FAA
Human Factors Division (ANG-C1)

Proposed Method for Evaluating the Human Performance Effectiveness of Identified Mitigations in Safety Risk Management Documents or Corrective Action Plans

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This report details the proposed methodology for evaluating the human performance effectiveness of identified mitigations through validating the predicted residual risk levels. The proposed methodology will identify human factors hazards, analyze human factors mitigations, assess the post-mitigation human factors hazards, and determine the effectiveness of the mitigations. A case study of the 2011 handoff risk profile has been proposed as a proof of concept.

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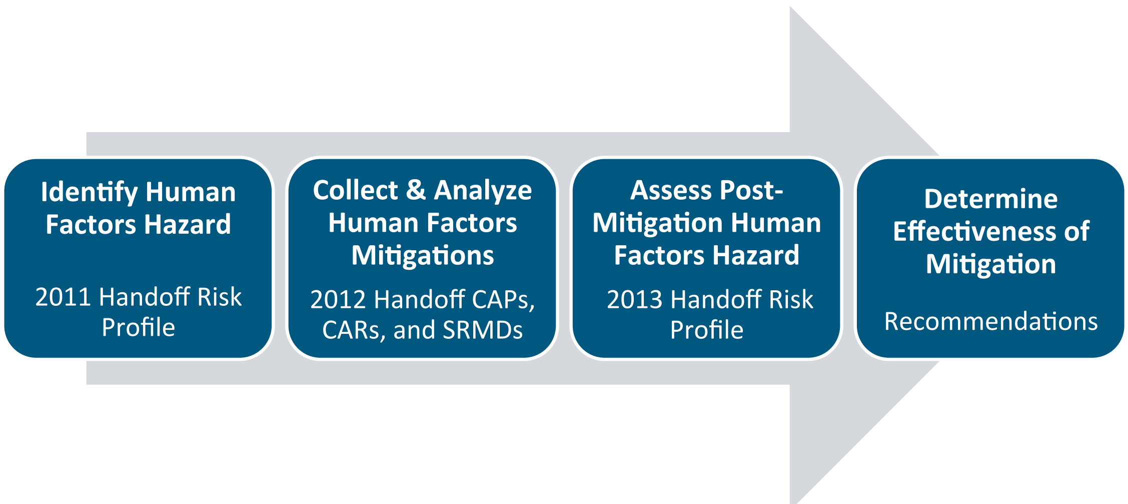
Executive Summary

This report details the proposed methodology for evaluating the human performance effectiveness of identified mitigations through validating the predicted residual risk levels. The proposed methodology will identify human factors hazards, analyze human factors mitigations, assess the post-mitigation human factors hazards, and determine the effectiveness of the mitigations. A case study of the 2011 handoff risk profile has been proposed as a proof of concept.



Based on the application of the proposed methodology, future steps will include developing human factors guidance for incorporation into the FAA's Safety Management Systems and Safety Risk Management process. Building on the results of proposed methodology and human factors principles, the future guidance will aim to assist the Safety Risk Management panel in the Phase 2 of identifying hazards and the Phase 5 of treating the risk. The guidance for the Phase 2 will focus on providing an Safety Risk Management panel user's manual for the Human – Organization Safety Technique of identifying human and system performance hazards. The SRM panel will also be provided with assistance in developing human factors metrics. The guidance for the Phase 5 will focus on providing the SRM panel with best practices for developing human factors mitigations and tracking those mitigations.

List of Acronyms

Acronym	Definition
AirTracs	Air Traffic Analysis and Classification System
ANG-C1	Human Factors Division
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO	Air Traffic Organization
ATSAP	Air Traffic Safety Action Program
CAP	Corrective Action Plan
CAR	Corrective Action Request
FAA	Federal Aviation Administration
HAW	Hazard Analysis Worksheet
HERA	Human Error in ATM
HESRA	Human Error Safety Risk Assessment
HFACS	Human Factors Analysis and Classification System
HOST	Human – Organization Safety Technique
NAS	National Airspace System
PHA	Preliminary Hazard Analysis
SMS	Safety Management System
SRM	Safety Risk Management
SRMD	Safety Risk Management Document
STPA	Systems-Theoretic Process Analysis

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Introduction

As part of the FAA's Safety Management System (SMS)[1], a common framework is provided to the FAA's Air Traffic Organization (ATO) to proactively identify safety hazards and risks associated with the introduction of change into the National Airspace System (NAS) through equipment, operations, and / or procedures. Figure 1 depicts the integrated nature of the ATO's SMS with one of those components being Safety Risk Management (SRM).

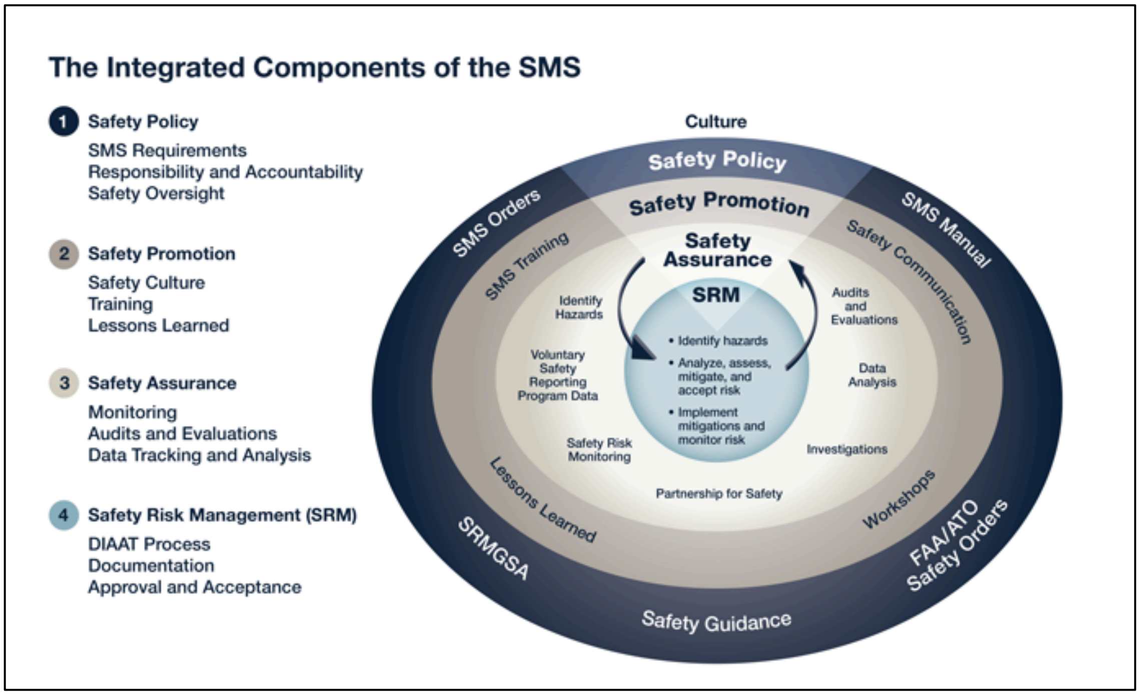

Figure 1: Integrated Components of the SMS (FAA, 2014)

As a key part of SMS, the SRM process aims to proactively identify hazards and risks associated with a proposed change to the NAS, and if warranted, provide mitigations to reduce the risk level associated with identified hazards. The process for identify and mitigating risks through SRM is the DIAAT process, which is shown in Figure 2. The SRM panel creates a Safety Risk Management Document (SRMD) detailing the application of the SRM DIAAT process.

Figure 2: SRM DIAAT Process (FAA, 2014)

Phase 2 of DIAAT is the Phase 2: Identify Hazard phase. While SRM suggests several methods, tools, and techniques for identifying hazards, the main SRM tool for assessing the hazards is the Preliminary

[1] Federal Aviation Administration. (2014). *Safety Management System Manual Version 4.0: Air Traffic Organization 2014*. Retrieved from https://my.faa.gov/org/linebusiness/ato/safety/sms/documents.html

Hazard Analysis (PHA) / Hazard Analysis Worksheet (HAW). The SRM panel is responsible for completing the PHA / HAW during Phase 2 through Phase 5 of the SRM process. The PHA / HAW has the following components for assessing the identified hazards:

- Hazard Name
- Hazard Description
- Cause
- System State
- Existing Controls
- Existing Control Justification
- Effect
- Severity
- Severity Rationale
- Likelihood
- Likelihood Rationale
- Initial Risk
- Safety Requirements
- Organization Responsible for Implementing Safety Requirements
- Predicted Residual Risk
- Safety Performance Targets

Once a hazard is identified, the SRM panel must analyze the risk of the hazard in Phase 3: Analyze Risk by determining the likelihood and severity potentials of the hazard and its effect. In Phase 4: Assess Risk, the severity and likelihood estimates are combined to determine the level of risk for each identified hazard. The SRM panel utilizes the SRM Risk Matrix (Figure 3) to determine the risk level and necessary action.

Likelihood \ Severity	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	Low	Medium	High	High	High
Probable B	Low	Medium	High	High	High
Remote C	Low	Medium	Medium	High	High
Extremely Remote D	Low	Low	Medium	Medium	High
Extremely Improbable E	Low	Low	Low	Medium	High* / Medium

Figure 3: SRM Risk Matrix (FAA, 2014)

In the final phase of the DIAAT process, the SRM panel must address those hazards resulting in a high risk by treating the risk. Additionally, the SRM panel has the option to treat the risk of those hazards resulting in a medium or low risk during this phase. To treat the risk, the SRM panel determines mitigation strategies and safety requirements for reducing the severity of the hazard effect, the likelihood of the hazard occurring, or both. After the mitigation strategies for treating the hazards have been determined, the SRM panel must determine the predicted residual risk for the hazard. The predicted residual risk is an estimate of the risk level that will exist after the safety requirements and mitigations are implemented. For example, if an SRM panel identifies Hazard A and determines Hazard A to be a high risk with a severity of Hazardous (2) and a likelihood of Remote (C). The SRM panel then develops Mitigation Strategy A to treat Hazard A. The SRM panel's mitigations strategy aims to reduce the likelihood of the hazard occurring and leading to the effect. After the implementation of the mitigation strategy, the SRM panel determines the predicted residual risk to be medium with a severity of Hazardous (2) and a likelihood of Extremely Remote (D).

In addition to developing safety requirements to address high risk hazards, the SRM panel must also develop safety performance targets to monitor and measure the predicted residual risk. A monitoring plan must be developed to track the safety performance target to ensure the effectiveness of the safety requirement in mitigating the high risk hazard.

Purpose

The purpose of the overall project is to assess the effectiveness of human factors mitigation strategies implemented through SRM or other similar processes, such as corrective action plans (CARs) or corrective action requests (CARs), by

1) Determining any areas of opportunity for improvement or success stories for human factors hazard identification, mitigation strategy development, and residual risk verification
2) Developing human factors recommendations for SRM human performance hazard identification, safety requirement development, safety target establishment, and residual risk level verification.

As part of the overall project, the purpose of this report is to develop a methodology for completing the first step. To do so, the methodology should evaluate the effectiveness of historical mitigation strategies and residual risk levels to determine their impact on the human factors hazard.

Proposed Methodology for Evaluating the Human Performance Effectiveness of Identified Mitigations in SRMDs or CAPs

The proposed methodology for evaluating the human performance effectiveness of identified mitigations in SRMDs, CAPs, or CARs is outlined in Figure 4. To illustrate the application of the proposed methodology, a case study will be introduced in this report and will follow through the entirety of the project as a proof of concept.

