I. The Extra-Terrestrial Imperative

Moon-Mars Crash Program Under a Four-Power Agreement

by Michael James Carr

Oct. 21—Gigantic forces are in motion under the surface of today's events. The Anglo-Dutch imperial system which runs today's world from the City of London and its subsidiary of Wall Street, will never give up. They will fight every inch of the way. But nevertheless, there is such a constellation of forces today—as reflected in the current leadership of the United States, China, Russia and India—that over the coming weeks and months, these Four Powers can join together to discuss, to negotiate, and then to create, a new world credit system. This will be a New Bretton Woods system as Lyndon LaRouche designed it, which can end monetarism and the millennia-old system of empire forever.

NASA

Earthrise photographed from Apollo 8, Christmas Eve 1968.

Not a monetary system, but a fixed-parity credit system. On the national level of perfectly sovereign nation states, and on the international level through agreements between those sovereign states, masses of new, non-inflationary credit will be issued. It will be non-inflationary because it will only be issued for creditworthy productive purposes, never for speculation or overhead, so that the productive use of the credit issued will later pay it back. Interest rates will be under 2%. The biggest new direction for such international credits will be for high-technology capital exports from nations such as the United States, Japan and Germany, into less-developed countries. Only under a fixed-parity system is such a volume of long-term, low-interest international lending possible. Other major new directions for new credits will be space exploration, as we discuss below, and fusion power.

This is no Utopia, but it will at last permit us to meet the critical tasks of our nations and of humanity, in exactly the the same way that we meet critical objectives in wartime—not in the Bush-Obama "wars of choice," but in real wars for national survival. In such a war, credits are extended to meet necessary objectives without regard to any competing claims, even if it means creating entire new industries from scratch overnight, as Franklin Roosevelt created the aluminum industry overnight, ignoring the screams of Wall Street. We saw something of the same thing in the Project Apollo of John F. Kennedy and his contemporaries who had returned from World War II.

This is a system in which governments (national, state and local) will be able to build what is necessary to provide for the future: high-speed rail, water systems, electrical power systems, and so on. The government projects and contracts in all of these areas build up a network of contractors and suppliers who can produce what is necessary to complete the government projects. These contractors and suppliers get the same access to credit as the government agencies, to be able to create the productive powers necessary to meet their government contracts.

This process builds up an array of individuals, companies, schools and so on (hereafter we shall just call them entities) with competence in many areas, but most important in the area of solving problems. Their real-world physical activity is the primary source of progress in physical science and technology. Computer modeling is no substitute for building and testing.

It is beyond the scope of this article to go through it in all detail, but just think about how the progression works: Andrew Carnegie, who first worked for a railroad, took up steel fabrication to build a railroad bridge across the Mississippi, and basically built the modern steel industry. Thomas Edison, who worked for telegraph companies, later created the electric power industry and made modern telephony possible with a viable microphone. Henry Ford, who worked for Edison, later created the modern automotive industry. William Shockley, who worked for AT&T's Bell Labs, in attempting to create mass-produced transistors, hired Robert Noyce who came up with integrated circuits and then central processing units. These are just a few examples from American history.

The basic idea here is that in a credit system, any competent entity with an idea of how to solve a necessary problem, and with a degree of rigorous determination, can get the credit to build it. This is why places such as Detroit and Houston are dotted with small and medium-sized plants which produce all sorts of specialized equipment relating to the automotive and general manufacturing industries, or, in the case of Houston, to the petrochemical and space industries.

Further, when coupled with a fair trade (not free trade) policy, it means that every country of any significant population begins to build up a "full set economy"—an economy which has capabilities to produce most of its needs in most areas domestically, and, most important, prototypes of completely new production processes. No longer are the imperial middlemen allowed to create artificial surpluses or shortages or artificial swings in currency values, in order to force nations into submission. Nations become *actually independent* and sovereign. Citizens become productive, independent and *creative*. So, it will be in this developing environment in which we will be building the global cooperation necessary to colonize the Moon and Mars.

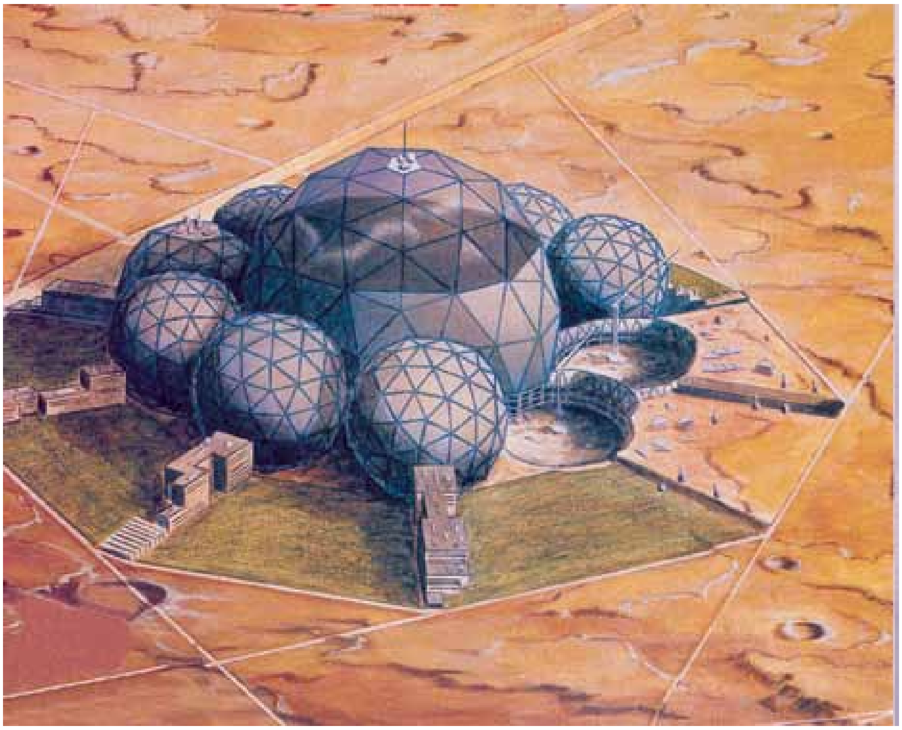
Under national banking and fixed exchange rates, even the smallest and previously poorest of nations will eventually be able to put Lyndon LaRouche's prescribed minimum of 5% of GDP into Research & Development (R&D). In that case, the global efforts at space R&D become the organizing principle around which every area of research revolves. Every problem encountered by Mankind in settling the Moon and Mars is also faced in some degree here on Earth. If we can solve a problem for space travel, we can solve its analogue on Earth. Nearly every earthbound problem could be considered a subset of the problems faced in space.

