U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE AND AERONAUTICS

HEARING CHARTER

Enhancing the Relevance of Space to Address National Needs

Thursday, July 16, 2009
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

I. Purpose:

On Thursday, July 16, 2009 the Subcommittee on Space and Aeronautics will hold a hearing on enhancing the relevance of space activities to address national needs. The hearing will (1) examine how recent reports by the National Research Council and The Space Foundation characterize the relevance of space-related activities, particularly their role in improving the health, economic well-being, and the quality of life of all Americans; (2) review what should be done to maintain and enhance that relevance; and (3) analyze whether enhanced awareness of the contributions from space-related activities would result in inspiring future generations of Americans. The hearing will focus on the following questions and issues:

- *How relevant is space to addressing important national needs, and what noteworthy benefits have been achieved as a result of past space-related investments?*
- *What should be done to maximize the benefits to be realized from the nation's space activities and the relevance of those space activities? How important is it for those activities to be aligned to national goals and objectives?*
- *How important is the inspirational component of the nation's space activities, and what would be the most effective ways to use space activities to motivate emerging generations of Americans to pursue studies and careers in science and engineering?*
- *How well does the public understand the relevance of the nation's space activities to meeting national needs and realizing societal benefits? Is there a need to "get the message out" on the relevance of those space activities and the benefits to be derived from our space-related investments? If so, how can that message be most effectively communicated?*
- *The nation's space program generated considerable public excitement during the Apollo era. What will it take to get today's public interested and enthused about the nation's space program?*
- *What challenges do communications media face in attempting to reach the broadest and largest possible audience while engaging and enlightening them about space? What tools and strategies are used to address those challenges?*

II. Witnesses:

General [U.S. Air Force, retired] Lester L. Lyles
Chair of the Committee on the
Rationale and Goals of the U.S. Civil Space Program
Aeronautics & Space Engineering Board
National Research Council

Ms. Patti Grace Smith
Board of Directors
The Space Foundation

Ms. Debbie Adler Myers
General Manager, Science Channel
Discovery Communications

Mr. Miles O'Brien
Journalist

III. Overview

Forty years after accomplishing the feat of landing humans on the Moon's surface, the U.S. civil space program, including its largest component, the programs of the National Aeronautics and Space Administration (NASA), finds itself at a critical juncture. Key factors that will influence the future of the U.S. civil space program include:

- **Upcoming results from an independent review of U.S. human space flight**. The Obama Administration has initiated an independent review of "*ongoing U.S. human space flight plans and programs, as well as alternatives, to ensure that the nation is pursuing the best trajectory for the future of human space flight—one that is safe, innovative, affordable, and sustainable.*" Led by Norman Augustine, the blue-ribbon committee held a public meeting in Washington last month and has several others planned in the weeks ahead. Results and supporting analysis are scheduled to be provided in August 2009, in time to support a decision on the way forward. Until then, NASA is continuing on a path to complete the International Space Station (ISS) and retire the Space Shuttle fleet in 2010, develop its next generation of human space transportation systems, and encourage the development of commercial space transportation systems capable of bringing cargo to the ISS.
- **Direction from a new NASA Administrator.** Charles Bolden, nominated to head NASA, said at his Senate confirmation hearing last week that he wanted to rekindle the pioneering spirit of the space agency's early manned space program. His strategy for achieving that objective will have an impact on the future direction of the agency.
- **Future NASA funding levels**. Many in Congress have argued that NASA's budgets have not kept pace with the tasks it has been asked to carry out. How this mismatch is resolved will have a major impact on NASA's future.

- **Competition and cooperation in space**. Other nations' ambitions in space have resulted in significant progress and accomplishments. China has joined the United States and the former Soviet Union as the only countries to have launched humans into space. Europe is considering the feasibility of developing its own human space flight transportation system, as is India. The once dominant U.S. civil space program finds itself no longer the only game in town. Moreover, it is now commonplace for U.S. commercial space interests to find themselves in vigorous competition with other nations' space companies in vying for business in a global environment. However, cooperation in space has long been a significant element of the U.S. civil space program. In establishing the National Aeronautics and Space Administration through the National Aeronautics and Space Act of 1958 (P.L. 85-568, as amended), Congress made clear its intent that the space program provide benefits to people, that research be utilized, and that the United States cooperate with other nations in "*the peaceful application*" of its space activities. Many of today's societal challenges including climate change, food security, and availability and access to natural resources and energy supplies are global in nature. Space assets and cooperation among nations in space activities are expected to be important in addressing these global societal issues. The future scope of international cooperation on space activities will likely shape the direction of the civil space program here in the U.S.
- **Relevance of space to the public**. While NASA remains generally popular with the public according to various polls, concern has been raised about public understanding of what the agency is doing and how space research and developments help improve our lives. At present, Americans and society at large use multiple services and technologies that were developed, initially, within the context of the U.S. space program. For example, communications satellites, space-based weather monitoring and prediction, and precision navigation and timing emerged from the nation's investments in space; today these assets are critical to our basic infrastructure. Space technologies have also enabled improved medical imaging, telemedicine, and disease tracking, among multiple other applications. NASA has documented many of the technologies, products and services derived from investments in the space program in its annual NASA Spinoffs publications (http://www.nasa.gov/offices/ipp/home/index.html). In addition, the agency has developed a tool called NASA City that allows users to trace the impact of space on their daily lives (www.nasa.gov/city). Yet, although the applications of space research and development are infused in the everyday life of Americans, there is a perception that the public lacks awareness of how space affects their lives, which can contribute to a lack of enthusiasm for space program investments.
- **Replenishing a skilled workforce for continued leadership in space activities.** The perceived lack of excitement may influence the maintenance of a skilled future civil space workforce. A February 2003 article by the Wall Street Journal stated: *"Many young people today with a technical bent are more entranced with the Internet or biotechnology than space exploration. Space travel, after all, was a fascination of their parents' generation"*.

The National Research Council recently examined the relationship between the U.S. space program and societal and national needs and priorities and how U.S. leadership can be maintained. Key elements of that report are described in the following section. In

addition, space advocacy groups have identified the benefits of space to society and have documented, for example, the contributions of space to the national and global economy. The Space Report 2009, published by the Space Foundation, which is summarized in this hearing charter, is one example. These and many other organizations have also emphasized the importance of space in inspiring the next generation to excel in science, technology, engineering and mathematics and in ushering in a steady pipeline of professionals to replenish an aging aerospace workforce. Communications and media organizations confront the challenge of how best to engage individuals by using science content related to space. Perspectives from such organizations and individuals can provide insight into some of the approaches that have been taken to effectively communicate the excitement of space to the public.

