

**STATEMENT OF GEORGE T. WHITESIDES  
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**BEFORE THE  
SUBCOMMITTEE ON SPACE, AERONAUTICS, AND RELATED SCIENCES  
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION  
UNITED STATES SENATE**

**Hearing on  
“Reauthorizing the Vision for Space Exploration”**

**May 7, 2008**

Chairman Nelson, Ranking Member Vitter, and members of the subcommittee:

Thank you for the opportunity to share with you the views of the National Space Society on the upcoming reauthorization of NASA.

I serve as the Executive Director of the National Space Society (NSS). NSS is an independent, grassroots organization with over 20,000 members, founded with the goal of promoting space exploration and development. NSS communicates the excitement and benefits of space to the public, and represents the perspectives of the space-interested public to policymakers.

Our members are citizens who live and work in every state in our great country. They include a wide swath of America, from teachers, to students, to business leaders, to elected officials, to even a few astronauts. Most, however, are simply everyday citizens without ties to the space industry, citizens who understand the importance of space to our nation and its future.

I am proud to represent the voices of our members to you today. In preparation for this testimony, we solicited their views on these issues, in addition to those of our board and policy committee, and the members responded with eloquent and nuanced comment on future space activities. I will share some of their words with you as part of this statement.

NSS was founded over 30 years ago by a group of leading Americans that included Wernher von Braun and Hugh Downs. Their vision, and that of our current governors, such as John Glenn, Tom Hanks, and Buzz Aldrin, continues to inspire us today. The ultimate vision of the society is:

“People living and working in thriving communities beyond the Earth, and the use of the vast resources of space for the dramatic betterment of humanity.”

While the first part of that vision emphasizes exploration and settlement of space, the second emphasizes how the resources of space can be used to improve life on Earth. These are both crucial, as I will discuss in more detail below, for they hold the key to the long-term future of the agency and its mission.

## **A. The value and importance of U.S. space exploration from economic and strategic perspectives:**

We live in a new age of discovery, in which we learn on a regular basis of new oceans under the crust of distant moons, new planets around distant stars, and new possibilities for life beyond Earth. Our astronauts regularly perform heroic feats on orbit, as they build the International Space Station, the largest and most complex science project in history. Meanwhile, a new generation of space entrepreneurs is emerging, with plans to transform the space sector with new services and lower costs. It is an exciting time.

It has been said that a thousand years in the future, our era will be remembered most for the birth of spaceflight, the moment in human history when we developed the ability to travel to space. It is humanity's ultimate destiny to explore the universe, to develop the ability to live for extended periods off planet Earth, and eventually, to build communities in space. I firmly believe that the individuals who have advanced the space frontier during these early years will be remembered as among the greatest heroes of our era, as those who recognized the historical importance of space to our nation and the world.

But we live in the present, and together we must confront three interlinked groups of challenges of our time:

- Education, competitiveness, innovation and our economy;
- Energy, resources, climate, and environmental protection;
- Security, diplomacy, and peace.

**My primary message to you today is that space is a key part of the solutions to all of these present-day, national challenges.** That fact is something that we do not hear enough of today, and it is critical to ongoing public support for future space activities. What America must understand is that the full breadth of NASA's skills, people and technologies will be required to meaningfully respond to and solve the biggest challenges of our time.

Our great country must apply its full abilities to solve these serious tests over the coming years:

- *We must inspire and educate our young people to become the scientists, engineers and innovators of tomorrow.* Nothing inspires children towards the study of science and engineering like an ambitious space program that matters to our country's future. At a time when our education system is falling behind, we must do all we can to motivate children to enter STEM careers, and to offer them jobs once they enter the workforce.
- *We must maintain and build our industrial base, and create innovations which build prosperity.* NASA's spaceflight capabilities are a strategic asset of the country, and its engineers and contractors have long driven critical technological advances that drive our economy. The space sector has grown to a quarter-trillion dollar global industry, and is one of the few in which the US maintains a positive balance of trade.
- *We must shift to new forms of energy production, and develop new resources to power and supply our global economy.* Space-based Solar Power offers a potential future energy source that is clean, fully renewable, and that provides baseload power. Helium 3 resourced from the Moon could provide a much cleaner fuel for fusion power.
- *We must protect the Earth's environment, and seek to forestall rapid climate change.* NASA is the world's foremost climate science agency. Going forward, its world-class system engineering

capabilities could help design solutions for climate change on a national and global scale.

