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Statement of
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before the

Subcommittee on Science, Technology, and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to speak about the recommendations found in the *Final Report of the Commission on the Future of the United States Aerospace Industry*. We appreciate the diligence and thoroughness of the Commissioners and the recommendations they have brought forward. We support the Commission's overall message that Aerospace will be at the core of America's leadership in the 21st century and that for this industry to remain healthy, the critical underpinnings of this nation's aerospace industry must be strong.

To achieve their stated vision, the Commission makes several recommendations that have a strong focus on research and technology. NASA is an investment in this country's future of the type that the commission recommends. In particular we are dedicated to providing technologies for leadership in aviation and space transportation, working with the educational community in growing and sustaining a technical workforce in our nation, and conducting the research needed to fuel the innovations of the future.

NASA Strategic Plan is in alignment with the Commission's Report

Under Administrator Sean O'Keefe's leadership, we have just released a new NASA Strategic Plan that is responsive to national needs and is very much in agreement with the thrust of the Commission's report. All members of Congress should have recently received a copy of this Strategic Plan. Our new Agency Mission Statement reads: "To understand and protect our home planet, To explore the universe and search for life, To inspire the next generation of explorers…as only NASA can."

I want to paraphrase this Mission Statement slightly to point to the Strategic and Enabling goals that NASA developed to support each element, and from there, discuss the work we do in specific support of the Commission's recommendations in Chapters 2, 3, 8 and 9.

To Understand and protect Our Home Planet …. leads to specific NASA goals for enabling a safer, more secure, more efficient and more environmentally friendly aviation system, and improving security and quality of life. As NASA works with the FAA and others to achieve these goals, we are in direct support of the Commission's report, especially the Chapter 2 recommendation to transform the U.S. air transportation system and the Chapter 9 recommendation to enable breakthrough aerospace capabilities.

To Explore the Universe and search for life. . . leads to specific NASA goals of assuring access to space, and developing revolutionary technologies that enable the agency's science missions of the

future, which in turn, open new opportunities to science, exploration and commercial space endeavors. These efforts support the view in Chapter 3 of the Commission report.

To Inspire the Next Generation of Explorers . . . leads us to NASA goals for working with educators, K-12 students, and the university community, to ensure that the aerospace industry has access to a scientifically and technically trained workforce as recommended in Chapter 8 of the Commission report.

As only NASA can . . . leads us to the unique basic research and technology development NASA performs to fulfill our Mission, particularly in areas that offer the potential for breakthroughs in critical aerospace capabilities such as propulsion and power, information technology, and nanotechnology as recommended in Chapter 9 of the Commission report.

Early last year NASA unveiled an *Aeronautics Blueprint* that outlined a new and revolutionary technology vision to address the aviation challenges we face in the 21st Century. The four critical areas for technological investment identified in the *Blueprint* and also included in the Commission's areas of emphasis are: a Digital Airspace, Revolutionary Vehicles, Aviation Safety and Security, and a State-of-the-Art Educated Workforce. These *Blueprint* elements have been incorporated in NASA's 2003 Strategic Plan.

Specific NASA activities in alignment with the Commission's Recommendations

Through our Mission and goals, we have set the priorities that guide our investment of the taxpayers' money, and clearly inform our Enterprises, Centers, and most importantly, each of our employees, how they contribute with their particular talents and capabilities to meet the nation's critical needs. This hearing is a timely opportunity to highlight changes Administrator O'Keefe has made within NASA, as well as elements in the President's Fiscal Year 2004 budget that speak directly to the Commission's recommendations. Recent highlights include:

- NASA has an Education initiative to turn the tide on declined interest in science, technology, engineering, and mathematics.
- NASA has a new Integrated Space Transportation Plan to more fully integrate its efforts in the International Space Station, the Space Shuttle and the Space Launch Initiative to support Science activities in space.
- NASA developed (with industry, academia, the FAA, and DoD) an *Aeronautics Blueprint* to define technologies that have the potential to open a completely new era in aviation by providing unprecedented air transportation safety and efficiency, a transformed national defense, new markets and economic growth, and enhanced quality of life.

