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Assessing Potential Human Performance Safety Impacts Associated with Integrating Multiple Time-Based Flow Management Concepts

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ASSESSING POTENTIAL HUMAN PERFORMANCE SAFETY IMPACTS ASSOCIATED WITH INTEGRATING MULTIPLE TIME-BASED FLOW MANAGEMENT CONCEPTS

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Time-Based Flow Management (TBFM) seeks to enhance system efficiency by improving scheduling and interval management tools that expand and enhance the flow of traffic. This paper presents the results of an integrated human performance safety assessment of TBFM concepts planned for implementation between 2016 and 2020. The assessment utilized the Human and Organizational Safety Technique (HOST) to provide a structured method for identifying potential human error modes and estimating their contribution to the risk profile. HOST further defined graphical human-system interaction models for each proposed change and an integrated interaction model across all assessed TBFM changes. The HOST assessment resulted in multiple potential human error modes across the individual TBFM changes. As no concept will be implemented in isolation, key interactions among error mode interactions were assessed utilizing the integrated human and system interaction model. These findings directly influenced the development of Next Generation Air Transportation System (NextGen) safety requirements.

The Federal Aviation Administration (FAA) is currently executing a considerable transformation of the National Airspace System (NAS). NextGen aims to improve the convenience and dependability of air travel while increasing safety and reducing environmental impacts. NextGen plans to meet these goals by introducing a variety of new systems and capabilities (FAA, 2013b). 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 (Berry & Sawyer, 2013). This is especially true when considering the system-wide impact and concurrent development of many of the systems (Sawyer, Berry, & Blanding, 2011; Zemrowski & Sawyer 2010). 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, 2013a).

This paper presents the results of an integrated human performance and safety assessment of TBFM concepts planned for implementation between 2016 and 2020. Proactive assessment of NextGen concepts is critical to understanding the cross-cutting impacts of proposed changes to the human-system interactions among all NAS actors (Austrian, Berry, Sawyer & DeHaas, 2015; Austrian & Sierra, 2013).The resulting hazards and overall human performance risk profile are provided to support the development of targeted mitigation strategies to ensure that new NextGen capabilities support human performance.

Time-Based Flow Management (TBFM)

TBFM proposes to enhance system efficiency by leveraging the capabilities of the Traffic Management Advisor (TMA) decision-support tool. TMA has already been deployed across Air Route Traffic Control Centers in the contiguous United States. Proposed NextGen improvements to TMA will improve its trajectory modeler, enhance TMA's departure capabilities, and optimize demand and capacity. Improvements will be made to enable controllers to more accurately deliver aircraft to the Terminal Radar Approach Control (TRACON) facility while also providing the opportunity for aircraft to fly optimized descents.

In the NextGen mid-term timeframe, this portfolio focuses on scheduling and interval management tools that further expand Time-Based Metering benefits to assure the smooth flow of traffic and increase the efficient use of airspace. These changes will be implemented through a series of improvements such as Point-in-Space Metering, Time-Based Metering in the Terminal Environment, and Improved Management of Arrival/Surface/Departure Flow. These changes are designed to extend, enhance, and increase metering operations; improve the accuracy of schedules and demand predictions for more efficient and predictable NAS operations; and continue the path toward trajectory-based operations. These changes also introduce the use of Interval Management-Spacing operations, using a combination of ground- and flight deck-based capabilities. These changes are described through a series of Operational Improvements (OIs).

Human Performance Hazard Assessment

A human performance safety assessment was conducted on these OIs to proactively identify potential positive or negative impacts to a controller's ability to provide safe air traffic control services. For the purpose of this assessment, four OIs from the TBFM portfolio were examined. The OIs listed below in Table 1 were retrieved from the FAA's NAS System Enterprise Architecture (FAA, 2014).

Table 1.
Time-Based Flow Management NextGen Operational Improvements

Operational Improvement
102118: Interval Management - Spacing
104120: Point-in-Space Metering
104123: Time-Based Metering Using RNAV and RNP Route Assignments
104128: Time-Based Metering in the Terminal Environment

Human and Organizational Safety Technique (HOST)

The assessment utilized HOST to assess planned TBFM changes. HOST provides a structured method for identifying potential human error modes and estimating their severity, likelihood, and recovery potential. As part of the HOST analysis, a team of air traffic control, commercial aviation, and human factors subject matter experts reviewed each OI to first identify the controller and pilot tasks impacted by the proposed change. Identified task impacts were then used to develop Human System Interaction Models (HSIMs) for each OI. Each HSIM depicts the interactions of actors and systems for a given change as identified by the working group.

