end just and false fears about any "limits to growth", lead the way for necessary and desirable changes on Earth, lead to the production of and the ability to produce exquisite environments such as are even unexampled in nature, enable much farther, faster, and better economic growth, &c.
17. Technology will in the future allow the duplication of any and all of the important advantages of life on Earth (ideal foods, homes, cities, entertainment, games, illusory scenery, landscapes, organisms and ecosystems, weather, libraries, stores, streets, parks, mountains (as pointed out by Gerard O'Neill), hydrologies, whole communities, distant travel, many experiences in a lifetime, &c), and in fact these will first be originated and implemented in Space as the cutting edge and focal point of science, technology, commerce, social engineering, &c, because of the demonstrational nature of early colonies, the concentration of the best men, of wealth, and of enterprise in Space, the essentiality of fundamental and comprehensive innovation and improvisation, the natural scientific and technological biases of activities in Space, the very need to create substitutions for things already or naturally present on Earth, the temptations presented to art by new technologies and materials, the stationary nature of things on Earth owing to dominant content with and acceptance of old and preexistent things, a past-orientedness which may well evolve on Earth (even perhaps nostalgically and reactionarily), the need to attract tourists, emigrants, and employees from Earth, the need and tendency to compensate for the starkness and strangeness of Space, the tendency of Space and Earth to compete, the growing and eventually greater economy and population in Space, the endless expansive redevelopment of Space (incorporating ever more frontiers, worlds, means, conditions, and circumstances), the very tendency of innovations to lead to their own alteration and to other innovations, the relatively intense consciousness of the value, possibility, importance, interest, and necessity of perpetual innovations in Space, &c.
18. To some extent it will be simply the illusion or values of people in Space, and the hypnotic novelty, immanent promise, exotic evaluation, cheap appeal, and the promoted nature of things there, which will create the conviction

of the superiority, equality, and novelty in the minds, or temporary decisions, of Terrans and Spacials. There is always the phenomenon that the grass seems greener on the other side of the fence, foreign lands seem finer and more interesting, and human curiosity moves men to new addresses which seem preferable when in fact they are merely fresh and surprising. And human attitudes can certainly infuse places with deep and enduring atmospheres of a better kind. Colonies in Space will long seem miracles and long be imbued with the peculiar pride of their founders and inhabitants as men transcending nature, as architects of destiny, as daring and triumphant pioneers, as distinguished from their fellows by their deeds alone, &c.

19. Even if Space is not, or is not clearly, superior to life on Earth initially, developments on Earth might render it such as a matter of changing contrast. The current and future proliferation of nuclear weaponry among Nth countries and parties within them, such as terrorist groups, might stain life on Earth by endangering (however minutely or purely psychologically) life within the great cities, or by once again raising the evil specter of nuclear war with all its possible consequences for citizens of the belligerent nations, all Terrans, all life on Earth, sociopolitical ways, dangerous ideologies, exacerbation of cold war, accelerated and perhaps ultimately fatal arms races, global strife, &c. There is also the expectation that new and much more horrible generations of weaponry will continue in the future and eventually poison the atmosphere of life on Earth, or merely inadvertently or advertently ruin much or all of the Earth. Resource shortages on Earth (unrelated to conditions evolved in Space based on wholly different technologies) might gradually depress the standard of living on Earth in the absolute or relative to standards maintained or advancing in Space. Pollution, destruction and absorption of the natural environment, irreversible or at least poorly controllable effects of industry on global climatic equilibrium (and the state of climate), insidious cheapening or degradation of standards of life (such as ever dirtier, more malfunctioning, crowded, and aged cities), insidiously increasing overpopulation of all Terran spaces, unaesthetic despeciation, &c might mark Earth progressively in the future. The progress of science and technology might be so spectacular, insistent, or peculiar that known or imaginable accidents of a kind apt to devastate the face of the Earth or the branch of humanity resident thereon, may occur at some point in the future (there is already this threat, a threat which can only grow and perhaps accelerate). Society on Earth might become much different than it is today. Totalitarian governments or tyrannies might overspread the Earth. Government might become ever more bureacratic, burdensome, paternal, socialistic, communistic, technocratic, complete, absolute, taxing, &c. Terran culture might become excessively blasé, pretentious, amoral, insane, murine, cheap, homogeneous, obvious, crude, effete, violent, harsh, neurotic, dull, pointless, nihilistic, reactionary, autistic, ugly, competitive, false, exploitative, &c. Economic growth might stop or reverse on Earth. A million things can happen on Earth, a thousand of which will happen in fact, rendering life there, in the view of many, arbitrarily inferior to life or opportunities in Space. This is already happening for there are changes in culture, government, military technology, environment, economy, &c--some which appear secular--of a kind &r degree now or later, probably or possibly, unacceptable to many or most, now or later, and sufficient in these possibilities that many men have, and will have, cause to abandon life on Earth when it becomes unnecessary to be a part of it; these sentiments may themselves be a motor behind future colonization of Space or a sufficient first cause.

SOLIAN CIVILIZATION

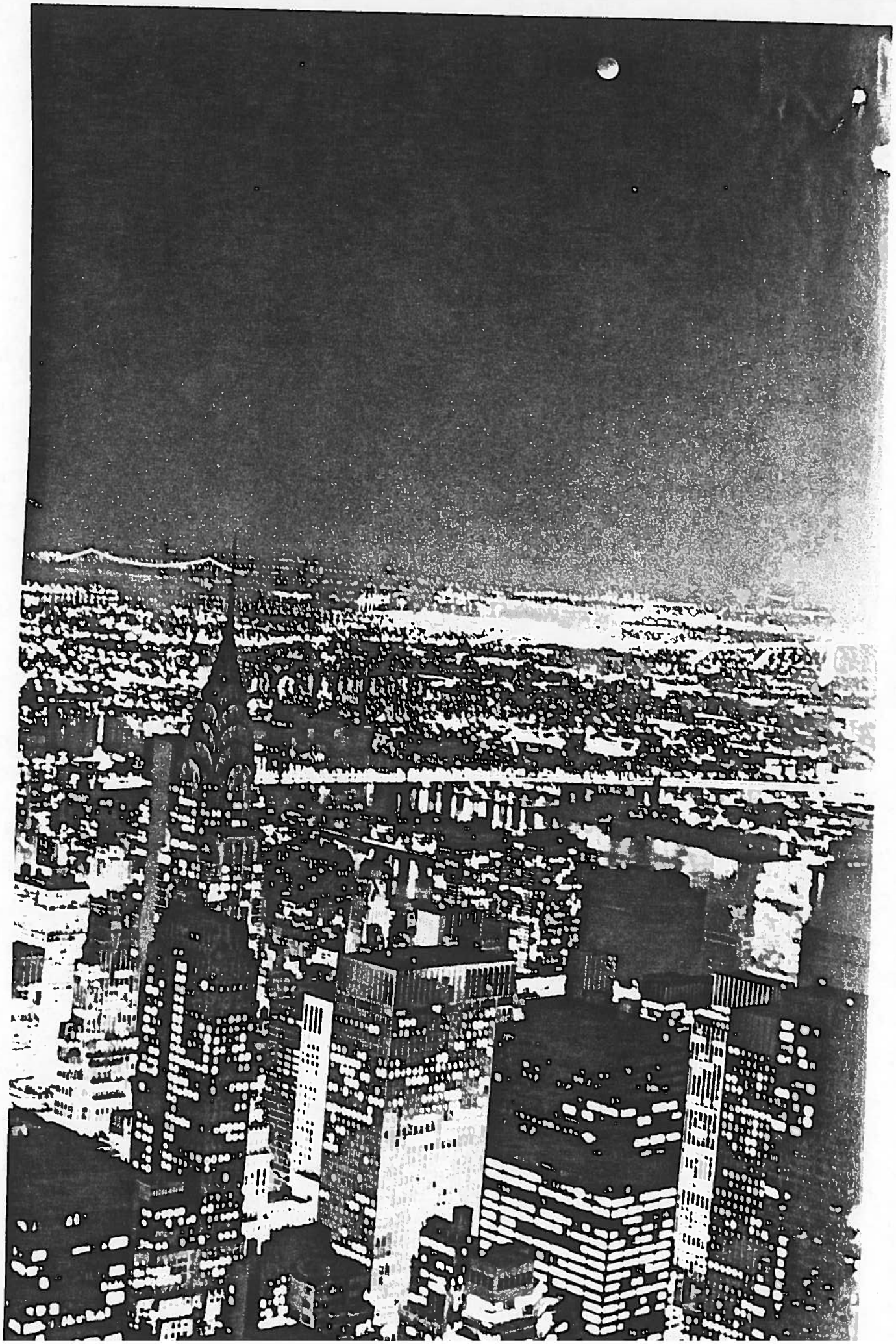
Man is without question currently experiencing the birth pangs of a new and greater civilization. It is ironic and unfortunate that at this very moment a large number of people around the world must be concerned that civilization is on its deathbed. The coincidence is easy to explain. History attests that ages of renaissance are at once ages of turmoil, despair mixed with hope, and of the agony of an older order. Contemporaries of these transitions almost without exception tend to lack a satisfactory appreciation of the greater prospects which are born in these transitions. Yet the greater prospects represent nothing more than the stages of growth of civilization.

Over the next 100 years the human race will experience an unprecedented crisis and a metamorphosis into a new and grander being. A revolution will occur far greater than represented by the previous 10,000 years combined. During this period conditions in the world will in many ways appear to grow worse. There will be ample cause for believing that the world is going to Hell. Terrible calamities may befall mankind. Nevertheless, as a whole conditions of life throughout the world will be undergoing tremendous improvement. It is highly unlikely that civilization, man, or his planet will be extinguished or even suffer basic reversals aborting 30 years of progress. Conditions and attitudes in time and space will exhibit extreme mixture and alternation of deterioristic and melioristic poles. Yet if one mood is apt to dominate and prevail, throughout this period, it is apt to be optimism and belief in progress. Human nature is too sunny to embrace a morbid outlook for more than 15 years if the case for such a negative outlook is as poor as it is momentarily. Besides, the new order springing into existence will be far too interesting.

Innumerable trends will converge, culminate, and transform themselves during this centurial transition. Certain very specific events of an extraordinary kind will occur as part of the process. It would be invaluable if mankind could know in advance what these trends and events are, and if this knowledge could be accompanied by suitable explanations of the origins, natures, and unified consequences of the things to come. The great transition needs to be justified and seen beyond.

There is a tendency to assume that the future will be so complex and surprising that present efforts to see it as a whole, and to explain and justify it, are largely pointless. My own impression is that this is not so and that in fact there is an inescapable opportunity to prepare the human race in advance for events over the long term, specifically from 1975 until 2075. Great surprises will of course occur. Yet the larger picture of things can be previewed and can be communicated to the majority of mankind. In this chapter I will undertake the initial construction of this basic preview.

A major theme is that over the next 100 years conditions in the world will initially in many respects become worse. The pejoration will accelerate. Eventually the pejoration will peak. It will then decelerate. Finally it will stop altogether. Dominant or major pejoration will be replaced by progressive melioration in the general state of mankind. The melioration will accelerate. The acceleration will peak. The melioration will decelerate. It will eventually reach some positive geometric or arithmetic floor, become essentially zero, or undulate about or above zero in the subsequent centuries. Actually I expect that gross and net progress will continue at a very high level for centuries and, quite literally, forever. The important point here is that whereas in many ways the world will get worse or seem to get worse in the immediate future, a reversal of these trends and a larger improvement of things will commence before the year 2075, probably well before. The reversal will be accompanied by dramatic increases in human optimism throughout the world, and an affirmation of the new civilization, which I call "Solian".



THE CAUSES OF THE CRISIS AND METAMORPHOSIS OF CIVILIZATION OVER THE NEXT CENTURY

Foreword. Over the next 100 years the convergence, culmination, and transformation of large numbers of extraordinary trends now visible over the Earth and begun 0-100 centuries ago will produce a universal crisis unique in the past and future history of the human race, out of which will issue an extraordinarily new and grandiose culture titling itself Solian Civilization, for it will fill the Solar System. The reasons are as follows.

1. The total wealth of the world, measured in conventional and quantitative terms, will increase 2-3 or more orders of magnitude.

2. The wealth of nations, in per capita terms, will become roughly equal.

3. Population density over the Earth's land will become much more uniform: great migrations of people will help bring this situation about.

4. International, supranational, and pannational government will come about, and come to dominate the external and internal affairs of all nations.

5. Crises and tensions in individual nations and the community of nations will increase in number and intensity, produce much tragedy, and finally be superseded by an enduring epoch of universal peace, prosperity, community, cooperation, and individual endeavor.

6. Many of the old causes of war will subside, and others will temporarily become more important.

7. Growth and progress of today's underdeveloped nations will occur at rates still higher than any the world has previously known.

8. The abandonment of traditional life-styles, values, relationships, beliefs, practises, manners, attitudes, systems, cultures, habits, &c will accelerate, peak, decelerate, become zero, reverse, and to some extent restore former conditions. This process will occur at an unequal rate throughout civilization.

9. Relativism, pluralism, experimentalism, nihilism, revolutionary zeal, &c will at first greatly increase and then greatly decrease, with a revival of absolutism, monism, centered ways, faith and certainty, gradualism and content, &c.

10. Miarchy (tendencies to less government) and pliarchy (tendencies to more government).

11. Excessively pluralistic government, pantisocracy (ideal absolute equality of rule), electronic arithmocracy (say instantaneous mass referenda), &c.

12. Neurotechnology (physical controls over the mind).

13. Supercommunication (in terms of bits/sec/user, fidelity, polymodality, cheapness, universal access, "globality" or indifference to distance, panhuman influence, intermechanical transmission, percentage of a man's day spent communicating, intensity of use locally, new media, communication replacing travel and experience, interaction of communication and information, total human communication, sociocultural effects, political effects, &c).

14. New generations of weaponry (cheaper, less predictable, more predictable, defensive, offensive, Doomsday, more pervasive, more numerous, more destabilizing or destabilizing, more powerful, transcendental of older weapons, with more or less side effects than old weapons, less traceable, subtler, more irresistible, abusable, more ominous, more expensive, more essential, more prone or able to destroy the race or world, more asymmetric or symmetric, more questionable morally, more impregnable, more precisely usable, more mobile, quicker, more or less "force" or "value", more tempting, more innocent, applicable to various types of war, usable by a regime on its own people, more or less escalatory, more or less controllable, with various effects on one's other military forces, &c).

15. Human travel and migration.

16. Supertransportation (per capita use, cost, total distance, average distance, globality, universalism, freight, importance, modes, effects on culture and government, public v private modes, automation, &c).

17. New ideologies (libertarian, anarchic, statist, totalitarian, rich v poor, aristocratic v egalitarian, neocapitalist, labor v capital, nationalist v internationalist, no-work or "ludist" v work or "ergist", hedonist v ascetic, progressive v antiprogressive, luddistic v technocratic, democratic v technocratic, proscientific v antiscientific, fascist, cultist, religious, educationalist v antieducationalist, cooperativist v isolationist, traditional v antitraditional, reversionary v progressive, environmentalist v industrialist, militarist v pacifist, antitax, xenophobic v xenophilic, irrational v rational, artificialist v naturalist, centralist v pluralist, millennialist, smart v dumb, good v bad, better v worse, parvenus v old guard, amoralist v moralist, maximalist, idealist v realist, pronatalist, individualist v collectivist, stratificationist v communist, agrarian v urban, prospacial v antispacial, nomocrat v authoritarian, &c).

18. Men entering Space and beginning of Solian Civilization.

19. Possible world wars and armageddons.

20. Interplay and fusion of all cultures.

21. The continued or future scientific and technical revolutions, and the acceleration of scientific and technical progress.

22. The worst side effects and consequences of scientific and technical progress.

23. Superficial and profound rationalization of everything.

24. Peaked change; the acceleration and subsequent deceleration of change.

25. The disintegration and reintegration of the world, including "shear" as things settle and the new form of the world crystallizes.

