Federal Aviation Administration and
National Aeronautics and Space Administration

Next Generation Air Transportation System

Human Factors Research Coordination Plan

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Next Generation Air Transportation System
Joint Planning and Development Office

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Executive Summary

This report responds to the U.S. Government Accountability Office[1] (GAO) recommendation that the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) develop a cross-agency plan to coordinate their human factors research efforts for the Next Generation Air Transportation System (NextGen). It also responds to similar recommendations from the Joint Planning and Development Office (JPDO), the interagency office responsible for planning NextGen, and the U.S. Department of Transportation (DOT) Inspector General (IG).[2]

This report formalizes the current coordination process, building on the accomplishments that the GAO noted, namely, that the FAA and NASA have improved human factors research coordination. It also documents the initial focus areas that the two agencies' human factors research currently addresses, the availability of research facilities, and the processes employed for capitalizing on past and current research. It also identifies five initiatives to strengthen the current coordination process:

- Coordinated annual planning
- Reviewing FAA and NASA human factors research for mutual alignment with the NextGen operational improvements (OIs)
- Sharing of best practices
- Updating the FAA's *Human Factors Portfolio*
- Sharing expertise and facilities where possible

Both agencies acknowledge the importance of strengthening their research coordination efforts to enhance air transportation safety and increase system capacity. The human is the most important element in the air transportation system and must be considered first and foremost in the design of improvements to it. Humans design, develop, deploy, manage, maintain, and operate all elements of the system. Yet, the human component is often inadequately considered when improvements are made to the system. When this occurs, the net result can be contrary to the objectives of increased safety (e.g., operator or maintainer error), increased capacity (e.g., decreases in air traffic controller efficiency), and enhanced overall system performance (e.g., loss of National Airspace System [NAS] effectiveness).

Humans help to make the NAS operate more efficiently and are a source of error, as well. The National Transportation Safety Board (NTSB), for example, has determined that "[Human error] is the most common of all accident themes and exists in one form or another on nearly all accidents. It involves humans that, in the course of doing their work, make errors that are later shown to have caused, or substantially contributed to, the accident. These are human actions

[1] Government Accountability Office Report #10-824, *Next Generation Air Transportation System – FAA and NASA Have Improved Human Factors Research Coordination but Stronger Leadership is Needed*, (August, 2010).

[2] Department of Transportation Inspector General, Testimony Before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, U.S. House of Representatives, *Challenges in Meeting FAA's Long-Term Goals for the Next Generation Air Transportation System*, (April 21, 2010).

that, if done correctly, result in a safe outcome, but if done incorrectly, can result in an accident. It also represents one of the greatest opportunities for advancing safety by the application of targeted interventions which are intended to reduce the risks for human error."[3]

Given the increasing demand for air travel, the increasing complexity of the NAS, and the need to achieve the lowest accident rate possible, a human-centered approach is essential to achieve the intended benefits of the investments in NextGen. This FAA-NASA NextGen Human Factors Coordination Plan will help to ensure that research conducted by both agencies addresses these essential considerations.

[3] National Transportation Safety Board, Lessons Learned from Transport Airplane Accidents/Accident Common Themes, http://accidents-ll.faa.gov.

Preface

The FAA and the NASA intend to enhance their human factors research collaboration on NextGen by establishing a formal coordination process. The framework for the process and the sections in this report are based on the eight management practices suggested by the GAO to enhance joint or cross-agency collaboration.[4] Collaboration is defined as "any joint activity intended to produce more public value than could be produced when the organizations act alone."

Within the framework, this report specifically addresses the areas identified by the GAO to enhance FAA-NASA NextGen human factors research collaboration.[5] First, the FAA and NASA should agree on roles and responsibilities based on the differences in their research focus areas. Second, they should develop mutually reinforcing or joint strategies to leverage existing simulation capabilities that support research initiatives. Third, they should establish compatible policies, procedures, and other means to operate across agency boundaries that include capitalizing on past and current research through information sharing, participating in review and advisory committees, and applying the standard research process to review relevant literature. This report is laid out into five sections.

Section One. Who are we? This section defines the joint FAA and NASA mission, vision, and values with respect to human factors research.

Section Two. Where are we going? This section explains how FAA and NASA human factors research aligns with the mid- and long-term goals of the NextGen.

Section Three. Where are we now? This section addresses the initial research focus areas that FAA and NASA are currently addressing, research facilities, coordination mechanisms, and examples of research collaborations.

Section Four. How are we going to achieve the goals? This section presents strategies that the FAA and NASA will use to leverage their human factors research policies, programs, budgets, personnel, and partnerships.

Section Five. How are we doing? This section presents strategies that the FAA and NASA will use to monitor, evaluate, and report on the results of their research.

Leaders at both agencies are committed to ensuring that the research coordination process is accomplished and that human factors play a prominent role in the design, development, deployment, management, and operation of NextGen.

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[4] Government Accountability Office Report GAO-06-15, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, (October 2005).

[5] Government Accountability Office Report #10-824, *Next Generation Air Transportation System – FAA and NASA Have Improved Human Factors Research Coordination but Stronger Leadership is Needed*, (August, 2010).

Introduction

The air transportation system is designed, developed, acquired, operated, maintained, and used by humans. Without careful and systematic consideration of human capabilities and limitations, the system will not function effectively. As a result, every element of the system – the aircraft, the air traffic control (ATC) system, the airports and facilities, and the interactions among these elements and their people – need to be designed with the human in mind. This includes pilots, aircrews, inspectors, controllers, dispatchers, traffic flow managers, technicians, and trainers, as well as ground maintenance and service personnel. Therefore, human factors research needs to play a prominent role in every aspect of the air transportation system and in its design to ensure continued safe and efficient operations.

The FAA is leading an interagency[6] effort, through the JPDO, to transform the nation's air transportation system to a more capable, efficient, and safe system. This system, known as NextGen, will move the current radar-based system to a more automated, aircraft-centric, satellite-based system. Under NextGen, pilots and air traffic controllers may rely on more or different automation, changing their roles and responsibilities in ways that will require a full understanding of what are known as human factors issues. Human factors Research and Development (R&D) studies how humans' abilities, characteristics, and limitations interact with the design of the equipment they use, the environments in which they function, and the work they perform. FAA and NASA – the primary agencies responsible for integrating human factors considerations into NextGen – must ensure that NextGen explores human factors issues so that controllers, pilots, and others will operate NextGen components in a safe and efficient manner.

This document responds to a finding of the GAO[7]that the FAA and NASA lack a cross-agency human factors plan to coordinate their research efforts. In addition, this document builds upon current coordination mechanisms that include reciprocal participation on advisory committees and interagency agreements covering joint research efforts. The JPDO and the DOT IG have made similar recommendations. At the same time, the GAO recognized that the FAA and NASA have improved NextGen human factors research coordination.

As a result, the FAA and NASA are formalizing the current coordination process, depicted in Figure 1, to develop a NextGen Human Factors Research Coordination Plan. This will help to ensure alignment of human factors research, while mitigating gaps in human factors issues associated with NextGen OIs. Starting this year, the FAA and NASA will meet at least annually to coordinate and review the results of their research. They will focus on assessing research programs and gaps for aligning future initiatives and activities, as well as reviewing the research results and identifying ways to improve cooperation and collaboration.