In that light, space science and space engineering become the organizing principle around which civilization better organizes itself! Imagine, for example, populating the Sahara Desert or far North Siberia. If successful settlements can be built on the Moon and Mars, then they can be built in the "wastelands" of Earth. It is merely a matter of controlling the environment—instead of the submission of Man to the whims of the environment which the British Empire demands.

NASA's Special Role

But the organizing principle requires physical embodiment. It requires a Sergei Korolyov, a Wernher von Braun, or a Qian Xuesen. Such people are alive today (indeed in greater numbers), but they have not been given adequate backup. Once we restore a Hamiltonian credit system to the United States and establish national banking as an international norm of state sovereignty, then scientific and engineering leadership will be allowed to function again. Putting bold ideas into physical form, and running them through rigorous testing and evaluation, will not only be permitted, but promoted.

We applaud, honor and promote the rapid progress being made by China, India, and the newly emerging space programs of the world, but NASA has a special


Christopher Sloan

An artist's conception of Lyndon LaRouche's vision of a city on Mars.

leadership role to play in enabling the global space program to function at its optimum.

As America is a "nation of nations," it is looked to by others to play a special role of combining the best from each nation and each culture, to put together a brighter future for all of us. And NASA's history of achievement gives it a special stature.

When President Trump and NASA put forward a general plan along the lines we will lay out here—backed up by a revived Hamiltonian credit system—to settle and develop the Moon and Mars, every national government, every university, every company, and every student with an interest in this project will be happy to coordinate activity with NASA. The building and administration of the International Space Station (ISS)—via cooperation among 15 nations along with many companies and universities—is a model for the Moon-Mars project.

For future success, this model must become universal. NASA will not dictate, but will simply lay out the overall plan, and identify the problems to be solved and the types of hardware to be created. Each participant will volunteer to accept an area of responsibility and outline a plan to fulfill it. NASA will play a coordinating and integrating role, while also accepting important responsibilities itself in areas critical for the project, and effectively acting as guarantor of ultimate success overall.

Russia's space agency Roscosmos, for example, would likely offer to further develop its space nuclear power systems among other areas. Canada's Canadian Space Agency (CSA) might offer to take up the design and building of space construction equipment, after its experience in creating robotic arms for the ISS and Space Shuttle. China, after its incredible success in growing plants in arid desert sand, might take on the project of growing plants in the lunar and martian regoliths. Private corporations like SpaceX, with some demonstrated competencies but also somewhat fanciful ideas about Mars colonization, will also be brought in to play an important role in a competently designed and managed plan. Enthusiasm is a necessity, but must always be partnered with rigor.

This project is so big, so complex, and so daunting, that there will be enough work to keep all of humanity's researchers, dreamers, engineers, architects and manufacturers busy for a long time to come. As in a choral symphony, each will be able to take pride in accomplishing an important part of the overall project. And, it will serve to uplift Mankind's vision while spreading prosperity across the globe and beyond.

Once the decision is taken to act, everything changes.

No longer will investigators be forced to sacrifice viable programs to keep others alive, sacrificing a left arm in order to preserve a right arm. Researchers, stuck in the labs and universities with ideas and plans but no resources, will suddenly get the resources to solve the problems facing space development.

Immediately, the ongoing regime of active cooperation and sharing of resources in the current robotic exploration of Mars, for example, will be greatly expanded. Yet the risks and demands of human exploration

NASA

There will be no more cases like that of the X-38 International Space Station (ISS) Crew Return Vehicle: 90% built, but canceled because of the lack of money to test it in orbit. Here is the NASA Johnson Space Center team which built the X-38, pictured at the closing of the program. Shown left and right are two 80%-scale drop-test vehicles, and at rear the 90% built orbital test vehicle. The Crew Return Vehicle would have been able to safely glide an entire ISS crew of seven back to Earth from an emergency aboard the ISS.

and colonization are so enormously greater, that success in these manned missions will demand a far more integrated effort.

The October 11, 2018 "successful failure" of a Roscosmos manned rocket launch to the ISS, and NASA's response to it, have demonstrated once again the determination of the participating national space agencies to resolutely cooperate and support each other. The lessons learned in the ISS project will form the basis upon which to build a successful Moon base that becomes a Moon settlement—Krafft Ehricke's Selenopolis. The Moon experience will become the basis upon which to expand outward to Mars colonization.

