

Remarks by the Honorable Shana Dale
NASA Deputy Administrator Columbus Future Forum
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Thank you all very much. First off, I would like to thank David Chesebrough and his staff at COSI for being such wonderful hosts for this event.

I would also like to extend NASA's appreciation to our sponsors and key partners. They include Ball Corporation, Battelle, the Ohio State University, Tech Columbus, Nortech, the Dayton Development Coalition, Raytheon, National Institute of Aerospace, and finally the Ohio Space Grant Consortium.

Like many at NASA, being a part of our nation's space program is the fulfillment of a life-long dream for me. I think what attracted all of us at NASA to the space program is the same thing that keeps the American people so intrigued and inspired by our mission: the excitement of discovery, that irresistible human impulse to explore beyond the next horizon, the feeling of being a part of something bigger and grander than ourselves. Ultimately, I believe, that is what motivates this great voyage of discovery.

In my talk today, however, I want to focus on another side of NASA, a critical part of our story that doesn't get as much attention as our exciting missions and discoveries.

SPACE ECONOMY

I want to talk about what we call the "Space Economy" and the very tangible and pervasive ways in which exploration of space affects our daily lives here on Earth. To put this discussion in context, as we talk about the Space Economy and the promise of the future, we all should recognize that as taxpayers, the portion of the federal budget that goes to NASA is probably smaller than many of you might expect, six-tenths of one per cent, with which NASA performs all of its spectacular missions.

First, we need to define the Space Economy. With some help from experts, we define it as the full range of activities that create and provide value to human beings in the course of exploring, understanding and utilizing space.

Space is pervasive in our lives, invisible yet critical to so many aspects of our daily activities and well-being. In fact, the Space Economy impacts just about every aspect of how we live, work, and play, including weather and climate monitoring and space-based security applications that keep us safe. When we pay for gas at the pump, draw cash from an ATM, or listen to satellite radio we can experience the benefits of the Space Economy.

Space exploration has created new markets and new technologies that have powered our economy and changed our lives in many ways. Today, according to a U.S. Space Foundation report, the Space Economy generates nearly \$220 billion in total revenues worldwide, with the promise of new exciting markets including a nascent space tourism industry and the development of space logistics services that will further transform space into an even more robust commercial enterprise. So, while the commercialization of space for new emerging markets is just around the corner, the Space Economy has already arrived and is thriving.

So what does this have to do with NASA? And how does NASA contribute to the Space Economy?

Our mission is not to create commercial products or to stimulate the economy, although our work has often had those effects. Our focus is not on healthcare or medical research for the general public yet we have made significant contributions in those areas. We are not the nation's environmental agency yet we provide critical information that advances environmental understanding. The simple answer is that exploration of space demands that we push the limits of knowledge, technology and precision in ways that we could not have originally imagined and the benefits go far beyond our space exploration mission.

NASA's contributions to the Space Economy are through the three principal topics we will be discussing today: Inspiration, Innovation and Discovery. The space exploration mission is one that is unique in its ability to inspire the public. Who can witness a Shuttle launch or the view from a rover on Mars and not feel a sense of awe? Generations of students have been inspired to pursue studies in science, engineering and math with the goal of

getting a glimpse into the mysteries of our universe and understanding the mechanics of spaceflight. Over the last fifty years, many of those students went on to power every form of innovation from developing the computer chip to mapping the human genome.

NASA drives innovation by tackling hard, complex problems and overcoming seemingly insurmountable obstacles. Since our mission demands putting humans and robots into harsh, extreme environments, we must reach into the unknown to achieve our goals. This is where we are challenged to push the very limits of technology and where we realize the greatest innovations.

NASA's pursuit of discovery pushes the extremes of science to answer fundamental questions about who we are and where we come from; to achieve a greater understanding of the universe; and to determine what is happening to the Earth's climate and why. These discoveries, whether it is the discovery of how the first stars formed, the history of water on Mars, or uncovering the mysteries of space weather, they all serve to whet the appetite of future generations and inspire them to push further the ever-expanding frontiers of human understanding.