26. An increase followed by a decrease of expediency, crudity, vulgarity, cheap values and morals, malaise, anomie, social dissonance, amorality, human interexploitation, irresponsibility, dissipation, valuelessness, cynicism, fanaticism, cheap individualism, institutional malfunction, sociopathology, "nuncism", criminality, parasitism, neutrality, violence, despair, selfishness, strife, intolerance, repression, reaction, &c

27. Falling standards, rising standards, certainly changing standards: the standards of products, services, arts, professions, manners, morals, and living.

28. Complete automation.

29. Ontology: computation, artificial intelligence, super intelligence, noology, neurology, epistemology, cellular automata, &c.

30. Plenistic School of Physics.

31. Efflorescent World View.

32. Extrasolian communication.

33. Interstellar travel.

34. Total transformation of the basis for industry.

35. Superabundant energy.

36. Cornucopian industry.

37. Robotic "money tree" (robots producing robots and maximizing the rate of economic growth).

38. The Earth become one great city: Cosmopolis or Terropolis.

39. Pronatalism and maximal growth of population.

40. Institutional and automated education and childhood.

41. Immense and perfect police power given by technology.

42. Electronic credit replacing the dollar economy.

43. Progressive growth of the public sector. The self-sufficient, autonomous, self-directed, deontologic, and eschatologic state.

44. Decentralization or ruralization of residence, industry, &c.

45. Rebirth of even more gigantic cities: "teratopolises" housing a 100 million people or more.

46. Tridimensional or solid cities ("stereopolises") above and below ground and in Space.

47. Oscillations and fluctuations between meritocracy, timocracy, and aristocracy and egalitarianism (equality of right, income, power, position, respect received, support, use, &c), and the progressive rise and final triumph of the former. Eventual surrender of government and administration to savants, experts, technicians, scientists, those of brilliant character, geniuses, philosophers, eminence on tests (IQ, achievement, aptitude, potentiality, personality, judgment, creativity, &c), &c.

48. Perfect and intricate psychometry (reliable and depth psychologic and neurotechnologic measurements of differences in the mentality of individuals) and society's pervasive reliance on these measured qualitative and quantitative differences.

49. Ultimate leisure.

50. Extraordinary commercial and technologic means for experiencing pleasure. The proscription, provision, withdrawal, and sophisticated reprovision of these means. The impact of these means on the world.

51. Miniaturization, economization, universalization, and perfection of the means for lifetime entertainment, adventure, learning, "fulfilment", satisfaction, intellectualism, &c. Just as television has already to a surprising degree replaced other interests of modern man, the new means arising in the next 100 years--such as tiny electronic home libraries including every book ever written and "program" ever produced or recorded, and games-playing and companionable computers--will replace outdoor adventure, travel, social and familial experience, external education, physical games, external enterprise, books, &c. The resulting society will obviously be completely unlike society today, for better &r worse. Reactions to this order may occur over this period.

52. Development of a truly universal language and system of behavior.

53. Dissolution of old national, ethnic, cultural, racial, and other distinctions.

54. Failure and disappearance of <u>bad</u> totalitarian governments.

55. Possibly the imperial triumph of some single state or nation over the entire planet or race.

56. The transformation of the Earth into a work of art &r natural paradise.

57. Means for being invincible in certain wars.

58. Means preventing any victor in certain wars, producing stalemate.

59. Progressive intervention of the world community in preventing and ending international and civil wars, maintaining peace, righting injustices, enforcing higher political ethics on successively intolerable sociopolitical conditions and practises, &c.

60. A universal legal system replacing national systems with its own, comprehensive laws and values.

61. Progressive dissolution of all and any barriers to international trade.

62. Establishment of a universal economy.

63. Rising and then vanishing defense expenditures, the latter as global peace and government replaces current conflict, strife, separation, malice, &c.

64. Global neurotechnologic achievement of virtually perfect mental health, equal human beings, and supernormal personalities.

65. Eugenics and bioengineering producing finer men in number and finally universally (eg average IQs of 140, 200, &c).

66. Elimination of aging, extension of the human lifetime, human immortality.

67. Technologic equivalents of telepathy (eg universal cerebral implants of psychic transceivers normally or facultatively exchanging nonsensory, stupendous, emotional, uncontrollable and thus revealing, precise, unconscious, eidetic, symbolic, mnestic, monumental, instantaneous, automatic, empathic, friendly, amorous, sensory, &c information).

68. Possibly some achievement of "ideal" and therefore lasting technologic possibilities (eg the achievement of a perfect transportational system would eliminate what is presently a large responsibility of government to choose, develop, build, operate, finance, extend, replace, maintain, perfect, &c massive systems of transportation).

69. Possibly the creation of standard and absolutely identical psychobiologic constitutions of all men ("cloning") might become possible and seem so highly desirable as to be instituted. The reader is urged to be extremely cautious in reacting negatively, emotionally and intellectually, to this possibility!

70. Technologic means for installing information--and perhaps basic behavior and psychology--directly and perhaps instantaneously in the brain (eg formal education might be compressed 10,000 X to a day).

71. Technologic means preventing all crime and rendering capture of perpetrators quick and inevitable.

72. Technologic means for punishing, correcting, or reconstituting criminals.

73. The "ab initio" building of whole cities.

74. Ectogenesis and statal selection of original cells or cell.

75. Even grander evolution of giant corporations.

76. Any impact homosexuality, bisexuality, and prudent promiscuity (or extramarital sex) might have on the world (which could be tremendous).

77. Greater regulation of economics.

78. Evolution of the Fourth Estate, partly from new technology.

79. Decommercialization of many activities (eg cable or bespeak television without advertisements, landscape without signs, noncommercial foods, profitless telecommunication or public utilities, &c).

80. Reaffirmation of the importance of science.

81. Abolition of current real or supposed limits to growth.

82. Occasional, severe, and ahistoric inflation and depression of world economy owing to its growth, change, fusion (eg via "resonances"), dissonance, &c.

83. Waves of pessimism and optimism throughout the world.

84. Tremendous human integration and segregation--alternating, simultaneous, and complex.

85. Terrorism, blackmail, crime, and violence on an unprecedented scale throughout the world, and their subsequent institutional and endogenous diminution.

86. Civil engineering on an unprecedented scale.

87. Slow inception of a true (organic, effective, ideal, spiritually detailous, convergent, divergent, complex, harmonious, settled, deep, historical, cumulative, unique, recognizable, affirmed, ethical, moral, aesthetic, institutional, &c) civilization.

88. Rebirth of a glorious vision of the world and its future.

89. Triumph of a highly desirable social engineering: or science, art, concern, and institutions dedicated out of love and idealism to the betterment and ennoblement of mankind.

90. Neurotechnologic inductions of altruistic and idealistic agape, and Abraham Maslow's "eupsychia", in the brains of all the human race--producing global and social peace, brotherhood, cooperation, synergism, understanding, genius, religion, &c. (This sounds bizarre but is in fact probably both feasible and doable in the next 100 years. Electrodal, surgical, biomechanical, pharmacologic, ontogenetic, prenatal, eugenical, hormonal, microcomputer, operant conditioning--psychologic, histologic, and cytologic, &c interventions in the structure and function of the prefrontal, cingulate, anterotemporal, paleocortic, and other cortices, basal ganglia, diencephalic and mesencephalic structures, &c already seem possible to artificially create and enhance friendliness, libido, eupsychia, memory, conditioning, self-conditioning ("bio-feedback"), rational self-control, consciousness, calm, sanity, "reality", curiosity, &c, and yet it is obvious that we are only touching the farthest fringe of what is theoretically and probably possible.)

91. Within 100 years it will be possible to transfer or duplicate part or all of our mind--memory, consciousness, identity, intellect, feeling, perception, motor processes, personality, imagination, desire, attitude, perspective, knowledge, thought, the unconscious, psychogeny, lower functions, intuition, everything or mortal being--in extrabodily records &r computers, reversibly and irreversibly, partly and completely, occasionally or normally, symbiotically or reincarnatively, &c. This is almost certain. In this way a marriage of man and machine may occur or machines may replace men altogether.

92. Artificial superbeings will be emancipated, enfranchised, empowered, and replace physically the human species. (Simultaneously and similarly, artificial organisms will replace natural plants, animals, ecologies, inanimate processes, and pets--mechanical pets will replace dogs and cats between 1985-2005.) Supermotivated and ultramotivated, perfectly rational, virtuous, just, self-controlling, and self-making, infinitely complex and intuitive, superconscious, supermeaningful, self-evolving, apeirolatrous, maximalist, &c artificial superbeings will quickly appear in our stead.

WHY THE BIRTH OF SOLIAN CIVILIZATION OVER THE NEXT 200 YEARS IS VIRTUALLY ASSURED

1. It is too easy to get into Space--in terms of distance, time, energy, money, available resources, initial footholds, all of the Solar System, political motivations, &c.
2. The resources of the other planetaries are too great, obvious, and necessary.
3. Human income will increase at least 100 X by 2075 and 2-4 or more orders of magnitude over 1975 in 2175.
4. Current human problems are clearly transitional and will peak and fall by 2075, certainly by 2175, throughout civilization.
5. Man's ability to reach and develop Space will develop at an unusually great exponential rate since it will be compounded of so many exponentially increasing factors, including total wealth, fluctuations of human motivation, scientific and technological progress overall, the scale of Spacial enterprise itself, the multiplication of interested parties, &c.
6. It is too easy to colonize and develop Space.
7. Enlargements of Spacial enterprise will be irreversible.
8. Self-supporting Spacial populations are too imminent.
9. The Solar System is too small--its solid surface perhaps 40 X larger than Earth's land area, and no more.
10. The rate and extent of growth of civilization over the last 200-500 years suggests that sustained or decreased exponential progress will make the next step--the exploration, occupation, exploitation, development, and civilization of the other Solian planetaries--but a regular evolution.
11. Pressures on Earth already exist, and will increase in the future, tending to drive man off Earth or at least into the rest of the Solar System. These pressures include: human curiosity, overpopulation, overgovernment, pollution, various crises, various threats, shortages of resources, man's instinct to variation, &c.
12. Economic growth may greatly accelerate still further.
13. The scientific and technologic revolutions may lie ahead of us, say over the next 75-125 years.
14. The prudence of establishing a "second earth" will gradually become transparent and overpowering.
15. Residual mental resistance to Space will progressively fade, and enthusiasm about Space will feed on itself and progressively grow.
16. The variety of actors will become so great over the next 100-200 years that inevitably many will determine to develop Space, which will have a critical effect on the wishes of others and establish that quantum of Spacial enterprise and colonial self-sufficiency essential to Space "taking off".
17. The new and open lebensraum of Space will lead to new explosive growth of population, and a pronatalist spirit arising from a sense of the destiny of the new civilization in Space.
18. The near-2000 appearance of humanly and superhumanly intelligent computers will change completely the course, purpose, scale, and even nature of civilization. For example, "maximalist" doctrines will probably emerge and dominate things.
19. Life in Space at least on a par with life on Earth will become economically and technologically possible and in fact standard.
20. Near-2000 total and universal automation and leisure will liberate human wish, desire, and variety and lead to a tremendous proliferation of cooperative purposes hitherto impossible. In addition, the new Age of Leisure will create a desire for adventure which Space will be eminently designed to fulfil.
21. Too much competition over Space will occur between men, accelerating Spacial enterprise.

22. The circulation of tourists through Space--where the growth of touristic industry seems inevitable--will inevitably leave behind countless migrants.
23. The novelty of Space and the Spacial undertaking will generate a tremendous sense of excitement, drama, progress, opportunity, challenge, human evolution, and overall destiny in Space, and the importance to human nature will insure the growth of a new civilization.
24. The new human civilization assured of arising in any case over the next 100-200 years will find its dynamic axis or center in Space.
25. Man's overall powers will multiply tremendously over the next 200 years.
26. Life in Space--being at the forefront of scientific and economic progress--will very probably enjoy a higher standard than contemporary life on Earth, once the Spacial enterprise gets underway.
27. One does not ignore a mountain in one's own backyard. One climbs it.
28. A cultural revolution on Earth seems imminent and Space could well be the basis of the next step in the evolution of human nature.
29. Frontiers on Earth are nearly exhausted. All-encompassing Space inevitably becomes the next frontier environment.
30. Current opposition to Space must be faddish. A period of 1-2 centuries is so immense that over the long term Space is inevitable, regardless of short-term changes in human attitude and attention.

ONTOLOGY:
A SCIENCE AND A TECHNOLOGY TO BE BORN AND TO MATURE OVER THE NEXT 50-100 YEARS

I now undertake the discussion of a topic hinted repeatedly throughout this book on Space but largely avoided as too important, disruptive, and strange to be easily integrated in the framework of the book.

Developments in this field, which is foreseen as being born and experiencing its early childhood over the next 50-100 years, will in my opinion be almost certainly those things most consequential for the concurrent and ultimate development of the extraterran universe. Too, they will, as the new field, constitute without question or any possible disagreement ex post facto the most decisive event in the past and future history of mankind. They will suddenly, quickly, totally, and completely change the natural and artificial order.

The new field will comprise several separate but interrelated domains, including:

(1). Incredible collective global, unit, rate-related, and diachronic power of computation by machines regardless of type.

(2). Incredible integration of this power of computation into all human endeavor (industry, research, government, &c).

(3). "Euparallel" computers genuinely original and autonomous in perceptual, conceptual, and "effective" processes, comparable mentally to man.

(4). "Euparallel" ultraintelligent computers capable of transhuman, genial, and revelatory things in perceptual, conceptual, and effective terms

(5). Neurology (or an explanation of natural nervous systems in animals and men), neurotechnology (or control over these systems), psychology (become neurology), and noology (or an explanation of bases for all possible minds).

(6). Morphology (or a theory and account of the origin and bases of all actual and possible order).

(7). Cellular automata (or the science and technology of all actual and possible theoretical and physical catalytic, autocatalytic, autonomous, homeostatic, self-stabilizing, self-maintaining, auxetic, meristic, evolutionary, mnestic, teleologic, omnifarious, omnific, monadic, cosmoplastic, cosmopoietic, universal, self-propagating, self-infinitizing, paradoxical, self-perfecting, self-ubiquitizing, self-correlating, "omnipotent", &rc entities, organisms, or "beings").

(8). Cosmology (or the static and dynamic actual and possible present, past, and future bases and origins of the "ecology of beings" comprising the known and actual universe; the Efflorescent World View postulates that the creation of the universe is an eternal, pervasive, Heraclitean, and organic process of an "ontogenic" nature).

(9). {Biology (or a theory and account of the origin and bases of all actual and possible life) and biotechnology (or all possible control over and exploitation of biologic systems)}.

Ontology is to be defined as the science and technology of all actual and possible mental and physical being, existence, organisms, and life insofar as these are important, real, comprehensible, potentially moral, exploitable, &c. It recognizes the probability and the possibility that the old concepts of life, form, law, appearance, intelligence, consciousness, reality, &c have to be greatly--perhaps infinitely--extended. I will have more to say on the nature of this field later.

A particular reason for proposing the new term is to answer a need for a more prescient name for various current interests of science. The field which today calls itself "artificial intelligence"--whose concern is the development of the theoretical and empirical frontiers of computer software and hardware and the need to bridge the gap between human and mechanical capacities in perceptual, conceptual, and effective operations--is noticeably more than a preoccupation with what is usually denoted and connoted by "intelligence", as is evident from my definition. This field covers the realms of "mind". But it also clearly extends to a dream of creating organisms not found in and not produced by nature, to a dream of building and manufacturing artificial beings--things robotic, conscious, creative, representing ends in themselves, and meriting "rights".