IV. Background

National Research Council's Report on *America's Future In Space: Aligning the Civil Space Program with National Needs*

The National Academies' National Research Council (NRC) recently released a report that recommended a series of measures to better align the civil space program with national needs. The report's overall conclusion is " *that a preeminent U.S. civil space program with strengths and capabilities aligned for tackling widely acknowledged national challenges—environmental, economic, and strategic—will continue to make major contributions to the nation's welfare*." The impetus for the NRC's chartering a review was its recognition of a changing national and international context for space activities. The U.S. space program, initially driven by competition with the former Soviet Union, now finds that many nations have established, or are aspiring to develop, independent space capabilities. Developments over the past 50 years have led to an explosion of scientific and engineering knowledge and practical applications of space technology. Space activities now play critical roles in commerce, government, and science. Furthermore, the private sector has become a significant factor in the expansion of space-related products and services.

In light of this changing context, the NRC established the *Committee on the Rationale and Goals of the U.S. Civil Space Program* and charged it to prepare a report to advise the nation on key goals and critical issues in 21st century U.S. civil space policy. The committee's report, prepared under the oversight of both the NRC's Space Studies Board and Aeronautics and Space Engineering Board, is entitled "*America's Future In Space: Aligning The Civil Space Program With National Needs*".

In its initial discussions, the committee concluded that debates about the direction of the civil space program often focused on addressing near-term problems and issues "*without first putting those issues in the context of how a disciplined space program can serve larger national imperatives. In the committee's view, characterizing the top-level goals of the civil space program and the connection between those goals and broad national priorities is necessary as a foundation on which the nation (both now and in the future) can devise sustainable solutions to nearer-term issues.*"

Consequently, the committee chose to focus on the long-term, strategic value of the U.S. civil space program. In responding to its charge, the committee "*sought to provide a long-term, strategic perspective that frames a vision for civil space activities that can endure for many years*." According to the report, the committee's thinking was informed by the following national priorities:

- "*Ensuring national security,*
- *Providing clean and affordable energy,*
- *Protecting the environment now and for future generations,*
- *Educating an engaged citizenry and a capable workforce for the 21st century,*
- *Sustaining global economic competitiveness, and*
- *Working internationally to build a safer, more sustainable world*."

The report added that *"A common element across all these urgent priorities is the significant part that research and development can play in solving problems and advancing the national enterprise in each area."* The importance of space-related activities to generating interest in science was not lost on the committee. The report noted:

"The high visibility of space activities attracts students' attention to science, technology, and mathematics, and space activities are an exciting focus for teaching those subjects. Commercial space-related ventures now figure significantly in global economic competitiveness, and, while government investments to stimulate the nation's fragile economy will have short-term impacts, R&D investments can be counted on to make longer-term sustainable contributions to the nation's economic strength. As has countless times proved the case, research in and from space will continue to lead to important future, and not always currently predictable, benefits that hold the promise of progress toward realizing U.S. as well as shared international goals".

The committee believed that to be a strategic leader in a globalized world, the United States needed "*a civil space program whose breadth, competence, and level of accomplishment ensures that U.S. leadership is demonstrated, accepted, and welcomed*." Consequently, the committee identified six strategic goals that it regarded as basic for guiding program choices and resources planning for U.S. civil space activities. The goals identified in the committee's report are:

- *"To re-establish leadership for the protection of Earth and its inhabitants through the use of space research and technology. The key global perspective enabled by space observations is critical to monitoring climate change and testing climate models, managing Earth resources, and mitigating risks associated with natural phenomena such as severe weather and asteroids.*
- *To sustain U.S. leadership in science by seeking knowledge of the universe and searching for life beyond Earth. Space offers a multitude of critical opportunities, unavailable in Earth-based laboratories, to extend our knowledge of the local and distant universe and to search for life beyond Earth.*

- *To expand the frontiers of human activities in space. Human spaceflight continues to challenge technology, utilize unique human capabilities, bring global prestige, and excite the public's imagination. Space provides almost limitless opportunities for extending the human experience to new frontiers.*
- *To provide technological, economic, and societal benefits that contribute solutions to the nation's most pressing problems. Space activities provide economic opportunities, stimulate innovation, and support services that improve the quality of life. U.S. economic competitiveness is directly affected by our ability to perform in this sector and the many sectors enabled and supported by space activities.*
- *To inspire current and future generations. U.S. civil space activities, built on a legacy of spectacular achievements, should continue to inspire the public and also serve to attract future generations of scientists and engineers.*
- *To enhance U.S. global strategic leadership through leadership in civil space activities. Because of the growing strategic importance of space, all nations that aspire to global political and economic leadership in the 21st century are increasing their space-faring capabilities. Continued U.S. global leadership is tied to continued U.S. leadership in space."*

To contribute to realizing these national objectives, the committee identified four foundational elements it viewed as "*critical to a purposeful, effective, strategic U.S. space program, without which U.S. space efforts will lack robustness, realism, sustainability, and affordability*". These are:

1. *"Coordinated national strategies—implementing national space policy coherently across all civilian agencies in support of national needs and priorities and aligning attention to shared interests of civil and national security space activities.*
2. *A competent technical workforce—sufficient in size, talent, and experience to address difficult and pressing challenges.*
3. *An effectively sized and structured infrastructure—realizing synergy from the public and private sectors and from international partnerships.*
4. *A priority investment in technology and innovation—strengthening and sustaining the U.S. capacity to meet national needs through transformational advances."*

"The committee found that, in spite of their promise and utility, components of the civil space program are not always aligned to fully capitalize on opportunities to serve the larger national interest. Decisions about civil space priorities, strategies, and programs, and the resources to achieve them are not always made with a conscious view toward their linkages to broader national interests." The committee made seven recommendations:

1. *"Addressing national imperatives. Emphasis should be placed on aligning space program capabilities with current high-priority national imperatives, including those where space is not traditionally considered. The U.S. civil space program has long demonstrated a capacity to effectively serve U.S. national interests."*
2. *"Climate and environmental monitoring. NASA and NOAA should lead the formation of an international satellite-observing architecture capable of monitoring global*

climate change and its consequences and support the research needed to interpret and understand the data in time for meaningful policy decisions."