- *We must forge new alliances with allies and competitors, and strengthen our economic and national security.* As space becomes increasingly important for the global economy and global security, America must lead to establish a new system for lasting peace and stability in space and on Earth.

NASA can be the keystone to the future, critical to the great challenges of the present, central to solving the issues that Americans care most about. But only if we can put forward a bold program that links the needs of Earth with the potential benefits of space.

**The Vision for Space Exploration provides the foundation for such a bold program, and as such, it should be reauthorized by the Congress.** Endorsed with bipartisan support, the Vision sets out an inspiring path towards human habitation of the Moon, Mars and other destinations in the solar system. It builds on the hard-won wisdom following the Columbia accident: that the risk faced by American astronauts deserves a worthy goal, that of exploration of the solar system. Under the Vision, an official path for human exploration beyond low earth orbit was set out for the first time in at least a decade.

**We would recommend that two themes within the general direction of the Vision be explicitly directed by Congress within the Authorization:**

- **To link the work of human and robotic exploration more closely with the response to the pressing needs of planet Earth, particularly those issues related to climate and energy;**
- **To recommit to engaging, building and using commercial space services as the preferred option for NASA's needs whenever available.**

The first theme anchors the Vision to the real challenges facing America today, creating real sustainability. That, in turn, will help build public understanding and support for NASA's mission. The second utilizes the full powers of the American entrepreneur, creating dynamics that over time will grow our economy, lower the cost of space access, and enable NASA to focus its own efforts and funds on exploration of the frontiers. Both themes will ultimately support the sustainable expansion of our civilization outward to the Moon, Mars and beyond, and the expansion of the Earth's economic sphere to include those bodies.

Ultimately, space is the main path forward to resolving the great humanitarian and environmental challenge of our time – the global disparity between rich and poor. One of our members, James Martin of Springfield Virginia, captured the real scope of the issue at hand:

It seems to me that the great challenge facing the world in the coming decades is a growing contention for resources - most acutely energy - between the industrialized world (the "haves") and those rapidly industrializing countries (the current "have nots") that seek a lifestyle similar to ours. China and India, with the world's two largest national populations, are leading this quite natural urge of the "have nots" to improve their lot in life. This is leading to increased demand on global resources by economic growth in these two countries - a situation that can only get worse. It has been said that we would need three Earths to provide the energy and mineral resources to support the entire human population at a standard of living equal to the current industrialized countries (who make up only 1/6 of the planet's population). This leads to a grim conclusion that the "haves" will increasingly have to fight to defend their current advantaged position (a dubious moral proposition), or we will have to change the "playing field" by accessing energy and

mineral resources beyond this planet. Moreover, fossil fuels cannot support a massive increase in global industrialization without pushing us even further into environmental collapse.

There has never been a better time for a fundamental change in our perception of the future. If mankind can access resources beyond Earth, we can offer the hope of economic well-being and a clean environment for all, and avoid debilitating future resource conflicts that will only make us all poorer. America's space program must be oriented toward creating this future.

## **B. The Implications and Consequences of Any Gaps in the Nation's Space Capabilities**

Curtis Schroeder of Atlanta, Georgia, wrote to me, in preparation for this testimony,

“We cannot outsource our manned space flight needs to other countries if we are to be a world leader.”

Perhaps the most urgent space issue our nation faces in the next few years is the human spaceflight gap between the retirement of the Space Shuttle and the start of Constellation Program operations. This gap, right now estimated to be five and a half years, will be about as long as the gap the nation experienced between the retirement of the Apollo hardware and the launch of the Space Shuttle.

Our nation's space program survived that gap, but the environment was much different then. Where we once had a single competitor in space, we now have several. Where before we faced competition in orbital operations rather than lunar adventures, today there are three other nations orbiting hardware around the Moon, with Russia and China both expressing interest in sending humans there, possibly before Constellation's target date of 2020. We are running the risk of falling behind in space, even if no “space race” has been declared.

The consequences of the gap, as seen during the transition between Apollo and Shuttle, are well known and ominous. Loss of funding translates into a loss of NASA's most critical assets: the knowledge, corporate memory, and hands-on skills of its people. With a loss of jobs comes a loss of economic vitality in communities like Brevard County, Florida, and New Orleans, Louisiana, as people move away to look for jobs and take their money and families with them. Once those people are gone, restoring diminished capabilities and communities will not be as simple as issuing a call-back after a brief layoff.