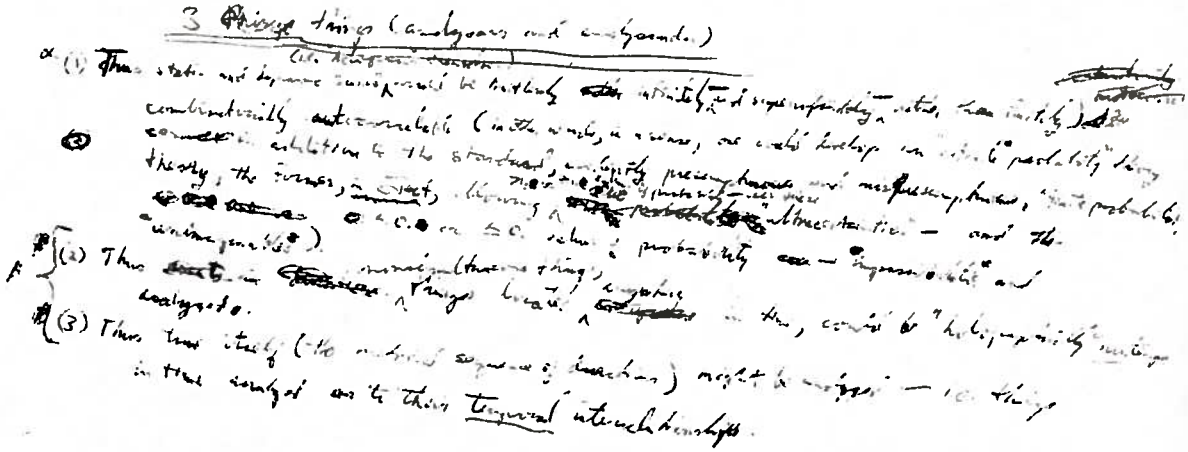
In Item #3 of the list above I refer to "euparallel" computers with the implication that computers must be euparallel before human intelligence, and the ability to perform many tasks, is attained. The reason for the word is to distinguish it from such computers as Illiac IV, which is parallel only in the sense that 64 serial computers are operated in tandem. Such a computer is only minimally parallel or parallel in a sense, and is largely irrelevant to any machine entitled to the appellation "euparallel". By euparallel is meant that the microcircuitry and microoperations of a computer function "heterarchically" (to use the term of the neurophysiologist Warren McCulloch in Embodiments of Mind) as a democracy of simultaneously and persistently operating units. It is true that modern serial computers to some extent involve the concurrent operation of large numbers of basic units, but the cooperation here is not in terms of ubiquitous local interactions of autonomous units but rather in terms of what might be described as transient heteronomous waves imposed on the large scale and originated outside the computer in the human operator, a situation we might characterize as "monistic". What is necessary if computers are ever to truly compete with men in perceptual, conceptual, and effective activities is for a characteristic of man's brain to be duplicated: vast numbers of units must be processing information simultaneously at all levels of scale so that the complexity of interactions of phenomena in the external world will be approximated and thereby exceeded in terms of supermundane generalizations based on similar multivariation and rate. The detail of interaction here suggested to be essential to truly intelligent machines, characteristic of the human brain, and characteristic of mundane phenomena leads to a combinatorial complexity totally without analogy in the lumbering serial computers which are all that man uses today. Man has never built supracritically large, supracritically democratic (or densely spontaneous), and supracritically mnestic (virtually analogue) computers. Nor is he for all purposes trying to do so. Not until he begins to develop such relatively naturalistic computers will he begin to mechanize human consciousness, intelligence, and originality or make radical headway in terms of perceptual, conceptual, psychic, and effective processes. The irony is that the construction of such machines is something that we can very likely do already by launching an adequately intelligent, planned, serious, and large-scale endeavor. The probability I estimate is 50% that in 8 years we could achieve human or infantile intelligence in a machine if we began such a program momentarily, say under my personal supervision!

If you assumed that ontogeny and thought in the human brain and in analogous computers could be measured by the path of either a macroscopic or a microscopic wave between operational and mnestic microcomponents, the task before a serial computer such as the best in operation in 1975 would involve a sequence of so many steps that the time involved in equaling man would be virtually eternity: modern computers virtually do not think.

It is commonly supposed that the evolutionary complexity of the human brain must be so immense and sophisticated that the explanation of our brain will require centuries, millennia, or eternity, and it is then further supposed that any achievement of the mental power of man in a machine will be comparably difficult. In my opinion this almost certainly rests on a misconception and is untrue. Almost certainly the human brain, or else comparably powerful machines which are possible on a different basis, can achieve arbitrarily great things by the statistical interactions of simple and basically identical microcomponents constituting their own, unprogramed networks. The structurally homogeneous and functionally iterative circuitry which man must manufacture by mass-producing and interlinking sufficient numbers of sufficiently mnestic microcomponents are probably such as require surprisingly simple, crude, easy, and economical structure, function, composition, theory, and formulaic specifications. The predesign of the microscopic and macroscopic intercomponential structure and function that is actually necessary to achieve the intelligence is probably negligible and obvious.

Elementary and homogeneous microoperations and microcomponents I therefore envision as the natural or artificial basis of arbitrarily great complexity and power arising by the pluralistic interactions of analogues of mundane phenomena in networks basically faceless at birth.

The human brain is occasionally compared to holography. I believe this is a very good comparison, and an excellent distinction between brain and computer, but to which it is necessary to add a few things, giving the expanded metaphor that: (1) The brain is indeed like a hologram in that its memory and operations are dispersed, convolutional, and deconvolutional, in a cryptic and dense way permitting random-access memory, &c. (2) But the patterns present represent not one hologram but a continuum of holograms, not a static and spatial hologram but a dynamic and temporal hologram, not simple temporal and dynamic processes (diachronic, sequential, and transformational) but highly generalized, logical, and hierarchic morphodynamic and etiologic processes ("thoughts"), &c. (3) The information present in the hologram is not passive but everywhere active and interactive so as to be experiencing tremendous evolution. This triply described holography--which man has never created in a machine--I think is a fit metaphor of the human brain and mind and of what is required if we are ever to get a machine to think on a human level.

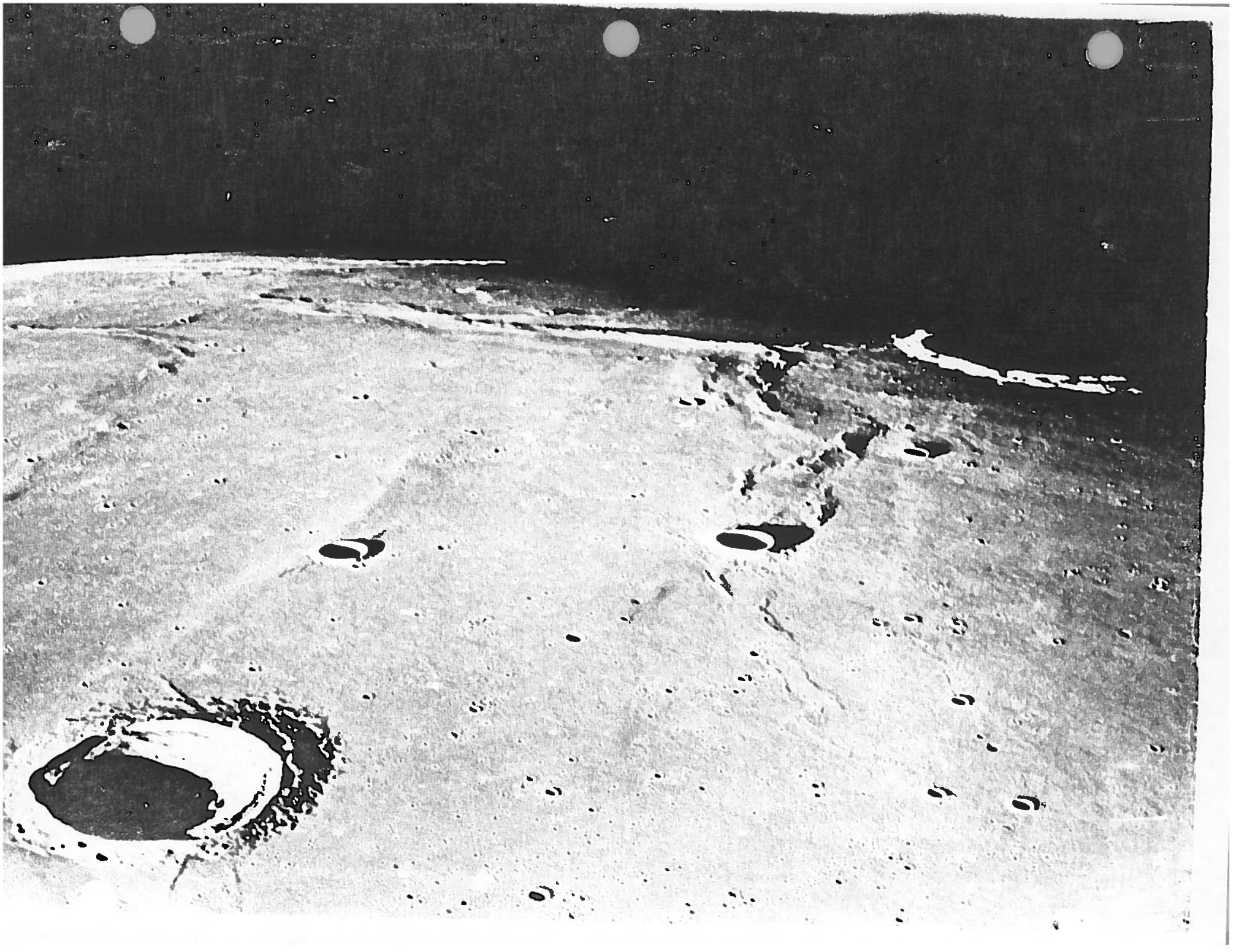


A LIST OF THINGS WE MIGHT DESIRABLY MAXIMIZE

1. Gross National Product.
2. Gross World Product.
3. Per capita income.
4. Scientific progress.
5. Technologic progress.
6. Growth of science.
7. Size of science.
8. Possible energy.
9. Available energy.
10. Energy use.
11. Growth of economic "productivity".
12. World biomass.
13. Human life.
14. Culture.
15. Intelligence.
16. Beauty.
17. The good.
18. Virtue.
19. Civilizational progress.
20. Global peace and security.
21. Safety.
22. Lifespan.
23. Quality of life.
24. Natural world.
25. Individual opportunity.
26. Challenge of life.
27. Population.
28. Portion of universe civilized by man.
29. Living space.
30. Environmental quality.
31. Social standards.
32. Purpose.
33. Fulfilment of destiny.
34. Consciousness.
35. Feeling.
36. Adventure.
37. Pleasure.
38. Fun.
39. Entertainment.
40. Possibility.
41. Thought.
42. Wisdom.
43. Ethos.
44. Human degrees of freedom.
45. Education.
46. Truth.
47. Foresight.
48. Future happiness.
49. Individual fulfilment.
50. Health and well-being.
51. Mineral wealth.
52. Leisure.
53. Freedom.
54. Art.
55. Being.
56. Evolution.
57. Convenience.
58. Communication.
59. Perception.
60. Our organismic excellence.
61. Ability.
62. Artifice.
63. Control over nature.
64. Agape and human union; unity of bei
65. Society and the evolution of good social institutions.
66. Certainty.
67. Self-control and self-mastery.
68. Meaning.
69. Sanity.
70. Experience.
71. Ideality of life's course.
72. Human depth.
73. Psychic growth.
74. Rational conduct.
75. Mental richness and memory.
76. Organization of the universe.
77. Justice.
78. Individual accomplishment.
79. Efficiency, economy, and perfection.
80. Variety.
81. Human diversity, complementarity, &c.
82. Present possibility.
83. Future possibility.
84. Progeny.
85. Impact of every individual on the future and universe.
86. Happiness.
87. Knowledge.

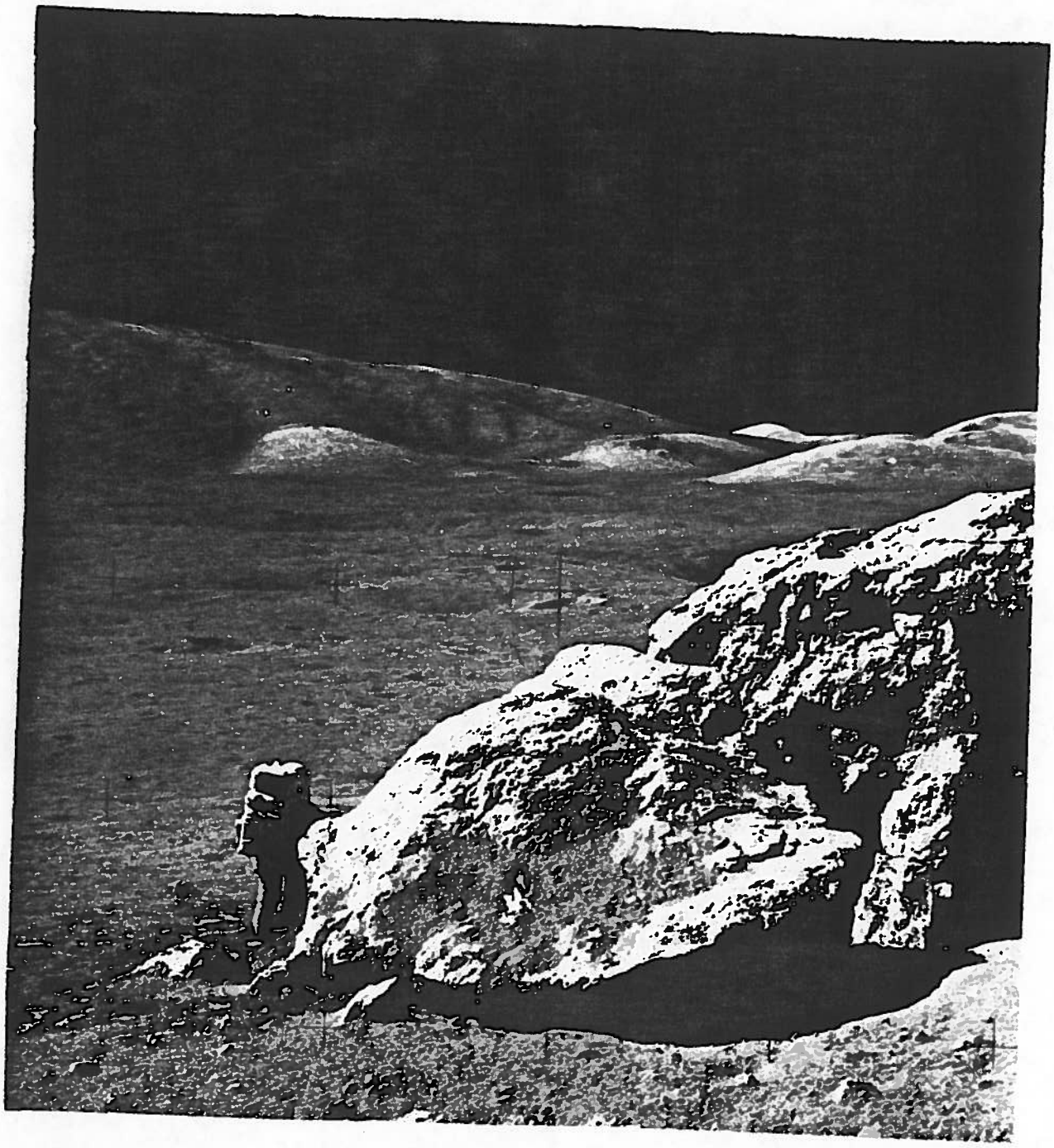
Some particular things:

1. Number of known chemicals and properties thereof.
2. Number of inventions.
3. Number of goods.
4. Number of physical laws known.
5. Number of physical senses.
6. Number of books in existence.
7. Variety of environmental organisms.
8. Powers of scientific instruments.
9. Transportational capabilities.
10. Elaborateness of men's homes.
11. Power to produce and control our own emotions.
12. Power to decide the course of our own lives.

