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Statement of
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before the

Subcommittee on Aviation
Committee on Transportation and Infrastructure
U.S. House of Representatives

Chairman LoBiondo and Ranking Member Larsen, and Members of the Subcommittee, thank you for this opportunity to appear before you today to testify on NASA's aviation safety research.

NASA Role in Aviation Safety Research

NASA has made decades of contributions to aviation; every U.S. aircraft and U.S. air traffic control facility has NASA-developed technology on board. The continuous efforts to reduce risk in commercial aviation have made it the safest mode of transportation. Addressing known hazards and responding to issues illuminated by post-hoc analysis of incidents and accidents, commercial aviation has achieved exemplary safety records and inspired the confidence of the flying public.

Historical Examples

For decades, NASA research has contributed to this outstanding safety record. For example, in the 1980s NASA initiated research and development efforts associated with synthetic and enhanced vision systems (SVS/EVS). These cockpit systems present information to pilots about the external environment derived from static databases and onboard imaging sensors. The information, displayed on the pilot's heads up display, provides enhanced awareness of terrain and other obstacles. In the early 2000's, NASA supported initial testing of EVS on a Gulfstream aircraft which supported development of certification standards for SVS/EVS systems through participation on the RTCA committee that publishes standards.

The safety benefit of these systems has been recognized by the FAA. Aircraft equipped with SVS/EVS are permitted to land in low visibility conditions, conditions that would require a missed approach for non-equipped aircraft. In addition, the Commercial Aviation Safety Team identified additional potential safety benefits of SVS/EVS in their analysis of "loss of control" accidents. A large percentage of the accidents analyzed

occurred in low visibility conditions, and SVS/EVS systems can provide information necessary for maintaining proper situational awareness in the absence of out-the-window information. Today a large number of Gulfstream, Bombardier and Boeing business jets offer SVS/EVS capabilities and multiple manufacturers have developed systems for tablets that can be used on board general aviation aircraft.

Another good example, from the late 1970's was NASA research that led to the identification of cultural norms within the aviation community that resulted in increased vulnerability to crew communication errors. The typical command hierarchy discouraged co-pilots from questioning captains when they observed them making mistakes. While the concept is in many ways intuitive, several of the deadliest accidents of the era were found, through analysis of cockpit voice recordings, to have ineffective communication as a contributing factor. NASA developed training methods and techniques to support improved Crew Resource Management (CRM). CRM training teaches crews the effective use of all available resources for flight crew personnel to reduce errors, avoid stress, and increase efficiency through better understanding of human performance capabilities and methods for effective communication in the cockpit. United Airlines was the first airline to provide CRM training for its cockpit crews in the early 1980s. Since then CRM has become a global standard with training requirements mandated by the FAA, ICAO and EASA.

Current Aviation Safety Research Challenges

Now, as we look forward, aviation is on the verge of a significant transformation with the rapid evolution of new technologies, vehicles, and operations on the horizon, while retaining the high standards for safety to which we are accustomed. Maintaining a safe system will require recognition and timely mitigation of safety issues as they emerge, before they become hazards or lead to accidents. A shift toward proactive risk mitigation will become critical to meet these needs. In collaboration with the aviation community, NASA has developed a vision for safety assurance that is achieved by leveraging growing sources of aviation data, commercial data analytics methods, architectures, and the "internet of things" to enable monitoring, prediction, and prognostics capabilities. We are building on previous research to develop the underlying methods, tools and techniques necessary to effectively monitor ongoing operations, assess operations in real-time for emerging risks, and provide in-time strategies to mitigate those risks. Partnerships with operators and the FAA provide opportunities to validate our technologies, to tailor them to meet various needs, and a path for transition to the end users.

NASA has continued to develop methods to identify and predict potential safety incidents through analysis of operational data, which would otherwise go undetected. Through direct partnerships with airlines and the FAA, NASA researchers have been able to identify and detect additional safety relevant incidents using tools tuned to analyze large sets of flight data or radar track data. The knowledge gained from these tools has led airline partners to make adjustments to procedures to address these potential safety issues before they are realized.