Jerry Carr, Commander of the final Skylab flight – a man who knows about such issues firsthand – wrote me the following comments:

“I thought that we had learned the lesson during the seven-year hiatus between the Apollo and Shuttle programs. A huge body of NASA and contractor skill and experience just left to do something else. Then the workforce had to be built up all over again at no mean cost in order to proceed with the Shuttle and Space Station programs.

“Where is the incentive to build up our scientific and technical base if we have no space program to which those young minds can aspire? Space exploration is where the United States has shown leadership, and in the current climate ... we can't afford to abdicate the heritage we have established in space.”

Over 20 years ago, a prescient report came out following the Challenger accident, The Report of the National Commission on Space. It made a similar observation then, and today the situation is significantly more pressing:

“Should the United States choose not to undertake achievement of these economies in launch and recovery capability, then the Nation must face the probability that other nations will rapidly overtake our position as the world’s leading spacefaring nation. The competition to get into space and to operate effectively there is real. Above all, it is imperative that the United States maintain a continuous capability to put both humans and cargo into orbit; never again should the country experience the hiatus we endured from 1975 to 1981, when we were unable to launch astronauts into space.”

Another gap is indeed upon us. NSS believes that this committee should make that gap as short as possible, and should use multiple means of doing so.

### **Fund Acceleration of the Constellation Program**

NASA and its contractor team are well on their way toward development of the Ares I launch vehicle and Orion capsule. Starting over or even stopping to re-evaluate the designs would further extend the gap. Therefore, we believe NASA should receive the resources it needs to develop the Ares/Orion architecture as it now stands.

With an additional \$2 billion a year, NASA could close the gap to three and a half years. This would also reimburse the agency for the expenses it sustained in adding safety systems to the Shuttle following the Columbia accident. However, many of the processes needed to develop the new Ares launch vehicles and Orion crew exploration vehicle are linear in nature and cannot be hurried along by additional money or resources. NSS asks Congress to fully fund these development efforts to meet their best-case schedules.

### **Authorize and Fund COTS Option D**

In addition to supporting NASA’s current efforts to reduce the gap, NSS favors providing additional funding for commercial development of crew transportation to the International Space Station. In recent letters addressed to the Senate and House Appropriations Committees, Gary Barnhard, NSS Executive Board Chairman, and Greg Allison, Executive Committee Chairman, argued for additional funding of Part D of the Commercial Orbital Transportation Services (COTS) program. We support COTS Part D because we believe that it could:

- Shorten the “gap” in U.S. human space access after the Space Shuttle is retired;
- Foster technological diversity and competition among the companies providing these capabilities, which also can be used to support other operations;
- Allow innovative providers to use their best practices to develop and provide needed capabilities, outside traditional Government organizational or procurement channels;
- Add budgetary flexibility to NASA’s ISS servicing efforts, potentially at a lower cost than NASA could do otherwise; and
- Attract outside investment, if the program is properly structured.

### **Improve Opportunities and Incentives for Commercial Space Activities**

As the COTS program matures, Congress can further both commercial development of space transportation systems and provide productive uses for the International Space Station after its scheduled defunding in 2016. This can be done by encouraging NASA to buy services for ISS, to conduct space-based research, and to develop space-based education opportunities where it can to help stimulate services where none exist today. A combination of Space Act agreements and traditional contract vehicles could

increase demand for commercial transportation services, fund new space ventures, and serve as a bridge between ISS's status as a government laboratory and its future as a commercial outpost.

The American taxpayer wants to know that the efforts made and money spent to complete the Station have been worth it. One NSS member, Mr. James Grosbach, wrote to me in an email:

Almost as distressing as the upcoming "gap" is the projected date of 2016 as the retirement date of the ISS. My God, we'll no sooner have the thing built than we'll be looking at abandoning it. Funds should be made available to upgrade and refurbish ISS systems to keep it usable well into the third decade of the century!

In short, NSS members believe that it is both good and proper for the nation to continue funding and using ISS as a lab for productive science and commercial ventures—either through NASA, the private sector, or a combination of the two.

### **Develop New Heavy Lift Vehicle**

It is critical for exploration of the Moon and Mars for NASA to be authorized to continue past development of the Ares I to a new heavy lift vehicle. NASA currently has baselined the Ares V vehicle, a new development program which will possess the capacity to launch the payloads required for lunar surface exploration.

