

Space Exploration: A Measure of American Competitiveness

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Good evening. I thank the Chicago Council on Global Affairs for hosting this lecture, one of a series commemorating NASA's 50th Anniversary year. These are busy days for us at NASA, and it takes an occasion like this to provide a reason to pause and assess where we are today, how we got here, and most importantly, where we are heading.

Last week, the Space Shuttle *Discovery*, commanded by USAF Colonel Pam Melroy, lifted off from Cape Canaveral. They are now docked to the International Space Station (ISS), and are busy installing the Italian-built Harmony module, which will allow us to connect the European and Japanese laboratory modules that will be flown on later Shuttle flights.

Also onboard this Shuttle mission is astronaut Dan Tani, who grew up just west of Chicago, in Lombard, Illinois. Dan and I overlapped

briefly in industry, at Orbital Sciences, prior to his selection as an astronaut in 1996. He will be a flight engineer on the ISS for the next few months and will be executing several space walks, continuing the assembly of the ISS, while working with veteran astronaut and ISS commander, Peggy Whitson.

In my usual clueless fashion, I had failed to notice – until receiving a question from a member of the media – that this is the first time we have had women commanding both the Space Station and the Space Shuttle. They are literally “the best of the best of the best”, because less than 1% of those who even apply to become astronauts are selected. Over the years, approximately 41,000 applications have been received from prospective astronauts, while only 321 individuals have been selected. Peggy Whitson has a Ph.D. in biochemistry, and previously lived and worked for six months onboard Station in 2002. Pam Melroy has a master’s degree in earth and planetary sciences from MIT, flew combat missions during Operation Desert Storm, and piloted two previous Shuttle missions to the ISS.

Times have changed from the NASA of the 1950s and 1960s, and they should. The stereotypical buzz-cut test pilot and white male engineer are no longer representative of our agency. NASA depends for its success upon the ideas in our people's heads, not upon the package containing them. And while I do indeed care about the egalitarianism of society, I am also being pragmatic. For America to continue to be pre-eminent in the world economy, to be the world's leader in innovation, science, and technology, and to be a leader on the frontier of space exploration and aeronautics research, NASA will need the best ideas, hard work, and dedication from *all* those who would like to be involved with this most exciting enterprise of our time.

In orbit approximately 200 miles overhead, Pam Melroy, Dan Tani, and Peggy Whitson already know this. They are living it. So let me spend some time here tonight talking about the connection between American competitiveness, innovation, and space exploration.

This month, we marked the dawn of the Space Age with the 50th Anniversary of the Soviet Union's launch of Sputnik, the first man-made satellite. I was eight years old at the time, and I clearly remember

looking up in the night sky with wonder. But many Americans felt vulnerable to Soviet missiles that, if they could place a payload in orbit, could also strike anywhere in the United States. No other adversary had ever produced such a threat to the American homeland, and, protected as we were by two oceans, no one had ever imagined that anyone ever could. Nikita Khrushchev's November, 1956 admonition – “we will bury you” – reverberated in America’s collective consciousness.

In being embarrassed so publicly by the Soviet Union, first with the launch of Sputnik and then later with the launch of Yuri Gagarin, Americans felt that we were falling behind in our much-vaunted technical know-how and industrial capability. The small metal orb beeping overhead, visible in the clear fall sky to anyone who looked – and nearly everyone did – reminded us of this. We felt that we were in second place, that we lagged in exploring what President Kennedy later named, so perfectly, “this new ocean”. And we felt that it mattered. NASA was born out of this competition with the Soviet Union.

Today, we collaborate with the Russia, Europe, Japan, China, India, and many other countries in space exploration. In fact, over half

of NASA's robotic science missions, ranging from Earth science, heliophysics (or the study of the Sun's effects on planet Earth), planetary missions, and NASA's great astrophysical observatories, involve international partnerships.

We also compete with these countries in other areas. Individuals, companies, universities, and cities compete or collaborate with one another in many and various fields of endeavor, just as nations do. This is good. Healthy competition brings out the best in all of us. It motivates us to stretch when we set our goals, and stretch again to reach them. And this pays enormous benefits, both directly and indirectly.