Overall NASA has aligned its programs to better represent and reflect national priorities and to better concentrate our efforts. What follows is a summary of some of our key activities.

AVIATION

The Commission has called for, in Recommendation #2, an air transportation system that meets the needs of civil aviation, homeland security and national defense. The President's Fiscal Year 2004 Budget reprioritizes investments and increases funding for three new initiatives focused on *National Airspace System Transition, Quiet Aircraft Technology, and Aviation Security.*

A critical element for the work in aviation is the need to set up an interagency organization to guide and coordinate efforts for a National Aviation System Transformation. FAA, NASA, and OSTP have coordinated a proposal for such an organization that would set goals and align missions across

government to ensure that the United States can meet future system demands, and stay at the forefront of the global aviation industry.

National Airspace System Transition: Prior to the attacks of September 11, 2001, the aviation system was showing unmistakable signs of gridlock. Most air travelers had experienced congested airports, flight delays, and unreliable service. Since deregulation of the airline industry in the United States in 1978, air travel has tripled while the air transportation support infrastructure has remained relatively unchanged. Only one large hub airport and seven new runways have been opened in the past decade, while the number of departures had grown nearly 30 percent from 7 million to 9 million per year.

As a result of the impact of September 11th on the economy and air transport system, the current demand has been reduced but we believe that the capacity issues that we faced prior to the attacks will return. Specifically, the growth in delays in the years 2000 and 2001 significantly outpaced the growth in air traffic. Our existing airspace management system clearly cannot accommodate projected growth. We need to continue the development of technology to solve the problem of limited capacity of the National Airspace System (NAS). We do not want to have a situation where the capacity of the system constrains national economic growth.

Safety and security have taken on a whole new perspective since the terrorist attacks. NASA is committed to working with airlines, airports, and other Federal agencies to develop concepts and technologies, which will reduce the vulnerability of aircraft and the NAS to criminal and terrorist attacks.

I am pleased to report that through reprioritization within the President's FY 2004 budget, there is increased funding to address these critical aviation issues and begin the development of technology to increase the efficiency and capacity of the National Airspace System (NAS).

We will invest $27 million in FY 2004 for this initiative, which we call the National Airspace System Transition ($100 million over 5 years). The major challenges are to accommodate the projected growth in air traffic while preserving and enhancing safety; providing all airspace system users more flexibility, efficiency and access in the use of airports, airspace and aircraft; enable new modes of operation that support the FAA commitment to "Free Flight" and the Operational Evolution Plan (OEP); and develop technology to enable transition to a next generation National Airspace System beyond the OEP horizon.

The research within this program will be focused on developing a more flexible and efficient operational approach to air traffic management. For example, together with the FAA, NASA will investigate and solve the technical challenges of increasing runway capacity in inclement weather to eliminate the biggest source of delays – poor visibility. We will also develop totally new concepts that allow the system to scale with increasing traffic levels. We are developing sophisticated new modeling capabilities of the nation's air traffic system so we can test out our tools and concepts.

As the Commission has pointed out, the transfer of technology – to ensure its application – is essential to realize its value. Through efforts such as an interagency program office we will strengthen ties between the member agencies, and work similarly with academia and industry to transition the research into technologies, products and services useful to the nation.

Quiet Aircraft Technology: Noise is typically a primary objection that communities have to airport or runway expansions. Airports located in remote areas when they were built are now located in the midst of sprawling communities. They are subject to an increasing number of noise restrictions affecting airport and aircraft operations. Since 1980, noise restrictions at airports grew worldwide from 250 to over 800 airports with specific additional restrictions beyond normal regulations.

The U.S. has spent more than $4 billion from the Aviation Trust Fund and Passenger Facility Charges over the last 20 years to mitigate airport noise (e.g., sound-insulating nearby homes, building

protective barriers). Reducing the noise impact on communities is a key issue for 21st Century aviation.

