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PLANNING FOR THE FUTURE: HUMAN FACTORS IN NEXTGEN AIR TRAFFIC MANAGEMENT

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The National Airspace System (NAS) Enterprise Architecture (EA) describes Next Generation Air Transportation System (NextGen) goals, operational changes, and guidance materials. While the primary focus of the NAS EA is on infrastructure delivery, the function of human factors is to assess and respond to the impacts of planned changes on end-users. The Federal Aviation Administration's Human Factors Research and Engineering Division has strengthened the presence of human factors activities in NextGen products in the Human Systems Integration (HSI) and other Roadmaps. This paper will present the HSI Roadmap and explore NextGen human factors integration opportunities in tower operations. Opportunities have been identified through the analysis of operational improvements (OIs), decision points, and information obtained through stakeholder interviews. When examining the tower domain and surface operations, 35 OI-actor pairings were identified with 15 describing automation enhancing situation awareness, two describing decision-support tools, one describing procedural changes, and 17 describing mixed changes.

The Federal Aviation Administration (FAA) is executing a transformation of the NAS through the implementation of NextGen. NextGen aims to increase safety, capacity, and efficiency through the introduction of new capabilities to controllers, maintainers, and other NAS users (FAA, 2012). Guiding the implementation of these NextGen capabilities is the NAS EA. The FAA's NAS EA serves as a blueprint for top-down operational and NAS infrastructure improvements. It establishes "a foundation from which the evolution of the NAS can be explicitly understood and modeled" (FAA, 2015). Within the NAS EA are two sets of roadmaps – Service and Infrastructure Roadmaps. Service Roadmaps depict the evolution of current air traffic services to meet future NAS demands through the implementation of OIs. Also to meet future NAS demands, Infrastructure Roadmaps depict the evolution of NAS infrastructure through decision points and regulatory milestones (FAA, 2015). Together, this information enables users to develop a comprehensive, integrated understanding of NextGen changes as well as potential air-ground human factors opportunities (Austrian & Piccione, 2013).

The HSI Roadmap (sample in Figure 1) is the only actor-centric roadmap in the NAS EA. The HSI Roadmap Version 8.0 (FAA, 2014) depicts the evolution of air traffic control (ATC), technical operations, and aviation industry NAS actors by highlighting changes to user-specific technologies and procedures over time. These changes are illustrated through the depiction of key NextGen decisions, milestones, and strategic activities. The identification of actor-NAS EA data element relationships enables the Human Factors Research and Engineering Division (ANG-C1) to define new opportunities for future NextGen human factors research in support of

FAA infrastructure and NextGen capability delivery. Additionally, the HSI Roadmap supports the need to “ensure that human factors issues are fully integrated throughout the development of NextGen systems” by providing a tool to coordinate key enterprise-level human factors activities and needs with relevant stakeholders (GAO, 2010).

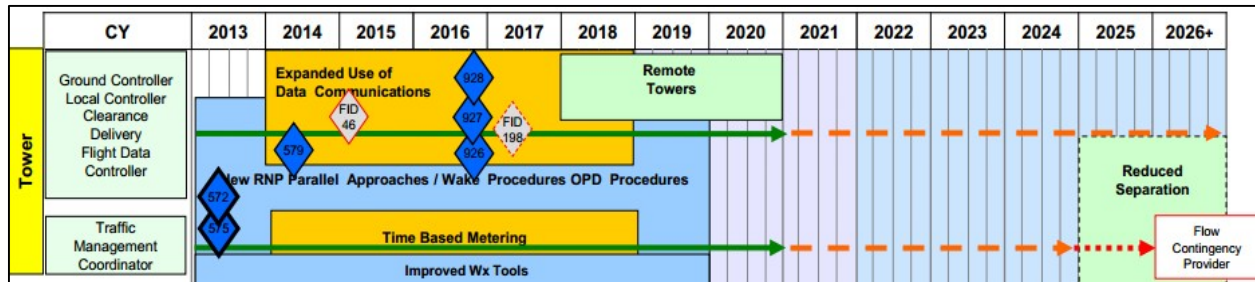


Figure 1. ATCT Portion of the HSI Roadmap Version 8.0 (FAA, 2014). Modified for printing.

Purpose

The concurrent development and implementation of NextGen changes must consider the system-wide impacts to all NAS actors (Zemrowski & Sawyer, 2010; Berry & Pace 2011). This paper aims to utilize the relationships defined in the HSI Roadmap to identify and classify mid- and far-term NextGen human factors research opportunities. These opportunities can be employed to prioritize potential human factors NextGen contributions. As a part of a larger initiative, this paper will present the findings of the HSI Roadmap analysis for the airport traffic control tower (ATCT) domain.