## **C. NASA's Needs for Accomplishing the Vision for Space Exploration**

### **Full Funding Under the VSE's Original Budget Run-out**

According to the Congressional Research Service<sup>1</sup>, when the Vision was first proposed in 2004, the Bush Administration stated that \$12.6 billion dollars would need to be added to the NASA budget over the course of Fiscal Years 2005 through 2009, with NASA projected budget chart suggesting that \$150-170 billion would be spent on the Vision from FY2004 to 2020. Most of the money was to come from other NASA programs, such as the retiring Space Shuttle. The \$12.6 billion, for example, comprises \$1 billion in new money, and \$11.6 billion that is redirected from other NASA activities.

In the FY2005 budget, the White House projected that NASA's total budget would increase about 5 percent per year for FY2005-2007, then at less than the rate of inflation—about 2 percent—for FY2008-2009. However, according to Administrator Griffin's budget testimony and actual budget figures, NASA's budget did not meet the expected profile in 2006 and 2007, and received a budget increase of 3.1 percent for the entire agency for FY 2008.

What do these figures mean? In simple terms, NASA needs the money originally proposed for the Vision to ensure its continued success. At present estimates, NASA will require an additional \$1-2 billion to accelerate Constellation, repay for Columbia, support COTS-D, and protect our national commitments to science.

This funding will require the joint efforts of the next president as well as both parties in both houses of Congress to look after our national interest and make good-faith efforts to sustain the Vision. The NSS believes there is sufficient cause for hope, given this body's bipartisan support for the 2005 Authorization.

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<sup>1</sup> Smith, Marcia S. "Space Exploration: Issues Concerning the 'Vision for Space Exploration' Resources, Science, and Industry Division." CRS Report for Congress Code RS21720, Updated June 9, 2005

## **A Sustained National Commitment to Space Exploration**

One of the virtues, but also one of the challenges, of living in an elected, representative government is that personnel and priorities constantly change. Fortunately, the nation as a whole, the Congress, and the president have all seen the value of supporting space-related activities since the initial space race of the 1950s. While that support has waxed and waned over the years, the Gallup organization reports that the percent of Americans who want NASA's budget to remain the same or increase has never been lower than 51 percent since 1984.<sup>2</sup> I take that as a hopeful sign for what we can accomplish in the future.

This nation has always stood for progress, expanding the frontiers of the possible, and improving the lot of its citizens. If the American people are willing to maintain a consistent belief in the value of space exploration, then I believe any future president or Congress would be safe in continuing this valuable national investment. It is about more than following the polls; it is about continuing to support an activity that, to the majority of Americans, stands for progress and a better future. It also means demonstrating this nation's commitment to being a leader in high technology of all kinds. Space exploration is a national emblem of achievement and soft power of which its citizens can be justly proud. Support for the Vision, then, is not just a matter of material support in the form of passing budgets every year; it is a national enterprise that deserves our constant verbal and moral support.

## **An Environment That Encourages Private-Sector Participation**

NSS greatly admires NASA's exploration efforts; that is why we are here to support them. And we want NASA to continue its role on the cutting edge of technology and the space frontier. However, if we are going to have a true "space economy"—one where individuals and businesses are buying and selling goods and services beyond Earth orbit—then space activities must be opened more fully to private-sector participation. The long-term viability of space requires it.

As I stated earlier, NASA needs to buy services for ISS, research, and education where it can to help stimulate commercial services where none exist. ISS can become, over time, a pioneering commercial outpost in low-earth orbit. If there are activities in which the private sector stands to make a profit, then competing, enterprising companies of all types will race to fill the niches. They will diversify, lowering the cost of services available for purchase by the government, as well as broaden the tax base and create new, spinoff niches that the government hadn't considered—that is what it does best.

Other activities Congress and NASA can perform to ensure a welcoming environment for the private sector include:

- Allowing commercial firms to make fixed-price bids on cost-plus procurements so they do not have to reorganize their business processes to meet the administrative burdens of cost-plus contract accounting when dealing with NASA.
- Increasing the use of fixed-price, milestone- or performance-based procurements for certain, smaller R&D projects.
- Using emerging commercial space flight capabilities for space and earth science, aeronautics, and exploration-related crew familiarization and training missions, including but not limited to parabolic flights, suborbital vehicles, and emerging launch vehicles.
- Not demanding a broad use license for intellectual property originating in the private sector as a term of funding demonstrations of the relevant technology, or the development of applications for the technology, but rather agreeing to license this intellectual property for public uses.

