Beyond the Satellites:

Stimulating a New Wave of Commercial Space Development

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I. INTRODUCTION

"With you I trust, that the discoveries we have made, will not long remain unimproved; and that the same sentiment which dictated to our government, an investigation into the resources so liberally bestowed by nature on this fair portion of the globe, will prompt them to avail themselves of those resources, to promote the cause of liberty and the honour of America."

--Merriwether Lewis, 1806

Nearly 200 years ago, Lewis and Clark took the first steps into a new frontier. These two explorers opened up an area that has since become a home to millions, a thriving and essential sector of the U.S. economy, and an integral part of America itself.

Despite the success of the Lewis and Clark expedition, had it not been for the farmers, bankers and entrepreneurs who followed them, the expedition would have ultimately ended in failure. Exploration is never an easy task. However, it is in the taming, settling and development of a new frontier that the greatest obstacles are faced and the greatest rewards are achieved.

Two hundred years after the Lewis and Clark expedition America continues to explore new frontiers. The manned space program of the late twentieth century has opened the door to almost limitless possibilities. Yet, despite the brave efforts and sacrifice of astronauts both American and Russian, the U.S. and other nations have failed to capitalize on the hard earned achievements of the national space programs. As was the case 200 years ago, exploring the frontier was relatively simple when compared with the difficulties of surviving and profiting in a new and hostile environment.

Unlike past space endeavors, settling and developing space cannot be accomplished by government programs and personnel. The U.S. Government could fund and order Lewis and Clark to explore the West, but it could not pay or force pioneers to settle the region. Governments do have an important role to play in creating an environment conducive to space development, but

it is the pioneering entrepreneurs, not the soldiers or bureaucrats, who can tame and colonize a new frontier.

The task will not be easy, but the benefits, both to the U.S. and the global economy, will be unprecedented. The commercialization of the Internet, a field which also was once the exclusive domain of the Government, has resulted in the birth of entire new industries and brought with it extraordinary prosperity. The private, commercial development of space promises to do this and much more.

However, realizing this opportunity will require a change in direction. The Government, not the private sector, currently controls, owns and oversees the domestic manned space launch and space station industry. For true development to occur, private enterprises must be given the ability to own and operate space stations and other advanced space assets.

It has been difficult for the private aerospace community and even academia to address this issue, since most if not all aerospace entities are financially beholden in some fashion to the U.S. Government. It is never a good policy for a corporation or any institution to criticize the source of its funding. There are positive roles for the Government to play in space development. However, it is readily apparent that a significant change in NASA's current outlook must take place before the true promise of commercial space development can be realized.

This Report will begin by describing the tremendous benefits of private, commercial space development. Many of these applications and opportunities have received little public attention. Although there are numerous lucrative and substantial opportunities that the commercial use of space will generate, the Report focuses on what are likely to be the first four areas of significant development: microgravity manufacturing, microgravity experimentation, space-based power generation and space tourism. After describing these opportunities and their impact on the U.S. economy, the Report will then examine how the U.S.'s current space policy and NASA's actions are in need of adjustment to accommodate the future ownership and development of space-based assets by the private sector. The Report concludes by articulating specific policy solutions that would result in the Government supporting rather than inhibiting the development of a privately owned commercial space industry.

II. THE FUTURE AND POTENTIAL OF A PRIVATELY OWNED COMMERCIAL SPACE INDUSTRY

A. Background

History has shown that technology and economic activity are inextricably linked. From the industrial revolution to the electronic revolution, a society's technological innovations and capabilities have fueled the growth of commerce. The most recent example of this is the economic impact of the Internet. The prosperity that America has enjoyed over the last decade is largely a result of the development of e-commerce and the Internet/Information Technology ("IT") field.[1] This prosperity can be perpetuated by continuing to develop new technologies and capitalizing on the opportunities that they present.

Like the Internet, the private, commercial development of space represents a unique and extraordinary economic opportunity. Moreover, as was the case during the initial introduction of the Internet, the commercial benefits of private space development and their tremendous scope are generally unknown and unanticipated. What follows is a brief description of only a few of the promising new industries that a privately owned commercial space industry will create.

B. Microgravity Manufacturing

Microgravity[2] manufacturing capability for both organic and inorganic substances is the next critical step in humanity's technological evolution. In the fields of material science, power generation, telecommunications, medicine and computing, microgravity manufacturing opens up

[1] In 1996, total spending on IT was approximately $500 billion in the U.S. and $1 trillion worldwide. Strassman, Paul A., Method Software, Scientific American, 7/97. In 1998 the Internet alone generated $301 billion in revenue. Warner, Margaret, Economics.com, July 7,1999.

[2] Microgravity is the condition of near weightlessness that occurs when an object is removed from Earth s gravitational pull. Microgravity News and Research, August 17, 2000, www.microgravity.com.

new possibilities that would be impossible to achieve with ground-based systems. Scientists and engineers are only now beginning to understand the overwhelming implications of microgravity manufacturing to almost every industrial field. Below is a discussion of a brief sampling of commercial microgravity applications that are being explored today.