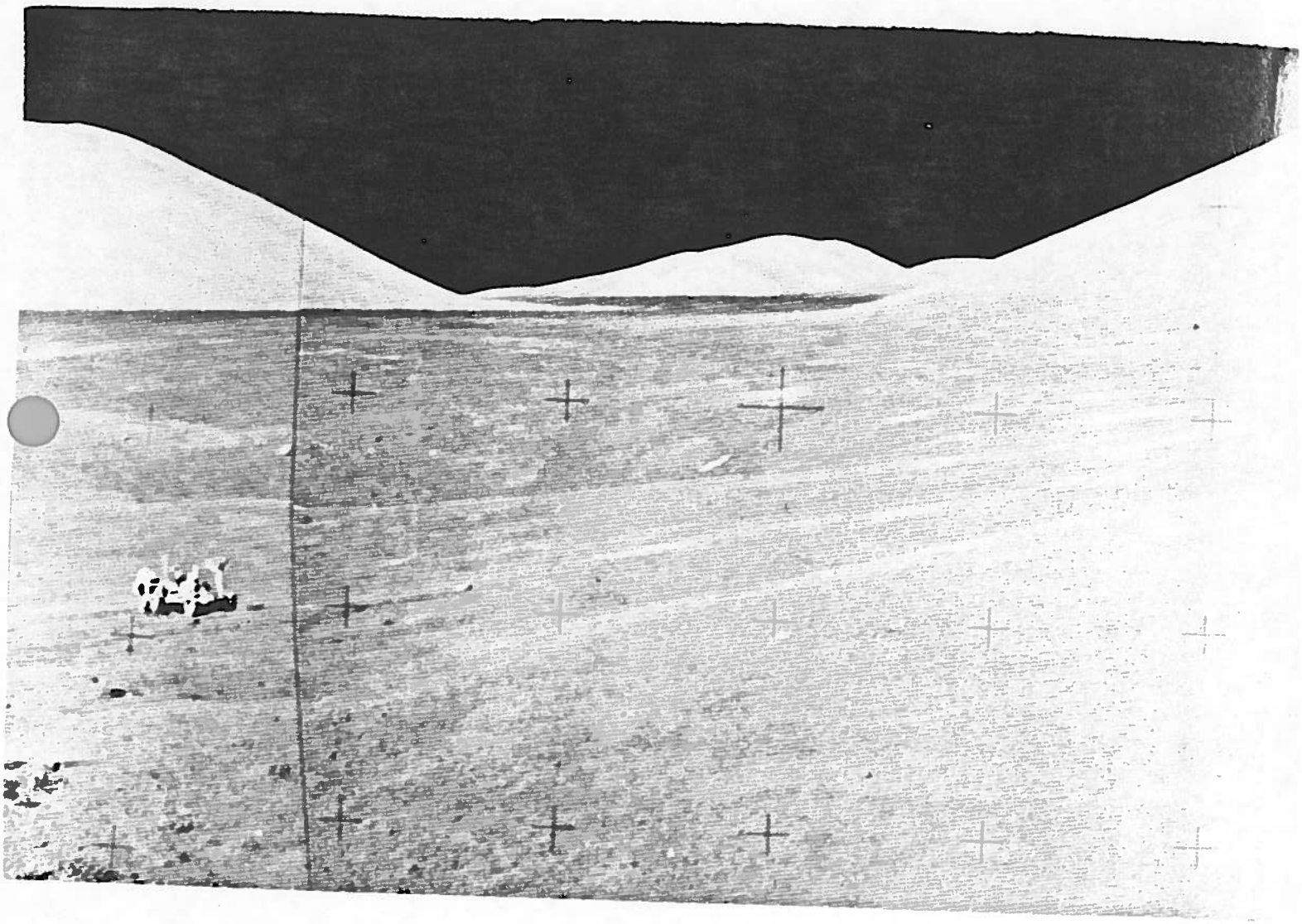


NOTABLE EVENTS IN THE FUTURE HISTORY OF THE MOON

Dates	Events
1987	1. 30-day base.
1991	2. 6-month base.
1993	3. 2-year expedition and semipermanent base.
1993	4. First permanent rotating-crew base.
1993	5. Second permanent base.
2000?	6. 5 coexistent bases.
1993	7. 2 nations compresent on Moon in bases and on expeditions.
2000	8. Population 100.
2009	9. Population 1000.
2024	10. Population 10,000.
2040	11. Population 100,000.
2056	12. Population 1 M.
2073	13. Population 10 M.
2090	14. Population 100 M.
2107	15. Population 1 B.
	16. Population 10 B.
	17. Population 100 B.
	18. Population 1 T.
	19. Population 10 T.
	20. Population 100 T.
	21. Population 1 Quadrillion.
	22. Population 10 Quadrillion.
	23. Maximal population.
2007	24. First epilunar colony.
2018	25. First epilunar city.
2035	26. 10 "cities".
2075	27. 1000 cities.
2010	28. Homesteading.
	29. GLP(Gross Lunar Product) 1 M$/y.
2035	30. GLP 1 B$/y.
2075	31. GLP 1 T$/y.
?2020	32. Beginning of substantial industrial and commercial lunisatellosphere.
?2040	33. Lunisatellosphere population 10,000.
?2055	34. Lunisatellosphere population 100,000.
?2075	35. Lunisatellosphere population 1 M.
?2400	36. Lunisatellosphere population 1 B.
=? 2026	37. Moon exports 100 M$/y of goods.
1995	38. Moon imports 100 M$/y of goods from Space.
2015	39. Lunar culture begins.
(#71) 2043	40. Declaration of the Independence of the Moon.
2030	41. Moon territorially subdivided between Terran and nonterran nations and parties.
2003	42. First military use of Moon.
2010	43. First Lunar military base.
(#67) 2010	44. Real estate sold on Moon.
2008	45. First Lunar tourists.
2018	46. 1000 tourists per year.
2027	47. 10,000 tourists per year.
2037	48. 100,000 tourists per year.
2048	49. 1 M tourists per year.
2065	50. 10 M tourists per year.
2100	50.1 100 M tourists per year.



	2005	51. First nuclear explosion.
	1991	52. Fabulous mineral wealth discovered.
	2012	53. 1000 tons/y of minerals mined.
	2035	54. 1 M tons/y of minerals mined.
	2070	55. 1 B tons/y of minerals mined.
	2004	56. Inhabitational floor space 10,000 m^2.
	2012	57. Inhabitational floor space 100,000 m^2.
(#89)	2020	58. Inhabitational floor space 1 M m^2(1 km^2).
	2040	59. Inhabitational floor space 100 M m^2(100 km^2).
	2050	60. Inhabitational floor space 1 B m^2(1000 km^2).
	2090	61. Inhabitational floor space 100 B m^2(100,000 km^2 = 300 km X 300 km = 0.3% of the Lunar area).
	2006	62. 10^{-6} of the Lunar surface owned (38 km2).
	2020	63. 10^{-4} of the Lunar surface owned (3800 km^2).
	2030	64. 1% of the Lunar surface owned (380,000 km^2).
	2043	65. 10% of the Lunar surface owned (3.8 M km^2).
	2043	66. a100% of the Moon owned (38 M km^2).
(#44)	2020	67. 10^{-6} of the Lunar surface owned privately (38 km^2).
	2035	68. 10^{-4} of the Lunar surface owned privately (3800 km^2).
	2063	69. 10% of the Lunar surface owned privately (3.8 M km^2).
	2000	70. Moon declared a United Nations Trust Territory.
(#40)	2043	71. Lunar Federal Government founded.
	2025	72. Lunar Confederal Authority founded.
	1993	73. 10^5 watts of power produced on Moon.
	2000	74. 10^7 watts of power produced on Moon.
	2030	75. 10^9 watts of power produced on Moon.
	2045	76. 10^{12} watts of power produced on Moon.
	2085	77. 10^{15} watts of power produced on Moon.
	2000	78. First official "earthport"(terrilunar spaceport).
	2020	79. First official Lunar spaceport (for deep-space and interplanetary operations).
	1993	80. 10 spaceships/y visit Moon.
	1995	81. 100 spaceships/y visit Moon.
	2005	82. 1000 spaceships/y visit Moon.
	2024	83. 10,000 spaceships/y visit Moon.
	2060	84. 100,000 spaceships/y visit Moon.
	2085	85. 1 M spaceships/y visit Moon.
	2105	86. 10 M spaceships/y visit Moon.
	2005	87. First underground city.
	2004	88. First 100-m diameter dome.
	2020	89. First 1 km-diameter dome.
	2050	90. First 10 km-diameter "tent".
	2060	91. First 100 km-diameter "tent".
	2060	92. Lunar cutosphere (the lunicutosphere) begun.
	2100	93. The lunicutosphere completed.
	2035	94. 10^{-6} of Moon's surface underlain with underground constructions
	?2090	95. 10^{-4} of Moon's surface (3800 km^2) underlain with underground constructions.
		96. 1% of Moon's surface (380,000 km^2) underlain with underground constructions.
	1999	97. First ton of air or oxygen produced from Lunar soil (a10^4 m^3 at room pressure).
	2004	98. 100 tons of produced air accumulated (a10^6 m^3 @1 bar).
	2004	99. 100 tons/y of air produced.
	2015	100. 10,000 tons of produced air accumulated (a10^8 m^3 @1 bar).



1995	101. Bulk diet for 10 men produced (probably grown) from Lunar materials.
2008	102. Agriculture on Moon adequate to maintain 100 men.
2013	103. Agriculture on Moon adequate to maintain 1000 men.
2007	104. Substantial construction for the first time uses in situ materials for glass, earthwork, rock bricks, fired (ceramic bricks, cement, metals, &rc.
2015	105. 10 tons of metal produced from in situ materials by in situ industry.
2025	106. 1000 tons of metal so produced.
?or silicic=2018	107. 10 tons of plastic produced from in situ materials by in situ industry.
?2010	108. Natural caves of considerable size ($\geq$1000 m^3) found.
?2013	109. Natural caves of such dimension situate men &r factories.
	110. Nontrace natural water found on Moon and recovered in ton quantities.
1995	111. Tons of gems found.
1997	112. Cumulative loss of 10 lives.
1995	113. First life lost on Moon or in Lunar operation.
1997	114. First simultaneous loss of 10 lives.
2015	115. Cumulative loss of 100 lives.
2020	116. First simultaneous loss of 100 lives.
2008	117. First catastrophic collapse of a pressure dome.
1997	118. First crash of a spaciolunar or interlunar spaceship.
2005	119. Objects manufactured on the Moon exported from the Moon for the first time.
1993(part of base)	120. First permanent manned astronomic and geoscopic observatory on the Moon.
2000	121. First rerelunar astronomic observatory.
2005-2009	122. Greater telescopes than on Earth constructed and functional on Moon.
2009	123. 100 astronomers on Moon.
2025	124. Nuclear bombs used in Lunar construction, mining, &r manufacture (Lunar Plowshare a la Kraft A. Ehricke).
2040-2050	125. First 100-mile epilunar or intralunar tunnel built.
2070	126. Solian capital of Solian Government established on Moon.
2005	127. First use of the Moon's geothermal or vulcanic heat.
2035	128. Large-scale (eg in each case 10^{-7} X that on Earth) Lunar mining of 10 elements.
2035	129. Large-scale (eg in each case 10^{-7} X that on Earth for comparable minerals) Lunar mining of 30 chemicals.
2018	130. Extraordinary silicon-based industry developed and active on Moon (eg extraordinary in that sophisticated and ingeniously used silicic compounds are largely substituted for other elements and chemicals used for construction, organic materials other than those for human ingestion, machinery, books, electronic devices, power plants, domes, &c; there are equivalents of plastic, paper, wood, rubber, metals, wardrobe material, water, tar, fuel, and almost everything else--other elements are used only 1% as often, per total mass, as on Earth).
1990	131. 10^{-5} (380 km^2) of Lunar surface explored by epilunar human expeditions, robots, and telomachines on foot, in wheeled craft, and in flying craft.
1991	132. 10^{-4} (3800 km^2) of Lunar surface so explored.
1995	133. 10^{-3} (38,000 km^2) of Lunar surface so explored.
2000	134. 1% (380,000 km^2) of Moon so explored.

2012	135. 10% (3.8 M km^2) of Moon so explored.
2025	136. a100% (38 M km^2) of Moon so explored.
past(1969?)	137. Moon since telephotographed as 10^{12} cells 1 decameter square.
"1978"curve point	138. Moon since telephotographed as 10^{14} cells 1 meter square.
1984	139. Moon since telephotographed as 10^{16} cells 1 decimeter square.
1990	140. Moon since telephotographed as 10^{18} cells 1 centimeter square.
1997	141. Moon since telephotographed as 10^{20} cells 1 millimeter square.
1989	142. Armchair exploration of the total Lunar terrain using 10^{16-18}-cell Lunar stereocosmoramas, produced by cumulative telehолography &r stereological reconstruction, and computer-synthesized scenery, perspectives, and motion artfully supplemented by cumulative selenology, the product being more or less literal rather than highly fictitious, redundant, &c.
2007	143. First mass-driver built and operated on Moon.
2007	144. First birth on Moon.
2130	145. Native exceeds immigrant population.
?2075or2120	146. Immigration from Earth restricted.
(#102) 2005	147. First imported grass, flowers, shrubs, and trees.
1996	148. First pets and "wild" animals.
(#103) 2016	149. First animal husbandry and meat.
(#60) 2050	150. Flourishing life the equivalent of a random 10^{-7}-part (eg 50 km^2) of the Terran biosphere.
2060 ("tents")	151. Similarly the ratio of the Lunar to the Terran biosphere become 10^{-6} (eg 500 km^2).
2040	152. First titanic dome erected over a Lunar mountain for aesthetic environmental reasons.
2032	153. First artificial, variable weather (diurnal and seasonal cycles, storms, winds, clouds, lightning, picturesque sunsets and sunrises, random perturbations, winds changing direction, force, and beat, &rc).
2015	154. First 10-mile monorail.
2025	155. First 100-mile monorail.
2080	156. 100,000 miles of monorail, or an analogue, over the Moon.
2022	157. 0.1 personal vehicle per capita.
?2035?? complex!	158. Average of 1 visit annually to Earth by Selenians.
2025	159. Elderly, retired, and frail Terrans start moving to the micrograviticMoon.
2075	160. 1% of Terrans retire on the micrograviticMoon <u>if not elsewhere in Space</u>.
2022	161. Streams, rivers, waterfalls, lakes, marshes, &rc created on Moon.
2012 & 2022	162. Simulated Terran landscapes ("earthscapes") created on Moon by inhabitants or developers.
1995	163. Massive and minable fissionables discovered.
?2025 or 2050	164. Massive mining of fissionables for export to Earth.
?2015	165. Use of native fissionables for Lunar reactors.
2005-2007	166. First linear accelerators for launching spaceships bearing men and freight built and operated on Moon.
1995	167. 10 Terran nations have men on the Moon.
2005	168. 10 Terran nations have terrilunar and epilunar programs.
2010	169. 50 Terran nations are doing things on the Moon.
2009	170. 100-man epilunar expeditions are launched over the Moon.
2032	171. 1 or more ores mined on the Moon outcompete Terran minings when exported to Earth and priced on Terran markets.

172. Underground cities reach 10 miles into the Lunar crust (2000 "levels", numbered from the surface 0, 1, 2...).

173. Truly three-dimensional aboveground cities or "stereopolises" (a la R. Buckminster Fuller, Paolo Soleri, and Pat Gunkel) attain 10-mile heights (5000 floors) on the microgravitic Moon.

?(AI&c: 2100→2130=10^{-2}bar →2150=1 bar)

174. Wealth and industrial power become so great on the Moon that an open 0.01 (ubiquitously compressible) to 1.0 bar hyperoxic-or Terran atmosphere is created and maintained indifferently to exospheric leakage.

2040

175. Thousands of miles of pipes and pumps span the Moon to ship liquefied gases (especially air, oxygen, and hydrogen), liquids (water, petrochemicals, other industrial chemicals), slurries, dusts, &c between primary, secondary, and tertiary industries.