A Short Digression

We digress here for a moment to note that an important aspect of the Four-Power agreement overthrowing British world domination, will be the repeal of the British-instigated laws, regulations, and general hysteria run by the FBI and the media, to prevent the natural cooperation of China with the United States in space. This is not a recent phenomenon, nor is President Trump the only victim. The founder of the Chinese nuclear and space programs was Qian Xuesen (Tsien Hsue-shen), a Hangzhou, China-born Caltech professor, who was one of the three founders of NASA's Jet Propulsion Laboratory. Qian had sought American citizenship, but he was driven out of the United States and back to China in 1955, in the British-instigated, anti-communist hysteria of that period. He had not been permitted to continue building the space program in America, so he had to found one back in China.

One little-known fact about China will help to clarify China's intentions toward Americans. Today, every schoolchild in China, starting in kindergarten, is required to learn the American English language, in addition to Mandarin. There are nearly as many students of English in China, about 300 million, as there are Americans altogether. China is making great efforts to be able to better integrate into playing an important role in the world of scientific

Courtesy of Krafft Ehricke

A painting by visionary space pioneer Krafft Ehricke of the interior of the lunar city Selenopolis at Christmas.

and technological progress. If we finally shut down the British/FBI witch hunt apparatus, we should expect the China National Space Agency (CNSA) to assume its natural role, and not only participate in the project, but take up important responsibilities within it.

Because of the long-developed relationship of mutual trust, respect and friendship going back to the time of the Apollo-Soyuz Test Project of 1975, British-FBI operations against Russian-American cooperation in space have not been able to be as effective as those against China. And, any astronaut will tell you that NASA would never have accomplished what it has, had it not been spurred on by the successes of the Russian space program.

The Wolf Amendment of 2011, which prohibits co-operation between NASA and CNSA, has shut down most routine communications across the Pacific. It is high time to clear out the old land-mines left behind by the Empire on its way out.

Problems, Problems …

Some agencies may put forward variations or alternatives to what we outline here, but the overall requirements of a Moon-Mars program for exploration and colonization were already outlined long ago by Krafft Ehricke, Lyndon LaRouche, and, to a lesser degree, the 1986 National Commission on Space. There have been only a few subsequent technological and political changes which require revisions.

As with the Apollo Project of the 1960s, we are dealing with a critical path of problems to be solved. Each solved problem affects all of the subsequent problems in the path; nevertheless, we don't tackle these problems sequentially, but simultaneously. In this way, as unknowns are resolved, workable architectures begin to appear out of the haze of uncertainty. The problems to be overcome are huge but manageable. Here are some:

- Compact fusion and fission propulsion systems
- Routine spaceplane access to low Earth orbit (LEO) for humans and delicate hardware
- Completely new, heavy-lift maglev launch technology
- Removal or control of LEO space junk
- New construction techniques for lunar and martian settlements
- Technologies to "live off the land" on the Moon and Mars
- Mining and manufacturing technologies
- Technologies for space farming and food preparation
- Air and water recycling and creation
- Healthcare in space
- Space defense against harmful radiation and meteorite impacts
- Psychological effects of long-term separation from Earth
- Physiological and psychological effects of childhood development on the Moon and Mars.

Since about 1967, which saw the peak of Apollo Project funding along with the beginning of the British Tavistock Institute's all-out assault on American scientific progress, the American space program has turned away from pursuing revolutionary "best solution" technologies, towards "cost effective" or "off the shelf" derivative technologies instead. Yet "off the shelf" technologies actually tend to cost more—because they do not lead to revolutionary effects throughout the rest of the economy. For the space program does not return revenue paid out by the Man in the Moon or by little green Martians, but rather through the transformation of the earthly economy by new ideas and technologies transmitted out of the program.

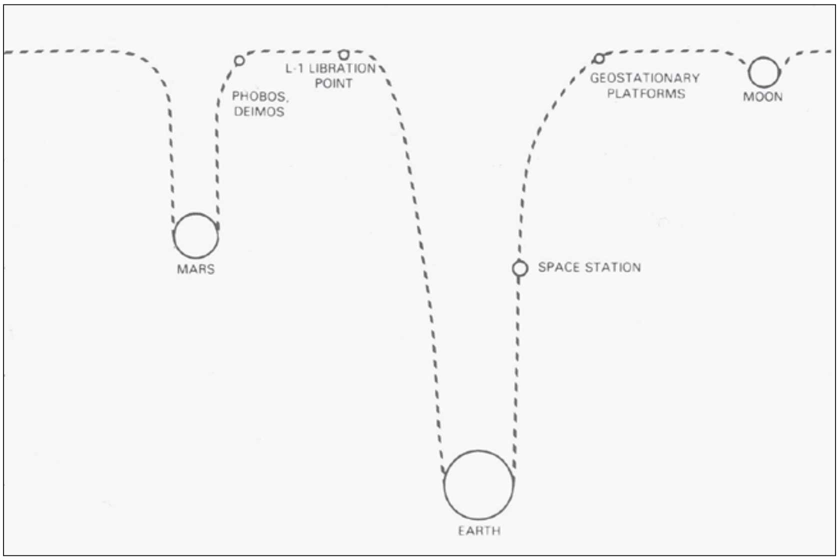
It is this conveyor belt of new technologies and optimism fed into the American economy which led to returns of far more than $10 for each dollar invested into the revolutionary Apollo Project. And, even this is really a faulty measure of value, because the power at the command of one dollar before Apollo was much inferior to the power at the command of a dollar after Apollo had transformed the technologies of every area of product and production.

