

The Space Economy

NASA 50th Anniversary Lecture Series

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Thank you for coming today.

We've gathered to kick off this lecture series commemorating NASA's upcoming 50th birthday. But we're celebrating more than what NASA has done and the benefits that have followed; we're celebrating who we are, and who we can be, as a people.

NASA opens new frontiers and creates new opportunities, and because of that is a critical driver of innovation. We don't just create new jobs, we create entirely new markets and possibilities for economic growth that didn't previously exist. This is the emerging Space Economy, an economy that is transforming our lives here on Earth in ways that are not yet fully understood or appreciated. It is not an economy in space. Not yet. But space activities create products and markets that provide benefits right here on Earth, benefits that have arisen from our efforts to explore, understand, and utilize this new medium.

In its last Space Report, in November 2006, the U.S. Space Foundation estimated the Space Economy at \$180 B in 2005, with over 60% of that figure coming from commercial goods and services. This growing economy affects just about every aspect of how we live, work, and play, and other emerging new markets are just around the corner. It enables satellite communications including radio and television, telemedicine, point-to-point GPS navigation, weather and climate monitoring, and space-based national security assets. It also includes the nascent space tourism industry and the development of space logistics services that will transform space transportation into a viable commercial enterprise.

Fifty years ago, space was a far off place – the stuff of science fiction. Today it is pervasive in our lives, critical to a range of activities that create and provide value to human beings. It all grew from NASA's roots in space exploration, so I'd like to talk about that for a few moments.

People all across our country, and all across the world, find what we do exciting, they find it inspiring, and they find it so for many reasons. The courage and competence of our astronauts, and the dedication of the engineering teams that put them into space. The quest for knowledge which is realized by awe-inspiring pictures of distant galaxies or Martian craters. The challenge of the frontier, the final frontier, the frontier that begins anew on each new planet and with each new discovery. The way we take on seemingly impossible tasks, tasks that challenge human skill and ingenuity to the utmost, like building a million-pound space station as

a toehold on that frontier. What we do at NASA is, quite simply, larger than life, bolder than the boldest dreams, and we all know it.

So everyone knows and appreciates NASA, but to most people what we do is “out there”, literally out of this world. The daily, immediate connection between what we do and its impact on our lives is either unnoticed or taken for granted. In part, this is due to circumstance, or more properly to a change in circumstance.

NASA was born and came of age during the Cold War, in a historical context that is difficult for many who were not there at the time to appreciate. It was a time when our very way of life had been called into question. The Soviet Union declared that our democracy was too weak and inefficient to compete with communism, and after the successful launch of Sputnik, there were many people in our country who feared that they might be correct. And there were many others who were committed to proving them wrong.

The Moon race was more than exploration for its own sake, and a lot more than an exercise in national pride; it was considered a real-life test of the viability of our open society – a vindication of the very concept of freedom. The American people admired NASA’s expertise, derring-do, and can-do attitude, a reflection of America itself. They marveled at our ability to meet John F. Kennedy’s challenge to land a man on the Moon in just eight years and two months, a feat that seems ever more wondrous as we grow, year by year, more distant from it.

But it was more than just that. The Soviet Union had shown that success on the frontier of space could translate into power and influence in the world. In the Cold War, we were in a strategic competition for just such power and influence against a totalitarian regime whose core values were abhorrent to most Americans. So when Americans watched the Moon missions depart, our belief in freedom and in our way of life, our hopes for a better life for our children and their children, were riding along with the astronauts. For a moment, we could leave our anxieties about the larger struggle of the Cold War back on the launch pad and let our spirits ascend into the skies. But we knew, always, that we *were* locked into that struggle, that it was playing out most visibly on the space frontier, and that we were, finally, winning. Because of this, the connection between what we do at NASA and the daily lives of Americans at that time was immediate and intense.

Even more, this event was inspiring to the world, not just to the United States. The world was cheering us on because of the sheer magnitude of the accomplishment. American self-confidence – our belief that we can do what we set out to do – drew admiration from across the world, then as it does now. And NASA, then as now, was the embodiment of that spirit.

We’re in a very different world today. The military and political competition has largely receded into the background; today we are primarily engaged in an economic competition. We increasingly live in a global economy where rising wealth and living standards also mean ever-heightened levels of competition from places we never before considered. There are now more software engineers in Bangalore, India than in Silicon Valley. Japan, Taiwan and South Korea generate more than one-quarter as many patents as the U.S. does each year – and their percentage is growing rapidly. The products of this innovation are all around us, in what has become a

world marketplace. How many of you have a cellphone, television, or car from a U.S. manufacturer?

