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# The Political Economy of Very Large Space Projects

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**Abstract**

*While popular science writers typically describe the benefits to be derived from their favorite very large space development project in detail, their treatment of the crucial initial capitalization of such projects is typically sparse or implausible. Capitalization is a crucial problem for these projects because the total capital investment required is very large and the investment takes a very long time before producing economic returns. "Chunky" investments are unattractive to most private investors and lenders. Very large space development projects are best understood as massive public works projects which are necessary to open frontiers. Despite the libertarian sentiments in much of the popular science writing on very large space development projects, government would likely have to play a large role in capitalizing such projects.*

Space development enthusiasts typically explain the significance of their favorite very large space projects−whether constructing orbital colonies or cities beneath the surface of the Moon, terraforming Mars or Venus, or launching interstellar spacecraft−in terms of their promise to produce vast new wealth, open frontiers to serve as social "safety valves" for the ambitious or the dissenting, generate the novel problems that drive dramatic advances in science and engineering, provide new sources of natural resources, and permit population dispersal to assure the long term survival of our species. Without question, these are all laudable reasons for the adventure of space and any very large space project would probably meet several of these objectives. However, if the economic and social promise of these projects is so extraordinary, and if the social losses which result from failing to undertake them are so large, why haven't humans embarked on them? Why aren't we even close to beginning one of these great enterprises? Given the assertion made by many space development enthusiasts that the basic technology needed for their favorite projects already exists or can be developed from the available science, asking these questions is entirely fair. The answers must be found in political economy, some rudimentary understanding of which will be necessary before realistic planning for any very large space project can begin.

Reading the popular science literature reveals that remarkably few space development enthusiasts have given the political economy of their very large space projects serious thought. Instead, they have chosen to describe the exciting science and engineering possibilities while promising the moon and stars to those who would dare to exploit them. Performing this public relations role is certainly crucial if any very large space project is ever to be realized. Both elite and mass public opinion will be to be inspired if the kind of resources necessary for development are to be mobilized. But something much more fundamental is missing. What needs explaining are the rational motivations for investors to risk their capital in ***opening*** a very distant, completely uninhabited frontier that is subject to extreme environmental conditions. Why should investors risk the enormous sums necessary to realize these dreams? Unfortunately, space development enthusiasts typically respond to this question, not by answering it directly, but by itemizing the likely economic benefits derived from space ***after*** the capital investments necessary to open the frontier have

been made. Space development enthusiasts are also given to lamenting that annual public and private spending on space development compares unfavorably with annual consumer spending on beer and pizza, and to discounting the present value of public and private spending on space against what humanity will gain over the long term from that spending. Granting the truth of all of these arguments, the fact remains that the technology and personnel for very large space projects are less in doubt than is the necessary capital investment. Capital is the essential missing ingredient. The voluntarism evident in so much of the popular science writing about space development is a liability when it prevents recognition of this crucial problem.

**Castles in the Sky**

A number of popular science writers have addressed the political economy of their proposals for very large space projects. Gerald O'Neill's visionary classic, **The High Frontier,** otherwise so breathtaking in its conception, unfortunately set a low standard for such discussions (1977: 161−162). O'Neill's L5 colonies were to emerge as extensions of the terrestrial economy, capitalized through borrowing billions from investors on Earth, constructed with materials mined on the moon, and selling energy and space manufactured goods in the terrestrial economy. Given the experience of underestimating the costs of constructing the International Space Station, the estimates of the capital needed for the first L5 colony offered by O'Neill in 1976 now seem wildly optimistic. If contemporary large space projects like the International Space Station are "intrinsically difficult to price," then very large space projects must be even more difficult to price, and that would introduce a risk which would make them less attractive to private investors (Johnson−Freese and Handberg 1997:142).

James Lovelock and Michael Allaby (1984: 173−174), writing before the end of the Cold War, proposed to pay for the terraforming of Mars with a post−Cold War peace dividend, investments made by a commercial industry anxious to develop new space markets to replace declining military markets, and sales of abstract rather than actual plots of Martian real estate to prospective colonists. As a token to the members of the peace and environmental movements of the 1980s, who appear to have been their target audiences, Lovelock and Allaby propose that enlightened technocrats would coordinate the terraforming process to produce a garden world free of pollution and war. The fate of the actual peace dividend ought to serve as a caution to anyone expecting to finance their big plans for space using *found money*.