1. Zeolites

One of the most immediate and promising products of microgravity research are improved zeolite crystals. Zeolites,[3] which have been described as a substance that is "as hard as a rock but works like a sponge" have a rigid crystalline structure with a network of interconnected tunnels and cages, similar to a honeycomb.[4] Enhanced zeolites promise to first drastically reduce the nation's dependency on foreign oil supplies and soon after replace petroleum with hydrogen as America's primary fuel source.[5]

Virtually all of the world's gasoline is produced by utilizing zeolite crystals.[6] Zeolites act as catalysts reducing complex hydrocarbons like crude oil to refined products such as gasoline and heating oil.[7] Improved zeolite crystals will allow more gasoline to be produced from each barrel of oil, making the entire industry more efficient.[8] Even a small increase in efficiency can have a significant economic impact. For example, ***a one percent increase in the amount of gasoline generated from a barrel of oil would result in a $400 million reduction in the balance of payment between America and foreign oil producers.***[9]

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[3] The name "zeolite" comes from the Greek words "zeo" (to boil) and lithos (stone), literally meaning "the rock that boils". "It Stores, It Filters, It's...", Space Product Development News, Marshall Space Flight Center, NASA, July 10, 2000, http://spd.nasa.gov/news/zeolite.html.

[4] Id.

[5] "Space Research May Help Reduce Dependency on Petroleum and 'Leapfrog' to Fuel of the Future", NASA Marshall Space Flight Center Press Release, August 14, 2000.

[6] Id.

[7] "Growing Zeolites: Crystalline Keys to Cleaner, Cheaper Energy", Environment News Service, August 15, 2000.

[8] "Space Research May Help Reduce Dependency on Petroleum and 'Leapfrog' to Fuel of the Future", NASA Marshall Space Flight Center.

[9] "Space Research May Help Reduce Gas Dependency", SpaceDaily, August 14, 2000. "Currently, zeolites represent a $2 billion-dollar-a-year-market, but development of zeolite technology could increase that figure dramatically. Since chemical processing is a trillion-dollar industry worldwide, any improvement in the understanding of zeolite materials could have an enormous economic impact. Perhaps more importantly, zeolites could be used in even more ways to make Industry safer and less damaging to the environment." "It Stores, It Filters, It's...", Space Product Development News, Marshall Space Flight Center.

However, enhanced zeolite crystals cannot be developed without utilizing the microgravity environment of space. Zeolite crystals produced on Earth are far too small for the necessary research and development to take place. The size of terrestrially grown zeolite crystals are approximately two to eight microns, which is roughly the size of a microscopic bacteria.[10] To better define their crystalline structure and develop more effective zeolites, crystals must be grown that are 200 to 1,000 times larger than their normal terrestrial size.[11] According to Dr. Albert Sacco Jr., Director of the Center for Advanced Microgravity Materials Processing, the microgravity environment holds the key to larger zeolite development.

> "Data from space experiments are helping us to grow better zeolite crystals on Earth .... In microgravity, materials come together more slowly, allowing zeolite crystals to form larger and with better order - these larger, more perfectly formed space-grown crystals tell us more about the way the crystal is made and how it works."[12]

Beyond increasing the efficiency of gasoline production, zeolites may someday eliminate America's dependence on oil entirely. ***Hydrogen, the most abundant element in the Universe, has the potential to become an inexpensive, pollution-free, infinitely renewable source of energy.***[13] However, current storage technologies are still too primitive to fully utilize hydrogen as the nation's primary fuel source. Again, enhanced zeolites hold the key to developing this revolutionary technology.

> "Zeolites can store quite a bit of hydrogen, but we need to find out how to store enough hydrogen so that it can be used in a car fuel tank at normal operating temperatures and pressures - one way to do this would be to make zeolites or zeo-type materials that can store hydrogen much like a liquid in a bottle. If we can find a way to store hydrogen safely and inexpensively, in 10 to 15 years, you'll see America turning from gasoline to hydrogen as the main fuel source."[14]

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[10] "Space Research May Help Reduce Dependency on Petroleum and 'Leapfrog' to Fuel of the Future", NASA Marshall Space Flight Center Press Release.

[11] Id.

[12] Dr. Albert Sacco, Id.

[13] "It Stores, It Filters, It's...", Space Product Development News, Marshall Space Flight Center.

[14] Dr. Albert Sacco, "Space Research May Help Reduce Dependency on Petroleum and 'Leapfrog' to Fuel of the Future", Marshall Space Flight Center Press Release.

The ability to utilize hydrogen as a primary fuel source is indicative of the technological evolution that microgravity manufacturing capability will engender. Dr. Sacco describes hydrogen fuel as a 'leapfrog' technology and likens the impact of the change to society's previous movement from coal to petroleum.[15] Yet, without microgravity research, development and expertise, the enhanced zeolites vital to this technological revolution cannot be created.