3. *"Scientific inquiry. NASA, in cooperation with other agencies and international partners, should continue to lead a program of scientific exploration and discovery."*
4. *"Advanced space technology. NASA should revitalize its advanced technology development program by establishing a DARPA-like organization within NASA as a priority mission area to support preeminent civil, national security (if dual-use), and commercial space programs."*
5. *"International cooperation. The government, under White House leadership, should pursue international cooperation in space proactively as a means to advance U.S. strategic leadership and meet national and mutual international goals."*
6. *"Human spaceflight. NASA should be on the leading edge of actively pursuing human spaceflight, to extend the human experience into new frontiers, challenge technology, bring global prestige, and excite the public's imagination."*
7. *"Organizing to meet national challenges. The President of the United States should task senior executive-branch officials to align agency and department strategies; identify gaps or shortfalls in policy coverage, policy implementation, and in resource allocation; and identify new opportunities for space-based endeavors that will help to address critical issues now confronting the United States and, to a considerable extent, the world as well."*

In the course of this report, several points were made that are relevant to the work of the Subcommittee:

- **There is no single rationale for a U.S. civil space program**: *"The committee's view is that there is no single rationale for the U.S. civil space program, but rather that, as a significant component of the nation's R&D enterprise, the U.S. civil space program should be structured and supported to fulfill multiple responsibilities to assist the nation in achieving its goals of exerting strategic leadership and improving the well-being of people. The U.S. civil space program should be preeminent in the sense that it can influence, by example, how nations take advantage of the opportunities afforded by space. For the United States to be a strategic leader, its civil space program must demonstrate breadth, competence, and a record of accomplishment so that U.S. leadership is accepted and welcomed."*

- **There is unavoidable risk in human activity in space**: *"Humans have proven effective in carrying out a variety of important roles as engineers and scientists in space. It is reasonable to expect that, in this century, humans will again surpass previous limits and will visit asteroids, travel to the moons of Mars, and establish a martian base similar in scale to those in Antarctica. In the committee's view, the leadership and inspiration achieved by expanding the frontiers of human spaceflight are worth the dangers faced in such exploration; lesser objectives may not be worth the same risk."*

- **By pursuing the goal of inspiring, the space program will create other benefits**. Through pursuit of such a goal, the report said that the space program will:

- *"Instill a sense of interest, excitement, and optimism about opportunities for scientific and technological advancements to enhance the well-being of the nation,*
- *Attract and encourage members of the next generation of the nation's technical workforce, and*
- *Create a new generation who can draw on the advantages offered by space to help solve problems on Earth, and ensure U.S. leadership, building on the solid achievements of the past 50 years of U.S. investments in space."*

- **Civil space activities provide an important stimulus for the next generation to pursue careers in science, technology, engineering, and mathematics. "***The NASA Authorization Act of 2008 states that "NASA, through its pursuit of challenging and relevant activities, can provide an important stimulus to the next generation to pursue careers in science, technology, engineering, and mathematics". While specific to NASA, this statement applies to all aspects of the U.S. civil space program. Furthermore, a reputation for competence in executing space missions that advance the frontier is likely to help attract talented foreign nationals to study and work in the United States as well as to inspire our own students to enter technical fields."*

- **A vigorous space program generates optimism**. *"Civil space activities also can exert an influence in building citizens' confidence in a brighter future. We live in a world with many immediate concerns--notably including a weakened world economy, regional conflicts and global terrorism, and threats of the consequences of climate change and limitations in energy sources. It is a time when people can be fearful that our tomorrows will be less promising than our past; that our children will have fewer opportunities than we enjoyed.*

  Surely, a vigorous civil space program will be a strong signal that our future as a nation is promising, that life can be better, that our prospects are boundless. Civil space assets, with their global perspective on the changing Earth, can provide knowledge to enable wise stewardship of our planet's bounty. We can become a true space-faring society with new opportunities for our economy. Civil space activities will add to knowledge of our place in the cosmos and thereby expand the cultural richness of our nation.

  The United States, leading by example and in cooperation with others in the exploration and utilization of space, can be a strategic leader in the world, not to be feared or despised, but rather to be valued for its concerted attention to basic challenges facing people worldwide."

- **Matching responsibilities to resources does not currently exist today**. *"A coordinated, sustainable set of strategies should ensure that responsibilities are realistically matched to available resources. Such a match does not exist today. For example, NASA has a central role in civil space, yet by any reasonable measure it is inadequately funded to pursue its many responsibilities. NASA now follows the U.S. space exploration policy established in 2004 by then President George W. Bush but*

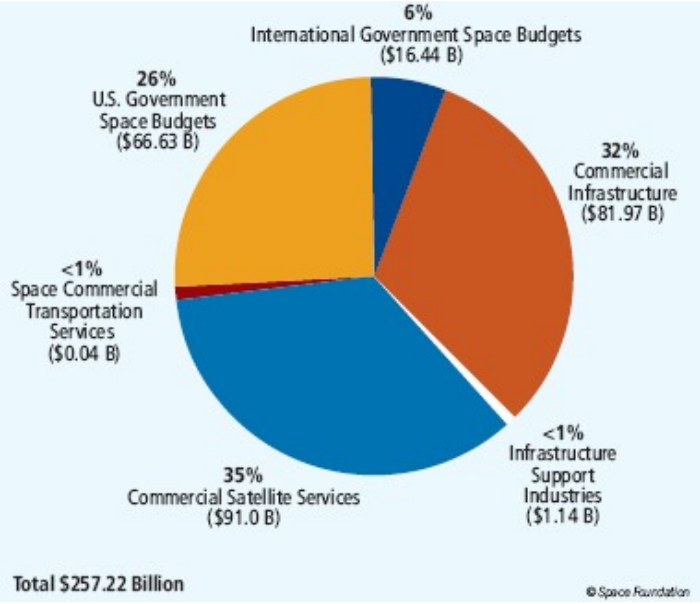
must implement that policy within the budget constraints imposed by the Administration and Congress. The committee concurs with the primary conclusion of a 2006 NRC report, which summarized the situation by saying, "NASA is being asked to accomplish too much with too little. The agency does not have the necessary resources to carry out the tasks of completing the International Space Station, returning humans to the Moon, maintaining vigorous space and Earth science and microgravity life and physical sciences programs, and sustaining capabilities in aeronautical research". Rather than requiring that a broad and ambitious program be fit into an arbitrarily constrained budget as has been the case in recent years, a sustainable strategy would first define the program that the nation is committed to undertake and then realistically define the resources that are required to accomplish that program."

- **Budget levels need to recognize space programs' connection to the nation's most prominent problems.** "*The budgetary situations faced by NASA and NOAA* [National Oceanic and Atmospheric Administration] *are a consequence of a trend in recent administrations to view the space program as an isolated stovepipe, with little or no connection to the nation's most prominent problems. Civil space programs have largely been assigned budget levels that are incrementally based on previous years' budgets, with only tenuous connections to the evolution of the programs or their capabilities. An effective process would connect space policy to broader national needs, and then consider the necessary resources and implementation, improve efficiency by considering interdependencies and broad system effects, enhance productivity by providing focus and a longer-term view, and encourage a culture of collaboration among government agencies, the private sector (including both industry and academia), and international partners. This process would then provide a necessary foundation for continuing U.S. space leadership."*

General Lester Lyles, Chair of the Committee on the Rationale and Goals of the U.S. Civil Space Program, will be a witness at the hearing and can provide further details on the committee's work. The Executive Summary of the committee's report is included in Attachment I.

