ANG-C1 Review of HF Activities

Sept 2015 – February 2016

HF REDAC Emerging Areas

1. **System Information Management**
2. **Automation/Autonomy Roles and Responsibilities**
3. **Integration of UAS/RPAS into the NAS**
4. **Dealing with Mixed Equipage Operations in the Design and Evolution of the NAS**
5. **Human Machine Design, Integration, and Certification**
6. **Workforce Selection, Training, and Proficiency**

ANG-C1 Response

- **Map each emerging area to current research programs**
- **Provide status update for these programs**
- **Identify recent R&D successes**

System Information Management

Focus areas: Information automation and management, information requirements

ANG-C1 Activities

Flight Deck

- Flight Deck Task Management
- Complexity: Definitions, Empirical Findings and Recommendations for Training and Design

Air Traffic

- NextGen Alarms and Alerts Management
- Common Information Requirements
- Process Development for NextGen Flight Data Presentation/Management

Automation/Autonomy Roles and Responsibilities

Focus areas: Human-automation system design

<u>ANG-C1 Activities</u>

Flight Deck

- Flight path management
  - Cognitive and manual skill loss
  - Manual handling
  - Comprehensive document on air carrier procedures and training
- Human Factors for Advance Autopilots & Automation Technologies in GA airplanes

Air Traffic

- NextGen Human-System Resiliency

UAS/Remotely Piloted Aircraft System (RPAS)

Focus area: Integration of UAS/RPAS in the NAS

ANG-C1 Activities

Flight Deck

- UAS Enroute Contingency Operations
- Human Factors Considerations of Unmanned Aircraft Systems (Detect and Avoid)
- Human Factors Considerations of Unmanned Aircraft Systems (UAS) – control station design and visual observer

Air Traffic

- N/A

Dealing with Mixed Equipage Operations

Focus Area: Examine mixed equipage as NextGen advances are phased in

ANG-C1 Activities

Flight Deck

- Data Communications – message set
- TCAS Study – TA only with ADS-B traffic

Air Traffic

- N/A

Human Machine Design, Integration, and Certification

Focus area: Emerging technologies

ANG-C1 Activities

Flight Deck

- LVO/SMGCS
- Advanced Vision (EFVS, CVS, SVS, HUD, HMD)
- Electronic Displays Task Management
- Research on tactile displays and controls
- Advanced Controls (tactile, eye/gaze, touch)
- 3D Displays
- Human Factors R&D for Improved Rotorcraft Operational Safety
- Angle of Attack indication
- Electronic Flight Bag
- CDTI/Airport Moving Map
- General Guidance Document

Human Machine Design, Integration, and Certification Cont.

Focus area: Emerging technologies

ANG-C1 Activities

Air Trafffic

- Display of Time-Based Information for ATC
- NextGen Display of NOTAMs for ATC
- NextGen TechOps Safety Assessment and System-Level Guidance (Planned)

Workforce Selection, Training, and Proficiency

Focus area: Skills, aptitude, and traits for the NextGen workforce

ANG-C1 Activities

Flight Deck

- Design of Standard Procedures
- Performance-based ATP
- Fatigue Mitigation in Flight Operations
- Identify and assess state of the art CRM approaches
- Maintenance Risk Management
- Human Factors R&D for Improved Rotorcraft Operational Safety

Air Traffic

- NextGen TFM Tool Assessment
- NextGen Mid-Term Controllers Strategic Job Analysis
- NextGen Mid-Term TechOps Strategic Job and Training Needs Analysis

Other Project Areas

<u>ANG-C1 Activities</u>

Flight Deck

- Instrument Procedures
  - Briefing Strips for Arrivals and Departures
  - Subjective Complexity

Air Traffic

- HF in AMS: HF Guidance for Service Analysis and Concepts and Requirements Definition
- HF in NAS EA: Human Systems Integration Roadmap
- Safety: NextGen Segment Bravo Human Error Condition and Mitigation
- PBN: Performance Based Navigation Procedure Guidebook