The initial coordination process also includes the development of the *Human Factors Portfolio*. This Portfolio lists relevant past, active, and proposed human factors R&D projects conducted by

[6] Partners include the Departments of Commerce, Defense, Homeland Security, and Transportation, and the White House Office of Science and Technology Policy.

[7] Government Accountability Office (GAO) Report #10-824, *Next Generation Air Transportation System – FAA and NASA Have Improved Human Factors Research Coordination but Stronger Leadership is Needed*, (August, 2010).

government agencies, contractors, and academia. Further, the initial coordination process includes development of the *Research Facilities Database*, which lists facilities that are available to conduct human factors research. The coordination process does not replace existing FAA and NASA planning processes, rather it is intended to promote improved coordination of human factors research programs and projects between the two agencies throughout the development of NextGen systems.

To make the best use of human factors research investments, the results of the research, where appropriate, must be applied. Formalizing the coordination process between the FAA and NASA will help the FAA to meet its regulatory, certification, and operational roles in the NextGen environment.

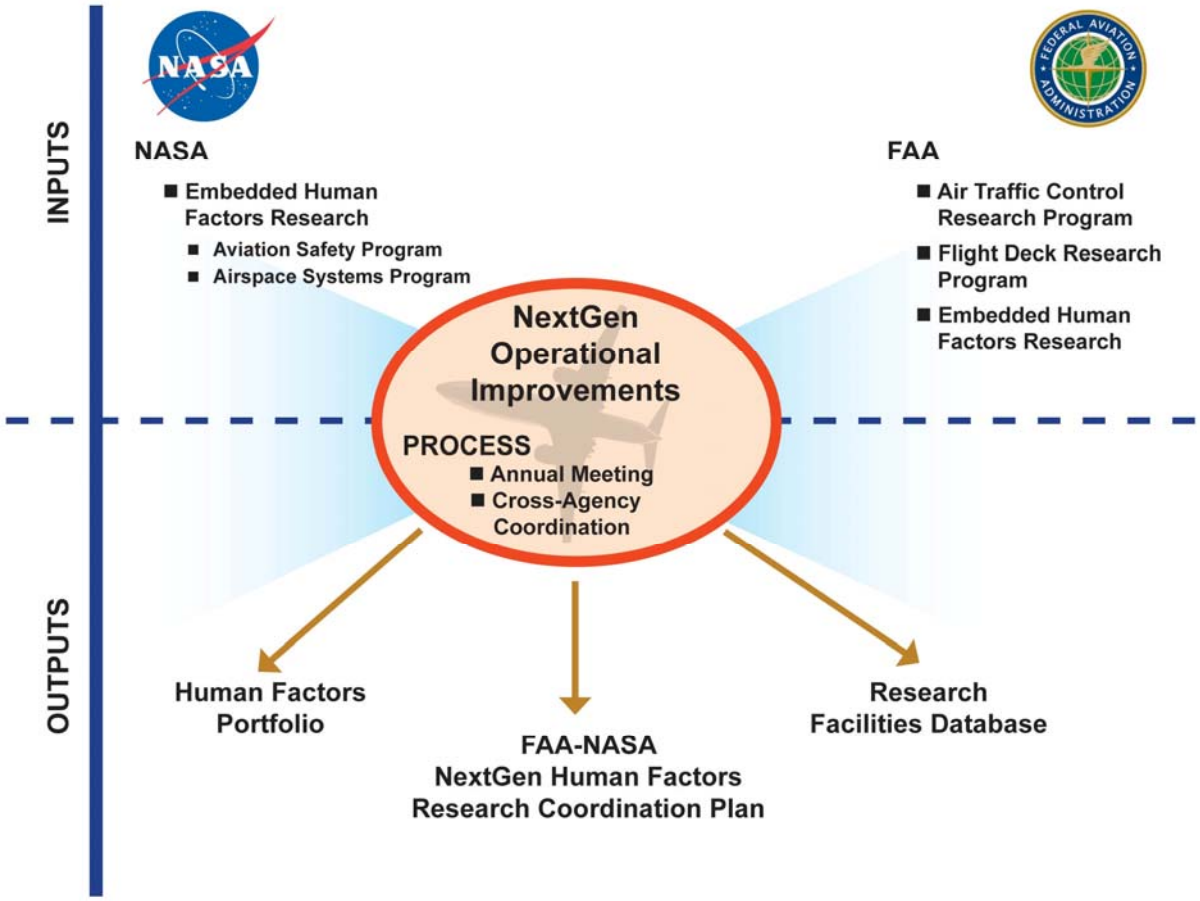

Figure 1. FAA-NASA Human Factors Research Coordination Process

The FAA and NASA have conducted and/or sponsored human factors research as part of their programs and other projects for decades. The intent of this research has been to understand the factors affecting human behavior and performance (e.g., capabilities, limitations), identify ways to enhance human performance and eliminate human error, and ensure that all organizations and

people involved in the system use the results of the research to enhance system safety and performance. Both agencies have done this within the general roles of their respective agencies, with the FAA focusing primarily on today's system and mid-term research and NASA on mid- and far-term research. There have also been several collaborative research activities that have served to ensure a transition path across the time horizons.

Much of the agencies' current human factors research is accomplished collaboratively through various mechanisms, such as program reviews, joint participation in research program reviews, and jointly-funded research activities. The research has led to many innovations, policy changes, and technological advances in air transportation that have resulted in improved system safety and performance. For example, a joint NASA, FAA, and Massachusetts Institute of Technology (MIT) Lincoln Laboratories effort to develop a Center Terminal Radar Approach Control (TRACON) Automation System (CTAS) in the early 1990s led to the FAA version of a Traffic Management Advisor (TMA) system that was deployed nationally at all en route centers and TRACONs in the 2000s.

This report discusses the complementary human factors research approaches undertaken by the FAA and NASA to support NextGen, provides initial research focus areas of mutual interest to both agencies, and describes ongoing and evolving coordination strategies. Both agencies are committed to building on past successes to more efficiently and effectively coordinate, integrate, and focus their respective human factors research on the challenges facing air transportation today and in the future.

Section 1

Who are we?

Mission, Vision, and Values

This section defines the joint FAA and NASA mission, vision, and values with respect to human factors research.

FAA

The mission of the FAA is to "provide the safest, most efficient aerospace system in the world."[8] It does this by developing and implementing aviation policy, safety regulations, and standards. It also operates and maintains the NAS.

To carry out this mission, the FAA conducts R&D, and leverages R&D from other agencies to support policy and planning, regulation, certification, standards development, and modernization of the NAS. As such, it conducts applied R&D as defined by the *Office of Management (OMB) and Budget Circular A-11*. Applied research is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. Development is defined as systematic application of knowledge or understanding directed toward production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

The FAA R&D mission is to "conduct, coordinate, and support domestic and international R&D of aviation-related products and services that will ensure a safe, efficient, and environmentally sound global air transportation system." FAA human factors R&D supports today's system and mid-term (2013-2018) goals and addresses the specific needs of sponsoring organizations, including Aviation Safety, the Air Traffic Organization, Airports, Commercial Space Transportation, and Aviation Policy, Planning, and Environment. It encompasses a range of research activities from fire safety and human factors to the development of new products, services, and procedures.