Inspiration, innovation and discovery: each is interdependent and through a virtuous circle of renewal they combine to create a formula for future growth, prosperity and an improved quality of life. These form the essence of the Space Economy and it is through them that NASA makes its most fundamental contributions to life here on Earth.

This year we're celebrating NASA's 50th anniversary. And for the last five decades we've made amazing achievements in space. We've seen complete hurricanes for the first time; we've stepped on to the surface of the Moon; and we've seen to the far reaches of the universe. We've discovered evidence of dark matter and dark energy, and with that realized that all we can see is a tiny fraction of what is actually out there.

This forum is dedicated to celebrating these and other phenomenal achievements, but it is also to focus our attention on the incredibly exciting missions of the future. It's about recognizing that we have all benefited from the space program in both direct and subtle ways, and realizing that each of us has the opportunity to be part of humankind's next steps outward.

Most importantly, today's Future Forum is about how NASA and the Space Economy contribute to your community.

Through inspiration, innovation and discovery we're building bridges towards a stronger, more competitive economy, a more sustainable environment and an improved quality of life for us all to enjoy. Let me expand a bit on the importance of these three critical themes and NASA's role in each.

INSPIRATION

Let's face it. It all begins with education and because space exploration is so exciting and so cool, space exploration inspires kids to go into science and math and engineering.

Maintaining our nation's leadership role in the global economy requires that we encourage more American students to focus on these fields. We know from example after example of today's science and technology leaders that for many, their road to greatness began when they first looked up at the stars. Using the inspirational pursuit of space exploration to spark the imagination of our youth is critical for keeping this Nation competitive and creating a scientifically-literate populace.

Of course when the subject of inspiration comes up, our nation owes a great debt to the spirit of Ohio, whose good people nurtured such inspiring pioneers as aviators Orville and Wilbur Wright; the first American to orbit the Earth, Senator John Glenn; and of course, the first man to walk on the Moon, Neil Armstrong. Indeed, there are 19 Buckeyes in all who have joined the ranks of our astronaut corps.

The example of youth who dream big and achieve great things is also essential to your economy right here in Columbus. Success in space starts in the classroom. That's why we're investing significant resources in education. For instance, we support the Ohio NASA Space Grant Consortium as it reaches students and educators at all levels. Last year, NASA provided over \$12 million to 16 Ohio universities to increase the research capability of these institutions to help sustain and strengthen the Nation's commitment to long-term basic research. Additionally, NASA

currently funds 84 Space Grant Scholars in the state at 19 universities and colleges, providing over \$300,000 in funding for their educations. Another NASA educational initiative in Ohio we're quite proud of is our Science, Engineering, Mathematics and Aerospace Academy or SEMAA. NASA SEMAA sites throughout Ohio have engaged students and their parents in after-school and Saturday programs. Finally, our NASA Glenn Research Center brings dozens of high school, college students and teachers to the center each summer to participate in the Lewis' Educational and Research Collaborative Internship. These paid internships allow students and educators to have hands-on experiences and exposure to the cutting-edge science and engineering underway at a NASA center.

We bring space to students in other ways too. For instance, during the first ten expeditions to the International Space Station, astronauts interacted with almost a million students via live video conferences. Last year, Barbara Morgan became our first teacher turned astronaut in space. I hope some of your students will follow her into space.

Our current venue, COSI is one of the most respected science centers in the nation, serving almost one million people a year. COSI's groundbreaking, award-winning education programs are tailored to support national and statewide science curriculum and standards. COSI engages in mentoring programs for young people to inspire the next generation of scientists and engineers through programs like COSI Academy, a program focused on high school students who are passionate about science and the Miracle-Gro Capital Scholars program which is working with 50 Columbus City High School students in a dynamic after-school college prep program.

In the past years NASA and COSI have partnered on the creation of your Space exhibition area and several educational competitions and programs. We also partnered with COSI to provide live uplinks connecting students to the space shuttle during John Glenn's return to space. For NASA, for the nation and for communities such as Columbus, inspiring students to pursue science, engineering and math fields as COSI does is critical to economic growth and global competitiveness. I look forward to a solid discussion today on how best to build the next generation of innovators and scientists.