Harrison H. Schmitt's (1996:2 8−30) "Millennium Project" combines mining of Helium−3 on the Moon to be used as fuel in future fusion reactors and the establishment of an "outpost" on Mars as prelude to colonization of the planet. Where capital for constructing the mining facility on the Moon is to come from is left unstated. But Schmitt does write that the first Mars missions will cost a mere one percent of the annual gross national product (GNP) of the United States. Presumably the subsequent missions to Mars to maintain the outpost would also cost one percent of United States annual GNP. Just how that one percent is to be extracted from the economy of the United States and spent on the Mars missions is also left unstated.

Selling Martian real estate to mining interests serves as the primary device for financing the colonization of Mars in Robert Zubrin and Richard Wagner's **The Case for Mars** (1996: 233−239). Recognizing that an essential element in selling real estate anywhere entails offering good title to prospective purchasers, they accept the necessity for a government, either that of the United States or a prospective Martian Republic would serve, to grant and by implication to enforce property titles. What is less clear is whether capital earned from those sales would be used to finance construction of the original human settlement or used for the subsequent terraforming of the planet. Nor is it clear that the sums derived from the sale of mining rights would be sufficient for either purpose. Potential investors in Martian mining operations would consider not only production costs but also transportation costs in moving commodities from production plants on Mars to markets on Earth. The existence of less expensive alternative sources on Earth would deter rational investors. Moreover, while mining is an important sector in many national economies, with the interesting exceptions of several of the Persian Gulf states (oil) and Nauru (guano), few national economies on Earth are sustained primarily from the sales of mining royalties or mining rights. A permanent human settlement on Mars which depended on commerce with Earth for its survival would probably need more than a mining sector and associated service sector to flourish.

As is true for most treatments of very large space development projects in popular science writing, Zubrin and Wagner offer a more detailed description of the subsequent economic activity than of the crucial initial capital financing of their proposed venture. Their Mars would be largely peopled by highly skilled immigrants who will have financed their own transportation from Earth (See Lewis and Lewis 1987: 295−296). In the near term, Zubrin and Wagner's Mars would export deuterium and new ideas to Earth. In the long term, a triangle trade system would emerge in which Earth exports high tech manufactured goods to Mars, Mars exports low tech goods to the asteroid belt, and the asteroid belt exports metals to Earth.

Mining also serves as the primary economic rationale in Donald Cox and James Chestik's (1996: 138−146, 211−272) proposal to colonize the asteroids. Planetary defense against asteroids and comets which might strike the Earth, transportation facilities intermediate between Earth and Mars, research facilities, and tourism and retirement homes all provide additional reasons for making asteroids the first focus for human expansion into space. Although Cox and Chestik offer little detail about financing their proposal, this may be excused because the probable incremental nature of exploiting the asteroids is likely to mean that attracting capital should be comparatively less difficult than for other very large space development projects. Each asteroid mining venture might be financed separately and the total capital necessary for mining the asteroids could be raised over time and in smaller amounts. Robotic mining of asteroids passing near the Earth might be within the technological and economic reach of private firms and government space agencies in the next century. Subsequent robotic mining ventures of bodies farther from the Earth might build on that initial experience. Yet rather than open a new frontier for human settlement, such incremental economic development via robotic mining might foreclose it. Private investors and government space agencies might be content to limit space development to those ventures which yield economic returns in the short term. Given better returns on investments on Earth and demands for government spending for public services, the occasional robotic mining ventures on near Earth asteroids might be the most ambitious space development project ever undertaken. It is difficult to see why such investments would generate other economic activity in space. Part of the problem is that robots might be too cost−effective.

After several decades of experience with lunar and planetary exploration, it is reasonable to project that using robots in space will be more cost effective than using people in space for the same tasks. The relative cost effectiveness of using robots over humans in space is a function of the accelerating speed of machine computation, now commonly believed to double every 18 to 24 months, and the lower costs of protecting and maintaining machinery over living flesh in space. [1] Robots will grow ever more competent in performing complex tasks while humans will continue to need lots of expensive protection in space. Work requiring higher level decision−making is likely to performed via remote tele−operation by humans on Earth. If mining or other tasks in space can be undertaken by cost effective robots, why would rational decision makers in private firms or space agency use cost ineffective humans in space? The development problem here is that sending robots rather than humans into space would mean a smaller human workforce in space.[2] A frontier in space "settled" solely or primarily by robots is clearly very far from what most space development enthusiasts envision. Their intuition is that the successful development of space requires that large numbers of humans work and live in space. That intuition is supported by something we know about pioneers. They develop economic, political, emotional, and philosophical interests which are different from the interests of the people in their place of origin. A new frontier may produce economic opportunities, demands for self−government, emotional attachment to place, and philosophical belief in the moral value of pioneering as a way of life. People working and living in permanent space settlements are likely to develop reasons for capital investment in space development which have little to do with the profit maximizing decision making of capital lenders and investors on Earth.