To illustrate this challenge of reducing aircraft-generated noise, we have conducted analyses of aircraft noise at Chicago O'Hare International Airport. Using the baseline 1997 aviation fleet noise-level contours, objectionable noise levels extend many miles from the airport and affect approximately 600,000 people in the surrounding community. A quieter fleet of aircraft with a 10-decibel reduction in noise will reduce that impact on all but approximately 55,000 people. NASA's research and technology development continues to be focused on how to eliminate noise as an issue—by confining any objectionable noise to within the airport boundaries.

The President's FY 2004 budget has increased the funding to address this critical aviation issue. NASA's *Quiet Aircraft Technology* Program is the primary source of technology to achieving the noise goal and includes an increase of $15 million in FY 2004 (an increase of $100 million over 5 years) for this work.

NASA is developing technologies that can directly change the noise produced by jet engines. Through an understanding of the basic physics of noise production we are able to interfere with the way that sound is produced, creating quieter aircraft for future travelers. We have also determined that a large part of the objectionable noise comes from parts of the aircraft other than the engines when the aircraft are approaching the runway. NASA is developing concepts for landing gear and wing configurations to reduce this objectionable noise. Physics-based tools for noise propagation allow us to test the benefits of new flight profiles to bring the aircraft noise closer to the airport while maintaining flight safety.

In FY 2001, NASA was able to conduct full-scale demonstrations of noise reduction technologies that would result in a 5 decibels reduction in perceived noise. This technology has been transferred to industry and is already being offered on production aircraft and engines. Based on these results and the increased funding provided in the President's Budget for research, we will be able to work in partnership with the engine and aircraft manufacturers to bring additional noise reduction technology to new aircraft more quickly than had been otherwise planned. We are expecting to demonstrate an additional 5-decibel reduction in perceived noise by the end of FY2007, leading to a total of 10dB reduction in comparison to the 1997 state of the art. To better understand the significance of this accomplishment, we can refer back to the illustration of Chicago's O'Hare airport. With a 5-decibel reduction the area encompassed by the contour of objectionable noise was reduced by 40 percent, with a 10-decibel reduction, the effected area is reduced almost 70 percent.

Aviation Security and Safety: Aviation has a long-standing tradition of being the safest among all modes of transportation. The rate of accidents and fatalities on a per-passenger-mile basis for commercial aviation is at least a factor of two lower than that achieved by any other mode of transportation. However, as aviation continues to grow, there are concerns that unless steps are taken to drastically reduce accident rates, increased flights will lead to more accidents. Any incident receives visibility, and some are deemed national tragedies. Each affects the public's faith and confidence in aviation as a whole. Thus in 1997 the National Civil Aviation Review Commission endorsed a goal to cut the fatal accident rate by 80 percent by 2007. Much progress has been made in NASA technology development for aviation safety. In particular we have seen the transition of advanced cockpit weather technology into operational practice—both forecast and real-time. In the area of security for aviation there is a lot of synergy with the technologies for safety.

Since the terrorist attacks of September 11, 2001, safety and security have taken on a whole new perspective. NASA is committed to working with airlines, airports, and other Federal agencies to develop concepts and technologies that will reduce the vulnerability of aircraft and the national airspace system to criminal and terrorist attacks

As part of the President's FY 2004 Budget request, NASA will begin a new effort in Aviation Security. We will invest $21 million in FY 2004 for this initiative ($225 million over 5 years). Research in this program will focus on concepts and technologies that can protect aircraft and the airspace system from criminal and terrorist attacks while dramatically improving the efficiency of security. In the near-term, NASA will develop and demonstrate decision support technologies for ground-based air traffic management systems that detect and assist in the management of threatening situations. Other areas include technologies to reconfigure the aircraft to fly safely in the event of damage, and flight controls technology that would prevent the aircraft from being purposefully crashed. While details of the program are in formulation, it is currently expected that the long-term research will address:

- Protection of Aircraft & Airborne Systems from Electro-Magnetic Interference
- Airspace Operations
- Transfer of Fundamental Information Technology to Security Applications
- Transfer of Fundamental Sensor Technology to Security Applications

NASA has and will continue to work closely and partner with the Department of Defense (DoD), the Department of Transportation (DOT), the Federal Aviation Administration (FAA), the Department of Homeland Security, academia, and industry to ensure that the research that NASA pursues is deliberately and methodically integrated into useful and timely products and processes.