INNOVATION

That leads me to innovation. NASA helps drive U.S. innovation that, in turn, builds our economy. We tackle hard, complex problems in the harsh, remote and unforgiving environment of space.

Doing so produces real achievements like assembling the enormous components of the nearly 500 metric ton International Space Station, and just recently, sending our MESSENGER spacecraft hurtling past Mercury and exploring it for the first time in over 30 years. But there are less visible achievements as well, like creating the key technological breakthroughs that fuel local economies and keep our nation competitive.

Many of you may have heard of NASA spin-offs: specific technologies the agency has developed for its missions that the private sector has then picked up and refined or transformed for commercial use. There are over 1,500 documented NASA-derived technologies, ranging from better cancer detection methods to robots that clear caves and cross minefields in Iraq and Afghanistan in advance of our soldiers and marines. I'll talk more about those invisible essentials in a moment. But my first point is that they, like the visible essentials of space – rockets and satellites – are all part of the Space Economy.

The Space Economy consists of space-related products and services, as well as the new markets and possibilities for economic growth that space exploration encourages. The Space Economy is emerging, growing, and already very valuable. As I noted earlier, the Space Foundation's 2007 estimated that the global space industry produced nearly \$220 billion in total revenues in 2006, up nearly 20 percent from the year before. That's an incredible rate of growth.

In its report, "The Space Economy at a Glance 2007," the international Organization for Economic Co-operation and Development (OECD) pointed out that, "The many derived space-based services have positive impacts on economies and societies." For instance, early semiconductor companies were challenged by the Apollo program to develop integrated circuits that met stringent quality and performance requirements – they had to be smaller and more powerful than ever before. That straightforward technical requirement was catalytic, starting a cascade of developments which has led to countless new products and entirely new markets. Today the phone booth

has gone the way of snail mail: We simply send e-mails, or use our cell phones to call our friends around the world. Satellites have made that near-instantaneous information sharing possible, creating global networks of friends and trading partners, as well as improved climate monitoring and better weather forecasting.

SPACE-DERIVED TECHNOLOGIES

NASA innovations also show up at the doctor's office. For instance, algorithms developed to analyze images from Mars have been adapted to an advanced diagnostic tool for heart disease that can detect arterial blockage earlier and more effectively than other techniques. The best part is that scalpels are not needed, and the patient is not exposed unnecessarily to radiation, since the new tool is non-invasive.

In the 1990s, NASA invented a device called a bioreactor that today helps the National Institute of Child Health and Human Development of the National Institutes of Health and hundreds of laboratories around the world to culture cells in new ways. That bioreactor has enabled new, promising venues of cancer research, and has led to more than 25 patents.

NASA's work has contributed to other advances in cancer detection and treatment. Breast biopsies are critical for the detection and treatment of breast cancers. And thanks to high resolution, real time imaging technology derived from the Hubble Space Telescope program, breast biopsies can be performed with a needle instead of a scalpel. The needle biopsies leave only a small mark instead of a large scar, cost significantly less than traditional biopsies, and can be performed in a doctor's office as opposed to an operating room.

Critically-ill heart patients waiting for heart transplants are now being kept alive by implanted heart pumps developed by engineers from the Johnson Space Center in Texas and supercomputer experts from the Ames Research Center in Mountain View, California. The team analyzed blood flow through the heart pump using the same methodologies we've been employing to analyze fuel and oxidizer flow through rocket engines. To date, more than 400 of these extraordinary heart pumps have been implanted in people worldwide, giving them a second chance at life.

NASA-driven innovations have also improved LASIK eye surgery. The eye is constantly moving and doesn't stop during surgery. So eye tracking devices must be able to fix the eye's position at least 1,000 times per second if surgery is to be safe. Today, many eye surgeons across the country are using a system, developed in partnership with the Johnson Space Center, based on laser technology developed to enable unmanned space vehicles to dock with and service satellites in orbit.