The Space Foundation's "*The Space Report 2009*"

In chronicling the previous year in space along with an outlook on what lies ahead, the Space Foundation's *The Space Report 2009,* released in April 2009, establishes the relevance of space by detailing the overall space economy; space products and services; space infrastructure; and economic impacts, workforce, and education. The report states that, "*in a troubled financial environment, the space industry managed to maintain and increase its revenues in 2008, with estimated budgets and revenues from public and private sources of $257 billion. Total revenue for space products and services in 2008 reached an estimated $91 billion, 10.4% more than the $82.4 billion total in 2007".*



(Source: The Space Report 2009)

Of particular interest to this hearing is how *The Space Report 2009* treats space products and services. The report notes that:

"*The space industry has passed the point where all the ways in which space products and services are used can be described within the covers of a single publication. The examples in this report represent a small sampling to illustrate the breadth and ingenuity of the space industry in creating new ways to serve governments and the private sector. From private space travel to mobile Internet services to high-tech swimsuits, the space industry is fully engaged in finding new applications for existing technology and in developing new technologies to solve persistent problems. Common themes around some of these products and services involve making life easier and more interesting. In 2008, ICO Global Communications began testing a mobile TV service using a satellite over the United States designed to deliver up to 15 television channels for entertainment starting in 2010. Fishermen around the world are using satellite maps that report sea surface data to help guide them to profitable fishing grounds. The world watched U.S. Olympian Michael Phelps swim into the record books at the Beijing games. Less well known is the fact that Phelps and other Olympic swimmers were breaking records with the help of swimwear developed as a result of a technology spinoff from atmospheric drag research conducted for the Space Shuttle program.*"

In comments regarding how pervasive and integral space products, services, and spinoffs have become, the report states:

"Space products and services and their related space technology spinoffs have become part of the fabric of daily life in ways that people increasingly take for granted, and often in ways that do not even bring space to mind." The report provides a table listing examples of such technology spinoffs:

NASA Spinoffs, 2008

3-D immersive photography 3-D mapping & imagery software Advanced image analysis Aeroponic gardening system Automated panoramic photography Automotive lithium battery Clean energy-storing battery Deformation-resistant welding Dental water purification technology Drag-reducing Airtabs Electromagnetic biological cell separator Electron beam analyzer Faster prototyping software Fiber-optic sensing instruments	Friction-reducing swimwear Highly-durable polymer fabric High-speed, space-qualified circuit chip Improved space camera Industrial process monitoring system LED-based heat therapy Lockable knee brace Memory module for harsh environments Mid-power maximizer for outboard motors Non-invasive periodontal probe Nutrition fortification system Polymer coating for implantable medical devices	Polymer with high-temperature performance Portable rock and mineral analyzing device Pressure sensor for jet engine testing Protective suit for deep-sea divers Racecar testing system Rehabilitative robotic joints for horses Robotic arm for complex surgeries Robotic technology for harsh environments Robust, flexible thermal insulation Satellite development and testing technology Schedule management software	Software to identify scrap tire piles Stability augmentation for helicopters Stemless valve that reduces emissions Vehicle health manager Virtual reality software Vision screening technology Water filtration for disaster relief Water-based coating for circuit boards Web-based mapping system Weld-strengthening system Wireless fluid-level measurement for boats Wireless sensor network technology

(Source: The Space Report 2009)

The report also provides examples of how space products and services have contributed to improving health care. In describing one such example, the report stated:

"A collaborative effort between NASA and the University of Alabama at Birmingham (UAB) involves using satellite imagery to study and combat disease. Although this type of collaboration has occurred before, the new effort aims to formalize a training program. In 2008 a laboratory was set up to train public health students to use remote sensing for medical and public health applications. The students take courses both from NASA remote sensing scientists and UAB professors. Studies in the lab have been conducted on fighting malaria and the West Nile virus. Using infrared imagery from satellites, scientists can locate warm standing water, a breeding ground for disease-carrying mosquitoes. Satellites also collect data on pollution levels and other environmental factors in areas with high populations of asthma sufferers to determine the factors that might be causing asthma attacks."

In examining workforce issues, the report notes that:

"The highly visible rockets, satellites, telescopes, and other hardware that embody space exploration obscure the fact that these endeavors ultimately depend on skilled people. Scientists, engineers, astronomers, technicians, and administrators represent the true backbone of the space industry and are its most precious resource. The Space Report 2009 explores the talent pool needed to keep the space industry thriving. It describes the positive economic impact of space industry activity in states and metropolitan areas, and identifies a critical area of concern in the need to educate and train the next generation of U.S. space professionals. According to the U.S. Bureau of Labor Statistics, the U.S. space industry employs more than 262,000 men and women in 41 states including the District of Columbia. Between 2003 and 2007, the U.S. space industry sector added approximately 12,000 jobs at pay scales far above national averages. In just the commercial space transportation sector, the direct valuation according to the U.S. Federal Aviation Administration is $23 billion, and $139 billion when secondary and tertiary industries are included. This value exceeds 1% of the country's gross domestic product."

But keeping a flow of trained workers in the future will be a challenge. The report states:

"It is axiomatic that securing a skilled and technically trained workforce is critical to sustaining and growing the U.S. space industrial base. There is deepening concern that the young people who will make up the workforce required for the U.S. space industry to prosper into the future are not receiving the basic education they need in science, technology, engineering, and mathematics (STEM) fields. A long educational pipeline is required to develop these skills, beginning in elementary school and continuing through secondary and higher education. Science and technology levels in the United States, from kindergarten through the 12th grade (K-12) and at the postsecondary level, place the nation at a disadvantage relative to other countries. The most recent data shows that American students are slipping behind their international counterparts in math and science education. This situation is exacerbated as other nations such as China have become more aggressive in developing their indigenous technical talent base. These worrisome indicators point to a need for the U.S. space industry to intensify its advocacy for the highly educated and technically trained workforce that enables it to thrive.

The success of space-related activity depends upon workers with great technical expertise, from astronauts and aerospace engineers to space scientists. The U.S. Bureau of Labor Statistics (BLS) occupational outlook projections show that demand will be high during the next ten years for workers in key space occupations as the needs and demands of the space industry grow. For instance, the BLS projections confirm that total employment levels for aerospace engineers will be 10% greater in 2016 than the 2006 employment level. The number of advanced degrees awarded in the United States for space-related fields of study has been on the rise for years. However, virtually all of this growth can be attributed to an increasing percentage of foreign graduate students in these subjects."

In examining the state of science, technology, engineering, and mathematics education in the United States, the report provides some sobering and worrisome statistics about the nation's ability to address future workforce challenges:

"The results of this examination confirm prevailing concerns about shortages in the ranks of aerospace engineers as the scientists and technicians who began their careers during the era of the Mercury, Gemini, and Apollo programs reach retirement. According to U.S. government estimates, the employment levels for aerospace engineers needed to sustain anticipated activity will be 10% greater in 2016 than a decade earlier.