Having understood this much, it is best practice to put resources into multiple possible solutions for a problem (even into apparently "far out" possible solutions), because the successful revolutionary solution will more than pay for the other failed solutions. And in fact, the economic consequences of such failures can be enormously beneficial.

Columbus failed in his experimental journey to China, yet the failed experiment became the basis for a civilizational transformation, precisely because of its unexpected result. Like Columbus, we may not reach exactly the objectives we project in every initiative; however, it is precisely the unexpected results of an all-out campaign to solve problems which generate new knowledge and thus new powers of humanity as a whole. Those who believe that "we already know it all" have a lot to learn!

With this physical-economic standpoint in mind, we will take a look at NASA's future. We shall maintain and expand current efforts funded at rates consistent with the earliest possible safe deployments of new capabilities for the ISS, the Space Launch System, the Webb Telescope, deep space probes, etc. However, with the new responsibilities NASA will assume, we will make adequate funding available to meet its new obligations.

So, for starters, we shall be speaking about tripling the NASA budget to the range of $50 billion plus, per year. This is a ballpark figure which may see further growth over time as NASA projects move up its "Application Readiness Levels" ladder from research projects into operational hardware.



From: *Pioneering The Space Frontier* by the National Commission on Space, 1986

In the "Gravity Well" graphic above you see the relative effort required to reach Low Earth Orbit in the vicinity of the Space Station, as against achieving Geostationary Orbit or the Moon. You also see that the relatively small Gravity Well of the Moon makes it an ideal pit stop to pick up supplies and fuel en route to anywhere else.

Similarly, we should expect that especially Russia, China, India, Europe, Japan and Korea—as nations or groupings with leading space capabilities—would also double or triple their commitments to space research. Newly developing space efforts, such as those of South Africa, Nigeria, Brazil and Argentina, would be wise to expand efforts by even greater multiples.

Maintaining Hubble

One of the most important space projects of all time has been the continuing success of the Hubble Space Telescope project. The new Webb Telescope will also provide incredible returns, but it will not be a replacement; the two telescopes operate in different frequency ranges.

Hubble has completely changed Man's perceptions of the Universe. The last Shuttle mission to service it, took place in 2009; we need to re-establish a capability to service it on a timely basis. We need a space truck and we will need it in roughly five years. Here is a case where international cooperation and timing is of the essence: We are talking about building a capability which is mostly based upon known technologies. Much of it could be put together from test articles left over from the Shuttle, Spacelab and ISS projects in Canada, Europe and the United States—but this project needs one agency or company to put forward an integrated design. This must be put on a high priority and started now.

What will be required is a spacecraft with some of the capabilities of the Shuttle. However, this new spacecraft will be docked to the ISS and have no need of reentry capability. It will require a pressurized module for ISS docking, and an airlock to allow astronauts to do spacewalk service work on the Hubble (or other spacecraft in other situations). It will need a sort of flatbed on which to attach parts, and upon which a satellite may be mounted for servicing; and it must feature an arm like the Shuttle's "Canadarm" (the Shuttle Remote Manipulator System, or SRMS).

Most important, it will have to be able to carry a very large propellant supply, in order to navigate between the orbital altitudes and inclinations of the ISS and various satellites, such as the Hubble. It will naturally need to be refueled in orbit (not necessarily while attached to the ISS).

From Earth to Orbit

Turning back now to the longer-term issues, problem number one is power and propulsion in general. As long as we are limited to using chemical reactions to generate thrust, we have been, and will be unable to fly a single integral or unitary vehicle into orbit without shedding portions (or stages) in order to shed weight to allow vehicles to attain orbit. The power densities of rocket fuel/oxidizer combinations are so low that huge volumes of physical space must be used to contain chemical reactants. Thus, the great weight both of the propellants themselves, and of the very sizeable housing necessary to contain them and support the rest of the vehicle's mass, have left no alternative but "staging."

Reaction Engines Ltd.

An artist's rendition of a SABRE powered spaceplane deploying a satellite to geostationary orbit.

Even as we continue to accelerate development of the Space Launch System (SLS) family of heavy-lift launchers, we will initiate two new projects for Earth-to-orbit operations. First, to gently and safely move humans and delicate hardware into and out of Earth orbit, we shall build a winged spaceplane using the revolutionary SABRE air-breathing rocket engines developed by Reaction Engines Ltd. in Britain (see *EIR* Vol. 45, No. 23, June 8, 2018). Work in this area is ongoing also in China, where world-leading hypersonic wind tunnels have been built, and in Russia. Military applications of the family of technologies around hypersonics and SABRE or combined-cycle (turbojet/ramjet/scramjet) engines, make cooperation in these areas difficult, but in the new atmosphere of a Four-Power agreement, countries may be more amenable to open collaboration.

Because this will be a first-of-a-kind project, knowledge shared across borders will be very important to successful attainment of this long-sought capability. As with other launcher systems, particular nations may wish to build their own spaceplanes, but each should at least have the advantage of shared research.

Secondly, we will initiate the development of the maglev launch system called StarTram. This high-risk/high-payoff proposal by Dr. James Powell, the developer of the superconducting maglev rail system being built now for regular passenger operation between Tokyo and Nagoya, Japan, has the potential to put 150,000 tons of supplies into low Earth orbit per year. Indeed, the experience of Japan, Germany and China in maglev development would make them very good candidates to take leading roles in this project.