The Human Factors Research and Engineering Group within the Office of Research and Technology Development under the Air Traffic Organization's NextGen and Operations Planning Service Unit manages the FAA's *Human Factors Portfolio*. Its NextGen human factors research programs are aligned with the *NextGen Implementation Plan* for the mid-term, as well as requirements from the FAA's Aviation Safety line of business. FAA flight deck research typically yields data to support the FAA's role in regulation and certification of pilots, operations, equipment (including avionics), operators, procedures, and other aviation functions with the airspace system. Its ATC research supports the FAA's role in workforce development, and in developing, managing, and maintaining systems and equipment, and the use of these

[8] Federal Aviation Administration, *FAA 2009-2013 FlightPlan*, October 2008 (http://www.faa.gov/about/plans_reports/media/flight_plan_2009-2013.pdf).

things in NAS operations. In addition, human factors are embedded in research projects such as those in the programs of the Concept Development and Validation Group.

NASA

NASA's aeronautics mission is to "conduct cutting-edge, fundamental research in traditional and emerging disciplines to help transform the nation's air transportation system, and to support future air and space vehicles. Its goals are to improve airspace capacity and mobility, improve aviation safety, and improve aircraft performance while reducing noise, emissions, and fuel burn."[9] This research is managed by the NASA Aeronautics Research Mission Directorate (ARMD). There are five programs within the ARMD: Fundamental Aeronautics, Airspace Systems, Aviation Safety, Aeronautics Test, and Integrated Systems Research Programs. Two of the programs, Airspace Systems and Aviation Safety, include human factors as part of their research portfolio.

NASA uses several key references to guide its research planning for NextGen. These references include the *JPDO Integrated Work Plan (IWP)*, the *Decadal Survey of Civil Aeronautics, Foundation for the Future*, and the *National Aeronautics Research and Development Plan*. NASA transfers its research results and technology innovations to both the FAA and industry. When the results of NASA's research are transferred to FAA, they are either integrated with the FAA's research requirements or directly support the FAA's regulatory or NAS operational roles.

FAA-NASA Human Factors Research

FAA and NASA human factors research are complementary and synergistic. NASA's research targets primarily mid-term (2013 to 2018) and far-term (2019 to 2025) OIs envisioned by the JPDO. OIs describe specific operational transformations or improved levels of performance needed to achieve the FY 2025 NextGen vision, as defined in the *NextGen Concept of Operations*.[10] The FAA's research leverages the research conducted by NASA and focuses primarily on the mid-term OIs planned for NextGen. This research produces results that facilitate the transition from researching technology to developing it, and contribute to establishing the technical and scientific foundation supporting the development of FAA guidelines, handbooks, advisory circulars, rules, and regulations that help to ensure the safety and efficiency of aircraft operations. Based on this perspective, there are commonalities across the agencies on the mission, vision, and values for human factors R&D.

[9] www.aeronautics.nasa.gov

[10] *NextGen Integrated Work Plan*, Appendix 1, http://www.jpdo.gov/iwp.asp.

Joint FAA-NASA Human Factors R&D Mission

Both FAA and NASA human factors researchers provide the scientific and technical expertise to facilitate and ensure that human factors are an integral part of the acquisition, certification, regulation, and standards development process for the air transportation system and civil aviation community. Their research results support inclusion of human factors considerations in policies, procedures, regulations, and NAS system development programs in NextGen.

Joint FAA-NASA Human Factors R&D Vision and Values

FAA and NASA human factors researchers have consistent values that will enable them to improve their collaboration, manage their programs better, and achieve the common long-term vision for NextGen which is to: "Develop an air transportation system that can adapt to, compensate for, and augment human performance to ensure safety and optimize system performance." These values are:

- Goal driven – Achieve the mission. FAA and NASA will use R&D as a primary enabler to accomplish their goals and objectives.

- World class – Be the best. The FAA and NASA will deliver world class R&D results that are high quality, relevant, and improve the performance of the aviation system.

- Collaborative – Work together. The FAA and NASA will partner with other government agencies, industry, and academia to capitalize on national R&D capabilities to transform the air transportation system.

- Innovative – Turn ideas into reality. The FAA and NASA will empower, inspire, and encourage their people to invent new aviation capabilities. They will create new ways of doing business to accelerate the introduction of R&D results into new and better aviation products and services.

- Customer focused – Deliver results. The FAA and NASA R&D programs will deliver quality products and services to the customer quickly and affordably.

Section 2

Where are we going?

Goals

This section explains how the FAA and NASA human factors research aligns with the mid-term (2013-2018) and long-term (2019-2025) goals for NextGen. Through formal FAA-NASA coordination, the human factors research conducted by both agencies will better focus on achieving the NextGen goals. The initial focus areas for human factors research, the *Human Factors Portfolio*, and the *Research Facilities Database*, described in Section Three facilitate human factors research contributions to NextGen.

NextGen Goals

The FAA's and NASA's human factors research focuses on the same set of goals – to provide new capabilities that make air transportation safer and more reliable while improving the capacity of the NAS.

The *FAA Enterprise Architecture (EA)* provides the overall architecture for the FAA and for NextGen. Two of its parts, the NAS Enterprise Architecture (NASEA) and NAS Regulatory Enterprise Architecture, contain the systems and operational changes for the command and control of the NAS, including mission support systems, design, management, and procedures, and for the regulation of the NAS, including policy definition, procedure certification, environment regulation, and safety management, respectively.

NextGen Operational Improvements

The NASEA is represented by a set of fourteen technical roadmaps describing how the current NAS will transition to NextGen and its OIs. The OIs represent the goals, objectives, and milestones around which the FAA and NASA human factors researchers will plan and work together to implement NextGen. The NASEA provides the mid-term target architecture for 2018 and the transition strategy to achieve that architecture. It also provides the operational and technical framework for all FAA plans, including the *NextGen Implementation Plan (NGIP)*, the *Capital Investment Plan*, and the *National Aviation Research Plan* (*NARP*). The FAA and the JPDO have aligned FAA EA planning with the JPDO's *NextGen EA* and *NextGen IWP*.

One of the fourteen technical roadmaps addresses Human System Integration (HSI). The HSI Roadmap can be found at: https://www2.hf.faa.gov/HFPortalNew. An analysis of the 87 OIs comprising the NASEA confirms that 86 OIs entail human factors considerations across all NAS personnel and positions as shown in Table 1. Note that any one OI can pertain to multiple NAS actors.

Time Frame	OIs with HF for all NAS Actors	OIs with HF for Sector Controller	OIs with HF for Local Controller	OIs with HF for Pilot
Mid-term	46 of 46	20 (44%)	18 (39%)	18 (39%)
Far-Term	40 of 41	23 (56%)	19 (46%)	22 (54%)
Total	86 of 87	43 (49%)	37 (43%)	40 (46%)

Table 1. Operational Improvements with Human Factors Considerations

Further analysis of the 18 NextGen mid-term OIs pertaining to pilots is provided in Figure 2. This graphic shows the cumulative changes through 2018. These changes, which involve new equipment, automation, and procedures, are categorized by implementation segments. The width of an OI rectangle corresponds to the currently-planned earliest and latest implementation schedules.

Both FAA and NASA human factors research activities are aligned to support these plans and roadmaps. The FAA's research focuses on the mid-term needs from its *NGIP*. It focuses on transitioning the results of that research into the programs and activities of the FAA business lines, which are responsible for safety and for developing and operating the ATC system. NASA research, on the other hand, focuses on the mid-term and the long-term needs as described in the interagency JPDO *IWP*. NASA research results feed into the FAA's research efforts and, where appropriate, directly into the programs and activities of the FAA business lines. As a result, transfer of FAA and NASA NextGen human factors research results support the temporal transition to the FAA's *NGIP* and its OIs.