NASA-derived technologies do more than return people to health. They prevent them from getting hurt in the first place. That's made a difference in high-hazard areas like battlefields. For instance, a robot created at the Jet Propulsion Laboratory in California for Mars exploration has been further developed into a tactical reconnaissance robot. U.S. troops are using those robots in Afghanistan and Iraq to clear caves and bunkers, as well as to cross minefields and to deal with the dangers of improvised explosive devices.

Such robots have saved lives. According to iRobot, the company that makes them, soldiers have given their robots nicknames. According to the *Washington Post*, the robots' military keepers become so attached that they have even awarded the robots with unofficial "purple hearts" and "battlefield promotions."

And there is more in regards to international affairs. There are the ongoing concerns about the condition of people in the developing world. And here again, NASA-derived technologies come into play. Water recycling and filtration systems engineered to sustain astronauts living on the International Space Station have been adapted to provide safe, affordable drinking water in poor and remote regions where clean water can mean the difference between life and death.

NASA technologies can help ensure that water gets where it is most needed in other ways as well. When terrible blazes raged across Southern California last fall, NASA's Earth-observing satellites helped monitor their spread. We also sent an unmanned aerial vehicle equipped with thermal-infrared sensors and sophisticated real-time transmission equipment over the fires. The Ikhana aircraft peered through heavy smoke and darkness and found hot spots and flames. It then transmitted the information to the National Interagency Fire Center which distributed the imagery to fire incident commanders over the Internet. These commanders were able to use this

information from NASA and deploy firefighters real-time to the most vital locations.

We are very proud that researchers from NASA's Glenn Research Center were recently recognized by the editors of R&D Magazine and a panel of outside experts for developing products that rank among the top 100 most technologically significant products of the year. Dr. Quang-Viet Nguyen of Glenn's Combustion Branch received an R&D 100 award for developing a High Speed Electro-Mechanical Shuttler for Imaging Spectrographs, a device that will help engineers design and build cleaner-burning and more fuel-efficient aircraft engines of the future. And doctors Dongming Zhu, Robert Miller and Narottam Bansal, of Glenn's Structures and Materials Division, were awarded for the development of high-tech coating systems that will help advance the development of state-of-the-art turbine engines.

These are only a few examples of what NASA technologies mean for all of us here on Earth, but it is by no means an exhaustive list. The point is that technology advancement doesn't recognize boundaries. The same capabilities that apply "out there" in space also apply directly to our most critical needs back here on Earth. Those advances are then refined, adapted or transformed to meet the challenges we face, from heart pumps to advanced breast cancer imaging to compact water filtration systems.

They also benefit Columbus, and the State of Ohio, in direct ways. Over the past five fiscal years, NASA has invested well over \$1.1 billion in the state of Ohio. Last year (FY 2007), more than \$204 million went to Ohio businesses and nearly \$12 million to state educational institutions like Ohio State University. Large companies like Lockheed Martin and Rockwell Automation have benefited from those investments, but smaller ones did too, including: Advanced Reading Concepts, Edison Welding Institute, Sci Tec, and Sensotec.

These investments and innovations as well as the Space Shuttle program, the International Space Station, future human explorations, aeronautics research, and all of our science endeavors – are happening on a budget with a funding level that is six-tenths of one percent of the federal budget. Through those investments, we are:

- Embarking on the human journey back to the Moon for a mission that is vastly different from Apollo. About twelve years from now we'll

- live on the surface of that world, and learn enough to take the next steps;
- Observing our Earth from the unique vantage point of space, which is essential for climate change research and disaster response and mitigation;
 - Conducting fundamental research in aeronautics that will lead to quieter, safer, and more efficient airplanes;
 - Expanding our knowledge about the universe and our place in it, through projects like the Hubble Space Telescope;
 - Leading the largest international cooperative endeavor in the history of science and technology: the International Space Station; and
 - Engaging the commercial aerospace industry in an exciting initiative to facilitate U.S. private industry development of reliable, cost effective access to low Earth orbit and to create a market environment in which commercial space transportation services are available to government and private sector customers. On Tuesday, we announced that Orbital Sciences Corporation has been selected to develop and demonstrate commercial orbital transportation services under this initiative, which we call COTS, or Commercial Orbital Transportation Services.