StarTram will use buried superconducting coils to store up electrical energy over a long period, to be released in a short burst to accelerate a payload through a 100 km evacuated tube. The tube will curl 5,000 meters up a mountainside, allowing the spacecraft to proceed past the atmosphere, where a small chemical rocket burn can circularize its orbit. The first-generation system could launch twelve 40-ton spacecraft per day, each with a 35-ton payload. Thus, it could put 150,000 tons of supplies into orbit per year. This is the order of capability necessary to begin a permanent manned presence on the Moon or Mars.

By comparison, NASA's Space Launch System will initially have a 77-ton-to-orbit capacity, which will grow to a 143 ton-to-orbit capacity in the fully developed system. Even 1,000 launches per year (three a day) of the fully developed Space Launch System could not match the capability of the StarTram system.

StarTram, being completely different from all other space launch systems, poses high risk of failure,

Stratolaunch Systems

Stratolaunch has built the largest plane in the world, from which it intends to launch spacecraft to orbit.

but will be a tremendous success if it can be made to function. However, it must be recognized that its 30 G acceleration in its tube, followed by a 6 G deceleration upon exiting the tube and entering the ambient atmosphere, makes the first-generation system suitable only for cargo. Of course, the demands for freight shipment to LEO, the Moon and eventually Mars will only continue to grow as the human presence in space spreads.

On the Moon, with no atmosphere, Ehricke had long ago proposed a simpler maglev launch system (no tube or tube endcap system required) to propel supplies with the relatively little energy required to attain lunar orbit from the Moon's surface. So, if we can get it to work on Earth, we will put a derivative on the Moon to easily catapult lunar-created materials (such as Helium 3 fusion fuel, water, hydrogen and oxygen) to orbiting spacecraft heading to Mars and points further out, or back to Earth.

At the same time that NASA is heavily committed to developing the revolutionary technologies mentioned above, it will continue to encourage and oversee the development of the private space transportation systems which have been evolving from chemical rocket technologies, but which use new approaches that offer the possibilities of somewhat lower operational costs per ton to orbit, and generally incrementally improved ease of access to LEO. Of note here are the efforts of SpaceX, Blue Origin, Sierra Nevada, Stratolaunch, and United Launch Alliance. A great deal of NASA's efforts will necessarily center on improving logistics. Every attempt to improve space logistics will be encouraged.

Even as we work on improving logistics-to-orbit and encourage participation from around the world, it is important to stress the need for agreement at the beginning on common measures, standards, fastener types, voltages, interfaces, docking systems, connectors, and so forth. It is not necessary to source each component from the same producer, but it is necessary that parts and modular components be capable of being recycled or repurposed from one space vehicle or building to another, without much need for modification. There will be many situations far from Earth in which one piece of equipment must be cannibalized to produce a part for something more critical to mission success.

We will also need a modular intermodal freight system. Like the Trailer Equivalent Unit (TEU) intermodal truck-rail-ship container system on Earth, we will need to configure a standardized container system for space. Especially for freight, we will want containers or pods which can detach from launchers, reattach

NASA

First drop-test flight at NASA's Dryden Flight Research Center of the Dream Chaser spacecraft from Sierra Nevada Corp.

SpaceX

SpaceX Falcon Heavy reusable boosters landing on pads 1 and 2 at Cape Canaveral, Florida.

to translunar or interplanetary tugs, and in some cases transfer to reusable landing craft at Moon or Mars orbit. More on this in a moment.

From Earth Orbit to Anywhere

Martian reconnaissance aside, any human development of Mars will be dependent upon the industrialization of the Moon. As Krafft Ehricke said, "If God had meant for Man to explore space, He would have given him a Moon!" So, we begin with the Moon.

Most of the initial exploration, prospecting, construction and operational activity will be accomplished by robotic systems. People will be primarily engaged in solving problems, making repairs and modifications, in future planning, and carrying out various kinds of research.

The ISS has established the important capability of recycling wastewater into drinking water. However, on the Moon, over time we will need to develop the ability to produce more and more of the food requirements of the lunar residents.

Since the lunar night lasts about two weeks, local solar food or solar power production is not even theoretically viable. Only nuclear fission, and later on, the even more energy-dense nuclear fusion power will suffice for powering lunar agriculture and other activity.

By 2070, we should expect that per capita energy consumption per person on Earth should be 1,000 times the level found in the United States today. In the settlements on the Moon, energy use per capita will be far greater—as the Moon will become the industrial center of the inner Solar System. It will not only yield the perfect fusion fuel, Helium-3, but also metals such as iron, aluminum, titanium and manganese, which are found here in greater general concentrations than are found on Earth. Combined with the 1/6th Earth gravity on the Moon, these metals make the Moon the ideal shipyard for spaceships and related hardware. But energy requirements will be extreme. To a certain extent, plentiful power can substitute for the deficiencies of habitability of the Moon. With enough power available, we can turn lunar regolith into the missing air and water we need.

Once an initial base site is chosen, robotic equipment will be sent to the site to begin producing supplies of water and its constituents, oxygen and hydrogen. Humans on the Moon will require protection from cosmic radiation and incoming meteorites. Therefore, other robotic equipment will begin to dig out access to underground caves, such as the long lava tubes discovered by Japan's JAXA SELENE orbiter, and install habitation modules there. Later, they will build lunar igloos around habitation modules placed on the surface along with power plants and basic infrastructure.