Figure 4: Overview of Proposed Methodology

First, a human factors hazard will be selected to establish a baseline. In this step, a review of a NAS change or improvement will be conducted to identify any potential human performance hazards associated with a change to the NAS. This step will utilize the Human – Organization Safety Technique (HOST), which is an amalgamation of human factors and system safety tools and methodologies for proactively identifying safety risks in complex systems. The HOST process will be explained in the following sections of this report. Building on the HOST process, human factors metrics will be identified to measure the hazard.

For the case study application of the methodology, the handoff process will be examined. In 2012, an analysis was conducted to examine the human factors hazards associated with the handoff process utilizing data from April 2011 – September 2011.[2] The analysis resulted in a 2011 handoff risk profile. The report detailing the assessment can be found in Appendix A. This analysis utilized voluntary safety reports from the air traffic community to identify human and system performance factors in near or actual safety events. To identify and quantify factor relationships, the Air Traffic Analysis and Classification System (AirTracs) was utilized to develop a 2011 Handoff Risk Profile for Human Factors Issues. This risk profile will serve as an initial view of handoff operations. The AirTracs process will be explained in the following sections of this report.

Following the identification of a human factors hazard, any human factors mitigations or safety requirements will be gathered. Mitigations strategies can originate in SRMDs, CAPs, or CARs. FAA databases will be queried to collect any implemented mitigations that address the human factors issue

[2] Berry, K.A., & Sawyer, M. W. (2012). *Human Factors Assessment of ATC Process using ATSAP Reports*. Retrieved 2013 from http://www.hf.faa.gov

identified in the previous step. For the case study application of the methodology, the 2011 handoff risk profile assessment supported a CAR initiated by the Air Traffic Safety Action Program (ATSAP). The CAR can be found in Appendix B. Additional queries will be conducted to identify SRMDs related to handoffs or point-outs resulting in any mitigation strategies deployed from October 2011 – December 2012.

Third, the impact of the mitigations will be assessed to determine their level of effectiveness. For this step, a similar approach to the assessment in step one will be conducted to examine the human factors metrics related to a hazard post-mitigation implementation. For the case study application, handoff related safety reports from April 2013 – September 2013 will be analyzed using the AirTracs taxonomy, and a 2013 handoff risk profile will be established.

Finally, the effectiveness of the mitigation strategies identified in step two will be determined. A statistical analysis will be conducted to compare the human factors metrics for the hazard prior to and following the implementation of any mitigations. Furthermore, recommendations will be developed for identifying human factors hazards, establishing human factors metrics, and developing human factors mitigation strategies. For the case study application, any statistical differences between the 2011 and 2013 risk profiles will be identified, and recommendations will be determined.

Human – Organization Safety Technique

Human error has long been cited as a leading contributor to accidents and incidents across many domains.[3] In many cases, however, the human error that is identified is a direct result of inadequacies in the design of the systems or procedures that provided to the human operator. Even new systems and procedures designed to reduce impact of human error may inadvertently introduce new human error modes by changing the role and responsibilities of the human operator. This is especially true for large-scale changes that include concurrent development of multiple system components. From a risk management perspective, a comprehensive human factors and system safety assessment into these effects is needed to address the potential for both positive and negative impacts on the safety of the overall system.[4] The proactive Human-Organization Safety Technique (HOST) was developed to fill this need.

Building on human factors and systems engineering theories, HOST combines elements from the Human Error Safety Risks Assessment (HESRA)[5] methodology with elements from the Systems Theoretic Process Analysis (STPA)[6] to provide stakeholders with a comprehensive view of potential safety risks. Through the application of HOST, human and system performance hazards and their impacts are identified. Utilizing systems engineering processes and control structure diagrams, the ramifications of those hazards are traced beyond the immediate hazard actor impact to identify other system and actor impacts. HOST provides a structured methodology for assessing and prioritizing human and system performance hazards based on severity, likelihood, and the ability of human actors to detect and recovery from the potential hazard. The resulting prioritized listing of potential human and system performance hazards allows for mitigation strategies to be developed and targeted towards the highest priority hazards. Figure 5 outlines the process steps for the HOST proactive technique.

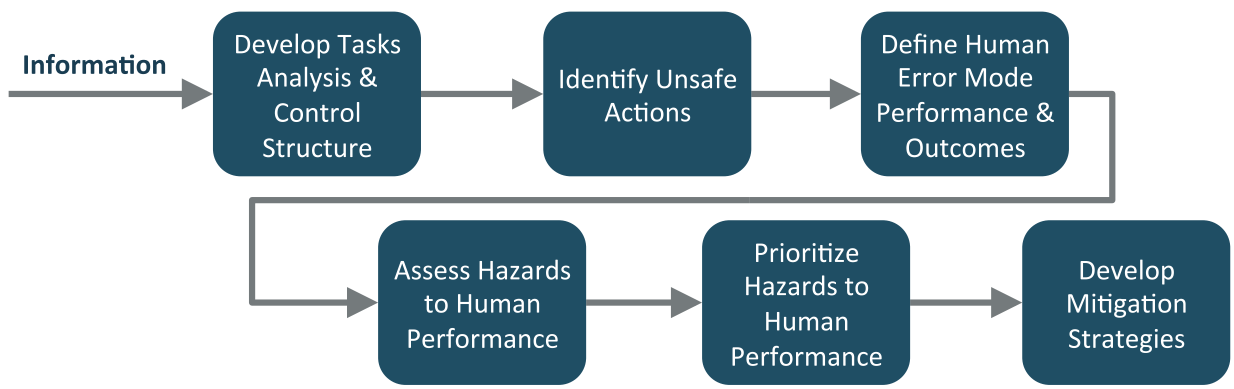

Figure 5: HOST Process Steps

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[3] Wiegmann, D. A., & Shappell, S. A. (2003). *A human error approach to aviation accident analysis: The human factors analysis and classification system*. Burlington, VT: Ashgate Publishing, Ltd.
[4] Berry, K. & Sawyer, M. (2012). Assessing the Impact of NextGen Trajectory Based Operations on Human Performance. In the Proceedings of the *4th Annual Applied Human Factors and Ergonomics Conference*, 2012, San Francisco, CA.
[5] Federal Aviation Administration. (2009). Human Error and Safety Risk Analysis for Federal Aviation Administration Air Traffic Control Maintenance and Operations. Retrieved 2014, from http://www.hf.faa.gov
[6] Leveson, N. G. (2011). *Engineering a Safer World: Systems Thinking Applied to Safety*. Cambridge, Massachusetts: The MIT Press.

The HOST methodology aims to identify, assess, and mitigate risks associated with the implementation of new or existing systems and procedures. The proactive approach will allow for safety professionals to address human and system risks before an accident or incident – or better yet, before a system or procedure has been deployed to the field. The integration of proactive human and organizational performance safety assessments into the earliest stages of the design process will not only reduce industry cost but will also improves system design, development, and implementation.

Air Traffic Analysis and Classification System

Development of an Air Traffic Control (ATC) Human Factors Safety Taxonomy

Over the years, many human factors accident investigation taxonomies have been developed to help identify and classify the causal factors involved in near miss events, incidents, and accidents. These taxonomies exist at many levels of details from generalized taxonomies to domain-specific taxonomies – each with its own benefits and limitations. Generalized taxonomies, such as the Human Factors Analysis and Classification System (HFACS), are easy to understand and allow for trend analysis of broad causal factors, but can be limited in identifying domain-specific mitigation strategies. Domain-specific taxonomies, such as JANUS and Human Error in ATM (HERA), may more accurately describe individual ATC events, but can have too many causal factors to provide a meaningful systemic analysis.

In order to examine the various error pathways and causal factor associations, an expansive, human factors taxonomy is needed to ensure various human performance modes and causal factors can be identified to allow for such a detailed analysis. AirTracs was developed to systemically and thoroughly examine the impact of human performance on air traffic accidents and incidents.[7] In the following sections, the taxonomies serving as the foundation for AirTracs will be discussed, and the details of the AirTracs taxonomy will be examined.

Air Traffic Analysis and Classification System - AirTracs

AirTracs was developed through merging the HFACS and HERA-JANUS taxonomies to accommodate the strengths of each taxonomy while addressing their weaknesses. The framework of the AirTracs causal factor model is based on the Department of Defense HFACS model[8], while the detailed causal factor categories incorporate factors from HERA-JANUS[9]. The AirTracs framework (detailed in Figure 6) promotes the identification of human factors causal trends by allowing factors from the immediate operator context to agency-wide influences to be traced to individual events while still being able to identify human factors patterns and trends. Similar to the HFACS taxonomy, the AirTracs model follows a tiered approach while incorporating the detailed causal factors of HERA-JANUS.

- The first tier, Operator Acts, addresses those causal factors most closely linked to the actual safety event and describes the actions or inactions of the operator. Operator Acts causal factors are classified as Willful Violations or Errors, with Errors being categorized as Sensory, Decision, or Execution.
- The second tier, Operating Context, describes the immediate environment associated with the operator and the safety event. Operating Context causal factors are classified as Controller

[7] Berry, K., Sawyer, M., & Austrian, E. (2012). AirTracs: The Development and Application of an Air Traffic Safety Taxonomy for Trend Analysis. In *Proceedings of International Conference on Interdisciplinary Science for Air Traffic Management* 2012, Daytona Beach, FL

[8] Department of Defense (2005). *DoD HFACS: A Mishap Investigation and Data Analysis Tool*. Retrieved 2014 from http://www.public.navy.mil/navsafecen/Documents/aviation/aeromedical/DoD_hfacs.pdf.

[9] Isaac, A., Shorrock, S.T., Kennedy, R., Kirwan, B., Anderson, H., & Bove, T. (2003). *The Human Error in ATM Technique (HERA-JANUS)*. (EUROCONTROL Doc HRS/HSP-002-REP-03).

Workspace, which is categorized as Physical Environment and Technological Environment; Controller Readiness, which is categorized as Cognitive and Physiological Factors and Knowledge/Experience; and NAS Factors, which is categorized as Airport Conditions, Airspace Conditions, Aircraft Actions, and Coordination and Communication.

- The third tier, Facility Influences, describes the factors related to the actions or inactions of individuals at an ATC facility that have the ability to impact the whole facility or multiple individuals at a facility. Facility Influences causal factors are classified as Supervisory Planning, Supervisory Operations, and TMU.
- The fourth tier, Agency Influence, examines those factors related to the actions or inactions of the Agency (in this case, the FAA) and is classified as Resource Management, Agency Climate, and Operational Process.
- The fifth tier, Outside Influence, describes the factors related to the actions or inactions of non-FAA actors or organizations (e.g., airlines, military) that directly or indirectly impact the FAA agency, facility, or ATC operations and is classified as Organizational Influences, Supervisory Influences, and Operational Influences.

Table 1 defines the four AirTracs tiers and the supporting causal factors for each tier.