Let me return to the astronaut-selection statistics I mentioned earlier. NASA has selected 321 people to become astronauts – but tens of thousands have applied! From a national perspective, it might well be said that the most important aspect of the competition to become an astronaut is that thousands upon thousands of young men and women have been inspired to acquire the education and training to become one. Our nation produces many thousands more of our best aviators, engineers, and scientists who, whether selected as astronauts or not,

eventually turn their talents to developing innovative technologies, conducting world-class research, and solving complex engineering problems. This work enriches our economy, increases our productivity, and improves our way of life.

Because of the excitement inherent to human spaceflight, and the historic nature of the scientific advances we make, NASA enjoys very high public approval, and extraordinary “brand recognition”. With this comes an interesting fact; when polled, most Americans believe our budget to be much higher than it is, comparable to that for the Pentagon. In fact, NASA’s budget is less than 0.6% of the overall Federal budget, and is only a few percent of that allocated to DoD. Some critics question the value of even this investment in NASA, an amount which many of my fellow engineers would typically refer to as “rounding error” in the grand scheme of things.

It is my goal to get these critics to recognize that the development of space is a strategic capability for our nation, a view completely in keeping with the founding principles of the American nation – pushing back the frontier. There was a time when the land upon which we stand

here in Chicago lay far beyond our western frontier. Today, that frontier lies in space. We've sent out the first few explorers, and they returned with wondrous tales. In President Kennedy's famous words, "Now is the time to take longer strides". The geography of our solar system dictates that these next strides will again be to Earth's moon – three days journey away. But this time, a lunar outpost will follow soon afterward, allowing us to exploit its resources and its vantage point.

Tonight, as you leave here, I ask you to look up at our moon and recall that twelve Americans once walked upon its surface, and imagine a future where even more are living and working there on a new American frontier.

For about a half-cent of every federal dollar, our nation's investment in exploring that frontier and, one day, colonizing other worlds, also ignites the development of technologies that benefit us here on Earth. It produces space-based capabilities like communications, weather monitoring, remote sensing, and GPS navigation that have been estimated to contribute \$220 billion/year to our economy. More importantly, this investment in NASA inspires millions of people to

pursue careers in science and technology, enormously benefiting our nation's broader economy. Today's investment in NASA is a down payment on our nation's future in many different dimensions, from ensuring a presence on humanity's frontier to ensuring a commanding presence in the world economy.

NASA is in the inspiration business, and the resulting technological innovation drives our nation's growth. If America is to remain a leader in the burgeoning global competition, I contend that we must continue to be a nation known for our innovation, and we must continue our work on the New Frontier of space.

This cannot happen without a continuing supply of "the best of the best", and so this evening, I must explore with you some alarming trends, and seek your help in finding some answers. Our children and grandchildren are not as inspired by space exploration as they once were. Today, some young people actually question whether we ever went to the moon, and if the Apollo program was all a hoax. It has been almost thirty-five years since Gene Cernan and Jack Schmitt were the

last astronauts to leave their mark there. That is ancient history to today's younger generation.

A recent report by the National Academy of Engineering, "Rising Above the Gathering Storm", cites some alarming statistics. Fifty years ago, almost twice as many bachelor's degrees in physics were awarded in the United States than in 2004. Last year, the United States produced more undergraduates in sports exercise than in electrical engineering.

About a third of U.S. students who plan to study engineering when they entered college switch majors before graduating; they probably are not switching to mathematics or theoretical physics. Today, there are more software engineers in Bangalore, India than in Silicon Valley. In 2000, 38% of all U.S. science and technology Ph.D.s were conferred upon foreign-born graduate students, most of whom return to their home countries.

I hope you agree with me that America's economic growth is driven by technological innovation, and that societies which foster such innovation become leaders in the world. But as NASA begins its next fifty years, I am deeply concerned about our nation's "bench strength" in

carrying out our mission of space exploration, as well as other technical endeavors. We need “the best of the best of the best” in more than just the astronaut corp. The alarming statistics I have quoted here tonight have broad implications for our ability to maintain economic and technological leadership in today’s world.