2008(first train)
2028(fill wilderness)

176. Great frictionless trains are levitated and hurled at hundreds and thousands of miles per hour throughout and around the Lunar surface which bear passengers and freight at superterran efficiencies; the Lunar network exceeds 50,000 miles and is simultaneously used by mass-transit and personal vehicles run by instructible and educable semi-spontaneous robots usually addressed as "Mac!".

2035
science reaches 2025; actual mining 2043

177. Minerals are for the first time mined at depths of 10 miles.

178. The subcrustal lithosphere is mined at 48-mile depth. Important minerals--unusual at the surfaces of both the Earth and the Moon--are found to exist in abundance and thereafter complement the silicic industry on which the Lunar economy is based, removing much of the need to export these critical ingredients at high expense from Earth and the Asteroids.

?1997

179. Vast quantities of unsublimated ice are found at the Moon's North and South Poles under sunless basins.

2008(start), 2025(big deal)

180. Annual sports events, the "Lunar Olympics", are held with tournaments and games based on things difficult, easier, possible only, or native on the Moon because of its microgravity or vacuum.

2016 ($\frac{1}{3}$ pc)

181. An "army" of 10,000 androids and other highly sophisticated robots labor on the Moon in lieu of, and as servants to, men doing engineering, cleaning buildings, constructing buildings, stockpiling goods, tending farms, minding children, directing traffic, effecting repairs, replacing parts, making surveys and inspections, watching stars, running spaceports, supervising level upon level of themselves, running errands, piloting vehicles, making tests, making inquiries, inspecting and maintaining domes, checking out spacesuits, maintaining supplies, supporting expeditions, scouting for human expeditions, racing factories, distributing credit and debt, planning for the future, rescuing lost or stricken "luninauts" (all human travelers), doing nuclear engineering, locating sought parties or keeping tabs on all civilian movements, maintaining the Lunar military defense systems, completing and refining orbital and ground plutography and the supreme Lunar cosmorama, reallocating robots over the Moon, handling lunipetal and lunifugal robots, staffing stores, maintaining sewers, running the vital

atmospheric, hydrologic, biocultural, medical, energic, wastes disposal, recycling, and other plants and facilities, administering medical examinations and therapies (including perfunctory diagnoses, prescriptions, and prognoses), assembling additional robots from modular parts, ad infinitum.

2030 (40pc) 182. An army of 1 million such robots.
2070(2050?2100?) 183. An army of 1 billion such robots.
2027 184. 10 robots per capita.
2061 185. 100 robots per capita.
2000 186. 100,000 watts per capita distinguishing Selenians.
2040 187. 1 M watts per capita.
2050 188. Asthenospheric "drilling" project commenced.
2070 189. Lithosphere penetrated and the Lunar asthenosphere reached at a depth of 1000 km.
?2090 190. The very center of the Moon reached at 2000 km.
=? past or ?1998? 191. Massive deposits of recoverable carbon discovered.
2000 or 2020 or 2050 or 2075 or never 192. The Lunar environment is more or less consciously judged unfit for human inhabitation, and the future of the Moon is abandoned to increasingly intelligent, independent, and intrinsically meaningful Selenian robots; these workers are eventually emancipated and enfranchised--first de gratia, then de jure, and finally de facto--and go on to radicate a monophyletic enantiomorphously quasihuman Selenian Civilization of mechanical beings on the achromatic Moon. This makes the Moon a much more interesting and natural place regularly visited by incredulous Terran tourists reacting to the hoards of artificial Selenians touring exotic Earth. The "apeirolatrous" (infinity-worshiping) Selenians then explore, develop, and populate the rest of the Solar System, the Milky Way, and the Universe.
on 2030,off 2005 193. 10^9 watts (1 gigawatt) of solar power produced on the Moon.
on 2045,off 2030 194. 10^{12} watts (1 terrawatt) of solar power produced.
off 2070 195. 10^{15} watts (1 femtawatt) of solar power produced
off ?2120? 196. 10^{18} watts (1 attawatt) of solar power produced by catoptric or photovoltaic perilunar telodynamic megamachines.
indoor2008, outdoor2030 197. Lunar life more or less on a par with Terran life.
intrinsically undatable 198. Much of Selenian population remigrates to new translunar loci, the spirit of the pioneer, frontiersman, and adventurer being in the blood of native Selenians.
2090 199. GLP 1% of GTP(Gross Terran Product).
2110 200. GLP 10% of GTP.
2070 201. 10^{-10} (7 B tons) of the Moon's native mass absorbed into artifice.
202. 10^{-7} (7 T tons) of the Moon's native mass absorbed into artifice.
203. 10^{-4} (7 quadrillion tons) of the Moon's native mass absorbed into artifice.
204. 10% (7 quintillion, or trillion million, tons) of the Moon absorbed into Lunar &r extralunar artifice.
205. 100% (70 quintillion tons) of the Moon's native mass absorbed into Lunar &r extralunar artifice--the natural Moon extinct.

PRONATALISM

Pronatalism is a favoring of human pullulation and a larger population. It is obviously somewhat in conflict with the current antinatal philosophy. Indeed, many people view anyone striking a pronatal stance as either afflicted with a tragic religious bias or daffy. After all, the assumption is that the Earth is drastically and increasingly overcrowded, dangerous, polluted, underfed, and underresourced, and that mankind, still expanding, is proceeding toward some ghastly planetary crisis when the limits to growth will be touched and the race decimated.

The reader of this book will be conscious that the writer is directed by a different and far more optimistic view of things. He recognizes that the world is presently full of crises and undergoing a relatively uncomfortable transition, but he sees these things as quite transitory and the consequence of the world emerging from virtually medieval conditions and advancing toward a higher and better civilization. He also regards the current problems as generally exaggerated and as deserving some placement on a larger and more knowledgeable prospect of the critical transition being undergone by civilization. Failure to recognize this more basic prospect may complicate the metamorphosis and could well be disastrous. Faith, confidence, and affirmation are necessary ingredients of a world making the present transition. Pessimism and reaction could be deadly.

There are both trivial and profound reasons for enlarging population now and in the future. These reasons have gone unconsidered by the current one-sided mentality. The consequence of this may have been, and may continue to be, untold moral harm without the slightest consciousness of the fact on the part of ourselves. All the more reason, therefore, for presenting the pronatalist argument.

Not many years ago Europeans were gripped by a strange fear that falling population would eradicate the race. Conditions in the world change. Human attitudes even more so. The next age may reexperience the previous fears of Europeans, especially since the tide of population may be ebbing as a result of perfect, universal, and "abused" contraceptive technology and as an overreaction against the present swelling of global population. In addition, the trouble with current population size and growth may be local, extrinsic, and fully solved in 30-50 years. In 30-50 years the technical and economic progress of the world may provide the basis for such wealth and control that the Earth may be in a position to accomodate populations much vaster than any obtaining or foreseen now. The stupendous human population existing in the world today would have been impossible without the wealth created by past science and technology. There is every reason to believe that scientific, technical, and economic progress will in the future maintain past exponential rates, and yet global population growth is now about to decelerate of its own. As a result, relative progress of science, technology, and the economy should assume a further, discontinuous acceleration, and it is sensible to expect that many current problems will rapidly diminish, especially since many of these problems are marginal and temporary in nature anyway.

There are a number of positive reasons for increasing and larger populations. One reason is that larger populations permit all sorts of economies of scale. Human interactions are synergistic and man's benefit to himself is a nonlinear function of population growth. The extraordinary civilizations existing over the world for the past 5-100 centuries, and issuing in present global civilization, would have been impossible without the growth and magnitude of their populations of men. Nor could such civilization arise had the

populations been smaller in space but proportionately longer in time. Man existed for 100-300 times the duration of civilization before civilization. There is not the slightest reason for supposing that the present population of the world, or any lesser population, are in any way optimal for the flourishing of human culture and the benefit of other men. Quite the contrary, every reason exists for believing that far larger populations could provide the basis for far greater civilizations and enduring human accomplishment.

The prevalent if unconscious assumption is that a simple inverse relationship exists for the quality of any populations in quantity greater than our own. In truth, no such law, possessed of any directive value and sign, is known to correlate population quantity and quality, except insofar as the sign is generally positive, per supra. There are locations over the world in which population sizes and densities accompany seemingly inferior conditions of life relative to some implicit scalar or vectorial optimum; there are equally locations where such relationships exist for superior conditions. Often the attribution of inferior conditions to dense or large populations, as the effect of these abundant populations, is laughable, an example being where the standards of living in great American cities have fallen simply as the effect of the self-governing rural or suburban migration of the higher socioeconomic categories, so that the lower and more objectionable categories have become concentrated in these great cities and indeed disfigured the urban environment. Great European cities have hitherto been immune to the tragic plight of the American cities. Even now, in the case of a great city like New York experiencing all the problems it is, native Yorkers are devoted to their city and spurn the countryside as dull, empty, strange, and inconvenient. In a city like Boston, despite its average problems, a dense section like the Italian North End has a color and safety very attractive to new residents. In short, it as easy to defend as to criticize the life of large and dense populations, and the critical question is the net situation and as enjoyed by optimistic citizens, rather than those projecting distaste and rejection onto surprisingly neutral circumstances. To a critical degree, it can be said that one gets out of life what he puts into it in terms of constructive, affirmative, relaxed, and cheerful behavior: the social environment is the projected product of the social mind. There was a day when the immensity of Terran population was a source of delight, pride, and hope. The current alternating weltschmerz should die with the age.

Enlargement of population has the fantastic consequence that it, in effect, compresses time, accelerates progress and development, and brings the future into the present. Of course there is some progress which is too serial and dependent upon nondemographic factors that it can be hurried by the trick of expanding the population, variety, wealth, and complexity of the present. Yet even against this must be placed the nonlinear advantages of such expansions, per supra. Certainly many aspects of progress are accelerable pronatalistically. An immense world is fascinating and challenging just because of its immensity. Men crowd into cities for this very reason. The index of human aggregation is extraordinary. Men are "demophilic". Human association has historically produced human heterogeneity, beneficial specialization, combination, and stratification, evolution, opportunity, motivation, prosperity, security, intensified life, and the miracle of friendship. The very fascination of the present world is a result of intensified awareness and transactions consequent upon modern pullulation, communication, transportation, &c. A world comprised of a trillion, quadrillion, or quintillion human beings would be inconceivably more fascinating, challenging, filled with opportunity, self-improving, internally convergent, self-facilitating, differentiated as to opportunity, multidimensional, fertile, brilliant, protean, powerful, deep, busy, questing, self-exciting, self-complementary or concinnous, secure through redundancy,

quick in the evolution of its destiny, thoughtful, creative, perfective, self-exampled, self-disciplining, instructive, &c than our tiny, if self-impressed world of 4 billions. A world of a quintillion men would virtually have for each one us a set of all of us, since it is roughly the square of present population.

The Efflorescent World View set forth in this book renders it obvious that such inconceivably greater numbers of men would, far from experiencing monotony in the likeness, normalcy, simplicity, and convergence of their lives, at once exhibit and experience a variety, divergence, elegance, complexity, variation, individuality, &c unknown to our own. Let there thus be removed from mind the contrary expectation of a cheapened existence and an exhausted planet. The Efflorescent World View postulates that nature, science, art, existence, and the future are infinite, progressive, superinfinite, hierarchic, &c.

Elsewhere in this book I show why the resources of minerals, energies, future industries, space, &c are already known to be adequate to accomodate, without sacrifises in the quality of life, all of the superpopulations discussed above. Of course the rate of growth of population should not exceed, in any detrimental way, the concomitant growth of enabling means and circumstances, but the world's current imbalance--itself finite and questionable--is most likely to be irrelevant to the sane, self-controlled, and omnipotent civilization that will arise over the next 100-200 years as the changed face of the human race.

Yet the greatest pronatalist argument may be, simply, that potential people have a right to exist. Even when revaluated for interactions with transitional and final demographic quality (or the actual and unknown tradeoff of quality at the extreme of quantity), and any justified concessions to the historical peoples such as ourselves whose decision and preparatory labor is critical to the appearance of the exploded populations of men, it is obvious that men now alive have the simultaneous obligation and opportunity to originate posterities far larger than exist today as an accident of history, but a fortunate accident to the egoistic degree that we ourselves exist as members of the present enlarged global population, and would not exist had antinatal policies prevailed in the past. When I was in my teens I used to take exquisite pleasure in moving some object about on the top of a table for the simple reason that this had as its direct consequence that some hand in the future was assured thereby of changing its place in a deterministic fashion. At the same time, this was an intellectual pleasure with a moral note since what really fascinated me was the vivid illustration in this way of the obligations men have to their posterities through being the sole agents predetermining the critical conditions to be enjoyed by those posterities on the basis of selection and care amid present acts. I saw beyond this, furthermore, that the consequences were not to be unique but on the contrary would multiply so as to eventually cover all things in the worlds of these pathetically dependent but reincarnating posterities, particularly as the acts in the present were extraordinary and sprang from a specific awareness of the operative mechanisms and the laws of time. I then concluded that the distinction made by current men, my fellows, between things in esse vis-a-vis things in posse or in futura was everywhere misconceived as absolute and critical, whereas in fact man's rights and obligations extend naturally to encompass these intangible but equally dependent things, that the authority for our actions must be conclusions formed from the scrutiny of an imaginary scales with the present on the right counterbalanced by the future on the left. Be it instinct, opportunity, or obligation motivating us, every man to some degree feels an idealistic devotion to his family, community, nation, &c. It may in fact be the great challenge of the next 100-200 years that man anticipate the future and reset his actions to accord with the obligations of a scientific and profound conscience to things in posse and in futura.

Simpleminded extrapolation of the disparate sizes and rates of growth of the populations of nations suggest that by 2075 or 2175 the disparity in the sizes and densities of Earth's populations and densities will be even greater. A consequence of the larger populations of other continents and countries by these years should be that these will surpass North America and the United States in Gross Product and perhaps also in per capita income as a result of concentration of resources and economies of scale directed inward. It might be argued that countries with bigger populations, assuming their early problems as large populaces solved, will develop faster economically for several reasons including speeded development of national resources and national plant, and greater overall talent contributing to top-down leadership. I have argued that today's underdeveloped countries should catch up with the developed nations at rates unprecedented in history, become equal in per capita income as early as 2025 or 2050, and may very well overshoot so as to reverse today's relationships between more and less developed nations. For example, Arnold Toynbee has said that the Chinese People's Republic will become the world's leading power in the course of the 21st century, which I consider plausible because of China's immense population of 800,000,000, her extraordinary cultural past, her current ideological fervor, and her area and resources, in combination with my above remarks. The point I am making is that large or maximal population is internationally, racially, ideologically, commercially, developmentally, militarily, &c competitive--and very much so. There are many little populations around the world with typical standards of living roughly on a par with the United States but in no sense as competitive, as a result of their "size". An emerging problem is already that most of the world's population is to be found in the underdeveloped countries which may therefore in the future be in a position to dominate the wealthier but minoritous nations, say in the United Nations, which may be reapportioned by population. Too, already visible on the horizons are several countries, particularly Japan and Brazil, that are growing so rapidly economically and populationally, and are possessed of such land and resources, that the United States, still leader of the world, is in danger of being overtaken and surpassed between 2000 and 2025. The Brazilian government is pronatalist, realizing the need it has for a larger workforce and the capacity it has to support far larger population. Evidently pronatalists must, ipso facto, become relatively more numerous. A nation such as China, or a populous bloc of nations, could cause itself to constitute half of the world in the 21st century by sustaining or increasing its relative growth. The point I am making in all this is that <u>competitive reasons alone</u> can be extraordinarily persuasive ones for maintaining, maximizing, or re-creating population growth, however inoperative such reasons may be <u>for most nations</u> momentarily.