Table 1: AirTracs Causal Factor Descriptions

Operator Actions
Sensory Acts: Occur when a controller's sensory input is degraded and a plan of action is determined based upon faulty information.
Factors: Auditory Perception, Visual Perception, Temporal Perception
Decision Acts: Occur when a controller's behaviors or actions proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation.
Factors: Alert Comprehension, Knowledge / Planning, Prioritization, Tool / Equipment
Execution Error: Occur when a controller's execution of a routine, highly practiced task relating to procedure, training, or proficiency result in an unsafe a situation.
Factors: Attention Act, Communication Act, Inadvertent Operation, Controller Technique
Willful Violation: The actions of the operators that represent a willful and knowing disregard for the rules and regulations. Willful Violations are deliberate.
Factors: Willful Violation
Operating Context
Physical Environment: The operational and ambient environment of the controller's immediate workspace.
Factors: Workstation / Work Area, Lighting, Noise Interference, Vision Restricted
Technological Environment: The workspace automation factors and includes a variety of design and automation issues, including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors, and automation.
Factors: Communication Equipment, Display / Interface, Software / Automation, Warnings / Alerts, Data Block, Flight Progress Strips, Field Equipment
Airport Conditions: The environmental and design conditions of the airport involved in the event.
Factors: Combined Positions, Ground Vehicle Traffic, Aircraft Traffic, Airport Weather, Signage / Lighting / Ground Markings, Construction, Layout / Design, Runway Conditions
Airspace Conditions: The physical or design conditions of the airspace involved.

Factors: Combined Sectors, Combined Positions, Sector Traffic, Sector Weather / Turbulence, Sector Design
Aircraft Actions: The actions or inactions of the aircraft involved in the event that lead to an unsafe situation.
Factors: Deviation, Unexpected Aircraft Performance, Aircraft Equipment / System Operation, Responding to Abnormal Situation, Go Around, Flight Planning, TCAS RA Response
Coordination and Communication: The teamwork factors of coordination and communication involved with the preparation and execution of a plan that result in an unsafe situation.
Factors: Controller-Controller Communication, Controller-Flight Deck Communication
Cognitive and Physiological Factors: Cognitive or mental conditions and the physiological or physical factors that result in an unsafe situation.
Factors: Distraction, Workload, Complacency / Vigilance, Automation Reliance, Expectation Bias, Fatigue
Knowledge/Experience: The experience or knowledge level a controller has for a task, procedure, or policy that result in an unsafe situation.
Factors: On-the-Job Training / Developmental, Trainer Intervention, CPC Experience, Unfamiliar Task / Procedure
Facility Influence
Supervisory Planning: The planning and preparation of operations conducted by facility management that result in an unsafe situation.
Factors: Facility Procedures, Staffing, Equipment Readiness, Training
Supervisory Operations: The day-to-day operations and tasks conducted by facility management that result in an unsafe situation.
Factors: Sector Combination, Position Combination, Controller Assignment, Oversight / Assistance, Sector / Airport Configuration, Supervisory Coordination
Traffic Management Unit: The operations of the traffic management unit and its impact on the controller that result in an unsafe situation.
Factors: Weather Response, Special Use Airspace, Traffic Management Initiatives, Traffic Regulation / Delivery
Agency Influence
Resource Management: The organizational-level decision-making regarding the allocation and maintenance of organizational assets that result in an unsafe situation.
Factors: Equipment / Facility Resources, Human Resources
Agency Climate: The organizational variables including environment, structure, policies, and culture that result in an unsafe situation.
Factors: Culture, Policy
Operational Process: The organizational process including operations, procedures, operational risk management and oversight that result in an unsafe situation.
Factors: Operations / Procedures, Oversight, Response to Event / Report
Outside Influence
Organizational Influence: the actions or inactions of non-FAA actors or organizations (e.g., airlines, military) that directly or indirectly impact the FAA agency, facility, or ATC operations
Factors: Airline Influences, Military Influences, Contract Towers, Other ANSPS, Other Influences

For each factor identified in Table 1, the classification level has been determined to identify the factors association with the outcome of the safety event. The classification levels are causal, contributory, observed, or positive with definitions of each found in Table 2.

Table 2: Factor Classification Definitions

Classification	Factor Definition
Causal	An immediate/direct factor that identifies an active error or failure of critical components of equipment, systems, or human error. *Causative: If "A" occurs, then "B" will occur.*
Contributory	An underlying/root factor that identifies latent errors or failures related to human performance, operating environment, task procedures, training, supervision, or policy that influence the presence of causal factors. *Probabilistic: If "A" occurs, then the probability of "B" occurring increases.*
Observed	A factor that is present but the associated impact of the factor on the safety event has not been proven. It is recorded to note its potential influence on the event or actors involved and to be incorporated into trend analysis.
Positive	A factor that positively contributed to the safety of an event. This can include factors or actions that contributed to the detection of or recovery from an adverse outcome.

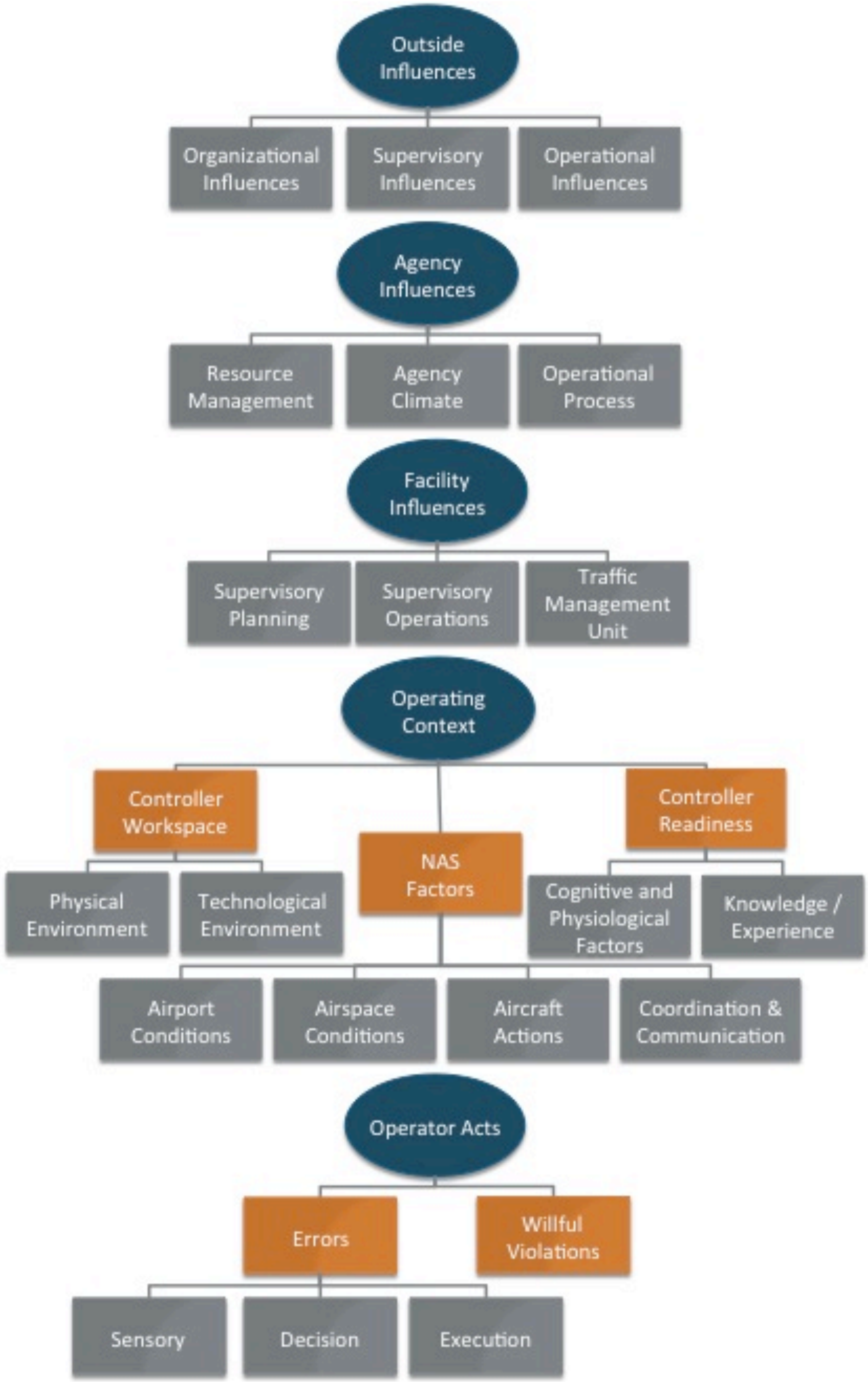

Figure 6: The Air Traffic Analysis and Classification System - AirTracs

Conclusion

This report details the proposed methodology for evaluating the human performance effectiveness of identified mitigations in SRMDs, CAPs, and CARs. The proposed methodology will identify human factors hazards, analyze human factors mitigations, assess the post-mitigation human factors hazards, and determine the effectiveness of the mitigations. A case study of the 2011 handoff risk profile has been proposed as a proof of concept.

Based on the application of the proposed methodology, future steps will include developing guidance for assisting the SRM panel in the Phase 2 of identifying hazards and the Phase 5 of treating the risk (Figure 7). The guidance for the Phase 2 will focus on providing an SRM panel user's manual for the HOST technique of identifying human and system performance hazards. The SRM panel will also be provided with assistance in developing human factors metrics. The guidance for the Phase 5 will focus on providing the SRM panel with best practices for developing human factors mitigations and tracking those mitigations.

Figure 7: SRM Areas of Focus for Human Factors Guidance

Appendix A: Results of the 2011 Handoff Risk Profile Assessment

FAA
Human Factors Division (ANG-C1)

Human Factors Assessment of ATC Handoff Process using ATSAP Reports

Version No 3.0

FINAL REPORT

Report Date: May 2012

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EXECUTIVE SUMMARY

In a 2011 Briefing Sheet, the ATSAP office highlighted the handoff process as a prominent causal factor in ATC incident reports. Members of the FAA's Human Factors Division (ANG-C1) identified the need to assess the potential human factors implications of the current issues of the handoff process in NextGen operations.

Conducting a human factors safety assessment allows for the causal factors associated with current handoff operations to be identified in a methodical and comprehensive manner. A human factors analysis of 100 ATSAP handoff safety reports was completed utilizing the AirTracs taxonomy. From this assessment, the leading contributing factors to handoff safety events were identified along with detailed patterns and trends. The leading contributing factors and trends are as follows:

ATC Software/Equipment: Automatic Handoff Feature

- Unknowing Inhibition of Automatic Handoff Feature by Controllers
- Auto Handoff Feature Handing Aircraft Off to Incorrect Sector

Controller-Controller Communication

- Inter-facility Communication
- Knowledge/Experience: On-the-Job Training
- Display/Interface Characteristic: Data Block Overlap

Supervisory Influences in Loss of Separation Minima Handoff Events

- Sector/Position Combination

Recommendations and mitigation strategies for each contributing factor and underlying trend were developed and described. The primary recommendation of this assessment targeted the various ways in which the automatic handoff feature can become disabled. The results of this assessment aided the development of a Corrective Action Request (CAR) regarding the automatic handoff feature that was delivered to Technical Training. The CAR identified numerous ways to inhibit the automatic handoff feature and established the need to educate controllers of the automatic handoff feature and the methods for its inhibition. While the CAR aims to address the main issue of discontinuation of the feature, there are still areas for improvement, which this report discusses along with potential NextGen implications to the handoff process.