Current NASA work in this area is focused on advancements that will allow users and airlines to identify anomalous behavior and precursors to known hazards in real-time. Progress in this area will allow users and airlines to verify information arriving through streaming operational data, assessment of data in real-time, and greater emphasis on advanced warning, including the ability to provide information about the likelihood of an emerging risk.
Human operator fatigue is a well-known risk to aviation safety but has proven difficult to monitor in operational settings. NASA's Fatigue Countermeasures research group has made progress in developing tools to monitor pilot or controller performance and is currently conducting studies to understand how duty times and schedules affect pilot performance. The goal is to deliver, in the near-term, tools and methods that human operators and their managers can use to predict degrading levels of fatigue and make necessary adjustments to schedules or procedures to lessen the risk or likelihood of a safety incident.

In addition to developing technologies to enable in-time monitoring and mitigation of safety hazards, NASA ARMD is addressing difficulties associated with assuring the safety of increasingly complex and autonomous aviation systems. We are supporting our traditional avionics partners and the FAA by developing and making available to the broad community improved methods, tools and guidance to support cost-effective paths for achieving the level of safety assurance required for the introduction of highly reliable advanced avionics and future Air Traffic Management (ATM) systems. Industry estimates of costs associated with Verification and Validation (V&V) activities reveal that these costs are becoming unsustainable and have begun to stifle innovation. Current NASA work builds on recent experiments with industry partners and includes development of additional tools and techniques that can reduce the costs and improve effectiveness of V&V, and therefore reduce overall development costs. NASA continues to provide tools and techniques to enable assurance early in the development process, when most errors are introduced, bringing down cost and improving safety coverage. Industry is working with us to evaluate the impact of these new tools and techniques with specific use cases. In addition, we are continuing to provide tools and the guidance to the FAA that can assist in modifying standards and existing certification processes.

NASA has served as a member of the Commercial Aviation Safety Team (CAST) since its formation in 1998. Co-chaired by industry and the FAA, the team is chartered with identifying safety risks and recommending voluntary safety enhancements. NASA researchers have contributed to the analysis and research associated with many of the safety concerns tackled by CAST. Most recently NASA has contributed to the CAST activities regarding causes of loss of airplane state awareness. We are currently completing research and development of cockpit systems with predictive algorithms to alert pilots, models for aircraft stall performance to improve fidelity of training environments, and specific flight crew training methods. All of these tools enable enhanced safety and will transition directly to the commercial aviation community through the CAST.

Under contract for the FAA, NASA has established the Aviation Safety Reporting System (ASRS) data. The ASRS is an important facet of the continuing effort by government, industry, and individuals to maintain and improve aviation safety. The ASRS collects voluntarily submitted aviation safety incident/situation reports from pilots, controllers, and others. Users can then act on the information these reports contain. Using the data, users can identify system deficiencies, and issue alert messages to persons in a position to correct them. Its database is a public repository which serves the FAA and NASA's needs and those of other organizations world-wide which are engaged in research and the promotion of safe flight.

NASA also is a member of Aviation Safety Information Analysis and Sharing (ASIAS) Executive Board. ASIAS leverages internal FAA datasets, airline proprietary safety data, publicly available data, manufacturers' data and other data. ASIAS fuses various aviation data sources in order to proactively identify safety trends and to assess the impact of changes in the aviation operating environment. NASA has and continues to develop data analytic algorithms for mining of the ASIAS data to proactively identify issues, and continuously transfers these technologies to the FAA and industry partners.

Emergent Users

Special attention is being directed toward assuring safety of emerging operations, such as small unmanned aircraft operating at low altitude in the near-term and autonomous passenger aircraft in the longer-term. Ongoing research is dedicated to understanding hazards unique to these domains and identifying data needs associated with monitoring such operations for potential risks. NASA is developing and testing models of new operational concepts to enable prediction of increased risk.

