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THE EXPORT ECONOMY OF A MARS SETTLEMENT

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ABSTRACT

The rise of a settlement on Mars, from a nucleus of a permanent exploration outpost, will require a transition from government-backed space agency organization and funding to the creation of a true on-site economy including income from exports to Earth, to fund the imports and continued expansion of a settlement. One ideal form of asset for interplanetary export is intellectual property, which can form the basis of a strategy for rapidly initiated return on investment between the planets.

INTRODUCTION

2004 has seen a dramatic rise in the stated goals of the United States in terms of space exploration. The U.S. adopted as its policy the goals of sending human crews back to the Moon and thereafter to Mars. Although NASA has not yet committed itself to a timetable for putting humans on Mars, engineers have convincingly demonstrated that a dedicated effort could put people on the red planet in under ten years, with further piloted missions at each 26-month launch window, within a budget that is modestly greater than what NASA has recently enjoyed. With these plans apparently in progress, it becomes natural to compare the program of humans on Mars to the NASA missions of the Moon of 1969-1972. Despite the valuable research performed on the six piloted landings on the Moon, the program was limited in its effectiveness by the shortness of the missions; and the overall program was tragically canceled after only six landings, despite a small cost per mission compared to the sunk cost in developing the capabilities for the lunar program, due basically to the fickleness of Congressional funding. In contrast to the Moon, Mars mandates longer missions, by its greater distance and the need to work around launch windows determined by its synodic positions relative to the Earth. Mars also allows longer missions by providing the resources, uniquely among possible target bodies in the Solar System, to allow relatively easy on-site production of fuel, breathable air, and drinkable water, while also providing moderate temperature extremes, useful radiation protection options, and even a day-night cycle close to that of Earth. It may be hoped that initial missions will spend around eighteen months on the planet at a time, taking full advantage of the period from one launch window to the next; and that after several such missions, it will become a relatively feasible jump to go from stays of eighteen months at a time to indefinite sojourns on the planet, to a permanent settlement, with people determined to make Mars their home.

Despite the popular hobby of using a speculative future on Mars as a platform for political utopianism of all stripes, the initial projection of a human presence on Mars will almost certainly require a traditional series of missions by one or several major, government-run space agencies. However, it is almost as certain that such a government-backed program cannot provide the sustained level of interest and funding to set up a permanent community of settlers on Mars.

Instead, private investment and innovation will probably be required, in combination with the technologies and infrastructure already developed with government backing on both planets, to allow the eventual capability of allowing private settlers on Mars. There's no doubt that the technology for settling Mars is within our grasp. Whether Mars can become home to a human settlement then comes down to how it might be financed. Robert Zubrin framed this challenge as follows:

"Can Mars really be colonized? From the technical point of view, there is little doubt that we can eventually do just about anything we want on Mars… But how much can we afford? While the exploration and base-building phases can and probably must be carried out on the basis of government funding, during the settlement phase economics comes to the fore. While a Mars base of even a few hundred people can probably be supported out of pocket by governmental expenditures, a developing Martian society, one that may come to number in the hundreds of thousands, clearly cannot. To be viable, a real Martian civilization must be either completely autarkic (very unlikely until the far future) or be able to produce some kind of export that allows it to pay for the imports it requires." The Case for Mars, p. 218 (emphasis added)

THE ECONOMICS OF SETTLEMENT

A future Mars settlement may rapidly be able to supply itself with its own fuel, oxidizer, water, and air; and in the medium term, with its own basic construction materials and food. However, it would still need to import high-end goods such as computer chips from Earth for a long time. And if a Mars colony is to become a permanent and ever-growing settlement, it must make the leap from a government-financed mission of exploration, to a self-sustaining community. The wealth of a Mars settlement, and its corresponding ability to succeed over time, will depend on its ability to produce goods and services for export to Earth, to acquire currency reserves and achieve a reasonable import/export account balance. As it continues to expand and grow, it will ultimately become capable of reproducing the entire repertoire of Earthbound industrial and technological production. However, that would require a very long period of continued growth and progress, on a scale that is probably impossible without developing exports to Earth as a major component of the economic basis. Even after a Mars settlement fully matures, it will still function more efficiently and be capable of more rapid growth by economic interdependence and trade with Earth.