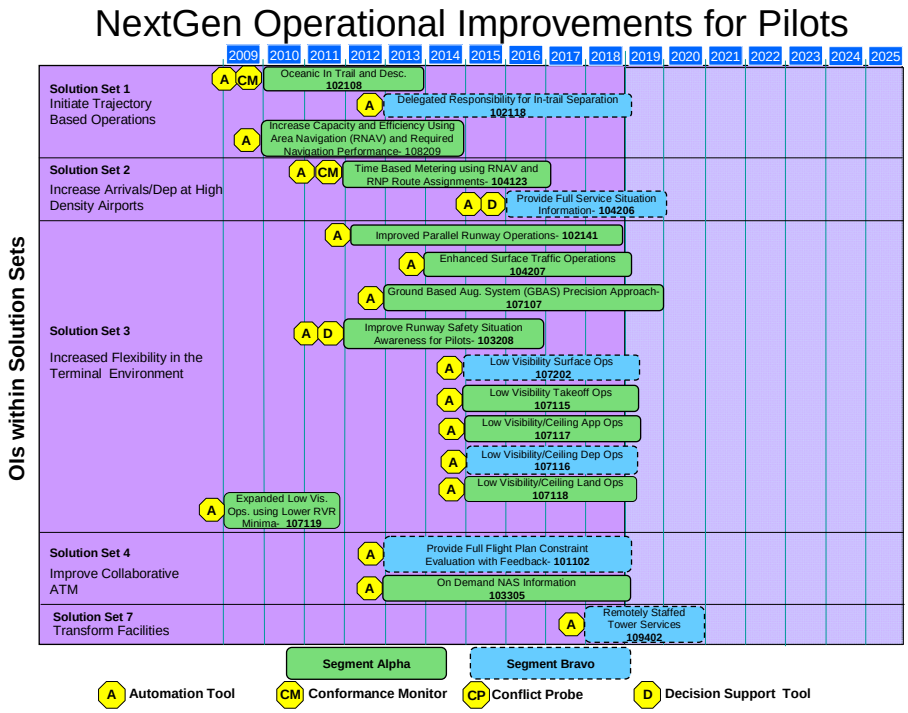

Figure 2. NextGen Operational Improvements (OIs) for Pilots

Section 3

Where are we now?

Current Research Overview

This section provides an overview of the initial focus areas for research that the FAA and NASA are currently addressing, the *Human Factors Portfolio*, the *Research Facilities Database*, coordination mechanisms, and examples of representative research collaborations.

Initial Research Focus

The FAA and NASA are working collaboratively to address the operational needs and challenges of developing and transitioning to the NextGen. Operational needs, such as maintaining on-time arrivals and departures, present challenges from factors such as weather uncertainty and human performance limitations of pilot and controller situational awareness. Many of the operational needs and challenges can be addressed through research. In those cases, initial focus areas for research help to target research funding to support development and implementation of NextGen OIs.

For example, research on decision support tools (DSTs) for traffic flow managers helps to minimize disruptions caused by hazardous weather. In the NextGen environment, NAS operations will be more safe and efficient in relying on a single source of weather information for use in collaborative decision making (CDM) between pilots and controllers.

The initial focus areas for NextGen human factors research are listed below and described in Appendix A. The initial focus areas are:

- Workforce development
- Workstation requirements
- Safety assessment and management of risks
- Ground operations optimization
- Traffic flow management (TFM) and collaboration
- Human interaction with technology and automation
- Human automation functional allocation
- Procedure design and training
- Trajectory-based operations (TBO)
- Air/ground integration

These initial focus areas are a synthesis of the human factors issues that FAA and NASA research currently address. They highlight the range of challenges posed by new NextGen technologies, automation, and procedures to NAS actors. These challenges are best understood by examining the different goals and activities of FAA and NASA programs and projects.

Under NextGen, aviation's reliance on ground-based technology will be replaced with state-of-the-art satellite-based technology, data communications, and flight deck technologies, that will

give pilots and controllers the same view of the system. It will create greater capacity and more fuel-efficient routes. The transition to NextGen requires extensive research into the many facets of ATC from both the pilot and the air traffic controller perspective. Together, the FAA and NASA human factors research programs address these challenges through a broad array of research projects as described in Appendix A.

The different orientations between FAA and NASA in their human factors research activities are shown in Figure 3.

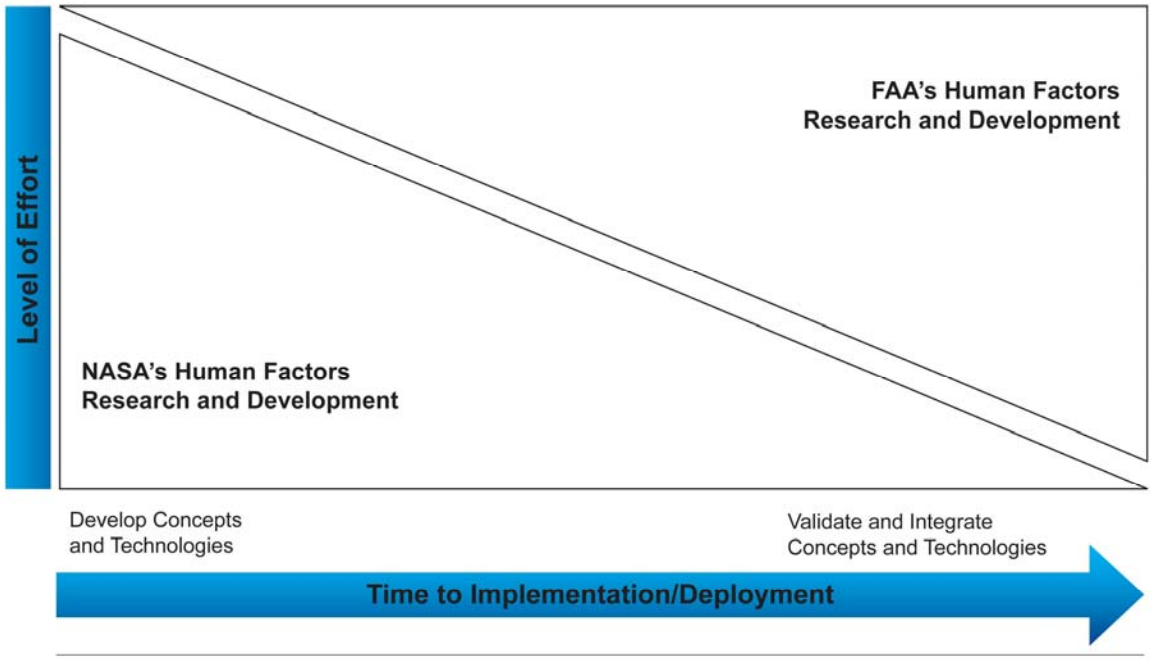

Figure 3. Differences between FAA and NASA in Human Factors Research.

