# NextGen Human Factors Division
# Summary Annual Technical Review:
# Fiscal Year 2017

Manage, Direct, and Coordinate
Human Factors Research and Engineering
At the Federal Aviation Administration

**February 9, 2018**

FAA Order 9550.8, Human Factors Policy, defines human factors as follows:

"Within the FAA, human factors entails a multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to equipment, systems, facilities, procedures, jobs, environments, training, staffing, and personnel management for safe, comfortable, effective human performance."

https://www.faa.gov/documentLibrary/media/Order/9550.8.pdf

## To the Aviation Community

Over the course of 2017, the NextGen Human Factors Division (ANG-C1) continued to deliver high value research products and engineering services that support FAA goals for safety and efficiency in aviation systems and operations. Our efforts addressed research requirements coming from three FAA lines of business, specifically the Office of Aviation Safety (AVS), the Air Traffic Organization (ATO), and the Next Generation Air Transportation System (NextGen). We addressed research requirements that spanned near-term human performance issues as well as pre-implementation human factors with NextGen technology and automation. We also provided the backbone for the human factors discipline across the FAA as demonstrated by hosting semiannual Human Factors Reviews with national and international participation.

Underpinning our approach is the business model of ***Research to Reality*** as shorthand to explain the paths that sponsors, industry, and others use to transition our products into practical applications. The reach of our human factors research and engineering services extends outwards potentially touching U.S. commercial airlines and air operators, air traffic controllers, air traffic control (ATC) technical and systems specialists, aviation safety inspectors, and acquisition specialists responsible for programs in the ATO Program Management Office (PMO).

The team of ANG-C1 program/project managers excels in their work providing superior research products on time and within budget. We collaborate with sponsors in portfolio management to ensure doing the right projects at the right time and producing results that exceed expectations. We systematically apply project management methods with researchers to maximize the value in doing the projects right. We also apply program management principles to connect projects between ourselves and other offices to avoid duplication, leverage expertise, and integrate results.

In addition to the sponsorship from AVS, ATO, and ANG, these research programs leverage the exceptional contributions from scientists at the FAA Civil Aerospace Medical Institute (CAMI) and William J. Hughes Technical Center (WJHTC), other federal researchers at the National Aeronautics and Space Administration (NASA), and the Volpe National Transportation Systems Center, as well as human factors experts in industry and academia. The programs and services undergo semi-annual reviews provided by the FAA's external Research, Engineering, and Development Advisory Committee (REDAC) and several of its subcommittees.

The sections that follow provide a cross-section of research from ANG-C1's four programs as well as the engineering services supporting the PMO's acquisition programs. The descriptions draw from existing documentation. A new section is added compared to past issues of this Review providing an Outlook on future NextGen research. I welcome your comments on this Annual Technical Review that can be sent to me at Paul.Krois@FAA.GOV.

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## Table of Contents

## Human Factors Research Programs

| Time Frame / Domain | Near-Term | Mid- to Far-Term |
|---|---|---|
| **Air Traffic Control** | Core ATC and Technical Operations Program | NextGen Integrated NAS Design and Procedure Planning Program |
| **Flightdeck** | Core Flight Deck/Maintenance/ System Integration Program | NextGen Air Ground Integration Program |

# Section 1 — Core (Near-Term) Flightdeck / Maintenance / System Integration Research

The purpose of this program is to provide the research foundation for FAA guidelines, handbooks, orders, advisory circulars, technical standards orders and regulations that help ensure the safety of aircraft operations. It also develops human performance information that the FAA provides to the aviation industry for use in designing and operating aircraft, and training pilots and maintenance personnel.

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| **Identifying CRM Training Techniques in the Airline Industry** | Crew Resource Management (CRM) has been implemented into the aviation training curriculum in order to enhance safety on the flight deck. Due to a lack of standardization, there are differences in CRM training administration and assessment methods among airlines. As a result, a survey protocol has been approved to collect and compare information from airlines regarding their current CRM training curricula and assessment methods in order to identify gaps in training and assessment to help advance CRM towards the needs of the modern flightcrew. The approach includes gathering information related to CRM training practices currently being implemented by air carriers in the U.S., Canada and Western Europe. In addition, this research aims at assess the state of Single Pilot Resource Management (SRM) training and assessment of Part 135 operators (air taxis). The results of this research serve to provide information to augment specific CRM guidelines, principles, procedures, and tools that have been developed to improve CRM training and assessment across US airlines, including the update to Advisor Circular 120-51, Crew Resource Management Training. |
| **Rotorcraft Operational Safety** | Research is needed to address a number of operational and technology challenges for the rotorcraft community that may impact operational safety. The three research vectors are: Helicopter Training Devices, Scenario Based Training for parts 61 (FAA-approved flight instructor), 91 (private pilot), 141 (flight schools), and 135 (commercial pilot of non-scheduled charter and air taxi operations, and Helicopter Crew Resource Management (CRM) for Part 91 and 135 operators including Helicopter Air Ambulance (HAA) operators. Research evaluated pilot decision making using onboard weather aiding resources. Off-nominal event training current practices were reviewed for scenario based testing for off-nominal events. Overall, this research intends to Increase the safety |