Meanwhile, results of proficiency testing in science and mathematics show reason for serious concern about low achievement levels in U.S. elementary and secondary schools, as the report details. Only 29% of the nation's 4th graders rated proficient in science; 39% in math. In a comparison of 36 nations, U.S. 4th graders ranked 11th in math achievement and 8th in science achievement. The nations outperforming the United States in these subjects include several that are pursuing ambitious space programs. Among 12th graders, only 18% achieved proficiency in science; 23% in math. In the physical sciences, more

than 93% of middle school students are taught by teachers who are not certified or did not major in those fields.

The worrisome trends in U.S. science and math education extend to the college level. Between 1986 and 2006, bachelor's degrees awarded in Earth and atmospheric sciences, engineering, math, and computer science fell 8%. Graduate level degrees have increased significantly at both the master's and doctoral levels, but that is due in part to the large number of foreign students studying in the United States. Immigration policies are making it harder for such students to come to the United States and study, and to stay once they graduate.

Engineering bachelor's degrees have declined by 11% in the United States over the past two decades. The percentage of undergraduate degrees in science and engineering has also dropped considerably in the past 20 years. Engineering degrees comprised only 5% of all bachelor's degrees awarded in 2006, down from 8% two decades earlier.

In addition to improving the quality of math and science education in secondary schools, the space profession has recognized the need to recruit more women into the field. While women represent a majority of the students who received bachelor's degrees in 2006, only one in five of the degrees in engineering were awarded to women that year. Female representation in the aeronautical and astronautical engineering fields has increased, but has a long way to go to reach parity.

Unless the current declining trend of space-critical degrees is reversed, many of these new jobs may go unfilled, opening the door to increasing competition from other countries for a field the United States has dominated for two generations."

In projecting its outlook for the future, *The Space report 2009* states:

"The picture of space activity that emerges in The Space Report 2009 is one of continued innovation and risk-taking in the private sector, and ambitious exploration and international cooperation in the public sector. So far, the clearest visible impact of the global economic downturn on the space industry is in the equity markets, where space industries collectively sustained deeper valuation losses than broader market indexes. The raw numbers concerning space activity in 2008 — employment, payroll, output, manufacturing, and launches — generally showed continued steady growth. There may be a lag time before a downturn in some of these measures of the space industry becomes apparent. If historic trends are indicative, the full impact of the economic slowdown on the commercial space industry may not be visible until 2009 or 2010 due to the numerous corporate growth program commitments and the consistently strong cash flows produced by the industry."

"Space activity has integrated itself so thoroughly into broader business activity, with an array of services vital to communication, travel, broadcast, and other industries, that the space industry is now part of the mainstream economy. It continues to demonstrate the

potential for growth, expanding its breadth and volume of activity, and growing new business arenas in which the space industry is, or has become, a key player."

Ms. Patti Grace Smith, a Member of the Board of Directors of The Space Foundation, will be a witness at the hearing and can provide further details on the Foundation's report.

Surveys and Polls of Public Views on Space

The National Academies and Space Foundation reports documented the importance of space to our national needs and the myriad ways in which space benefits our lives and society at large. However, the extent to which the public is aware of those benefits appears to be limited. In recent years, NASA and other nongovernmental entities have sponsored national surveys and public opinion polls to acquire feedback on how the public views NASA and the nation's space program. One of those surveys, which was conducted for a NASA Strategic Communications Implementation Framework, showed that public perception about the relevance of space changed after individuals were informed of examples of how space affects their lives.

- Gallup Polls

  Since 1990, Gallup has conducted polls to ascertain public attitudes about the job NASA is doing and public spending on space. According to Gallup, "*the public has generally rated NASA positively*." The two most recent Gallup polls were conducted in 2006 and 2007. The 2007 poll results were based on telephone interviews with 1010 adults (18 years of age or older).

  An October 31, 2007 article on Gallup's website, "Americans Continue to Rate NASA Positively*," on the results of the Gallup poll states: "According to the Sept. 14-16 poll* [2007], *56% of Americans rate the job NASA is doing in positive terms, with 16% saying it is doing an 'excellent' job and 40% a 'good' job. Meanwhile, just 8% say it is doing a poor job, with most of the rest describing NASA's performance as 'only fair*'."

  Gallup has asked the same question---"*How would you rate the job being done by NASA—the U.S. space agency? Would you say it is doing an excellent, good, only fair, or poor job?*" since 1990. According to the 2007 article, "*NASA has had less-than-majority positive evaluations just twice since 1990, when Gallup first asked this question. The initial 46% rating in July 1990 came shortly after a flaw in the Hubble telescope was discovered. Gallup measured the historical low rating of 43% in September 1993 after a series of mishaps, which included the loss of contact with the Mars Orbiter and a couple of last-second decisions to scrub planned space shuttle missions*." In addition, the 2007 article notes that "*The high point in NASA's ratings came in November 1998, shortly after Sen. John Glenn – one of the earliest U.S. astronauts – made a much-heralded return trip to space*."

- Public Views of Space Exploration: An Independent National Survey

In February 2009, The Everett Group, conducted an independent national survey to:

  - "*Gauge Americans' impressions of the space program relative to other national institutions*
  - *Determine what the public perceives to be the greatest benefits of the space program*
  - *Gauge the level of public support for an increase in funding for the space program*
  - *Identify future missions that the public would support."*

The survey included a random sample of 360 U.S. adults.

In response to the question, "*How would you describe your overall <u>interest</u> in the U.S. space program?"*, the participants answered: *very interested (15%), somewhat interested (44%), not too interested (22%), and not at all interested (19%).*"

In response to the question, "*Can you think of any ways that your life has been improved directly by the U.S. space program?*", "*Half of the public says 'Yes' and can name one or more ways the space program improved their life*." "*The other half says 'No' and believes that the program has not improved their life in any way*." Of those that answered that space improved their lives and provided an example, "*satellites, knowledge about the universe, and new technology"* were the three most common examples cited. Other responses included "*computers, Velcro, foods, cell phones, plastics, knowledge about weather/environment, microwaves, medical advances, communications, clothes/fabrics, educating young scientists, and entertainment/pictures*".

The write-up of the survey lists "Key Take-Aways" as:

  - "*Most Americans are interested in the space program (60%) but an alarming number have no interest at all (19%). Interest is particularly soft among women.*
  - *On the positive side, large majorities feel that the space program is important to national security (71%), contributes to national pride (79%), and inspires young people to study math and science (82%).*
  - *Half of the public feel that the space program has not directly improved their lives in any way. Those who do, however, cite technological developments and knowledge about the universe.*
  - *Most believe that the U.S. continues to explore space in order to maintain our status as an international leader or because it is human nature to explore.*
  - *The majority of Americans (60%) reject the idea that the space program is a waste of taxpayer money. They are not convinced , however, that more funding is needed.*

- *A plurality feel that a manned mission to Mars should be the next major mission, but there is some sentiment that this should not be pursued during the current economic recession.*
- *Many Americans would prefer to see the space program's resources used to help solve terrestrial problems rather than extraterrestrial ones for the time being.*"

NASA Strategic Communications Framework Implementation Plan

In 2007, NASA's Office of Strategic Communications developed an Implementation Plan with the purpose of putting "*forward specific messages and initiatives based on the Strategic Communications Framework and recent round of market research and analysis*." According to the Plan, the overall Agency communications goals were:

"*1. Build greater public support for NASA's mission and activities. Authority for effort based in:*
   - *Space Act of 1958*
   - *2005 NASA Authorization Act*

2. *Make Agency communications more participatory*
   - *Increase users of MyNASA, Inside NASA, and communications.nasa.gov*

3. *Change communications behavior within the Agency*
   - *Reach out to new audiences*
   - *Demonstrate relevancy and benefits to key audiences.*"

The report states that "*Messages and outreach activities are informed by relevant policy guidance: Vision for Space Exploration, National Space Policy, National Aeronautics Research and Development Policy*".