Methodology

During the annual HSI Roadmap update process, data was gathered from the NAS EA Portal and through stakeholder interviews to support HSI Roadmap development and derivation of potential future research opportunities. From the 2015 NAS EA Portal data, 77 OIs were analyzed and classified by a panel of ATC, flight deck, and human factors subject matter experts who utilized a consensus methodology to determine the impacts of OIs on ATCT operations. From those OIs directly impacting ATCT operations, the panel first identified the NAS actor from the ATCT domain (ground controller, local controller, ATCT traffic management coordinator (TMC), and pilot) directly impacted by the NextGen improvement being introduced to the NAS. The panel then determined the specific human factors change to current operations associated with each OI. Those human factors changes were then classified for each ATCT actor as either:

- Situation Awareness (SA) Automation
- Decision Support (DS) Automation
- Procedure Change
- Mixed Change (a combination of two or more of the above change classifications)
- No Human Factors Impact

In addition to the OIs, 139 decision points and regulatory milestones were analyzed through one-on-one working sessions with stakeholders. Each of the 139 decision points and regulatory milestones were linked to the ATCT actors by NextGen timeframe. Decision points

and regulatory milestones represent key infrastructure acquisitions or regulatory changes that could impact ATCT operations and NAS actors at specific points in time.

NAS EA Data Elements

NextGen OIs capture a collection of capabilities that will be incrementally deployed to deliver a variety of benefits to users. To accurately capture cross-cutting NextGen capabilities, OI descriptions are service-focused and lack a direct linkage to NAS infrastructure or systems. Complimenting the OIs and other NextGen data elements are NextGen decision points and regulatory milestones, which capture specific NAS infrastructure investments, acquisitions, or related operational activities that have a clearer linkage to NextGen capabilities. Based on these relationships, it is assumed that OIs may assist in the definition of future NextGen capabilities. These capabilities may drive future NAS infrastructure investments and related changes. As such, both data elements were included in this analysis to obtain a comprehensive understanding of potential NextGen impacts on the ATCT domain and related actors.

Results

Table 1 shows the number of classified OIs that have potential to introduce changes to ATCT actors in the NextGen mid- and far-term.

Table 1.
ATCT OI Classification Analysis Findings

NAS Actor	Total OIs			Human Factors OI Classifications			
	Mid-Term	Far-Term	Total	SA Automation	DS Automation	Procedure Change	Mixed Change
Ground Controller	5	2	7	4	1	0	2
Local Controller	9	4	13	3	1	1	8
ATCT TMC	8	2	10	7	0	0	3
Pilot	3	2	5	1	0	0	4

Table 2 shows the number of decision points and regulatory milestones that may impact ATCT actors in the NextGen mid- and far-terms.

Table 2.
ATCT Decision Point and Regulatory Milestone Findings

NAS Actor	Total Decisions / Regulatory Milestones		
	Mid-Term	Far-Term	Total
Ground Controller	5	2	7
Local Controller	10	2	12
ATCT TMC	11	2	13
Pilot	24	10	34

Discussion

The ATCT OI classification analysis results revealed that seven OIs will impact the ground controller, 13 OIs will impact the local controller, 10 OIs will impact the ATCT TMC, and five ATCT OIs will impact the pilot. Below are examples of impact classification results by

actor. The listed examples also show how an individual OI (e.g., Improved Parallel Runway Operations) may simultaneously impact more than one NAS actor.

OI: Initial Integration of Weather Information into NAS Automation and Decision Making

Related ATCT Actor: ATCT TMC

HF Impact Classification: Situation Awareness Automation

Classification Rationale: This OI proposes the introduction of improved weather data quality and availability to controllers and NAS stakeholders. Users will have the ability to access tailored weather information that enables informed, collaborative decision-making that supports the timely initiation of group or individual flight re-planning actions.

OI: Initial Surface Traffic Management

Related ATCT Actor: Ground Controller

HF Impact Classification: Decision Support Automation

Classification Rationale: This OI proposes the introduction of automation enhancements that support controller surface movement decisions. Automation will share surface information across NAS systems and integrate departure sequencing times with surface movement information to support the prioritization of aircraft staging.

