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The United States Senate

Committee on Commerce, Science and Transportation

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Senator Nelson, Members of the Committee, and Committee Staff, thank you for your service to our nation, and thank you for the opportunity to offer testimony on the impact and importance of U.S. space programs – both in meeting the needs of humanity, and achieving the strategic goals and objectives of the United States. The Space Foundation is a 501(c) 3 non-profit operating foundation, and our mission is "to advance space-related endeavors to inspire, enable and propel humanity." Implicit in this mission is our understanding that the exploration, development and use of space really *does* inspire our nation and the world, enable us to dare greatly and achieve our goals and propel us confidently into the future.

Growth of the Global Space Economy

First, the global space economy. The Space Foundation pursues our mission by educating and informing. The bedrock of our ability to do this is our commitment to providing accurate, fair, impartial and nonpartisan data and analysis. *The Space Report*, our annual publication on the global space economy, is the authoritative guide to global space activities. The data I am citing today is from our most recent report.

Over the past six years, the global space economy has grown by 48 percent – from $164 billion in 2004 to $276 billion in 2010. The average annual growth rate of the industry increased from about 5 percent to nearly 8 percent last year.

The space economy comprises products and services, and both terrestrial and space-based infrastructure. While government space activities continue to play a major role, the space economy is today predominantly commercial. Commercial satellite services and commercial satellite infrastructure together accounted for some $189 billion in 2010 – nearly 70 percent of total space activity. In addition to being heavily commercial, space is very international. Of the 25 largest satellite communication companies in the world, only one is headquartered in the United States. Roughly three quarters of all commercial satellites are manufactured outside the U.S. Global space employment has been stable over the past couple of years, with job increases in Japan, India, Germany and other nations offsetting job losses in the United States. Nonetheless, with civil and national security space programs totaling some $64.67 billion in 2010, the United States remains by far the largest government player.

Space systems today form the essential infrastructure of modern life, providing everything from routine weather forecasts, driving directions, entertainment and telephone service to inventory tracking, resource management and telemedicine. There is increasing awareness of the value of space as an economic engine that is crucial to many other economic sectors.

In 2010, as the global economy continued to battle back from recession, the space industry not only maintained its growth, but actually gathered momentum. The commercial sector flourished, adding billions of dollars to the economy. The commercial sector has long been involved in national space programs, primarily as contractors and service providers. This role is expanding due to new government policies that encourage greater reliance on commercial providers, particularly in the United States. These policies provide opportunities that have generated significant interest among traditional aerospace companies, as well as newer space actors, as the commercial sector seeks resources to develop its technological capabilities.

Additionally, more countries are becoming involved in space or are revitalizing dormant space programs, with Australia, South Africa and Iran as recent examples. In many cases, these space actors are incorporating a deliberate commercial element in their space programs that targets economic development and technology creation.

The role of civil society in space activity is also evolving. The emergence of smallsats and cubesats is lowering costs and barriers to entry, offering civil actors new avenues to engage in space activity. When smallsats are networked, the opportunities for new science and commercial applications can grow exponentially. Commercial human spaceflight also opens an avenue for people to experience space on a personal level, and it furthers public interest in space activity even for those who do not leave the ground. The growing engagement of society in space pursuits not only stirs our imagination, but also brings us closer together - researchers, scientists, business professionals and government officials - to explore the practically limitless opportunities that space promises.

Space as an Economic Engine

Space products and services are an integral part of daily life, expanding each year into new areas of human activity. In one dramatic example, space technology and expertise helped to ensure the survival and rescue of a group of Chilean miners trapped underground. This experience was but a single instance of how the knowledge gained from human activity in the challenging environment of space can be applied to life on Earth. In more commonplace situations, new space applications are helping people communicate with each other and access entertainment as they travel by ground, sea or air. Satellite-enabled Internet connections are becoming commonplace as airlines outfit their fleets with the latest equipment. Navigation applications for cell phones can combine input from built-in cameras and GPS chips, enabling users to view directions as an overlay on an image of their surroundings. GPS tracking systems installed on racecars

allow people playing computer games to participate in virtual competitions against professional drivers during real racing events. Whether during work or leisure hours, most people reap the benefits of space systems and technology as an integral part of their daily lives.