Recent Success: Flight Deck

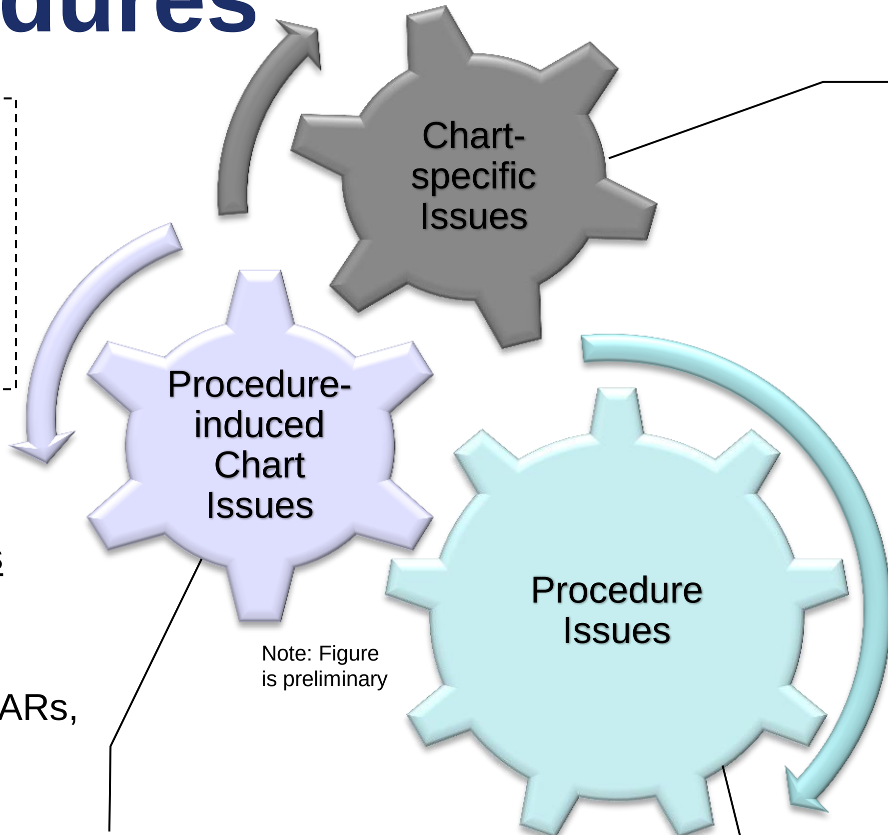
INSTRUMENT PROCEDURES

Description: Instrument Procedures

- **Purpose**
  - Provide data to FAA to identify issues and to develop human factors guidelines for the design and depiction of instrument flight procedures (IFPs) and associated aeronautical charts
  - Address future hazards and risks by considering a variety of aircraft types, operators, and aircraft equipment (e.g., VNAV)
  - Help the FAA consider flightcrew issues early in the design of new IFPs to smooth their operational implementation

Accomplishments: Instrument Procedures

Operational Complexity
- ATC interventions
- Aircraft equipment or performance
- Crew factors
- Operator factors
- Environment factors



Note: Figure is preliminary

- Arrangement of data
- Placement of sections
- Placement of elements within sections
- Depiction Inconsistencies
- Custom notes

Cross-cutting Issues
- Visual density
- Inconsistencies between SIDs, STARs, and IAPs

- Ambiguity
- Route variability
- Number of transitions
- Holds (if flown)
- Waypoint names
- Number and content of notes
- Vectors
- Restricted airspace
- Constraints
- Problem connections

- Visually noncontiguous paths
- Depiction of variability, transitions, holds, constraints, notes, restricted airspace
- Non-standard layouts

Outcomes: Instrument Procedures

- **Contributions to recommendations from Performance Based Operations Aviation Rulemaking Committee (PARC) subgroups**
  - VNAV Action Team recommendations on design of Optimal Profile Descents.
  - PBN Procedure Naming and Charting Action Team recommendations.
  - Pilot-Controller Procedures Systems Integration Working Group recommendations in development.
- **Goal to brief Metroplex procedure design teams on subjective complexity framework.**