2. ZBLAN Optical Fiber

Discovered by a group of French scientists in 1974, **ZBLAN**, named after the heavy metals found in its chemical composition,[16] has the potential to form advanced optical fiber cables that ***can carry 100 times more data than today's silica-based lines.***[17]

Currently, the most widely used optical fibers have a number of limitations, including narrow optical "windows" which are the small band of wavelengths they transmit through.[18] For example, current fiber optic cable is good at transmitting visible light, is a moderate transmitter of near-infrared light and turns black in the deeper infrared spectrum. ZBLAN, however, transmits from near-ultraviolet to near infrared.[19] In fact, a perfect ZBLAN glass should transmit light virtually as well as any form of matter would allow.[20]

In addition to its revolutionary potential as a data carrying fiber optic cable, ZBLAN applications also include medical surgery and cauterization, temperature monitoring, infrared imaging, fiber-optic lasers and optical power transmission.[21]

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[15] Id.

[16] **Z**irconium, **B**arium, **L**anthanum, **A**luminum and sodium (**N**a). Effects of gravity on processing heavy metal fluoride fibers published in *J. Mater. Res*., 12:9, 2223-2225 Sept. 1997.

[17] Microgravity News and Research, August 17, 2000.

[18] ZBLAN continues to show promise , Marshall Space Flight Center, February 5, 1998, http://science.nasa.gov.

[19] Dr. Dennis Tucker, in Id.

[20] Id.

[21] ZBLAN Research Takes Step Forward , Marshall Space Flight Center, June 3, 1997, http://science.msfc.nasa.gov.

It is difficult to imagine the impact of fiber optic cables that represent a 10,000% increase in efficiency. The benefits to the IT and computing field alone would be immense. Only considering the limited uses of ZBLAN that we know of today, the development and application of the material could mean as much as an $8 billion increase to the U.S. economy annually.[22]

Unfortunately, the promise of ZBLAN will go unfilled until practical microgravity manufacturing becomes a reality. ZBLAN manufactured on Earth has a tendency to crystallize which severely degrades its optical properties.[23] However, ZBLAN produced in orbit showed no signs of crystallization.[24] ZBLAN is a prime example of a substance with tremendous economic potential that can only be effectively produced in the microgravity environment of space.

3. Medical Research and Development

In the past, drug design has literally been a hit-or-miss proposition.[25] Penicillin and sulfa, the wonder drugs of the mid-20th century, were fortunate accidents.[26] However, to combat new diseases as well as old viruses that are becoming resistant to traditional treatments, new and more effective means of research are required.[27]

The best approach to develop a treatment for a virus is to study its biology through crystallization. The most important chemicals in life can be grown as crystals[28] and their structures can then be analyzed via X-rays. Unfortunately, most biological chemicals have large, spongy molecules that deform when grown on Earth. This fact limits the clarity of the crystals and the details that can be seen within the molecule.

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[22] Telecommunications - $7.5 billion; Imaging Fiber Bundles- $15 million; Laser Surgery- $25 million; Spectroscopy- $15 million. Microgravity News and Research, August 17, 2000. Research on ZBLAN is currently being conducted by Bell Labs division of Lucent Technologies, Infrared Fiber and Galileo Corp. ZBLAN continues to show promise , Marshall Space Flight Center.

[23] ZBLAN Research Takes Step Forward , Marshall Space Flight Center.

[24] ZBLAN continues to show promise , Marshall Space Flight Center.

[25] On Target for a Cure , Marshall Space Flight Center, July 11, 1997, http://science.msfc.nasa.gov/newhome/headlines/msad11ju197_1.htm.

[26] Penicillin was inadvertently discovered when a bread mold contaminated a bacterial sample. Sulfa was discovered when a chemical dye worker failed to develop an infection after an industrial accident. Id.

[27] Id.

[28] E.g., diamond is crystallized carbon.

However, just the opposite is true when the same crystals are grown in space. Crystals grown in a microgravity environment are large and contain very few defects.[29] Such crystals are perfect for X-ray analysis, and the improved data gained from these crystals significantly enhance scientists' understanding of a virus's or protein's structures. This enhanced knowledge allows pharmaceutical companies to pursue 'targeted' structure based drug design.[30]

The benefits of biological microgravity research may soon come to fruition. In seven years, space-based organic crystallization research has defined the structure of 30 different proteins.[31] This work has resulted in several different therapies that are in various stages of human clinical trials.[32] Close to completing testing is a treatment for T-cell lymphoma, an aggressive cancer. Food and Drug Administration ("FDA") approval for this particular treatment will be sought within the next few months.[33] Additional drug therapies that will also soon be submitted for FDA approval will include treatments for psoriasis, a painful skin disease, and rheumatoid arthritis, a disease where the body attacks its own joints.[34] Also under development are advanced treatments for diabetes[35] and research into Human Immunodeficiency Virus ("HIV"), Ebola virus, the flu, influenza, lyme disease, as well as prostrate, breast, ovary, lung and colon cancer.[36] According to the scientists at Marshall Space Flight Center, ***the products of these and other efforts will improve the lives of 1.3 billion people.***[37]

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[29] Protein Crystal Growth , Microgravity Research Division, Biotechnology, NASA, GPO-1998-637-443.