LIST OF ACRONYMS

Acronym	Definition
AirTracs	Air Traffic Analysis and Classification System
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATSAP	Air Traffic Safety Action Program
AV	Airspace Violation
CAR	Corrective Action Request
DoD	Department of Defense
FAA	Federal Aviation Administration
HFACS	Human Factors Analysis and Classification System
LOS	Loss of Separation Minima
NAS	National Airspace System
OI	Operational Improvement
TRACON	Next Generation Air Transportation System
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control

AirTracs Acronym	Definition
AA	Aircraft Actions
AC	Agency Climate
APC	Airport Conditions
ASC	Airspace Conditions
CC	Communication and Coordination
CPF	Cognitive and Physiological Factor
DE	Decision Error
ExE	Execution Error
KE	Knowledge/Experience
OP	Operational Process
PE	Physical Environment
RM	Resource Management
SO	Supervisory Operations
SP	Supervisory Planning
TE	Technological Environment
TM	Traffic Management
SE	Sensory Error
Vio	Willful Violation

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Introduction

The Air Traffic Safety Action Program (ATSAP) provides controllers an outlet to report safety issues in a non-punitive, anonymous manner. The ATSAP office issues a biweekly briefing sheet that emphasizes trending and current topics within the NAS. In the August 11, 2011 ATSAP Briefing Sheet the handoff process was highlighted due to the handoff causal factor "rising dramatically". The handoff causal factor increased 75% from Quarter 2 FY11 to Quarter 3 FY11. The briefing sheet identified the following as leading contributing factors:

- Expectation Bias
- Sector/Team Coordination
- Misinterpreting Visual or Auditory Information
- Lack of Planning with Other Controllers

In response to the briefing sheet, members of the FAA's Human Factors Division (ANG-C1) identified the need to assess the potential human factors implications of the issues currently present in the handoff process on NextGen operations.

Purpose

The purpose of this assessment is twofold. First, this assessment presents the results of a human factors analysis of safety incidents related to the handoff process in current NAS operations. Conducting this assessment allows for the human factors causal factors to be identified in a methodical manner. The potential impacts of the issues present in current handoff operations are then examined in the context of NextGen operations.

Methodology

In order to identify leading contributing factors in current day handoff operations, a comprehensive methodology for examining human factors issues in incident reports was applied. The Air Traffic Analysis and Classification System – AirTracs – systematically and thoroughly examines the impact of human performance in air traffic safety events. In the following sections, the AirTracs taxonomy will be discussed, and the application of the taxonomy will be described.

Air Traffic Analysis and Classification System

The Air Traffic Analysis and Classification System (AirTracs) was developed by merging the HFACS and HERA-JANUS taxonomies to accentuate the strengths of each taxonomy while addressing their weaknesses (Berry, Sawyer, & Austrian, 2012). The framework of the

AirTracs causal factor model is based on the Department of Defense (DoD) HFACS model (DoD, 2005), while the detailed causal factor categories incorporate factors from HERA-JANUS (Isaac et al., 2003). The AirTracs framework promotes the identification of human factors causal trends by allowing factors from the immediate operator context to agency-wide influences to be traced to individual events while still being able to identify human factors patterns and trends. The AirTracs causal factor model can be found in Figure 1, and the details of the causal factors can be found in Table 1.

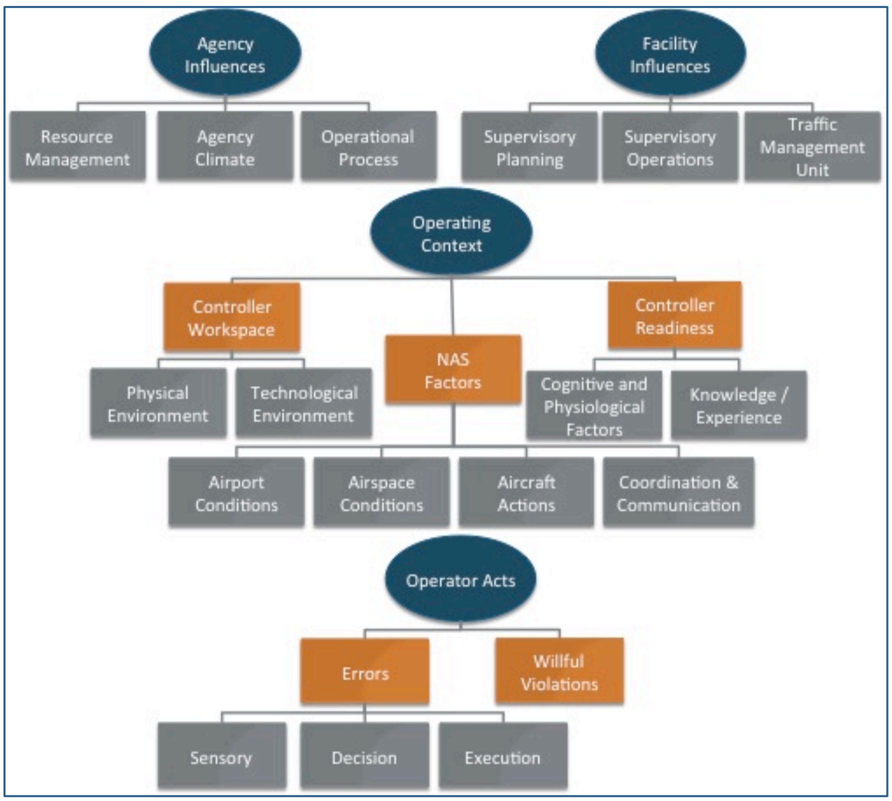

Figure 1: The Air Traffic Analysis and Classification System – AirTracs

The AirTracs model follows a tiered approach. The first tier, Operator Acts, addresses those causal factors most closely linked to the actual safety event and describes the actions or inactions of the operator. Operator Acts causal factors are classified as Sensory Acts, Decision Acts, Execution Acts or Willful Violations. The second tier, Operating Context, describes the immediate environment associated with the operator and the safety event. Operating Context causal factors are classified as Controller Workspace (Physical and Technological Environment), Controller Readiness (Cognitive and Physiological Factors and Knowledge/Experience), or NAS Factors (Airport Conditions, Airspace Conditions, Aircraft Actions, and Coordination and Communication). The third tier, Facility Influences, describes the factors related to the actions or inactions of individuals at an ATC facility that have the ability to impact the whole facility or multiple individuals at a facility. Facility Influences causal factors are classified as Supervisory Planning, Supervisory Operations, or Traffic Management Unit. The fourth tier, Agency Influences, examines those factors related to the actions or inactions of the agency and includes the causal factor categories Resource Management, Agency Climate, and Operational Process.

Table 1: AirTracs Causal Factor Descriptions

Operator Actions
Sensory Acts: Occur when a controller's sensory input is degraded and a plan of action is determined based upon faulty information.
Categories: Auditory Error, Temporal Error, Visual Error
Decision Acts: Occur when a controller's behaviors or actions proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation.
Categories: Alert Error, Knowledge-Based Error, Prioritization Error, Rule-Based Error, Tool/Equipment Error
Execution Error: Occur when a controller's execution of a routine, highly practiced task relating to procedure, training or proficiency result in an unsafe a situation.
Categories: Attention Error, Communication Error, Inadvertent Operation, Memory Error, Procedural/Technique Error
Willful Violation: The actions of the operators that represent a willful and knowing disregard for the rules and regulations. Willful Violations are a deliberate.
Categories: Willful Violation

Operator Context
Physical Environment: The operational and ambient environment of the controller's immediate workspace.
Categories: Ergonomic Issues, Lighting, Noise Interference, Vision Restricted, Workspace Clutter
Technological Environment: The workspace automation factors and includes a variety of design and automation issues, including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors and automation.
Categories: Procedure, Communication Equipment, Display/Interface, Software/Automation, Warnings/Alarms
Airport Conditions: The environmental and design conditions of the airport involved in the event.
Categories: Ground Vehicle Traffic, Aircraft Traffic, Combined Positions, Airport Weather, Signage/Lighting, Construction, Layout/Design
Airspace Conditions: The physical or design conditions of the airspace involved.
Categories: Sector Overload/Traffic, Sector Weather, Turbulence, Sector Design, Combined Sectors, Combined Positions
Aircraft Actions: The actions or inactions of the aircraft involved in the event that lead to an unsafe situation.
Categories: Deviation, Unexpected Aircraft Performance, Equipment/System Malfunction, Responding to Abnormal Situation, Go Around
Coordination and Communication: The teamwork factors of coordination and communication involved with the preparation and execution of a plan that result in an unsafe situation.
Categories: Controller-Controller Communication, Controller-Flight Deck Communication, Coordination

Cognitive and Physiological Factors: Cognitive or mental conditions and the physiological or physical factors that result in an unsafe situation.	
	Categories: Attention, High Workload, Complacency/Boredom, Automation Reliance, Expectation Bias, Fatigue, Medical Illness/Medication
Knowledge/Experience: The experience or knowledge level a controller has for a task, procedure, or policy that result in an unsafe situation.	
	Categories: On-the-Job Training/Developmental, Low Experience CPC, Unfamiliar Task/Procedure

Facility Influences	
Supervisory Planning: The planning and preparation of operations conducted by facility management that result in an unsafe situation.	
	Categories: Procedures/Policy, Staffing, Equipment, Training/Briefing, Planning Violation
Supervisory Operations: The day-to-day operations and tasks conducted by facility management that result in an unsafe situation.	
	Categories: Sector Combination, Position Combination, Sector/Airport Configuration, Controller Assignment, Operational Tempo, Supervisory Coordination, Operational Violation
Traffic Management Unit: The operations of the traffic management unit and their impact on the controller that result in an unsafe situation.	
	Categories: Weather Response, Special Use Airspace, Traffic Management Initiatives

Agency Influences	
Resource Management: The organizational-level decision-making regarding the allocation and maintenance of organizational assets that result in an unsafe situation.	
	Categories: Equipment/Facility Resources, Human Resources, Monetary/Budget
Agency Climate: The organizational variables including environment, structure, policies, and culture that result in an unsafe situation.	
	Categories: Culture, Organizational Structure, Policy
Operational Process: The organizational process including operations, procedures, operational risk management and oversight that result in an unsafe situation.	
	Categories: Operations, Procedures, Oversight

For safety events classified with the AirTracs framework, the presence or absence of each AirTracs causal factor at all four tiers were examined. The AirTracs causal factors are not mutually exclusive, and safety event classifications should include causal factors from all four tiers, when appropriate. For example, an individual safety event can include an Execution Error, a Sensory Error, a Cognitive and Physiological factor, a Supervisory Operations factor, and an Operational Process factor.

Application of AirTracs

The data utilized for this assessment was gathered from the FAA's ATSAP program. ATSAP is a voluntary, non-punitive reporting system for air traffic controllers. For this assessment, ATSAP reports describing handoff incidents from the FY11 Quarter 3 and Quarter 4 time period were queried resulting in 691 narratives. Due to time and resource constraints, this assessment sampled 100 reports for analysis. The 100 reports sample included 73 reports from the ARTCC facilities, 15 reports from TRACON facilities, and 12 reports from combined radar and approach controller tower facilities.

The resulting 100 ATSAP reports were classified with AirTracs utilizing the consensus method, which required a consensus or agreement on the causal factors contributing to the report by a panel. The panel members included human factors, air traffic control, and flight deck experts. Each report was evaluated across all levels of the AirTracs framework, and the presence or absence of each AirTracs causal factor was recorded. It is important to note that the AirTracs categories are not mutually exclusive. For example, an individual report can include both an Execution act and a Decision Error.

Additional Factors

The severity of each report was classified on the following scale: No Event, Near Airspace Violation, Airspace Violation, Near Loss of Separation Minima, or Loss of Separation Minima. Additionally, the primary causal factor pertaining to the handoff procedure issue was classified utilizing the primary causal factors listed in Table 2.