Specific to the realm of spaceflight, I am concerned that America’s real and perceived leadership in the standing of the world’s spacefaring nations is slipping away. As Admiral Hal Gehman noted in his report of the Space Shuttle *Columbia* Accident Investigation Board a few years ago, “previous attempts to develop a replacement vehicle for the aging Shuttle represent a failure of national leadership.”

We have only recently begun developing the new *Orion* Crew Exploration Vehicle and *Ares* rockets, which will ferry astronauts to and from the Space Station and, more importantly, allow us once again to go beyond low Earth orbit to the moon. We plan to retire the Space Shuttle in 2010, but this new capability will not come on-line until 2015, according to current budget projections. With an operational stand-down like this, I am concerned that even more highly-skilled aerospace

engineers will simply exit the field altogether, as happened at the end of the Apollo program. Worse, between now and then NASA will pay over \$700 million, and possibly a good deal more, to the Russian Space Agency to support the ISS with their *Soyuz* and *Progress* crew and cargo vehicles. Other countries, like Malaysia and South Korea, and certain wealthy individuals are already paying the Russians for trips to the International Space Station. So, fifty years after Sputnik, and thirty-five years after the last American footprint on the moon, I must ask: who is currently the recognized leader in spaceflight?

China has also emerged as one of the three spacefaring nations, because they understand the value of space activities as a driver for innovation and a source of national pride in being a member of the world's most exclusive club. China today not only flies its own taikonauts, but also has plans to launch about 100 satellites over the next five to eight years. It should be no surprise, especially to those who have read Tom Friedman's book "The World is Flat" or John Kao's "Innovation Nation", that this environment in China is breeding thousands of high-tech start-ups.

The Chinese have adapted the design of the Russian *Soyuz* to create their *Shenzhou* spacecraft. However, the similarity between the two ends at the out mould line; the *Shenzhou* spacecraft is both more spacious and more capable. They plan to conduct their first spacewalks and orbital rendezvous operations, and to build their own space station – admittedly simpler than ours – in the coming years. While they have not stated an intention to do so, the Chinese could send a mission around the moon with the *Shenzhou* spacecraft, as we did with the Apollo 8 mission, which inspired our nation and the world during the Christmas season of 1968. China could easily execute such a mission with their planned Long March V rocket, currently under development and reportedly rivaling any expendable rocket in the world today. I have no doubt that they will have it in use, as they plan, by around 2012.

I am pointing out such things, matters of engineering capability, because I believe that it is important to understand our strategic competitors as well as those with whom we wish to collaborate. We must also understand ourselves, and the framework of our real and perceived leadership in the world. As John Kao couches the issue, we

are currently facing a “Silent Sputnik” where “many countries are racing for a new innovation high ground while our own advantages are showing signs of serious wear.”

All this being said, I believe that America’s greatest days in space exploration lie always ahead of us. However, this can only be true if we recognize such problems and strive with some concerted energy to fix them.

So how do we inspire young people to be more interested in science and engineering, in space exploration, rather than the many and varied distractions of today’s popular culture? Such efforts must be great and small. They can start with taking our children and grandchildren to places like Chicago’s Museum of Science & Industry or the Adler Planetarium. Trips like this inspired Chicago native Ed Weiler, now the Director of NASA’s Goddard Spaceflight Center, to purchase his first 2.5-inch Tasco refractor telescope at the age of eleven. He went on to study astronomy at nearby Northwestern University, and a few years later was instrumental in building the *Hubble Space Telescope*. Later came NASA’s other Great Observatories, the Mars

Rovers, and much more. And by the way, those Rovers are still going. Initially planned to operate for only three months, both *Spirit* and *Opportunity* have now been tooling around Mars for over 45 months.

We must also make math and science exciting for our kids, because it is trigonometry, calculus, astronomy, and engineering which allow us to unlock the secrets of how and why our universe works. For example, only in the past decade have astrophysicists concluded – based on *Hubble* data – that our telescopes can only observe 5% of our universe, and that the remaining 95% is unseen “dark matter” and “dark energy”. There is so much we simply do not comprehend. We must convey that sense of wonder, adventure, and discovery to our children and grandchildren. If we do it well, we will attract them to study the hard sciences so that they can be part of it all, like those who came before them, people like Ed Weiler, Dan Tani, Peggy Whitson, and Pam Melroy. This is the generation that will build the next space telescopes, perhaps on the Earth’s moon, and send not only rovers to Mars, but the first human expedition as well. There will always be New Frontiers to discover.

