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Big payback from Mars Colony mission

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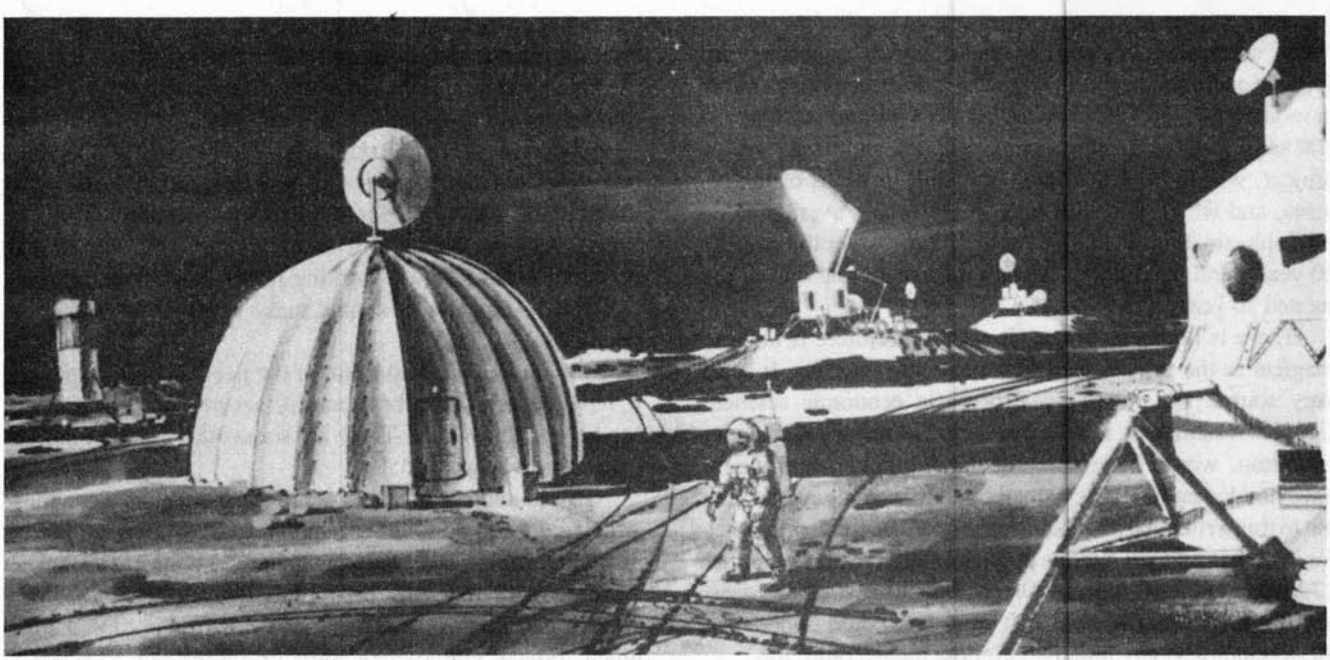
If the United States follows the approach I have proposed, we shall have our first permanent colony on Mars by the year A.D. 2027. During a few years following that, that colony will grow into an increasingly self-sustained community, the size of a medium-sized city on Earth. Long before A.D. 2027, the average U.S. taxpayer will have gained an enormous personal profit from the earlier, preparatory stages of the program as a whole.

Once the colony is operating, the benefits sent back to Earth will be many times greater than the cost of building and operating the colony; but, that profit will not come back as manufactured products, nor shipments of ores from the asteroid belt. There are presently no natives out there in the Solar System, waiting for the door-to-door salesman coming out from Earth.

This payback will come, even long before the colony on Mars is established. It will come, beginning the next 10 years, as increased income from the use of space technologies right here. Average income will be increased as a direct result of U.S. industrial, and other investments of new space technologies in production here on Earth. During the course of the first 10 years, the federal taxable portion of this increased average income could become larger than the government's annual space-budget. The space program's benefit to the average household and business should average four to five times the increased federal tax revenues generated.

During the second and third decades, this profitable tax investment in space-development will grow to an enormous amount. Over the course of the first 10-odd years, average productivity in the United States should increase at the more modest rate, of between 3% and 5% per year. However, the rate of growth will climb, at ever faster rates, during the second, third, and fourth decades.

The following are only rough estimates, but our estimates are on the conservative side, and they are good enough for purposes of illustration. By the end of the 1990s, under this 40-year space program, the increases in operatives' productivity caused chiefly by industries' investments in use of space program-stimulated technology, should bring productivity to about 50% higher than today. By the year



Regular manned flight to Mars will require the industrialization of the Moon, to construct the space vehicles used to transport freight and persons to the Mars orbit. Here, an artist's conception of a manned base near the lunar South Pole. Power stations and processors are in the background, and the astronauts' landing capsule in the right foreground.

A.D. 2010, more than four times today's productivity. By the year 2020, 15 to 20 times today's productivity. By the scheduled year for establishing the permanent colony on Mars, operatives' productivity should average more than 40 times higher than the average productivity in the United States today.

We should stress the obvious fact, that all this will occur during the average working-life of the students who graduated during the year 1988.

Pipe-dream? Not at all; those estimates are cautiously conservative. We have allowed for much of the usual slippage, between what could have been achieved, and the delays and errors inherent to political, managerial, and other sources of lost opportunities. This report will indicate some of the facts which justify such an optimistic view of our nation's options for the future.

True, compared to our experience of the past 20-odd years, these may seem to be spectacular rates of growth. Yet, we have had periods in our national history, and periods in the economic history of other nations, during which more or less comparable rises in productivity have occurred. Reaching annual rates of 3-5% increase of operative's productivity, with 50% cumulative increases over a 10-year period, is a commonplace for vigorous economic recoveries. If the recovery is continued through a second 10 years, with increasing rates of capital formation, the increase of productivity accelerates. So, our projections for the first 20 years are in line with lessons of past experience. If the nature of the technologies being used is considered, the estimates given are cautiously conservative.

Neither the federal budget, nor the U.S. Bureau of Labor Statistics see space exploration as such. For them, "Space" is merely a statistical category in accounting procedures. Under "Space," the budget sees tax revenues spent, on the one side, and the increase of the nation's taxable income, on the other. Under "Space," the Bureau of Labor Statistics sees employment, incomes, and productivity in industries affected by the technologies developed for space exploration.

From the standpoint of Washington's federal statisticians, they see government funds going into the development of objects. To them, these objects have something to do with space exploration, but no revenue comes flowing into Earth from outer space as a result of shipping these objects up into orbit or beyond. In other words, we obtain no revenues from sales or the export of these objects to persons or companies in that foreign land called Outer Space. These are simply objects, which the federal government is spending considerable sums to develop and produce.

Lo, and behold! By investing in the development and production of these objects, U.S. employment and productivity are increased. Incomes of businesses and households increase. As a result of the increase of incomes, the government obtains its share as tax revenues at standard rates. After a while, the government is obtaining more tax revenue from the margin of increased national income generated by the investment in space technology than government is investing. In the meantime, total national real income is increasing by a margin of expansion four to five times as great as the increase of federal tax receipts.

The Washington federal acccountants' reaction to all this?

"Who cares what happens to those objects once they are shipped out to space; this investment is the best money-maker in modern history." What Washington's groundling bureaucrat sees, is a large and growing research and development project, which more than pays for itself in terms of tax returns, and which is on the way to increasing average U.S. (real, physical) productivity about 10 times over the coming 20 years, and in sight of 10 times more than that during the second 20 years.

There is no hocus-pocus. It works, but there is nothing magical in the principles which cause this success. It is all very sound, and relatively very basic economic science. George Washington's U.S. Treasury Secretary, Alexander Hamilton, would have comprehended quickly, and would have nodded enthusiastic agreement. He would have pointed out to this writer that he, Hamilton, explained these principles for increasing the productive powers of labor in his December 1791 report to the Congress, *On the Subject of Manufactures*. So, if a bright fellow from 200 years ago could understand these principles, any intelligent fellow today could, too.

The politician who says, we can not afford a major space program, reminds us of the sly character who argues, "Look at the amount of money I'm saving on commuting costs," as an excuse to turn down a high-paid job, to take a low-paid, unskilled job, within walking-distance, at a nearby fast-food stand.

Why a Mars Colonization program? Would not some other project, closer to Earth, provide the same kind of economic stimulant? For the short run, there are several possible, large-scale research and development programs which would have somewhat similar effects. The difference is: The Mars project gives a higher rate of payback to the taxpayer, and over a much longer period of sustained economic growth, than any alternative in sight.

There are other, compelling motives and reasons for assigning priority to such a space program. We shall list some of these, turning first to the simplest, most easily understood of all of these motives, that of the ordinary citizen raising a family.

It is your life, after all

What does the taxpayer gain from the U.S. government's decision to proceed with a 40-year space mission? His or her income is increased, of course; but, what are some of the deeper feelings the taxpayer ought to have when he or she thinks of the effect of this program on the future security and happiness of the family?

