

Committee on Science, Space and Technology
'An Overview of the NASA Aeronautics Research Mission Directorate's Budget for Fiscal Year 2013'
Testimony of Boeing CTO and Sr VP EO&T, John Tracy

INTRODUCTION:

Good morning, Chairman Palazzo, Ranking Member Costello and members of the committee. On behalf of The Boeing Company, I wish to convey our gratitude for your continued support of NASA. Your efforts have enabled NASA to create a balanced aeronautics portfolio that continues to enhance safety, reliability, and efficiency of the world's aviation community. Without your committee's support, these continuing advancements would not be possible. It is an honor to be a participant on this distinguished panel and provide Boeing's view on aeronautics research and the efforts of NASA's Aeronautics Research Mission Directorate.

In my role as Chief Technology Officer for Boeing I have the great challenge to help our company identify how to invest for our future. This topic is central to the existence of Boeing, as we work to build on a 96-year-old legacy of awe-inspiring technical achievement. Our products include the revolutionary 787 Dreamliner airplane, the first true commercial jetliner of the 21st century. In 2011, our total research and development expense amounted to \$3.9 billion. Our investments in future technologies will enable us to strengthen our role as a global leader in technology and innovation. And just as importantly, these investments will help ensure that our 172,000 employees design and create cutting-edge products that are sought by customers worldwide. We at Boeing are proud to be the Nation's No. 1 exporter, and our diligent, talented team is working hard to ensure we retain this esteemed rank.

I would like to discuss a forum that was initiated August 25, 2011, by the National Research Council. This forum is called the Aeronautics Research and Technology Roundtable, and I serve as its Chair. This forum convenes the senior-most representatives from government, industry, and universities to define and explore critical issues related to the nation's aeronautics research agenda that are of shared interest. It is designed to facilitate candid dialogue among participants, foster greater knowledge among the aeronautics community, and carry awareness to the wider public. This forum is just one source for NASA's Aeronautics Research Mission Directorate (ARMD) planning activities for the future of aeronautics. And as the Roundtable meetings continue, they will be a powerful forum for a range of industry stakeholders to contribute to the dialogue about the Nation's investment in aeronautics research.

We agree with the current NASA Aeronautics policy that the agency should focus on enabling a safer, more secure, efficient, and environmentally friendly air transportation system. We also support the strategy of NASA investments in the fundamental, basic questions of how to improve a technology or a way of doing something, to more complex, systems-level questions of how best to integrate those new technologies and operations concepts. The advances NASA makes, which are available for the benefit of the entire aeronautics industry, result in characterizing the maturity, efficacy, and applicability of

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technology to the entire aviation community. It is then up to industry to privately finance the development of products, systems, and services, with or without these technologies, for commercial markets.

We were asked today to comment to three questions about the future of aeronautics at NASA. I will discuss my thoughts on those now.

Question 1. What do you consider to be the three biggest challenges confronting the aerospace industry, and how well does ARMD's research portfolio, and its resources, address them?

First, the three biggest challenges we see for the aerospace industry in aeronautics research are:

1. a wholesale change for the Air Traffic Management system,
2. aviation systems and solutions that are environmentally responsible, and
3. improvement of analytical and simulation tools for integrating complex aviation systems and accelerating verification and validation for certifications.

I will talk about each of these areas in a little more depth to outline how we believe ARMD's research portfolio, and its resources, address them.

1. Air Traffic Management – Today's airspace users are grappling with the challenges of managing an ever-growing amount of air traffic. Outdated infrastructure and operating methods hamper the industry's ability to operate efficiently. So we are working with partners around the world to improve today's global air traffic management (ATM) system. These upgrades will enhance safety, improve operational and environmental efficiency, and prepare for the expected growth in global air travel. Our view of a transformational system is based on satellite navigation that takes advantage of sophisticated airplane flight management systems and other advanced technologies. Key elements of this system include digital command and control, trajectory-based operations, satellite-enabled technology and the integration of ground systems that support the capabilities of modern airplanes and secure network-centric operations. To advance the required technologies needed for a transformational system, we are involved in numerous global research and development contracts. They include, most notably, the Next Generation Air Transportation System (NextGen) with the U.S. Federal Aviation Administration (FAA) and Single European Sky ATM Research (SESAR) in Europe.