Table 2: Primary Causal Factor

Automation
HOST/Automation Failure: HOST or other similar automation platform fails or malfunctions
Air Traffic Control
Lack of Handoff: Transferring controller fails to handoff aircraft or receiving controller fails to accept handoff
Late Handoff: Transferring controller conducts late/untimely handoff or receiving controller fails to accept handoff in a timely manner
Point Out Failure: Controller conducts inadequate point out of aircraft
Readback/Hearback: Controller experiences a readback/hearback error
Assumed Auto Handoff Accepted: Transferring controller incorrectly assumes the automation will automatically handoff the aircraft
Accepted Handoff Does Not Meet Expectations: Receiving controller accepts handoff that fails to meet controller's expectations
Conducts Inadequate Handoff: Transferring controller conducts inadequate handoff
Handoff Procedure
Procedural Issue: Inadequate procedures for handoff process
Flight Crew
Flight Crew Failure: Failure or inadequate performance by the flight crew

FINDINGS

Findings will be presented and discussed in three sections. First, the key findings from the AirTracs analysis will be presented, and potential mitigation strategies will be discussed. NextGen implications of the key findings will be identified. Additionally, the overall high-level AirTracs results will be outline. Detailed results will be presented in Appendix A.

KEY AIRTRACS CAUSAL FACTOR FINDINGS

From the overall AirTracs analysis (to be discussed in second half of findings section), the leading contributing factors to the current day handoff process are as follows

- ATC Software/Equipment
- Coordination and Communication
- Supervisory Planning
- High Controller Workload
- Airspace Conditions
- Attention
- Expectation Bias

The first three contributing factors will be discussed in more detail.

ATC Software/Equipment

Software/Equipment was classified as a category in the Technological Environment causal factor. The Software/Equipment category identified events where the design or performance of an automation system contributed to the risk level associated with the event. The Software/Equipment causal factor was classified in 16% of the reports with a majority of those reports originating from ARTCC facilities. Table 3 details the systems that controllers reported as being inadequate.

Table 3: ATC Equipment/Software

Type of Software / Equipment	Number of Reports
Auto Handoff Feature	12
Radar	2
HOST	1
Transponder	1

When examining the feature in more detail, two trends emerged and are as follows:

1. **Failure of the auto handoff feature to activate**
   Controllers report the auto handoff feature of HOST would not activate resulting in a near or actual airspace violation. In many cases, the controller would accidently and unknowingly discontinue the auto handoff feature for an aircraft. For example, a transferring controller would have an aircraft in auto handoff mode by flashing the datablock to the next sector. The transferring controller would then have to edit or update the route and would take the datablock back. When the route update was complete, the controller would then rely on auto handoff to initiate handoff of the datablock back to the next sector. However, the handoff would not occur because the auto handoff feature had been disabled. The controller later determined that the auto handoff feature was disabled when he took the initial handoff of the datablock back. Upon further coordination with the ATSAP team, it was determined that there are at least 17 ways for a controller to discontinue the auto handoff feature and many controllers are unaware of those conditions.

2. **Auto handoff feature handing aircraft off to incorrect sector**
   Controllers also reported the auto handoff feature handing aircraft off to the incorrect sector. Controllers determined that if a controller flashes an aircraft immediately after entering the altitude to the aircraft, the handoff might be conducted to the incorrect sector.

Coordination and Communication

The Coordination and Communication causal factor identified when a breakdown in communication or coordination contributed to the risk level associated with an event and was classified in 38% of the reports. Table 4 describes the actors in the coordination and communication reports. Most of the coordination and communication reports involved controller-controller communication, which indicates the handoff process as being susceptible to inadequate controller-controller communication and coordination.

Table 4: Coordination and Communication Actors

Actors Involved	Number of Reports
Controller-Controller	34
Controller-Flight Deck	4

The detailed results of the controller-controller communication factor are provided below in Table 5. The communication was classified into four groups – Position, Sector, Intra-Facility, and Inter-Facility.

Table 5: Controller-Controller Communication Level

Controller-Controller Communication Level	Number of Reports
Position	**3**
Position Relief Briefing	3
Sector	**1**
R Side – D Side	1
Intra-Facility	**17**
TRACON	7
ARTCC	10
Inter-Facility	**13**
TRACON-ARTCC	2
ARTCC-ARTCC	11

A majority of the communication issues were at the intra- and inter-facility level. While there were slightly more intra-facility issues cited, there are also significantly more opportunities for intra-facility communication events. As can be seen in Figure 2, inter-facility communications only occur at the facility boundary sectors (outlined in blue), while intra-facility communications occur among all adjacent sectors within a facility (outlined in green). Many sector boundaries within a facility create many more opportunities for intra-facility communication issues than inter-facility communications. Therefore, the similar number of occurrences of intra- and inter-facility communication issues suggests a disproportional number of communication issues present at the boundary between two facilities. Inter-facility issues should be the subject of further investigation to develop targeted mitigation strategies aimed at reducing the inter-facility communication error rates.

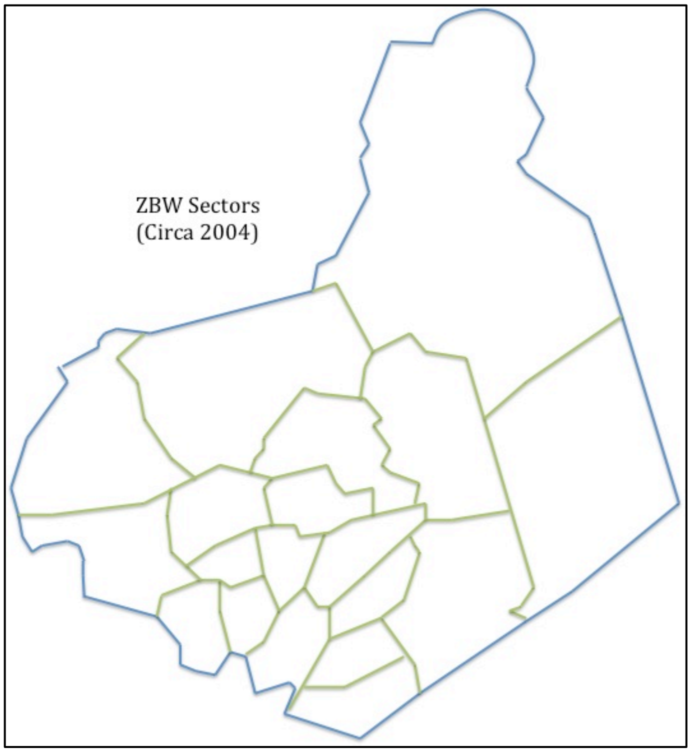

Figure 2: Sample ZBW Low Altitude Sector Map

In examining the risk pathways associated with the communication and coordination causal factors, two AirTracs causal factors were found to be significantly associated with the communication causal factor.

1. **Knowledge/Experience – Communication and Coordination**
   Reports citing a Knowledge/Experience causal factor were 4.1 times more likely to have a Communication causal factor than reports that did not identify a Knowledge/Experience causal factor. For this particular assessment, the Knowledge/Experience causal factor indicated the presence of a trainee or on-the-job training during the event.

2. **Display/Interface Characteristic – Communication and Coordination**
   Reports citing a Display/Interface Characteristic causal factor were 5.5 times more likely to have Communication causal factor than reports that did not identify a Display/Interface Characteristic causal factor. Overlapping data blocks was the primary Display/Interface Characteristic causal factor present in these reports. Overlapping data blocks have previously been reported to account for 20% of all controller entries. While the TRACON workstation has an integrated algorithm available to controllers to automatically offset data blocks, the En Route workstation, where most of this assessment's reports originate, currently lacks this algorithm (Willems & Hah, 2008). However, studies have been conducted on future

en route workstations to demonstrate the effectiveness of this capability (Willems & Hah, 2008; Zingale, Willems, & Ross, 2010).

Loss of Separation Minima

The severity of the outcomes described in the handoff reports was classified in addition to the AirTracs causal factors. Eight of the reports indicated a loss of separation minima (LOS) as a result of an inadequate handoff. While only a small portion of the reports in this assessment, these reports describe a severe outcome and should be examined in more detail. When comparing LOS reports with non-LOS reports, many similarities exist throughout the AirTracs taxonomy, including causal factors at the Agency Influence tier, Operator Context tier, and most of the Operator Acts tier. Disparities between LOS and non-LOS report were identified at the Facility Influences tier and with the Decision Act causal factor. Decision Acts were classified in approximately 20% of non-LOS reports and 50% of LOS reports. This disparity indicates that LOS events are a result of errors in decision-making rather than errors in sensory processing or plan execution.

Additionally, causal factors at the Facility Influences tier were classified in 38% of LOS reports versus 17% of non-LOS reports. These LOS reports indicate that the supervisor plays an important role in the severity of the outcome of events. The leading Facility Influences casual factors in the LOS reports were Inadequate Letters of Agreements, Equipment Maintenance, Sector Combination, and Sector Configuration.

RECOMMENDATIONS

Expanding beyond the overall AirTracs analysis, the leading contributing factors to the current handoff process were examined and are as follows

- ATC Software/Equipment
- Coordination and Communication
- Supervisory Influences in Loss of Separation Minima Handoff Events

Mitigation strategies and recommendations for the handoff process should incorporate the AirTracs findings and the resulting three main contributing factors.

Automatic Handoff Feature

The automatic handoff feature was demonstrated to be a factor in safety events associated with the handoff process. The automatic handoff feature is meant to allow the computer to automatically initiate a handoff when an aircraft is at a preset distance from the sector boundary. This handoff point is designed to be close enough to the boundary that the aircraft has most likely received any necessary control instructions but far enough away to allow the receiving controller to become aware of the handoff and accept it in a timely fashion. The auto handoff feature was designed as a safe guard to prevent operational deviations for those occasions where a controller forgets to hand-off an aircraft. However it was apparent from the reports that some controllers relied on the auto handoff feature as their primary method for initiating handoffs. Issues arose when these controllers unknowingly disabled the automatic handoff feature and the aircraft entered the receiving sector without a formal handoff resulting in an airspace violation.

It is recommended that the automatic handoff feature be examined to identify the ways the automatic handoff feature could potentially become disabled. At the time of this report, the ATSAP office has issued a Corrective Action Request (CAR) to Technical Training. This assessment aided the development of the CAR regarding the automatic handoff feature. The CAR identified 17 ways to inhibit the automatic handoff feature and established the need to educate controllers of the automatic handoff feature and the methods for its inhibition.

Additionally, when an aircraft is in inhibit mode for automatic handoff, the indication of the inhibition to the controller is a carrot character (^) in the aircraft's datablock. However, the indication is too passive for a controller to accurately and easily identify that an aircraft will not automatically handoff. When a controller enters an aircraft into automatic handoff mode, the controller will still monitor the aircraft for separation purposes, but may not monitor the aircraft closely enough to notice the subtle carrot indicator. It is recommended that the way inhibit mode is presented to the controller be examined to ensure controllers can accurately and easily identify when an aircraft is in inhibit mode.

While the CAR aims to address the main issue of discontinuation of the feature, there are still areas for improvement. It is recommended that the instances where the automatic handoff feature is handing aircraft off to the incorrect sector should be examined in more detail to properly identify the technical and human components of the issue. Furthermore, it is recommended to examine the automatic handoff feature in ERAM as well to ensure the same issues do not continue with the transition from HOST to ERAM.