If "taxpayer" refers to the family household, family interest is centered around the future of the children and grandchildren. Why not be personal about the space program, in that way? It is your taxes the government must put up as investment. Apart from the pleasant fact that it increases your income level, what does such a 40-year project do for you, the taxpayer? How does it benefit your personal, family interest in the deepest, most personal ways?

Once your children complete their education, we hope they have a life-expectancy, in good health, of about 60-odd years beyond graduation day. About 40 or more of those 60-odd years will be spent, either working for an income, or maintaining the home for the partner who does (a job in itself). As your children of today choose their educational preparation for a future working profession, those children and you, their parents, should make some rather important decisions.

Obviously, we must think of the need of every graduate to have opportunities for economic security during the coming half-century or so. There are some other, rather obvious questions to be asked.

On the subject of these other questions, the first thing which comes to mind is the fact that most of the adult life of an income earner is used up in the daily routine of work. The standard work-year now, is approximately 2,000 hours; if we allow a minimal average commuting time, and time out for lunch, typical employment uses up more than 50 hours a week, or about 2,500 hours a year. Times 40 years, that is 100,000 hours. Put the same facts another way: During the average 40 years of adult working-life, a person will expend not less than 45% of his or her waking hours on work plus commuting, often even more than 50%.

That makes a very persuasive argument for choosing the right kind of educational and related qualifications. We used to say, "Choose a life that amounts to something." Forty-odd years later, shall we look back to say, "I spent half the waking hours of my adult life on something in which I take little pride?" Should we not hope that the days are ended, when work was viewed as a kind of punishment, a sacrifice made in order to have the price of bread? Individuals ought to have the right to enjoy work, to know that that for which they are spending half the waking hours of their working-adult life is something important to the society. A person has a right to the opportunity, to walk with pride, to say, "I am spending half my waking hours doing something which not only feeds my family, but which is so important for society around me, that I am entitled to respect for the importance of the kind of work I do."

Parents and students have a right to ask, will the kind of career for which a student is becoming qualified continue to be a meaningful career opportunity, 10 or more years ahead? It is not pleasant to be told, "You have become obsolete; why don't you try for a job washing dishes?" This involves economic security. It involves the right to have an opportunity to do something one can take pride in contributing to society.

Intelligent citizens who look a bit into their own and their family's future in this way, can see the political side of this problem rather easily. The citizen, the family, the community, are, each by themselves, small and weak, when compared with the forces which determine the markets and the investment climate. Without the right form of government, and without the right governmental policies, there is no way the family can assure satisfactory conditions for itself over the coming 40-odd years.

Admittedly, under our federal Constitution, the economic functions of government are limited.

The Constitution gives the federal government authorities, duties, and responsibilities in the following key areas. U.S. currency and federal banking and other credit policies. Fiscal functions of government. Regulation of foreign and interstate commerce. Providing basic economic infrastructure, including water management, production and distribution of power, general transportation, communications, and so on.

The federal government has a division of labor with state and local government, for providing such economically essential elements of infrastructure as education, and ensuring that both sanitation and an adequate health-delivery system exist. Government provides needed infrastructure either as an economic undertaking of federal, state, and local governments, or by fostering private investment in regulated public utilities, and by fostering regulated or self-regulated professional standards in these areas of basic economic infrastructure.

In other words, government's economic functions are limited to matters in which private entrepreneurs can not meet the general need efficiently, unless they are very large-scale monopolies. Where we think the inefficiencies of government preferable to placing the nation at the mercy of giant monopolies, we rely upon the options of government undertakings, or federal or state regulation of privately owned public utilities.

Implicitly, our Constitution limits government's undertakings to those we have indicated, and to the right of government to operate arsenals. The rest is left to private enterprise.

That American System of political-economy, established under George Washington's administration, is the best economic system ever devised, with the best kind of division of labor between government and the private entrepreneur.

In this arrangement, the combined economic weight of monetary policy, government fiscal policy, and basic economic infrastructure are, combined, the largest single component of the national economy as a whole. In these combined areas, what government does, or fails to do when it should, is the largest single factor determining the health or sickness of the economy at large.

In addition to the raw power of government's economic functions as a whole, there is another factor in which government plays a major role. This "other" occupies the largest part of our attention to economic factors in this report. The name of this other factor is "technology."

From the middle of the seventeenth century, in the Massachusetts Bay Colony, Americans have understood that the increase of the standard of living depends upon advances in average productive powers of labor. Until a change came in national policy, about 1966-72, we Americans understood, over the past 350 years, that advances in productivity occur as a result of a policy of investing in advances in technology. If we can maintain the flow of technological progress into production and infrastructure investments at relatively high rates, the average productivity and income of the population will grow accordingly.

Government has no monopoly on technology. Scientific and technological progress begins as scientific discoveries by individual minds. Once the advances leave the laboratories, technology is developed chiefly in the machine-tool sector of the economy. For the most part, the machine-tool sector is made up of small private firms, in which most of the management is composed of scientists, engineers, and other very skilled and innovative technicians. Another important source of technological progress is the suggestion box of the enlightened manufacturing firm, which depends upon the voluntary ingenuity of industrial operatives working in their spare time as individuals or small teams. Then, there are those indispensable mavericks, the lonely, individual inventors.

Government's own economic roles in military and aerospace development, and in basic economic infrastructure, add to the total flow of technologies through the society as a whole. This is a rather important factor in determining the rate of technological progress generally. However, in terms of those kinds of concerns of the private citizen we described above, government has the responsibility of fostering technological progress in the society as a whole.

Government fosters private technological initiative, by building policies which encourage such private initiative, into its monetary, fiscal, and regulatory functions. For example, investment tax-credit policies have proven very effective. Job-creating investments in production which foster growth of employment, and increase the productivities and incomes of labor may find their profits taxed at slightly lower rates than profits which are not reinvested for such purposes. Credit should flow into technologically progressive investments at relatively cheap rates, and in relative abundance. Firms and households should be provided incentives to save, and to steer a goodly portion of those savings into equity and loans for such purposes.

In addition to these things, government plays a leading role, although not an exclusive one, of course, in the way our nation adopts a technological consensus. Some examples from our past history help to make this clearer.

Virginia's colonial governor Alexander Spotswood gave the nation its first major public postal service, a function taken over by Benjamin Franklin later. This was very important in the fostering of technology, among other benefits. Spotswood's program of building roads as a way of opening up large regions to development, was another feature of our early development. Government's responsibility for fostering a system of canals, and then the development of railways, are another example. Developing urban centers in such a way as to provide a desirable climate for certain kinds of technological investments, is another example.

Generally, if government makes a long-term commitment to fostering progress in development of certain technological improvements, and does this well, the economy as a whole is assured this is a field of investment and production which will be sound over the coming 20 or more years. Government says something like the following: "Here is a list of the kinds of technologies which are likely to dominate progress over the coming generation or two. Government is committed to using these technologies, wherever they are suitable, in its own economic functions, such as infrastructure. Government is building incentives for such investments into its monetary, fiscal, and regulatory policies, and commits itself to maintain these kinds of incentives over 20 or so years to come."

Therefore, the individual citizen is able to control the prospects for the family, in terms of opportunities for economic security, and career perspectives, for more than 20 years ahead. The citizens must work together politically, and in other ways, to ensure that the representatives they elect, and the policies demanded of those representatives, are consistent with that kind of longer-range security.

The Mars Colonization program is a very valuable, very large element of the kind of policy that the citizen's family will require for the kind of security it has a right to expect over the coming 40-odd years. Government must say to the citizens, in effect, "Here is the space program, and this is the way it provides your children the kind of economic and career-opportunity security they require over the coming 40-odd years." If the citizens agree to this choice, that must become the policy-commitment of government over the 40-odd years to come.

Through a properly functioning system of representative government, the individual citizen, otherwise too weak to control the vast and powerful forces of the economy as a whole, is able to steer government into choosing those kinds of long-range policy-commitments which ensure the opportunities for the children's future career and security over 50 years or more to come.

For such reasons, one of the first things citizens should ask of any political candidate, especially for federal office, is, "What is your policy for ensuring technological progress and career-opportunities for us and our children, over the coming 50 years?"

That said, we identify some of the most basic principles governing the way the Mars Colonization program will foster security and career opportunities over the coming 40-odd years.

Physical economy

Before plunging into our explanation of the economic impact of the space program, we must clear up a handful of ABCs of economics. We must do so, because there is much confusion as to the meaning of that term. "Economics," in the sense the founders of our republic defined it, is no longer taught in our universities, and very few among those professionals called "economists" know the original meaning of the word. Most citizens are confused by what they read about it in the press, or hear from politicians, and from so-called "experts" on the TV screen.