The cost of certification is the primary concern of our traditional and emergent industry partners, and the aviation industry faces significant technical challenges associated with certifying increasingly complex systems. Future aviation systems and high-density operations will rely on increasing autonomous capabilities. The methods to assure the safety of autonomous systems are in their infancy, and thus approaches will need to be investigated and evaluated for effectiveness. Given our past success in applying new safety assurance methods to autonomous systems for space missions, NASA is uniquely positioned to address this challenge. We have already performed initial demonstration of some valuable tools and other governmental agencies, like FAA and AFRL, are looking to NASA for leadership in this area. Specifically, NASA initiated the Unmanned Aircraft System in the National Airspace System (UAS in the NAS) project to enable routine access to larger class UAS into the regular controlled airspace. The UAS in the NAS project is focused on development of communications standards, detect and avoid technologies, human systems integration capabilities, and approaches to determining airworthiness requirements. In addition, NASA's UAS Traffic Management (UTM) research project may enable Beyond-Visual-Line-of-Sight (BVLOS) access by small UAS to the uncontrolled low altitude airspace below 400 feet. In collaboration with the FAA, the UTM project has established a cloud based federated architecture to enable safe operations of unmanned vehicles at low altitudes. The project has focused on

standardization of altitude reference schemes, understanding effects of wind on vehicles, multi-vehicle airspace operations, and position detection technologies.

Vehicle Research

NASA is building on a strong history of conducting research that advances state of the art in vehicle technologies in order to reduce the risk of flying in hazardous conditions. For example, NASA has addressed the issue of atmospheric icing hazards for decades, and has developed some of the key design tools to better understand how to reduce the impact of airframe icing. Now engine icing research builds on this long heritage of airframe icing. The phenomena that creates engine icing issues is not well-understood so NASA has conducted flight tests to better characterize the environment and has emulated these conditions in a ground test facility that is already proving to be very beneficial to industry. NASA successfully tested a highly instrumented engine in a broad range of engine ice crystal conditions and altitudes, enabling future NASA and external users to have greater confidence in the engine data collected under these simulated conditions as compared to natural atmospheric conditions in flight. This new capability will provide NASA with reliable datasets to develop engine ice accretion tools that assist in assessing new and existing engines. NASA will confirm its capability that can simulate the high ice water content cloud conditions experienced in nature to the degree required to simulate aviation safety issue of engine icing. In addition, NASA supported the development of new radar capability to detect high altitude ice crystal icing conditions to avoid engine icing conditions, which will help aircraft avoid these conditions in the future. NASA's data collection and analysis will also provide the FAA with the basis to establish and update standards as needed.

NASA and FAA Research Transition Teams

To enhance implementation and the capabilities of NextGen, NASA and the FAA have established Research Transition Teams or RTTs to develop joint research plans, fund our respective portions, and facilitate the handoff from NASA to FAA of the research results. The RTTs have been a best practice mechanism between NASA and FAA in ensuring effective coordination and transition of research to implementation. To ensure that research and development for aviation safety is jointly identified, conducted, and effectively transitioned to the implementing agency, NASA, along with FAA's NextGen Office (ANG), Air Traffic Organization (ATO), and Aviation Safety (AVS), have jointly established RTTs for System Wide Safety Assurance, UTM, and UAS in the NAS. Under each RTT, senior researchers and program managers of both agencies define needed research products and the transition path for implementation for both current and emergent users of the national air transportation system. Furthermore, through the RTTs, NASA works jointly with FAA's William J. Hughes Technical Center on joint simulations of the research products and on testing of a suite of assurance tools to help FAA assess aviation systems.

Concluding Remarks

NASA has a long and successful history of aviation safety research that has made a real difference in the remarkable safety record that our system enjoys. And we are constantly

looking for ways to continue to contribute – with a major emphasis on more prognostic approaches that will allow the aviation community to get out in front of issues before they become safety risks. Let me conclude by thanking you again for this opportunity to appear before you to discuss NASA's Aviation Safety research and to answer your questions.