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<sup>2</sup> Jones, Jeffrey M. "Support for Space Program Funding High by Historical Standards." *Gallup.com*  
<http://www.gallup.com/poll/9082/Support-Space-Program-Funding-High-Historical-Standards.aspx> August 19,2003.

The private sector has historically relied on the government to spend money on the difficult, unglamorous things that do not readily generate revenue but are necessary for the functioning of a healthy economy. These include building physical infrastructure, establishing legal “rules of the road,” and protecting the individual consumer.<sup>3</sup> Congress and NASA have several excellent opportunities to do all of these things through the following programs:

- **COTS / COTS D Demonstration Programs** – As stated earlier, NSS strongly encourages NASA to fully fund the existing COTS cargo and crew launch demonstration and development programs. Even if the competitors currently receiving funding—SpaceX and Orbital Sciences—do not manage to close “the gap,” I believe the capabilities they develop will only serve to strengthen U.S. commercial space transportation. After all, if it is truly NASA’s goal to focus on exploration, then it will be left to the private sector to handle basic transportation services to low-Earth orbit. The more providers in the market, the lower the potential cost to the government when it needs services in the future.
- **ISS Crew and Cargo Operational Services** – Once SpaceX, Orbital, or other providers begin to show results, it is incumbent upon NASA to select those services to support ISS *first*, with Ares and Orion providing the backup. If the private sector is truly able to generate the economies of scale necessary to dramatically reduce the cost of LEO access, it would truly be a waste of highly capable exploration hardware to make those trips.
- **Suborbital Commercial Vehicles** – Suborbital commercial spaceflight will transform the public’s relationship with space, and unlock new opportunities for scientists and astronauts to fly to space with unprecedented frequency. These advantages have been recognized and supported in multiple speeches by NASA Administrator Michael Griffin.

These new vehicles will serve as platforms for critical climate science research, and offer space professionals authentic space training at higher volumes and a fraction of the cost of orbital spaceflight.

Under the leadership of Administrator Griffin and Deputy Administrator Dale, NASA has already taken the lead on this opportunity by creating the Suborbital Scientist Participant Pilot Program, which would enable scientists to fly with their experiments as they do onboard high altitude research airplanes. NASA should take the next step for the program by issuing a Research Announcement this year to investigators, to implement the program as commercial vehicles come online over the next two years.

This program should be supported via Congressional authorization, receive appropriations as part of the new NASA initiative in suborbital flight, and be encouraged to expand, for it offers students and researchers the chance to operate space experiments affordably and at high flight rates. It will also encourage a new generation of young people to pursue science and engineering degrees, knowing that they have a good chance to fly to space. Additionally, the US astronaut corps may find it valuable for space training, particularly during the gap in American orbital spaceflight capability.

- **Parabolic Flight:** NASA has recently engaged an outside provider of parabolic flight services after a lengthy competition. This direction is the right direction for the agency, because outside companies can defray their costs over multiple customers, saving the government money while

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<sup>3</sup> Sadeh, Eligar. *Space Politics and Policy: An Evolutionary Perspective*. ISBN 1402008791, Springer, 2003.

building commercial American capability. The Senate should support this activity, and encourage the agency to pursue similar efforts.

- **Centennial Challenges** – Congress should reinforce the important role Centennial Challenges can play in developing new technologies and capabilities critical to NASA’s mission, and in creating economic benefit for taxpayers. This is a relatively low-cost, low-risk way for the government to obtain the benefits of new technology, paying only for success.

All of these activities enable private citizens, especially our young people and students, to learn, develop, and be rewarded for new technologies.

### **Participatory Exploration Activities**

As a tactical and practical matter, NASA must integrate public participation meaningfully at the initial design phases of its missions. This means using the tools of the Internet as means of allowing private citizens access and input into future exploration missions. This goes beyond the simple distribution of images via the Web, to an era in which the public truly experiences space exploration, in real-time and in high resolution. Participatory exploration offers the opportunity for NASA and other space organizations to redefine the public’s relationship with exploration, and energize the public about space exploration goals and missions.

Ames Research Center’s open forum in the “Second Life” web-based graphical environment, known as Co-Lab, provides one such model for participation. Private citizens are allowed to join in discussions about goals and experiments being developed for robotic exploration of other worlds.