What can the Mars settlers export? In The Case for Mars, Robert Zubrin lists the following options as exports from a Mars settlement to Earth, Earth orbit, the Moon, or the asteroids:
Consumables, i.e. air, water, fuel, oxidizer;
Food grown on Mars;
Minerals;
Deuterium, as raw material for nuclear fission or fusion reactors;
Real estate and tourism, for those willing to come to Mars; and
Ideas.

Each of these investment options has a different market and a different duration of time before beginning to yield returns on the investment. A strategy for developing an export base should include export industries for the short term, medium, and long term, and in each case should

focus on comparative advantages that a Mars settlement could have over Earthbound producers. Dr. Zubrin showed in The Case for Mars how the lower gravity to overcome at launch can provide Mars with a comparative advantage over Earth in supplying air, water, fuel, and food to other locations in the inner Solar System, including even the Moon, as opposed to lifting these materials to such locations out of the Earth's gravity well; although there will be no advantage in transporting these materials to Earth itself. This assumes the infrastructure is in place, on the Moon and asteroids, that would be able to create demand for such shipments. This could take the form of supplying telescopes, communications assets, or outposts, in the vicinity of the Earth or on the Moon, or temporary maintenance missions to any of these assets. For example, there are several expensive unmanned assets currently operating in the vicinity of Earth but far away from low-Earth orbit, that could be reached with lower delta-V propulsion requirements and therefore more cheaply from Mars than from Earth. These include the Wilkinson Microwave Anisotropy Probe (WMAP), which operates on the far side of the Moon from Earth; and the Spitzer Space Telescope, which trails behind the Earth in its orbit about the Sun. Maintenance missions or the raw materials needed by such missions might be launched more cheaply from Mars than from Earth. Eventually, Mars could also include in such exports not only consumable raw materials, but also food and simple manufactured items, such as fuel tanks and structural components. However, developing the infrastructure to enable Mars-based provisions to supply such assets as these, and the increase in such assets to create further demand for such supplies, will both require time. Exporting fuel, water and air will therefore probably not provide significant returns on investments in Mars-based assets until the medium to long term.

High-value minerals might profitably be sent from Mars to Earth itself, although doing so in significant quantities would require a significant infrastructure for transporting such materials to the Earth's surface effectively and safely. These demands would probably push the return on investment from minerals shipments from Mars to Earth to the medium to long term. Deuterium for nuclear power has a mass-to-commercial-value ratio that should make it more easily profitable to ship back to Earth in small quantities. However, its effective collection and refinement on Mars would still require a substantial infrastructure on the red planet, pushing the return on investment on this option also out to the medium to long term.

Tourism and real estate, while not exports, still involve transfers of services and assets to people from Earth who pay Earthbound currencies into the Mars economy in return. Offering tourism or other services to temporary visitors and real estate and other Mars-based assets to permanent occupants, including scientific bases, companies, and private individuals, will also have their growth constrained by the need to develop Mars-based infrastructure, and therefore will also not provide returns on investments until the medium to long term.

Finally: ideas, in the form of intellectual property assets that can be licensed between the planets, have unique properties that make them a primary option for aggressive return on investment beginning in the very near term. As Dr. Zubrin said,

EXPORTING IDEAS

"Ideas may be another possible export for Martian colonists. …the conditions of extreme labor shortage combined with a technological culture will tend to drive Martian ingenuity to produce

wave after wave of invention in energy production, automation and robotics, biotechnology, and other areas. These inventions, licensed on Earth, could finance Mars even as they revolutionize and advance terrestrial living standards…" The Case for Mars, p. 225.

Ideas that are licensable on Earth, and thereby can serve as revenue-bearing exports, will take the recognized forms of intellectual property, such as patents, trademarks and copyrights. Intellectual property is unique among potential exports in that it does not suffer from the one great comparative disadvantage of economic products of Mars, that of separation from Earth, since intellectual property can be comprised in massless signals that are transmitted at the speed of light. In addition, returns on investments in copyrights and trademarks can be immediate, so that returns on investments can begin to flow right from the start. Mars also provides additional comparative advantages for exporting intellectual property, as follows.

As one example, Mars provides a unique and awesome new platform for copyrightable visual works, both of itself and as a dramatic environment for the humans living there. Mars and the people living there could be the subject of documentaries, photography, or even reality shows. Copyrighted still images and video/movie footage can be beamed to Earth cheaply. Earthbound crews can work with Mars dwellers to produce and edit final products, but the people on Mars will have rights to creative works they produce or to which they contribute, and avenues of compensation will be open from Earth to the people on Mars. Moreover, such copyrightable materials can be transmitted from day one of a voyage to Mars, and can continue earning revenue cheaply and indefinitely.