[30] Id.

[31] On Target for a Cure , Marshall Space Flight Center.

[32] Id.

[33] Id.

[34] Id.

[35] New Life Science Experiments on the Space Shuttle , NASA Science News, Marshall Space Flight Center, http://science.msfc.nasa.gov/newhome/headlines/msad11ju97_1.htm. Space grown insulin samples have enabled researchers to understand structures that are key to developing an inter binder for insulin. This research will allow diabetics to avoid the long-term damage caused by their injections.

[36] Measuring a Microverse with a Universal Yardstick , NASA Science News, Marshall Space Flight Center, http://science.msfc.nasa.gov/newhome/headlines/msad25sep97_1.htm.

[37] New Life Science Experiments on the Space Shuttle , NASA Science News, Marshall Space Flight Center.

4. Microgravity Research and Development

It is important to emphasize that the opportunities described above only represent the potential that *we are currently aware of.* As is the case in any new field of development, the most significant products and concepts have probably yet to be discovered. The first microgravity manufacturing facilities may focus on protein crystal growth and ZBLAN creation, but what will be discovered as a result of these efforts is, in all likelihood, where the greatest potential lies. This is why microgravity research and development capability will not just be a luxury, but a necessity for corporations in the near future.

> "The low and microgravity environment is an important part of science. In any kind of research and development it is important to conduct your experiments in as many different environments as possible, or that you can afford. Not knowing how zero-g [zero gravity] affects a process is reason enough to experiment with it. Being able to exploit it [microgravity environment] is going to be tremendously important to the U.S. economy."[38]

In much the same way that no one could have envisioned electricity leading to the computer age, what microgravity manufacturing capability will lead to is unknown. However, as the unique properties of enhanced zeolites and ZBLAN illustrate, the progress will be revolutionary.

C. Space-Based Power Generation

Almost 90% of the world's energy is currently generated through the burning of fossil fuels.[39] Depleted natural resources and concurrent increased costs, pollution and growing power consumption all contribute to the rising need for inexpensive, clean energy.[40] ***Space-based Solar Power ("SSP") holds the key to increased, efficient and pollution-free power generation.***

All life on Earth depends upon solar radiation for its survival. However, Earth's atmosphere, the angle of the Sun, and weather conditions greatly reduces the impact of the Sun's

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[38] Woodard, Dan, Outreach and Education Officer for the Microgravity Research Program Office, Marshall Space Flight Center, personal interview, September 2000.

[39] Climate Change and Energy Options , Space Solar Power Newsletter, Vol. 1-March 1997, http://www.netdepot.com/~preble/.

[40] The current global energy level is expected to continue growing at 6.6%/yr in developing countries and 1.9%/yr in the U.S. Id.

rays. Ultimately, the entire Earth receives only one part in two billion of the Sun's radiant energy.[41] Night, clouds, storms and the atmosphere in general block the Sun's rays.

However, in space, there is no atmosphere and the power density of the Sun's rays, 1,360 W/m2, is extremely high.[42] Solar collectors in geosynchronous orbit receive almost twice the maximum intensity of light striking clear equatorial areas on Earth. A solar collector located in space receives approximately ten times the light that the same area would receive on Earth.[43] The vast amount of solar energy in space can be captured by photovoltaic cells in orbit and transferred to Earth via microwave radiation.[44] These energy transmissions would pose no health risks[45] and would not interfere with satellite communications due to their low power level.[46] Additionally, the energy conversion process would be highly efficient, at around 85% or more.[47]

Both NASA and the U.S. military are already exploring the potential of SSP generation. In the fall of 1999, NASA provided $6.4 million to fund 23 proposals that could lead to the development of a space-based power generating system. According to Axel Roth, head of the Flight Projects Directorate and selection team lead at the Marshall Space Flight Center, NASA hopes to harness the Sun's energy for use on Earth, and by spacecraft that will travel throughout the solar system.[48]

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[41] Id.

[42] Space Based Solar Energy , Sunsat Energy Organization, http://www.sunsat-energy.org/Ver.2/WEASpace2.html.

[43] Climate Change and Energy Options , Space Solar Power Newsletter.

[44] Blasser P.E. et al, Solar Power Satellites, Ellis Horwood, New York, 1993, and second edition, *Solar Power Satellites a Space Energy System for Earth,* Wiley, Chichester, 1997.

[45] Unlike x-rays or ultra-violet radiation, which are termed ionizing radiation and are inherently unsafe at any level, microwave radiation falls into the broad spectrum called EMF radiation, which is non-ionizing. In its 314-page review of 17 years of EMF research released October 31, 1996 in Washington, D.C., the U.S. National Research Council (NRC) of the Academy of Sciences (NAS) concluded: No clear, convincing evidence exists to show the residual exposures to electric and magnetic fields (EMF) are a threat to human health There is no conclusive evidence that electromagnetic fields play a role in the development of cancer, reproductive and developmental abnormalities, or learning and behavioral problems. Climate Change and Energy Options , Space Solar Power Newsletter.