Permanent human settlements in space will need human populations large enough to attract new members and to keep their existing members. Settlements with populations too small could be abandoned by their residents with greater ease and greater finality. Settlements with populations too small would generate fewer internal economic transactions and thus less economic activity. Less economic activity might mean that less wealth would be accumulated and that the settlement would be more dependent on inputs from Earth. Of course, constructing the infrastructure and amenities needed to attract and keep a larger population will require large capital investments.

Warren Salomon (1996:243−259) presents a tongue in cheek but still interesting proposal for the political economy of very large space development projects in their most daunting form: the prospects for developing interstellar trade conducted using spacecraft moving at less than the speed of light. While anticipating that governments will finance the initial voyages to stars with habitable planets, Salomon speculates that subsequent interstellar voyages will be paying propositions because they would transport goods paid for with interstellar letters of credit beamed as "lasergrams" between star systems as well as investors busy exploiting relativistic time dilation to build wealth through compound interest on their investments in different solar systems. These investors would be joined on the outward bound leg of the interstellar journey by the immigrant poor whose fares would be paid by governments interested in reducing welfare rolls. Proprietary colonies would provide a possible mechanism for financing the initial colonization of the destination planets. Three problems with Solomon's proposal are apparent. First, positing that governments will pay for the initial round of interstellar voyages of discovery assumes what ought to be explained. Why should governments on Earth bother to go to the expense of sending people in spacecraft when sending robotic probes will probably do that job less expensively? Persuading governments to pay for interstellar robot probes which might take decades or centuries to return data will be an impressive undertaking by itself. Second, and crucially, it is improbable that the total value of goods transported across interstellar distances would ever be sufficient for the kind of lasergram banking that Salomon proposes. Our current electronic banking system makes sense only because the money being moved electronically ultimately represents exchange value−the ability to purchase some tangible commodity. The time and energy expenditure involved in moving tangible goods between stars would make that improbable. Autarky rather than interdependence is thus a more reasonable expectation for the economies of solar systems and that probably spells doom for proprietary interstellar colonies. Investors want to be able to move their money where they can spend it or where it will earn the highest rate of return. Why own part of a distant proprietary colony from which one can derive no benefit? [3] Third, future advances in biomedical research may present investors with the means here on earth, suspended animation and longer lives, to exploit compound interest over long periods of time without the dangers of traveling between the stars. Means that are either more humanitarian or less humanitarian, and in either case less expensive, than subsidizing immigration to the stars are likely to be preferred policies of governments when dealing with the poor of the next centuries.

**Why Capitalization is the Principle Problem**

Attempting to persuade investors to risk enough capital to finance the construction of a very large space development project would run up against the same capitalization problems now faced by entrepreneurs seeking capital for ordinary space development projects such as launching communication satellites. Investors and lenders seek to maximize economic returns from capital while avoiding risk. The cost of capital is higher for riskier investments. Persuading investors and lenders to part with their capital requires making credible promises that they will receive better returns than they would have received from making alternative investments during the same time period commensurate with risk. While investors often accept higher levels of risk than do lenders, they do so in the expectation of even better returns. Ordinary space development projects confront not only the risks that their businesses might not make money and that the technology might fail to work as projected, but also that they might not attract enough investment because the necessary capital investment is too "chunky." In other words, the "up−front" capital investment necessary to proceed with even an ordinary space development project tends to be relatively large and to take a relatively long time period before generating cash flows or profits (Simonoff 1997: 73−74; U.S. Department of Commerce 1990: 55−60; McLucas 1991). It is important for the subsequent discussion that the reader note that many investors typically understand the phrase "long time period" to mean "5 years" (Marshall and Bansal 1992: 99−100).

If attracting capital for projects using proven technologies like communications satellites remains difficult, imagine the difficulty of attracting sufficient capital to construct a mining facility on the Moon or terraforming Mars or Venus. Such projects are extraordinarily "chunky" in that they would require massive amounts of capital to be invested "up front" and would take long or very long time periods before generating economic returns. The total amount of capital available for investment in anything is finite and the private investors and lenders who control most of it normally enjoy multiple investment opportunities. Investors and lenders

are typically reluctant to concentrate their risks on a single project. Investors and lenders are also reluctant to lock up their capital in very long time investments or loans because this increases their opportunity costs.