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| | of rotorcraft operations and help reduce the frequency of rotorcraft accidents. |
| **Fatigue Mitigation in Flight Operations** | Human factors researchers supported the Flight Standards Service – Air Transportation Division (AFS-200) by reviewing Fatigue Risk Management Systems (FRMS) proposals from industry. This involved review of the scientific integrity of FRMS proposals during the processes outlined in AC 120-103A as required for certificate holders in their demonstration of an alternative means of compliance with the new regulations. This included evaluation of the review and analysis procedures for FRMS exemption for standardization and scientific validity. In addition, human factors experts contributed their scientific expertise to assist in the preparation, documentation, review, and release of other fatigue-related materials as appropriate and associated with 14 CFR Part 117 flightcrew member duty and rest requirements. This research will be used to develop and update policy for 14 CFR § 117 (flight and duty limitations) and 121 (scheduled air carriers) and OpSpec A318, Authorization to Conduct Operations Under a Fatigue Risk Management System. |
| **Enhancing Aviation Safety – Integrated Angle of Attach (AOA)** | Research is needed for evaluating existing and potential Angle of Attack (AoA) indicators that are *integrated* into the Primary Flight Display in order to determine whether they contribute to reducing or eliminating accidents related to stall-spin and other similar situations. The approach was to define and compare formats of integrated AoA instrumentation in the context of flight tasks that are supportable using AoA indications. The goal was to identify those features of integrated AoA instrumentation that are critical to providing usable data to the pilot for defined tasks and to provide guidance/recommendations for the design, certification, and use of such integrated indicators in small GA aircraft. The effort concluded in 2017 with findings from a simulator-based study of integrated displays. The research is intended to produce recommendations for minimum integrated AoA indicator display requirements, without discouraging innovation in the design of AoA display presentations, and is thus expected to enhance safety with better stall margin awareness in existing aircraft and new designs. This was a high-priority research topic for the General Aviation Joint Steering Committee and addresses one of the National Transportation Safety |

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| | Board's (NTSB) Top 10-most wanted issues called Prevent Loss of Control in Flight in General Aviation. |

# Section 2 — NextGen Flight Deck Air Ground Integration Research

This research provides human factors scientific and technical research products for the FAA Office of Aviation Safety technical sponsors that enable their development of FAA guidelines, handbooks, orders, advisory circulars, technical standards orders and regulations. This important human factors regulatory and guidance material supports the Aircraft Certification and Flight Standards personnel who approve new flight deck displays, devices, and procedures that comprise NextGen capabilities, to ensure that pilots can conduct operations that leverage NextGen capabilities. This research also aligns with the NextGen approach to integrate air and ground capabilities together to yield increases in air transportation efficiency, capacity, and safety in the National Airspace System (NAS). Research to assess human performance addressing new NextGen technologies and procedures is necessary for developing updates to standards, FAA orders, RTCA guidance documents, and federal regulations.

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| **Pilot Training and Cognitive Skill Degradation Mitigation** | In today's operational environment, there is no operational baseline for how much manual flying is done in commercial airlines as indicated by autopilot status and modes. Further, there is no research on the impact of automation resulting from use of NextGen technologies in the long-term. Guidance is needed on how to use training to mitigate possible cognitive skill degradation from increased use of NextGen automation. This research examines how an increase in automation may contribute to cognitive and motor skill degradation in manual flight operations, and which may increase the chance for errors to be made. To date, focus group meetings of subject matter experts (SMEs) have been reviewing the literature and identifying operational and training recommendations. These recommendations will be further evaluated in 2018. |
| **NextGen Advanced Instrument Procedures** | Flightcrew pre-flight briefings involve use of briefing strips for Instrument Approach Procedures (IAP). However, complexity of area navigation (RNAV) and required navigation performance (RNP) arrival and departure procedures can pose challenges for effective crew coordination. An assessment was completed on IAP briefing strips and potential content for use in alternative visual depictions for RNAV/RNP arrival and departure procedures. Research was also started assessing the pilot's information needs for RNAV/RNP arrival and departure procedures. These assessments will lead to developing alternative visual depictions of IAPs that better meet pilot needs. This research provides a scientific basis for instrument procedure design for NextGen arrivals and |

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| | departures and supports updating Flight Standards 8260 series Orders that are related to charting standards. |
| **Procedures, Tasks, Skills, and Training for NextGen Air Carrier Pilots and Dispatchers** | Asiana Airlines Flight 214 was a scheduled transpacific passenger flight from Incheon International Airport near Seoul, South Korea, to San Francisco International Airport (SFO) in the United States. On the morning of Saturday, July 6, 2013, the Boeing 777-200ER crashed on final approach into SFO.<br><br>The NTSB found that the 'mismanagement of approach and inadequate monitoring of airspeed' led to the crash of Asiana Flight 214. The NTSB determined that the flight crew mismanaged the initial approach and that the airplane was well above the desired glidepath. In response, the captain selected an inappropriate autopilot mode, which, without the captain's awareness, resulted in the autothrottle no longer controlling airspeed. The aircraft then descended below the desired glide path with the crew unaware of the decreasing airspeed. The attempted go-around was conducted below 100 feet, by which time it was too late. Over-reliance on automation and lack of systems understanding by the pilots were cited as major factors contributing to the accident.<br><br>In 2013 the Flight Deck Automation Working Group of the Performance Based Aviation Rulemaking Committee (PARC) published a series of recommendations addressing factors that contributed to aviation accidents related to Flight Path Management (FPM). Several research studies have sprung from the work of this important Working Group. First, MITRE completed an update of the accident and major incident data and analysis contained in the original Working Group report. For the second study, MITRE characterized the FPM skills including Pilot Monitoring duties and flightcrew Mode Awareness in a line operations environment. Interviews with air carrier flight training departments were completed along with a survey of air carrier line pilots. A forthcoming report from MITRE will inform recommendations to update Part 121 training practices for NextGen and provide a basis for recommendations formed by industry working groups.<br><br>The FAA anticipates that NextGen will add complexity to the flightcrew’s operational tasks and research is needed on new training approaches for these complex operations. An analysis of tasks and focus groups with subject matter experts (pilots, controllers, avionics manufacturers, and FAA certification experts) |