NASA is a critical member of the FAA NextGen team which is implementing a plan for the ongoing transformation of the National Airspace System (NAS). NextGen represents the evolution from a ground-based system of air traffic control to a satellite-

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based system of air traffic management I mentioned before. As a part of their contribution we see the need for NASA to conduct extensive research on fundamental technology that will need to be integrated into future solutions for air traffic management. Safety is always a top focus item especially as automation and autonomy like that in Un-crewed Aerial Systems (UAS) enter the National Airspace System. Automation and autonomy are examples of key technologies that can be applied to all vehicle types and every sector of aviation that present high potential solutions for reducing cost, increasing performance, enhancing safety, driving efficiency and enabling new operational modes for the transportation industry.

2. Environmentally Responsible Aviation –We at Boeing are committed to improving the environmental performance of our operations, products and services. In the nearly 40 years of the jet age, fuel consumption and carbon emissions have been reduced 70% and jet noise footprints brought down 90%. And we intend to continue this progress by incorporating technologies that will make our products and operations even more environmentally progressive. As an example of this commitment, our new 787 Dreamliner airplane burns about 20% less fuel and has a noise footprint that's as much as 60% smaller than today's comparable airplanes.

Our strategy is to lead the way in pioneering new technologies for environmentally progressive products and services – which we design, develop and build in an environmentally responsible manner. We are also committed to working together with customers, agencies, suppliers, and others to improve the aviation industry's environmental performance. We see this as critical to building a more sustainable future. The technology areas in which we are engaged include fuel efficiency and noise reduction, sustainable aviation biofuels, more efficient flight operations, and airplane production and recycling. These engagements have led to environmental achievements such as successful biofuel test flights on numerous commercial airplanes, as well as a U.S. Navy F/A-18E/F Super Hornet fighter jet; reductions in energy and water consumption across our company, even while we have increased production; and the opening of a new factory near Charleston, South Carolina, that was built to meet federal energy net-zero standards. And to quickly touch back on the benefits of upgrading our air-traffic management system, I'd like to note that if system improvements could reduce every flight by one minute, we could reduce carbon dioxide emissions by 4.8 million tons per year.

In the NASA Environmentally Responsible Aviation (ERA) program it was recognized in 2010 that the combined reality of persistently strong growth in air traffic and the vital economic role of the air transport system result in continued demand for the progress of technology for the reduction of aircraft noise, emissions of oxides of nitrogen, and fuel burn. As stated for their goals in the program, ERA targets noise reduction of 42 decibels below current levels, a 75% reduction in emissions, and reduction of fuel burn

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of 50% below today's standards. This critical research includes evaluation of alternate aircraft configurations and in the future will need to include electric and hybrid propulsion systems which have high potential to be transformational enablers. NASA will complete the ERA Phase I investigations at the end of fiscal year 2012, and is expected to move directly into a three-year Phase II with continued inputs from industry, academia, and other government agencies.

3. **Advanced Testing and Evaluation** – Our journey at Boeing over the last few years has resulted in us integrating critical functions into one organization to support the enterprise – known as Engineering, Operations & Technology (EO&T) – to efficiently and effectively support our business. Among the integrated teams that serve our entire Boeing enterprise is Boeing Test & Evaluation, which ensures the safety and integrity of all Boeing products and services by validating that they operate as designed and meet the rigorous requirements of regulatory agencies and Boeing customers.

Where NASA can be focused in the future is on fundamental technologies and multidisciplinary processes that can accelerate product development, test and evaluation through analysis and simulation to provide rapid validation and verification for quicker certifications with regulatory agencies. The activities NASA currently has in its portfolio include: Aeronautics Test Program, Airspace Systems Program, Aviation Safety Program, Fundamental Aeronautics Program, and Integrated Systems Research Program. As well, the agency is a partner with the FAA on the NextGen Program I discussed earlier. Within these programs, NASA has projects covering many critical areas including items for advanced air traffic management such as Concepts and Technology Development Project and Systems Analysis, Integration & Evaluation Project. In the Aviation Safety Program the agency has three research projects that cover the top 10 technical challenges for safety (Assurance of Flight Critical Systems; Discovery of Safety Issues; Automation Design Tools; Prognostic Algorithm Design; Vehicle Health Assurance; Crew-System Interactions and Decisions; Loss of Control Prevention, Mitigation, and Recovery; Engine Icing; and Airframe Icing). In the Fundamental Aeronautics Program, NASA researches four technology areas that promote future capabilities for configurations with subsonic fixed wing, subsonic rotary wing, supersonics, and hypersonics. Finally, the Integrated Systems Research Program includes two research areas, Environmentally Responsible Aviation Project, and UAS in the National Airspace System Project.