Yet, almost any literate citizen can understand the ABCs of real economics, once the matter is explained slowly and patiently, by someone who knows. So, we must examine those features of that branch of economic science, "physical economy," which bear most directly on the way the Mars Colonization program will expand their family's income. Only those with appropriate qualifications in physics will understand all of it thoroughly, but all readers will be able to follow the general argument, the ABCs; they will get the gist of the rest, and that will be useful to them in following our description of the Mars program itself.

A hundred years ago, and earlier, "economics" was shorthand for "political-economy." Political-economy had two parts. One involved money and related things; that was the administrative side. The other was the study of the principles of physical economy, in which land, labor, and market-baskets of households' and entrepreneurs' goods were the area of concentration. "How may we best increase the fertility of land, increase the physical output of labor per capita, and increase also the standard of living?"

Physical economy as such takes up a large portion of the paper on economic doctrine of President George Washington's administration, Treasury Secretary Alexander Hamilton's December 1791 report to the U.S. Congress *On the Subject of Manufactures*. That is still a good textbook in economics, to the present day.

All of the calculations needed, to calculate the estimated impact of the space program upon the American standard of living, are made in terms of physical economy, without taking money calculations as such into account. Instead of money, we use standard market-baskets: Three market-baskets are needed. The first, obviously, is per capita household consumption's requirements; that market-basket must be improved as time passes. The second, also rather obviously, is the market-basket of entrepreneurs' goods required, per operative employed. The third, is the market-basket of basic economic infrastructure; this we measure both in per capita terms, and in units of land-area developed.

Although the development of a science of "physical economy" was well under way by the end of Leonardo da Vinci's life, it was established first as a true branch of physical science over the years 1672-1714 by Gottfried Leibniz. The eighteenth-century founders of the United States took their principles of physical economy from Leibniz, some directly, some indirectly.

If the reader understands the ABCs of physical economy, the rest of political-economy is no great intellectual challenge. Money and credit involves processes that are sometimes as complicated as governments, bankers, and accountants, and Harvard Business School can make them confusing, but not much more mental ability is required to understand the principles involved than one needs to plan today's family's household budget. All of the science in political-economy, is locked up in the study of physical economy.

Leibniz's discoveries center around two topics. The first is the principle of the heat-powered machine. In this connection, Leibniz examined the relationship between increasing the amount of power supplied to a machine, and the resulting increase of the productivity of the operative. The second, is passed down to us as the term "technology," a term for which Leibniz supplied the original scientific meaning.

So, in the theory of machines and analogous kinds of investments, we distinguish two ways to increase the productivity of society. The first is to increase the effective amount of heat-power, or equivalent power, per machine (per operative). The second is to improve the principles of internal organization of the machine or analogous device; this is *technology,* or *technological progress.*

The simplest kind of illustration of what *technology* signifies, is sharpening the blade of a knife, or the point of a punch. So, a sharp knife cuts, when a dull knife does not. As these very simple examples suggest, the measurement of technology is a branch of geometry, the only way in which degrees of organization can be measured intelligibly.

Power and technology are not strictly two separate factors. There are lower and upper limits for the amount of power required per capita for any level of technology. Below that minimum level of power, the technology does not work. At the upper limit, to obtain further net gains, new, improved technologies are required.

The reason for the existence of these lower and upper limits is, that in production we are pitting the organization of the tools (technology), and the power behind them, against the organization of the material being worked. For example, let us imagine we have increased the average temperature (*energy-flux density*) of a process to a level above the critical temperature at which tungsten ore boils to form not only a gas, but turns that gas into a plasma. This would require us to work this plasma within magnetic confinement. By this, and associated changes in technology, we would achieve a major breakthrough in the kinds of things we could do. We would raise the heights of increased productivity we could achieve in many old and new branches of production.

That example is a real one. That is among the changes in technology we shall develop as part of the Mars colonization project.

This reporter's professional specialization is the measurement of technology. Technology is measured in terms of what we call "negative entropy," or simply "negentropy." This is the only possible way in which to measure an increase in the level of organization of a process. Machines, or analogous designs of processes which have higher states of organization, by this standard of measurement, represent higher levels of technology than processes which are less "negentropic."

We must put in a few words of caution on the definition of "negentropy."

In physical economy, we do not measure "negentropy" as one finds in the usual undergraduate physics textbook. We use a different measurement, based, as we have noted, on geometry, rather than statistics. The kind of geometry we must use, especially for the case of modern technologies, is what is called the constructive geometry of the complex domain, as based chiefly on the work of two leading nineteenth-century scientists, Karl Gauss and Bernhard Riemann. This geometric approach enables us to show a direct relationship between the increase of the level of technology represented as investments, and a resulting increase in the average productive powers of labor. That approach permits us to estimate with relatively great precision what the economic benefits of the Mars Colonization program will be.

The essence of physical economy is study of the ways in which increase of power and technology, combined, increases the average productivity of labor. Now that we have introduced the term "technology," we must define the other side of the equation, "productivity."

Instead of measuring productivity in terms of money-income, our simplest unit of measure is what the leading nineteenth-century U.S. economists termed "economy of labor." For example, if so much labor is required to build a house or an automobile of a certain kind and quality today, how much labor will be required after 10 years of technological progress? The house should cost less to replace, but how much less? Good estimates can be made on the basis of calculating the "economy of labor" resulting from use of improved technologies. It is a bit more complicated than that, but that gives the general idea.

We measure this, as we said, in per capita unit-values of market-baskets. Using a standard market-basket for household consumption, for example, for the U.S. year 1968, what percentage of the total labor of society must be employed in producing enough to satisfy that unit-standard of market-basket for the average member of the household? If the amount of labor required to produce such a standard market-basket increases, that is bad; if it decreases, that is good.

However many hours of paid labor are required to buy the house you possess today, fewer hours should be required for a house of at least identical quality 10 years ahead. Fewer hours of paid labor should be required to provide each of the members of your family an improved diet 10 years from now, than today. And so on. That is the general idea of "economy of labor." That is a good crude sort of measure of the changes in the average productivity of a society over time.

So, when we foresee a 3-5% annual increase in productivity, not too far down the road ahead, that means a more than 3-5% increase in the "economy of labor."

This is not a matter of being generous for generosity's sake alone. In order that members of households entering the labor-force may be able to assimilate improved technologies efficiently, they require a higher cultural standard in the home and other aspects of personal life, including educational improvements. To increase the level of potential productivity significantly above 1968 U.S. standards, in later years, we require a better market-basket than we required in 1968.

Therefore, we could not base the measurement of productivity in 1998 on a 1968 standard market-basket. In terms of quality and quantity, there must be more and better goods in the 1998 basket. So, over successive years, as technological progress increases the number of "widgets" per day produced by the average operative, part of that increase must be diverted into increased real wages. If not, the potential productivity of the operatives will not keep pace efficiently with future technological progress. So, instead of measuring physical productivity in terms of a number of standard physical objects produced per day, we must measure the number of daily average market-baskets of goods being produced, per operative per day. We must do this under conditions that the quality and quantity of goods in the standard market-basket are being increased as technology advances.

Therefore, there is a marginal statistical loss of gains in productivity, because of increased standard market-basket requirements. This margin of loss is not bad; it is necessary to keep economic growth under way.

There are many facets to this sort of study; but these have been covered in published writings. Here, we are limiting our attention to those matters which bear directly upon the impact of the Mars Colonization project. We now concentrate our attention on energy.

Rather than using the term "energy" in the customary sense, let us use the term "power." "Power" is a more complex magnitude than "energy" is used to signify generally today. In Leibniz's work, "power" (*Kraft*) signifies a quantity of what Leibniz defines as physical least action. "Physical least action" is the name for the way "power" must be defined for purposes of constructing mathematical functions of technological progress.

"Physical least action" signifies the maximum amount of work accomplished by a minimal quantity of action. This means "work" in the sense we use "work" in physics, not the everyday use of the word. We explain.

The idea of "physical least action" was discovered by Nicolaus of Cusa, as first reported in his *On Learned Ignorance,* and in other published writings and manuscripts. It arose out of the so-called "Maximum Minimum" principle, that the circle is the minimum circumference enclosing the relatively largest area, or that the sphere is the minimum surface enclosing the largest volume. This signifies that the area being generated by circular action is larger than the area generated by any other pathway of action.

From this came scientific studies which showed that the universe as a whole functions on the basis of such a principle of physical least action. The modern meaning of the term was established by Leibniz; it was on this basis that he discovered the proper definition of "technology." Least action, or power, is analogous to the action of generating the perimeter of a circle, or surface of a sphere; the net work accomplished, is analogous to the area or volume generated by that action. It is more complicated than that, but that is the germ of the idea.

This least action is expressed today in electromagnetic units of action, but the definition of electromagnetic is more complex than one finds in the standard physics undergraduate's textbook.