[46] The microwave power density chosen for transmission would not interfere with communications satellites because the power level is 1/5 of the level necessary to produce interference from scattering and harmonics generation. Id.

[47] Space Based Solar Energy , Sunsat Energy Organization.

[48] NASA Looks for New Ways to Harness Sun s Energy for Earth and Space , Marshall Space Flight Center, News Release, June10, 1999.

The military, which sees space as the 'ultimate high ground', has developed numerous plans and concepts as to how the U.S.'s space-based assets will be protected and how space forces can be utilized to support terrestrial combat.[49] The military envisions numerous space-based platforms and weapons systems that will perform a variety of functions.[50] The operation of these systems will require significant amounts of power. Due to budget cuts and the expense of developing programs, the military is depending on the private sector to provide energy for its space-based systems.

> "It is highly likely that very large orbiting solar power stations capable of delivering energy to the Earth will be built in space in the next several decades by the commercial sector. … These systems will likely use microwaves or millimeter waves for power transmission. It is not likely that we could use such systems in a dual-use mode as space weapons.. [however] … the DoD [Department of Defense] could purchase power on demand from such systems."[51]

For both the commercial and military world, the tremendous impact of SSP is undeniable. Recent studies have indicated that the collection and transmission of solar power from space could become a reality within the decade.[52]

D. Space Tourism

The public has always been fascinated by space exploration and space travel. Television series, movies, books and every form of media has been dedicated to the subject. The space industry is unique in having captured the public's imagination and interest. This interest in space will translate into a new travel/tourism industry. Although there have not been many consumer market studies conducted in regard to space tourism, those that have been done indicate the existence of significant interest and potential for capital generation.[53]

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[49] See, e.g., Long Range Plan, Executive Summary , United States Space Command; New World Vistas: Air and Space Power for the 21st Century , United States Air Force Scientific Advisory Board.

[50] Id.

[51] Hagen, Regina, Military Interest in Space-based Solar Power , Global Futures Bulletin #69, Institute for Global Futures Research, October 1, 1998.

[52] Mankins, John C., Power from Space: A Major New Energy Option? , Paper 4.1.16, Proceedings of the 17th Congress of the World Energy Council, Houston, Texas, September 13-18, 1998.

[53] Owen, Wendy, Space Tourism Surveys , George Washington University, Space Tourism Initiative; http://www.gwu.edu/~spctour/market.html.

For example, the first market research on the demand for space tourism was conducted in Japan by the National Aerospace Laboratory ("NAL"). The NAL found that 70% of those under the age of 60 and more than 80% under the age of 40 stated that they would like to visit space at least once in their lifetime.

Another market research poll conducted in the U.S. by Roper Starch Worldwide Inc. for Bigelow Companies found that 20% of all adults would spend over four years of their income to travel into space for six days to the moon and back.[54]

Although many are skeptical regarding the potential of space tourism[55] it is impossible to argue with the relevant figures. Travel and tourism is one of the world's largest industries. Travel and tourism's gross revenues exceed $400 billion per year in the U.S. alone. Additionally, the industry is the U.S.'s second largest employer.[56] Today, 10 million people per year visit space related facilities as tourists. This industry is estimated to produce $1 billion per year.[57] All of the relevant studies suggest that the space tourism industry has overwhelming commercial potential. Additionally, since space tourism is a technologically intensive field, it will provide quality jobs in an industry where the U.S. has significant advantages over its foreign competition. ***Space tourism represents a chance to establish a lucrative new industry which will be dominated by domestic U.S. companies.*** Moreover, due to scientific advances in space launch technology, the opportunity could be closer than many would think.

> "Fortunately, critical advances have been made during the past decade in many of the technologies that can enable non-astronaut human space travel to become both technically and economically feasible, and more are foreseen. ***As a result, the potential exists for the creation, in the next very few decades, of a $10-20 billion… per year 'general public space travel and tourism' business.***"[58]

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[54] Roper Starch Worldwide Inc. Spacecruiseship Study, October 1999 , prepared for Bigelow Companies.

[55] Indeed, one of the significant challenges to space tourism development lies in the giggle factor that exists in both the general population and the aerospace community. Owen, Wendy, Space Tourism Surveys , George Washington University, Space Tourism Initiative at INTRODUCTION .

[56] Id. at SUMMARY .

[57] Id. at GENERAL .

[58] Id. at INTRODUCTION .

III. OBSTACLES TO DEVELOPMENT: THE GOVERNMENT SPACE MONOPOLY

Billions of dollars, hundreds of thousands of jobs, entire new fields all dominated by U.S. corporations and employing U.S. citizens, this is the promise and potential of a privately owned commercial space industry. The opportunity is real, the benefits almost incalculable, however, without a significant change in policy by the Federal Government, the full potential of commercial space development will never be realized.