There is much room for innovation here, possibly using inflatable modules inside caves or igloos which are made of lunarcretes (lunar concretes). The idea is that we need at least some minimum of shielding from radiation and meteorites for the initial Moon base. Later on, we can develop a more sophisticated, active space defense system, but at the beginning, we will have to settle on passive shielding.

Here again, we have an example of a space problem whose solution solves a problem on Earth. Humans on Earth are threatened with the effects of collisions with large asteroids and comets. Humans on the Moon will be threatened by them as well, along with very tiny incoming particles. If we can create a lunar defense system to defend us against the tiniest incoming objects, then we can certainly figure out how to defend Earth from much smaller numbers of larger objects.

Human Transport Infrastructure

"Direct ascent" to the Moon was ruled out during the Apollo program, in favor of the successful Lunar Orbit Rendezvous approach. This meant that only a small Lunar Module went down to the lunar surface from lunar orbit, and then eventually returned to lunar orbit to rendezvous with the much larger Command Module. For the same reasons, the best approach to a deep space transportation system will be to separate out the Earth-to-Earth-orbit, Moon-to-Moon-orbit, and Mars-to-Mars-orbit processes, from the transfer processes between Earth orbit, Moon orbit and Mars orbit.

This means that out beyond low Earth orbit, we will need several specialized spacecraft. We already have the ISS in Earth orbit which can function as the initial Earth orbital spaceport.

We will need a lunar transfer vehicle or tug to operate between Earth orbit and lunar orbit. A lunar ascent/descent vehicle between the lunar surface and Moon orbit will also be needed (possibly using Krafft Ehricke's "slide lander" design).

To sustain people on Mars, we will need a corresponding set of vehicles with special characteristics.

It is important to note here that the relative closeness of the Moon to Earth, the relatively small gravity well, the presence of water and of Helium-3 fusion fuel, and the high concentrations of useful metals in the regolith make the Moon the ideal shipyard/refueling stop on the way out to anywhere.

Abundant potentials open up here, but the initial teams of astronauts, cosmonauts and taikonauts will site, oversee and coordinate the further introduction of robotic mining and processing facilities. Over time, oxygen, hydrogen, Helium-3, and eventually fabricated metal parts will be catapulted up to lunar orbit via the Ehricke maglev launcher mentioned above.

While the initial base is likely to be facing Earth, China's CNSA may wish to follow up on its Chang'e-4 lunar far-side astronomy work by further developing observatories on the lunar far side, away from Earth electromagnetic noise.

Along with wheeled vehicles, suborbital flying vehicles will be needed. As mentioned above, as much as possible, it were a good idea to design all of the relevant vehicles to be able to transport interchangeable freight or passenger containers—or pods. Every effort to simplify logistics will have a big payoff in the long run.

The Energy Density of Fuels

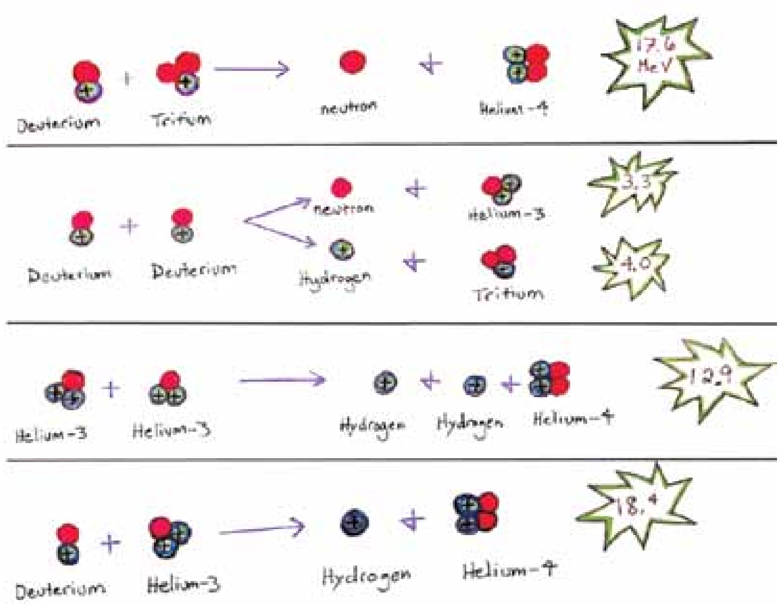
FUEL SOURCE	ENERGY DENSITY (J/g)
Combustion of Wood	1.8×10^4
Combustion of Coal (Bituminous)	2.7×10^4
Combustion of Petroleum (Diesel)	4.6×10^4
Combustion of H_2/O_2	1.3×10^4 (full mass considered)
Combustion of H_2/O_2	1.2×10^5 (only H_2 mass considered)
Typical Nuclear Fuel	3.7×10^9
Direct Fission Energy of U-235	8.2×10^{10}
Deuterium-Tritium Fusion	3.2×10^{11}
Annihilation of Antimatter	9.0×10^{13}

LaRouche PAC

As seen here, the energy density of nuclear fusion fuel is on the order of a million times that available in chemical fuels. The figure on page 17 of typical fusion fuels shows that the Helium-3 + Deuterium reaction gives the greatest energy output per reaction. More important is the fact that the reaction products do not include neutrons. This means that the reaction products can be controlled by magnetic fields, and that released neutrons do not cause unwanted transmutations in the surrounding machinery. This prevents unwanted derivative radioactive decay and consequent human and equipment health effects. Most important for spaceflight: the power of the charged products can be directly converted to electrical power. In other words, the relatively heavy and wasteful heat transfer to steam, to turbine, to generator can be bypassed. In technological progress in general, many areas of power production, transmission and use are moving away from heat-based processes to more efficient electromagnetic processes, as with maglev propulsion, fuel cells, or the light emitting diodes (LEDs) in your phone. This includes the space propulsion technologies, described in this article, which come under the general heading of Electric Propulsion.