Following the development of the HSIMs, the working group reviewed each impacted actor/system interaction point to identify potential human performance hazards associated with not executing the action, completing the interaction in an unsafe way, and completing the action too soon or too late. Worst credible outcomes for each potential hazard were then identified and assessed based on the potential severity, likelihood, and recovery impact of each hazard. Resulting hazards were then prioritized based on potential impact to human operators in the NAS.

Results and Discussion

The HOST analysis of the TBFM portfolio resulted in two primary results. Phase one of HOST yielded HSIMs for each of the OIs and an integrated HSIM showing the interactions among the four OIs in the portfolio. Each HSIM was then used as the basis for identifying potential hazard conditions associated with each impacted actor-system interaction. Selected results will be presented for OI 104123 followed by aggregated results across all TBFM OIs.

104123: Time-Based Metering Using RNAV/RNP Route Assignments

Provided below in Figure 1 is the completed HSIM for 104123: Time-Based Metering Using RNAV and RNP Route Assignments. The development of the HSIM outlined the key impacts of the proposed change on the en route controller. Primary impacts were seen on the interaction between the en route controller and the en route automation system and flight crew.

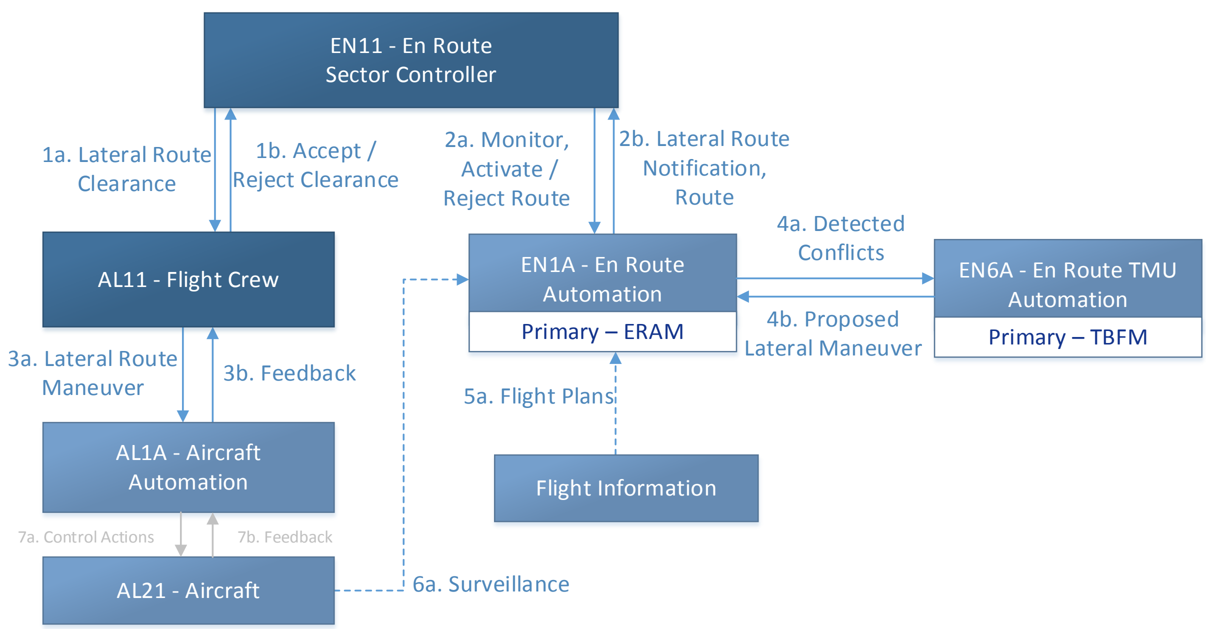

Figure 1. HSIM for 104123: Time-Based Metering Using RNAV and RNP Route Assignments

Following the development of the HSIM for each OI, the human performance hazard assessment was completed to identify potential human performance hazards introduced or impacted by each OI. The working group identified 10 potential human performance hazards associated with OI 104123. An example of an identified human performance hazard and the associated impact data is included below in Table 2.

Table 2.

Example Hazard identified for OI 104123

Impacted Task	2b. En Route Automation provides controller with lateral route instruction generated to help aircraft meet meter time		
Potential Error Mode	Automation provides controller with path stretching instruction with inadequate return point		
Worst Credible Outcome	During path stretching operation, actual aircraft performance and airspace conditions differ from predicted traffic flow and conditions. Return point no longer provides required separation minima for path stretching aircraft.		
Hazard Actor	Automation	**Hazard Activity**	Non-Controller Task
Outcome Actor	En Route Controller	**Outcome Activity**	A6: Manage Traffic Flows and Sequences
Effect Type	Safety	**Human Factors Priority**	Moderate

Aggregated Human Performance Safety Impacts

Across the four OIs included in this assessment, 48 human performance hazards were identified. These hazards and their evaluated priorities are included below in Figure 2. OI 102118: Interval Management – Spacing showed the largest number of potential human performance hazards. This included the one high human factors priority hazard which related to the impact of a deviation by the lead aircraft in an interval management pair. Identified hazards demonstrated the potential impact to the controller's ability to detect and resolve spacing issues when aircraft are actively managing the interval spacing behind another aircraft.