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| | involved a problem-solving and decision-making approach to training. The results from this research will contribute to the development of criteria for Flight Standards inspectors when evaluating air carrier training programs to ensure conformance with FAA regulatory and guidance material (14 CFR Parts 119, 121, and 135).<br><br>The Flight Standards Service identified a need for human factors recommendations and guidance to update regulatory and advisory materials to address flightcrew performance in managing the flight deck tasks in normal and non-normal situations. Research was conducted to define, train and check pilot performance on task management as part of flight deck operations. The research also provided guidelines to address issues in the NextGen environment, including guidelines for pilot training, operational procedures, and flight deck design. |
| **Electronic Flight Bag (EFB) / Personal Electronic Device (PED)** | Data from safety reports suggests that pilots rely on electronic map displays/charts more than their paper charts, even though the electronic medium does not always show all the needed information. The presentation of information on electronic displays and Electronic Flight Bags/ Personal Electronic Devices (EFBs/PEDs) is compelling, that is, the information presented on those devices draws attention and conveys validity. For this reason, research is needed to identify and evaluate the effectiveness of potential mitigations when the EFBs/PEDs are not the best source of information. The results of this research will be used to update regulatory and guidance material for the authorization of EFBs/PEDs, including AC 120-76C and the EFB/AMM Job Aid.<br><br>Additional research is being done for EFBs assessing human factors considerations for the display of misleading or inaccurate information. This display can result from the loss of information integrity and when recognized by the flightcrew can diminish their trust in information display. The initial phase of this research is assessing the different ways that pilots may identify misleading information, how it affects their trust of the systems, and what is the proper flight crew response.<br><br>Advisory Circular 120-76C does not specifically address the challenge of using multiple EFB applications and the effect on flight crew performance although the circular states that “The EFB software design should minimize flight crew workload and head- |

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| | down time." This project produced data contributing to the update of human factors guidelines in Advisory Circular 120-76C. |
| **Advanced Vision & Display Technology** | Industry continues to innovate in developing applications for Head-Mounted and Head-Worn Displays. These applications use emerging display features and functions. This research examines the use of information with these displays, and potential changes to the operational evaluation and the certification and approval of such display-system technologies. The research also identifies the pilot interface and usability aspects of head-mounted display technologies especially with regards to synthetic-vision applications.<br><br>Under the NextGen plans to improve efficiency for aircraft landing under low visibility conditions, Synthetic Visual Guidance Systems (SVGS) is considered a "key enabling technology." Use of this technology for specific low visibility airport operations involves Head-Up Displays and Head-Down Displays with 150-ft Decision Height and a 1200 or 1400 ft Runway Visual Range at selected airports. This research will characterize pilot performance to identify human factors issues and considerations that would affect recommended changes to operational standards and approval criteria for specific SVGS operations. A human-in-the-loop simulation provides data on specified measures such as lateral/vertical path tracking, stabilized approach, touchdown force, touchdown dispersion, missed approach rates, and workload measures. The results will inform Flight Standards as to minimum training, recent flight experience, and proficiency requirements for SVS on pilot Special Authorization (SA) Category 1 (CAT I) approaches.<br><br>NextGen also aims to improve efficiency for aircraft taking off under low visibility conditions. The approach uses Enhanced Flight Visual Systems (EFVS) when operational conditions involve lower than standard takeoff minima. With regards to takeoff, research will determine the minimum airport infrastructure requirements for aircraft equipped with EFVS and could extend the range of weather conditions in which aircraft could takeoff and increase the safety with which aircraft could operate at these airports in reduced visibility. This research will be used to inform new NextGen concepts of operation and operational improvements. It will inform Flight Standards and RTCA-213 in standards development. |

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| **Electronic Data-Driven Charts** | Electronic data-driven charts (DDC) are automated and interactive, presenting human factors considerations in the display of en route chart information. With manufacturers beginning to propose DDC software applications, this research will be used to aid in the development of a standard means of compliance for approving them. It may also feed into an update of regulatory and guidance material on the presentation of electronic charting information, including material related to Advisory Circular 120-76C. |
| **Preventing Clutter and Confusion** | Mitigation of clutter and confusion on NextGen flight deck relies on guidance for the design, evaluation, and approval of visual, auditory, and tactile (touch) displays and controls. Researchers surveyed current and proposed NextGen visual, auditory and tactile displays and controls and the survey findings led to several human-in-the-loop simulation studies. These studies examined the use of spatial tactile cues for separation/collision avoidance as well as the effectiveness of visual and auditory feedback for touch screens. This project established an empirical basis for regulatory guidance for flight deck tactile displays as well as an empirical basis for regulatory guidance for visual and auditory touch screen feedback. This regulatory guidance applies to Part 23, 25, 27, 29.<br><br>Another important human factors area for preventing clutter and confusion on NextGen flight decks pertains to the Field of View and Alert Designs. This research evaluated existing FAA regulatory and guidance material to identify, explain, and recommend consolidation of guidance related to field of view in the aircraft flight deck. Researchers identified the extent to which the research literature supports the guidance material as well as possible gaps that should be addressed in future updates to the FAA material. The FAA published the Alert Designs Report as a supplemental reference for AC 25.1322-1. |
| **Improved Efficiency with Advanced Vision Systems** | With NextGen there are multiple operational opportunities for commercial airlines to improve efficiency through use of Advanced Vision Systems. Our research fills gaps and provides a scientific framework for ensuring safety with these efficiency improvements.<br><br>▪ Takeoff at lower minima – Recommendations for addressing research gaps with Combined Vision Systems. This research |