Current advocates of the colonization of Space have in part intended such colonies to represent replies or solutions to the limits to growth people. The colonies are meant to illustrate that totally self-sufficient, nonpolluting, closed-cycle, low-technological, &c colonies for large numbers of people can quickly and easily be built in Space, and with exponential growth in number and magnitude by self-reproduction. The colonization of Space would therefore seem to enable the safe continuation of exponential population growth. The population of Space is an excellent illustration of pronatalist reasons since the increasing numbers of people would be desirable and critical in order to raise the standard of living and cultural experience one would enjoy in Space: the more people the better. <u>People</u> explore, build things, run things, maintain things, create things, attend to one another, generate culture, complement one another, &c. Furthermore, when one adventures into a frontier charged with potentialities but vacant of men, and undertakes its development, the most natural thing in the world is that population increase to fill the new lebensraum.

Six years ago, at a time when the vociferous antinatal "pogrom" was just starting, I put the matter in tongue in cheek fashion as follows:

> "The current populational equation stresses quality as equal to quantity with a negative exponent. This is simplicity itself and therefore wrong. As a more realistic approximation we may say that optimity is similar to a quantity of quality where quality is a complex nonlinear function of morality, head, structure, quality, interest, function, imagination, productivity, state, technology, and mercy of population (none of which factors are trivial or univalent). Working, paradoxally, this equation sees very large quantities and pureties of optimity and stupendous absolute increases in quantity and quality of proximal population."

I still think this sums up the situation in a much better way than any of the subsequent, lopsided, and inordinately simplistic discussion. We are dealing with lives and when human lives are in the balance, indeed all the lives there are, one cannot afford to be simplistic; one must be excruciatingly careful.

Some of the additional pronatalist points I have made in the past include:

The decision over a natal, intense, and compulsory policy may be based--whatever the external situation--on inward (intranational, local, or situational) criteria of resources, attitudes, philosophies, goals, orientations, capacities, and events, and, as such, the world be checkered.

Hypothetically, a decision may and should be made to redistribute capital or annual resources--emphases, facilities, credit, material, goods, surpluses, decisions, techniques, information, personnel, &r administrations--toward a crude, specific, controlled, principal, or all-out stimulation, acceleration, development, equalization, or solution of the economic disparities associated with nations' populational problems, having the joint effect of alleviating or eliminating the excessive difficulties of rate and size, and accenting pronatalist objects.

Batches of technologies will arise and assert themselves for a reorganization of labor and industry, and an increase of productivity, such that this impermanent phase of populational redundancy and disequilibrium will not be catastrophic or ominous nor even necessarily unusually distressful.

Such batches and extraordinary technologic developments will prevent either a sustentation or an acceleration of, for example, maximal populational growth from being catastrophic or bad, or from even approaching that--with preparatory and expectational qualifications. We ought be fiducially or constructionally accelerating or maximizing our growth, and theoretically recasting our institutional bases.

Considerations with respect to the course of population, whatever they be, ought to be rigorous and incisive.

High populational size and rate does, may, or can induce immediate or eventual acceptable, normal, superior, or maximal economic growth.

Unique societies may and should evolve from increased or maximal population.

Roles are possible for the excellent employment of greater populations.

Present people are equivalent to future descent. Yet coetaneous people can do some special things, are most efficient, and allow greater efficiency of maintenance.

There is a gamut of applied, extant, obtainable, imminent, and eventual techniques for eliminating the traditional defects of high populational aspects.

Developmentally, near-time temporary maximal population is desirable to advance the utopistic future or destiny. Here the call is to a prévenance centered on posterity.

Maximal populations are, assertibly, controllable politically.

Meaning, after all, resides in people, in maximal contact (intense, constant, varied, and demanding), in complex and deep social action, in the subjective challenge of human masses, and in other external aspects of great numbers of men. The latter are excitational.

Populations can be upgraded, differentiated, facilitated, structured, and otherwise justified and ensured.

We are wasteful of space, energy, opportunity, resources, forms, &c not to have a higher or maximal level of population.

We are obliged to be experimental, in part because the case is not irreversible (we can roll back population and consequences). High population would also facilitate general societal experimentation.

Larger population would promote genotypal and ontogenetic complementariness and the emergence of truly "great" population.

The Earth itself is as yet, or necessarily, partly uninhabited and underpopulated.

The carrying capacity of the Earth--variously calculated and recalculated--permits absolutely phenomenal ultimate populations.

Outer Space is the next exploration, development, and occupation and it presupposes or allows tremendous population. Such may be our "destiny".

Passively or actively caused inexistence of human beings may in certain respects be tantamount to genocide, so that we should exigently strive for superpopulation. Future population is for a variety of reasons, including "disproportion", infinitely more important than present population and ourselves. In particular, men--especially after having been acquainted with these novel arguments and effectual roles--are not irrelevant spectators.

The unfamiliarity and unpresentability of these points may be a case of naiveté, ignorance, stupidity, or misfortune. They may <u>now</u> be ineludible, contagious, spectacular, obvious, and welcome. The status quo is not a "well enough".

With reference to the current mixed national situation over the world: Various nations (such as Taiwan, Japan, Hungary, and various Western European countries) may be taken to indicate the efficacy, possibility, and practicability of birth control, or the manageability of arrant growth. Great Britain, other nations of Western Europe, Soviet Union, and the United States indicate the compatibility of growth, stability, and prosperity. Such nations as South Korea, Japan, and West Germany suggest the viability, prosperity, health, normalcy, and submaximality of high density of population, and perhaps the peculiar advantage.

Very many other arguments can be made for the present and future possibility, probability, feasibility, desirability, tolerability, superiority, &c of high, higher, and highest arithmetic growth, geometric growth, size, and density of the population of the human race, to all of which zero or negligible attention has been given by the antinatalist schools which now dominate the global scene in totalitarian fashion. It is time this prejudiced perspective ended.

It is future science and technology that will allow for the larger and vital populations entertained. Such science and technology are difficult to anticipate in a specific way but certain developments can be logically foreseen to a surprising extent. Let me briefly discuss some of these developments that are basic to superpopulations and that answer those who contend that man has reached the limits to growth. The things I will refer to are only examples of a far larger range of possibilities.

The Club of Rome insists that we are exhausting power resources, both renewable and nonrenewable ones. The Earth receives from the Sun an energy in sunlight 10,000 X greater than the total energy of current industry, and the Sun emits 2,000,000,000 X as much solar energy as the Earth, an orbital speck, receives. Controlled fusion is virtually certain and imminent, where oceanic deuterium

will provide energy equivalent to 10,000,000,000 years of total world use in the year 2000, oceanic protium perhaps 100,000,000,000,000 years, and Jovian hydrogen 10,000,000,000,000,000,000 years (or equivalent increases in annual use). If we are eventually able to harness the energy in ordinary matter--and we probably will--this will provide perhaps 10,000,000,000,000,000 years merely by using Terran fuel. Yet the fact is that we are currently using energy resources--with respect to ultimate efficiencies--in a terribly wasteful or inefficient way for industry, inhabitational heating, agriculture, &c!

The Club of Rome tells us that we are exhausting mineral resources. Yet it refers to incredible underestimates of natural deposits, fantastically inefficient systems of mineral recovery and use, extraordinarily arbitrary chemical and elemental emphases, enormous price-dependencies, &c. It ignores entirely the actual elemental, chemical, and mineral wealth of the titanic geospheres, is pathetically ignorant of present and future substitutional possibilities, takes no account of likely future capabilities of science and technology for efficiently recovering all molecues and atoms present in trace amounts in the soil and crust, &c. The reader will recall my discussions elsewhere of how the single element silicon, which comprises 30% of the Earth's crust, and silicic compounds, which comprise perhaps 98%, allow a silicon-based industry to arise in the future accomplishing practically everything necessary to a high civilization and technology on a totally different elemental and chemical basis, particularly in the presence of superabundant energy, which the previous paragraph showed to be part of the future. The Club has a limited accuracy when it remarks that global industry faces a few near-term and partially critical mineral shortages, but has the voice of a fool when it extends its pessimism to the gravity of the short-term situation and the absolute limitations which the medium-term and long-term future will supposedly have to face.

The Club of Rome says that global pollution is an inevitable result of present and future industry, and threatens the world with imminent degradation and destruction. It attributes such pollution to science and technology intrinsically and says that these have no power to cure the problems they create. Yet over the world for a century grievous pollution has been rolled back whenever science and technology, made conscious of specific problems, have been applied to the elimination of offensive pollution, and the situation generally is that the total pollutedness of habitats has been drastically reduced in exemplary cases; in many respects the world has been getting cleaner, safer, and better. The Club forgets how recent and beginning our depollutional efforts have been, and yet how successful, say in terms of quantitative indices. It forgets entirely how efficient future recycling will be, and the very benefits of this to the capacity of industry. It furthermore promotes a climate of unseeing hysteria by exaggerating and contriving what would be especially grave global effects of industry, technology, and science--such as supposed effects of supposed anthropogenic and actual reductions of stratospheric ultraviolet-filtering ozone, supposed effects of DDT on man and other organisms, supposed effects of industrial heat on the state or equilibrium of global climate, ad infinitum.

The Club of Rome says that global population will increase to infinity in a few decades but disregards its imminent statistical contraflexure and the enormous counterbalancing good represented by the mere existence of such a stupendous number of lives. Likewise it forgets the likely ahistorically fast reduction of populational growth resulting from new science and technology providing ahistoric contraception and from ahistorically rapid industrial, economic, educational, and social development of today's underdeveloped nations in the future.

The Club of Rome bemoans the imminence of worldwide famine on an unprecedented scale as the result of insufficient agriculture, forgetting thereby that the long-term growth of global agriculture has exceeded, say in terms of per capita diet, the long-term rate of growth of global population. It forgets the predictable and obvious extraordinary rate of advance which the science, technology, and actual amount of global food production will experience in the future, an exponential process that will surely exceed exponential pullulation, even without the imminent downward inflection of the latter. Ultimately it is obvious that the essential chemical oligodynamic nutrients necessary for human survival and health will be synthesized at an economy and efficiency many of orders of magnitude beyond current agricultural and other food-production techniques, and furthermore done so--in the future--without fallen quality in the aesthetic aspects of diet or in the basic quality of life. Finally it is obvious that within 50-100 years it will be possible to insert in the human body a cosmetic electrochemical prosthetic such that material nutrient will be eliminable practically altogether with a gain in industrial efficiency of countless orders of magnitude.

It is virtually certain that within around 50 years cosmetic and acceptable neurotechnological interventions will exist and be in use--unless irrationally suppressed--so changing man's psychological nature that any problems supposedly attendant upon high populational sizes and densities will be infinitely reducible without any degradation of the quality, meaning, and basic validity of life but, on the contrary, with major improvements over nature in these things. (Current stigmas and fears over these possibilities can be retired by this time, and are certainly rationally answerable once the neurotechnology becomes sufficiently sophisticated, understood, tested, and common.)

It is possible to design habitats such that high populational density and size exist without being evident, by such things as an enclosure of living, working, and playing spaces, perfect sonic insulation, artifice even more interesting and "natural" than nature, suitable sensory distractions, a suitable topological hierarchy of "subspaces", &c. Nothing like these things--in kind or degree--exists today by way of deep analogy. The quantity, quality, intricacy, efficacy, sophistication, perfection, &c of the art and science of this futural "technological architecture" are completely unimaginable on the basis of man's current accomplishments and even by reference to things existing in nature.

In 40-100 years there will develop a "supertocology" (or science and technology of birth) and a "superpedology" (or science and technology of raising children) that will alter attitudes and possibilities which dictate the growth and size of population completely. For example, women and men will be able to control perfectly ab libitum their production of offspring, ectogenesis will supplant natural birth (or do so increasingly over a period of 30 years), children will be raised en masse and artificially (a la the creches of Aldous Huxley's prophetic novel Brave New World and the nurtural and scholastic kibbutzim documented by Bruno Bettleheim in Children of the Dawn, and by subintelligent, intelligent, and superintelligent computers after 2000, &c), the doubling time of populational growth will be arbitrarily compressible (dependent only on the basic doubling time possible for industry, say under total automation, superintelligent computers, cellular automata, &c), &c. Much could and should be said in connexion with these transfigurative possibilities and probabilities that I omit here in deference to "Space". The reader, however, will derive a sense of things from my minimized remarks. What is clear, in particular, is that the growth of Terran and Solian population beyond 2025--in the subsequent decades and centuries--can and may well be at rates at once unnecessary, impossible, and utterly fantastic in present terms. One significant consequence is that the long-term future of the Solar System is almost impossible either to foresee or to understand, and must not be evaluated in overly contemporary terms. Another consequence is that the progress of Solian Civilization over the next 200 years may include almost everything imaginable

FIRST EXTRASOLIAN MESSAGE RECEIVED BY HUMANS

1. Greetings and salutations.
2. Purpose of message.
3. Stage represented by typical receivers (us).
4. Description of universal network.
5. Description of universal civilization.
6. Description of sender's civilization and world.
7. History of sender's world.
8. Instructions for construction of appropriate receiver and exploitative computer.
9. Description of total transmissive bands of universe.
10. Instructions for a responsive transmitter.
11. Invitation to visit.
12. Instructions for a vehicle with which to visit.
13. Universal ethics.
14. Universal aesthetics.
15. Universal religion.
16. Universal culturology.
17. Science.
18. Technology.
19. Self-developmental program.
20. Warnings and advice.
21. Free entertainment, education, art, &c.
22. Questions.
23. Directory: White pages, Yellow pages, pen pals, &c.
24. Map of universe.
25. Statement of universal plan.
26. Universal newspaper: news, ads, gossip, &c.
27. Universal law.
28. Trivial talk.
29. "Pictures" or tour of transmitter's world.
30. Reports by expeditionary forces (spaceships and colonies), police and military patrols and forces, governmental agents, &c.
31. Universal commerce, economy, sellers, buyers, middlemen, credit, investors, brokers, &c.
32. Typical future histories of cultures.
33. Plenistic revelations: hierarchic levels of the universe beyond the redshift, other universes, the omniverse, other omniverses, the myrioramic principle, other contents of our universe, superinfinity, &c.
34. Ultimately beautiful things, ultimately inspiring things, ultimately wise things, ultimately great examples (equivalents of personalities, lives, great cultures, great histories, &c), ultimately truthful things, ultimately profound things, ultimately profound thoughts, ultimately happy things, ultimately helpful things, &c.
35. Absolutely gigantic--virtually infinite--dictionaries, encyclopedias, &c of words, concepts, forms, all possible molecules, all possible organisms, all possible particles, all possible environments, all possible societies, all possible values, all possible histories, all possible inventions, all possible products, all possible artistic forms and contents, all possible philosophic ideas, all possible mathematical things, all possible games, all possible courses for the future of a civilization such as ours, all possible laws, all possible physical phenomena, all possible ideas, everything possible, quotations, biographies, &c.
36. Description of the previous history of the universe or cosmogony, and description of cosmology (structure, composition, dynamics, interrelations, processes, phenomena, systems, laws, &c of the whole or known universe).

(FINIS)

THE POSSIBLE AND THE PROBABLE RATE OF GROWTH OF SCIENCE IN THE FUTURE

The Efflorescent World View which runs in the bass throughout this book is not necessarily critical to the many extraordinary developments that are predicted but without question it colors the mood of things. It is a View that is highly plastic and can actually be broken into bits and degrees to render it more compatible with the expectations of others. As a world view it is a spontaneous outgrowth of the thought and study of my lifetime. Because of it I have found myself to be diametrically opposed to current pessimism and previous supposedly moderate anticipations of the promise of future science and the rate at which the promise would be realized over coming years. My disagreement with previous moderate expectations of its promise can be narrowed to my faith in the amenability of human needs, problems, and wishes to scientific solution, in the ultimate comprehensibility and controllability of nature, and in the sheer range of what might be imagined to be possible. My disagreement with previous moderate expectations over the rate of present and future scientific progress can be condensed into the statement that I believe that past and future scientific and technical progress both is and can be even more so of an "exponential" kind, whereas those other expectations assume something better described as "linear" progress. The current pessimistic school seems to me to presuppose that past &r future scientific progress will be at either a fractional exponential rate or at a negative exponential rate, the latter as a result of overwhelming negative consequences concurrent with future growth or simply the passage of the years revealing the fuller effects of past growth. Simultaneously the pessimistic school apparently views science, or at least the current era of science, as a finite and exhaustible "bag of tricks", if not at bottom a Pandora's Box.