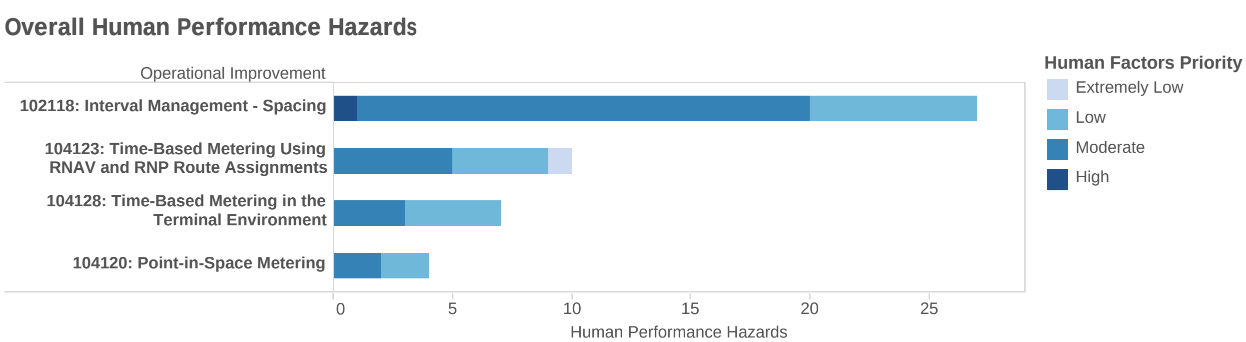

Figure 2. Overall Human Performance Hazards

Impacted Controller Tasks. The controller tasks associated with introducing a hazard (Hazard Task) and the tasks associated with mitigating each hazard (Outcome Task) were also identified for each of the 48 hazards. Impacted hazard tasks for TBFM OIs are included in Figure 3. Results indicated that the majority of identified hazards were introduced, not through controller tasks, but by actions initiated either by automation or by the actions of the flight crew. Of the impacted controller tasks, most hazards related to the controller developing and managing traffic flows and sequences. Many of these hazards relate to the controller interpreting the information provided by the automation to develop and implement a traffic flow.

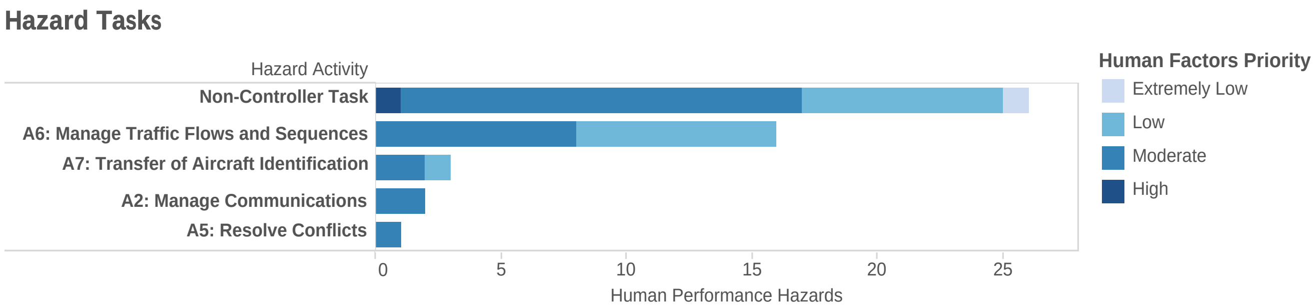

Figure 3. Identified Hazard Tasks for TBFM OIs

The outcome tasks associated with resolving or recovering from each human performance hazard are shown in Figure 4. While many of the hazards were initiated by non-controller tasks, 44 of the 48 hazards will require controller actions to resolve or recover from the impact of the hazard task. Many of the potential hazards will require controllers to resolve traffic flow.