On the analysis of market research, the report provides a NASA Brand Balance Sheet:

"*Strengths*

1. Near Universal Awareness
2. Enormous Public Appreciation
3. High Support
4. Wide Appeal

Challenges

1. *Little Specific Knowledge*
2. *Lack of Relevance*
3. *Low Excitement*
4. *Disconnect from Activities*
5. *Lack of Current Context"*

The report recommends that NASA communications should:

- *"Demonstrate NASA's role using message components:*
  - *Science*
  - *Economic*
  - *Security*
  - *Leadership*
- *Illustrate NASA's relevance by highlighting*
  - *The importance of space to America's economy*
  - *The benefits to people that exist because of technology developed by NASA*
- *Engage and inspire audiences about the future benefits of NASA and its leadership in space exploration, aeronautics research, science, and education.*

In developing the 2007 Strategic Communications Framework Implementation Plan, NASA commissioned independent entities to conduct market research (focus groups and a survey) to:

- "*Set benchmarks in areas of knowledge, relevance, and excitement*
- *Testing of key words and messages*
  - *Development of messages around Space Exploration including Moon/Mars missions*
- *Effects of specific benefits in terms of illustrating relevance*
- *Gain insight into demographic differences*"

The summary of market research results is as follows:

- "*NASA's overall public image remains high and a large number of Americans believe continuing space exploration is important*
- *However, fewer Americans rate NASA as relevant to their daily lives and perceptions of NASA's economic contribution vary*
- *Telling people about specific NASA-related technologies has a tremendous impact on both relevance and economic measures*
- *Among messages tested, there were no "weak" reasons for continuing space exploration, though some reasons were stronger than others*
- *When talking about NASA programs and activities, framing NASA communications in terms of relevance and benefits is most effective*".

The report identifies outreach strategies [as of 2007] including the 50th Anniversary of NASA, NASA Future Forums (conferences to discuss how innovation helps promote and sustain economic development), NASA Lecture Series, the use of Shuttle launches to engage state and local leaders, public service announcements, strategic alliances, and the use of new media that takes advantage of customized and personalized webpages and opportunities for online interaction (MyNASA), as well as an upgrade of the NASA Website and an online catalog of NASA benefits and stories provided by individuals on how space affects their lives.

Social Networking and Other Forms of Communications and Outreach

As noted in the above sections on public awareness and strategic communications, many Americans are unaware of how space affects and benefits their lives. Enhancing the public's awareness involves communication and information dissemination, including by means of new communication modes and tools that are widely used by younger generations. As stated in a March 2009 article in Discovery News, "*Ask most folks around NASA what lured them into the space business and they'll tell you about how shivers ran down their spines watching Neil Armstrong step onto the moon in 1969. That's a problem for an agency that exists to inspire the young and explore the unknown*."

One of the ways that NASA is attempting to address this issue is through the use of social networking. According to the Webcontent.gov information on Social Networks and Government, social networking tools are "*websites that connect people*" and involve "*online communities*" that people can join without cost and create a webpage with their profile. These sites "*allow users to find people they know among the members, or look for other members with similar interests or affiliations*." NASA is employing these tools as another means of communicating with the interested public, especially with younger people who are active users of social networking sites. The Mars Phoenix Lander mission has tens of thousands of Twitter followers. NASA astronaut Jose Hernandez used Twitter to relay insights in both English and Spanish on his Shuttle mission training. NASA is on Facebook and also disseminates video using YouTube.

NASA is also using naming and voting contests as another means to engage the public in its programs. A contest on what to name a new node of the International Space Station attracted considerable attention when participants voted to name it after comedian Stephen Colbert. (NASA elected to name the new ISS node, "Tranquility", but named a new treadmill, the Combined Operational Load Bearing External Resistance Treadmill (COLBERT) after the comedian.) Another contest allowed participants to vote, for example, on an observing target for the Hubble Space Telescope.

In addition, NASA has upgraded its website to incorporate other tools that invite public participation in NASA activities. One example is a webpage entitled "Collaborate and Connect with NASA" that provides links to Twitter, Facebook, USTREAMTV, myspace, YouTube, and flickr and provides multiple links that provide opportunities to collaborate with NASA. The *Collaborate and Connect with NASA* webpage also provides links that outline how readers can help identify landforms in satellite images of Mars, one that has offered contests for artwork on the lunar environment, and a site that provides teacher lesson plans, access to Earth science data, and opportunities to participate in citizen science projects relevant to Earth science, among other means to engage with NASA activities.

ATTACHMENT I

Executive Summary of the Report

America's Future In Space: Aligning the Civil Space Program with National Needs

From its inception in 1958, much of the U.S. space program was driven by opportunities to serve national interests in a geopolitical environment heavily colored by Cold War threats and fears. Originally, the true potential of space activities was largely speculative. In the ensuing decades, however, early expectations for discovery and technological accomplishment have been richly exceeded. Without a doubt, the first 50 years of the space age have been transformative. Astronauts have stood on Earth's moon while millions watched. Commercial communications and remote sensing satellites have become part of the basic infrastructure of the world. Satellites support worldwide communications, providing a critical backbone for daily commerce—carrying billions of global financial transactions daily, for example. Direct broadcasting beams television signals into homes globally, delivering images that bring unprecedented awareness of events occurring throughout the world. Military global positioning satellites provide ubiquitous signals that support a stunning variety of services, from assisting in the navigation of civilian airplanes, shipping, and automobiles to transmitting timing signals that enable cell phone and power grid switching. Remote sensing satellites obtain high-resolution images of Earth's surface, available now on the Internet for people worldwide to view and use, and provide critical information to monitor changes in our climate and their effects.

Our understanding of every aspect of the cosmos has been profoundly altered, and in the view of many, we stand once again at the brink of a new era. Space observations have mapped the remnant radiation from the Big Bang that began our universe. We have discovered that the expansion of the universe continues to accelerate, driven by a force that we do not yet understand, and that there are large amounts of matter in the universe that we cannot yet observe. We have seen galaxies forming at the beginning of the universe and stars forming in our own galaxy. We have explored the wonders that abound in our solar system and have found locations where life might have occurred or might even now be present. We have discovered planets around other stars, so many that it is ever more likely that there are other Earths comparable to our own.