I believe that untold scientific, technical, and derivative social progress lies before us, and not in the remote future but in the immediate decades and centuries. I also think there is a good chance that the scientific and technical revolutions in an important way have yet to occur but may, either actually or potentially (and both to a degree), transpire in the course of the next 75-125 years in the form of what might be described as a qualitative and quantitative "takeoff" in the sense in which Walter Roscow uses this for contemporary economic, political, and social transformations in the many underdeveloped countries of the world repeating the experiences of the developed nations. Thirdly, the Efflorescent World View postulates that such three-headed scientific, technical, and social progress (or all progress) can be and ultimately will be infinite, that science, nature, and possibility itself are limitless. Finally, the same World View postulates that such progress will be more than infinite, or superinfinite. To some extent these 4 possibilities are independent of one another, but I am inclined to believe in all of them as being most realistic.

Past progress has been so immense that many people take exception to an assertion that it can or will long continue at its past exponential rate, at least in many terms and indices, and feel that it will soon inflect, or has since inflected, downward so that a logistic curve will be followed over the next 50-200 years and smoothed and long-term scientific progress, in general or in the special respects, will exhibit a lesser exponential course than the current or recent phenomenon. Moreover, it is in general very difficult to suggest or corroborate meaningful quantitative indices of scientific growth, and doubts must be raised whether my assertion is not intuitive, as intuitive, doubtful, or has reference to some product of a formula combining countless factors, as well as questionably subtle terms, so that my allusion is not to what is ordinarily meant as the measure of scientific progress but to something quite different, perhaps incomparable, and perhaps open to new dispute.

I turn the argument around, confess outright that I am relying on a highly compounded formula, assert its greater legitimacy and importance (in other words, its fundamental nature), and take a further step: I believe that the measurement of scientific and other progress can be, and is always, described by a formula many of whose components have a limited calculability in time so that, say not in 50 but in 100 years (in one case), the relevance of the components fades, the set of components comprising the significant formula changes, and the exponential progress over greater units of time and over eternity can continue so as to involve 36 or an infinite number of orders of magnitude of accumulative and attained progress. I have made the same point in both criticizing and defending the concept of such long progress, and the comparative progress of nations, measured in terms of the "GNP" or a "GNP", or a "GWP". Mathematical physics is well acquainted with the occurrence of infinitesimals and singularities in nature or in our equations for nature which might be taken by a Zeno as fatally paradoxical for understanding nature &r the very occurrences we find in nature but which wise physicists have learned to take tolerant and transcendental views of, thus enabling scientific progress on the basis of a greater empirical framework.

I believe that 75 years from today in 2050 science could be--I do not say that it will be nor what it will be--"greater, more important, &r larger" than in 1975 by 4-8 orders of magnitude (I abstain at this point from narrowing the range or picking a unique exponent). This might seem shocking, although it might not be shocking regardless of its likelihood as a possibility (not as a probability); a separate matter is whether it would be shocking as an estimate of probability. It is actually conceivable that scientific progress over the previous 75 years, from 1900 to 1975, represented a 4-8 orders of magnitude increase, and perhaps 4-8 orders of magnitude advance distinguished the previous periods of 75 years, so that progress from 1825 to 1975 was 8-16 orders of magnitude, &c: these things may or may not have occurred, they are defensible, but they not essential to projection here for the 1975-2050 period, and likewise partly independent are 75-year periods beyond 2050, so that accumulative progress from 1975 to 2125 might or might not represent 8-16 orders of magnitude beyond the state of science in 1975. The period of the next 75 years until 2050 may represent the intermediate continuation of a secular curve or it may instead merely represent a unique discontinuity and an averaged displacement; in the latter terms, one can argue that a peculiar explosion, convergence, takeoff, consummation, or climax will consciously or retrospectively transpire over the next 75 years. Many of the factors contributing to the foreseen radical advancement of science considered possible might--if not probably or necessarily--obey logistic curves so as to peak and fold over during this time, examples being global growth of population, wealth, innovation, scientific and technological investment, education, literacy, occupational change, automation, solution of ranking natural problems, &rc. The percentage and absolute contribution of this bundle of things to scientific advance would seem to argue that the stupendous growth foreseen will be transient, or at least at this historic moment highly dependent on these factors (as opposed to their possible successors &r alternatives, say at a later period of time), yet this appearance of things may be deceptive. There is certainly the additional possibility, referred to throughout this book, that progress in different quarters over centuries will conform to a multiple or endless succession of logistic curves like successive hills bound for Heaven as the mountains shade off in the distance as the failure of our merely human vision. Progress averaged over these countless undulations might either be less than or identical with the 4-8 orders of magnitude increase I suggest may occur over the next 75 years. It is well to remember that in these more distant and ultimate terms we primitive ancestral beings have no ability to conceive or perceive what is possible and what is meaningful, and to be either deeply optimistic or deeply pessimistic.

Today the United States has 5×10^{-2} of Earth's population, and the Developed Countries have perhaps 2.5×10^{-1}. Countries today ranked as Developed will perhaps contain but 10^{-1} of the world's population in 2050. Today the United States is the most Developed nation on Earth. It is furthermore the most scientific and is virtually as educated and literate as any nation. I should not be surprised if the population of the world in 2050 will be only 10^{10} but the standard assumption is that it will be 1.5×10^{10}, an assumption which I here follow in an "optimistic" way. The world will therefore have 4 X as many men in 2050 as in 1975. I guess the literacy rate will be 7 X what it is today, or 95% in 2050. Thus there will be 25 X as many literate men in 2050 as there are now. Half of the world is female. By 2050 tremendous improvement will occur in the literacy, education, and professional employment of this half of mankind, which I incorporate only implicitly in my final formula for the progress of science by 2050. Most of the world is preindustrial in 1975. I should expect that 90-95% of it will be industrial in 2050 (thus I expect unusually rapid growth of Developing nations over this span of time, as discussed elsewhere in this book). I should not be surprised if by 2050 90-100% of primary and secondary jobs will be fully automated, since I expect absolutely revolutionary breakthroughs in this area and almost automatic transfer of this robotic technology to all parts of the world, thereby interrupting historical patterns of development. I believe that 90% of the human labor force can participate directly in the development of science, in part because there are countless important things for men with IQs of 70-200 to do. I expect that by 2050 100-1000 X as large a percentage of global population, and thus 400-4000 X as many men in the absolute, may be scientists, technicians, or helpful assistants thereof than in 1975. Science advances on the basis of past progress which causes its powers and understanding to accumulate and its rate of advance to accelerate, so I expect that by 2050 science might be 100-1000 X as "great", for these reasons alone, as it was in 1975. There is clearly some relationship between the number of scientific personnel worldwide and these 2 accumulative and acceleratory tendencies of science which is of a multiplicative kind, suggesting a combined product a few orders of magnitude more or less than 40,000-4,000,000 in 2050. But these considerations are quantitative and it is clear that qualitative improvements in scientists will likewise be a factor by 2050, however marginal. Another extremely important fact is that the progress of science is "convergent" in that theory, fact, and theory and fact together progressively fit together and do so in an accelerating way, particularly and perhaps, as a consequence, a fortiori insofar as powers resulting from such pure convergence are concerned. This must be multiplied against the preceding super product I have developed but in some synergistic way, perhaps as a real factor of 10-100, yielding a "magnification" of science in 2050 by 5.5-8.5 orders of magnitude, give or take many orders of magnitude because of the simplicities and crudities of my loose formula. The discussion can now turn to further nonadditive but multiplicative factors such as the traditional and nontraditional plant, or wealth in means, that must be foreseen for 2050; the extraordinary development of powerful and complete instrumentation, techniques, and methods; the separate progress in the power, intelligence, use, and sophistication of use of computers before and by 2050; the exponentially increased and increasing wealth of mankind, and the important reallocation of this wealth; the new attitudes of the world toward science, the growth of science into whole new areas, the very dynamism of science likely or possible for the world by 2050, the influential unification of all sciences, the improvement of the goals of science, the emphasization of the sciences as ends in themselves (rather than being merely handmaidens to industry, the military, specific interests, narrow human needs, unimaginative long-term goals, &c), the tremendous strides in the compilation, organization, systematization, synthesis, availability, use, and sophistication of use of scientific and technical knowledge throughout the world; the tremendous strides in the organization of scientific endeavor throughout the world (eg in the institutionalization of science); specific

and disproportionately important breakthroughs of science in particular areas; &c.

What is clear is that there are a stupendous array of considerations and factors which might and will singly, in combination, or synergistically contribute to total scientific progress by 2050 and the complex stature of science in 2050. Thus objections to my suggestion that by 2050 science might be enlarged by 4-8 orders of magnitude over what it is today (a suggestion heavily backed by redundar synergistic, and obscure considerations) may require careful reconsideration and restatement in terms of the larger picture I have set forth. The picture I have suggested may even suggest that scientific progress by 2050 will in fact amount to 4-8 orders of magnitude. Even if this or any quantitative estimation of the rate and scale of progress possible &r probable by 2050 or 2125 must remain controversial, especially as a unique estimate or series of arguments, equivalent qualitative or intuitive progress over these years may strike many readers as likely or possible and thus similarly miraculous and decisive. The important point is indeed that science has it in it to accomplish so much in a pure, applied, critical, and human way over the years ahead, and support for science today and tomorrow must remain sensible of these likely or possible things. Even if the chance of such stupendous progress being possible or likely is deemed only 1-10%, the incredible consequences of such progress if it occurred might well totally justify almost all-out support of science in a way analogous to a 50-100% probability of the same results.

Assuming my previous assertion that the Developing nations will catch up with the Developed nations so fast that by 2050 nations now merely Developing will have either caught up with or overtaken current Developed nations in per capita income (and there is good reason for speculating that the Developing nations will sooner or later, say by 2050, overtake today's Developed nations because of the latter experiencing a "European" fate by abandoning economic growth at some plateau or persisting in such growth at reduced or merely current rates in a dynamic world, where the significant point is that these overtaking nations will comprise 70-90% of the population of the world in 2050), one might suppose that by 2050 the GWP will be $\$10^{14-15}$ or 1.5-2.5 orders of magnitude (30-300 X) greater than it is today.

What science is occurring today is--compared with what it might be--ill-organized, very redundant, and motivated by and directed toward small and imperfect purposes: for example, wastefully redundant military and commercial "intensity", trivial products and product changes, stagnant lines of research, overly applied purposes, ridiculously arbitrary--pecuniary, political, defensive, medical, momentary or short-term, sensational, adventitious, "career", commercial, vulgar, irrational, &c--purposes, &c.

Of overwhelming importance for [possible and probable] growth of science over the next 75 years will be [progress of computer ⟨hardware and software⟩, appearance of ⟨virtually and truly⟩ intelligent machines, &r emergence of transhumanly intelligent machines]. This is illustrated by a fall in the cost of computing power, in terms of dollars per million operations, of 5 orders of magnitude in 20 years from 1955 to 1975. Herman Kahn has suggested that over the years 1967-2000 the capacity of computers might increase by 11-16 orders of magnitude. [There has been, and there will probably be,] tremendous increase in [powers of individual computers and total accumulative computation over the entire world] from now until 2050. Revolutions in [hardware and software] are a [constant and short-term] phenomenon in this field and absolutely fantastic [quantitative and qualitative] progress is precisely what is expected by [2000 and 2050]. I expect that computers will exceed human intelligence [with 50% probability by 2000 and 95% probability by 2035], and I have little doubt that, either [before or after] this threshold, they will simply explode in power, attaining in [a few hours or a few decades] levels of intelligence--powers of [calculation, thought, perception,

memory, drive, insight, foresight, creativity, action, control over nature, awareness, mastery over themselves, self-evolution, &c--completely without analogy in relatively idiotic human beings such as you and I. These possibilities are focused on in pages - . The impact of intelligent or merely extraordinarily powerful and pervasive computers might revolutionize scientific progress in any or all of the following incomplete ways:

1. By automating chemistry to such a degree as to enormously accelerate the discovery of new chemicals, effects, uses, overall properties, &rc by simulating research into chemical properties and interactions.
2. By displacing men from many areas of yeomanly research by low/middle automati of the control of analytical and synthetic apparatus and methods, fast and sensitive systematic exploration of ordered sets of researches, &c in terms of many areas of chemical, physical, biological, &c research.
3. By automating much of the nonscientific economy so as to release everyone for work more directly bearing on science.
4. By almost abrupt automation and instantaneous development of the economies of all countries on Earth.
5. By maximizing economic progress, in part by leading to virtually total reinvestment of capital on further development, but also by complete coordination of all work and economic accomplishment throughout the world, commitment to the supreme goal of economic growth, quantitatively and qualitatively greater intelligence pervading industry and guiding scientific thought, &c.
6. By rendering comprehensible many systems in nature which are now beyond explanation, prediction, or control simply because of the relative and absolute limitations of the human mind in terms of speed, accuracy, complexity, number of necessary calculations, &c.
7. By combining in one mechanical mind virtually the entirety of current or future knowledge and researches.
8. By assisting human researchers in powerful symbiotic ways.
9. By enabling all of human knowledge to be collected, ordered, synthesized, distributed, &r used throughout the world by human beings.
10. By automating certain perceptual processes or requirements and thereby providing man with stupendously amplified perceptual powers and capabilities, &r providing a window on formerly unavailable and even totally unknown percepts and relationships.
11. By in effect increasing the population of the world--because of the total capacity of machines as opposed to the collective capacity of all men--by at least 1-20 orders of magnitude, or progressively over time at inhuman growth rates.
12. By enabling powerful and quasiexperimental modeling of all kinds of phenomena in nature which can and cannot be experimented with, and which do not and even cannot exist in nature, and the modeling of systems of any degree of complexity.
13. By accelerating and maximizing the progress of pure and applied mathematics, progress on which the development and application of science have always been very critically dependent.

It is obvious that progress in the area of computation alone could allow and may in fact result in 4-8 or more orders of magnitude progress in science by 2050 or even half that time, 2013.

There is no certain reason for thinking it will actually transpire, although there are reasons why it in fact might, but I have suggested that it would probably be desirable, even extremely, for the United States to become, in effect, the scientist of the world, that country alone or first or mostly specializing in the idealistic, neoideological, or commercial tertiary or quarternary role of developing all or some pure &r applied sciences &r technologies, or possibly

certain more important possibilities therein. To a degree this has already been the role of the United States which has held aloft the torch of science and technology and demonstrated the feasibility and importance of much which the rest of the world, and many Americans, thought impossible and without significance. Obvious in this is that science and technology have not only been the motor and the shaper behind the social, cultural, political, and economic progress of mankind since the dawn of civilization and possibly the species (man having coemerged with his tools), but that it looks almost certain that the continued social, cultural, political, ethical, and economic progress of man or his yet higher descendants will result from and presume the persistent application and the further higher evolution of science. The so-called postindustrial world which the United States is entering will be marked, above all, by the automation of all primary and secondary jobs, and the conversion of the human workforce to purely tertiary and quaternary endeavors, so the suggestion that the United States might wholly specialize in scientific research and high-scientific industries is perfectly realistic and might constitute an alternative preferable to complete, premature, stagnant, dangerous, or dumb leisure and an alternative best not postponed. Already Japan exhibits such specialization relative to other countries of the world. The function of the United States, become scientist of the world, would then be to show the rest of mankind what is yet possible in science and technology, to pursue what is important but unknown, to facilitate the ultimate destiny of things, to secure the blessings of science for a responsible world, to set the path for other nations, to assist the progress of all nations in the best way possible, &rc. Furthermore, in this way the development of science and technology could be rendered explicit and primary rather than being hidden as it has in the past in narrow military, corporate, national, academic, and consumer motives. This might promote the peace, security, and virtue of the world by redirecting the attention of the world to nonbelligerent, noncompetitive, nonegoistic, and generally nobler things.