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| | assessed Enhanced Flight Vision System (EFVS) for operational credit to 300ft Runway Visual Range (RVR) to enable lower than standard takeoff minima and the impact of using EFVS for lower than standard takeoff minima to inform RTCA-213 standards development.<br>▪ Approach to Landing – Research addressed pilot performance and gaps associated with use of sensor technologies (multi-sensor IR, millimeter wave radar, LIDAR, other real-time imaging sensor technologies) for transport category aircraft during Special Authorization (SA) Category (CAT) I approaches. To support the expansion of technology and Limited Visual Operations (LVO) procedure benefits, the FAA requires data that characterize human performance when using SVGS/HUD and SVGS/HDD in transport category. The FAA also needs to understand potential HF considerations that might be associated with certain concepts of operation that are not in use today:<br>— Taxiways – To examine use of EFVS at airports with little or no infrastructure to allow aircraft to get into and out of the airports during low visibility, researchers analyzed results from similar studies and prepared a B737 high fidelity simulator to evaluate relevant operational scenarios. This project will help to determine the limitations of use of EFVS to support landing and taxi/surface operations. The research may allow the extension of low-visibility operations to airports that do not have specific infrastructure. This research would also extend the range of weather conditions in which aircraft could access unequipped airports, increase the safety with which aircraft could operate at these airports in reduced visibility, and possibly open up additional airports as alternate options when reduced-visibility conditions are encountered.<br>— Considerations for the Use of Airport Moving Maps in Low Visibility – This research addressed the design, installation, and integration issues associated with use of airport moving maps in combination with EVS or SVS in NextGen to provide low-visibility taxi, takeoff, and approach, which may eventually lead to operations in zero forward unaided visibility and zero cloud ceiling conditions gate to gate. This research identified gaps in requirements and research relative to using an Airport Moving Map Display in |

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| | conjunction with EFVS to support LVO/SMGCS operations. |
| **Advanced Controls** | Industry is developing new interfaces for flightdeck controls. Research is assessing human factors considrations for displays that are controlled by touch, visual gaze, and speech. Alternative modes of input are also being examined to generate data on multimodal controls that combine different control modalities. This research activity will support the update of Advisory Circular 20-175 (Controls). |
| **NextGen and Unmanned Aerial System (UAS)** | From an ATC perspective, it is critical that the UAS behaves in a predictable manner and is compatible with manned aircraft operations. However, there are unique needs of UAS operations that arise during various contingency conditions, for example, the need to reacquire a lost control link. Researchers at the FAA WJHTC worked with a panel of SMEs (controllers and UAS pilots) to examine potential procedures and technological solutions to mitigate the safety impact and workload of UAS contingency operations to reacquire a lost control link. This research set the stage for planning a human-in-the-loop (HITL) simulation to be undertaken in 2018. The results from this research will inform standards development for UAS operations in contingency situations, including minimum service standards for ATC. UAS is considered a new entrant to the NAS in the NextGen time frame.<br><br>A scientific basis is needed to develop display and alerting requirements and human interface recommendations to inform RTCA SC-223 for a minimum operational performance standard for UAS Detect And Avoid (DAA) systems. These detect and avoid displays are necessary to allow a UAS pilot to remain well-clear of other aircraft. This work leads to planning a full mission simulation at CAMI, to be completed in 2018, that will evaluate recommended displays. The data will support development of regulatory and guidance material that addresses traffic performance, alerting, and flight path guidance that supports adequate UAS pilot performance. |

# Section 3 — Core (Near-Term) Air Traffic Control and Technical Operations Human Factors Research

This research provides technical sponsors in the Air Traffic Organization (ATO) with timely and appropriate research and development (R&D) products and consultation services. Research products respond to research requirements identified through the *ATO Human Factors R&D Requirements Roundtable Process* and ANG-C1 management. These requirements intend to improve safety and efficiency of complex ATC systems.

The program provides services that support Human Factors efforts within FAA acquisition programs. This involved responsibility for approval of human factors items contained in the In-Service Review (ISR) Checklist, as well as updates of Acquisition Management System (AMS) Policy. In addition, the ANG-C1 NextGen Human Factors Integration Lead provided human factors guidance to acquisition offices as they launched new programs.

The program addresses R&D needs within five focus areas: Workforce Optimization Human Factors Efforts, Human Factors in NAS Technology Integration, Improved Safety, Human Factors Standards, and Human Performance Enhancement. The ATO's human factors research requirements Roundtable identified 18 projects that were started in 2016, 15 that were performed in 2017, and the Roundtable process identified some 29 projects for possible execution in 2018.

Methods used include measuring individual and team performance of air traffic controllers and technical operations specialists, and recommending and testing improvements to design, procedures, training, selection and placement; and mitigations to address human performance shortfalls.

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| **Content Validation of AJW's Common Principles Training Course** | In order to ensure safety and improve business efficiency, the ATO Technical Operations Service (AJW) desires to attach job jeopardy to student performance in Common Principles, which is the initial training course for newly hired Airways Transportation Systems Specialists (ATSS) in labor category FV-2101. To attach job jeopardy to the course, the course content must be clearly based on job requirements as described by a current job/task analysis in accordance with agency policy, the Uniform Guidelines on Employee Selection Procedures, and relevant professional standards, principles, and practices. However, the most recent ATSS job/task analysis was completed in 2002. That analysis was found to not reflect substantive changes in maintenance operations and concepts, such as the shift to reliability-centered maintenance, organizational changes, and new technologies and services introduced into the National Airspace System (NAS) over the last decade. Therefore, a new, updated job/task analysis (JTA) was required to justify attachment of job jeopardy to the Common Principles course. |