Power takes note of several qualities associated with what most people think of as "energy." This includes the simple quantity of electrical energy, for example, as measured in watts. It includes also the density of that energy, as, for example, how many watts per square centimeter of cross-section of the energy-flow flow onto the work-area considered (e.g., *energy-flux density*). We must measure the relative coherence of the energy-flux density, as we measure the purity of the radiation from a laser.

We must also take into account something most readers have not been exposed to in their earlier studies: the gain in work accomplished (e.g., per square centimeter or cubic centimeter) by what is termed a "nonlinear" form of electromagnetic pulse.

Nonlinear electromagnetic pulses are highly organized packets of power. For the layman, perhaps the most convenient mental image is that of a hologram. "Analytically," these packets look like holograms, although sometimes very complicated ones. They are more powerful than so-called linear electromagnetic radiation, such as sometimes by a factor of about 1,000, because they operate on the harmonic structure of living and nonliving processes, and this in ways which were wrongly predicted to be impossible in standard electrical-engineering textbooks.

These several aspects of power are a leading feature of many of the space technologies we are now in the process of creating in the laboratories. Future technologies on Earth will make more and more use of these principles.

Now, look at some practical examples of how these principles work together.

Energy-density

Look back to about the year 1970, and compare some basic statistics for the economies of the U.S.A., West Germany, and Japan. We choose that year chiefly for two reasons. First, at that time, among the three nations, the levels of productivity of operatives and technology were approximately the same. Second, that is the point at which the productivity of the United States began to collapse. Compare the results with the cases of India and mainland China.

Look at **Table 1.** We have compared the economies listed in terms of 1) land-area of the nation, 2) size of the population, and 3) total energy-consumption, using standard official statistics. We have converted this data into the following derived statistics: 4) energy-density per hectare of land-area, 5) energy-density per capita, 6) population-density, in persons per hectare, and 7) energy-density per per-capita unit of population-density: watts per unit-per-capita area of population-density.

One point about the accuracy of the last data should be considered, so that no reader thinks we are misleading him.

Some readers would recognize, independently, that there is an obvious margin of error in the way the data in the last column is calculated: The calculation assumes that the land-areas of the respective nations are of comparable quality, on the average. There are differences in the quality of the land-area of the nations considered. Japan, for example, is composed of a high percentage of mountainous regions.

The refinement of studies along these lines, is the most basic feature of the day-to-day statistical work of physical economists. Refinements must include assorting the land-area among classes of land-use, such as farmland, pasture, forested areas, mountain areas, deserts, land-area consumed by transportation, and division of urban areas among sectors such as industrial, commercial, and residential.

Not only do we consider various classes of land-use, in that way. We must recognize that, although the type of land-use may be constant from location to location, the quality of the land used varies. It varies in natural quality; it varies as land is improved, has been spoiled, or has been allowed to deteriorate.

Obviously, we must study the population-densities of residence in each land-use area, and the weighted population-densities of operatives in the production to which that area is assigned. We must also adjust for the difference in quality of land-areas used; data not adjusted for this, we call measures of *population-density*; data which has been adjusted for functional differences in quality of land-areas, we call measures of *relative population-density*.

Such corrections would make Table 1 a large and complex one, and would prove little more than the point already nicely illustrated by that table in the form shown. It is obvious that the level of effective use of variations in technology varies according to energy-density per unit-per-capita value of *relative population-density,* but that this fact is illustrated by using the simpler data for average population-density.

Some subsidiary points of explanation to be made on that are as follows.

One of the leading reasons for some of the interesting features of the statistics on the three industrialized nations compared, is the role of basic economic infrastructure. This emphasizes water-management systems, general transportation infrastructure, the generation and distribution of power, and so on. In every industrialized nation, basic economic infrastructure is a major energy-consumer. So, the larger an area for which we must develop basic economic infrastructure per capita, the more energy that economy requires per capita.

TABLE 1

Energy per per-capita unit of population-density*

Year	Country	Teracalories
1970	United States	1.459×10^7
	Fed. Rep. Germany	1.625×10^6
	India	1.846×10^3
	Japan	1.352×10^6
	P.R.C.	2.974×10^3
1975	United States	1.442×10^7
	Fed. Rep. Germany	1.226×10^7
	India	2.322×10^3
	Japan	1.896×10^6
	P.R.C.	2.263×10^3

*Square root of energy per capita × energy per square kilometer

Then, compare the cases of India and mainland China. With the very low energy-densities per per-capita unit of population-density, those nations could never reach anything near 1970 Japan levels of economic development. They might develop a few industrialized areas, almost to the level of competing with industrialized nations; but, the average output—the poverty—of the economy, the society as a whole, will remain at about the level indicated by the very low energy-density per per-capita unit of population-density.

That is the general idea of what we mean when we say that the level of energy-density is a "constraint." It signifies a condition which must be satisfied, in order to reach a certain level of effective use of improved technologies.

Energy-flux density

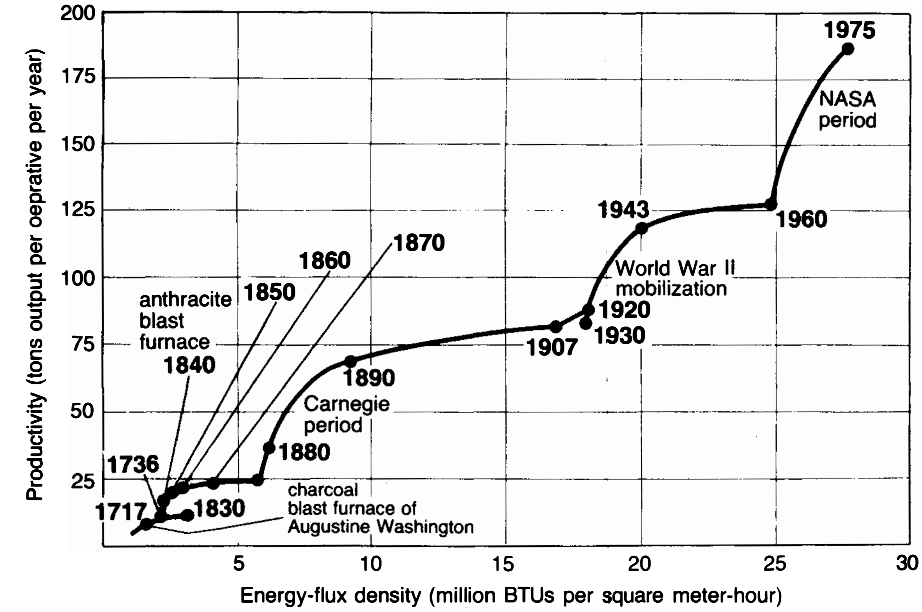
We have a second kind of energy-constraint to consider: This is usually identified today by the term *energy-flux density*. Look at **Figure 1.**

EIR researcher Robert Gallagher compiled data on the history of the iron and steel industry. He compared the energy-flux density of each successive general advance in iron and steel production, with the increase of productivity obtained by going to higher levels of *energy-flux density.* The case for iron and steel is true for every class of industry, and for agriculture, too.

To realize a given level of technology, not only must be have the necessary energy-density available, that power must be available at the required minimal level of energy-flux density.

FIGURE 1

How technology elevated the power of labor in blast furnaces (1700-1975)



The example to which we pointed earlier: The critical temperature (energy-flux density) at which tungsten becomes a plasma, falls into the same category as Figure 1's summary of the correlation between energy-flux density and productivity in the development of the iron and steel industry.

These two constraints are the key to design of the Mars Colonization project. They are key to the effect of those space technologies on productive investments here on Earth. By replacing *energy* with the appropriate, least-action definition of *power,* we are able to combine energy-density and energy-flux density constraints into a single constraint in terms of power.[1]

Technologies required for space

There are three basic categories of scientific-technological progress required for the success of a Mars Colonization program:

1) Controlled electromagnetic plasmas of very high energy-flux densities. The use of controlled thermonuclear fusion as mankind's primary source of power, during the course of the next century, is the usual example of this. Our reference to the "boiling" of tungsten into a plasma-state, illustrates the most obvious sorts of industrial-process designs derived from this line of progress.

2) Controlled pulses of electromagnetic radiation, including lasers as the simplest model, and continuing through very complex electromagnetic nonlinear pulses. This will emerge as the basis of machine-tool design during the coming years. It also affords man the means to control the electromagnetic environment in a general way.

3) The superseding of ordinary molecular biology by new developments in optical biophysics.

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[1] For the reader who insists on having the nature of this power-constraint identified, we summarize. The construction begins as follows. We define the physical space-time of electromagnetic action in terms of conical, rather than linear or simply cylindrical electromagnetic coordinates: electrical moment, magnetic moment, and frequency of each, respectively. The least-action character of each coordinate is expressed as the quality of coherence of frequency of isoperimetric, self-similar-spiral rotation in each coordinate. This situates electromagnetic least action in a constructive-geometric space corresponding to the complex domain of Riemann, et al. This implies the elaboration of the multiple connection among the three conical (self-similar-spiral action) coordinates.