ACCESS TO SPACE

The Commission has called for ensuring our nation's ability to explore and utilize space, in Recommendation # 3, as well as in Recommendation # 9, which calls for increasing federal investments in basic aerospace research with the goal of reducing the expense and time to reach space safely and reliably.

NASA agrees with the need to ensure and improve access to space. In the President's Budget Amendment for Fiscal Year 2003, NASA has formulated the revised Integrated Space Transportation Plan (ISTP) to ensure that safe, affordable, capable, and reliable space transportation systems are provided to support NASA's missions. The Space Launch Initiative (SLI), which began in 2001 as a key component of the ISTP, will provide the necessary technology development, risk reduction, and systems analysis to enable future space access capabilities. Based on recent system analyses, the ISTP has been updated and SLI has been refocused. As a result, NASA has a more tightly integrated plan to support its science driven missions. We believe the revised ISTP is a good plan, but we are committed to re-examining it if necessary in light of future investigation findings on the Columbia accident. The Space Launch Initiative budget is now focused on the highest agency space transportation priorities: investing in an Orbital Space Plane (OSP) for assured access to the ISS and the Next Generation Launch Technology (NGLT) Program that focuses on the most critical technology development activities, such as propulsion, vehicle health monitoring, and high temperature structures.

The OSP Program will develop a human-crewed vehicle with multi-purpose utility for the Agency. Initially serving as an ISS Crew Return Vehicle launched on an Expendable Launch Vehicle, the OSP will also provide crew transfer and limited cargo capability. The results of the OSP will enable a transition path to future space launch vehicle systems under development in NGLT.

The NGLT Program will be NASA's research arm for access-to-space technologies. As in aeronautics, access to space will require interagency partnerships to meet common needs. NASA is in the beginning of a cooperative effort with the Department of Defense, through the National Aerospace Initiative (NAI), jointly working to build a technology roadmap for hypersonics research

and access to space technologies. We will also work with the Air Force Space Command on analyses for alternatives, and towards developing requirements for the next-generation launcher.

In-Space Propulsion Research

Consistent with the Recommendation #9 of the Commission, *to reduce the transit time between two points in space by 50 percent,* NASA supports the Aerospace Commission's recommendation that more research is needed in power and propulsion systems. These systems have the potential for enabling missions that are not currently feasible. High performance propulsion systems will allow spacecraft to explore regions of space currently out of our reach, carry significantly greater scientific payloads, and will significantly reduce the time required to travel to destinations within the Solar System. This technology is needed to undertake sophisticated science operations in the outer Solar System that support the search for life. Moreover, this technology can greatly increase the speed, robustness, and science return of future robotic missions, while also serving as a stepping-stone to potential future human exploration beyond Earth orbit.

The NASA Research Centers successfully pioneered the basic research on ion propulsion that led to the first demonstration of this technology on Deep Space One in 1998. They also developed the pulsed plasma thrusters demonstrated on the Earth Observing One spacecraft in 2001. The President's budget continues the development of the next generation of propulsion technologies. Our goals are to increase the operating power of electric thrusters, to extend thruster lifetime, and to develop analytical models for optimizing thruster performance. The President's budget request for NASA also includes funding for an augmented nuclear program – now called Project Prometheus – as one of the agency's top priorities. Project Prometheus enables robust and flexible missions to explore areas of our Solar System where solar power is not practical, and it opens the door to a new generation of space exploration missions. Project Prometheus will focus on two major areas of nuclear power and propulsion research and development: improved versions of traditional radioisotope systems and development of a fission reactor to provide the necessary electricity to power electric engines and more capable science instruments.

The first demonstration of this capability is planned for the rovers of the Mars Science Lander, scheduled for launch in 2009. This new generation of radioisotope power systems will allow spacecraft, landers, and probes to operate 24 hours a day, seven days a week, with increased mobility and reconnaissance capabilities.