The commercial sector continues to incorporate space technology both in its manufacturing processes and in its products. The glass manufacturing industry is incorporating techniques used in the analysis of data from the Hubble Space Telescope and the semiconductor industry is creating more powerful microchips using technology developed for building ESA's XMM-Newton X-ray observatory. Consumers can purchase clothing made from textiles originally developed for use by astronauts or have their hair styled with tools that smooth and soften hair using nano-ceramic technology developed by NASA. Not only does space contribute to the wealth of products available to consumers, it also enables companies to estimate consumer activity by observing the ebb and flow of customer traffic in the parking lots of retailers by means of satellite imagery.

On a more global scale, satellites offer a unique perspective that helps to explain the human relationship with the environment. From enabling forestry managers to track the spread of tree-destroying Rocky Mountain pine beetles to helping coordinate cleanup efforts after the Gulf of Mexico oil spill to monitoring the effects of the earthquake in Japan, satellite data is critical to managing natural resources and the response to manmade disasters. It is almost unthinkable now to consider the prospect of facing a natural disaster without the communications and imaging capabilities provided by space systems.

Individuals, companies and nations continue to create new space-related products and services, capitalizing on the intellectual and financial investments made in space technology. Many governments have realized the benefits of using space technology as a

tool for carrying out their responsibilities and as a means of generating economic growth. These governments play an important role in developing new space technology, with methods such as financing commercial companies, transferring government technology to the commercial sector and creating a supportive regulatory regime.

Regardless of the exact measures undertaken, it is clear that governments recognize the need for further growth of space capabilities. Government space spending around the world increased to $87.12 billion in 2010. The U.S. government space budget, which accounted for 74% of worldwide governmental space spending, was flat at $64.63 billion. Numerous governments announced their intent to expand their national space programs in 2010, including Canada, Germany, Israel, Japan and India. As these policies translate into budgets and program activities, they will increase total government spending on space globally; to the extent that funding for U.S. federal space programs remains flat, both inflation and increased spending by other nations will erode U.S. leadership.

The degree to which U.S. national investments in space have proven to be high-impact investments of tremendous national benefit cannot be overstated. After all, today's robust commercial space industry has its origins in government space investment. DirecTV, Sirius/XM radio, CNN, ESPN, Monday Night Football and countless other satellite services are all the grandchildren of America's Telstar program. Google Earth, satellite weather, commercial imagery from space and countless related, value-added applications are the descendants of the Corona spy satellite program. The U.S. aerospace industry, which by some estimates accounted for 50 percent of the new wealth generated in America between 1962 and 2002, built its muscle on government space programs like Dyna-Soar, X-15, Mercury, Gemini, Apollo, the X-24A, M2-F3, HL-10, the Space Shuttle and the International Space Station.

Uniquely, however, U.S. national investments in space have spawned new technologies and new industries that could not even have been imagined when those

investments were made. The act of doing things "not because they are easy, but because they are hard[1]" leads to the creation of capabilities that have not previously existed; these, in turn, can lead to entirely new industries. Take, for example, the cordless tool industry. Prior to NASA having a requirement for cordless power tools on the Moon, the power tool industry was content to continue manufacturing longer and longer extension cords. The unique NASA requirement gave birth to a solution that no one had imagined; NASA contractor Martin Marietta hired Black & Decker, and the rest is history. Today cordless power tools are manufactured in Maryland, North Carolina, South Carolina, Georgia, Mississippi, Tennessee, Arkansas and Texas – and increasingly in Japan, China and Europe.

This is a very important phenomenon to understand: that investing in research to support a specific desired outcome will generate solutions and technologies that otherwise would not develop.

Take the humble, modern microwave oven. Research directed at improving the common oven would likely have resulted in ovens that are better insulated, more energy efficient and so on. But such efforts would probably not have resulted in a microwave oven. The use of amplified microwaves, initially in a device called a Klystron, came not from the oven or appliance industry, but from a directed effort to develop defense radar.

This is the way that invention and discovery works, and this is why America's past investment in space programs has yielded such stupendous returns:

- Because spacecraft needed a renewable source of energy on orbit, today we have a solar power (photovoltaics) industry.