Recent Success: Flight Deck

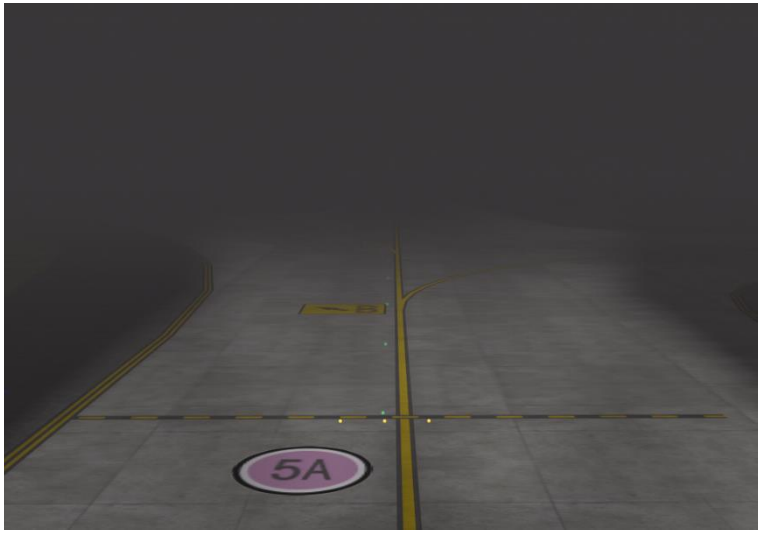
LVO/SMGCS

Description: LVO/SMGCS

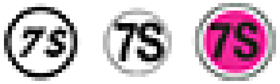
- **Purpose**
  - Provide data to the FAA to support the development of recommendations for the design of LVO/SMGCS charts and Level 3 operations (less than 300 ft RVR)

Accomplishments: LVO/SMGCS

- Evaluated the usability of LVO/SMGCS charts in simulated 300 ft RVR
  - Established that pilots can safely taxi in 300 ft RVR without losing position awareness



Pilot's out-the-window view in the simulator at RVR 300 ft

Information Type	Symbol Shapes
GPM	
ILS hold line	
Combination of RGL *and* stop bar lights	

- Identified "representative" LVO/SMGCS symbol set

Outcomes: LVO/SMGCS

- Provided to recommendations for LVO/SMGCS chart design
- Provide data to FAA to support joint FAA/ICAO effort to develop recommendations for LVO/SMGCS chart symbology

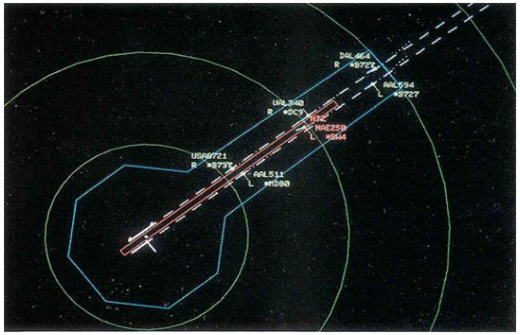
Recent Success: Air Traffic

COMMON INFORMATION REQUIREMENTS (CIR)

Description: CIR

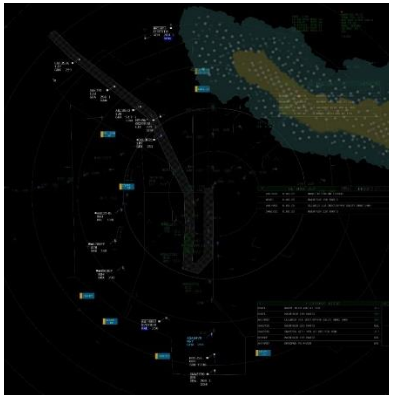
- **Purpose**
  - Provide guidance on the design and potential implementation of a common set of functions, information elements, user interfaces, and interactions across Air Route Traffic Control Center (ARTCC) and Terminal Radar Approach Control (TRACON) controller workstations