I don't think I need to spend more time on these points; they are superbly treated in Tom Friedman's *The World is Flat*, and in the report, "Rising Above the Gathering Storm", by the National Academy of Engineering. But I think the bottom line is that we all want our economy to continue to grow. We want better lives for our children. We want to be able to compete in the world. But economic growth and competitive success result primarily from the introduction of new products and services, or from finding more efficient ways to produce existing ones. Economic growth is driven by technological innovation. Societies that foster it lead the pack, while others lag behind.

But if technological innovation drives competitiveness and growth, what drives innovation? There are many factors, but the exploration and exploitation of the space frontier is one of them. The money we spend – half a cent of the Federal budget dollar – and the impact of what we do with it, doesn't happen "out there." It happens here, and the result has been the Space Economy. So if America is to remain a leader in the face of burgeoning global competition, we must continue to innovate, and we must continue to innovate in space.

There is another factor driving innovation as well, too often overlooked, or if seen, too often dismissed. Success in an economic competition depends upon image as well as substance. Companies the world over have a choice as to where to do deals, and with whom to do them. The nation that appears to be at the top of the technical pyramid has taken a large step toward being there in fact. Developing countries like China recognize the value of space activities as a driver of innovation, a source of national pride, and a membership in the most exclusive of clubs – that of spacefaring societies. And it is no coincidence that we're seeing thousands of high-tech start-ups in China.

NASA is uniquely positioned to drive the Space Economy with both substance and style, because our mission requires us to push the technological envelope every day, and to do it in the most publicly visible manner of any human enterprise. Our human and robotic ventures into the solar system, our attempts to fathom the mysteries of the Universe, require for their accomplishment a voyage of discovery beyond the limits of knowledge, and they are accomplished for all to see on a stage of breathtaking scope and grandeur. At once, we have an endeavor which places the highest possible demands on technical ingenuity, requires a calculated yet stunning audacity for its success, and returns a product with which all the world is fascinated. And even when we fail, we do so, in Teddy Roosevelt's immortal words, "while daring greatly". This is why, each year, the National Air and Space Museum is the world's most visited museum.

At NASA we explore the frontier; in fact, we create that frontier. To do it, we have to answer a lot of questions that wouldn't even have been questions without that commitment to the unknown. The answers to those questions are answers that power our future.

Because our mission is flight in all its forms, in space and in the air, we think and work and do our engineering and our science at the extremes – and that's where the greatest discoveries are made. In celebration of its 25th birthday, USA Today recently offered a list of the

“Top 25 Scientific Breakthroughs” which have occurred since its founding. Nine of them come from space, eight of them directly from NASA.

We see the transformative effects of the Space Economy all around us through numerous technologies and life-saving capabilities. We see the Space Economy in the lives saved when advanced breast cancer screening catches tumors in time for treatment, or when a heart defibrillator restores the proper rhythm of a patient’s heart. We see it when GPS – the Global Positioning System – developed by the Air Force for military applications – helps guide a traveler to his or her destination. We see it when weather satellites warn us of coming hurricanes, or when satellites provide information critical to understanding our environment and the effects of climate change. We see it when we use an ATM or pay for gas at the pump with an immediate electronic response via satellite. Technologies developed for exploring space are being used to increase crop yields and to search for good fishing regions at sea.

Sometimes a personal example carries more weight than the most comprehensive factual data. So consider the case of Sarah Moody and her young nephew, Steve, who was born with a rare disorder. He had no sweat glands to cool down during the summer, and his body would overheat dangerously. After one too many close calls, Sarah thought to herself what many have thought before: if we can put a man on the Moon, why can’t someone figure out a solution to Steve’s problem? So she called NASA, and was put through to what is now our Innovative Partnerships Program.

NASA scientists were able to adapt cooling technologies developed for the Apollo astronauts to create a cooling vest for Steve. It worked. Sarah started a foundation that has delivered some 650 such vests to people suffering similar disorders. Her foundation also turned to NASA for help with kids who had to live in dark rooms to avoid suffering tumors when exposed to ultraviolet light. NASA’s contractors helped create suits that blocked it, allowing these kids to go outside. Sarah Moody died a few years ago, but her legacy lives on.

Gary Thompson, an athletic 50-year-old man with a family history of heart disease, was given a clean bill of health in a series of tests with several doctors a few years ago, then had a heart attack while running a marathon. He survived, and subsequently heard of a new ultrasound imaging technology derived from algorithms used to process images of Mars at the NASA Jet Propulsion Laboratory. He was diagnosed correctly with this new technology, something all the other tests had failed to do. He was so impressed, he started a company, Medical Technologies International Inc., to make this new technology more widely available. It is now in use across the country.