What will the next 50 years bring? Today we live in a globalized world of societies and nations characterized by intertwined economies, trade commitments, and international security agreements. Mutual dependencies are much more pervasive and important than ever before. Many of the pressing problems that now require our best efforts to understand and resolve—from terrorism to climate change to demand for energy—are also global in nature and must be addressed through mutual worldwide action. In the judgment of the Committee on the Rationale and Goals of the U.S. Civil Space Program, the ability to operate from, through, and in space will be a key component of potential solutions to 21st century challenges. As it has before, with the necessary alignment to achieve clearly

articulated national priorities, the U.S. civil space[1] program can serve the nation effectively in this new and demanding environment.

In its initial discussions, the committee concluded that debates about the direction of the civil space program have too often focused on addressing near-term problems and issues without first putting those issues in the context of how a disciplined space program can serve larger national imperatives. In the committee's view, characterizing the top-level goals of the civil space program and the connection between those goals and broad national priorities is necessary as a foundation on which the nation (both now and in the future) can devise sustainable solutions to nearer-term issues. Therefore, the committee focused on the long-term, strategic value of the U.S. civil space program, and its report does not address nearer-term issues that affect the conduct of U.S. space activities other than to provide a context in which more tactical decisions might be made.

The national priorities that informed the committee's thinking include ensuring national security, providing clean and affordable energy, protecting the environment now and for future generations, educating an engaged citizenry and a capable workforce for the 21st century, sustaining global economic competitiveness, and working internationally to build a safer, more sustainable world. A common element across all these urgent priorities is the significant part that research and development can play in solving problems and advancing the national enterprise in each area. Instruments in space have documented an accelerating decline in arctic sea ice, mapped the circulation of the world's oceans, enabled the creation of quantitative three-dimensional data sets to improve the quality of hurricane forecasting, and created new tools to address a host of agricultural, coastal, and urban resource management problems, to cite only a few examples. Such capabilities demonstrate what can be achieved when technologically challenging space problems stimulate innovation that leads to long-term advances with applications beyond the space sector. Civil space activities are central to the R&D enterprise of the nation, often in a transformational way, and thus present powerful opportunities to help address major national objectives.

Observations from space offering unique capabilities for global environmental and land-use monitoring are essential to informed decision making about energy production and climate change policies, and they help provide the understanding required for wise management. The high visibility of space activities attracts students' attention to science, technology, and mathematics, and space activities are an exciting focus for teaching those subjects. Commercial space-related ventures now figure significantly in global economic competitiveness, and, while government investments to stimulate the nation's fragile economy will have short-term impacts, R&D investments can be counted on to make longer-term sustainable contributions to the nation's economic strength. As has countless times proved the case, research in and from space will continue to lead to important future, and not always currently predictable, benefits that hold the promise of progress toward realizing U.S. as well as shared international goals.

[1] The committee considered "civil space" to include all government, commercial, academic, and private space activities not directly intended for military or intelligence use.

The committee's overall conclusion is that a preeminent U.S. civil space program with strengths and capabilities aligned for tackling widely acknowledged national challenges—environmental, economic, and strategic—will continue to make major contributions to the nation's welfare.

GOALS FOR THE CIVIL SPACE PROGRAM

Structured and supported to match multiple responsibilities in serving key national objectives, the U.S. civil space program should be preeminent in the sense that it can influence, by example, nations' use of space. To be a strategic leader in a globalized world requires that the United States have a civil space program whose breadth, competence, and level of accomplishment ensures that U.S. leadership is demonstrated, accepted, and welcomed.

The committee identified six strategic goals that it regards as basic for guiding program choices and resources planning for U.S. civil space activities. The goals all serve the national interest, and steady progress in achieving each of them is necessary.

- *To re-establish leadership for the protection of Earth and its inhabitants through the use of space research and technology*. The key global perspective enabled by space observations is critical to monitoring climate change and testing climate models, managing Earth resources, and mitigating risks associated with natural phenomena such as severe weather and asteroids.
- *To sustain U.S. leadership in science by seeking knowledge of the universe and searching for life beyond Earth*. Space offers a multitude of critical opportunities, unavailable in Earth-based laboratories, to extend our knowledge of the local and distant universe and to search for life beyond Earth.
- *To expand the frontiers of human activities in space*. Human spaceflight continues to challenge technology, utilize unique human capabilities, bring global prestige, and excite the public's imagination. Space provides almost limitless opportunities for extending the human experience to new frontiers.
- *To provide technological, economic, and societal benefits that contribute solutions to the nation's most pressing problems.* Space activities provide economic opportunities, stimulate nnovation, and support services that improve the quality of life. U.S. economic competitiveness is directly affected by our ability to perform in this sector and the many sectors enabled and supported by space activities.
- *To inspire current and future generations*. U.S. civil space activities, built on a legacy of spectacular achievements, should continue to inspire the public and also serve to attract future generations of scientists and engineers.
- *To enhance U.S. global strategic leadership through leadership in civil space activities*. Because of the growing strategic importance of space, all nations that aspire to global political and economic leadership in the 21st century are increasing their space-faring capabilities. Continued U.S. global leadership is tied to continued U.S. leadership in space.

FOUNDATIONAL ELEMENTS

To contribute to realizing critical national objectives including those listed above, the U.S. space program, both the civil and national security components, must have a strong foundation and adequate resources. While the breadth of the civil space program has grown, there is also a sense that the program has been unfocused, with corresponding impacts on the organizations and institutions that support it. The United States can no longer pursue space activities on the assumption of its unchallengeable dominance—as evidenced by the view of other nations that the United States is not the only, or in some cases even the best, option for space partnerships. U.S. leadership in space activities and their capacity to serve urgent national needs must be based on preeminent technical capabilities; ingenuity, entrepreneurialism, and a willingness to take risk; and recognition of mutual interdependencies. The time has come to reassess, and in some cases reinvent, the institutions, workforce, infrastructure, and technology base for U.S. space activities.

The committee identified four foundational elements critical to a purposeful, effective, strategic U.S. space program, without which U.S. space efforts will lack robustness, realism, sustainability, and affordability:

1. *Coordinated national strategies*—implementing national space policy coherently across all civilian agencies in support of national needs and priorities and aligning attention to shared interests of civil and national security space activities,
2. *A competent technical workforce*—sufficient in size, talent, and experience to address difficult and pressing challenges,
3. *An effectively sized and structured infrastructure*—realizing synergy from the public and private sectors and from international partnerships, and
4. *A priority investment in technology and innovation*—strengthening and sustaining the U.S. capacity to meet national needs through transformational advances.