OpenNASA.com has become a sounding board for NASA’s Generation Y employees to share their experiences and thoughts about how to improve the agency at a technological and cultural level.

To encourage future interest and mass participation in future missions, NASA could incorporate Web-based interactivity into robotic landers from the start. For example, viewers could vote on where a rover might travel to next, where to place the American flag on a future human mission to the Moon or Mars, or what to name particular features of a landing site.

All of these methods are electronic means of attracting and holding the attention of a generation that has grown up with the Internet and *expects* interactivity—in technologies as well as organizations.

### **D. Other Relevant Items for the Attention of the Committee**

It might seem paradoxical, but while support for NASA remains consistently high, the public often has little specific knowledge of the benefits they receive from the agency’s activities. NASA’s human exploration missions can be used to address most of the major issues threatening our uncertain world, from energy independence, to economic, national, and environmental security. In other words, the space program can help address issues Americans are concerned about most.

### **Energy Resources: Space Solar Power**

Space-based solar power, supported by lunar resources and human settlements in space, is a solution that could one day have tangible benefits directly affecting all Americans, and is a strategic goal worthy of our imaginations and national spirit. While SSP is not a short-term solutions for national energy production, the nation must begin investing in such technologies at higher levels, so that we will be ready for transitions away from traditional fuel sources in the decades to come. **Congress should authorize NASA and related agencies to create a space-based solar power prototype satellite, to be operated**

**in Earth orbit or at the International Space Station**, as well as other space-based technologies that can address these problems.

The historic investment in aerospace capabilities which America has made through NASA, and related space investments from DoD to Comsat, have matured at a critical time. Robert Hirsch testified before the House Science & Technology Committee on February 29, that the dean of world oil analysts, Charlie Maxwell, “expects gasoline at \$12-15 per gallon within a few years”.

Competition for global oil production has produced these soaring prices. Shell Chief Executive Jeroen van der Veer said, “We are experiencing a step-change in the growth rate of energy demand due to population growth and economic development, and Shell estimates that after 2015 supplies of easy-to-access oil and gas will no longer keep up with demand. As a result, society has no choice but to add other sources of energy.”

Coal use in China, India and elsewhere is rapidly expanding. In 2006, China built 100,000 megawatts of coal-fired power plants, according to the International Energy Agency, which far exceeds the entire generation capacity of the United Kingdom. India built 22,000 megawatts of new electricity plants in the last five years and has plans to add 70,000 megawatts in the next five years.

By 2010 plug-in hybrid vehicles are scheduled to replace some gasoline demand with electric vehicles using "smart" utility meters to charge these at night. The Pacific Northwest National Laboratory found that existing U.S. power plants could meet the electricity needs of 73% of the nation's light vehicles if the vehicles were replaced by plug-ins that recharged at night. Such a huge shift could cut oil consumption by 6.2 million barrels a day, eliminating 52% of current imports. But where will all the energy come from in the decades to come?

Many energy “solutions” have been proposed, including conservation, windmills, bio-fuels plants, ground-based solar cells, “clean” coal and nuclear power. While useful, these still merely nibble at the vast energy, economic & environmental problems we face. Robert Hirsch has repeatedly emphasized in Congressional statements what the International Energy Agency has been saying, that we – as well as the other developed countries, are “doing nothing on the scale required” to address our growing global energy shortfall.

One future option is Space Solar Power. SSP offers the potential for reliable, virtually unlimited, clean, baseload energy. The potential advantages are clear:

- SSP can take advantage of our current and historic investment in aerospace expertise to expand employment opportunities. SSP’s technologies are near-term and have multiple attractive approaches. Many thousands of STEM jobs, on inspiring work that we understand how to do is needed to bring them to practical fruition.
- Unlike coal, oil, gas, ethanol, and bio-fuel engines, SSP emits very little CO<sub>2</sub>, only an antenna is on the Earth (the proper term is rectenna, or “rectifying antenna”).
- Unlike bio-ethanol or bio-diesel, SSP does not compete for increasingly valuable farm land or depend on natural-gas-derived fertilizer. Corn and other foodstuffs can continue to be a major export instead of a fuel provider.
- Unlike nuclear power plants, SSP produces no hazardous waste or nuclear weapons-grade material.
- Unlike terrestrial solar and wind power plants, SSP is available 24 hours a day, 7 days a week, in endless quantities. SSP ignores cloud cover, night, storms, dust

and wind. Our understanding of the magnetosphere & solar wind interaction – SSP’s GSO operating environment – has become highly mature since 1962.