As another example, promoting trademarks from Mars through endorsements and advertisements is another cheap export that can operate from day one of a voyage to Mars. There will be a tremendous sense of wonder attached to the early human presence on Mars, which will translate into an incomparable cachet and prestige associated with such a mission. At the very least, the manufacturers of the assets used by the Martian residents will recognize the incalculable value of having footage beamed back to Earth of their products, adorned with their trademarks, being relied on by the early Mars settlers. Even simple naming rights might become a significant source of revenue. The Ansari family of Texas reportedly paid a sum in the millions of dollars just to change the name of the X Prize to the Ansari X Prize. A great potential will exist for revenue through trademark licensing and related endorsement contracts and advertising.

How much revenue is available due to copyright-protected material? The top-grossing documentary has earned over $100 million domestically. The reality TV show Survivor is reported to have made $100 million in one season, due not only to the copyrighted show but also to several trademark licenses for product placement within the program. Even still images could contribute revenue streams; a benchmark for an analogous collection of Mars photographs might be the high-end exploration photography book Antarctica: Explorer Series Volume I, by photographers Pat and Rosemarie Keough, which has sold briskly for $3,000 per copy.

If documentaries, reality shows, still images, and trademark licensing and advertising and endorsement rights from Mars-based content are comparable to successful examples of these revenue sources on Earth, this could mean in the range of a quarter of a billion to a few billion dollars per year for a moderately aggressive, well-managed licensing effort. This would not

likely fund a Mars settlement by itself, but neither is it anything to sneeze at; it could make a substantial contribution to the economy of a Mars settlement. As a revenue source, copyright and trademark licensing also has the great advantage that it can begin yielding revenue immediately. On the other hand, it has the disadvantage that it may actually hit its maximum value very early and decrease in income potential over time, as the novelty of people on Mars, and the planet itself, wears off. Yet, with strong creative direction and licensing management, copyright and trademark licensing have the potential to continue providing a significant component of Martian revenue indefinitely.

Which raises an important caveat on copyright and trademark licensing as a revenue source. They will never earn more than the average IMAX movie if produced by a NASA committee. We need the finest possible cameras on Mars, with transmission bandwidth to match, strong creative minds contributing to the production of content. Documentaries or reality-type programs of the Mars settlers will succeed as far as they capture the real human drama of people struggling to succeed on another planet.

PATENTS

Aside from licensing copyrightable works, trademarks, and endorsement and advertising contracts, intellectual property licensing from Mars could also be based on patents. Patent licensing has an even greater potential for producing revenue for the Mars settlement. Although it would not begin to yield revenue immediately, it has a greater potential to produce more and more licensing revenue from Earth to Mars as time goes on. It also requires nothing more than transmission signals to be sent between the planets, and so enjoys the same advantage over other investment options; and it also could be based on unique advantages enjoyed only by people on Mars.

Patent licensing can form a quite substantial form of income, offering excellent prospects for long-term revenue growth. The patent licensing revenues of U.S. businesses grew from $15 billion in 1990 to $115 billion in 1999, and to a projected $180 billion in 2004. IBM alone has generated annual revenue of $1.3 billion from licensing. Rambus, a company focused on coming up with new inventions and licensing the patents to those inventions as its main revenue source, has had about a $2.5 billion market capitalization in 2004 with only about 200 employees, no inventory, and no manufacturing capability. This may be an ideal basis of comparison for a similar project at a Mars settlement, where a few hundred clever and highly trained professionals might be similarly productive in producing new inventions, and would be equally capable of securing patents on those inventions and licensing those patents, by working with Earthbound patent attorneys and managers. If such a group on Mars were able to raise a similar market capitalization in the low billions, let alone the actual revenues from the licensing deals, this could make a significant contribution to the economy of the Mars settlement.

Mars settlers would presumably have a lot to do other than work on new inventions. On the other hand, they would also enjoy some unique comparative advantages, a few examples of which follow.

First of all, as a team of very selectively chosen engineers and scientists immersed in a difficult environment, where labor is at a premium and their lives closely depend on a wide variety of ongoing engineering work, the Mars settlers will have profound new motivation, a factor not to be underestimated, to invent labor-saving or life-saving devices and innovations. Making technical innovations would be a way of life on an alien planet, rather than merely a job, in a way that must extend further than it ever could on Earth, no matter the level of devotion to one's job. On the other hand, you could always keep these inventors on Earth and offer them other incentives, perhaps not as effective, but a lot cheaper.