Mentoring, volunteering, and participating in organized activities like an astronomy club, rocket-building competitions, and science lectures not only help our children and grandchildren become more technically literate, but also ensure that we ourselves continue to learn new things throughout our adult lives.

We can contribute our time, and we can contribute our resources to this effort to better educate our kids about the wonders of science, the mysteries revealed by mathematics, and the enabling powers created through engineering and technology. This is not simply a problem for government to address, but for each and every one of us as well as the organizations of which we are a part. In that regard, I want to commend the Boeing Company for their commitment in offering scholarship opportunities for kids to pursue technical fields of study. I was at Purdue University just this past weekend for the dedication of the Neil Armstrong Engineering Building, and many of those kids, as well others throughout the country, need such scholarships and compete for them. In a different time, I was one of those kids. After *Sputnik*, our nation made a concerted effort to make such things available. Why not again?

A good friend of mine, Pedro (Pete) Rustan was born in Guantanamo, Cuba in 1947. He graduated as valedictorian from his high school, and was in his junior year of college studying electrical engineering when he decided that he could never make an important contribution to society while living under communism. Pedro was also a member of the swim team. So in 1967, he escaped to freedom by timing the patrol boats and swimming across Guantanamo Bay to the U.S. naval base. He arrived in Miami with no material or financial possessions, and through the help of family, various church groups, and scholarships, he moved to Chicago, where he had some family. He earned his master's degree in electrical engineering at the Illinois Institute of Technology a few years later. Pete and I first worked together in the early 1990s, when I assigned him to become the program manager for *Clementine*, a small spacecraft which mapped the moon's surface and led to the discovery of what might be water-ice in a crater at the moon's south pole. Pete served in the Air Force for 26 years, and today directs the National Reconnaissance Office's Advanced Systems and Technology programs. The small scholarship he received in 1967 has resulted in an

enormous return on investment for our nation. Such allocations of time, resources, and energy matter greatly to the future of our country.

NASA cannot get to the moon, Mars, and beyond by itself. It requires everyone pulling on the oar to keep America on the forefront of this new frontier. Quite frankly, I do not have all the answers for everything NASA must do, or everything each of us must do collectively and individually to counter the alarming trends of which I spoke earlier. The first step, though, is to recognize the problem and to realize that we are in this together.

We in the space community must change the way we speak to the public and amongst ourselves. We must speak plainly. NASA's engineers and scientists unfortunately tend to speak in a language that causes us to lose touch with the American public. We must overcome that shortcoming, as well as our tendency to introversion, in order to convey the excitement and sense of wonder inherent in our work to our children and grandchildren.

The art, science, engineering, and business of space exploration is the hardest thing we do as a people. With it, we turn science fiction into

reality. *This is rocket science.* Quite simply, space exploration is the highest expression of human imagination of which I can conceive.

Thus, it troubles me – and I hope it concerns you as well – that I see America losing its competitive edge in this field. It matters greatly.

On October 29, 1960, exactly 47 years ago, the junior senator from Massachusetts spoke about the New Frontier which was to become the lasting legacy for his presidency. He concluded his speech, as I would like to conclude mine tonight, with this thought: “Twenty-four years ago, Franklin Roosevelt told the Nation: ‘I, for one, do not believe that the era of the pioneer is at an end; I only believe that the area for pioneering has changed.’ The new frontiers of which I speak call out for pioneers from every walk of life – in the White House in Washington, but in the country at large as well. Their challenge can be concealed for a little while, but it cannot be ignored, and it cannot be met by a soft complacency, a satisfaction with things as they are, or a commitment to the past... The new frontier of which I speak is not too hard for us, neither is it far off. No one need bring it to us, it is here, both its dangers

and its opportunities, and we must meet its challenges here, in our hearts.”

It cannot be said better.

Thank you.