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| | A personnel psychologist at the FAA's Civil Aerospace Medical Institute completed the ATSS Job Analysis. The results were briefed to the Technical Operations Service Vice-President (VP) and Deputy VP to inform their decision regarding the use of the training course for employee selection. The job analysis provided substantial evidence for the validity of the Basic Electronics module and Math Refresher module (through trigonometry), mixed support for the Transmission Lines and Antennas module, and no support for the Networking module in Common Principles. The recommendation was that job jeopardy might be attached on an interim basis to student performance in Common Principles. |
| **Understanding Why Some Developmental Controllers Fail To Succeed in Field Training** | Training failures are costly to both the FAA, the employee, and the taxpayer. The FAA needs information to develop strategies and/or policies to increase the probability that Air Traffic Control Specialist (ATCS) developmentals will succeed in field training at their first facility. Understanding the factors that contribute to the failure of developmentals at their first air traffic control (ATC) facility will benefit the FAA in multiple ways. First, the information may be useful in determining if a failed developmental has the potential to succeed in training at a less complex ATC facility and should be retained and transferred. A second benefit will be in determining if the factors found to contribute to training failures could be mitigated by the implementation of one or more intervention strategies.<br><br>Personnel research psychologists at the FAA's Civil Aerospace Medical Institute collected survey data to assess the factors that were thought to be contributing to training difficulty for developmentals. Overall, on-the-job training (OJT) was seen as the most helpful for preparing developmentals to control air traffic although many developmentals experienced difficulty with lack of consistency in approach and standardization of expectations between OJT Instructors (OJTIs).<br><br>Developmentals describe issues regarding lack of family support or presence, low pay, and lifestyle stressors such as commute and childcare to be factors which added difficulty to their experiences in field qualification training. While these factors are external to the training program and unstable in nature, facilities may make efforts to mitigate the effects of stress for developmentals.<br><br>Overall, developmentals believed that individual ability was important in becoming an air traffic controller, but that having a "hostile-free" work environment that fosters positivity and support was necessary in |

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| | order to succeed. During the study, developmentals who were successful most frequently commented on factors related to individual ability and individual well-being; indicating hard work, effort, personal ability, and mental stability in relation to stress were paramount to becoming a successful controller.<br><br>The researchers recommended five key areas for intervention: 1) development of training standards for OJT, 2) use of simulation training for developmentals with their OJTIs prior to OJT, 3) improving interpersonal dynamics and facility culture, 4) training for developmentals in stress management, and 5) greater involvement of developmentals in option selection and facility placement. |
| **Instructor Training and Handbook Development: Improvements to On-The-Job Training Instructors (OJTI) who Train Developmental Controllers** | Air traffic On-The-Job Training Instructors (OJTIs) in the field would like to enhance their skills in particular areas that will increase the likelihood of success in training developmental controllers. This project applied the expertise of CAMI human factors psychologists to the development, implementation, and evaluation of OJTI initial and refresher training, and adaptation of the Aviation Instructor's Handbook (currently used for teaching pilots) into an air traffic instructor's handbook to support OJTI for controllers.<br><br>Initial participation extended to course updates for OJTI Initial Training and OJTI Cadre Training that were completed in December, 2016. CAMI's human factors team provided supplemental training, comparative, and evaluative materials. The Air Traffic Instructor's Handbook was provided as a multi-purpose deliverable. It is a readily accessible resource for OJTIs, Cadre instructors, and Front Line Managers (FLMs). Following review by NATCA and SUPCOM, initial Air Traffic Instructor's Handbook revisions were completed in November, 2016. The Handbook will be further modified in 2018 to be congruent with current AJI-2 instructional direction. The Handbook will be revised for use by OJTIs, other instructors, and SUPCOM as a reference document and by AJI -2 as a training supplement. Specific modifications requested include removing extraneous information, extracting job aids and checklists, updating outdated information, and ensuring alignment with what is taught in the OJTI and OJTI Cadre courses. |
| **25-Year Summative Evaluation of the Air Traffic Collegiate** | In the 1989 FAA Flight Plan for Training, the Federal Aviation Administration (FAA) proposed testing the concept of off-loading some portion of air traffic control specialist (ATCS) training onto |

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| **Training Initiative (AT-CTI)** | colleges and universities. This was the genesis of the program that became known as the Air Traffic Collegiate Training Initiative (AT-CTI). Beginning in 1989, the FAA entered into partnerships with selected post-secondary educational institutions to conduct some portion of ATCS technical training. The program grew from an original five institutions to a total of 36 participating colleges and universities by 2012.<br><br>More recently, Congress mandated specific ATCS hiring procedures in Public Law 114-190 (FAA Extension, Safety, and Security Act of 2016, July 15, 2016). Public Law 114-190 essentially requires the FAA to have an AT-CTI program (whereas under 49 U.S.C. § 44506(c) the AT-CTI program is discretionary). However, the discretionary language, "The Administrator of the Federal Aviation Administration may maintain the Collegiate Training Initiative program…" at 49 U.S.C. § 44506(c)(1) was not changed by Public Law 114-190. As part of the program oversight for AT-CTI, ATO's Office of Safety and Technical Training (AJI-2) requested that CAMI personnel psychologists provide a summative review of the AT-CTI for its first 25 years of existence. The last review of the program was completed in 2006, so it is important to have an update that provides a current assessment of the program's performance as a means for controller initial training.<br><br>The project has three components. First, in April, 2017 CAMI completed an analysis of training outcomes for 2005-2013 CTI hires by school. In September, 2017, CAMI completed a report containing a factual summary of the AT-CTI program history. CAMI plans to complete its AT-CTI program summative evaluation report by September, 2018. AJI-2 will use the CTI evaluation to inform consideration of changes in partner schools, curriculum, and other program aspects, based on costs and benefits. |
| **Research on Methods for Improving Controller Visual Scanning** | In air traffic control, scanning refers to a systematic and continuous effort to acquire all necessary information in order to build and maintain a complete awareness of activities and situations which may affect the Air Traffic Control Specialist's (ATCS) area of responsibility. ATCSs continually scan their environment for information necessary to safely and expeditiously guide aircraft to their destination. Investigations of runway incursions and losses of separation involving aircraft often attribute the incident at least in part to a scanning failure. This relationship found in incident reports has led scanning-related topics to be included repeatedly in the ATO's Top |