Consider the proposal for terraforming Mars by manufacturing halocarbon gases to cause a greenhouse warming of the planet (Zubrin and Wagner 1996: 260−268). Perfluorocarbons and sulfur hexafluoride are popular candidate gases because they dissociate slowly under ultraviolet radiation (Fogg 1995: 237). Warming would cause the Martian regolith to release its carbon dioxide and genetically engineered plants would release oxygen from carbon dioxide. After 900 years of greenhouse warming, atmospheric pressure would increase to 600 millibars, which is slightly less than the average atmospheric pressure in Denver or the normal cabin pressure in international carriers. Humans who are acclimated to low atmospheric pressure might take up residence on Mars within 700 years (Fogg 1995: 106; Zubrin and Wagner 1997: 262). The price for this proposal is described as "several hundred billion dollars" (Zubrin and Wagner 1997: 265).

A "back of the envelope" calculation involving six assumptions drawn from the proposal outlined above will illustrate the capitalization problem. Assume the "up front" capital investment needed for the project is $200 billion and that this sum could be borrowed from private lenders at 5% interest compounded annually for 700 years. Assume there would be no inflation and no deflation during this 700 years. Assume the project would produce a breathable atmosphere in 700 years. Finally, assume the project would generate all of its cash flows from the sale of Martian real estate and lenders would be willing to wait 700 years for payment. Before any profit would be realized, real estate sales would have to produce a staggering $1.36 \times 10^{15}$ billion dollars to pay off the debt accumulated over 700 years. Assuming further that seas cover only 10% of the surface of Mars, the dry remaining 90% of Martian surface area which might be sold would total $1.3 \times 10^{13}$ meters$^2$ (Carr 1996: 6; Fogg 1995: 310). Thus an average square meter of Martian real estate would have to fetch 1,046 billion dollars to pay off the creditors. While we may hope for a vast, general increase in wealth over the next 700 years, this would still appear to make Martian real estate awfully pricey.

Rather than accumulate this mind boggling burden of debt to finance its halocarbon plants, promoters might export goods and services from Mars to Earth worth the 30 billion dollars in annual interest payments. That, however, would require additional large capital investments to for industries to produce the goods and services to be exported. Certainly extreme caution is in order whenever the proposed solution to a debt problem involves taking on more debt. Nor could there be any guarantee that these additional large capital investments would result in profitable business ventures. To make matters worse, the number and size of business ventures which might be operated more profitably from Mars than from anywhere on Earth may be very small.

If the idea of borrowing massive amounts of capital from commercial banks for 700 years beggars the imagination, then consider the chances of attracting enough capital for the same project by offering equity to venture capitalists or the managers of major public corporations. The time period between the initial investment and the economic payoff is far longer than that contemplated in any business plan. Indeed, it is telling that the short list of formal organizations which have operated continuously for the last 700 years or more does not include a single business enterprise. Instead, all of the organizations are either governmental or religious bodies. If "operated continuously" is taken to mean absolutely no interruptions in operation, then the governmental bodies fall out and the list narrows to include a surprisingly small number of religious bodies.

The lesson is that, *ceteris paribus*, very large space development projects are probably too unattractive as investments for private investors and lenders. For the current generation of space development enthusiasts, indoctrinated in the principles of neo−classical or free market economics popularized in the Reagan years, this is a very disquieting conclusion. Many exhibit a fierce libertarianism. They share an ideological conviction that private enterprise and unfettered markets are capable of overcoming almost any technological or economic obstacle.[4] Government appears less as the driving force for space exploration than as the political and bureaucratic obstacle to technological innovation and the commercial development of space. Given the disappointing performance of NASA in the 1970's and 1980's, convictions such as these are hardly surprising (Kay 1995:161−171). Space development enthusiasts watched as government funding for NASA

programs declined steadily while important opportunities for commercial launch capability and space industrialization in near Earth space were lost. Yet the “lessons” drawn about from the disappointments of the 1970's and 1980's are probably the wrong lessons for space development. Government participation in the economic development of space is essential. Why else would promoters combine libertarian denunciations of the government’s role in space development with political demands for indirect subsidies in the form of tax credits for space commerce and the privatization of public assets in the form of the International Space Station (Lehrer 1999). Complaints about the role of government in space development would be more convincing if private sector efforts in space had produced comparable results. Government space programs can point to records of successfully launching interplanetary probes and spacecraft with human crews. Even after all the excuses have been made, the record of private sector accomplishments in space is unimpressive. Of course, identifying space sector efforts as “private” is somewhat problematic because many employ technology developed with government funds, or employ castoff parts and borrowed facilities from government programs, or anticipate that the government will be their primary buyer.