OI: Improved Parallel Runway Operations with Airborne Applications

Related ATCT Actor: Local Controller

HF Impact Classification: Procedure Change

Classification Rationale: This OI proposes the introduction of policies, procedures, and standards that support the use of advanced aircraft avionics to fly dependent approaches to closely spaced parallel runways while maintaining designated spacing intervals.

OI: Improved Parallel Runway Operations with Airborne Applications

Related ATCT Actor: Pilot

HF Impact Classification: Mixed Change

Classification Rationale: This OI proposes the introduction of policies, procedures, and standards that support use of advanced aircraft avionics to fly dependent approaches to closely spaced parallel runways while maintaining designated spacing intervals.

Collectively, the implementation of the analyzed OIs could equip ATCT NAS actors with the tools, capabilities, and information to maintain an increasingly accurate and up-to-date view of high density airport and system-wide NAS operations. Further supporting this assumption are specific NAS infrastructure changes that are detailed through NextGen decision points and regulatory milestones. Below are sample decision points that were included in this assessment and linked to ATCT NAS actors:

Decision Point 46: Final Investment Decision (FID) for Terminal Flight Data Manager (TFDM)

Decision Point 198: FID for TFDM Segment 2

Related ATCT Actors: Ground Controller, Local Controller

Rationale: TFDM is a phased FAA acquisition program that will deliver NextGen capabilities and decision support tools to ATCT NAS actors (ground, local, etc.) throughout the NextGen mid- and far-terms. Decision support capabilities will enable the integration of surface, flight, and traffic management information. Additionally, TFDM will introduce electronic flight strips, surface traffic management, and scheduling capabilities to ATCT NAS actors.

Decision Point 927: Decision on the Implementation Strategy of NextGen ATC Alarms, Alerts, and Notification Guidance

Related ATCT Actors: Ground Controller, Local Controller, ATCT TMC

Rationale: Decision point 927 represents a collection of human factors products that are actively being conducted in support of future NAS infrastructure delivery. Specifically, the development of alarms and alerts standards and guidance materials could influence Terminal and En Route system designs.

Potential NextGen Human Factors Opportunities

Many NextGen improvements aim to improve airport and airspace capacity through the implementation of increasingly complex air-ground procedures. These procedures are dependent on NAS infrastructure improvements, conditional amendments to legacy separation requirements, upgraded aircraft technologies, flight crew eligibility, and strict aircraft procedural conformance. Potential NextGen human factors research opportunities have been identified through the analysis of NextGen OIs, NAS EA decision points and regulatory milestones, and information obtained through stakeholder interviews. These potential research opportunities have been categorized as either surface operations or closely spaced runway operations based on operational relevance.

Surface Operations. Several NextGen changes leverage improved air-ground surveillance technologies, decision support automation, and new procedures to further increase surface efficiencies during adverse weather conditions. To-date, a large portion of NextGen research has focused on mid-term concepts. For far-term concepts, research opportunities will be examined as the concepts mature. Potential research areas may include the development of information integration needs, air-ground information management strategies, and identification of controller-to-controller and controller-pilot information needs. Potential concepts may include data communications during surface operations, utilization of air-ground automation and related technologies to support surface conformance monitoring, examination and prioritization of new air-ground alerting functions, and identification of individual and integrated far-term off-nominal conditions.

Closely Spaced Runway Operations. Several NextGen changes aim to conditionally reduce Terminal aircraft-to-aircraft separation requirements to increase high density airport throughput. Many of these mid-term concepts have been examined individually. However, opportunities exist to understand the integrated impacts of these concepts on human performance. Potential research areas may include the development of controller-controller and controller-pilot information needs to support individual and collaborative decision-making during critical phases of flight. Research aimed at understanding perceived air-ground workload and procedural complexity during closely spaced parallel runway operations could support the implementation of NextGen concepts. Terminal information needs will also be required to support the seamless integration of unmanned aircraft systems (UAS) into daily NAS operations. Potential concepts that may benefit from this research include interval management-spacing, UAS surface operations, and UAS terminal airspace operations. This research could support the integration and implementation of multiple operational concepts to enable closely spaced runway operations.

Conclusion

The 2014 HSI Roadmap is the only roadmap in the NAS EA to be actor driven. As such, the HSI Roadmap may be used as a tool to develop NextGen human factors dependencies and a method to drive the identification of future potential human factors opportunities. Multiple NextGen human factors opportunities exist to support the successful delivery of NextGen infrastructure and capabilities throughout the mid- and far-terms. Functionally, the HSI Roadmap may be used as means to identify those opportunities and proactively close NAS-wide human factors gaps.

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