ATC Communication

Communication between controllers was identified as a leading contributing factor in the handoff process and in particular, inter-facility communication was leading communication level. However, the narrative-based ATSAP reports do not permit for researchers to accurately and thoroughly determine the nature of the communication issue. The ATSAP submitters may identify inter-facility communication as an issue, but submitters do not necessarily describe the information being communicated or the details of the communication breakdown. Therefore, it is recommended that addition human factors research be conducted to identify the type of information being miscommunicated and to determine potential mitigation strategies for combatting inter-facility communication breakdowns. Additionally, it is recommended that Letters of Agreements be examined for any potential communication hazards.

This assessment also linked controller-controller communication with on-the-job training and display issues with the data block. The method of training developmentals on the handoff process varies from facility to facility. It is recommended that the various techniques being utilized to train developmentals on the handoff process be identified and a listing of best practices be compiled. This listing of best practices should then be utilized to improve training on the handoff process before on-the-job training of developmentals. The handoff training should incorporate a developmental practicing the handoff procedure in both nominal and operating conditions. For example, developmentals should practice the handoff procedure in adverse conditions, such as but not limited to delayed acceptance by the receiving controller and inadequate automatic handoff feature. Additionally, the handoff training should be expansive by including intra-facility handoffs, inter-facility handoffs, manual handoffs, rejected handoffs, airspace violators, and point outs.

Controller-controller communication was also associated with display/interface characteristics with the data block. It is recommended that data block overlap be examined in more detail to determine the extent of the issue and the outcomes associated with the overlap. Initial studies have identified that 20% of all controller entries in the field are data block movement entries (Willems & Hah, 2008). However, the impact of data block overlap on safety should be examined to determine the outcomes associated with data block overlap. Furthermore, an Automatic Data Block Offset algorithm has been created to move the data blocks automatically to eliminate overlap and deployed in the TRACON domain (Willems & Hah, 2008; Zingale, Willems, & Ross, 2010). The expansion of this algorithm to the en route domain workstations should be examined.

Supervisory Planning

The impact of supervisory planning was evident in the handoff reports resulting in a loss of separation minima. The role of the supervisory is fundamental in the combination and decombination of sectors and positions. It is recommended that focused research should be conducted to identify supervisory best practices for handoff related issues and for sector/position combination and decombination.

NextGen Implications

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 aviation systems and capabilities through operational improvements (OIs) (FAA, 2012). 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.

Automatic Handoffs

As part of the OI 102114: Initial Conflict Resolution Advisories, the automatic handoff feature will be expanded. Currently, the transfer of radar identification can be conducted automatically. With OI 102114, both the transfer and the acceptance of radar identification will be fully automatic without any controller activity, and if the aircraft is data comm equipped, the transfer of communications will also be conducted automatically. The fully automatic handoff procedure may potential eliminate unnecessary tasking from the controller, but may also induce new error modes for the controller and reduce situational awareness. Controllers frequently utilize the handoff acceptance of an aircraft as an opportunity to learn about the aircraft and to include the aircraft into their mental model of the sector traffic. Expanding the automatic handoff feature potentially eliminates this opportunity for essential flight planning and sector traffic planning for the receiving controller. In a recent study conducted at the William J. Hughes Technical Center (Zingale et al., 2010), controllers interacted with a prototype en route workstation that incorporated fully automated handoffs, and one controller identified the following issue with the automatic handoff acceptance feature – "You're not as sure where a/c is located or where he's going (traffic planning)." It is recommended that the automatic acceptance of handoffs be reexamined due to the potential loss of situational awareness and ability to accurately construct a mental model of sector traffic.

OVERALL AIRTRACS RESULTS

The findings from the AirTracs analysis of 100 ATSAP reports can be viewed in Table 6. The percentages in Table 6 do not sum to 100% since reports typically are associated with more than one causal factor. Along with the percentage of reports containing a particular causal factor, the leading sub-category for each causal factor is identified. For example, 60% of reports contain an execution error with the leading execution error being a procedural/technique error.

Table 6: AirTracs Findings

Operator Actions	Percentage of Reports	Leading Category
Execution Error: Occur when a controller's execution of a routine, highly practiced task relating to procedure, training or proficiency result in an unsafe a situation. Categories: Attention Error, Communication Error, Inadvertent Operation, Memory Error, Procedural/Technique Error	60%	Procedural/ Technique Error

Decision Acts: Occur when a controller's behaviors or actions proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation. Categories: Alert Error, Knowledge-Based Error, Prioritization Error, Rule-Based Error, Tool/Equipment Error	24%	Rule-Based Error
General Operator Act: The actions or inactions committed by the operator result in human error or an unsafe situation. In these instances, not enough information regarding the act is known to be able to classify the act.	13%	N/A
Sensory Acts: Occur when a controller's sensory input is degraded and a plan of action is determined based upon faulty information. Categories: Auditory Error, Temporal Error, Visual Error	2%	Auditory Error
Willful Violation: The actions of the operators that represent a willful and knowing disregard for the rules and regulations. Willful Violations are a deliberate. Categories: Willful Violation	0%	N/A
Operator Context	**Percentage of Reports**	**Leading Category**
Cognitive and Physiological Factors: Cognitive or mental conditions and the physiological or physical factors that result in an unsafe situation. Categories: Attention, High Workload, Complacency/Boredom, Automation Reliance, Expectation Bias, Fatigue, Medical Illness/Medication	51%	High Workload
Coordination and Communication: The teamwork factors of coordination and communication involved with the preparation and execution of a plan that result in an unsafe situation. Categories: Controller-Controller Communication, Controller-Flight Deck Communication, Coordination	37%	Controller-Controller
Airspace Conditions: The physical or design conditions of the airspace involved. Categories: Sector Overload/Traffic, Sector Weather, Turbulence, Sector Design, Combined Sectors, Combined Positions	23%	Sector Weather
Technological Environment: The workspace automation factors and includes a variety of design and automation issues, including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors and automation. Categories: Procedure, Communication Equipment, Display/Interface, Software/ Automation, Warnings/ Alarms	23%	Software/ Automation
Knowledge/Experience: The experience or knowledge level a controller has for a task, procedure, or policy that result in an unsafe situation. Categories: On-the-Job Training/Developmental, Low Experience CPC, Unfamiliar Task/Procedure	11%	On-the-Job Training
Aircraft Actions: The actions or inactions of the aircraft involved in the event that lead to an unsafe situation. Categories: Deviation, Unexpected Aircraft Performance, Equipment/System Malfunction, Flight Planning, Responding to Abnormal Situation, Go Around	6%	Unexpected Performance

Airport Conditions: The environmental and design conditions of the airport involved in the event. Categories: Ground Vehicle Traffic, Aircraft Traffic, Combined Positions, Airport Weather, Signage/ Lighting, Construction, Layout/Design	1%	Other
Physical Environment: The operational and ambient environment of the controller's immediate workspace. Categories: Ergonomic Issues, Lighting, Noise Interference, Vision Restricted, Workspace Clutter	0%	N/A

Facility Influences	Percentage of Reports	Leading Category
Supervisory Planning: The planning and preparation of operations conducted by facility management that result in an unsafe situation. Categories: Procedures/Policy, Staffing, Equipment, Training/Briefing, Planning Violation	13%	Procedure/ Policy
Supervisory Operations: The day-to-day operations and tasks conducted by facility management that result in an unsafe situation. Categories: Sector Combination, Position Combination, Sector/Airport Configuration, Controller Assignment, Operational Tempo, Supervisory Coordination, Operational Violation, Facility Safety Culture	9%	Sector Combination
Traffic Management Unit: The operations of the traffic management unit and their impact on the controller that result in an unsafe situation. Categories: Weather Response, Special Use Airspace, Traffic Management Initiatives	5%	Traffic Management Initiatives

Agency Influences	Percentage of Reports	Leading Category
Operational Process: The organizational process including operations, procedures, operational risk management and oversight that result in an unsafe situation. Categories: Operations, Procedures, Oversight	3%	Operations
Agency Climate: The organizational variables including environment, structure, policies, and culture that result in an unsafe situation. Categories: Culture, Organizational Structure, Policy	2%	Culture
Resource Management: The organizational-level decision-making regarding the allocation and maintenance of organizational assets that result in an unsafe situation. Categories: Equipment/Facility Resources, Human Resources, Monetary/Budget	2%	Equipment/ Facility Resources

The findings from the primary causal factor classification can be found in Table 7. Only one primary causal factor could be selected for each report. The leading primary causal factor is Lack of Handoff indicated that a transferring controller failing to handoff an aircraft to a receiving controller.

Table 7: Primary Causal Factor Findings

Automation	Percentage of Reports
HOST/Automation Failure: HOST or other similar automation platform fails or malfunctions	7%
Air Traffic Control	
Lack of Handoff: Transferring controller fails to handoff aircraft or receiving controller fails to accept handoff	24%
Late Handoff: Transferring controller conducts late/untimely handoff or receiving controller fails to accept handoff in a timely manner	15%
Assumed Auto Handoff Accepted: Transferring controller incorrectly assumes the automation will automatically handoff the aircraft	13%
Point Out Failure: Controller conducts inadequate point out of aircraft	12%
Conducts Inadequate Handoff: Transferring controller conducts inadequate handoff	11%
Accepted Handoff Does Not Meet Expectations: Receiving controller accepts handoff that fails to meet controller's expectations	8%
Readback/Hearback: Controller experiences a readback/hearback error	1%
Handoff Procedure	
Procedural Issue: Inadequate procedures for handoff process	5%
Flight Crew	
Flight Crew Failure: Failure or inadequate performance by the flight crew	4%

CONCLUSION

In summary, the FAA's Human Factors Division (ANG-C1) initiated an effort to examine the human factors issues in the current day handoff process. In order to identify key causal factors, a human factors analysis of 100 ATSAP handoff safety reports was conducted utilizing the AirTracs taxonomy. The leading contributing factors and trends are as follows:

ATC Software/Equipment: Automatic Handoff Feature

- Unknowing Inhibition of Automatic Handoff Feature by Controllers
- Auto Handoff Feature Handing Aircraft Off to Incorrect Sector

Controller-Controller Communication

- Inter-facility Communication
- Knowledge/Experience: On-the-Job Training
- Display/Interface Characteristic: Data Block Overlap

Supervisory Influences in Loss of Separation Minima Handoff Events

- Sector/Position Combination

Recommendations and mitigation strategies for each contributing factor and underlying trend were developed and described.