The fundamental problem in opening any contemporary frontier, whether geographic or technological, is not lack of imagination or will, but lack of capital to finance initial construction which makes the subsequent and typically more profitable economic development possible. Solving this fundamental problem involves using one or more forms of direct or indirect government intervention in the capital market.

When space development enthusiasts describe how permanent human communities might be established in space, they often draw analogies to the European colonization of the Americas and to the “winning” of the western frontiers of the United States and Canada, analogies which are often given a very contemporary libertarian spin. Complex historical processes are offered up as examples of the triumph of individualism and private enterprise.

The unspun truth about European colonization in the Americas, and in Asia and Africa, is that the state played a central role in all colonial enterprises. European colonies often emerged out of trading ventures organized as joint stock companies chartered by the colonizing state and in which the crown invested both its prestige and its capital. Colonial territory was conquered and defended by soldiers and sailors paid either by the colonizing state or the local colonial state. Plantations and mines were often directly owned by the local colonial state. Trading monopolies and tax privileges granted by the colonizing state to the local colonial state were used to attract capital investment. Indeed, conceptual distinctions between public and private economic activity which seem so clear today were much less clear in the heyday of colonialism.

The unspun truth about the “winning” of the western frontiers of the United States and Canada make for even poorer libertarian dramas. Notwithstanding all the hardy pioneers in their covered wagons, the western frontier of the United States was really “won” by the U.S. Army and the construction of the railroads which were capitalized by enormous Federal land grants.[5] Similarly, the western frontier of Canada was “won” by cash grants, subsidies, loans, and the guarantee of bond issues by the Canadian government to finance the construction of the railroads.

A better historical analogy for establishing permanent human communities in space is actually provided by one of the greatest civil engineering project of this century−−the construction of the Panama Canal. As would be true with any very large space development project, constructing the Panama Canal required that tough new engineering and science problems had to be overcome in an unforgiving environment, a labor force had to be imported and supported, and sufficient capital had to be invested despite the fact that private investors could not or would not provide the financing necessary to complete the task. After twenty years of failed efforts by private French firms to dig a canal across the isthmus of Panama and the failure of a private American firm to dig a canal through Nicaragua, it was the United States government that successfully completed the construction of the Panama Canal.[6] Financing by the United States government and management by U.S. Army engineers succeeded where the private sector failed. Engineering problems more difficult than those which were encountered in constructing the Suez Canal were solved, yellow fever and malaria were effectively controlled, a new sovereign nation−state was created, and world commerce was facilitated.[7] Not bad for government work.

Very large space development projects should be understood as massive public works projects constructed to provide the environmental and economic requirements for permanent human settlement beyond Earth. If these new human settlements are to attract and keep the kind of people needed, then they will have to be livable communities. Making them livable will provide plenty of scope for private firms to profit from the provision of goods and services. But private firms will not do the heavy lifting necessary to finance the construction of the very large space project within which and around which such a livable community may grow.

**What is to be Done**

The crucial difference between governments and private firms is not that governments are better at managing very large projects, but that they are better at financing very large projects. Sovereign national governments may print currency, sell or mortgage public assets, or levy taxes on property and persons within their territories. Governments may borrow from private lenders or other governments against future tax revenues or guarantee payment of loans made between private lenders and private borrowers against future tax revenues. Governments may issue bonds backed by nothing more than their promise to redeem at face value. Governments are not liquidated when they are bankrupt. Governments may offer a wide range of direct and indirect subsidies as incentives for private investment. In effect, governments exercise the kind of power over the movements of money that is tailor made for expensive development projects. Given the problems inherent in trying to finance very large space projects with entirely private borrowing or investment, it makes sense to look to government for direct and indirect assistance.