In this third critical area people in our community have said that there is a continued need for research and technologies to achieve substantial structural, propulsive and aerodynamic efficiency improvements in all vehicle classes. For example, the transition to composite structures in commercial aviation provides extensive research opportunities to further advance and integrate materials, structures, and manufacturing processes. Faster and more efficient design and certification, through high fidelity virtual

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testing, would increase opportunities to develop and field new vehicle systems. Software development and certification is a large and growing cost for civil aviation, especially for complex, integrated software-intensive systems; this, complex systems engineering, including verification and validation, and fundamental software engineering need to be addressed through long-term research. Given the increasing integration of information systems in vehicle design and operations, future system architecture designs should account for cyber-security risks.

Question 2. What are your views about ARMD's strategy of supporting a broad portfolio of research? Given current funding levels, would ARMD be more effective by focusing its resources on high priority activities? How would you gauge their tolerance for risk across its research portfolio?

Part 1. What are your views about ARMD's strategy of supporting a broad portfolio of research?

In our view the portfolio of research underway with NASA covers the spectrum of critical issues facing general aviation today. NASA would be remiss in their responsibility to the flying public to address the challenges that still exist in our nation's air transportation system if the breadth of their current portfolio were reduced. NASA continues to work with aeronautics stakeholders to prioritize their current portfolio initiatives within budget constraints and has done an excellent job of addressing the critical subset of aviation issues. We support the intent to restore flight demonstrations to NASA's portfolio to compliment fundamental capabilities and technologies, as flight demonstrations provide the validation and a pathway to encourage further maturation and adaptation into general aviation.

Part 2. Given current funding levels, would ARMD be more effective by focusing its resources on high priority activities?

As we have learned within Boeing it is important to have a critical mass of investment to be able to accomplish technical objectives in research activities. We believe the research we see NASA performing and the way they are investing as appropriate for the funding levels they currently have. This fundamental research is the seed corn that forms the basis for next generation capabilities. Flight research is the next step in maturing NASA's fundamental research to validate analysis and wind tunnel results in a dynamic flight regime.

Based on historical costs associated with flight demonstration, further emphasis in this activity should be above and beyond the budget level that NASA ARMD already receives for the critical research it is already doing. Costs associated with flight research are directly related to the complexity of the demonstrator, and can be controlled by the limiting

the inclusion of technologies to those deemed critical or enabling to the goals of the program. While fundamental flight research is a critical element in maturing aeronautics technologies, significant research and development efforts are still required before any of these technologies can be integrated into a commercial or military aircraft. As the results of NASA's fundamental research are shared openly to improve global aviation, the aviation industry looks to NASA to have responsibility for the preponderance of flight research funding.

Part 3. How would you gauge their tolerance for risk across its research portfolio?

The way NASA is investing today demonstrates that they have reviewed their risk factors to decide which technology areas make the most sense for them to engage. In their current funding level and the way the portfolio is laid out, they are able to manage risk well.

Question 3. From your perspective, does ARMD advance emerging technologies to a state of maturity that enables their adoption by industry?

Ultimately, the commercialization of aeronautics knowledge into products and services that serve the market is the responsibility of private industry. NASA has played an invaluable role in encouraging and helping to fund the development of a foundation of knowledge that can then be leveraged by industry to serve the public. For instance, NASA, like its European counterparts, has been funding critical foundational research into automating the air traffic management system with the goal, among other things, to increase safety and decrease the environmental impact of aviation. That kind of research is critical to future of the air travel and of our planet. It's critical of course that collaborative NASA and industry research activity be consistent with the obligations of our trade treaties, but there is much valuable work for NASA to promote within those bounds.

Conclusion

In closing, funding NASA's aeronautics activities in a balanced portfolio is the right approach to advancing the safety, reliability, and efficiency of the aviation system. The world needs to upgrade the Air Traffic Management system to support the economic growth that comes from a robust commercial aviation industry and to reap the environmental benefits of a more effective system. Our future is going to include automated systems in the National Air Space and NASA is contributing hugely to efforts to enable that to happen. The work NASA is doing for improving the environmental footprint for aviation is critical for our country's green future. This balanced portfolio will help America strengthen its global stature as a leader in technology.