Thus, this three-coordinate relationship is elaborated with respect to historical time.

Such a multiply-connected domain is characterized by the generation of increasing cumulative density of geometrically determined mathematical discontinuities (singularities). This generation is *harmonically ordered* within the Gauss-Riemann domain so constructed, in the same spirit that physical space-time is harmonically ordered in the work of Kepler. To this, an elaboration of Georg Cantor's most crucial theorem applies: the implicit enumerability of the increase of density of mathematical discontinuities per arbitrarily small interval of action of an axiomatically nonlinear form of continuing process.

Such an increase of density of singularities is a measure of negentropy, as we define it in physical economy. So, our definition of power is geometrically conformal with our definition of productivity (potential population-density). Thus, the causal correlation among technological progress, power-constraints, and increases in productivity, is made susceptible of intelligible representation as a measurable relationship.

TABLE 3

Energy-density of fusion fuels compared to other rocket fuels

Mass (1 kg)	Kilowatt-hours	Energy (joules)
Chemical (H_2/O_2)	3.72×10^1	1.34×10^7
Fission	10×10^6	6.5×10^{13}
Fusion (D-D)	25×10^6	9.0×10^{13}
Fusion (D-T)	92.5×10^6	3.3×10^{14}
Fusion (D-^{3}He)	97.5×10^6	3.7×10^{14}

Source: *EIR Quarterly Economic Report.*

All three are aspects of the same, revolutionary development of mathematical physics. All three are currently in progress, being developed, although not rapidly enough. All three are susceptible of measurement in terms of a causal correlation among *technology, power,* and *productivity.*

In the space program as such, the development of these technologies has the following, most prominent objectives:

1) When we arrive at Mars, the amount of power required to maintain a synthetic environment (under "domes") suited to permanent human habitation, is more than a decimal order of magnitude greater than in industrialized urban life on Earth today.

2) When we arrive on Mars, and, before that, as we "industrialize the Moon," to supply most of the weight carried from Earth orbit to Mars orbit, we shall require new kinds of industrial extractive and other applications. These are akin to the example we identified, turning tungsten into a plasma-state. To accomplish this requires very high power-flux densities built into tools used.

3) On Mars, and in extended space-flight, we are confronted with new challenges in biology. We must create artificial environments suited to protect the health of space voyagers and Mars colonists. We must cope with the problems of maintaining plant-life and so forth, in space, and in colonies. Of special importance is the potential for development of new kinds of infectious and other diseases in space and on foreign planets. These problems require advances in optical biophysics.

4) We require new kinds of materials, such as ceramic materials with the kind of "aperiodic" paracrystalline structures first described by Kepler. We have presently a foot in the door respecting the methods of producing these; this is the replacement for the old metallurgical industries, such as steel, in reach during the early future.

For example: As we approach atmospheric and supra-atmospheric speeds of Mach 8 and beyond, ablative and other tricks for combating heat-accumulation in the outer hulls of vessels become of marginal value, and worse. Initially, in the vicinity of the presently technologically feasible Mach 8, this becomes an important factor of cost; at higher speeds, it becomes a physical constraint beyond mere cost considerations. Rather than trying to resist heating effects, we must absorb them in a convenient way. New qualities of materials are part of the key to these solutions.

5) There is a partly known, and also partly incalculable risk, in carrying crew and passengers in extended space flight at micro-gravities for periods of many months. The optimum solution for this, is to base human space travel on trajectories defined by a constant acceleration-deceleration equivalent to one Earth-gravity, or near that. This would reduce lapsed time from Earth orbit to Mars orbit to approximately an average of 48 hours.

See the summary calculations which researcher Heinz Horeis and others pulled together in **Tables 2** and **3.** There is not enough matter available to us to complete such one-gravity trajectories by chemical rockets' impulses. The only solution is what we may identify conveniently as a "second-generation" fusion-energy system. This, as Horeis indicates, suggests a propulsive power-unit of one terawatt output,

TABLE 2

Calculation of velocity and time of flight

Distance	Acceleration 1g	Time
30×10^9m	$v_e = 7.7 \times 10^5$m/sec	$t_e =$ 77,460 sec = 21 h
200×10^9m	$v_e = 2.0 \times 10^6$m/sec	$t_e =$ 200,000 sec = 55 h
	Acceleration 1/6 g	
30×10^9m	$v_e = 3.16 \times 10^5$m/sec	$t_e =$ 189,700 sec = 53 h
200×10^9m	$v_e = 8.16 \times 10^5$m/sec	$t_e =$ 489,900 = 136 h

We assume that the Mars ship accelerates for half the distance, s, *with constant acceleration* $a = 1$ *g, or* $a = 1/6$ *g, and then decelerates with 1 g, or 1/6 g for the remaining half. With* $v = (2as)^1|^2$, *and* $t = (2s/a)^1|^2$, *we get for the respective half-distances the values of* v_c *and* t *shown above. Note the short flight times: less than 2 days for the shortest distance and 11 days for the longest, compared to 260 days for chemical rockets.*

Source: *EIR Quarterly Economic Report*

readily feasible in a "second generation" fusion system. This would permit manned space travel in one-gravity trajectories, and the movement of gigantic, unmanned "freighters," using the same propulsion system, at lower trajectories.

6) We must, more immediately, decrease the cost of putting a ton of weight into Earth's geocentric orbit. Our objective should be a cost less than 10% the present ones.

Until we develop this new system, we should continue to use present systems of elevating persons (shuttles) and objects into lower and higher orbits. There is work which must be done, which must not wait until the new systems are completed during the 1990s. However, we can not proceed economically, to build the Earth orbit based interplanetary systems, until we have the new systems, modeled upon the work of space-scientist Sänger, which not only reduce the cost by about 10%, but also make possible frequent travel between the Earth's surface and the geocentric orbit in which interplanetary space-stations must be located.

As this reporter indicated, in his 1986 proposal, and in the March 1988 half-hour *The Woman on Mars* national TV broadcast, the key to achieving such economies and convenience is a two-stage system, involving a rocket, somewhat like the shuttle, piggybacked onto a scramjet aircraft with a top speed of Mach 8. The piggybacked shuttle will reach low Earth orbit; "space tugs" assembled in low Earth orbit, will carry persons and freight to (Earth-point-stationary) geocentric orbit.

7) Although we should resume the sending of unmanned instrument packages to Mars, we should postpone manned landings on Mars until we have the right systems to do so intelligently and with reasonable safety for space voyagers' health during the round trip. We should adopt as early goals, the placing of permanent instrument packages into Mars orbit, and on the surface of Mars. The use of obvious improvements in present reconnaissance satellite technologies will provide us most of the chemical and meterological information we require for a preliminary Mars survey.

Regular manned flight to Mars requires the preliminary stage of "automated industrialization" of the Moon. This industrialization of the Moon requires rather early development of fusion power and of some of the new kinds of tools indicated. Most of the bulk and weight of space vehicles used for transporting freight and persons to Mars orbit, must be constructed through the performance of the stages of extraction, refinement, and components fabrication on the Moon, using raw materials available on the Moon.

The entire, 40-year project is organized in a way not unlike the construction of a modern skyscraper. The construction proceeds in planned phases. We develop technologies to meet scheduled times when products based on those technologies must be delivered to begin each next phase of the construction. The research and development, and the industries based on this, are being developed in parallel to the completion of other phases currently in progress of completion.

In other words, we start all phases of the construction now, giving each element of the entire project a time schedule for completion of its development. The early phases must come on line earlier; the later phases have, variously, 10, 20, 30, or 40 years, approximately, to complete their part of the task. This also means, that we begin training high-school and college students now, for the kind of work required of each element and phase of the project. It also means, we begin to assemble the scientific and management teams required for the project as a whole, and each phase and element of the project.

In this sense, the project uses the principles of management proven earlier in development of transportation infrastructure, skyscrapers, and so forth. It means going back to the sound principles of industrial management, in which we used to be among the world's leading nations, and applying those lessons of past experience to the kinds of technologies this project introduces.

The purposes of the colony itself

The Horeis calculations shown here, point to our need for a scientific revolution which carries mankind beyond the limits of fusion power. Putting the point crudely: How much power can we extract from a ton of fusion fuel? For reasons implicit in the calculations, manned space travel along one-gravity trajectories would limit round trips based on the fuel carried out by the vessel, to the vicinity of the Asteroid Belt! How do we break through this barrier?

(One obvious solution, is to send low-trajectory space tankers out ahead of the manned craft. The manned craft can then be refueled at such space-based "filling stations." A useful trick for manned exploration of the outer Solar System, but not really a solution to the problem we have posed.)

