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Many Next Generation Air Transportation System (NextGen) Operational Improvements (OIs) aim to provide controllers with decision support tools and other automation specifically designed to provide safety enhancements to National Airspace System (NAS) operations. While these changes may indeed produce positive safety improvements, the introduction of each new system and capability also offers the possibility of introducing new human performance hazards into the NAS. A thorough review of the proposed NextGen midterm OIs was completed to identify the potential for both the positive and negative impacts on the human contribution to risk in the NAS. A summary of these findings was presented by linking the proactive human performance assessment with the Federal Aviation Administration's (FAA) top five hazards in the NAS for fiscal year 2013. The results showed that while some of the human performance hazards present in current operations were reduced or eliminated, many new human performance hazards could also be introduced as these systems are implemented.

The FAA is currently executing a considerable transformation of the NAS called NextGen, which aims to improve the convenience and dependability of air travel while increasing safety and reducing environmental impact. NextGen plans to meet these goals by introducing a variety of new systems and capabilities, such as the introduction of data communications and Automatic Dependent Surveillance-Broadcast (FAA, 2012). NextGen ventures to improve the capacity, efficiency, and, perhaps more importantly, safety of the NAS through the implementation of OIs. Many operational improvements aim to provide controllers with decision support tools and automation specifically designed to provide safety enhancements to NAS operations. While NextGen may produce many positive safety improvements, the introduction of each new system and capability also offers the possibility of increasing the human contribution to risk in the NAS (Sawyer, Berry, & Blanding, 2011). This is especially true when considering the system-wide impact and concurrent development of many of the systems (Berry & Sawyer, 2012). From a risk management perspective, research into these effects is needed to address the potential for both positive and negative impacts on the safety of the NAS (FAA, 2011).

The human factors community of practice has played a significant role in the enhancement of safety in the aviation and air traffic control (ATC) domains. However, in terms of traditional safety assessments, many of the tools and techniques utilized by human factors practitioners are often retrospective in nature. These techniques and tools serve as aids in the analysis of incident and accident data gathered post-hoc. While these tools and techniques have been and are still valuable in assessing the safety of the NAS, these tools and techniques are limited in regards to analysis of future systems, such as NextGen (GAO, 2011; FAA, 2011). The ability to proactively identify potential hazards to human performance associated with a new system before the new system is introduced into the NAS has long been identified as a need (GAO, 2010; GAO, 2011). Since NextGen is introducing several new systems and capabilities, the integration of proactive human factors safety research into the earliest stages of system design and acquisition could not only reduce industry cost, but also improve system design, development, and implementation (EUROCONTROL & FAA, 2010). A standardized approach to proactively identifying and assessing human performance hazards is needed to ensure these hazards are identified, described, and tracked. The purpose of this proactive safety assessment is to examine the potential changes in the human performance risk profile of current NAS operations with NAS operations in specified NextGen timeframe. Furthermore, the paper will present a summary of results of NextGen human performance assessments (Berry, Sawyer, & Austrian, 2012; Berry & Sawyer, 2012) in comparison with FAA Air Traffic Organization's (ATO) list of top hazards in the NAS for FY2013.

Methodology

This analysis will focus on the Segment Bravo portion of the NextGen midterm timeframe. The midterm and Segment Bravo are comprised of seven solution sets represents changes planned to be implemented beginning in 2015 (DOT IG, 2012). The solution sets are a compellation of related operational improvements grouped by overarching themes (FAA, 2013). Each solution set contains multiple OIs with each OI proposing a new system or capability. The comparisons in study will be made at the OI level.