These examples only begin to tell the story. All of us can be proud that they exist, but equally we recognize that we wouldn’t create a space program in order to get these collateral benefits. But NASA is transformative. We don’t just help develop new technologies, we inspire whole new industries, revolutionize existing ones, and create new possibilities.

I often wonder if it might be possible to quantify the value to society of upgrading the standards of precision to which the entire industrial base of that society operates. Any company bidding on space projects – anyone who wants to be a subcontractor or supplier, who even wants

to supply nuts, bolts and screws to the space industry – must work to a higher level of precision than human beings have ever had to do before. How do we value that asset? I don't know, but I know that it is real.

In a related vein, another benefit of space to the economy is the way it inspires people to go into the technology sector. People like Steve Jobs, Bill Gates, and Burt Rutan immediately come to mind, but it is more important to realize that a large number of technical professionals, in all fields, first got hooked on space and were then inspired to pursue technical careers. This is truly one of the best “spinoffs” we have, and the space exploration enterprise should receive due credit for it. At a time when we are concerned about declining enrollments in engineering, science, and mathematics, this should be no small factor in our thinking.

Most of you know how the demands of spaceflight sparked the revolution in integrated circuitry. But we didn't only get integrated circuits from the effort to master spaceflight, we got all of the other technologies that made them possible. These capabilities now permeate our entire industrial base, and the use of integrated circuits is so ubiquitous, in devices whose very existence would have been almost unimaginable only a few years ago, that we no longer even notice it. Cellphones are given away as a competitive inducement to select one wireless provider or rate plan over another. Devices that can store gigabytes of information, a capability once beyond price, are given away as keychain fobs in promotional advertising. Built into your checkbook can be a calculator that Newton or Gauss would have given years of their careers to have. For a few hundred dollars, you can buy a device that will allow you to navigate to any address in the country over any road on the map. And who even notices?

Today, NASA is again among those at the forefront of microprocessor development, as evidenced by the recent demonstration of a Quantum Computer Chip – a device that operates at the limits of our understanding of the physical universe and makes use of the strange and elusive properties of quantum mechanics. Quantum computing won't be just one more incremental improvement on present-day computing – it will revolutionize it. It's the kind of breakthrough you get when you set the bar impossibly high, simply because the rigors of space exploration demand it.

To stimulate economic growth, increase our international competitiveness, and create better lives for our citizens, we must stimulate technological innovation. NASA's own programs accomplish this in one way, but as we have seen, the Space Economy today is much bigger than NASA and becoming more so. But NASA has another role to play, that of an important catalyst for new ideas and new technology by setting extraordinary goals and engaging the imagination and drive of entrepreneurs in the private sector.

One such effort is our program to enable the creation of new, low-cost commercial space launch capability, using as an anchor market the logistics for the International Space Station. The COTS – for Commercial Orbital Transportation Services – program is intended to demonstrate capabilities to provide low-cost transportation services to orbit for cargo and crew. If this experimental program is successful, NASA will purchase commercial services for delivery of cargo and crew to the ISS. We envision multiple flights per year beginning after 2010.

Fifty years into the Space Age, the greatest obstacle to the exploration and utilization of our solar system is the very high cost of space transportation. No government effort has yet made a successful attack on this problem. But when we do have it, we will find that commercially viable, low-cost space transportation will be as transformative to the economy as the transition from steam to diesel power, or the achievement of powered flight. It will open up possibilities that now appear impractical, if not outlandish.

This takes us to the Vision for Space Exploration, laid out by the President in 2004 and enacted in the NASA Authorization Act of 2005. In the wake of the Columbia tragedy, it calls for NASA to extend human and robotic presence to the Moon, Mars and beyond. As the President's Science Advisor, Dr. Jack Marburger, stated in his March, 2006 speech at the Goddard Symposium, "As I see it, questions about the Vision boil down to whether we want to incorporate the Solar System into our economic sphere, or not." Precisely so. Every aspect of human knowledge will be tested and advanced: physics, chemistry, biology and their practical applications in engineering, medicine, materials science, computer science, robotics, artificial intelligence, power, and many other fields – and we haven't even mentioned rocket science. This is a legacy the crew of Columbia would be proud to know we had carried forward.

Reaching for the unknown, making our lives bigger and our horizons broader, achieving things never before possible, are the heart and soul of what we do at NASA. By pushing beyond the frontier, by setting for ourselves seemingly impossible challenges, we are transforming our lives for the better here on Earth even as we explore new worlds in space. If, as Shakespeare said, life is but a stage, then NASA takes the play to the grandest possible stage. And in doing so, we create the Space Economy. At NASA, we are making the future happen – now.

Thank you very much.