The Federal Government is not an entrepreneur. Industries that are controlled by the Government will not and cannot flourish. These contentions are clearly illustrated in the stark differences between the manned and unmanned space launch industries. The unmanned launch market is dominated by the private telecommunications sector. Control of this industry resides at the company, stockholder, investor and customer levels. This is as it should be and encourages a healthy and competitive marketplace.[59]

Unlike the telecommunications industry, manned space launch has never grown beyond its government sponsored inception.

> "On the manned side, here is the U.S., we have a defacto Federal monopoly on all manned space activities. Nobody but the feds fly manned missions. Over the years, this taxpayer supported monopoly has been particularly resistant to breaking. One of the things that a monopoly will tend to do over time is to do things that will maintain that monopoly and expand its size, scope and authority. A federal, taxpayer supported bureaucracy will be particularly resistant to giving up its monopoly unless forced to do so."[60]

According to a senior manager at a large domestic aerospace company, the Government's control over the advanced[61] and manned space industry is virtually total. On the basis of anonymity, the official summed up the opinion of many industry insiders by stating that, "if NASA or the Air Force doesn't want it, we're not doing it."[62] Therefore, with the exception of telecommunications, the U.S. Government currently controls and dictates the activities of private space companies. ***This Federal Government 'Space Monopoly' is inefficient and contradicts the***

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[59] Gimarc, Alex, Motivating the Bureaucracy , Space Policy Digest, http://www.spacepolicy.org/page_ag0100.html .

[60] Gimarc, Alex, Motivating the Bureaucracy , Space Policy Digest.

[61] For the purposes of this Report advanced space activities will include any space-based operation that is not currently performed by the private sector today.

[62] Anonymous interview, August, 2000.

fundamental tenants of a capitalist economy. Until the ownership of the advanced and manned space launch industry is transferred to the private sector, the promise of aggressive commercial space development will remain unfulfilled.

The Federal Government's inability and resistance to breaking its monopoly is understood and unfortunately, perpetuated by NASA. Although the authors of this Report and the aerospace industry in general have a tremendous respect for NASA, its employees, and everything that the Agency has accomplished, in regard to private sector development, some significant changes need to be made.

> "We need to stop looking at NASA as the Space Agency. We need to start looking at it as simply another federal bureaucracy that acts like every other bureaucracy. This is not NASA bashing. This is simply a description of the lay of the land. The rules governing how a bureaucracy operates and grows are well known and have been thoroughly described, for bureaucracies have been with us since the Imperial bureaucracies of ancient China."[63]

It should come as no surprise that NASA, like any other bureaucracy, has a strong desire to maintain itself and grow the organization. However, NASA's direction must be shifted so that this future growth does not interfere with the development of private sector ownership. NASA is currently attempting to support commercialization, *but not private ownership of facilities*.

In examining this dilemma, it is important to establish the difference between space privatization and NASA's legislative definition of "commercialization". Privatization of space assets would mean that stations, manned launch systems, etc., would be owned and operated by the private sector. Under privatization, the Government's role would be purely regulatory or as a customer.

Unlike privatization, commercialization, at least NASA's current definition of it, simply means that the private sector has an opportunity to rent, lease or participate in a Government owned, operated and controlled system. Under commercialization, private companies can only conduct activities with NASA's permission and support. Unfortunately, commercialization is currently the dominant method of conducting business in space.

[63] Gimarc, Alex, "Motivating the Bureaucracy", Space Policy Digest.

The implications of such a system become readily apparent when space is removed as a factor. For example, imagine if to open a business an entrepreneur was required to gain the Department of Labor's approval for the business, and could only rent facilities from the Government. Such a system would crush business development, eliminate entrepreneurialism and innovation, and result in a stagnant economy. This is exactly what has occurred in the field of advanced commercial space development.

In Stanley Kubrick's 2001: *A Space Odyssey*, and other forms of popular fiction from the late 1960s, it was commonly believed that by the year 2000 the U.S. would have developed a significant presence in space. This has not happened. The last great American space project, the moonshot, occurred over thirty years ago. ***The reason for this lack of progress is that the astronauts made it to space but the entrepreneurs never did***. As it is on Earth, the key to capturing private sector interest is through the promise of ownership and profit. Therefore, until the ownership of space-based assets is shared between the Government and the private sector significant business development will never occur.

Such a change will not be easy to accomplish. NASA is an entrenched government bureaucracy, and one that, unfortunately, has a history of having to fight just to maintain its funding. Since Apollo, NASA has, until very recently, watched both its budget and relevancy slowly decline. In an age where "big government" has become a buzzword, NASA knows that it must develop new sources of revenue to survive. This is in part why, without any overt or intentional decision, the Agency has maintained its exclusive ownership over the nation's advanced space activities.

In the future, NASA plans to grow and exploit this ownership to the point where the Agency can actually generate revenue. This will be accomplished at the expense of the private sector. The increased efficiency, innovation and superior entrepreneurialism that private development engenders may be completely lost.