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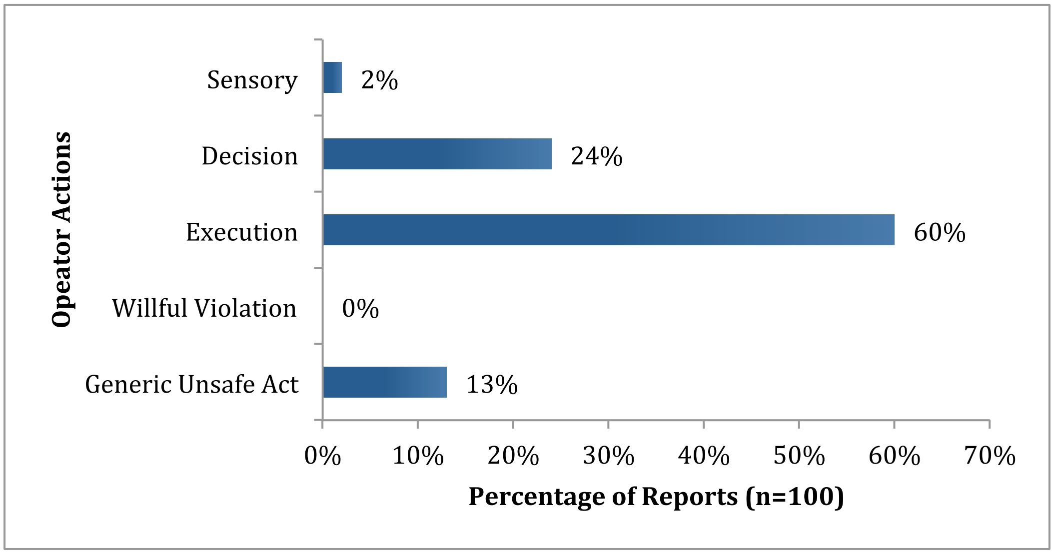
APPENDIX A: OVERALL ATSAP CAUSAL FACTOR RESULTS

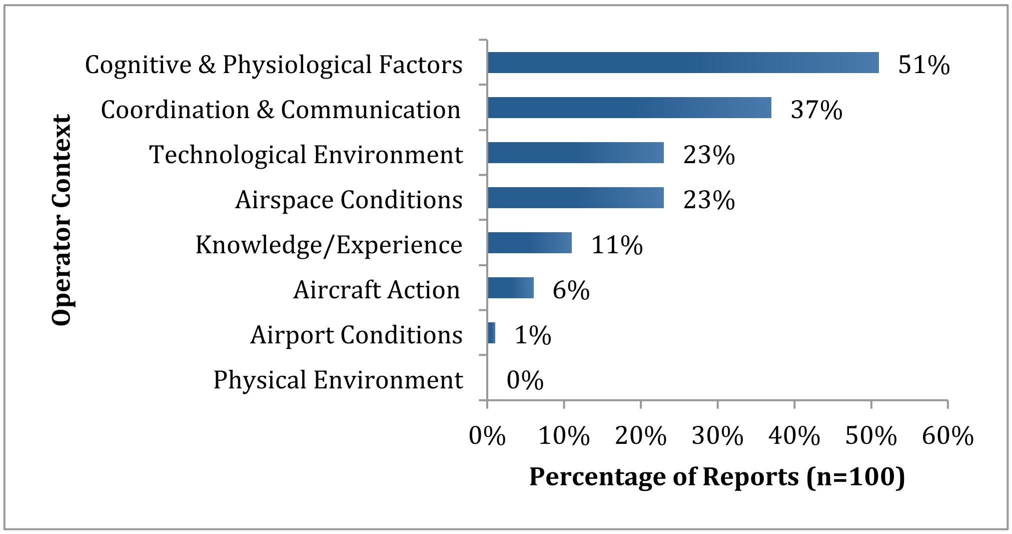
AIRTRACS ANALYSIS

Operator Acts



Operator Acts	Percentage of Reports
Sensory	**2%**
Auditory Error	1%
Temporal Error	1%
Decision	**24%**
Rule-Based Error	11%
Knowledge-Based Error	8%
Prioritization Error	7%
Tool/Equipment Error	1%
Execution	**60%**
Procedural/Technique Error	27%
Attention Error	23%
Memory Error	9%
Inadvertent Operation	7%
Other Execution Error	1%
General Operator Act	**13%**

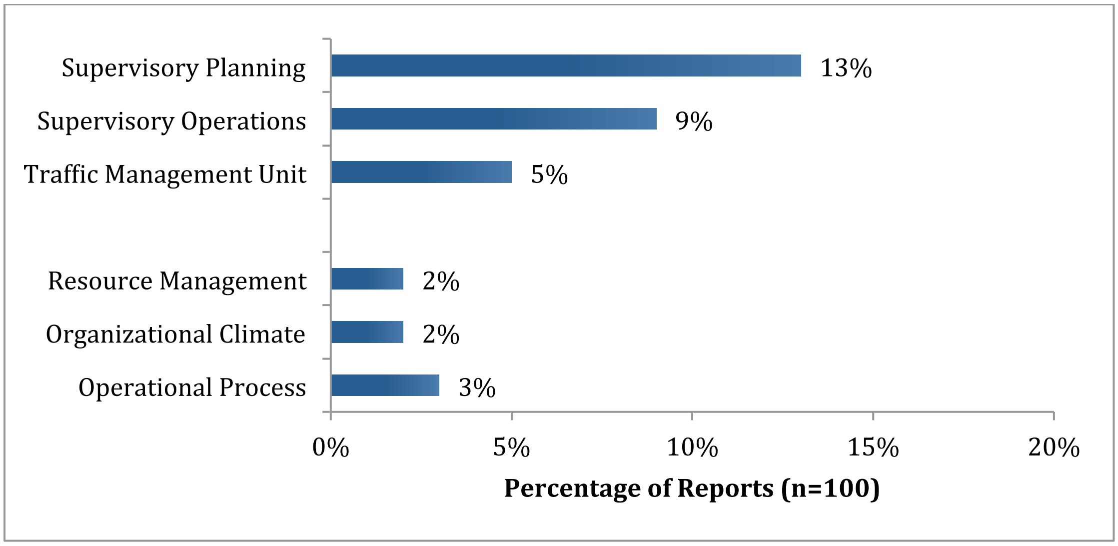
Operator Context



Operator Context	Percentage of Reports
Technological Environment	**23%**
Software/Automation	16%
Display/Interface Characteristics	5%
Communication Equipment	3%
Procedure	1%
Cognitive and Physiological Factors	**51%**
High Workload	24%
Attention	16%
Expectation Bias	12%
Fatigue	2%
Complacency/Boredom	1%
Other Cognitive/ Physiological Factors	1%
Knowledge/ Experience	**11%**
On-the-Job Training/ Developmental	7%
Unfamiliar Task/Procedure	4%

Operator Context	Percentage of Reports
Airport Conditions	**1%**
Other Airport Condition	1%
Airspace Condition	**23%**
Sector Weather	10%
Sector Overload/ Traffic	5%
Combined Sectors	5%
Sector Design	3%
Combined Positions	1%
Aircraft Actions	**6%**
Deviation	2%
Unexpected Performance	4%
Coordination and Communication	**37%**
Controller-Flight Deck	23%
Coordination	11%
Controller-Controller	6%

Facility and Agency Influences



Facility Influences	Percentage of Reports
Supervisory Planning	**13%**
Procedure/Policy	8%
Staffing	3%
Training/Briefing	3%
Supervisory Operations	**9%**
Supervisory Combination	3%
Supervisory Coordination	3%
Sector/Airport Configuration	2%
Position Combination	1%
Traffic Management Unit	**5%**
Traffic Management Initiatives	5%

Agency Influences	Percentage of Reports
Resource Management	**2%**
Equipment/Facility Resource	2%
Agency Climate	**2%**
Culture	2%
Operational Process	**3%**
Operations	2%
Procedures	1%

Facility Analysis

Category	ARTCC	TRACON	Combined
Sensory	3%	-	-
Decision	25%	13%	33%
Execution	60%	60%	58%
Willful Violation	-	-	-
General Operator Act	11%	27%	8%
Physical Environment	-	-	-
Technological Environment	23%	27%	17%
Airport Conditions	-	7%	-
Airspace Conditions	27%	13%	8%
Aircraft Action	5%	13%	-
Coordination & Communication	34%	40%	50%
Cognitive & Physiological Factors	58%	20%	50%
Knowledge/Experience	7%	27%	17%
Supervisory Planning	14%	13%	8%
Supervisory Operations	12%	-	-
Traffic Management Unit	7%	-	-
Resource Management	3%	-	-
Organizational Climate	3%	-	-
Operational Process	1%	-	17%
Total Reports	**73**	**15**	**12**

PRIMARY CAUSAL FACTOR ANALYSIS

Outcome	N	Operator Acts				Operator Context						Facility			Agency		
		SE	DE	EX	UA	TE	ASC	AA	CC	CPF	KE	SP	SO	TM	RM	OC	OP
Automation	**7**	**-**	**1**	**4**	**-**	**6**	**-**	**1**	**1**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**-**
HOST/Automation Failure	7	-	1	4	-	6	-	1	1	3	1	1	-	-	1	-	-
Air Traffic Control	**84**	**2**	**21**	**56**	**11**	**15**	**20**	**2**	**33**	**44**	**10**	**8**	**8**	**4**	**1**	**2**	**2**
Lack of Handoff	24	-	3	19	2	2	5	-	3	11	3	2	3	1	-	-	1
Late Handoff	15	-	6	9	1	2	7	-	6	8	3	1	3	1	-	-	1
Assumed Auto Handoff Accepted	13	-	2	10	1	7	3	-	4	11	-	1	1	-	-	-	-
Point Out Failure	12	-	4	5	3	2	3	-	6	8	1	3	-	2	1	-	-
Conducts Inadequate Handoff	11	1	5	8	-	-	2	1	7	5	1	1	1	-	-	-	-
Accepted Handoff Does Not Meet Expectation	8	-	1	4	4	2	-	1	6	1	2	-	-	-	-	1	-
Readback/Hearback	1	1	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-
Procedure	**5**	**-**	**1**	**-**	**-**	**1**	**2**	**-**	**2**	**2**	**-**	**4**	**1**	**1**	**-**	**-**	**-**
Handoff Procedure	5	-	1	-	-	1	2	-	2	2	-	4	1	1	-	-	-
Flight Crew	**4**	**-**	**1**	**-**	**2**	**1**	**1**	**3**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
Flight Crew	4	-	1	-	2	1	1	3	1	2	-	-	-	-	-	-	1

SEVERITY ANALYSIS

Category	No Event	Near Airspace Violation	Airspace Violation	Near Loss of Separation	Loss of Separation	Total
Sensory Error	-	-	1	-	1	**2**
Decision Error	3	5	10	2	4	**24**
Execution Error	5	10	35	6	4	**60**
General Unsafe Act	2	2	4	3	2	**13**
Technological Environment	4	3	12	3	1	**23**
Airport Conditions	-	-	1	-	-	**1**
Airspace Condition	2	3	13	2	3	**23**
Aircraft Action	-	-	3	2	1	**6**
Communication & Coordination	9	3	16	5	4	**37**
Cognitive & Physiological	5	11	31	2	2	**51**
Knowledge / Experience	1	3	4	1	2	**11**
Supervisory Planning	4	3	5	-	1	**13**
Supervisory Operations	1	-	6	-	2	**9**
Traffic Management Unit	1	1	2	1	-	**5**
Resource Management	-	2	-	-	-	**2**
Organizational Climate	1	-	1	-	-	**2**
Operational Process	1	-	2	-	-	**3**
Total Reports	**17**	**18**	**49**	**8**	**8**	

Appendix B: Results of the 2011 Handoff Risk Profile Assessment

FAA

Corrective Action Request 2011 – 026:
Auto Handoff

ATSAP Corrective Action Request

Air Traffic Safety Action Program

CAR ID: CAR-2011-026 Auto Handoff					
Assigned Service Unit:	AJS	**Issue date:**	12/21/2011	**Respond by:**	1/26/2012

Your Service Unit is responsible for correcting the safety issues identified by the Event Review Committee (ERC) and must comply with the ATSAP MOU, which states: "The FAA will work with NATCA to develop appropriate changes for systemic issues." Coordination between representatives from each of the parties at the level of the organization responding to this request is necessary in an attempt to resolve these issues and will expedite the closure of this CAR with the ERC.