To any astrophysicist, the nature of this limit is most fascinating. In Kepler's system, as checked by modern physics calculations, the Solar System is divided into two principal regions (excepting Pluto). There are the inner planets, composed largely of heavier elements, and the outer gaseous giants. The division between the two zones, is the Asteroid Belt. If we correct Kepler's calculations of the harmonic values associated with the orbits of the Sun and planets, if we set the Sun at C below Middle C, the band which is the asteroid belt has two rims, of which the innermost rim is at F above Middle C, and the outermost rim at F-sharp: This is the normal bel canto voice register shift for the soprano voice.[2]

There is nothing occult in this. If we correct Kepler's calculations from the standpoint of the nineteenth-century work of Gauss, Riemann, et al., we understand the necessary reasons for this limit of fusion-powered manned space travel within the Solar System. Our understanding of this is greatly improved by recent experimental confirmation of this reporter's longstanding hypothesis, that subatomic space is harmonically ordered in the way indicated by a Gauss-Riemann correction of Kepler's construction of the harmonic ordering of the Solar System. Our insight is improved still more, by current work in progress, reconstructing the periodic table of chemical elements and their characteristic properties, on the basis of this experimentally confirmed hypothesis on the organization of subatomic physical space-time.[3]

The question is so posed: Is there not another kind of energy-reaction, which has a much higher energy-mass relationship sufficient to permit a round-trip beyond the Solar System, perhaps?

Experimentally, we know of one such reaction, the so-called "matter, antimatter" reaction.

There are some problems. The standard view of this reaction is based on relevant, but effectively contested dogmas advanced by Dirac—the so-called "Dirac Sea" hypothesis. No matter, we know that the reaction is constructable experimentally; it exists. Therefore, if there is an urgent reason for mastering this reaction, as a controlled reaction employed as an "energy source" by mankind, we must proceed to settle the unresolved theoretical and related questions.

This is one, if only a leading example of the key missions for which we require the assistance of the permanent Mars colony.

Although Earth has no urgent industrial or related need for controlled "matter, antimatter" reactions today, during the second half of the next century, this will begin to appear as a practical problem. This will occur during the lifetime of the grandchildren of the children of this reporter's nieces and nephews. This will begin to be seen as an upcoming problem for Earth at about the same time the scheduled Mars colony has settled in. So, this will be a leading research mission for that colony from the beginning of its existence.

During the second half of the next century, mankind will look at second-generation fusion energy with not only satisfaction, but also frustration. The increase of our planet's population-density will require that we become able to use the available land-areas with vastly greater efficiency than today. To develop the technologies, which make mankind's average lives not only wealthier, but more pleasant aesthetically, we must pay attention to the causal relationship among technology, power, and productivity. The fact that even second-generation fusion energy is a form of power with an upper limit, will be of concern to us on Earth, increasingly, during the second half of the coming century, and will become urgent during the course of the century following that.

If we look back, to the process of technology over the recent five centuries, even the past hundred years, we realize that our population-density of today could not be mastered successfully but for fundamental scientific discoveries of more

Lyndon LaRouche

From a nationwide half-hour television broadcast titled* The Woman on Mars *March 3, 1988.

Thirty - nine years from now, we shall hear the broadcast from Mars, announcing that the first permanent colony there is operational. Among those colonists will be some of the children and grandchildren of you watching this broadcast tonight. Many of you will be watching that first television broadcast from the new colony.

Already, the woman who will speak to you from Mars has just recently been born somewhere in the United States. We shall give our nation once again that great future which our children and grandchildren deserve.

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[2] Kepler showed that his system required the former existence of a planet in what we identify as the orbit of the Asteroid Belt, today. This was approximately 200 years before the existence of any asteroid was discovered. Kepler showed why, according to his construction of the entire Solar System, any planet in that orbit must have been torn apart. He supplied what later proved to be the correct harmonic values of the orbits for the asteroids. This later proof has the effect of being a conclusive proof of the correctness of Kepler's astrophysics, and a crucial experimental disproof of the approach represented by Galileo, Descartes, Newton, et al.

[3] On the basis of the experimental confirmation of this reporter's cited hypothesis, Prof. Robert Moon directed an investigation of the way in which the possible elements and isotopes of the periodic table must necessarily be determined. This determination depends upon defining the allowable number and theoretical positions of protons and neutrons in the atomic nucleus; this, in turn, determines the electron structure. The conventional ideas of "gravitational" and analogous "packing" of the atomic nucleus, are discarded. Possibly, a Beltrami space of negative physical space-time curvature is helpful in unraveling this a bit more.

The relevant point in the text is, that the indications of a conformal harmonic ordering of the physics of the periodic table with the composition of the Solar System, argue that the fusion reaction reflects the harmonic characteristics of Earth's spectrum of periodic table at one gravity on the Earth's average surface. The coincidence of fusion power's theoretical limits with the "voice register" phase-shift in the composition of the Solar System, is a stunning fact, but not properly a surprising one.

George Bush

From a speech delivered in Redding, California on Oct. 3, the day Discovery *successfully completed its mission.*

I am fully and utterly committed to the U.S. space program. I am convinced this is not only an adventure but a responsibility, and one we shirk at our peril. I believe we must move forward. And I believe we are at the beginning of this journey, not the end, and that we have miles to go.

There are budgetary considerations, of course. This is no time to be wasteful. But, bottom line, a good investment is a good investment, and that, in part, is what space is.

The way I see it, the logical order is this: first the Shuttle, then the space station. First the Moon, then—perhaps—Mars.

Why the space station? Because it is the critical next step in all our space endeavors. With it, we will be able to pursue further scientific, medical, and commercial experiments, and we will be able to make progress in becoming used to working and living in space.

Because of the key nature of the space station in all our future endeavors, I have decided this evening, to announce that I will, as President, commit this nation to the development of an operational space station by the year 1996.

This will demand the commitment of men and women and resources, but it is a commitment well made. This goal is achievable, sensible, and worthy of a great nation.

There has been debate, and there will no doubt be more, about whether the great space journeys of the future should be manned or unmanned. There is much to be said for the latter—safety, greater range, economy.

But I am convinced the future of the American space program includes manned flights, even puts the emphasis on them. The reason, to me, is obvious: These are journeys of discovery and daring, and they will lose their impact and their meaning if they are performed only by machines. Men and women do not follow machines, they follow great men and women.

Of course, there are risks, as there are in all great ventures, and every precaution must be taken. But we can work at planning and improving safety as we press ahead.

than a hundred years ago, and, thus on the scientific discoveries established up to more than a hundred years before that.

To develop what we call the "matter, antimatter" reaction, as a controlled primary source of energy for mankind, by the end of the coming century, if not earlier, we must start the work of fundamental scientific discovery today, lest our great-grandchildren, and great-great-grandchildren curse our memory for our failure to do so. Fundamental scientific revolutions, such as this one, take a great deal of time; progress in fundamental scientific discoveries is measured in generations of the adult working-lives of entire generations of scientists.

We may not solve the problem during the lifetime of any working scientists living today. However, by about the time the Mars colony is settled in, that generation of scientists must be equipped to attack the problem with a solution in sight during the lifetime of the generation of scientists following them.

"Pie in the sky"? No. As we have already indicated, our present generations, even during the 1990s, will begin to enjoy immediate benefits, as technology spillover into higher productivities and so forth, the which they would lack otherwise, unless we proceeded along these lines. Perhaps more important: Is it not a very good thing, to close one's eyes on the last moment of one's mortal life, knowing that one's great-great-grandchildren will have good reasons to smile on the memory of one's own mortal life? Is it not a very good thing, to be able to live one's life, during the decades before one's death, even during adolescent preparations for adult life, knowing that the work which one is assisting is leading to a happy thought about one's entire life, at the moment of one's death?

For what other purpose do we bring children and grandchildren into this world, and nurture the development of their moral character and intellectual powers? If we are wise about the living of this mortal life, do we not reflect upon the debt we owe to generations before us, many generations? Do we not reflect upon the fact, that after our life is ended, those who come after us will benefit from what we have contributed to the development of the moral character and intellectual powers of our children and grandchildren?

In the existence of mortal mankind, over hundreds of generations before us, and hundreds perhaps to come, what gives meaning to this tiny speck which is our own mortal existence? What mission might we perform, with this so tiny thing, our mortal existence, that we might look upwards to the heavens, and say to an unseen presence there: "I am happy, because I know that what I am working to accomplish makes my mortal existence a necessary life in the whole space of hundreds of generations before mine, and hundreds of generations still to come"? Can there be greater happiness than to live in such a way as to know, that one's existence is efficiently justified by the mission to which one's mortal existence is contributing?

Security and happiness in our immediate life are necessary conditions for the citizen, to which our Constitution's Preamble dedicates the functions of our federal government. Yet, where could there be true individual happiness, if all the meaning of our having lived were buried with our corpse? Do we not owe ourselves, our children, and humanity, something better than individualistic "materialist" gratifications? Is trudging to and from the securing of one's income, enough, even if the material standard of life secured so is better than adequate? To what higher purpose do we trudge so? Must we not be contributing, in some way, to building something which is good for the future?