Efforts to establish each of these elements to ensure a strong foundation for the nation's civil space program must overcome several impediments. The issues include a loss of focus on national imperatives, overly constrained resources, inadequate coordination across the federal government, missed opportunities to transition roles from government-led to private sector-provided services, obstacles to international cooperation, weakened institutional partnerships, and lack of emphasis on advanced technology development programs. Awareness of such issues—and not an effort to resolve specific instances—guided the committee in its development of recommendations to NASA, NOAA, and the federal government at the highest levels.

RECOMMENDATIONS

The committee found that, in spite of their promise and utility, components of the civil space program are not always aligned to fully capitalize on opportunities to serve the larger national interest. Decisions about civil space priorities, strategies, and programs, and the resources to achieve them, are not always made with a conscious view toward their linkages to broader national interests. Accordingly, the committee recommends as follows:

1. *Addressing national imperatives*. Emphasis should be placed on aligning space program capabilities with current high-priority national imperatives, including those where space is not traditionally considered. The U.S. civil space program has long demonstrated a capacity to effectively serve U.S. national interests.

Recommendation 1 provides a broad policy basis on which the committee's subsequent specific recommendations rest. The recommendations that follow address a set of actions, all of which are necessary to strengthen the U.S. civil space program and reinforce or enhance the contributions of civil space activities to broader national objectives.

2. *Climate and environmental monitoring.* NASA and NOAA should lead the formation of an international satellite-observing architecture capable of monitoring global climate change and its consequences and support the research needed to interpret and understand the data in time for meaningful policy decisions by:

a. Reversing the deterioration of the U.S. Earth observation infrastructure;

b. Developing and implementing a plan for achieving and sustaining global Earth observations;

c. Working with the international community to develop an integrated database for sensor information from all Earth-monitoring satellites;

d. Aggressively pursuing technology development for future high-priority Earth observation missions; and

e. Actively planning for transitions to continue demonstrably useful research observations on a sustained, or operational, basis.

3. *Scientific inquiry*. NASA, in cooperation with other agencies and international partners, should continue to lead a program of scientific exploration and discovery that:

a. Seizes opportunities to advance understanding of Earth, the objects of the solar system including the Sun, and the vast universe beyond;

b. Includes searches for evidence of life beyond Earth;

c. Contributes to understanding how the universe works, who we are, where we came from, and what is the destiny of our star—the Sun—our solar system, and the universe, and of the physical laws that govern them; and

d. Is guided by peer review, advisory committees, and the priorities articulated by the science communities in their strategic planning reports, such as the NRC's decadal surveys.[2]

[2] The NRC decadal surveys have been widely used by the scientific community and by program decision makers because they (a) present explicit, consensus priorities for the most important, potentially revolutionary science that should be undertaken within the span of a decade; (b) develop priorities for future investments in research facilities, space missions, and/or supporting programs; (c) rank competing opportunities and ideas and clearly indicate which ones are of higher or lower priority in terms of the timing, risk, and cost of their implementation; and (d) make the difficult adverse decisions about other meritorious ideas that cannot be accommodated within realistically available resources.

4. *Advanced space technology*. NASA should revitalize its advanced technology development program by establishing a DARPA-like organization within NASA as a priority mission area to support preeminent civil, national security (if dual-use), and commercial space programs. The resulting program should:

a. Be organizationally independent of major development programs;
b. Serve all civil space customers, including the commercial sector;
c. Conduct an extensive assessment of the current state and potential of civil space technology; and
d. Conduct cutting-edge fundamental research in support of the nation's space technology base.

5. *International cooperation*. The government, under White House leadership, should pursue international cooperation in space proactively as a means to advance U.S. strategic leadership and meet national and mutual international goals by:

a. Expanding international partnerships in studies of global change;
b. Leading an effort in which the Unites States and other major space-faring nations cooperate to develop rules for a robust space operating regime that ensures that space becomes a more productive global commons for science, commerce, and other activities;
c. Rationalizing export controls so as to ensure ongoing prevention of inappropriate transfer of sensitive technologies to adversaries while eliminating barriers to international cooperation and commerce that do not contribute effectively to national security;
d. Expanding international partnerships in the use of the International Space Station;
e. Continuing international cooperation in scientific research and human space exploration,
f. Engaging the nations of the developing world in educating and training their citizens to take advantage of space technology for sustainable development; and
g. Supporting the interchange of international scholars and students.

6. *Human spaceflight*. NASA should be on the leading edge of actively pursuing human spaceflight, to extend the human experience into new frontiers, challenge technology, bring global prestige, and excite the public's imagination. These goals should be accomplished by:

a. Setting challenging objectives that advance the frontier, scientific and technological understanding, and the state of the art;
b. Establishing clear goals for each step in a sequence of human spaceflight missions beyond low Earth orbit that will develop techniques and hardware that can be used in a next step further outward;
c. Focusing use of the ISS on advancing capabilities for human space exploration; and

d. Using human spaceflight to enhance the U.S. soft power leadership by inviting emerging economic powers to join with us in human spaceflight adventures.

National space policy too often has been implemented in a stovepipe fashion that makes it difficult to recognize connections between space activities and pressing national challenges. Often, senior policymakers with broad portfolios have not been able to take the time to consider the space program in the broader national context. Rather, policies have been translated into programs by setting budget levels and then expecting agencies to manage to those budgets. The committee believes that the process of aligning roles and responsibilities for space activities, making resource commitments, and coordinating across departments and agencies needs to be carried out at a sufficiently high level that decisions are made from the perspective of addressing the larger national issues whose resolution space activities can help achieve. How this process is accomplished might change from administration to administration, but the need for an approach that will elevate attention to the proper level remains essential.

7. *Organizing to meet national needs.* The President of the United States should task senior executive-branch officials to align agency and department strategies; identify gaps or shortfalls in policy coverage, policy implementation, and resource allocation; and identify new opportunities for space-based endeavors that will help to address critical issues now confronting the United States and, to a considerable extent, the world as well.

The effort should include the Assistant to the President for National Security Affairs and the Assistant to the President for Science and Technology, and should consider the following elements:

a. Coordinating budgetary guidance across federal departments and agencies involved in space activities;

b. Coordinating responsibility and accountability for resource allocations for common services and/or infrastructure;

c. Coordinating responsibility and accountability for stimulating, nurturing, and sustaining a robust space industrial base, including the commercial space industry;

d. Coordinating responsibility and accountability for initiatives to recruit and develop a competent aerospace workforce of sufficient size and talent, anticipating future needs;

e. Identifying, developing, and coordinating initiatives to address long-range technological needs for future programs;

f. Identifying, developing, and coordinating initiatives to establish and strengthen international space relationships;

g. Harmonizing the roles and responsibilities of federal agencies to eliminate gaps and unnecessary duplication in the nation’s space portfolio; and

h. Regularly reviewing coordinated national space strategies and their success in implementing overall national space policy.