There is also the possibility to create an artificial comparative advantage, which could be very effective. The U.S. government, or any other government, either together in a treaty or by themselves, could simply offer a longer patent term for inventions made on Mars.

A U.S. patent is currently enforceable from the date it is issued by the U.S. Patent and Trademark Office, until 20 years after the day on which the inventor(s) filed the patent application. Instead, the U.S. could provide for, say, a 30 or 40 year term for patents based on inventions that were invented on Mars. This would offer a tremendous new advantage to any such inventors.

How much would such a longer patent term be worth to a patentee? How much revenue would it add to the Mars export account balance? For the industry most dependent on patent rights for its revenue, the pharmaceutical industry, each year under patent for a single successful drug can make a difference of hundreds of millions or billions of dollars in revenue per year. Suddenly, every prolific inventor is going to have a strong incentive to go to Mars, and their employers will have a strong incentive to send them there. The potential value of the extra patent term, and an approximate measure of the added income to a Mars settlement, might therefore be in the billions of dollars, for a single patent.

Serious proposals have been discussed, and floated in the U.S. Congress, for offering large incentive prizes for accomplishing any of several milestones in off-Earth exploration. Such a prize has been offered and awarded in the private sector, in the form of the Ansari X-Prize. While this idea remains valuable, there are decisive advantages in extending the patent term for inventions conceived on Mars as an alternative. For one thing, the system is self-guiding: whereas the prizes considered by Congress would have their amounts for various milestones fixed by a political committee, the value of a patent is determined by the market. As another virtue, an extended patent term would not cost the government any money, whereas a bounty prize commits the government itself or other offeror to cough up cash. Which will be easier to convince the government to do? Which one would you rather rely on as a basis for present investment?

What about the balance of interests behind a patent? Governments grant patents to encourage the development of new inventions, and the financial security of looking forward to enforceably exclusive use of the invention for the term of the patent. Without such a policy, much of the investment that fuels technological progress simply would not be possible. On the other hand, a patent involves a compromise, as governments remove from their public the right to practice the new inventions of others until after a patent expires. This compromise is justified because the

public also wouldn't be able to practice the invention if it were never there in the first place, or at least would not be there until much later, if the patent system did not exist. However, the public receives a detailed knowledge of how the invention works, from the patent document, and receives the right to practice the invention freely after the patent expires. The patentee must give up any chance for further exclusive rights after the patent expires.

EXTENDED TERM PATENTS

A new patent with an extended term might disrupt this balance, by removing for longer still the rights of the public to practice an invention freely. However, this would still be balanced, by a dual interest in promoting the settlement of Mars as well as promoting inventions. Promoting the settlement of Mars would help accomplish a similar goal to the original goal of the patent system: to increase invention and technological progress, and by doing so, to promote the economic growth of the nation. Combining the two goals into a single program with a differential patent term for inventions developed on Mars makes sense.

Does the government have the authority to make such a longer patent term? It sure does. It has changed the term in the past: it used to be 17 years from the date of issue, rather than 20 years from the date of application. Another recent innovation in the duration of patent terms provided for an extension of up to five years on the patent term, to compensate for lengthy review by the Food and Drug Administration in certain cases. Finally, in the recent case of Eldred v. Ashcroft, 537 U.S. 186 (2003), in which the plaintiff challenged Congress's retroactive extension of the copyright term by 20 years, the U.S. Supreme Court said the Constitution gave unusually broad authority to Congress to legislate for copyrights as it pleases. The same constitutional mandate, in Article 1, Section 8, Clause 8, applies equally to patents as well as copyrights.

If an extended patent term is offered for inventions developed or conceived on Mars, why not broaden the range where inventors can take advantage of this change, for instance to include inventions conceived in Earth orbit or on the Moon? A crucial distinction must be applied, though, to such nearby locales. It would be too iffy about when the invention was conceived, for astronauts who might be away only for weeks or days at a time. Receiving the extra-special term should only be allowed when there is undoubted proof that the invention was conceived in the inventor's mind while she or he was away from Earth - such as on the necessarily long stay on Mars. A trip to Mars, with technology foreseeable in the near future, involves a round trip of at least a year and probably significantly more. This period of time is long compared with the time typically spent on conceiving a new invention, so it is workable for applying a separate class of patent privilege. Voyages to other bodies in the Solar System would be similarly long, and as a category, are cleanly separated in their required duration from trips in the local neighborhood of the Earth.