Because of these efforts, NASA is helping our high tech industries, a major force in U.S. economic growth, stay on the cutting edge of competitiveness.

DISCOVERY

Through innovation, NASA opens the door to new discoveries. We have discovered a great deal through NASA's research into lightweight composite materials, quieter and cleaner aircraft engine technologies, and advanced air traffic management tools. These are all making air travel safer, more efficient and more environmentally friendly.

Our aeronautics research program has contributed to innovations like winglets, which are vertical extensions of wingtips that improve an aircraft's fuel efficiency, cruising range, as well as the space required at the airport. They're being used around the world, on all types of aircraft. A more recent NASA/industry research collaboration resulted in a new engine nozzle design, which reduces engine noise.

In space exploration, we are in an exciting new age of discovery, going to the Moon, Mars, and beyond. Our mission is fundamentally different from the days of Apollo. In cooperation with our international partners, we'll construct an outpost there, a sustained human presence on the Moon.

Let me emphasize those words "sustained human presence." The outpost on the Moon will be a toehold to further exploration, a place where we will stay for long periods of time and learn how to live and work and conduct science far from home. We'll learn to live off the land at this outpost, using the Moon's abundant resources to strive for a self-sustaining operation.

Critical to that enterprise will be water as a vital source for life support oxygen, and for power and rocket fuel after it is broken down into its constituent elements of hydrogen and oxygen. Even if we don't find "water" in its frozen state, there are high concentrations of hydrogen and oxygen. Hydrogen extracted from the lunar soil can be used in fuels or combined with oxygen to create water.

Believe it or not, the outpost on the Moon also has significant potential for improving human health. Sustained settlement on the Moon will mean surmounting a whole new list of medical challenges. Despite care and planning, accidents can and will happen during extended stays in space. So those living in the lunar outpost will need new ways to treat injuries and illnesses, like remote diagnosis and telemedicine. They may even need new, "smart" medical devices, since no space mission is likely to have a full staff of medical specialists aboard. This need will be even more acute for the Mars mission, which will require months in space, and could be nearly three years – 1000 days – in total duration.

The lunar outpost may also require new abilities to detect and eliminate disease-causing microbes and toxins in the environment and to extend the shelf-life of medicines. The specific advances that could come from these areas are unknown, but their benefits to human health will be real.

And we are planning on making those missions happen. Under the Constellation program, work has begun on the spacecraft that will take us to the Moon and beyond: the rockets and the crew exploration vehicle. Components for those craft are coming together: They are going from blueprints to models to tests. People all across the country are working on the program, and many more are likely to have a part. We'll hear more about the Constellation Program later this morning.

SUSTAINABILITY

Meanwhile, as NASA's robotic probes continue to investigate the fascinating planets and moons of our solar system, others are peering down to monitor the health of our planet. I talked about NASA-driven innovations earlier. Now I'd like to talk about how NASA-derived discovery leads to sustainability of our planet and its natural resources.

Sustainability of our Earth permeates NASA's missions. For example, to survive on the Moon's surface we must find ways to create, collect, store and use energy without access to fossil fuels. Other sources of energy must be developed into practical resources that humans can use in extreme environments. As we continue to explore new sources of energy and delivery methods, these efforts can help to address the pressing demand for energy right here on Earth. Space exploration demands cleaner and more efficient sources of energy that can operate in extreme environments without toxic effects.

One example of a relatively clean energy source offering tremendous potential is solar power. NASA pioneered the use of solar cells in the Apollo Program and continues to push the limits of this technology today, with the solar "wings" that collect the sun's energy for use onboard the International Space Station. Technologies for capturing and utilizing solar power hold the promise of a clean and abundant energy source, one that is virtually limitless for as long as the sun endures. The potential impact of these alternate, clean energy sources, is so great that we can hardly imagine it, affecting the lives of not only Americans but of every person on the face of the planet.