Section 1: ERC Identified Safety Issue(s)

Based on information submitted through ATSAP and after a complete review of the data, the ERC finds: (Ensure that safety concerns are supported by data)

The transfer of radar identification is a core requirement of ATC operations. The HOST auto-handoff functionality is a tool that was envisioned to assist air traffic controllers in meeting the requirements of FAA Order JO 7110.65 Chapter 2 and Chapter 5, and the SOP procedures. The number of reports received by ATSAP indicates that a lack of understanding of auto-handoff functionality is making this process more ambiguous.

In researching this issue, ATSAP first made initial contact with En Route and Oceanic Services (AJE) Second-Level Engineering at the William J. Hughes Technical Center (WJHTC) in Atlantic City to obtain the technical description of the auto-handoff functionality and dependent parameters.

Review of the information provided indicated very complex software functionality, with numerous parameters that impacted either the availability or withholding of the auto-handoff functionality. For example, the availability of auto-handoff functionality is dependent on things such as the altitude displayed in the full-datablock, the status of DATACOM messages in the queue, user-defined inhibition, etc. A copy of the e-mails on the NAS MD's is attached for reference.

Anecdotal information, as well as ATSAP Safety Reports, also indicated that some observed behaviors might not be consistent with the functionality described in the NAS MD documents. An ATSAP analyst, who maintains operational currency at the Fort Worth ARTCC, captured several instances that may have indicated behaviors other than anticipated from auto-hand-off. The Fort Worth ARTCC facility automation support team (FAST) and Quality Control Offices reviewed these instances and provided replays and technical feedback to describe what we were seeing.

Finally, the ERC requested to review the qualification training materials associated with the auto-hand-off functionality. The provided training materials appeared to confuse the request with auto-acquisition functionality. Thinking there might have been confusion on our request we requested clarification. We were assured that the search of training materials was done on both auto-handoff as well as auto-acquisition. The ERC concluded that based on this information the training of the auto-handoff functionality is only accomplished through the OJT process. Based on the reports received we do not feel this to be an adequate training methodology for the accomplishment of a critical ATC procedure.

ATSAP Corrective Action Request

Copies of the NAS MD documents, ZFW Analysis, E-Mail with Training, and provided training materials are attached.

1a. ATSAP Report Summary

The ATSAP Program has received many reports from en route facilities indicating potential issues associated with the HOST “Auto-Handoff” (AHI) functionality. These reports indicated that air traffic control specialists:

a. Do not understand the parameters behind the Auto-Handoff functionality. This includes reasons that the QA functionality is either enabled/disabled.
b. Over-relied on the Auto-Handoff functionality to complete the requirements contained in FAA Order JO 7110.65 paragraph 2-1-14
c. Do not understand the auto-handoff functionality during the combining/decombining of airspace.
d. Do not understand associated behaviors when inhibiting auto-handoff functionality.

These reports indicate that the auto-handoff functionality is adding latent safety risk to the National Airspace System (NAS) because controllers are not aware of the parameters and behaviors of this functionality.

These reports describe conditions in which the identity of aircraft is lost, or the logical systemic functioning of the NAS is degraded. As a result aircraft may not receive the intended level of separation and safety alert services or encroach on adjacent airspace, including SAA airspace containing hazards to non-participating aircraft.

1b. ERC Recommendations (if applicable/needed)

1) Develop and administer refresher training on hand-off requirements and auto-handoff functionality.

2) Incorporate training on the auto-handoff (AHI) functionality into AJL developed lesson plans and testing materials for Stage III/IV of the En Route Qualification Training Program.

3) Ensure that adequate training has been developed to convey changes to auto-handoff functionality under the ERAM program.

Section 2: Action Plan Submission

***Note: Recipient – Complete section 2a-2g and return to the ATSAP CAR Coordinator**.*

Instructions: Submit a Corrective Action Plan to the ATSAP ERC that includes:

- The identified root cause of this issue
- Any planned interim corrective action and implementation date
- The planned final corrective actions and implementation date
- The planned completion date of all actions

If the Service Unit and the Bargaining Unit agree on the proposed Corrective Action Plan, only one response is needed. In the event that the parties do not agree, two responses may be submitted along with both representatives' signature under the response.

2a. Root Cause of the Identified Safety Issue

The party responsible for providing an explanation of what is causing this problem fills out this area by explaining the root cause. ROOT CAUSE ONLY PLEASE!

Historically, training on the auto-handoff function has been accomplished during on-the-job training; however, FAA Order 3120.4 and Academy lesson plans contain little (if any) formal training requirements concerning auto-handoff functionality.

2b. Interim Corrective Action

The party responsible for correcting the problem fills out this area to explain any interim actions necessary to temporarily mitigate the risk, while formulating and implementing a permanent solution.

Part 1: Enroute Training Requirements, AJI-232, in collaboration with the NATCA Training Representative, will submit an AJI Training Request Form no later than July 15, 2012, to start development on national courseware (such as eLMS) to deliver an auto-handoff overview. AJI-232 has already contacted Enroute Technical Requirements, AJE-36, to obtain a briefing from the Tech Center about auto handoff functionality and programming.

Part 2: The Parties are already seeking to add or improve any existing training content or requirements in Academy courses, field training stages, or FAA Order 3120.4 Instructional Program Guide (IPG) to address auto-handoff functionality. The AJI-212 (Development Team) manager is already aware of CAR 2011-026 and has offered to work with Academy to make lesson plan changes as needed.

2c. Interim Corrective Action Implementation Date

The party responsible for correcting the problem fills out this area with the expected implementation date of the proposed interim action.

Part 1: Submission of an AJI Training Request Form does not automatically result in immediate training development, as all such requests are prioritized by AJI for funding. If the scope of the project is such that it can be handled using existing staff, this may expedite development and delivery. Target date for field delivery of an eLMs course, Powerpoint presentation, or other training product, is September 1, 2012.

Part 2: Canvass/review of existing lesson plans and IPG is expected to be complete by September 1, 2012. Target is to implement needed content no later than November 1, 2012.

2d. Planned Final Corrective Action

The party responsible for correcting the problem fills out a detailed action plan to correct the identified issue.

Goal is to provide a continuously-updated eLMS course or similar product to provide enroute controllers basic information on auto-handoff functionality. Additionally, the Enroute Stage 1 course will feature auto handoff training. Auto-handoff may also be required lesson content in Enroute Stages 2-4, as appropriate.

2e. Estimated Final Corrective Implementation Date:

The party responsible for correcting the problem fills out this area with the expected implementation date of the proposed permanent action.

AJI-232 and the NATCA Training Representative will work to ensure all corrective actions are fulfilled by November 1, 2012.

2f. Responding for the Service Unit

Name: ***Bob Whitworth, Manager, Enroute Training Requirements, AJI-232***

Date: ***6/28/12***

2g. Responding for the Bargaining Unit

The NATCA representative with whom the correction action plan was coordinated indicates agreement or reasons for not agreeing.

Name: ***Tom Adcock, NATCA National Training Representative***

Date: ***06/28/12***

Section 3: ERC Review

Action: Return this form to the ATSAP Coordinator for submission to the ERC for Concurrence or Non Concurrence as to whether the proposed corrective action addresses the safety concerns raised by the ERC. *In the case of Non Concurrence, an explanation of why the proposal did not receive concurrence by the ERC will be provided to the party responsible for correction. The facility and/or Service Unit will have the option to submit a revised corrective action plan. Failure of the organization to correct an ERC-identified systemic safety issue in a manner satisfactory to all members of the ERC may result in referral of the matter for appropriate action*

ERC Concur ☒

ERC Non-Concur ☐

Reasons for Non-Concurrence

ERC Chairperson Signature: ***Ken Myers*** **Date:** ***8/28/2012***

NOTE: *Fill the section below ONLY if the response submitted was Non-Concurred by the ERC.*

3a. Response to Non-Concurrence with Revised Action Plan

If modification of the corrective action plan is made, the facility or organization must notify the ERC prior to implementation of the modification.

Revised Plan

ATSAP Corrective Action Request

3a1. Responding for the Service Unit

Name: Date:

3a2. Responding for the Bargaining Unit

The NATCA representative with whom the correction action plan was coordinated indicates agreement or reasons for not agreeing.

Name: Date:

3a3. ERC Review of REVISED Action Plan

ERC Concur ☐

ERC Non-Concur ☐

Reasons for Non-Concurrence

ERC Chairperson Signature: **Date:**

3b. Response to Non-Concurrence without Revised Action Plan

In the event that the responsible Service Unit declines to provide an amended Corrective Action Plan in response to a non-concurrence, the responsible VP will sign.

Reasons for no action:

Signature:

Name: Date:

Section 4: Corrective Action Implementation

Action: *Recipient completes this area of the form after correction of all identified issues has been completed.*

Implementation Date:

Comments:

4a. Responding for the Service Unit

Name: Date:

ATSAP Corrective Action Request

4b. Responding for the Bargaining Unit

Name: Date:

Section 5: Corrective Action Follow-Up

This section is used to verify the corrective action plan has been executed effectively.

5a. Verification of Implementation

This section is used to verify the effectiveness of corrective action(s) and to offer feedback on strengths or weakness identified after implementation.

5b. Re-verification of Implementation:

This section is used to follow up on any weakness identified in initial verification if initial corrective action was rejected.

Comments:

Section 6: Closure Statement

This section to be completed by the ERC.

Statement of Acceptance

(Rationale and conditions for final acceptance or rejection of corrective action):

This indicates all mitigations are complete and acceptable then signs and dates below indicating that the facility is finished with the CAR.

Name: Date:

CAR-2011-026 (AJI-CSA) Auto Handoff Implementation-Pending/Overdue

Issued on: 2/24/12 **Concurred on:** 8/28/12

Issue: ATSAP reports indicate potential issues associated with the HOST "Auto-Handoff" (AHI) functionality. These reports indicate that the auto-handoff functionality is adding latent safety risk to the National Airspace System (NAS) because controllers are not aware of the parameters and behaviors of this functionality.

Supporting documentation: ATSAP Reports, ERAM Lab Procedures and SOP, Initial En Route (training material).

ERC Safety Identified Issues: Air traffic control specialists: (a) do not understand the parameters behind the Auto-Handoff functionality -this includes reasons that the QA functionality is either enabled/disabled, (b) over-relied on the Auto-Handoff functionality to complete the requirements contained in FAA Order JO 7110.65 paragraph 2-1-14, (c)do not understand the auto-handoff functionality during the combining/decombining of airspace, (d) do not understand associated behaviors when inhibiting auto-handoff functionality. In instances where the identity of aircraft is lost, or the logical systemic functioning of the NAS is degraded, aircraft may not receive the intended level of separation and safety alert services or encroach on adjacent airspace, including SAA airspace containing hazards to non-participating aircraft.

Resolution: Enroute Training Requirements, AJI-232, in collaboration with NATCA, develop national courseware to deliver an auto-handoff overview. The parties are already seeking to add or improve any existing training content or requirements in Academy courses, field training stages, or FAA Order 3120.4 Instructional Program Guide (IPG) to address auto-handoff functionality. The AJI-212 (Development Team) manager is already aware of CAR and has offered to work with Academy to make lesson plan changes as needed.

POC: Bob Whitworth, Constance Mack

NATCA POC: Tom Adcock

Update: [1/28/14]: Currently Climb/Descend Via project and recurrent training have become the main projects. SU is currently pulling all resources to make sure these project's deadlines are met.