If the construction of any very large space development project is to be attempted in the next century, three objectives or tasks involving the use of government will have to be achieved. The first objective would be to persuade a sponsoring space−faring power or powers with the economic wherewithal, presumably the United States, European Union, or Japan, to absorb as much of the initial costs of the project, including exploration, technology development, planning, and infrastructure construction, as politically possible. The old fashioned term “power” is used here because the European Union is not a nation−state. It is not necessary that the power make a firm commitment to complete the entire project so long as it pays for some of the up front costs. Offsetting any of the costs at the beginning of the project would be valuable. However, project promoters should be able to exploit sunk costs arguments to appeal for additional assistance from the sponsoring power. If the sponsoring power could be persuaded to continue funding the project until completion through grants or low interest loans then the capitalization barrier is breached. Given the enormous sums of capital involved in the proposals for most very large space development projects, full funding from the sponsoring power seems unlikely. Yet each additional contribution would not only reduce the total amount of capital borrowing but would help to persuade private lenders that the project is credit worthy (Sweetman 1999:77).

Persuading a space faring power to support any part of a very large space development project will require mobilization of elite and mass public support. The historical experience of late 19 $^{th}$ century naval arms races and exploration (and colonialism) in Africa, of early 20$^{th}$ century polar exploration, and of late 20$^{th}$ century Cold War nuclear weapons race and space exploration all suggest that international competition offers a far better tool for mobilizing public support than international cooperation. At least in the short term, effective political advertizing and lobbying should be capable of emotionally engaging masses and elites in international competition over the further exploration and control of territory in space. International competition need not be military in nature to fire the public imagination. International competition in civilian endeavors such as Olympic sports can also whip up intense public passions, at least over the short term. Good propaganda requires the same elements as melodrama: a hero, a villain, and a simple story line involving struggle between good and evil. A public relations firm would have little difficulty locating all three elements in competition over space. The public relations job would be to convince elites and masses in the United States, the European Union, or Japan that competition for territory in space has erupted and that their team is being left in the dust. Such a neo−jingoist public relations and policy lobbying campaign would need to be coordinated by an interest group capable of keeping the focus of new public interest in space on competition in civilian endeavors.

The second objective is to charter either a “Development Authority,” a semi−sovereign governmental “entity,” or perhaps even a sovereign nation−state. This new government would come into being possessing legal ownership over the territory slated for development, whether it is the Moon, an asteroid, or Mars, which would be expropriated from common ownership. Under Article 11 of the 1979 Moon Treaty, extraterrestrial resources are deemed the “common heritage of mankind.” Thus, at least in principle, everyone on Earth “owns” all extraterrestrial territory. In practice, the treaty may discourage many from attempting to exploit extraterrestrial territory because of the potential for free−riding by other “owners” who might assert a claim for a share of any economic benefits. The rather commonsensical argument that the collective ownership of extraterrestrial territories discourages their economic development would provide political elites with justification for this expropriation, which might take place under cover of some claim that everyone would eventually benefit from economic development. Vesting legal ownership in a new government would free private lenders and investors from some of the legal risk involved in doing business in space. Contracts and titles to property in the extraterrestrial territory would then be enforceable in courts of law. Of course, payment of partial compensation for such an act of celestial squatting might be negotiated after the project has begun to pay off.

The creation of Development Authorities as special purpose governments with authority extending across the territory of several subnational or national governments is an increasingly common response to constructing and managing large public works projects in advanced industrial countries. Thus Harris (1998: 226−227) proposes creation of a Lunar Economic Development Authority, a Mars Economic Development Authority, and an Orbital Economic Development Authority. Each Economic Development Authority would be empowered to issue bonds to generate the capital necessary to finance public−private ventures and to lease industrial sites on the lunar surface. In effect, a special purpose government would be created to carry out the difficult job of capitalizing new ventures beyond the territory of an existing nation−state. Where the government proposed by Harris may fall short of the mark is in the degree to which it may exploit the law making and economic management tools available to government and in the question of sovereignty over extra−terrestrial territories.

While proposals for chartering Development Authorities are appealing as non−threatening and politically acceptable responses to the need for government creation in space, proposals for semi−sovereign governmental “entities” or sovereign nation−states would find fewer takers. Yet these organizations might be better suited to the purpose of developing space frontiers. Now in vogue among international relations scholars as responses to either intractable problems involving legal sovereignty over disputed and marginal territories or difficult international regulatory regime problems, the semi−sovereign governmental “entity” offers a form or organization which permits partial political subordination to one or more nation−states and/or partial economic dependence on one or more nation−states. The essential ambiguity of its political status is one of the attractions of the entity.[8] Creating new sovereign nation−states might seem audacious at first, but it has been a surprisingly common event in this century. Indeed, a majority of the members states in the United Nations came into being in this century as colonial powers handed over formal sovereignty at the stroke of a pen. While all three forms of government would possess the legal right to sell, lease, or mortgage public assets and issue their own bonds, the “entities” and nation−states could produce their own currencies, charter their own state banks, devise their own commercial and tax codes, adjudicate disputes in their own courts, and enforce their own legal decisions.[9] All of these might prove to be useful tools in economic development. The nation−state may have one clear advantage over the other two forms of government. A nation−state should be more difficult to dislodge from the territory in space that had been expropriated from “everyone.” Sovereignty ultimately rests on force and nation−states may use force or the threat of force to make good their claims to sovereignty. Given the sponsorship of a space faring power in the next century, whether the United States, European Union, or Japan, the fact of expropriation of extraterritorial territory by the new government would be difficult to prevent or undo.