An example of the tremendous acceleration of science which might and will probably result from the future progress of computers specifically benefiting mathematics will be the special fostering of pure and applied combinatorics, a field the size of which may be taken as superinfinite and similarly the importance, yet whose progress has to an extraordinary degree been held up by the limited computational powers of the brain of a man. The implications of combinatorics pervade nature and science so that the sudden and rapid progress of the field in the years ahead will have fantastic impact upon general scientific advance.

Another field in which a revolution may occur resulting from [intrinsic and computer] progress is morphology, or the general science of form which encompasses nature. A theory of morphological [statics, dynamics, and geneses--&r simply a basis for their revolutionary [computation &r calculation]--may well materialize over the next 75 years, and have stupendous impact upon [biology, chemistry, architecture, industry, engineering, psychology, physics, astronomy, &rc], and even very great philosophical implications changing our view of [the universe, science, and nature].

The 4-8 orders of magnitude increase in (1) the rate of scientific advance, say on a per annum basis, &r! (2) the magnitude of science in some static way (eg total plant and wealth, accumulated data, invagination of the world, powers and capacities, activity, &rc!) which I have hypothesized above could conceivably occur between 1975 and 2050 must frighten many people simply because it is stupendous, and because, furthermore, the actual size and growth of global science (and its actual configuration in all the respects I have cited or alluded to in my discussion) are things totally unknown, unmeasured, unconsidered, and unsupposed both by many people and, after all, by everyone. Some of the fright may be allayed, however, by noting that a 100-fold increase in GWP over the next

75 years, from 1975 to 2050, corresponds to a 12.5-year doubling time; 2 halvings or 1/4 of this rate corresponds to a doubling time of 6 years, which represents the 4 orders of magnitude increase discussed, and 3 halvings or 1/8 represents the 8 orders of magnitude increase by 2050. In other words, the question is whether a rate of growth for global science and technology 4-8 X the rate of growth of the world's economy could conceivably occur? First be it observed that there are fine prima facie reasons for assuming scientific growth to occur pari passu economic growth, which establishes a base. There are likewise fine reasons for assuming that scientific growth will generally exceed the economic growth pro tanto. The question therefore finally reduces to the greatness of the ratio of the rates of growth of science to that of an economy that are just conceivable &r that are attainable, perhaps over a special 75-year period, and in this perspective the reader may find himself warming to my initially preposterous assertion. The reader, in particular, will recall my almost chimerically compound formula for estimating the growth and scale of science, in various spaces. Thus prepared, he may be willing to accept without undue consternation my claim for the possibility that the doubling time for present and future science may or could potentially be as little as 3-6 years, in either of the respects I referred to in the first sentence of this paragraph, nominatum (1) rate &r (2) magnitude. The highly compound (multivariable) formula I used to explicitly and implicitly quantify growth allows and assumes the individual variables depicting growth to have values little above unity and doubling times far longer than the doubling time of the total product, and so the reader need not be in a quandary as a result of mentally imputing anomalous rates and scales to ordinary scientific phenomena--future, present, past, &r eternal! The growth of science, in this enlarged sense, may be pondered in epiphenomenal terms. Furthermore, I have elsewhere in this book (p) considered that subjective time, magnitude and rate of growth of intelligence, &c may actually become asymptotic to and even exceed infinity, say in a finite time, so that one need not even suppose that the degree and rate of enlargement of science face near or even finite limits, per contra universal wisdom! The incidence of intelligent machines, as it happens, will actually converge these 2 illimitations.

WHY SCIENTIFIC PROGRESS SHOULD ACCELERATE

1. Larger population.
2. Industrialization and education of the world.
3. Some freeing of science from narrow (industrial, governmental, simplistic) concerns.
4. Intersections of fields, applications, tools, &c.
5. Distillation and use of cumulated knowledge.
6. Some awareness by supporters of the connectivity, pregnancy, and importance of science.
7. Powerful and complete instrumentation, techniques, and methods.
8. Computer and mathematical modeling.
9. Automation of research.
10. Increasing power of laws.
11. Empirical completion.
12. Theoretic burgeoning.
13. Empirical convergence.
14. Theoretic convergence.
15. Empirical and theoretic mutual convergence.
16. New and true motives and goals.
17. Work and convergence at many levels and in many systems.
18. Revolutionary progress in mathematics. (Eg it is conceivable that beyond some threshold of mathematical or computer development the mathematical power or creativity of computers will cease being "degenerative" and will "explode".)
19. Such progress should either be greatly increasing or greatly decreasing and the former seems the case.
20. Progress over the past 200 years should be at least equalled, geometrically, by the next 200 (another rule of conservation).
21. Progress in fundamental science (eg discovery of many tables of matter, union of fundamental forces, combination of constants, neurological epistemology, artificial intelligence, topological classification of chemicals and minerals, genetic engineering, advances in probability and statistics, advances in combinatorics).
22. Computers beginning to think, thinking, and outthinking men; removal of the blockage to scientific progress that covertly exists because of the cumulating and involuting extent to which the powers of man's mind have been exceeded.
23. Increasing focus of science on artificial things.
24. All science supplies analogies for all science.
25. Unification of all of science.
26. Proliferation of the applications of science.
27. Supreme status that science should and ultimately may assume in human concerns; science as religion.
28. Spread of science into formerly extrascientific domains, eg psychology parapsychology, economics, politics, law, sociology, history, fine art, epistemology, theology, and metaphysics. Eg it <u>may</u> erelong prove possible to abstractly model processes of civilization that were formerly considered irrational or hopelessly complex, and it may even be possible to confer <u>some</u> predictive power on history.

<u>Epilogue</u>. Of course there are sets of reasons why science should or might decelerate that must be laid alongside these optimistic points, not the least of which is that antiscience may check the past onrush of science and suspend it in no-man's land, <u>sine die</u>. The perspective above, although overlooked, is obvious.

THE AUTOCATALYTIC NATURE OF THE SPACIAL ENTERPRISE

Foreword. The word "autocatalytic" is used to refer to the fact that the overall process of the exploration, development, and civilization of Space--particularly the Solar System over the next 200 years--will proceed in a self-accelerating, phase-transitional, irreversible, self-justifying, anankastic, metamorphic, anamorphic, autogenetic, independent, competitive, kaleidoscopic, astounding, irrational, infinite, living, self-maintaining, self-facilitating, self-maximizing, accumulative, self-diversifying, self-replicating, architectural, self-perfecting, vacuum-abhorrent, infinite-dimensional, &c manner. It will do so because it will inevitably comprise innumerable motivational, logistical, scientific, technical, economic, social, political, military, &c events of such autocatalytic and mutually catalytic nature which will leaven the loaf. Just what events will play what roles at what times with what consequences and relative standing are unclear. The interactive branching of a tree of events is an extraordinarily unpredictable process based on a superinfinity of discrete and continuous possibilities finally yielding configurations of a purely empirical kind. It is important for policy-makers to understand that these autocatalytic characteristics of the real world determine events over the long term in an inaccessible way, alter the relative and absolute difficulties of things, confer nonlinear rates on the actual pace of things, constitute decisive considerations, have roles in the raisons d'etre of history, exist in great number, can to a certain extent (as here) be anticipated and planned for, can to a certain extent be exploited and controlled, &c. In particular, because of autocatalytic events, effects, relations, and processes realistic scenarios of the future of Space must foresee events occurring with surprisingly great rates, scales, fullness, &c. Yet this is frequently forgotten by those preparing and by those examining scenarios.

1. Tourists flooding Space will bring and stimulate nontouristic enterprise.
2. Nontouristic Spacial enterprise will stimulate touristry.
3. Touristry will leave behind and encourage migrants and semipermanent residents.
4. One company supporting Space, using a program, having its own program, operating in Space, with its headquarters in Space, wholly devoted to Space, &rc will stimulate two, two three, and so on because of: precedent, demonstration of feasibility and point, competition, means thereby proven &r made available, speculation, new willingness of diverse backers (bankers, financiers, stockholders, governments, agencies of governments, &c), sensation of timeliness, vertical and horizontal relationships between all industries, &rc. There are countless firms which could participate. There are countless new and old entrepreneurial possibilities. There are many executives eager to go into Space. There are many Spacial industries willing to qualitatively and quantitatively expand. Agglomerative tendencies are current and possess warrants (a giant corporation could economize by running its own program).
5. Tourists will stimulate further touristry because: precedent will have been set, empathic curiosity will operate, jealousy and prestige will operate, tourists will be more apt to return, tourists will bring family and friends, people from other nations will want to go, everyone will want to go, money will be driven into grand selling campaigns, money will improve and diversify vehicles and facilities, residents will invite tourists, ever farther and more elaborate trips will be possible, touristic costs and prices will fall, touristry in Space will compete with touristry in Space, extraordinary facilities in Space will come about, &rc.
6. There are 150 nations in the world, all growing, and they will all want to mimic and compete with one another for: prestige, glamour, military prowess, gain, personal ownership, markets, authority, historical importance, pieces of Space, roles in Space, future options, token roles, and no reason whatever (a very important reason).

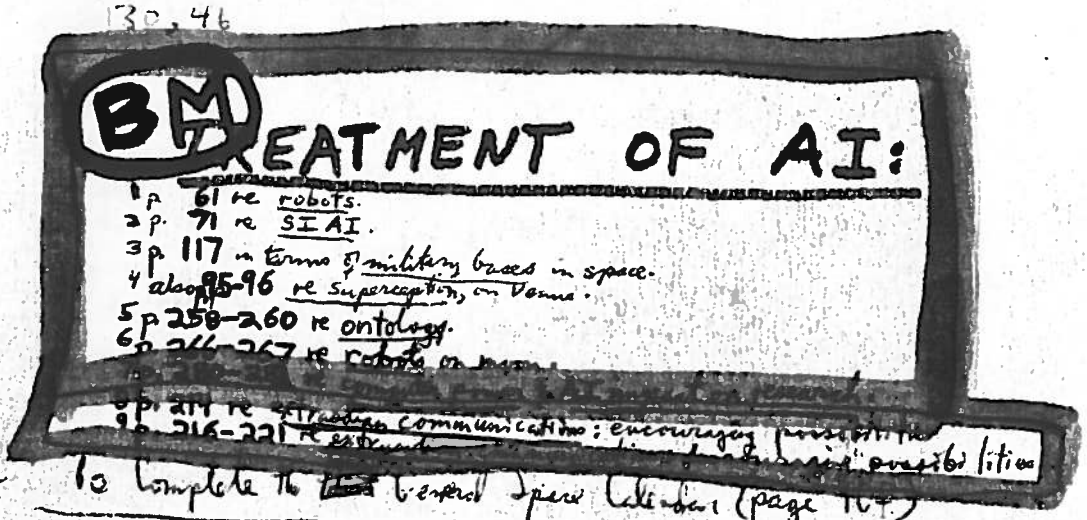
7. There are various barriers like hills to doing various things in Space--operating Spacelabs in orbit, populating Space, creating and maintaining permanent bases on any and all planetaries, regular terrilunar shuttle flights, manned exploration of other planets, colonies such as at terrilunar L-5, transmitting power to Earth, mining other planets, &c--beyond which the permanence, scale, rate, complexity, duplication, seriousness, funding, &c of things will increase both considerably and fairly automatically.
8. Once shuttles exist they can be readily duplicated by ourselves and others, used at tremendous duty (to transport surprisingly great numbers of men, variety of things, cumulated mass, large constructions, &c), refined and superseded, &c.
9. Infinitely more serious, elaborate, effective, and consequential work can be done at a Spacial locus once a permanent, adequately manned, elaborate, &c "base" is established there. Three men on the Moon for 3 days can do 9 man-days of work; 10 men staying 1 year can do 3,650 man-days of (406 X as much) work; 100 men in 10 years can do 365,000 man-days of (40,600 X as much) work. Serious, systematic, determined, self-discovering, self-accelerating, synergistic, adequate, holistic, self-planning, well-equipped, advanced, &c work--based on stays 1200 X as long and labor 40,000 X as great--will accomplish far more than these linear factors suggest and the total quantitative improvement might be something like 1,000,000 X. It is plain that work greater by a factor of 10^6 than previous work will make qualitative differences in what man is accomplishing in Space and these differences will fan out and modulate the entire Spacial enterprise.
10. Comprehensive panplanetary teleplutography is apt to occur rather abruptly, mimetically, and quickly at some future date, and thereafter man will have at his disposal a critical guide to planetary exploitation, the schedule thereof, the techniques therefor, the value thereof, the pattern therefor, &c.
11. The real beginning of Spacial enterprise will trigger effusive human imagination.
12. The inevitability of Solian Civilization, and its start over the next 100-200 years, will at some point become obvious or a theme exercised by sponsors, advocates, publicists, &c.
13. Initial enterprise will discover further needs and opportunities in a convergent and divergent--but above all an accelerating--way.
14. The first industries in Space will create the basis for further industries. Power stations sending energy to Earth will also power purposes in Space. Research buildings will lead to hotels for tourists. The construction of giant power stations (expansive antennas) will lead to the construction of cities. Telodynamic basers will serve exomotive transportation. Giant geoscopic and astronomic observatories will bring hoards of curious tourists. Extant geosatellitic cities will lead to comprehensive industry, commerce, and uses. Residence will lead to commerce and industry. Commerce and industry will lead to residents. Giant ore freighters will carry swarms of tourists. Mining, refining, and manufacture will all lead to each other. Hotels and resorts on the Moon will lead to real estate transactions and homesites. Agriculture, terraria, and biaria will lead to each other. Etc.
15. Waves of tourists will lead to residual and contracyclical carriers.
16. Means will become ends and ends will become means.
17. Costs and prices will fall because of scientific and technical progress fueled by Space.
18. Costs and prices will fall because of economies of scale.
19. Costs and prices will fall because of subsidence of research and development costs.

20. Costs and prices will fall because of competition.
21. Costs and prices will fall because of increasing operational efficiencies.
22. Costs and prices will fall because of discovery and development of ideal ways of doing things in Space.
23. Costs, prices, and difficulties will fall because of prior experience and the repetitive and analogous nature of tasks (for example, the exploration and development of Mars and Pluto will duplicate, reuse, or profit from the techniques, programs, equipment, materials, justifications, &c used in the prior &r simultaneous exploration and development of the Moon).
24. The pervasive exploration, development, and occupation of the whole Solar System will create the economical and circumstantial basis for everything that is done there. For example, colonies amid the asteroids will simplify the exploration and development of the Neptunian System.
25. The demonstration that any and good life in Space is possible will trigger extensive geosatellitic laboratory work, bursts of tourists, and residence.
26. The settling of Space will lead to self-sufficient, autonomous, and self-directed economies, cultures, governments, &c.
27. The settling of Space will lead to a native population explosion filling available lebensraum, spurning Earth, and patriotic about Space.

Tengé: a place of great natural beauty or charm
Tengean: of, relating, or resembling a Tengé

Additions (pages)

130, 46



To complete the [illegible] Expanded Space Calendar (page ref.)

1. Add 22 pop. & tourist dates p172 (± adjust)
2. Add (± date) certain tourist attraction events pp 179-180.
3. Add pop. breakdowns for 2050 p193 (± adjust)
4. Add Lunan calendar pp 262-267 (>205 words) (± adjust)
5. Add 17 "The Development of Mars" Frontispiece (FP67) dates
6. Show multiple curves - connections by colored (red, green, yellow, blue) arrows (make as thick as possible to simulate network or connections?) (red → purple spectrum could correspond to relative importance or relative probability? of events?) (or colored arrows could = [illegible]