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| | 5 Safety Issues. Yet, until now, little has been known about what patterns ATCSs use to scan their environment, if any scan patterns are better than others, and whether or not the ability to scan effectively can be learned.<br><br>Scanning seldom exists in isolation from accomplishing other tasks. Additionally, scanning is a sensory input to the development and maintenance of situation awareness. For tower controllers, scanning is facility-specific due to the variability of taxiway configurations, types of weather, aircraft mix, etc. There is little research to confirm how tower controllers scan the airport and vicinity. Additionally, there is little empirical support for identification of critical locations that controllers should observe, and how often, to avoid airport incidents.<br><br>The ATO's Safety and Technical Training service unit requested that CAMI human factors experts collaborate with scientists at the University of Oklahoma to define effective scanning techniques and develop recommendations for their inclusion in controller training. This research will lead to guidance that may aid ATCSs to guard against vulnerabilities in their visual scanning techniques. Guidance could inform development of recurrent training in optimal scanning patterns. This research may also aid the FAA Academy in developing training material to be used to help new controllers learn robust techniques for the critical scanning skill.<br><br>In 2016, CAMI reviewed how scanning is taught at the FAA Academy, worked with a group of air traffic subject matter experts to identify characteristics of a successful scan in the Tower environment, and collected eye-movement and other scanning-related data from 12 retired Tower controllers during a medium fidelity ATC simulation. Results from meetings with controller training personnel, pilots, cognitive psychologists and air traffic controllers led to suggestions regarding what makes for a successful scan.<br><br>Starting in 2018, results of this research will support development of methods to train scanning for tower controllers in FAA Academy and recurrent field training to reduce the likelihood of safety incidents attributable to scanning. ATO's Office of Safety and Technical Training (AJI-2) will incorporate human factors research results into briefings that provide guidance on effective scanning. Identified scanning best practices will be introduced into tower controller training at the FAA Academy and field facilities, where feasible. |

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| **Applying Operational and Empirical Data to Improve the Design of the Controller Display's Computer Human Interface (CHI)** | Controller displays are becoming more complex as new capabilities have been introduced into the design of the Computer Human Interface (CHI). Each data element in an automation system has the potential to create a human factors issue for the controller, and display of the.se data can build to a point where they could impair performance or cause safety issues. Two efforts at the NextGen Aviation Research Division, Human Factors Branch (ANG-E25), located at the William J. Hughes Technical Center (WJHTC) are ground-breaking attempts to use sources of available data to inform improvements in the design of the controller CHI.<br><br>First, the En Route Automation Modernization (ERAM) Air Traffic CHI technical documents and the Standard Terminal Automation Replacement System (STARS) manual provide a comprehensive list of all data elements and interactions that controllers can use in the ERAM and STARS systems while performing their air traffic control tasks. Comparing these documents and the 2011 Job Task analysis data allowed researchers at ANG-E25 to develop a method for assessing compliance with human factors design requirements and a system for ranking the human factors challenges that exist in these automation systems. In 2017, this analysis led to a number of recommendations for further evaluation. The approach in 2018 and beyond will be to use full-fidelity simulation to establish performance benchmarks with the existing systems. This will allow collection of empirical data on the effects of improvements in the design based on recommendations that result from the review of compliance with human factors requirements.<br><br>A second effort at ANG-E25 is demonstrating the use of real-time data repositories for obtaining information about controllers' interactions with the ERAM CHI during ATC operations. The data could help to identify aspects of the CHI that controllers are struggling to use, or that they are avoiding. In 2017, as an initial demonstration of this capability, researchers looked at the use of the ground-based interval management/spacing (GIM-S) tool and associated display information to investigate aspects of the CHI that might be contributing to or hindering controller performance. One of the interesting findings was that controllers who used GIM-S tools were more likely to get aircraft to the target fix on time, as compared to controllers who did not. This finding strengthened as the controller's time on position increased, suggesting that the GIM-S capability can help to ameliorate potential performance decrements associated with longer times on the position. Again, this was a demonstration project, with limited data being sampled, and the future plan is to do a more robust evaluation of the |

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| | automated tools and how they contribute or degrade performance on the air traffic controller task.<br><br>Both efforts at ANG-E25 are ground-breaking attempts to use sources of available data to inform improvements in the design of the controller CHI. |

# Section 4 — NextGen Human Factors Research: Air Traffic Control and Integrated NAS Design & Procedure Planning (INDP)

This research explores human factors implications for air traffic control (ATC) introduced by Performance Based Navigation (PBN) procedures and concepts. As these procedures are developed and introduced into the National Airspace System (NAS), it is necessary to understand the implications these changes will have on the users of the system, including air traffic controllers, and to develop and apply mitigation strategies to ensure user acceptance and utilization of PBN concepts.

In addition, this research provides system-level human factors guidance to assist with the evolution of the NAS infrastructure and its workforce with a focus on the early phases of the Acquisition Management System (AMS). These early AMS phases consist of Service Analysis (SA) and Concept & Requirements Definition (CRD).

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| **Established on RNP (EoR) Operations** | Required Navigation Performance (RNP) capabilities within the National Airspace System (NAS) allow for approaches where an aircraft is "established on RNP" (EoR). The accuracy of RNP monitoring allows suitably equipped aircraft and qualified crew to turn to final without requiring a minimum of 1000 feet vertical or 3 nautical miles lateral separation, once established on the approach. This also "automates" some of the air traffic control instructions provided to the aircraft. The benefits of EoR include a reduction in track miles and fuel burn. Delivering the benefits across the NAS requires air traffic controllers to recognize eligible aircraft, and to integrate EoR approaches into their planned landing sequence. Denver and Seattle have commenced EoR operations. This research captures this facility "know-how" and will share it more widely, to support increased use of RNP approaches within the NAS.<br><br>Controllers, instructors, supervisors, managers and engineering and technical personnel at Denver and Seattle have gained valuable experience implementing EoR. The research team visited these TRACONs to learn about their human factors challenges and successes. Information was gathered to develop guidance providing operationally focused suggestions to help personnel at other facilities introduce their EoR procedures, and to increase the use of these approaches among controllers, where appropriate.<br><br>There are some “trust” issues, related to being comfortable with one of the decision support tools (DSTs) that projects the curved path traffic onto a straight line approach (both have to be zippered in). But these issues are considered normal for the “testing-the-waters” |