- Unlike coal and nuclear fuels, SSP does not require environmentally problematic mining operations.
- SSP may one day provide true energy independence for the nations that develop it, eliminating a major source of national competition for limited Earth-based energy resources and dependence on unstable or hostile foreign oil providers.
- SSP can be easily “exported” anywhere in the world, and its vast energy can be converted to local needs, from appliances in Asia to desalination of sea water in the American West.

SSP would revitalize America by showing that a multitude of space-development-related educational fields, from telerobotics to space transportation, from wireless power transfer to photovoltaics and environmental sciences, are vitally relevant to these great problems. Reduced launch costs, the key enabler, will provide unprecedented access to space and space operations beginning with clean, baseload SSP - reliable power delivery and global energy security at greatly reduced environmental impact.

### **Resources: Helium 3**

Another potential space-based alternative energy source is atomic fusion using helium-3, an element rare on Earth, yet abundant on the lunar surface and in the atmospheres of the gas giants. This connects well with the Vision for Space Exploration, and offers a concrete material which NASA could prospect for.

America’s new launch vehicles and manned spacecraft are suitable to support a return to the moon and development of mining and refining technologies, and should therefore continue as planned. Our first outpost on the moon can be supported by engineering projects to create infrastructure supporting solar power satellite production as well as extraction and use of helium-3.

### **Global Climate Change**

NASA may be the most well-equipped agency in the world to help to solve the monumental challenge facing our generation: climate change. NASA was instrumental in diagnosing the problem, and now is well equipped to help ameliorate it.

The connections between NASA and the Earth’s environment are deep and powerful. NASA is one of the world’s foremost climate change research organization, producing more climate data than any institution on Earth. It also possesses world-class engineering capabilities. There is growing agreement that NASA must make climate and energy research more central to its mission and purpose, and that NASA can play a central global role connecting scientific results with solutions for the planet.

### *Modeling, Simulation, Visualization*

NASA plays a leading role in the international community by analyzing the earth observation data forecasting potential futures. Modeling and simulation can help to understand how quickly the climate is changing and assist with sustainable agriculture, urban planning and disaster response.

### *Systems Engineering*

NASA has a long history of successfully executive major engineering efforts such as the Apollo moon program, the Space Shuttle, and the International Space Station. In order to architect such large efforts, a mastery of systems engineering is employed. Moreover, in the case of the International Space Station, these engineering solutions have been created in an international context. The next step is to task NASA to conduct system engineering of the planet, organizing global efforts to understand and mitigate the drivers of climate change.

### *Technology Innovation*

Space is a challenging environment. To learn to live and work in the engineering constraints of the space environment has challenged NASA engineers to come to a deep understanding of the challenges of closed environmental systems. Under tight engineering constraints, NASA engineers have innovated by creating lightweight, low power, highly efficient, and closed loop systems. These innovations have direct applicability in the clean technology and green technology sector today. Further, solutions like Space Solar Power, in which energy is collected in orbit and beamed to earth, offer long-term prospects for clean, renewable energy that deserve measured investment today.

The world has known about the “greenhouse effect” since the 19<sup>th</sup> century, when scientists first began to understand the nature of our planet’s atmosphere and how it works. It acquired new urgency during the rise of the environmental movement in the early 1970s. Since that time, NASA’s Earth-monitoring satellites and sounding rockets have continued to record the planet’s temperatures, both highs and lows, at all levels of the atmosphere. If the world is to act responsibly in response to global climate change, it will require the climate data NASA collects as one of its many useful missions.

Exploring other worlds has also taught us about Earth’s climate. The first images transmitted from Venus in 1975 caused astronomer Carl Sagan to call it a “runaway greenhouse.” With its thick, poisonous, carbon-dioxide-rich atmosphere and 500-degree temperatures, Venus provided a theoretical model of what could happen to our own planet if we allowed our civilization’s emissions of greenhouse gases like CO<sub>2</sub> to get out of control. It was the first real example of how space exploration could affect not just our consciousness as a people, but also our behavior and policies. Venus became an object lesson in comparative planetology.