NASA will also complete research and development of the first reactor-powered spacecraft and demonstrate safe and reliable operations on long-duration, deep space missions. The Jupiter Icy Moons Orbiter (JIMO) has been identified as the first space science mission to demonstrate this capability. Scheduled for launch in the next decade, this ambitious mission will orbit three of Jupiter's moons, Callisto, Ganymede, and Europa, to explore their makeup, history, and potential for sustaining life. This mission not only demonstrates a valuable new technology, it addresses a highest priority science objective from the National Academy of Sciences – going to Europa to confirm growing evidence that a global ocean is hiding beneath its icy surface. "Europa is likely to contain the three things necessary for life to evolve -- liquid water, a source of heat, and organic material."[1] This technology makes it possible to realistically consider missions that orbit multiple targets sequentially. Such a capability is tremendously advantageous, and it paves the way for an entirely new generation of space exploration missions.

[1] Press Release, July 11, 2002 Missions to Kuiper Belt Now, Europa Within the Decade are Key to Space Discoveries, National Academy of Sciences

A Vision of the Future

Finally, to bring this together as a system, an approach we like at NASA, I would like to take you into the future to envision how these investments will help enable the aerospace system of the future.

The impact of information technology cannot be overstated – from the tools that help engineers develop the highly complex air traffic management system of the future, to the design of the new vehicles that will fly in it. To achieve unprecedented safety, information technologies will be critical in transforming data into knowledge to give pilots precise situational awareness of weather conditions, other aircraft, and terrain, as well as knowledge of their aircraft through "intelligent" and autonomous hardware and software systems that can adapt, self-improve, self-repair and self-reconfigure in response to component faults and failures. The application towards aviation security is equally powerful. It can detect aircraft that do not conform to normal operating patterns and determine whether there is malicious intent or help is needed. In either case, strategies would be in place to land the aircraft safely. Airports in the future are increasingly busy centers of commerce as businesses cluster there for the environment conducive for increased productivity, now free from the noise of aircraft operations and emissions, and the convenience of reliable and affordable service.

Industry-sponsored research on the Space Station will have created a constellation of commercial space platforms, some inhabited, others autonomously operated, meeting the needs of industry research, development, and production for space-based products. The Next Generation Launch Technologies research will have paved the way for reliable and affordable airline-like service transporting cargo and passengers to and from orbit on a routine basis. These new vehicles will diagnose their own "health" status, scheduling maintenance, identifying anomalies that require attention, self-correct and repair minor faults, and track trends that could lead to anomalies. Nano- and information technologies will have made these capabilities possible.

New space research vehicles will combine new propulsion and power technologies, high-strength low-mass structural materials, and sensors with dramatically increased sensitivity and low power consumption. High-speed transport to the outer planets and beyond, for science missions, will take weeks and months, not years and decades. Nano-technology will have exploited physical phenomena at the nanometer scale, creating "healing" metals for spacecraft skin to repair damage such as micrometeorite hits on long duration missions. Scientific returns per mission will increase 100-fold as research equipment and payloads are more capable and comprise the majority of launch mass. NASA will be conducting missions that go beyond our solar system. Robots will work collaboratively with humans to maximize scientific returns. Research in automated reasoning will have enabled these robotic assistants to contend with uncertainty, making them significantly more mobile, and more scientifically capable. Space communications will allow scientists high-data rate access to space assets, wherever they are, retrieving their data from extreme environments, over interplanetary distances and long mission lifetimes.

We also envision a vibrant educational system in the U.S.. Grade schools and high schools now have new teaching tools and curricula inspired by NASA's programs, and our efforts including the cadre of Teacher-Astronauts have inspired thousands of students to pursue scientific and technical careers. The universities with specialties in engineering and the sciences have full enrollment with growing programs, and their graduates will be finding exciting opportunities in both government research and the private sector job market.

These are only snapshots of the possibilities. As the last century of advances made possible by investments in aerospace research has shown, we are hard-pressed to imagine what is truly possible in an environment that nurtures innovation.