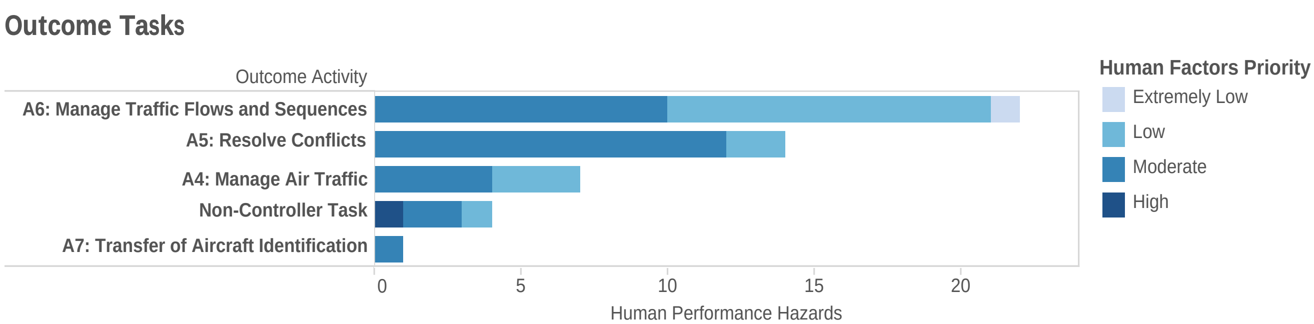

Figure 4. Identified Outcome Tasks for TBFM OIs

Inter-Actor Relationships. A comparison of hazard actor to outcome actor is shown in Figure 5. Breaking down the relationships between the hazard actor and outcome actor provides an overview of the critical human-system interactions necessary to support the implementation of these planned changes. As previously identified, the majority of hazards potentially introduced with these hazards will require the controller to mitigate. En route and TRACON controllers will be responsible for resolving the majority of the identified automation hazards. As many of these OIs propose additional automation tools to support scheduling and sequencing, system designers will need to ensure controllers are provided the necessary information to recover from hazards once they occur. Designers should ensure controllers consistently have access to the information needed to update their traffic flows for cases where automation has provided an adequate sequence.

A second key finding of this assessment revolved around the impact of flight crew actions on the en route controller's ability to implement TBFM concepts. As the flight crew begins playing a more active role in meeting meter times with concepts like interval management, the impact of an error by one flight crew can now impact other aircraft and the controllers monitoring their performance. The potential for vigilance decrements associated with decreasing controller-pilot interactions and reduced controller workload could further increase the consequences of a pilot error.

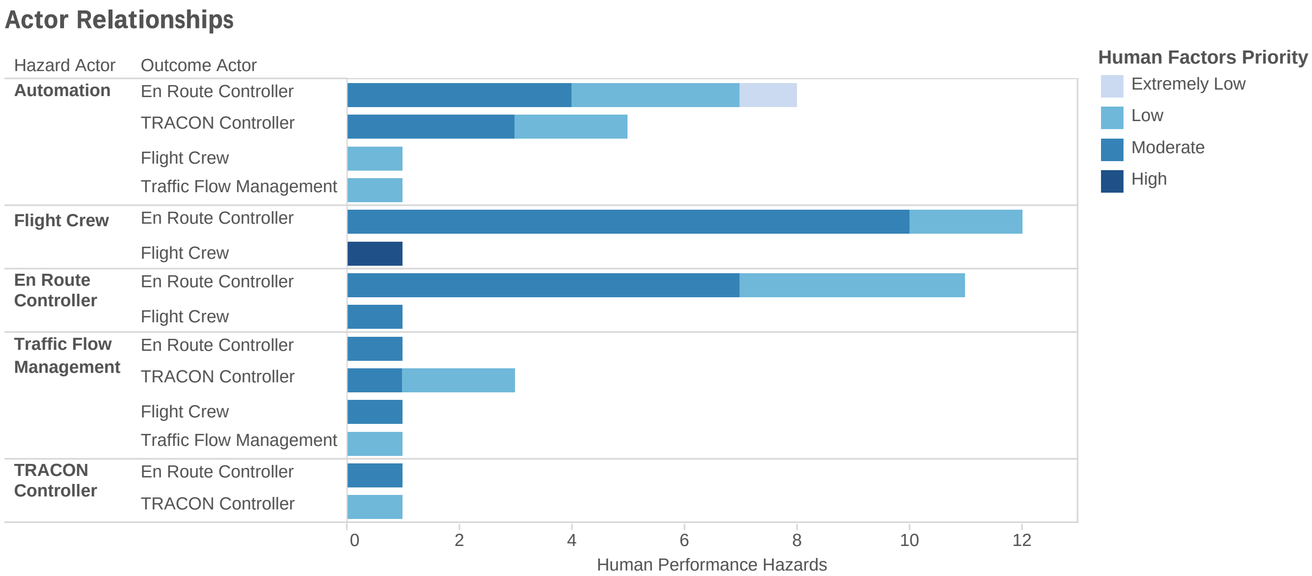

Figure 5. Actor Relationships for TBFM OIs

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