The Human Error and Safety Risk Analysis (HESRA) tool was utilized to perform the assessment of the NextGen midterm Segment Bravo OIs (FAA, 2009). Based on a traditional Failure Modes and Effects Analysis, the HESRA tool provides a structured method for identifying potential human performance hazards and the associated worst credible outcome. A panel of ATC experts and human factors experts also estimated the severity, likelihood, and recovery potential for each potential human performance hazard. The FAA's Safety Management System likelihood and severity scales (FAA, 2008) were utilized in order to ensure that identified hazards could be managed in the existing FAA safety process. The recovery rating in the HESRA methodology assesses the ability to both detect and recover from the presence of hazards in the system. Recovery is essential to differentiate between hazards that will be detected and recovered from before the effects propagate through the system and hazards that will have major system effects before they are identified and corrected. These values are then combined to calculate a Risk Priority Number, which can be used to compare the relative risk associated with identified potential human performance hazard.

The FAA's ATO releases an annual listing of top hazards in the NAS each fiscal year (FY). The list is generated from extensive reviews of safety data and discussions with ATO stakeholders. The list, which represents the top safety hazards, aims to assist in prioritizing ATO resources in improving the safety of the NAS. The top five hazards list for FY2013 is provided in Table 1 (Teixeira, 2013). For this assessment, the FY2013 top five hazards were compared to the Segment Bravo assessment results in an effort to determine linkages between the two analyses.

Table 1. FY13 Top Five Hazards (Teixeira, 2013)

FY 2013 Top 5 Hazards
Recovery In some cases, margins of safety are not quickly re-established after a loss of separation.
Traffic Advisories/Safety Alerts Safety alerts and/or traffic advisories are not being issued when required, removing a safety barrier and increasing risk.
Failure to Monitor Initial Departure Headings Communications are being transferred prior to ensuring initial departure headings, resulting in aircraft being off frequency while controllers attempt to mitigate losses of separation.
Similar Sounding Call Signs Aircraft are operating with similar sounding calls signs, resulting in increased opportunities for confusion, and incorrect aircraft receiving or reading back clearances.
Conflicting Procedures Facility letters of agreement and standard operating procedures conflict with published arrival and/or departure procedures, increasing the likelihood for incorrect pilot readback and actions.

Results and Discussion

Sample potential human performance hazards from the Segment Bravo human performance hazard assessment were identified and linked to the FY2013 top five hazards. In the following sections, the linkage to the top five will be discussed, and additional human performance risk hazards will be identified.

FY2013 Top Five Hazards Linkage

Table 2 outlines sample potential human performance hazards that are associated with one of the ATO's top five hazards from FY2013.

Table 2. FY13 Top Five Hazards Linkage

Top 5 Hazard	OI	Hazard Condition	Potential Human Performance Hazard	Worst Credible Outcome
Recovery	102144	Expanded use of Automated Terminal Proximity Alert, which alerts approach controllers regarding separation problems for in-trail aircraft on final approach, to include use during complex dependent approach operations involving mixed wake categories.	Controller over-relies on automated terminal proximity alerting system and does not actively monitor spacing. Automation fails to display alert when necessary.	Controller fails to notice impending loss of separation. Potential for wake turbulence encounter.
Alerts	102406	Surface surveillance equipment is compatible with runway incursion indicating and alerting capabilities, so that controller and pilots would be warned if a ground vehicle enters an active runway, in a manner similar to that for an intruding aircraft.	Controller fails to notice alert regarding unauthorized ground vehicle entering an active runway due to alert salience.	Ground vehicle enters active runway. Potential for runway incursion between aircraft and ground vehicle.
Heading	102114	Monitor aircraft conformance and provide an alert on the Radar Console when an aircraft's track or position information indicates that the aircraft is laterally deviating from its assigned route.	Controller fails to notice alert regarding aircraft laterally deviating from its assigned route.	Aircraft continue on present trajectories until controller resolves issue or short term conflict alert activates.
Call Signs	104207	Initial D-TAXI service will be the principle communication of taxi-out instructions via data communications instead of voice, from ground controllers in the ATC tower to flight crews as their departing flights enter the movement area of the airport surface and head to their assigned runway.	Controller sends taxi instruction to incorrect aircraft due to mis-read of call signs. Taxi route is inadequate for aircraft characteristics.	Aircraft taxis via inadequate taxiway instruction. Potential for taxiway incursion. Controller re-routes aircraft to correct destination. Potential for ground delays.