On to Mars

Beyond LEO, we will want to have an infrastructure that features continuously powered flight, as opposed to coasting on force-free trajectories as we do today. This is true of flight to the Moon, but it is more important for the long flight to Mars. Humans should not coast to Mars for months through the high radiation of deep



21st Century Science & Technology

Deuterium is plentiful in seawater. Helium-3, while rarely found on Earth, is found in relative abundance in the lunar regolith (and in even greater concentrations in the atmospheres of the Solar System's gas giant planets).

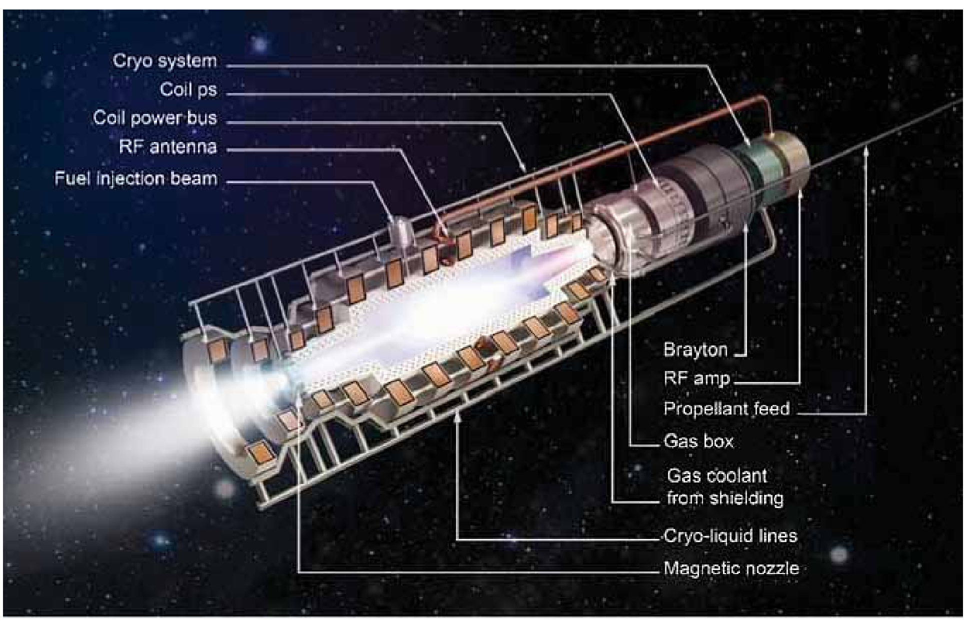
space. Even Columbus had sails to produce propulsion most of the time.

And this is not just a matter of radiation. The ISS has demonstrated the deleterious effects of long-term exposure of the human body to a zero gravity or microgravity environment. With continuous power, a continuous stress of some significant fraction of Earth's gravity—if not a full 1 G equivalent—can be maintained on the body. More research is necessary to determine the minimal sustained G force necessary to prevent deterioration of the human body, but the question becomes moot if we can develop a fusion rocket capable of sustaining a full 1 G acceleration.

This question was completely left open by the cancellation of the Japanese Centrifuge Accommodations Module of the ISS, (another X-38 situation) which might have given some clues to determination of a minimum G level required to prevent deleterious biological effects. For now, we can say that our propulsion system should aim at achieving a full 1 G acceleration and deceleration—if possible. The closer we get to that, the more we reduce zero G and radiation risks to crews.

To achieve continuous power and thrust on the scale we really need, nuclear fission or fusion must be the ultimate source of power. In the inner solar system, where solar energy is usually plentiful, there are applications for solar power, but for power-dense requirements such as continuous propulsion over long distances at a significant acceleration, only a nuclear fission or fusion power plant will do.

The earliest designs for nuclear rockets, such as the NERVA project, replaced the heat and pressure created by burning chemical rocket fuel with the heating of an inert gas by a nuclear fission reactor. Such engines are called nuclear thermal rocket (NTR) engines. They produce about twice the specific impulse (the measure of impulse created per unit of propellant) of chemical rocket engines. These would be a great improvement, but still not likely to be able to produce the continuous thrust we would really want to provide people heading



Princeton Satellite Systems

Artist's rendering of a Princeton Satellite Systems' Direct Fusion Drive engine, with interior cutout to show detail of the magnetic coils.

to Mars, for example.

NTR engines would perhaps suffice for the early development of the Moon. More likely solutions lie either in the realm of direct fusion rocket engines, or fission- or fusion-powered electric drives.


Ad Astra Rocket Company

An artist's rendition of a VASIMIR engine test firing aboard the ISS.

In 1980, Lyndon LaRouche, the Fusion Energy Foundation, and EIR News Service spearheaded a drive for a U.S. Government Manhattan Project-style commitment to the development of a demonstration fusion power plant to be completed by the year 2000. The Magnetic Fusion Energy Engineering Act of 1980 was passed by Congress and was even signed into law by President Carter. However, the funding was sabotaged.

Nonetheless, although slowed, progress continued internationally. Today, besides the International Thermonuclear Experimental Reactor (ITER)—a giant experimental reactor under construction in France—and various government and university projects, commercially viable fusion applications are thought to be so near, that roughly a dozen private companies are working to bring fusion power to the commercial product stage.