An extended patent term would be a simple and elegant mechanism for promoting at least long-term visits or assignments, and perhaps settlement, on Mars by well-qualified settlers. Aside from such an artificially created stimulus, there is another, potentially very great, inherent comparative advantage that Mars explorers and settlers would have in patent licensing: unique discoveries that could inspire invention, potentially including the discovery and investigation of past or present life on Mars.

THE DISCOVERY OF OTHER LIFE FORMS

If we discover new life forms on Mars, it will be one of the handful of greatest discoveries in the history of science. It will also raise the possibility of leading to new inventions, thereby opening a dramatic new comparative advantage for the export economy of Mars. A discovery itself, of something previously existing in nature, can't be patented? However, the discovery of something in nature can often inspire new inventions that would not have been invented otherwise. This may include, for example:
a purified form of the thing discovered
a method of making the thing discovered
a modified form of the thing discovered

As a specific example, U.S. patent number 6,448,381 is for purified forms of DNA from "bovine uterus and human placenta" that encodes heparin binding growth factor. The discovery and investigation of the gene, which exist naturally, inspired the inventors to figure out how to produce purified forms of the gene, which constitute a patentable invention.

Even a living thing can be patented, in the U.S. at least, though not in many other nations, when it meets the other criteria for a patent, such as when it is produced by genetic engineering, and did not previously exist in nature. This was established by the U.S. Supreme Court in the case of Diamond v. Chakrabarty, 447 U.S. 303 (1980). Ananda Chakrabarty, a scientist with General Electric, applied for a patent for a new microbe he invented, using genetic engineering, that liked to eat (and thereby clean up) hydrocarbon pollution. An example of the patent claims from Chakrabarty's patent: "A Pseudomonas bacterium containing at least two plasmids, each providing a separate hydrocarbon degradative pathway." Sidney Diamond, the commissioner of the Patent Office, argued that a living thing could not be patented. The Supreme Court held that there was no such condition for patentability in the U.S. patent law. This has remained good precedent in U.S. patent law.

A persuasive amicus brief was filed in the Chakrabarty case by the Regents of the University of California. They argued that "Economic incentives for research conducted by Amici will be reduced by a rule excluding all living organisms from patentability. Such a rule will adversely affect commercial development of the fruits of the research, and will negatively affect the competitive stance of American industry in the competitive field of biotechnology."

How much revenue might be generated by patents inspired by Mars life forms? Perhaps a useful guide is to compare to anticipated revenue of the Earthbound biotech industry so far, as reflected in investment made corresponding to that anticipated revenue. In the past 25 years, roughly $40 billion has been invested into biotech commercialization. This is a better gauge than revenue so far from the biotech industry, both because those revenues are anticipated only after many years of research and development and have not yet matured, and because the Mars settlers also will not have to wait for investments to mature – they only need to demonstrate revenue potential sufficient to attract investment, as the Earthbound biotech industry has done.

What would Mars microbes and their DNA do, that would have commercial value? It would be presumptuous to answer that. But to be make the attempt anyway, we could say two things:

1. We can try to anticipate what functions would have been selected for in the Mars microbes by natural selection. Who knows what completely different physiological mechanisms Mars microbes might have developed to compensate for the extreme aridity, temperature swings, ultraviolet, and other harsh conditions of their evolutionary history – or how those might be adapted to modify Earthbound crops for better growth under tougher conditions, to clean up pollution, to produce new medicines, or for some other purpose.

2. If panspermia has functioned so that the Mars microbes share a last common ancestor with Earth life forms, both the remaining similarities and the differences of its Earth-related DNA might shed a new window on and inspire new areas of understanding the genomes of Earthbound species, leading to new applications of which we might not otherwise conceive.

CONCLUSIONS

Whatever the details, there is little doubt that if present life forms, or well-preserved remnants of past life forms, are discovered on Mars, they will provide a whole new field of study, among the benefits of which will be a plethora of patents.

And even before an extended patent term is passed or Mars life is discovered, patent licensing has the potential to yield billions of dollars of revenue to Mars settlers per year, without them having to send a single rocket anywhere. Trademark and copyright licensing can form an important component of Mars settlement financing from the very beginning; patent licensing can begin to form a major component of Mars settlement financing, probably beginning in the short to medium term, potentially beginning within the first few years of a human presence on Mars.