Top 5 Hazard	OI	Hazard Condition	Potential Human Performance Hazard	Worst Credible Outcome
Conflicting Procedures	102114	Transfer of radar identification will be fully automatic and accomplished by the automation without any controller activity if the aircraft is problem free at the transfer point.	Transfer point identified by automatic handoff automation is inadequate. Transfer point is not in agreement with prior letter of agreement.	Aircraft automatically hands-off too early or too late to be in accordance with letter of agreement. Transferring controller inhibits automatic handoff automation and manually coordinated handoffs with receiving controller.

Recovery. The top five hazard of recovery is related to the ability of a controller to issue the necessary instructions to safely recover from an adverse safety event, such as a loss of separation or airspace violation. From a human performance perspective, this action is composed of two tasks: detecting the presence of an adverse event, and executing a strategy to reestablish positive safety. Since NextGen introduces many new decision support tools and additional automation, the potential exist for controller's to suffer skill degradation due to a reliance on automation. In the sample human performance hazard, automation may support the controller by monitoring the spacing of aircraft during final approach. However, the hazard exist that the automation may not be perfect and in a particular instance, many not identify a spacing issue. If the controller has become over-reliant on the automation over time, the controller may also not identify the impending conflict. While this hazard might not occur frequently, the recovery period and ability for the controller has been reduced due to over-reliance on automation and skill degradation. This potential human performance hazard and other similar hazards should be mitigated by training requirements that provide recovery training to controllers by improving the controller's ability to detect a problem occurring and to develop and execute a plan to correct the problem at hand.

Traffic Advisories/Safety Alerts. The top five hazard of traffic advisory/safety alert centers around the problems associated with safety alerts not being issued by controllers to pilots when the operational conditions present necessitate an alarm. In many situations, controllers have more knowledge regarding the conditions of the airspace or airport. For example, controllers may have more detailed weather information or traffic information. Relaying the information to pilots is necessary for ensuring the safety of the NAS. Currently, controllers proactively issue traffic advisories, and NextGen aims to assist the controller by providing decision-support tools to assist controllers in identifying when to issue such advisories. In the sample human performance hazards, ground automation may monitor ground vehicle movement in conjunction with aircraft movement. If a ground vehicle enters or is on a trajectory appearing to enter an active runway, automation will provide the controller with an alert regarding the vehicle. If the controller does not notice the alert because the alert is not salient enough for the environment, the controller may remain unaware of the ground vehicle and not issue the necessary instructions and advisories to avoid a runway incursion. This potential human performance hazard and similar hazards should be mitigated by design and research requirements that ensure the automation alert assisting the controller in the issuance of traffic advisories is salient and convey the correct information in the appropriate amount of time.

Failure to Monitor Initial Departure Headings. The top five hazard of failure to monitor initial departure headings is related to the controller's task of monitoring the aircraft's adherence to a specific route and, in particular, the initial departure heading. With NextGen, the usage of area navigation (RNAV) routes will be increased in an effort to reduce communications and improve efficiency. RNAV routes in conjunction with NextGen monitoring tools aim to reduce track deviations. In the sample human performance hazard, automation may monitor aircraft conformance to an assigned route. If the aircraft laterally deviates from the route, the automation may alert the controller. It is possible that a controller may fail to notice the track deviation alert resulting in a track deviation and potential conflict. While a decision support tool may assist in identifying potential track deviations, the possibility always exists for the automation to be imperfect or for the controller to not perceive the automation alert. Like the previous hazard, the salience of the automation notification or alert should be examined. However, other mitigation strategies exist for this particular top five hazard. For example, prior to departure a controller can verify the initial departure heading or first departure fix with the pilot. A procedural mitigation strategy may be implemented to address the hazard during the development of the automation strategy and may support the automation after deployment.