FAA research projects in the Human Factors Research and Engineering Group are aligned to the OIs comprising the *NAS Enterprise Architecture*, the *NextGen Implementation Plan*, and the requirements from the FAA's Aviation Safety line of business. Results of ATC research are systematically transitioned for use in air traffic systems and workforce development (i.e., selection and training), while the regulation and safety research provides the scientific and technical foundation for supporting certification and flight standards. The scientific and technical information is also used by airframe and avionics manufacturers, airlines, general aviation, and other aviation industry groups. FAA human factors research is also embedded in other programs and offices. This includes projects that address human factors and human performance considerations associated with the Concept Development and Validation Group, the Aviation Weather Group, and the NextGen Wake Turbulence Program.

NASA's NextGen Concepts and Technology Project and its milestones have been directly aligned with *JPDO's IWP* R&D elements. This also applies to NASA's Aviation Safety Program and its human factors research. NASA research products include concepts, technologies, and methods that support industry and FAA stakeholders. These products may

improve fundamental knowledge, thereby promoting the design of more capable systems and effective operations. For more mature research products, NASA may also work directly with stakeholders to support system-level testing and integration.

Human Factors Portfolio

The FAA currently maintains the *Human Factors Portfolio*, which is a repository of human factors R&D activities that support the flight deck and air traffic control/technical operations domains. The Portfolio documents and categorizes selected research activities across the NextGen human factors R&D community. The repository lists relevant past, active, and proposed human factors R&D projects. Appendix B provides additional information regarding the current Portfolio. The full Portfolio content will be updated annually, and is available at: https://www2.hf.faa.gov/HFPortalnew/HFPortfolioOverview.aspx.

Research Facilities Database

Appendix C provides a list of FAA and NASA facilities that conduct human factors research. Many specialize in human factors research, whereas others conduct research on human factors in conjunction with other disciplines. The inventory was compiled in September 2010 based on a broader survey that included universities and industry. More comprehensive information about each facility can be found at: www.hf.faa.gov.

Coordination Mechanisms

FAA and NASA coordinate NextGen human factors research and report research results through several mechanisms. These include joint participation in the following venues:

- Interagency Agreements – FAA co-funds a broad array of NextGen ATC and flight deck human factors research that is either led or conducted by NASA. In selecting NASA to conduct NextGen human factors R&D, the FAA considers NASA capabilities and experience, and works with NASA researchers to identify studies and approaches. This leverages NASA's portfolio of current and recently-completed human factors research. In 2010, work was conducted on 12 flight deck research tasks and four ATC research tasks under FAA-NASA interagency agreements. Research topics included:
    - Development of a standard taxonomy for collaboration and coordination methods between pilots, airline operations centers, and ATC
    - Development of integrated terminal (TRACON and ATC tower) controller workstation design requirements
    - Evaluation of training effectiveness in ATC tower simulation systems
- Working Groups – FAA established working groups to foster collaboration among the various ATC and flight deck human factors R&D efforts. These working groups include representatives from FAA, NASA, Volpe National Transportation Systems Center, universities, and industry partners as appropriate.

- Program Reviews – These reviews are held as needed to exchange ideas and results on research technical issues and are attended by NASA and FAA representatives. NASA conducts annual program reviews for the Airspace Systems Program and the Aviation Safety Program, both of which include FAA attendees. In addition, NASA participates in the FAA's semi-annual NextGen human factors technical reviews.

- Technical Conferences – The FAA and NASA participate jointly in several annual national and international technical conferences. Through such venues as the annual meetings of the Human Factors and Ergonomics Society (HFES) and the International Symposium on Aviation Psychology (ISAP), they share findings from human factors research through the broader human factors community. The 2010 Annual Meeting of HFES included a session led by FAA titled "NextGen Concepts for Air Traffic Control and Flight Deck." The session presented the latest FAA sponsored NextGen research. Of significant importance was the FAA-NASA track on the changes in roles and responsibilities between humans and automation during the transition to NextGen that is planned for the ISAP meeting in the spring of 2011.

- Seminars – Along with Eurocontrol, FAA and NASA co-host international air traffic management (ATM) seminars, such as the Ninth USA/EUROPE Air Traffic Management Research & Development Seminar, planned for Berlin, Germany, in 2011. The intent of the seminar is to further the science on ATM needed to lead to a harmonized global ATM system. These seminars provide a forum for researchers to present the results from innovative research, as well as investigative R&D to focus on OIs for the NextGen ATM system, as well as more near-term changes to today's systems. The seminars also create and reinforce working and personal relationships between leading experts and researchers in the ATM R&D community.

- Research Transition Teams (RTTs) – The FAA and NASA jointly established RTTs to identify R&D needs and to transition solutions effectively into NextGen. The RTTs provide a structured forum for researchers and implementers to work together on a continual basis and ensure that planned research results can be fully utilized and enable implementation of NextGen OIs. The teams have focused on:

    - Efficient flow into congested airspace
    - Integrated arrival, departure, and surface management
    - Flow based trajectory management
    - Dynamic airspace configuration

  These teams have provided guidance for NextGen implementation strategies. For example, NASA researchers have conducted human factors studies examining the changes in roles, procedures, and tools for controllers and traffic management coordinators when airspace is resectorized using simulated NextGen capabilities. The studies demonstrated user and system benefits including decreased flight distance, fewer reroutes, and increased airspace utilization.

Representative Research Collaborations

Much of the FAA's and NASA's human factors research is already accomplished collaboratively through various mechanisms. The research has led to many innovations, policy changes, and technological advances in air transportation that have resulted in improved system safety and performance. Following are examples of FAA-NASA research collaboration and results, and the uses of those results.

- In the past, the FAA and NASA collaborated through an Interagency Integrated Product Team to facilitate opportunities for technology transfer between the agencies. This approach resulted in numerous successes, such as a joint NASA, FAA, and MIT Lincoln Laboratories effort to develop a CTAS in the early 1990s. This subsequently led to the FAA version of a Traffic Management Advisor (TMA) system that was deployed nationally at all en route centers and TRACONs in the 2000s. TMA has improved traffic flow, reduced delays, and led to a more standard time-based metering of aircraft.

- NASA has developed task network models, such as the Man Machine Interface Design and Analysis System. The FAA uses these models to understand pilot roles and responsibilities, display requirements, and safety vulnerabilities under conditions of closely spaced parallel operations.

- NASA research on Dynamic Airspace Configuration, where controllers were given three multi-sector layouts to select from for modification, found that controllers were favorable to the concept but preferred only one system-generated sector configuration that they could then optimize. Multiple configuration alternatives hindered the controllers' ability to identify the optimal airspace configuration.

- The FAA and NASA jointly sponsored work on en route multi-sector planning as part of the Flow-Based Trajectory Management Research Transition Team. NASA conducted two major controller-in-the-loop studies exploring resolutions to local flow problems affecting multiple aircraft and air traffic sectors. The experiments focused on controller roles and responsibilities, infrastructure requirements, and concept and technology development. Results suggest a major improvement in weather mitigation and that controller workload can be achieved by incorporating the multi-sector planner functions into existing ATC positions.

- An FAA simulation of a Future En Route Workstation (FEWS) interface and three NextGen concepts for controller management of higher volumes of air traffic showed that controllers managed more aircraft safely and reported lower workloads with FEWS than the baseline system. They also managed more aircraft when airplanes were flying laterally- and vertically-constrained area navigation routes. The FAA is using the results to build the business case for data communications.

Section 4

How are we going to achieve goals?

