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Good morning, Chairman Udall, Congressman Calvert and Members of the Subcommittee. I am honored to be here this morning to testify on the Joint Planning and Development Office (JPDO) and the Next Generation Air Transportation System. I am Bruce Carmichael, Director of the Aviation Applications Program at the National Center for Atmospheric Research (NCAR). For the past 16 years I have worked at NCAR to improve weather information for pilots, dispatchers, and controllers with special focus given to the hazards of thunderstorms, turbulence, icing, winter weather, and ceiling/visibility. For almost three decades, I have been involved with the aviation industry in the automation of maintenance processes, air traffic control, and weather information. I serve the JPDO Weather Integrated Product Team as the Co-Lead of the Forecasting Group, and the National Business Aviation Association, Inc., as Weather Chairman of the Access Committee.

The importance of aviation weather research to the successful development and implementation of the Next Generation Air Transportation System (NextGen).

Advances in aviation weather research will be critical to the success of the Next Generation Air Transportation System (NextGen). Seventy percent of delays in today's system are attributed to weather. Moreover, as traffic grows, weather-related delays will worsen. The Federal Aviation Administration (FAA) estimates that unless we can make progress on better weather forecasts, by 2014 there could be 29 days of delay worse than the worst delay day of 2006. That is the bad news. The good news is that as much as 60 percent of today's delays and cancellations for weather stem from potentially avoidable weather situations. Enhanced weather forecasts as well as improved use of forecasts can contribute to a reduction in these avoidable weather impacts. Research guidance given to the JPDO departments and agencies including FAA, the National Oceanic and Atmospheric Administration (NOAA), the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA), includes many recommendations. A high priority is the development of a consolidated summer and winter storm forecast system. All of the agencies involved agree with that strategy. A goal is to gradually merge 16 different forecasting systems so that by early in the next decade we will have a single system that utilizes the best-of-the-best elements of today's technologies.

Skillful aviation weather information is a vital building block for NextGen, facilitating performance targets for the years 2015 and 2025 that will reduce congestion by providing far greater capacity than our current system with higher efficiency levels than we have today, while maintaining or enhancing safety. Improved weather information provides support for an agile decision-making process to manage the large volume of air traffic expected in the future. It allows the system to smoothly mitigate the potential impacts of summer and winter storms, turbulence, enroute icing, and reduced ceiling/visibility conditions. As a result, the system will be able to respond quickly to changing air traffic needs in the face of changing weather. This can only be achieved through the introduction of new technologies and procedures, innovative policies, and advanced management practices related to the observation, forecasting, dissemination, and integration of improved weather information into air transportation decision support tools and processes.

NextGen Network Enabled Weather (NNEW).

One of the program initiatives coming out of the JPDO to synthesize the weather research activities and to move the research toward operational capabilities is the concept of network enabled weather. The DoD already has a number of aspects of network enabled weather that it uses to collect, process and disseminate weather to operational units around the world. DoD, FAA and NOAA are collaborating on a joint program office concept that would begin to integrate the forecasting and dissemination capabilities of the different agency weather programs. A number of the research concepts that I've already mentioned would be incorporated into the NNEW program concept. The FAA has requested initial funding in FY 2008 and an interim goal is to move toward early working prototypes by the 2011-2012 timeframe. I would defer to other more directly involved to discuss the details.

Research on aviation weather safety issues, although not highlighted as a part of the NextGen activity, is actually assumed to underlie all other weather activity. Aviation weather safety research is essential to meeting safety objectives and NextGen performance targets. The potential of the NextGen system to handle tremendous growth in air traffic compels us to maintain our vigilance in weather safety research. We must continue to invest in weather safety to reduce accident rates to insure that an increase in accidents does not accompany the increase in traffic. Unmanned aerial systems will also require more precise weather forecasts. Investments in weather safety R&D over the last 25 years have yielded, and will continue to yield, critical safety improvements. Our scientists and engineers, for example, developed the solution to the microburst and wind shear problems; developed the state-of-the-art Aviation Digital Data Service (ADDS); improved forecasts of summer and winter storms, far more precise forecasts of airborne icing, turbulence, improved ceiling and visibility forecasts; and improved aviation radar products.

Weather research to transform airport operations in NextGen is also critical. Key elements of this research are to increase the capacity and improve the safety of aircraft operating from airports in winter weather and reduced visibility conditions. As the number of operations at our airports continues to rise, weather research projects must include integration with decision support tools that insure safe transit of aircraft on taxiways and runways, improving our understanding of the effects of winter weather on the safety of aircraft operating in ice and snow conditions, and the development of state-of-the-art technology that uses improved weather skill to minimize the disruption during deicing and plowing operations.