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[1] *"We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win." -- John F. Kennedy, Rice University, September 12, 1962*

- Because spacecraft needed to be guided and controlled, today we have accelerometer technology used in everything from triggering automotive seatbelts and air bags to orienting smart phones.
- Because NASA needed to accurately dock and undock spacecraft, today we have precision guidance technology that enables LASIK eye surgery.
- Because NASA needed to protect the environment from toxic chemicals associated with rocket launching, today we have advanced environmental containment and clean-up technologies.
- Because the Air Force required a precise global positioning system, today GPS is the fundamental underlying architecture for commerce, finance, logistics, inventory management and commercial, military, law enforcement, emergency services and personal navigation around the world.
- Because NASA required unprecedented turbo-pump capability to power the Space Shuttle main engines, today we have life-saving heart pump technologies.

None of these outcomes were expected. These technologies, and more than 40,000 others, are the result of our previous national investments in space.

Space and Foreign Policy, National Security

The funding of national space programs has also brought tremendous benefit to U.S. foreign policy and national security, both directly, and indirectly.

U.S. leadership in space has been a leading contributor to American "soft power" since the dawn of the space age. The nation's entry into the space race is often seen only as a reaction to the Soviet Union's launch of Sputnik; the doctrine behind this reaction is worth remembering. Kennedy's speech at Rice is often quoted for its inspirational and humanistic value. Less often quoted are the political and national security realities that America was coming to grips with:

> *". . . man, in his quest for knowledge and progress, is determined and cannot be deterred. The exploration of space will go ahead, whether we join in it or not, and it is one of the great adventures of all time, and no nation which expects to be the leader of other nations can expect to stay behind in this race for space.[2]"*

The mastery of space has always carried with it the not-so-subtle message to friend and foe: This is what we are capable of. You want to work with us. You want to be our friend. You want to follow our lead. You do not want to challenge us.

The message of the Apollo program was very clear – the U.S. triumphs over the Soviet Union and democracy triumphs over communism. We win. We are the leader. Follow us.

Whether our objective is to win the Cold War (Apollo), extend a hand in friendship (Apollo-Soyuz), incentivize collaborative behavior (Shuttle-Mir) or build a broad-based international community (ISS), the soft power of space programs is often one of our best foreign relations and national security tools.

Certainly, space programs have also been inextricably linked with "hard" power. Our current expendable launch systems descend from ICBM boosters. The Space Shuttle was configured so that it could carry out clandestine military missions. Friendly American satellites that carry out environmental monitoring and commercial satellites that deliver exquisite images of earth from space have their origins in Department of Defense space programs. Indeed America's largest secret space program, for decades, was the National Reconnaissance Office.

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[2] *Kennedy continues: "Yet the vows of this Nation can only be fulfilled if we in this Nation are first, and, therefore, we intend to be first. In short, our leadership in science and in industry, our hopes for peace and security, our obligations to ourselves as well as others, all require us to make this effort, to solve these mysteries, to solve them for the good of all men, and to become the world's leading space-faring nation."*

The ability to observe other nations, share intelligence instantly around the world and, when necessary, to strike, are all dependent upon our investments in national space programs. All Americans know about the successful mission to get Osama Bin Laden. They should also know that CIA Director Leon Panetta specifically praised the National Geospatial-Intelligence Agency (NGA) and its role as providing the essential satellite imagery of Bin Laden's lair that enabled the raid to take place.

Space and Our National Intellectual Capacity

Finally, it must be recognized that our national intellectual capacity – the brain power we can bring to bear on any problem, issue or challenge – is directly affected by our investment in national space programs. As the Apollo program was gaining momentum, enrollment in graduate studies in science and engineering was also gaining momentum. In fact, and again citing Kennedy's speech at Rice, the Apollo program was expected and *intended* to double the number of American scientists and engineers[3].

Doing the hard things requires our best and brightest minds. Developing this intellectual capacity requires inspiring, challenging, and exciting work to do. When America has made that investment, we have never failed to achieve our capacity for greatness.

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[3] *"Despite the striking fact that most of the scientists that the world has ever known are alive and working today, despite the fact that this Nation's own scientific manpower is doubling every 12 years in a rate of growth more than three times that of our population as a whole, despite that, the vast stretches of the unknown and the unanswered and the unfinished still far out-strip our collective comprehension . . . During the next 5 years the National Aeronautics and Space Administration expects to double the number of scientists and engineers in this area."*