Strategies

This section identifies initial strategies that the FAA and NASA will use to leverage their respective human factors research policies, programs, budgets, personnel, and partnerships to achieve NextGen goals.

Initial Steps

The FAA and NASA are establishing a formal NextGen human factors research coordination process to achieve the goals and contribute toward the OIs identified in the previous section. Over the next year, both agencies will work together to identify the policies, programs, budgets, personnel actions, and partnerships necessary to do this. Starting immediately, the FAA and NASA will establish:

- A more formal coordinated planning process – Starting this year, FAA and NASA researchers will meet at least annually to review their planned research efforts, identify gaps, monitor and evaluate progress, and report results. Both agencies will consider results from this review when updating their research plans.

- Complementary goals – The FAA and NASA will assess how their human factors research activities align to the NextGen OIs in the mid-term and long-term.

- Research best practices – The FAA and NASA will each follow best practices within their respective agencies to ensure accountability at individual and agency levels and consistency in implementation of policies and procedures. As part of the coordination process, the two agencies will share best practices and consider opportunities for improving existing procedures.

- Human Factors Portfolio – The FAA currently maintains an on-line Portfolio that contains descriptions of past, current, and planned human factors research. Where applicable, NASA and other organizations' research will continue to be integrated to help leverage past and current research of NextGen issues.

- Collaborative expertise and facilities – The FAA and NASA will share research ideas and leverage each other's researcher expertise and facilities for conducting new and ongoing NextGen human factors research.

Expected Results

These initial planning steps will help to do the following.

- Promote a common communications protocol among the FAA, NASA, and their laboratories, contractors, and other stakeholders to educate and inform human factors researchers about NextGen human factors requirements, progress, and changes.

- Identify best business practices in NextGen human factors research and management, including the development and implementation of common metrics.

- Facilitate evaluation of the NextGen human factors research planning, requirements definition, and program implementation process.

- Monitor the implementation of the FAA-NASA *NextGen Human Factors Research Coordination Plan* and evaluate the progress of research to achieve its goals and support NextGen goals and OIs.

- Facilitate and foster collaboration and CDM among NextGen researchers, customers, and stakeholders.

Section 5

How are we doing?

Monitor, Evaluate, and Report on Results

This Section outlines how the FAA and NASA monitor, evaluate, and report on the results NextGen human factors research. These activities enable the two agencies to prioritize their research better and identify gaps for improving collaborative activities.

Since R&D tends to focus on future capabilities, it does not lend itself to traditional return-on-investment analysis. As a result, the FAA and NASA monitor and evaluate their human factors research programs through both formal and informal reviews by internal and external groups as follows.

Internal Reviews

FAA and NASA R&D portfolios receive continuous internal review to ensure that programs and projects meet sponsor needs, are of high quality, and are well managed. These internal reviews will be conducted through:

- FAA-NASA Annual Joint Planning Meetings (New) – This coordination plan will be reviewed and updated as necessary and results will be monitored through regularly-scheduled meetings designed to evaluate progress, identify research gaps, and report results.

- FAA NextGen Human Factors Program Reviews – The FAA sponsors semi-annual human factors program reviews (which include NASA as invited guests) to share human factors research progress and plans. In these forums, FAA-sponsored NASA NextGen research is discussed in the context of the Portfolio, and their products and performers are presented as part of the FAA's human factors research programs relative to funding and tasking.

- FAA Planning Teams – To ensure effective engagement with research stakeholders, the FAA Office of Research and Technology Development uses program planning teams comprised of internal sponsors and researchers to review program outcomes and outputs, align and plan research efforts, and recommend research priorities and programs.

- FAA R&D Executive Board (REB) – When the annual R&D portfolio is formulated, the FAA REB provides approval. It is made up of representatives from the major lines of business of the FAA. This process helps the FAA establish research and budget priorities to meet its strategic goals and objectives.

- FAA Joint Resources Council (JRC) – The JRC is the FAA's corporate level acquisition decision-making body that provides strategic approval of the R&D portfolio and ensures that the research requirements support the FAA's NAS program.

- NASA Airspace Systems and Aviation Safety Programs Annual Reviews – NASA conducts annual program reviews to facilitate discussion of key R&D issues for NextGen. This forum provides the opportunity for presentation of recent developments and results, open technical exchange, and feedback to enhance the programs.

External Reviews

FAA and NASA R&D portfolios receive periodic external reviews from advisory committees and panels to ensure that they meet customer needs and are technically sound. The FAA also seeks feedback from the National Academies and the National Research Council, as well as through user surveys and discussion groups. Researchers also present progress reports at public forums and science reviews, publish and present technical papers, obtain formal peer validation of science, and maintain and share lessons learned.

- FAA Research, Engineering, and Development Advisory Committee (REDAC) – Established in 1989, the REDAC advises the FAA Administrator on R&D issues and assists in ensuring FAA research activities are coordinated with other government agencies and industry. REDAC considers aviation research needs in five areas:

    - NAS operations,
    - Airport technology,
    - Aircraft safety,
    - Human factors, and
    - Environment and energy.

    A maximum of 30 members can serve on the REDAC and represent corporations, universities, associations, consumers, and government agencies. For more information, see http://research.faa.gov/redac/default.aspx. FAA and NASA representatives participate on the Human Factors Subcommittee of the REDAC, which provides research program reviews and prioritization guidance from professionals in the aviation industry.

- External Reviews of NASA Research – The FAA provides human factors expertise in reviews of proposals addressing NASA Research Announcements.

- NASA Independent Review Panel – The FAA participates on independent review panels, providing human factors expertise for the NASA Aviation Safety and the Airspace Systems Programs.

Reporting Results

Currently, the FAA and NASA report the results of their human factors research through many of the coordination mechanisms identified in Section Three and the internal and external reviews mentioned above. In addition, specific results are disseminated to the aviation community through publications, presentations, and reports. The FAA and NASA also have online capabilities that provide real-time, community-wide access to information concerning their

human factors research programs and their products. The FAA human factors website, which can be found at https://www2.hf.faa.gov/HFPortalnew, includes linkages to:

- FAA-NASA *NextGen Human Factors Research Coordination Plan* and related documents,
- NextGen HSI Roadmap,
- *Human Factors Portfolio,*
- *Research Facilities Database,* and
- Human Factors literature surveys, studies, and reports.

APPENDIX A

FAA-NASA Initial Human Factors Research Focus Areas

The FAA and NASA are working collaboratively to address the needs and challenges of developing and transitioning to NextGen by focusing initially on the following human factors research areas.

- Workforce development – Workforce selection and training research helps to identify new skills, knowledge, and abilities that will be needed by NextGen controllers, maintainers, and pilots. The primary focus is on the changing role of NAS operators in the NextGen environment. For example, the strategic job analysis helps to predict how the job of the controller will change in the NextGen environment. Results enable modifying the controller selection criteria and process to match the needs of the new job, if necessary, and identification of impacts to required training. The strategic training needs analysis investigates NextGen controller and maintainer training needs, in order to ensure that training needs for those individuals are identified well in advance of the introduction of new technologies, policies, and procedures.