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| | phase of initial use of a new technology. Human factors personnel are also evaluating basic path performance, specifically, whether a controller can do a better job "manually" versus the procedures with the DST (in terms of path accuracy and timing). |
| **Performance Based Navigation (PBN) Human Performance Metrics** | One of the primary emphasis areas in NextGen is the increased utilization of Performance Based Navigation (PBN) through Area Navigation (RNAV) and Required Navigation Performance (RNP) approach and departure procedures. This project aims to develop and demonstrate human performance metrics that can be applied to assess the impact of PBN procedures on controller cognitive workload.<br><br>Controller cognitive workload has a well-established relationship with controller performance. Cognitive workload is primarily impacted by task-related factors (e.g., task demand, task complexity, and constraints) and cognitive workload stressors (e.g., situation awareness, trust, motivation, and acceptance). These factors can vary based on the demands of specific PBN operations alone or in combination with stressors. Identifying and measuring these factors will allow for mitigations to be developed, addressing procedure, technology, and training issues.<br><br>The Fort Hill Group is addressing human performance metrics for PBN procedures by collecting data on the effectiveness of human performance metrics for assessing cognitive workload associated with PBN procedures. This has led to developing a validated, repeatable framework for collecting, analyzing, and using PBN human performance metrics to facilitate controller use of PBN concepts.<br><br>Measuring cognitive performance will enable the FAA to develop more effective PBN procedures, increase PBN utilization rates, and ensure that future technology and procedure changes either reduce or do not unduly increase controller cognitive workload. |
| **Strategic Job Analysis Results For Tower, TRACON, and En Route Controllers** | American Institutes for Research (AIR) completed an update to the 2011 Strategic Job Analysis (SJA) which was the first evaluation of the anticipated impact on the controller's job of NextGen capabilities that were scheduled for implementation by 2018. The SJA update confirmed the main finding from the 2011 SJA: specifically, that by the mid-term timeframe (now defined as 2020), NextGen will not substantially change what controllers do on their jobs but, rather, |

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| | how they do their jobs. The reports identify how the controller's job will be changing by 2020 for a select set of NextGen capabilities (referred to in the reports as NextGen Drivers). Due to resource limitations, AIR was asked to review a subset of NextGen capabilities which were selected through a series of joint FAA-AIR collaborations, including input from FAA's NextGen subject matter experts and human factors practitioners with the ATO Program Management Office.<br><br>Themes affecting the controller's job that AIR identified (as associated with the transition to NextGen by 2020) include:<br><br>▪ Automation in the Air Traffic Control Tower (ATCT) control environment continues to increase.<br>▪ Aircraft are in closer proximity.<br>▪ Decision making among NAS stakeholders is increasingly collaborative.<br>▪ The control environment is increasingly dynamic.<br>▪ Change not only persists but also increases.<br>▪ Decision-making support continues to improve.<br>▪ The exchange of information is improved.<br>▪ The number of procedures that are customized for specific facilities is increasing.<br>▪ Interdependence among NAS automation systems continues to increase.<br>▪ Cumulative effects over time will create additional impacts.<br><br>Major takeaways from the AIR analysis include:<br><br>▪ Drivers have a differential impact on controllers both within and across facilities.<br>▪ The magnitude of each Driver's impact on controllers varies substantially.<br>▪ The current controller job analysis data stay largely the same.<br>▪ Driver effects on tools and equipment (T&E) vary significantly for tower and en route controllers.<br>▪ Various properties of the tasks and Knowledge, Skills, Abilities, and Other Attributes (KSAOs) change substantially for tower and en route controllers.<br>▪ Various properties of the tasks, KSAOs, and T&E change substantially for TRACON controllers.<br>▪ Some Drivers will require more efficient controller responses. |

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| | Although NextGen is still evolving, this research represents an important and timely opportunity to inform the pre-employment selection and training processes that are required to ensure that the workforce will be ready and able to perform the job effectively by 2020. Information contained in the three volumes of the final report can be used to inform future FAA efforts to improve controller selection and training that will facilitate the transition of the controller workforce to the capabilities of the NextGen air transportation system. |
| **Potential NextGen Human Factors Risks** | In 2017, American Institutes for Research (AIR) completed its update to the 2011 Strategic Job Analysis (SJA) which was the first evaluation of the anticipated impact on the controller's job of NextGen capabilities that were scheduled for implementation by 2018. As part of its update, AIR also provided a separate volume that described the potential human factors risks identified during its work to develop the updated SJA for controllers. This document, "Potential Human Factors Risks Associated with NextGen Mid-Term Drivers," is valuable for efforts to identify and mitigate safety concerns related to human factors that could arise during the implementation of NextGen capabilities. This work is complementary to hazard analysis products relative to human performance in the NAS. For the purpose of their analysis, AIR defined risk as a threat to safety or efficiency of the NAS that was proposed to occur as a result of implementing a NextGen<br><br>Driver and that could negatively affect controllers by the mid-term of 2020. The risks are based on information about the Drivers that was available to AIR as of May 2016. |

# Section 5 — NextGen Research Outlook

## NextGen Flight Deck Human Factors

In 2017 the NextGen Human Factors Division developed a multi-year plan for this program going out to 2020. Below is the Outlook for a cross-section of proposed outputs organized according to six higher level areas of research. Actual execution of associated research depends on priorities, funding, and other considerations.

- Human Factors Guidelines for Advanced Instrument Procedure Design and Use
  - FY2018 – Guidance for pilot training on new procedure designs.
  - FY2019 – Draft recommendations and considerations for the design and evaluation of electronic chart software.
  - FY2019 – For Performance Based Navigation (PBN) training and operations, lessons learned from current training practices and recommendations for training improvements.