The best example of NASA's plans to generate its own funding is the International Space Station ("ISS"). NASA is working to market ISS services, if possible, on a for-profit basis.[64] NASA, a bureaucratic government agency has gone into business for itself. According to NASA officials, the goal is for profits generated by ISS to pay for the Station's operations and other ISS related activities. Rather than assist private companies in supporting or creating their own space-based assets, NASA will ultimately develop ISS as a revenue stream in order to support the

[64] Heney, Michael K., First, do No Harm , Space Policy Digest, http://www.spacepolicy.org/page_mh1199.html.

Agency's growth and prosperity. Moreover, as the 'Alpha' designation for ISS indicates, a second space station dedicated to commercialization activities and owned entirely by NASA will be the result of the successful operation of the current ISS.

Further aggravating the situation, is the fact that NASA's ISS profit generating capabilities have been approved and supported by Congress. In NASA's most recent budget authorization legislation, H.R. 2684 (FY 2000 VA-HUD Appropriations Act), Section 434 states that:

> "(b) USE OF RECEIPTS FOR COMMERCIAL USE. – Any receipts collected by NASA from the commercial use of the International Space Station shall first be used to offset any costs incurred by NASA in support of the United States commercial use of the International Space Station. Any receipts collected in excess of the costs identified pursuant to the prior sentence *may be retained by NASA* for use *without fiscal year limitation* in promoting the commercial use of the International Space Station." (emphasis added)

This language explicitly grants NASA the ability, subsequent to offsetting costs, to retain its ISS "receipts" and to use such funds without fiscal year limitation. In plain English, Section 434 gives NASA permission to generate and retain ISS profits. Congress is thereby mandating NASA's entrance into the business world of revenue generation.

No one would object to NASA producing revenue to help alleviate the substantial costs of ISS, however, ***Congress must be aware of the dangerous precedent that such a program will establish.*** Once NASA develops a taste for the benefits that profits can bring, it is highly unlikely that the Agency will ever release control of what could become a profit generating device to support, feed and grow the Agency's bureaucracy. NASA will have every reason to insure the ISS's "commercial" success and will have no reason to turn it over to the private sector. Indeed, at the recently held 2000 International Space Symposium,[65] NASA Administrator Daniel Goldin admonished his NASA colleagues on this very point.

> "We'd like to be able to turn over the keys of the space station to a private corporation, if some of my dear NASA colleagues will have the courage to let that happen."[66]

[65] Held on October 24-26, 2000 the Symposium was sponsored by the Space Foundation.

[66] Quote from Mr. Goldin s speech, excerpted from NASA + Aerospace Industry = Business , by Leonard David and Mary Motta, Space.Com, October 25, 2000.

NASA should not be given the option to retain the "keys" to ISS. For all of the reasons described above, the Agency may never willingly hand over ownership of ISS to the private sector. NASA may fight to maintain ownership of ISS, since the profits that the station represents might some day become the key to alleviating the Agency's low pay and constant hiring freezes. If the business community is forced to depend on the "courage" of NASA bureaucrats, private sector development of the space station industry or any other advanced space systems may never occur.

> "The problem is that NASA as an institution is inherently hostile to the private sector. Bill Wisecarver, who worked at the Johnson Space Center for about a year writing business plans for space station commercialization, is pessimistic about the situation changing any time soon. *Space News* quotes him as saying, 'NASA has some fantastic engineers, and incredible scientific capabilities. But they don't know how to cut a deal. They make political decisions … not economic decisions. You can't just ask bureaucrats [who] are running the commercialization programs to do economic deals. You are asking them to go against their best interests. ***They are going to attack anything that takes away bureaucratic control.*** '"[67] (emphasis added)

Again, NASA's true attitude towards the private sector is readily apparent when the concept of turning ISS or even space shuttle ownership over to the private sector is discussed. Such ideas are still virtually "unthinkable".[68] If NASA was genuinely more interested in "commercial" development than maintaining its own relevancy, the Agency would not balk at the very suggestion of private sector ownership of such facilities.

> "At one point during the [Space Transportation] roundtable, a legislative assistant asked 'What can we do in the coming year to help you?" The [industry] answer was 'nothing'. The only helpful thing that could be done would be for the Government to promise not to compete."[69]

NASA's current ability to generate revenue from operations such as ISS is setting an extremely dangerous precedent. Instead, of private entrepreneurs settling space, the new frontier could remain under the exclusive control of a large government bureaucracy that is attempting to maintain its own funding, staff and relevancy. Such a situation would ultimately hurt both NASA

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[67] Whittington, Mark R., Space Commercialization in the Worst Way , Space Policy Digest, http://www.spacepolicy.org/page_mw0999.html.

[68] Heney, Michael K., First, Do No Harm , Space Policy Digest.

[69] Id.

and the entire advanced aerospace industry. Government bureaucrats do not innovate and are often required to make political rather than business decisions. Until control of space is shifted to the private sector the promise of this new frontier will remain unfulfilled.