We speak of the high value our culture places upon the sacredness of individual life, and respect for the freedom of that individuality. What do we mean by such words? What ought we mean, if we reflect upon the meaning of our mortal lives with a bit more wisdom? Hopes of an after-life may be happy ones, but the conditions in that after-life as such, are matters of faith, not something intelligible to mortals. Is it not the case, that what we do with this mortal life we have defines the measurement of merit placed upon our identity by the Creator? If we do the Creator's Will in relevant matters which are intelligible to mortal minds, can we doubt that the loving eye turned upward to the Creator in that moment, knows what practical thing on Earth such love commands us to do? Is not what we do respecting matters which are intelligible, the which is the expression of our conscience, that good conscience which is the state of true, deeper personal happiness?

The same reflections assume a somewhat different, practical form, as we shift the locus of such questions to the matters of policies of government.

Society, especially as defined by the sovereign republic our Declaration of Independence and federal Constitution, combined, founded us to become, is, as the Preamble of that Constitution avows, an included commitment to care for the well-being of our posterity, at the same time that the existence of the republic serves the current obligations of this federal Union. The nation so defined, is much more than the whims of capricious contemporary majority opinion might imply. It is our debt to preceding generations, and to our posterity over indefinite numbers of generations to come. The nation is properly defined as not less than that total population which has been, which is, and which might come to be if we today do not ruin this nation with foolish, capricious whims of momentary popular opinion.

That view of the nation—our republic, is the state of mind of the true statesman. Whoever lacks that standpoint, is no true statesman, however foolishly we might honor as statesman one who lacks that controlling element of conscience. The future we are building with our policies and efforts of today, is the central concern of the true statesman, and of

To solve the problems that lie ahead for mankind, we must start the work of fundamental scientific discovery today, lest future generations curse our memory for our failure to do so. For what other purpose do we bring children and grandchildren into this world, and nurture the development of their moral character and intellectual powers?

all others worthy of being regarded as "natural leaders" among the rank and file of our citizens.

To the citizen who grasps this moral point, we say we are addressing their deepest concerns, their rightful pursuit of true happiness. To the mere pragmatists, we say the simpler thing: "This will make your lives more meaningful, as well as more secure and prosperous than under any different sort of policy in sight."

We know already, how this challenge of controlled "matter, antimatter" reaction can be mastered during the span of time we have indicated it must. This reporter's principal contributions to economic science were based on solving that kind of problem. The exposition of this is profound, but simple; it is the basis for any correct approach to national science policy. Therefore, we summarize it at this point.

In mathematics, we say, that to the degree mathematical-physical knowledge is deductively consistent, all theorems of current scientific knowledge can be represented by a deductive theorem-lattice derived from an underlying set of Euclidean-like axioms and postulates. Mathematical physics is never fully consistent in that way, but all using deductive method center their work around the attempt to render it consistent in the sense of a deductive theorem-lattice. So, most disputes in science, especially those bearing upon correcting popularized errors of scientific education, or fundamental scientific discoveries, approach scientific matters with the idea that mathematical physics ought to become consistent.

Assuming either that mathematical physics is consistent, or is working to become so, what happens to a mathematical physics developed as a deductive theorem-lattice, when some crucial experiment demonstrates that one or more of the accepted theorems of that lattice are false? A short examination of this is key to defining properly the mission of the Mars colony.

The well-known characteristic of any deductive theorem-lattice, is what is called the "hereditary property." This signifies, that no theorem of such a lattice contains anything which was not implicit in the underlying set of axioms and postulates upon which the lattice as an entirety is based, and from which each and every theorem is directly, or implicitly derived. Therefore, a crucial experimental proof, that one or more of those theorems is false, proves that at least some part of the set of axioms and postulates is also false.

In a rigorous scientific practice, the immediate result of such a series of crucial experiments is, that the set of axioms and postulates must be corrected in ways which are in agreement with the results of these experiments. This leads us to the following procedure.

For easier reading, let us designate the theorem-lattice so refuted by a crucial experiment, as Lattice A. Once we change the axioms and postulates of Lattice A, in such a way as to correct for the error discovered, we have created an entirely new set of axioms and postulates. Every theorem in Lattice A must now be rewritten in such a way as to be fully consistent with the new set of axioms and postulates. The result we may designate as Lattice B.

In practice, it is not quite that easy. There may be a variety of changes in axioms and postulates of Lattice A, each differing from one another, but all apparently in agreement with the results of the crucial experiment. Each of these choices imply the construction of a corresponding Lattice. That means that we have a series of new Lattices from which to choose: B, C, D, and so on. What we must do, obviously enough, is to see which of these, either B, or C, or D, and so on, fits all the scientific evidence, not only the evidence of the particular crucial experiment which set this process of reexamination into motion.

The successful choice of either B, C, or D, for example, as the best new, experimentally consistent theorem-lattice of formal mathematical physics, is what we commonly identify as a "scientific revolution." Those kinds of crucial experimental discoveries are called "fundamental discoveries," and the reconciliation of this fundamental discovery with the larger body of mathematical physics is termed a "scientific revolution."

This is what we confront when we set out to accomplish a scientific revolution over the generation or so ahead, as we are doing in proposing a mastery of controlled "matter, antimatter" reactions. We continue with the discussion of such "fundamental discoveries' " effects on scientific work.

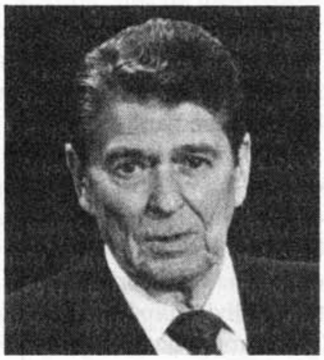
Suppose the hypothetical crucial experiment led us to adopt Lattice B as our improved formal representation of mathematical physics. The result would be, that no theorem of Lattice B would be deductively consistent with any theorem of Lattice A, and vice versa, of course. Thus, there would exist a kind of "logical gap" between the two lattices. Another word for such a gap is "a mathematical discontinuity." The closer examination of this kind of "logical gap," or "mathematical discontinuity," has been the center of the issues of method in physical science, and the theory of knowledge in general, since the seventeenth-century attack on Descartes by Leibniz. The roots of that dispute even go back about 2,500 years, to the ancient classical Greek discussions of a problem termed "the Parmenides Paradox."

Study of this issue is key to understanding scientific revolutions of the past, and is also key to preparing to effect one of the greatest scientific revolutions in history, during the course of the generations just ahead of us.

One of the most famous among the relatively modern statements of this problem is the central feature of Immanuel Kant's *Critiques*. The central feature of Kant's false reasoning, is his assertion that we can not construct an intelligible picture of the kinds of mental processes by which a valid fundamental scientific discovery is accomplished. Kant said such things were "unknowable."

Ronald Reagan

Excerpts from the speech by President Reagan at the Johnson Space Center in Houston, Sept. 22, 1988.



In the next century, leadership on Earth will come to the nation that shows the greatest leadership in space. It is mankind's manifest destiny to bring our humanity into space, to colonize this galaxy.

In the limitless reaches of space, we will find liberation from tyranny, from scarcity, from ignorance, and from war. I say that America must lead. The nation that has achieved the greatest human freedom on Earth must be the nation to create a humane future for mankind in space, and it can be none other.

Soon the world will be watching as five brave Americans lift off from Earth on the Space Shuttle *Discovery*. America is going to space again and we are going to stay. When *Discovery* takes off, seven precious souls will soar beside it, the seven heroes of the *Challenger*. With their lives, they moved a nation, they summoned America to reach higher still, and they wrote man's destiny into the stars.

Ill fortune can slow us down, but it cannot stop us. You can delay our long trek to greatness, but you cannot halt it. How better can we pay tribute to those who came before us than by continuing their quest for knowledge, their struggle against limits, by continuing to push to the far frontier?

We are a nation born of pioneers and we will always create our future on the frontier. Americans can live no other way. Our early settlers knew great risks and made great sacrifices, and moved the frontier forward to build a great nation. Neither can we stand still, nor be content, and we are not afraid.

Somewhere in America, there is alive, today, a small child, who, one day, may be the first man or woman ever to set foot on the planet Mars, or to inhabit a permanent base on the Moon.

Let every child dream that he or she will be that person, that he or she may one day plant the Stars and Stripes on a distant planet. You and I know that we are the nation that must do it.

This reporter's original contributions to a science of physical economy were prompted as a reaction to some absurd ideas about "information theory" popularized by Professor Norbert Wiener and John von Neumann, but Wiener's and von Neumann's blunders were merely imitations of the false reasoning of Kant. A refutation of Kant's blunder suffices to disprove modern "information theory" conclusively. It was also the starting-point for this reporter's original discoveries in physical economy.