Similar Sounding Call Signs. The top five hazard of similar sounding call signs identifies the issue of confusion associated with call signs and hearback/readback errors. With NextGen, the usage of voice communications may be supplemented with the increase usage of data communications. While issues particular to voice communications, such as similar sounding call signs, may be reduced, new human factors issues particular to data communications may arise (e.g., misreading similar looking call signs). In the sample human performance hazard, the ground controller to may utilize data communications to issue pilots taxi instructions. If the controller mis-reads a call sign, the potential exist for the controller to send the incorrect taxi instruction to the mis-read aircraft. The aircraft could then taxi via an inadequate taxi route. Future research should be conducted to further examine the mis-read of data communications for both the controller and pilot.

Conflicting Procedures. The tops five hazard of conflicting procedures is related to operational procedures not being in accordance with existing procedures or letter of agreements. NextGen operational improvements may implement many new procedures and systems that must interact with existing procedures and letter of agreements. It is important for designers to be familiar and incorporate those existing conditions and procedures into the NextGen capabilities. In the sample human performance hazard, the handoff of an aircraft's radar identification to the bordering sector may be automated to reduce controller workload. Once a aircraft reaches a specific transfer point in a sector, the aircraft will automatically handoff to the receiving sector. However, if designers have not incorporated an existing letter of agreement in the determination of the transfer point, the transfer point could be incorrectly placed resulting in an aircraft handing-off at the in proper time or manner. If the problem of the incorrect transfer point continues, the transferring controller may elect to inhibit the automatic handoff feature eliminating the benefits associated by the automation. This human performance hazard and similar hazards should be mitigated by developing design requirements for the incorporation of existing procedures and letter of agreements into new systems.

NextGen Human Performance Assessment

The ATO's top five hazards are associated with many of the NextGen human performance assessment hazards. Furthermore, the NextGen human performance assessment identified many other potential risks. For more detail information on portions of the NextGen human performance assessment please see Berry and Sawyer (2012), Berry, Sawyer, and Austrian (2012), and Sawyer, Berry, and Austrian (2012). These assessments and the overall assessment identified many human performance hazards associated with Segment Bravo, and also developed design, training, and research requirements targeted to mitigate or eliminate the impact of those hazards. The overall findings included human performance issues associated with data communications on the ground, enhanced vision systems for pilots, integrated en route display systems, inter-relationships of automated systems, and proposed alerts and notifications.

To expand on one of the human performance findings identified by the overall assessment, the findings presented by Sawyer, Berry, and Austrian (2012) revealed that many new alerts and notifications could potentially be implemented into the NAS in the NextGen midterm. Whereas current air traffic controllers have two primary safety-critical alerts, the conflict alert and minimum safe altitude warning, controllers in the midterm could have an additional nine alerts or notifications related to the implementation of new procedures with reduced separation standards. As each of these alerts is developed and implemented, a series of research studies will be needed to determine the proper implementation strategy and to determine if the potential for over-burdening the controller with too many alerts and too much information exist. These efforts should focus on determining the necessary mode, salience, location, required level of accuracy, and place in the greater air traffic alert hierarchy for each alert.

Conclusions

In an effort to improve the efficiency and safety of the NAS, NextGen introduces new automation and capabilities in the form of operational improvements. While these changes may indeed produce positive safety improvements, the introduction of each new system and capability also offers the possibility of introducing new human performance hazards into the NAS. A thorough review of the proposed NextGen midterm Segment Bravo was completed to identify the potential for both the positive and negative impacts on the human contribution to risk in the NAS. A summary of these findings was presented by linking the proactive human performance assessment with the ATO's top five hazards in the NAS for fiscal year 2013. The results showed that while some of the human performance hazards present in current operations were reduced or eliminated, many new human performance hazards could also be introduced as these systems are implemented.

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