In addition to renewable energy sources, space exploration contributes to sustainability in many other ways. In space travel, physical space is limited, weight is critical, and resources are severely constrained. Every watt of energy is accounted for; every resource is transported and monitored. Space exploration drives the development of technologies with minimal impact to these tiny ecologies – and, by extension, to the ecology of Planet Earth. These technologies include advanced recycling techniques; treating waste and converting it back into usable resources; as well as new, green power systems. Outposts on the Moon, as well as travel to Mars, will require lighter materials, manufacturing techniques with little waste or pollution, and even better methods of recycling and reuse, contributing to the development of sustainable systems on our own world.

EARTH SCIENCE

But perhaps NASA's biggest contribution to sustainability is the development and operation of Earth-observing satellites. NASA satellites supply more global climate change data than those of any other organization in the world. It is only through NASA's investments in measuring the forces and effects of climate change that we have such insights and understand its implications to our home planet. Fourteen of those research satellites that peer down on the Earth are in orbit today.

These satellites make countless contributions to the understanding of our home planet. They warn us of gathering storms, approaching hurricanes, and shrinking snowcaps. In regards to nitrogen oxide emissions, one of the greenhouse gases that form smog, NASA sensors helped researchers document their doubling in Asia from 2000 to 2006. These satellites provide essential information critical to helping us understand our changing environment, showing pollution from factories, and even increasing the productivity of farmers.

And we're not done: Seven more Earth science missions are under development at NASA, three of which will launch over the next 12 months. As of two weeks ago when NASA released the Fiscal Year 2009 budget request, we have initiated five more Earth science missions for launch by 2020. All in all, NASA invests about \$1.5 billion every year in Earth Science.

CONCLUSION

In coming here to Ohio, I noted that your official state quarter proudly reminds us that we are in the “birthplace of aviation pioneers.” So what is it about Ohio that makes a person want to reach for the stars? Well, just as the youth of today are inspired by astronauts ascending into the heavens, in their era, young Ohioans like John Glenn and Neil Armstrong were inspired by the dreams of flight that originated in this state. In John Glenn’s case, two years after Charles Lindbergh flew the Atlantic in the Spirit of St. Louis, in 1929, his father took him for a ride in an open cockpit Waco biplane in the skies above Cambridge, Ohio. John couldn’t get two things out of his mind...the view from the air and the amazing feeling of being suspended without falling. Soon, John was building model airplanes and preparing for his career as a Marine Corps pilot and later – as a Mercury 7 astronaut.

Neil Armstrong was six years old in 1936 when he went up in the skies with his father in a Ford Tri-Motor near their home in Wapakoneta, Ohio. As a teenager, Neil was obsessed with flight and he obtained his pilot’s license even before he could drive a car. It was that kind of drive and ambition that NASA wants to instill in our future generation of explorers.

Today, the state of Ohio remains one of America’s great engines of progress with its thriving aerospace industries and with our Glenn Research Center contributing to our nation’s technological advancement. You in Columbus are helping NASA build the space economy, and creating a better world.

Space exploration is all about inspiration, innovation, and discovery. It’s about imagining the future. It’s about taking new steps, and exploring beyond our limitations, and creating something bigger and grander and better than ourselves. Along the way, there are countless benefits, invaluable discoveries and technologies borne through the trials of exploration that enhance our lives on Earth. That’s been true for NASA’s first fifty years. And I have no doubt that it will be true in the next five decades.

Quests of discovery are as old as humanity itself. We go to see what is beyond the horizon, to test ourselves against the unknown, to face our fears and overcome the challenges using all of our ingenuity and determination.

We will continue our quest for new discoveries through the James Webb Space Telescope which will find the first galaxies that formed in the early Universe, connecting the Big Bang to our own Milky Way Galaxy. We will pursue our aeronautics research program to make our air transportation system safer, cleaner, and more efficient. We will establish a sustained human presence on the Moon, place the first footprints on Mars, and then go even further.

I look forward to a day of discussion about the future. A future brightened by the prospect of a growing space economy and continued space exploration, and all the promise that this holds for the people of Columbus, for our nation and for the world.

Thank you.