Kant's cited dogma was based on a false interpretation of the problem of theorem-lattices which we have just described above. He argued along the following lines. Let us assume the case, that the amount of change in the set of axioms and postulates of Lattice A, to generate Lattice B, is of the smallest possible degree. From Kant's vantage-point, in this case, the logical gap between the two lattices exists, undeniably, but no intelligible picture of the gap itself is possible.

The opposite approach, by Leibniz, by such founders of modern science as Nicolaus of Cusa, Leonardo da Vinci, and Kepler earlier, and by such as Bernhard Riemann later, was based on the method of the Socratic dialogue, as typified by Plato's dialogues. In those dialogues, a proposition is adopted for examination. The approach taken is, first, to identify the underlying assumptions on which that choice of proposition is based, and then, in turn, to examine the assumptions underlying the first set of assumptions. The second set of assumptions has the character of a set of axioms and postulates. Change of a false assumption in the second set, is then the basis for supplying a corrected, alternative form of the proposition.

This was the method used explicitly by Leibniz to effect some of his fundamental discoveries. Obviously, contrary to Kant, the processes of creative discovery are intelligible.

Later, during the ninteenth century, the work of Gauss, Dirichlet, Riemann, and Weierstrass showed us how to deal with this kind of lattice-work discontinuity among deductive systems of thought, in a systematic, mathematical way. This was key to this reporter's proving that the organizational process associated with Leibniz's definition of *technology* could be represented in the manner referenced above.

On the basis of those principles of technology, we are able to predetermine certain of the most crucial features of a next set of fundamental scientific discoveries. We do not have those discoveries in hand; far from it. What we do have is nonetheless of great practical value to us. We know the general form of the discovery, and we also know the general nature of the experimental investigations which lead us in the right direction.

Happily, much of the preparatory work toward our next major scientific revolution was already completed more than a hundred years ago, by such scientific workers as the already cited Gauss, Dirichlet, Riemann, Weierstrass, and Cantor, and also an Italian collaborator of Riemann's, Eugenio Beltrami. The experimental confirmation of the correctness of their approach, in work done over the recent hundred-odd years, leaves no reasonable doubt, but that this is the correct approach to our next major scientific revolution, and that this can be a successful undertaking within the time-frame we have suggested here.

What we must do, obviously, includes intensive study of important physical phenomena which contradict all generally prevailing ideas of physics today. There are three areas on which we must concentrate: astrophysics, microphysics, and optical biophysics. These are, so to speak, always the outer limits of experimental knowledge; it is by proving that newly discovered laws are consistently applied to the areas of these three experimental limits, more or less equally well, that truly fundamental scientific discoveries have been accomplished in the past centuries, and will be by the future generations of scientific workers. In these areas, the kinds of impudent phenomena we referenced, are termed "physical anomalies." They are phenomena which exist, without doubt, and yet their existence defies generally accepted scientific thinking.

Therefore, in effecting the scientific revolution which a controllable "matter, antimatter" reaction implies, we must concentrate, on the astrophysics side, on extremely anomalous astrophysical objects. To do this, we must examine intensively the entire electromagnetic spectrum of the universe, while concentrating special attention on these anomalous astrophysical objects.

This requires putting very large radiotelescopes, up to kilometers or more in effective electromagnetic-optical aperture, into space, as far distant from our noisy Sun as possible. So, the urgency of having a permanent science-city colony on Mars fully operating by the middle of the next century.

This task requires many radiotelescopes, not on Mars itself, but within convenient traveling distance from Mars. Since this will involve thousands of scientists and other specialists to construct and maintain the systems in nearby space, we need a logistical base to support these thousands of specialists. To establish a logistical base adequate to provide the indispensable sort of local logistical support to some thousands of specialists, requires a total population the size of a medium-sized city on Earth. Therefore, that must be a planet suited for building such cities, with synthetic environments, under domes. It must be such a planet as far out from the Sun as practicable for us up through the first half of the next century.

We know already the names and locations of some of the anomalous astrophysical objects to be included on our list. There is the Crab Nebula, a most curious object which supplies us our most intense cosmic ray showers. There are objects sometimes called "black holes," and better called powerful gravitational lenses. There are fast-rotating binary-star systems. And, so on and so forth. We also know, for these cases on such a list, that if we could build radiotelescopes with gigantic aperture, and aim these to collect relevant electromagnetic radiation from these objects and their immediate vicinity, the results would begin to revolutionize science in the laboratories, and also the production lines, back here on Earth.

We should also desire such devices as gamma ray lasers, or something of that sort, to explore more finely the structure of the atomic nucleus. And so on, and so forth. Optical biophysics study of the way in which nonlinear spectroscopy of coherent radiation governs the molecular and other features of living processes, is also relevant to this same inquiry. The astrophysical research is but one of three general areas of primary investigation on which the next scientific revolution depends.

How our economy is affected

If this reporter had his "druthers," the goals of U.S. employment to be reached by about A.D. 2000 would look somewhat like this.

Not less than 40% of the total labor-force would be employed as operatives in agriculture, industry, and basic economic infrastructure. Presently, the total is less than 20%, where it was about 60% at the beginning of the postwar period.

Not less than 10% of the total labor-force would be employed in research and development, as compared with the goal of about 5% generally accepted 20-odd years ago.

The number of teachers would be increased to not more than 16 pupils per teacher. Medical professionals would be increased as a percentage, similarly.

These changes would come from a combination of sources. To be reduced are the percentage of unemployed, to about 2% "frictional" unemployment, down from a current level of combined reported and officially overlooked unemployment of about 10% or more. Another source of labor for expanding the priority categories, would be a great reduction in redundant employment in administration, sales, and low-skilled services.

The feasibility, and desirability of such changes is indicated by observing the structural changes in composition of employment of the U.S. labor-force during the past 40 years, especially the most recent 20. At the beginning of the period, 40% of total labor-force was employed in "overhead-expense" functions of administration, sales, low-skilled services, and so on. Today, more than 80% is either unemployed, or employed in one of these "overhead expense" categories. Back in the late 1940s, every producing operative carried the cost of eight-tenths of a person on his back, so to speak; today, ignoring purely financial burdens, each productive operative must carry four persons on his back. Little wonder things cost so much, that the real standard of living for a growing majority of our people is falling as it is.

The point is, to reverse the "post-industrial" trends of the past 20-odd years. Government must act to restore incentives for investment in technological progress, and work with the private sector in developing a long-range technological commitment, a commitment which encourages entrepreneurs to invest with assurance of the soundness of that type of investment over the coming 20, 40, or more years ahead.

This means changes in education, obviously.

Look now, at the dynamic of interrelations among research and development, basic economic infrastructure, production of households' goods, and production of capital goods.

The key to injecting technological progress into production in general, is building up the machine-tool sector of employment. This must be matched by strong economic incentives for investment in the new technologies made available through the machine-tool sector.

By rebuilding our machine-tool sector, made up chiefly of small, highly skilled enterprises, we are able to supply the needs to the economy as a whole. The rate at which an expanded machine-tool sector delivers technological progress to investors, is limited by the number of scientists and others engaged in research and development: hence, the build-up of R&D, in all categories of physics and related natural science applications, to about 10% of the total labor-force.

In the industrial sector, there will be an accelerating shift in the composition of employment of operatives. There will be less emphasis on expanding the number of persons employed in production of household goods, and strong emphasis upon upgrading the labor-force into employment in machine-tool and other capital goods sectors. This does not mean a constriction in the supply of household goods per capita; it reflects simply the benefits of increased productivities in the household goods sector.

In infrastructure, apart from educational and health care capacities, the emphasis must be, first, on increasing the supply of power per per-capita unit of population-density. This means a proliferation of construction of modern energy-producing plants. This must be "clean energy," obviously, and must be at relatively high energy-flux densities. The more such installations we construct, and the more rapidly we complete each, the cheaper the costs of construction, and the greater the rate of improvements in quality.

With increased power per per-capita unit of population-density, major improvements in transportation infrastructure are in reach, including the general use of more efficient magnetic levitation rail systems for inter-city and inner-city rapid transit. Inter-city speeds, already, are within the range of 300 miles per hour: One can travel between Boston and Washington, D.C., by magnetic levitation quicker, cheaper, and more conveniently, than by air.

Obviously, we must act quickly on long overdue water-management development. This is key to a general, aggressive approach to building up the natural environment generally. As we know from studies of infrastructure investments during the period 1946-70, expansion of improvements in infrastructure has more direct impact, in such effects as increasing average productivity, than any other form of investment.

So, as long as we take this sort of approach to goals of national employment, and also rebuild our decaying national economic infrastructure to the level which satisfies constraints on technology, a 3-5% improvement in the economy of labor embodied in the design of a new machine-tool, transmits that economy of labor, billiard-ball fashion, throughout the chain of production of producers' and households' goods. This becomes a general increase of the productivity of the economy as a whole.

With those goals, with governmental commitments and investment incentives to match, and with one great, long-range "crash program" in the Mars Colonization project, this nation will readily reach the levels indicated at the outset of this report.