The third objective would be to maximize cash flows to pay for borrowing the capital necessary to begin construction. Here the partial political subordination of the new government to one or more space faring powers on Earth would be useful because they could alter their tax laws to encourage investment in the project and guarantee bond issues for the project. Such guarantees are routinely offered by states with international

investment banks for borrowing by states with developing economies, and that borrowing often finances large public works projects. Guaranteeing loans is politically popular because it is essentially cost free so long as the project produces revenues to pay interest. The resulting debt should be large enough that participating investment banks on Earth will participate in domestic political lobbies working to prevent the abandonment of the project should it run into trouble. Contractors and employee unions who benefit from the project constitute additional elements in the political lobby which would useful in helping the project through its inevitable rough patches. As is common with transfers of official development assistance (foreign aid) from donor states to recipient states, the sponsoring power's agreement to guarantee the bond sales might be tied to exclusive contracting for goods and services from firms in the economy of the sponsoring power.

For very large space projects close to the Earth, the new real estate rendered habitable or economically exploitable by the very large space development project would constitute the most valuable public assets which could be sold or leased to raise revenue. Sales of mining rights and profits from public−private joint ventures in mining would probably provide the chief source of cash for projects on the Moon and asteroids but their proximity might permit manufacturing.

Identifying sources of revenue sufficient to pay interest on borrowing for very large space development projects elsewhere is more difficult. Distance and thus higher transportation costs to and from Earth make the prospects for profitable mining ventures on Mars or other bodies in the solar system appear dimmer. Certainly, improved transportation technology might make mining on Mars profitable. If not, however, the proposal to terraform Mars bears a closer resemblance to other proposals which promise economic returns distant in time and space.

Consider, the proposal to build an interstellar spacecraft bound for 47 *Ursae Majoris*. As has been discussed, commerce over interstellar distances is improbable. Sales of mining rights or minerals would not finance the trip. However, a project to build an interstellar generation spacecraft might sell passage to immigrants. The desire to emigrate to new worlds which resemble Earth, or more practically to see one's descendants emigrate to new worlds which resemble Earth, will almost certainly increase as our knowledge about planets orbiting the neighboring stars increases. The problems with realizing these aspirations are that the journeys might last several conventional lifetimes and only a small number of spaces which might be available on an interstellar spacecraft. While promoters might find many applicants who are psychologically and physically fit for the rigors of the voyage, their combined passages are unlikely to be enough to pay for the project. But another source of revenue for the project might come from passages paid not to transport the living bodies of applicants but to pay the passages for their genes. Arguably, human beings have an interest in seeing their genes survive (Dawkins 1976: 103). The dispersal of one's genes among human populations on an Earth like extra−solar planet should increase the chances of their perpetuation. Thus the project might be capitalized by selling passages for frozen eggs, sperm and embryos in produce new generations of humans on the extra−solar planets. Genes would be far less expensive to transport in these forms than as living humans. Of course, this assumes impressive but entirely plausible advances in biomedical technology. If this particular proposal seems peculiar to people living on a crowded planet, it is important to member that frontiers on Earth are characterized by labor shortages and that a frontier on an Earth−like world would suffer a similar labor shortage. Moreover, this particular frontier would probably be characterized by a lack of human genetic diversity and thus the frozen eggs, sperm, and embryos would be valuable. While this kind of genetic colonization sacrifices the emotional ties which normally link different generations, it still presents the opportunity for biological ties to future generations of humans on a new world. To book passage for one's genes on an interstellar spacecraft would be buying the present enjoyment of the prospect of effective generic immortality. This project would also benefit from being able to store frozen genetic "colonists" as it accumulated the capital to pay for the interstellar spaceship.