- Workstation requirements – Workstation functional and design requirements research focuses on improving the operations of air traffic controllers and technical operations to ensure the envelope of human performance is considered as part of safety, capacity, and performance goals. It does this by developing workstation requirements that improve human system integration in a way that allows air traffic service providers, in concert with pilots and others, to move air traffic cooperatively and efficiently. This is accomplished by focusing on the tasks to be performed, the information required, and the measured enhancement to performance. These objectives encompass the requirements for the mid-term integration of NextGen workstations for en route, TRACON, and tower, as well as the far-term common NextGen workstations.

- Safety assessment and management of risks – Safety risk research develops and evaluates new methods that allow credible safety evaluations of highly complex, automation-intensive systems. Methods contribute to formal validation and verification of separation assurance operational concepts and DSTs. It involves safety assessments across different phases of flight across different levels of mixed-equipage aircraft and for off-nominal scenarios. In addition, risk and error management research investigates opportunities for pilot error with the introduction of NextGen automated systems and procedures and the associated pilot roles and responsibilities. Examples of research results include recommendations for design standards and development of evaluation tools that identify and mitigate errors.

- Ground operations optimization – Ground operations research addresses pilot and controller situational awareness in the use of NextGen capabilities during imprecise surface movements for improved operations in all visibility conditions. Research focuses on human capabilities and limitations with regard to improvements to NextGen flight deck equipment displays and airfield signage/lighting during low visibility ground

operations. It examines use of coordinated, optimized trajectory-based paths supported by high precision taxiing and conformance monitoring.

- Traffic flow management and collaboration – Traffic flow research develops strategies and DSTs that allow traffic flow managers to minimize disruptions caused by hazardous weather and to enhance CDM. It addresses sub-optimal strategic flow management decisions by developing modeling, simulation, and optimization techniques to minimize total system delay (or other performance functions) while accommodating increased levels of traffic in the presence of uncertainty.

- Human interaction with technology and automation – NextGen technologies encompass research on data communications and human-computer interfaces for NAS actors in the NextGen environment. For example, the research supports the implementation of data communication functions in NextGen. It produces human factors data to determine minimum required data communications display characteristics and flight crew procedures to achieve the desired performance. Example research results include recommendations for synthetic speech display and data communication procedures, graphical/symbolic display and control alternatives, and identification of potential operator training issues

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- Human automation functional allocation – Higher traffic levels and TBO will likely cause automation to take on a greater role in the NextGen environment. Humans, however, will continue to retain a prominent or leading role in many functions. Research in this area focuses on the proper allocation of functions to humans and automated systems, as well as human/machine roles and responsibilities within those functions. Exploratory design techniques consider ways to improve human understanding of complex automation decision making. Research also promotes common human/machine situational awareness, especially in cases of mixed equipage or off-nominal conditions. Human/automation considerations apply to both airborne and ground-based operations.

- Procedure design and training – NextGen implementation research centers on instrument procedures, training and personnel qualification, and single pilot research. It focuses on the special skills and knowledge needed by NAS actors to ensure the envelope of human performance considerations is adequately aligned with the development of NextGen capabilities in order to accrue intended benefits. This includes implementation of the Navigation Reference System including procedure design, naming conventions, and electronic depictions of NextGen procedures. It also includes training for new NextGen systems and procedures, as well as the potential for skill loss especially in the area of manual skills.

- Trajectory-based operations – NextGen operations research involves separation assurance and collision avoidance as well as trajectory based operations. It involves new operations under NextGen, such as pilot negotiation, selection, implementation, and monitoring of aircraft state relative to position, altitude, and time. This research explores greater levels of automation support to help mitigate controller workload. Trajectory research centers on requirements, uncertainty prediction, interoperability, and validation, and helps to

develop common protocols for exchanging trajectory information between ground-based and airborne systems.

- Air/ground integration – Air/ground integration research provides a systems approach to air-ground integration as the NAS transitions from current operations to new concepts, taking into account changes in responsibilities and procedures between controllers and pilots. It also addresses the balance of automation with NAS actors (pilots and controllers) as policies and procedures change during transitions across different types of airspace.

The initial human factors research focus areas listed above were derived from the following FAA and NASA internal research areas that either explicitly or implicitly address human factors challenges in transitioning to NextGen.

<u>FAA Flight Deck Research</u>

- Instrument procedures
- Separation assurance and collision avoidance
- Ground operations
- Automation/roles and responsibilities
- Data communication
- Risk and error management
- Trajectory-based operations
- Training and personnel qualifications
- Single pilot
- Decision making/decision support

<u>FAA Air Traffic Control Research</u>

- Workstation functional and design requirements
- Human performance in NAS safety
- Air/ground integration
- Personnel selection and training
- Collaborative air traffic management

FAA Human-Factors Related Research

- ATS Concept Development and Validation with human factors embedded in projects on:
    - Data Communications (Segment 2)
    - Conflict Resolution Advisories
    - Staffed NextGen Tower
    - 3D Path Arrival Management
    - Flow Based Trajectory Management
    - High Altitude Airspace
    - Flexible Airspace Management
- Weather Research
- Wake Turbulence Research

NASA Airspace Systems Program

- Dynamic Airspace Configuration
- Traffic Flow Management
- Separation Assurance
- Super Density Operations
- Safe and Efficient Surface Operations
- Integration, Evaluation, and Transition
- Interoperability Research

NASA Aviation Safety Program

- Methods for Verification and Validation of Flight Critical Systems
- Data Mining and Knowledge Discovery
- Human Systems and Solutions
- Prognostics and Decision Making
- Vehicle Health Assurance
- Effective Crew-System Interactions and Decisions in All Conditions
- Aircraft Loss of Control Prevention

APPENDIX B

NextGen Human Factors Portfolio

The FAA's *Human Factors Portfolio* is a repository of human factors R&D activities in the flight deck and air traffic control/technical operations domains that support the efforts across the FAA and NASA in the development and implementation of NextGen capabilities. It lists selected past, active, and proposed human factors R&D projects conducted by government agencies, contractors, and academia. It maps these projects to the OIs listed in the *NAS Enterprise Architecture* and facilitates the identification of supporting activities listed in the HSI Roadmap. It provides project descriptions, status, managers, stakeholders, performers, and NAS actors (e.g., pilots, controllers) affected.

The Portfolio helps researchers and others to develop concepts, establish requirements, identify R&D gaps, and determine additional research and engineering considerations. The Portfolio also can be used by interested parties to gain an understanding of the relationship of human factors R&D activities and NextGen initiatives.

The Internet link to access the Human Factors Portfolio is:
https://www2.hf.faa.gov/HFPortalnew/HFPortfolioOverview.aspx

APPENDIX C

FAA-NASA Human Factors Research Facilities

The following list was compiled in September 2010 based on survey of responses from government, academic, and industry laboratories. The "Capabilities" listed are simplified summaries. In addition, industry and university facilities are frequently used for research that involves human factors. More detailed data of each facility's capabilities are provided at www2.hf.faa.gov.