In NextGen, weather is also important if we are going to meet the increasing demand for flying in an environmentally sound manner. The weather focus of the environment goal is making aviation quieter, reducing pollution in communities around airports, and reducing climate impact. New investments in weather research are required to help us better understand how to couple weather information to an agile air traffic management (ATM) system to dynamically reduce noise, pollution, and climate impacts.

Given expected demand growth, it is important to improve operations well in advance of 2025 so we can avoid gridlock. With that in mind, weather research is critical now to support mid-term capabilities that must be put in place. The JPDO weather team is helping to define Initial Operating Capabilities that can deliver mid-term results and also provide needed stepping stones to NextGen.

Significant issues that need to be addressed if the nation is to successfully integrate aviation weather into the Next Generation Air Transportation System.

Fortunately, in collaboration with the FAA, the aviation weather research community has been steadily and carefully refining R&D goals and portfolios to meet the needs of the aviation community for more than twenty years. We continually assess our research programs in conjunction with our stakeholders and users to ensure we keep our R&D resources focused on the most critical tasks. Thus many of the issues are known and research is already underway.

Integrating Weather into Decision Support Systems

The weather R&D program has received expert advice and guidance from the FAA's Research, Engineering and Development Advisory Committee (REDAC). The REDAC, under its National Airspace System (NAS) Operations Subcommittee, recently established a Weather ATM Integration Working Group (WAIWG) to do a focused study on the difficult problem of automatically integrating real-time and forecast weather information directly into the software logic of ground-based and cockpit-based decision-support tools and processes. The working group includes weather and operations experts from national laboratories, MITRE Corporation, NASA, DoD and the airline industry. The weather research program will benefit significantly from the recommendations provided by this group regarding how to deal with weather ATM integration. This working group is interacting closely with the weather and automation R&D communities to develop recommendations that will be effective.

As a member of this group I can tell you that one of our greatest challenges is our ability to understand what the future system will look like. What new weather forecasting and decision-support technologies will be available? The JPDO weather team has developed a comprehensive Weather Concept of Operations to raise the questions needed to focus research and systems development. This is all significant work, essential to understanding the transformed operational environment and helping us to develop a plan for achieving it. It also makes clear many of the difficult questions that the weather research community must answer if NextGen is to succeed.

Better Processing of Huge Amounts of Information

To some extent our nation's aviation weather system has become a victim of its own success. We have created the most effective, efficient and safest system in the world dealing with weather issues. But we now face a serious and impending problem: today's weather system produces a large volume of information with such frequent update that human users are

overloaded when trying to effectively make use of the valuable detail available to systematically fine tune flight plans and their execution. We must continue to improve our forecast skill, and this implies increasing our time and space resolution. Automated decision-support tools will have to achieve several breakthroughs in order to effectively and automatically apply enhanced weather information to route planning, and route re-planning for FAA and airline traffic flow management specialists.

Weather research will help achieve NextGen by identifying challenges, understanding scientific barriers, and developing solutions that jointly address weather safety, weather mitigation of environmental impacts, weather for improved air traffic management, human factors associated with highly automated weather systems, systematic integration of weather into decision support tools, and effective system separation of aircraft from weather. NextGen must address the challenges of operating the safest, most efficient, high-capacity air transportation system in the world. We are a long way from knowing how to do the weather portion of this, but the job of research is to discover the solution. We must identify the scientific constraints and barriers imposed by weather to separate solutions that are effective from those that are not.

To address such issues, research in improved forecasting and integration of those forecasts into decision-support tools is absolutely critical to NextGen. It must be recognized that sustained and predictable aviation weather research funding at a significantly increased level is required in each of the JPDO stakeholder agencies. This funding stability is needed to allow the laboratories to hire and develop the highly specialized researchers needed to address the complex issues at hand.

Human Factors research and demonstration projects will be needed to develop the best approaches for integration of improved weather information into decision support systems to help mitigate potential errors and exploit the problem-solving capacity of humans. Performance metrics should be developed that measure the value added by people as elements of the weather decision system versus the impact of new technologies.