IV. SOLUTIONS: REALIZING THE FUTURE

The Federal Government has a critical and important role to play in building a privately owned commercial space industry. As always, the real question is how can the Government best plant the seeds for development and then get out of the way. (A task that is more difficult than it sounds.) As in the settling of the American Western frontier, the Government must establish programs that will create a conducive business environment for entrepreneurs to take advantage of. The Government's proper role in space development can be broken into three categories:

1) **Prohibiting and eliminating Government competition with the private sector**

2) **Providing funding for the development of technologies that represent too great a financial risk for the private sector to accommodate**

3) **Creating a regulatory and financial environment conducive to advanced space development**

A. Prohibiting and Eliminating Government Competition with the Private Sector

First and foremost, NASA cannot develop into a publicly funded business operation. The budget authorization bill discussed earlier is anathema to private, commercial space development. It is difficult to believe that Congress would allow a tax-payer funded agency to generate and retain profits, but this is exactly what Section 434's language allows NASA to do. Such language must be eliminated from any future legislation. Explicit clauses must be included in NASA's next budget authorization that will prohibit the Agency from retaining profits. Moreover, language should be included that will, when the ISS becomes profitable, transfer ***ownership and control*** of the Station to the private sector. Rather than depend upon the courage of NASA bureaucrats, Congress must pass legislation that would force the Agency to hand over the "keys" to the station. ***Tax-payer funded, tax-exempt government agencies have no business generating profits in space or on Earth***. Private sector companies must never be forced to compete for customers with NASA-owned space stations. Any future legislative material, particularly appropriations bills, must reflect this commonsense imperative.

Preventing NASA from going into business is not a difficult task. Congress simply needs to strike language such as Section 434 and replace it with new language that will "sunset" government ownership of ISS and NASA's other advanced space systems.

B. <u>New Exploratory Focus</u>

NASA is good at what it does. Nothing in this Report should be construed as an attack on a space agency that has produced tremendous achievements under extreme political pressure and budget constraints. NASA is being driven to compete with the private sector out of self-preservation. Like any institution, NASA wants to maintain its relevancy, increase its traditionally low pay and protect its jobs. NASA's "commercialization" efforts could accomplish all three of these goals.

Therefore, NASA cannot be faulted for its actions. Again, NASA has reacted as any institution interested in self-preservation would. As a matter of fact, the Agency's plans for space 'commercialization' are excellent, and would be laudable if NASA's gains were not made at the expense of the private sector. NASA's work and energy must be turned away from commercial space ownership. Even senior NASA officials have recognized the need for the Agency to move on.[70]

The most effective and beneficial method to prevent NASA from competing with the private sector is to give the Agency a new mission, mandate and focus that it could turn its energies towards. During the early days of the space program (i.e. Mercury and Gemini) and particularly during Apollo, NASA was enjoying a golden age.[71] The Agency's mission, goals and purpose was clear, put a man on the moon and bring him back.[72] Morale was high, the mission was successful and NASA proved its unparalleled exploratory and scientific capabilities.[73]

NASA needs to again focus on its primary mission of space exploration. Whether the program is a manned Mars mission, an aggressive unmanned probe campaign to Europa, or even

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[70] You don t need NASA s permission to make a profit in space. Our goal is to get out of the launch business, Alan Ladwig, Former NASA Associate Administrator for Policy and Plans. During a personal interview, one official from an entrepreneurial reusable launch vehicle company commented that, he [Ladwig] is right, you don t need NASA s permission, just their approval. Personal interview, September 29,2000.

[71] Launius, Roger D., NASA: A History of the U.S. Civil Space Program, 67 (1994).

[72] No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space President John F. Kennedy, NASA Apollo Video Collection.

[73] Launius, Roger D., NASA: A History of the U.S. Civil Space Program, 67.

an exploration of near-Earth asteroids,[74] a renewed focus on exploration is required to shift the Agency's attention away from low Earth orbit profit generating schemes that will compete with private sector development. A clear, defined and exciting exploratory program could accomplish this goal and concentrate NASA's attention on exploration rather than commercial exploitation. NASA leadership must design and implement a bold, new exploratory program and Congress then needs to support NASA's renewed exploratory and scientific focus.

V. CONCLUSION

Future private ownership and commercial development of space-based assets will result in unparalleled technological and economic advances. Whole new industries and markets will be created and the innovative materials and techniques developed will revitalize traditional sectors of the economy from farming to computing. All that is required is for the Government to share ownership with the private sector and allow the market to do what is does best. ***Capitalism works very well on Earth, there is no reason why it would suddenly fail to function in space***.

The nation owes at least this much to those brave Americans that died trying to take us to this new frontier. The crews of Apollo 1 and Challenger did not sacrifice their lives so that a handful of military and government personnel could go to space. Merriwether Lewis did not explorer the West so that he could be followed by future government expeditions. These explorers fought, worked and sacrificed to make the world a better place for all of us. It is up to the public, Congress and the American people not to let them down.

[74] Asteroid exploration has particular promise since asteroids contain a variety of precious metals and materials in startling quantities. If an efficient method can be developed to mine and exploit asteroid-based resources this could greatly increase the supply of precious metals and rare materials for use both on Earth and in future space-based construction. Ciotola, Mark, Asteroid Mining , Forum on the Future, Pavilion of Research & Commerce, www.pavilionplace.com/asteroid.html.