Agency	Facility	Labs/Complex	Capability
FAA	William J. Hughes Technical Center	En Route Integration and Interoperability Facility (EI2F)	**ATC** - Engineering and training facility that includes DSR, URET, and ERAM
FAA	William J. Hughes Technical Center	Target Generation Facility (TGF)	**ATC** - Emulation of ghost aircraft used in en route, TRACON, and tower simulations
FAA	William J. Hughes Technical Center	Cockpit Simulation Facility (CSF)	**Flight** - A320 and B737 cockpit simulation
FAA	William J. Hughes Technical Center	Airport Facilities Terminal Integration Laboratory (AFTIL)	**ATC** - 360 degree out-the-window tower simulation
FAA	William J. Hughes Technical Center	En Route Automation Modernization Test Beds	**ATC** - Engineering test and evaluation facility that includes ERAM systems, ERIDS, and supervisor workspaces.
FAA	William J. Hughes Technical Center	Standard Terminal Replacement System	**ATC** - Terminal automation test beds including STARS, CARTS, and ARTS IIE
FAA	William J. Hughes Technical Center	Oceanic Integration and Interoperability Facility (OI2F)	**ATC** - Engineering test and evaluation facility that includes the current Advanced Technologies and Oceanic Procedures (OCEANS21) system
FAA	William J. Hughes Technical Center	NextGen Integration and Evaluation Capability (NIEC)	**ATC -** 180 degree out-the-window tower simulation, en route and TRACON simulation, and multi-purpose area **Flight** - A320 and unmanned aircraft system
FAA	William J. Hughes Technical Center	Research Development and Human Factors Laboratory (RDHFL)	**ATC** - 330 degree out-the-window tower simulation, en route and TRACON simulation with eye-tracking system, multiple prototyping systems
FAA	Civil Aerospace Medical Institute (CAMI)	ATC advanced research simulator (ATCARS)	**ATC** - En route simulation; tower simulation

FAA	Civil Aeromedical Institute (CAMI)	NAS Safety Human Factors Laboratory	VLJ, GA, and rotorcraft simulation.
FAA	Mike Monroney Aeronautical Center (MMAC), AFS-440	Flight Operations Simulation Laboratory	**ATC** - En route and TRACON simulation **Flight** - D-Rated B737 & A320 Full-Motion Simulators
NASA	Langley Research Center (LaRC)	Air Traffic Operations Laboratory	**Flight –** Integrated, part-task commercial aircraft flight simulators (single and multi-crew) providing controls and displays for NextGen operations, not rated. **ATC** - Single Sector with Voice/Surveillance and Data Communications Simulation
NASA	Langley Research Center (LaRC)	Cockpit Motion Facility	**Flight** - D-Rated, Full-Motion Simulators for Multi-Crew Commercial, GA, Military, UAV aircraft; **ATC** - limited simulated capability
NASA	Langley Research Center (LaRC)	Human Autonomous Vehicle Systems Laboratory	**Flight** - Part-task fixed-base prototyping environment for haptic-multimodal interface concept development and evaluation.
NASA	Langley Research Center (LaRC)	Intermediate Design and Evaluation Systems (IDEAS) Lab	**Flight** - Part-task simulation facility for prototype development of new display work, Human-in-the-Loop (HITL) evaluations, or single pilot (or operator) simulation.
NASA	Langley Research Center (LaRC)	Operator Characteristics and Performance Investigation Lab (OCAPI)	**Flight** - Desktop part-task capabilities for research in Operator Characterization and Multimodal Interfaces
NASA	Langley Research Center (LaRC)	Visual Imaging Simulator for Transport Aircraft Systems (VISTAS)-III	**Flight** - Part-task visual flight simulator/workstation that uses Commercial-Off-The-Shelf rear-screen projectors to replicate a pilot's visual surroundings.
NASA	Ames Research Center	Human-Centered Systems Laboratory Airport and Terminal Area Flight Deck Simulator (ATAS)	**Flight** - D-Rated equivalent flight deck, non-motion, medium fidelity, 2-pilot, some communication./navigation
NASA	Ames Research Center	Distributed Team Decision Making Laboratory	**Flight** - Single-seat, Non-Rated, Non-Motion Simulation **ATC** - En Route Single/Multi-Sector, Low-Fidelity

NASA	Ames Research Center	ATC Lab Building 210	**Flight** - 12 medium fidelity pseudo pilots stations, not rated, with multiple pilots stations **ATC** - Single & Multi-Sector En Route and Arrival/Departure, Voice, Surveillance, DataComm Simulation
NASA	Ames Research Center	Airspace Operations Lab	**Flight** - Simulated medium-fidelity commercial multi-crew aircraft, non-motion, non-rated **ATC** - Single & Multi-Sector En Route and Arrival/Departure, Oceanic, Voice, Surveillance, DataComm Simulation
NASA	Ames Research Center	Flight Deck Research Laboratory (FDDRL)	**Flight** - Four Non-Rated, Non-Motion Commercial Aircraft Desktop Simulators; **ATC** - Multi-Sector En Route and Arrival/Departure, Voice, Surveillance, DataComm Simulation
NASA	Ames Research Center	Future Flight Central	**Flight** - 14 Non-Motion, Non-Rated Commercial Pseudo-Pilot Stations, Can Emulate 747, 757 Functionality **ATC** - 9 Tower Positions, 360 degree Tower View, Voice, Surveillance, DataComm Simulation
NASA	Ames Research Center	Crew Vehicle Systems Research Facility	**Flight** - 747 D-Rated, Full-Motion Simulation, 5 Pseudo-Pilot Multi-Crew Stations; **ATC** - Multi-Sector En Route and Arrival/Departure, Oceanic, Voice, Surveillance, DataComm Simulation
NASA	Ames Research Center	Training and Procedures Laboratory	**Flight** - University of Oregon non-motion flight simulation, certified for pilot training

APPENDIX D

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APPENDIX E

Acronyms

AFTIL	Airport Facilities Terminal Integration Laboratory (FAA)
ARMD	Aeronautics Research Mission Directorate (NASA)
ATAS	Airport and Terminal Area Flight Deck Simulator (NASA Ames Research Center)
ATC	Air Traffic Control
ATCARS	ATC Advanced Research Simulator (FAA)
ATM	Air Traffic Management
ATS	Air Traffic System
CAMI	Civil Aerospace Medical Institute (FAA)
CDM	Collaborative Decision Making
CSF	Cockpit Simulation Facility (FAA)
CTAS	Center TRACON Automation System
DOT	U.S. Department of Transportation
DST	Decision Support Tool
EA	Enterprise Architecture
EI2F	En Route Integration and Interoperability Facility (FAA)
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
F&E	Facilities and Engineering
FDDRL	Flight Deck Research Laboratory (NASA Ames Research Center)
FEWS	Future En Route Workstation
GAO	Government Accountability Office
HFES	Human Factors and Ergonomics Society
HSI	Human Systems Integration
ISAP	International Society of Aviation Psychology
JPDO	Joint Planning and Development Office
JRC	Joint Resources Council (FAA)
LaRC	Langley Research Center (NASA)
MMAC	Mike Monroney Aeronautical Center (FAA)
NARP	*National Aviation Research Plan*
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASEA	National Airspace System Enterprise Architecture
NextGen	Next Generation Air Transportation System
NGIP	*NextGen Implementation Plan*
NIEC	NextGen Integration and Evaluation Capability (FAA)
NTSB	National Transportation Safety Board
OI	Operational Improvement
OI2F	Oceanic Integration and Interoperability Facility (FAA)
RTT	Research Transition Team
R&D	Research and Development
RDHFL	Research Development and Human Factors Laboratory (FAA)
R,E&D	Research, Engineering and Development

REB	Research and Development Executive Board (FAA)
REDAC	Research, Engineering, and Development Advisory Committee
TBO	Trajectory Based Operations
TGF	Target Generation Facility (FAA)
TIMs	Technical Interchange Meeting(s)
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control