Historically, aviation weather R&D has had a focus on near-term operational goals and objectives. A large share of the R&D was focused on specific near-term safety and capacity issues. The weather research program must be adapted to be more flexible, balanced, and dynamic so that we can respond simultaneously to the critical near-term needs of the system while providing for the cutting-edge NextGen requirements. The JPDO weather team is the mechanism by which the multi-agency stakeholders and the community will assess weather R&D requirements for NextGen, and new initiatives will be reviewed and prioritized, before being recommended to one or more agencies for execution.

The aviation weather research community, with guidance from the JPDO, is incorporating NextGen into its planning activities, including a strong requirement for systematic integration of weather forecasts directly into decision-support tools and processes used by FAA traffic flow managers, airline dispatchers and pilots. In addition, the weather community is using the NextGen planning process to guide our transformation of weather capabilities in a way that is tightly coupled with the transformation of decision-support tools. In the past, the

weather research community's plans and execution successfully provided benefits in safety, capacity, and efficiency to the community. But the new approach of developing plans that are tightly coupled with the decision-support tool research community promises to significantly enhance our success. This includes the R&D work in decision support tools at the MITRE Center for Advanced Aviation System Development (CAASD). I believe that a timely and efficient transition to NextGen requires the weather research community to participate in concept development, validation, prototyping, and field demonstrations. Such involvement will give us in-depth understanding of required NextGen weather improvements and hasten our ability to implement NextGen weather systems. Of particular importance are demonstration projects that show the feasibility and utility of seamless integration of weather into new decision support tools that use System Wide Information Management (SWIM) as the source for weather. Such demonstrations can lower our risk and provide rapid implementation opportunities.

The weather research community is also using the JPDO process as a way to plan, execute and implement partnerships with private industry. Through the JPDO weather team we are seeking stakeholder input, evaluating available technologies, defining and prioritizing research and development requirements, establishing milestones and commitments, and providing status, context and guidance for weather initiatives related to NextGen.

The JPDO weather team also provides a single point for initiatives to be coordinated among all stakeholder agencies and institutions. It ties initiatives directly to each organization's budget process, and in this way moves us toward a coordinated development of JPDO's vision of the future aviation weather system. It provides an integrated view of the programs, systems and procedures that are critical to transforming the nation's aviation weather system; and it will let us plan our activities within the framework of the steps that must be taken by all JPDO agency weather partners in order to achieve timely implementation. It also allows us to understand the near-term steps and mid-term goals that we must accomplish to transform the aviation weather system on our way to the NextGen system of 2025.

The community of weather and automation researchers has been hard at work for three years supporting the JPDO planning process, almost entirely on a collateral basis. However, now that the planning stage has matured and we are on the verge of stepping up the tempo in research and applications dealing with weather and NextGen, it is critical that funding be appropriated to begin to directly support these expert teams and the program advances that the JPDO has identified.

Impacts that the changes to NASA's aeronautics program are having on the effectiveness of the aviation weather initiative.

NextGen is committed to reducing congestion in our nation's air transportation system. Future congestion can only be alleviated by transforming the system we have today through bold moves that include systematic integration of more skillful weather information into the heart of innovative new automated decision-support tools. The NASA aeronautics program has a wealth of experience in the development of decision-support tools for air transportation, and is a logical partner for the JPDO and FAA in this endeavor. The Center-TRACON

(Terminal Radar Approach Control) Automation System (CTAS) is a good example of NASA's prior work in this area. However, in my view, the current NASA funding direction in aeronautics provides little hope for a strong effort by NASA in the area of integration of weather into automated tools. This is very unfortunate.

The FAA is requesting substantial funding to support wake turbulence research to help increase capacity while maintaining safety. This will help us to safely reduce separation distances between aircraft, support the efficient use of closely spaced parallel runways, and allow airports to operate closer to their design capacity. NASA has a long track record of partnership with the FAA in this research area. Wake turbulence is viewed by the JPDO as a weather issue, and is part of the planning process for the weather team. In large part, this is because of the critical importance of the weather connection when predicting wake turbulence behavior. Wake turbulence is a research activity that is in need of significant JPDO attention to rationalize the activities of the various agencies. Uncertainty of NASA's funding and integration with the rest of the weather community in this area is creating difficulty in coordinated weather research planning.

Research in use of unmanned aircraft systems as platforms for targeted observations of the atmosphere offers considerable promise to improve forecasts in high value areas with sparse observations. NextGen needs to explore the integration of unmanned aircraft observing systems into the National Airspace System. This research is a natural fit for NASA, but programs in this area have disappeared.

This concludes my testimony, and I thank you for the opportunity to appear before the committee. I would be happy to answer any questions the committee may have.