And yet, nearly fifty million miles beyond Earth lies the planet Mars. It, too, has an atmosphere composed largely of carbon dioxide. And yet that atmosphere is very thin, and its surface temperatures range from barely warm to unbearably frigid. Why? What lessons does Mars have to teach us about planet Earth and how we behave on it? Unlike Venus, we can visit Mars using current technologies, and thus we can go there and find out for ourselves. Climate change is an issue Americans are passionate about. We owe it to our citizens and the people of the world to do all we can to collect the data we need to act wisely for future generations.

### **Planetary Defense**

There are vast numbers of asteroids in near-Earth orbits. Though it may seem unlikely, if we do nothing, sooner or later we will be hit by an asteroid large enough to threaten life on Earth. Given the nature of this threat, the space program is a logical place to start developing strategies for overcoming it. This is environmental protection of the highest order.

In October of 1990 a very small asteroid struck the Pacific Ocean with a blast about the size of the atomic bomb that leveled Hiroshima, killing roughly thousands of people in seconds. If this asteroid had arrived ten hours later, it would have struck in the middle of more than a million U.S. and Iraqi soldiers preparing for war. How would America have reacted to what looked like a nuclear attack?

In 1908 a small asteroid (perhaps 50 meters across) hit Tunguska, Siberia and flattened 60 million trees. That asteroid was so small it never even hit the ground, just exploded in mid-air. If it had arrived 4 hours and 52 minutes later, it could have hit St. Petersburg. At the time, St. Petersburg was the capital of Russia with a population of a few hundred thousand. The city would have ceased to exist. As it was, dust from the blast lit up the skies of Europe for days. Asteroid strikes this size probably happen about once every one hundred years. There was another Tunguska-class strike in the Brazilian rain forest on August 13, 1930.

Sixty-five million years ago a huge asteroid several kilometers across slammed into the Yucatan Peninsula in Mexico. This is the event that is thought to have caused the extinction of the dinosaurs (and many other species). The explosion was the equivalent of about 200 million megatons of dynamite. The blast turned the air around it into plasma — a material so hot that electrons are ripped from the atomic nucleus and molecules cannot exist. This scenario has been repeated perhaps once every 100 million years or so. As many as two-thirds of all species that ever existed may have been terminated by asteroids hitting the Earth.

We know about the asteroid that killed the dinosaurs because we found the crater. But when an asteroid hits the ocean, there may not be a crater. If a 400-meter (four football fields) diameter asteroid were to fall into the Atlantic Ocean, it would cause a tsunami 60 meters high.

The only way to eliminate the threat of asteroids is to detect and divert them. A vigorous space-based civilization capable of reaching, exploring, and diverting asteroids into useful, safe orbits would have enormous economic incentives to find and use every asteroid passing near Earth. The asteroids could be found, diverted, and mined for their materials, including platinum-group metals, water ice, and iron, which could be used to make steel. This would defuse the threat, make a lot of people extremely rich, and keep an entire world safe.

### **Peace and Security**

Civil space must be a key element of diplomacy for the coming years, because space is uniquely suited to addressing certain challenges of the current international landscape. The use of space as a strategic means of diplomacy can strengthen relations with allies, reduce future conflicts with strategic competitors, and engage members of the developing world in productive directions, all while accomplishing projects of value to America and the world.

The success of ISS and its international partnerships has formed a model for how nations can come together to build great things in space. While mistakes have been made and progress has not been as rapid as we would like, ISS has established an important precedent for strategic cooperation in space. We will need such cooperative ventures as we move on to explore and settle the Moon and the planet Mars. And cooperation in space can, we believe, lead to strategic and diplomatic goodwill on Earth-based matters as well.

### **Concluding Thoughts**

Our nation's human spaceflight program can be about more than just being "great," it can also be about being "good," by meeting the urgent needs of all Americans and the planet as a whole. Such efforts offer NASA a vision the public will follow for the long haul, embracing as it does both economic opportunities for individuals and technological benefits for the common good.

The nation faces an historic opportunity with regard to space this year. In a time of uncertainty, Congress and the next president can use human space exploration as a means to advance and improve this nation as part of a sustained commitment to solving the challenges we face today. Space exploration can provide a common keystone for the many issues confronting us today, from education to economic uncertainty to energy production, planetary health and safety, international cooperation, and economic competitiveness. A re-authorized Vision for Space Exploration, with the recommendations I've suggested, would be an excellent starting point for building a truly spacefaring civilization. Therefore, I encourage you to continue supporting human exploration beyond LEO, and onwards to Moon, Mars, and beyond.