A somewhat similar mechanism might also be used to pay some of the interest on capital borrowed to finance the terraforming of Mars. Buyers might willing to purchase the right to emigrate to a terraformed Mars seven centuries hence. The alienable right of one person to emigrate would be an intangible property with a real market value if prospective purchasers were confident that their right to the property was legally enforceable. Assuming that the new government owning Mars and overseeing the terraforming process

maintained public trust in its management and in the science and engineering of terraforming, the market value of the right should be expected to increase over time. The problem of winning and keeping trust is related to the longevity of human organizations. While the future may prove otherwise, the past suggests that businesses are likely to be shorter lived than states and religious bodies associated with established state religions. States and religious bodies are capable of drawing upon sustained and intense loyalties which have little to do with the kind of short term material self interest that is privileged in rational business decision making. But more than mere organizational survival would be demanded. For a terraforming project, what would be needed is an organization combining administrative and scientific competence with a commitment to constructing and operating a public works project which would take centuries to complete. Because historical precedents for such an organization are lacking, the default choice is the state. For all their recognized failings, states are sometimes capable of surviving for centuries, inspiring and exploiting non−rational loyalties, and of managing economies and large public works projects. Unless some new long−lived and more technically competent organizational form emerges as an alternative, the state remains the best available choice for these tasks.

**Conclusion**

Completing any very large space development project would probably win humanity a permanent presence in frontiers beyond Earth. New science, new technology, new wealth, and long term species survival might all be achieved with such a project. Winning this new Canaan in the heavens will need the kind of massive "up front" capital investment which it seems only governments are able to supply or to encourage. If the economic development of space is ever to move much beyond visionary pipe dreams and the contemporary timid exploitation of near Earth space, then the nature of the capital investment needed to open the frontiers of space to permanent human settlement and the role of government in meeting that need will have to be acknowledged.

[Editor's Note June, 2002: Reader's may want to consult; Hickman, John, and Everett Dolman. "Resurrecting the Space Age: A State−Centered Commentary on the Outer Space Regime." *Comparative Strategy* " 21 (January−March 2002): 1−20.]

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**Notes**

[1] While more difficult to express in monetary terms, the public relations “cost” involved in the destruction or loss of a robot in space would be less than that associated with the death of a human in space.

[2] Robert Zubrin's (1996:85−94) scenario for the colonization of the outer planets driven by mining and strategic military position encounters the same fundamental barrier.

[3] The requirement that money transferred in electronic banking must ultimately represent real purchasing power might be relaxed for commerce within the Solar System because the time between sending and receiving messages would be relatively brief. Electronic banking might be conducted using entirely automated banks on the Moon in much the same way that money is now moved electronically between banks on Earth. Once again, however, this would provide little impetus toward the permanent human settlement in space.

[4] The excitement among space development enthusiasts generated by the false rumor that Hilton Hotels Corporation intended to construct an orbital or Lunar hotel reveals something of the intensity of these beliefs (Tippit 1999). The fact that Hilton or any other hotel chain has not committed large amounts of capital to such a project may reveal something just as important about space development.

[5] State and municipal government assistance in capitalizing the construction of the railroad and canal systems east of the Mississippi River was also extensive (Johnson 1951: 48−51; 90−96). A surprising number of these railroads were built with capital from sales of government bonds and operated as publicly owned firms.

[6] Note that promoter Ferdinand de Lesseps succeeded in constructing the Suez Canal because the Egyptian state provided half the necessary capital and vast amounts of *corvee* or drafted peasant labor for the project (Marlowe 1964:55−92, 130−141). Yet he failed in Panama largely because he relied upon private investors to capitalize the project (Mack 1974: 355−376).

[7] The objection that the United States acted as an imperial bully in carving Panama out of the flesh of Columbia is entirely true but beside the point. This historical facts are not pretty. Yet contemporary Panamanians do not clamor to make Panama a part of Columbia once again. With endemic political and criminal violence in Columbia and roughly equivalent per capita GNP in Panama and Columbia, the silence of Panamanians on the subject of reunification with Columbia speaks volumes. The Republic of Panama and the Panama Canal are the undeniable "facts on the ground."

[8] Examples include the Palestinian Authority, the European Union, and possibly colonies in which colonial populations exercise broad local self government such the Faeroe Islands, Greenland, New Caledonia, and Puerto Rico. Sovereign micro−states which possess few or atrophied attributes of nation−states such as Andorra, Monaco, San Marino, and the Vatican occupy a position very close to the threshold between "entities" and sovereign nation−states.

[9] As the contemporary debate over dollarization in Argentina suggests, in the future some nation−states may dispense with national currencies as an unnecessary expression of sovereignty.

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