Of special note here is the ongoing work at Lockheed Martin's Skunkworks. Unlike the giant ITER, the Skunkworks' efforts aim at producing compact fusion reactors capable of powering flight—among other uses.

Also, as we reported in the July 21, 2017 issue of *EIR*, Princeton Satellite Systems is developing what it calls the Direct Fusion Drive Engine.

With power densities a million times that of chemical combustion, such engines hold the promise of delivering the needed acceleration to reach Mars relatively quickly and with minimal ill effects upon a crew.

A second possibility lies in the area of what is called electric propulsion. Besides the superiority of Russian-built liquid-fueled engines in some areas (such as the RD-180 engine currently used by the American United Launch Alliance Atlas V first stage), Russia has been the leader for decades in the use and development of electric propulsion systems. Today, Russian electric propulsion systems are also typically found on American satellites. There are many variations in this area, but a typical electric propulsion system first ionizes an inert gas, and then uses electromagnetic acceleration of the ions out the rocket nozzle at significant fractions of the speed of light, in order to get very high impulse per ion—thereby achieving very high specific impulse values.

Unlike chemical rockets which create lots of thrust in a very short time, electric propulsion systems have generally been used until now for slow and steady jobs—like the station-keeping of geosynchronous satellites. However, this is also a function of the relatively weak electrical power available on satellites. Could such engines, combined with fission or fusion electric power generators, be clustered together in enough quantity to provide the continuous acceleration of a significant fraction of 1 G that we seek for human flight to Mars and beyond?

Former NASA astronaut and plasma physicist Dr. Chiang-Diaz and his Ad Astra Rocket Company have built an electric-drive engine called the Variable Specific Impulse Magnetoplasma Rocket (VASIMIR) engine. It uses many of the technologies developed in magnetic confinement fusion research machines, such as radio frequency heating of the plasma, and appears to have characteristics close to what we would want. In 2015, plans to test a 200-kilowatt version of the VASIMIR rocket on the ISS were cancelled (another X-38 situation). Soon we will have enough money to finally be able to test systems in space!

We should also mention here more "far out" schemes, whose operation is said to be impossible by the "laws of physics." We are speaking about strange theories of a propellant-less "Radio Frequency Resonant Cavity Thruster" or EmDrive, laser propulsion, space elevators, etc. Whether ludicrous or cutting edge, such theories need to be physically and rigorously tested. In the build and test process, the "laws of physics" will either be reinforced or rewritten. Either way, Man's power in the Universe is increased.

All of these dark-horse candidates, plus every likely successful concept of propulsion, whether Nuclear Thermal Rockets, the Direct Fusion Drive, or VASIMIR, as well as every one of the multiple efforts at fusion power development, require the financial backup to be able to build and test in repeated cycles. We do not know which of the many efforts at solution to this problem will lead to practical space capabilities. We do know that accelerating this process will deliver the big payoff to the world economy. And we do know that the solutions are within sight.

Mars Itself

As better and better power/propulsion approaches are brought to fruition, and as we develop other technologies and capabilities in the process of lunar development, we begin to be able to plan for the founding of human operations on Mars. Mars is quite different from the Moon. It has a very thin atmosphere, which makes it seem more Earth-like. But, it is very far away from both the Earth and the Sun. One-way speed-of-light transmissions can take up to 20 minutes to reach Earth. This precludes assistance from ground controllers in emergency situations, as we have done on the Moon. Development of Mars will require much more autonomy and self-reliance than that of the Moon.

Mars colonization will have to build upon the successful solutions to the problems faced in lunar development. It will also benefit from the relatively cheap imports of metal parts and Helium-3 from the Moon. The very thin atmosphere composed mostly of carbon dioxide (great plant food!) suggests the possibility of martian agriculture in heated greenhouses (Mars is extremely cold).

Visionaries such as Lyndon LaRouche have long dreamed of "terraforming" Mars—potentially growing plants and forests on Mars. We shall see. As we get better and better control over the forces inhering in the atomic nucleus, we get better and better control of our Solar system.

The thin atmosphere also poses the possibility of the development of winged martian aircraft, both manned and robotic, to easily extend the reach of active operations. The ascent-descent vehicle for Mars will also have to be of a different design than the lunar ascent-descent vehicle because of its atmosphere.

Every aspect of human settlement on Mars is dependent upon successful attainment of fusion energy for propulsion and power. Otherwise it would be a dead end. But serendipitously, nearly every aspect of revolutionary progress on Earth is also dependent upon successful attainment of fusion power as the everyday underpinning of society. As we said at the beginning, the Moon-Mars project will properly organize the efforts of humanity on Earth to solve the problems on Earth. The spread of civilization into the Solar system could ironically just be thought of as a bonus byproduct!

Concluding Thoughts

Let us reiterate: Of course, we do not know in advance every particular of how this will all work out; much of it is still vague. It is left to the creative initiatives of people all over the world. There will be many advances beyond the bare outlines we have sketched here.

We *are certain* that someone and some nation must take the initiative to bring the future we seek into reality. We *are certain* that—for an array of historical and philosophical reasons—the world looks to the United States, with a restored Hamiltonian credit system, and NASA, to assume an initiating role in this process. We *are certain* that this will all more than pay for itself.

We do not go into space to get resources. We do not go to impress our neighbors. We do not go for immediate political advantages. We do not go to entertain the curious back on Earth. We do not go to win a race, for we shall all go together.

We take up this grand challenge as described in the immortal words of President Kennedy:

> We choose to go to the Moon . . . and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.