- Procedures, Tasks, Skills and Training for NextGen Air Carrier Pilots and Dispatchers
  - FY2019 – Assessment of commonly expected NextGen non-normal situations and analysis of similarities and differences between current day and NextGen non-normal situations with regard to required pilot response and procedure support.
  - FY2019 – Training instructional requirements analysis plan.
  - FY2020 – Results from training simulations and small group training tryout activities.
  - FY2020 – Recommendations on individual, crew, and team training and checking requirements for pilots and dispatchers operating in the NextGen NAS.

- Flight Deck Systems – flightcrew interfaces, installation, integration, and operations
  - FY2018 – Evaluation of improved awareness of other traffic using integrated ADS-B/ACAS advanced technologies
  - FY2018 – Guidelines and recommendations for advanced display technologies including 3D, stereoscopic, holographic, and head-worn glasses and displays.
  - FY2018 – Guidelines and recommendations on advanced control systems including gestures, speech controls, head-mounted, and haptic/tactile controls.
  - FY2018 – Report on electronic flight bag/personal electronic device display compellingness.
  - FY2019 – Findings and recommendations from the human-in-the-loop simulation evaluating the air and ground integration of terminal time based metering concepts with interval management concepts.

- NextGen Data Communication Human Factors R&D
  - FY2019 – Operational limitations for displaying D-Taxi clearances
  - FY2020 – Assess displays and procedures required for dynamic 4-D trajectory management

- FY2020 – Plan for simulation and flight demonstration and tests assessing the safety impacts of various equipage and pilot procedures as they interact within particular types of operations.

- Human Error and Complex Systems
  - FY2019 – Simulation assessment of task management with complex systems.

- Advanced Vision Systems (EFVS, EVS, SVS, CVS), Head-Up Displays (HUD), and Head Mounted Displays (HMD): Operational Standards & Approval Criteria
  - FY2020 – Completion of human-in-the-loop simulations with findings and recommendations for Enhanced Flight Vision System (EFVS), Enhanced Vision System (EVS), Synthetic Vision System (SVS), Head Up Display (HUD) and Head Mounted Display (HMD) research.

## NextGen Human Factors Research: Air Traffic Control and Integrated NAS Design & Procedure Planning (INDP)

In 2017 the NextGen Human Factors Division developed a multi-year plan for this program going out to 2022. Below is the Outlook for a cross-section of proposed outputs organized based on fiscal year (FY). Actual execution of associated research depends on priorities, funding, and other considerations.

Proposed FY2018 program deliverables:

- Strategy Assessment for Optimizing the Utilization of Time, Speed, and Spacing Tools
- Strategy Assessment for Contingency Operations in a Degraded NextGen Environment
- Catalog of Automation Trust Considerations

Proposed FY2019 program deliverables:

- Human Factors Considerations for Successful Change Management and Implementation
- Human Performance Guidance for Contingency Operations in a Degraded NextGen Environment

Proposed FY2020 program deliverable:

- Assessment of Communication and Collaboration during Trajectory Based Operations

Proposed FY2021 program deliverable:

- Strategy Assessment for Optimizing Collaboration and Coordination in Trajectory Based Operations

Proposed FY2022 program deliverable:

- Guidance for Enabling Efficient Collaboration and Coordination in Trajectory Based Operations

# Acronyms

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| AJW | ATO Technical Operations Service |
| AIRAMS | Acquisition Management System |
| AOA | Angle of Attack |
| AT-CTI | Air Traffic – Collegiate Training Initiative |
| ATCS | Air Traffic Control Specialist |
| ATC | Air Traffic Control |
| ATCS | Air Traffic Control Specialist |
| ATCT | Air Traffic Control Tower |
| ATO | Air Traffic Organization |
| ATSS | Airways Transportation Systems Specialist |
| AVS | Office of Aviation Safety |
| CAMI | Civil Aerospace Medical Institute |
| CHI | Computer Human Interface |
| CRD | Concept and Requirements Document |
| CRM | Crew Resource Management |
| CVS | Combined Vision System |
| DAA | Detect and Avoid |
| DST | Decision Support Tool |
| EFB | Electronic Flight Bag |
| EFVS | Enhanced Flight Vision System |
| EoR | Established on RNP |
| ERAM | En Route Automation Modernization |
| FFRDC | Federally Funded Research and Development Center |
| FLM | Front Line Manager |
| FPM | Flight Path Management |
| FY | Fiscal Year |
| GA | General Aviation |
| GIM-S | Ground-based Interval Management/Spacing |
| HAA | Helicopter Air Ambulance |
| HMD | Head Mounted Display |
| HUD | Head Up Display |
| INDP | Integrated NAS Design & Procedure Planning |
| ISR | In-Service Review |
| JTA | Job/Task Analysis |
| KSAO | Knowledge, Skill, Ability, and Other attributes |
| NAS | National Airspace System |

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| NATCA | National Air Traffic Controllers Association |
| NextGen | Next Generation Air Transportation System |
| NTSB | National Transportation Safety Board |
| OJT | On-the-Job Training |
| OJTI | On-the-Job Training Instructor |
| PARC | Performance Based Aviation Rulemaking Committee |
| PBN | Performance Based Navigation |
| PMO | Program Management Office |
| PED | Personal Electronic Device |
| PMP | Project Management Professional |
| R&D | Research and Development |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| RTCA | Radio Technical Communications of America |
| SJA | Strategic Job Analysis |
| SME | Subject Matter Expert |
| STARS | Standard Terminal Automation Replacement System |
| SUPCOM | Supervisor Committee |
| SVS | Synthetic Vision System |
| TRACON | Terminal Radar Approach Control |
| UAS | Unmanned Aerial System |
| VP | Vice President |
| WJHTC | William J. Hughes Technical Center |