Final Monitoring Aid



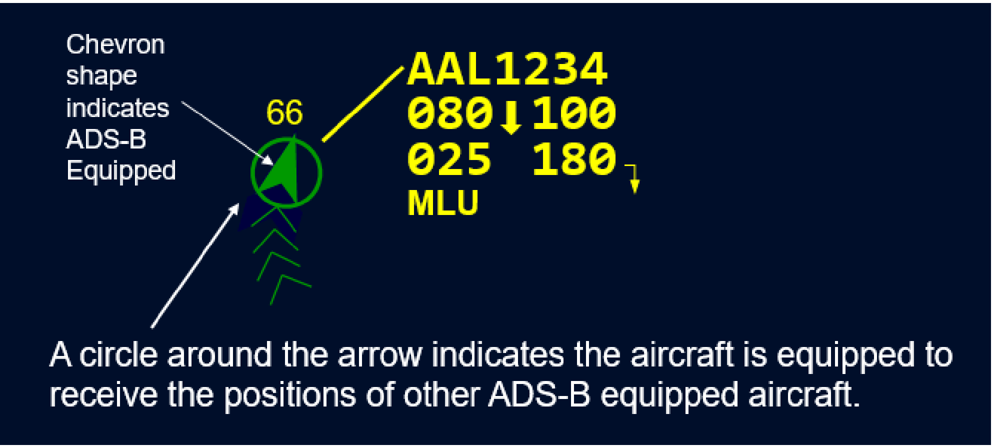
ATPA

Adv Wx Info



Accomplishments: CIR

- A final walkthrough session was organized in Houston on 10 and 11 February
  - Data was collected with input from controllers from En-Route and TRACON facilities originating from Houston ARTCC and TRACON



- Data is analyzed and results will be integrated to complete the CIR report

Outcomes: CIR

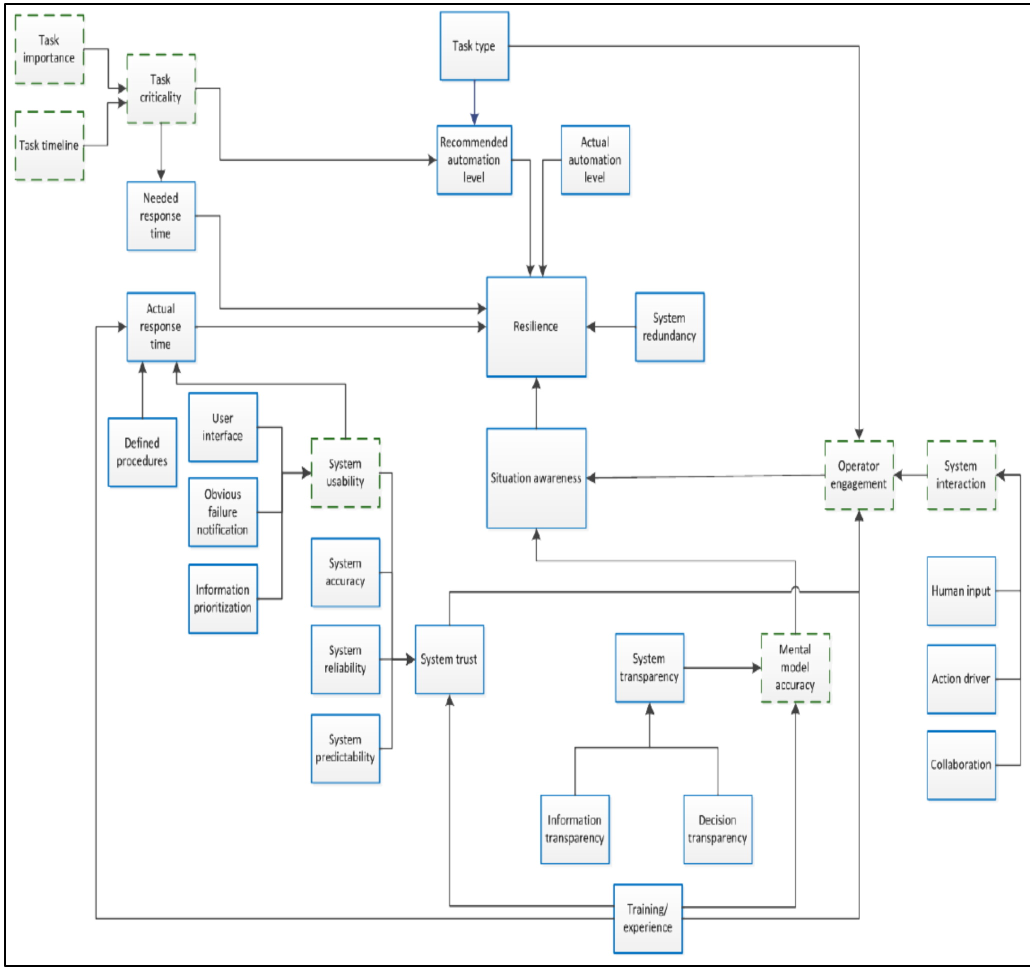
- Controllers have a better understanding of tools used across domains which may enhance common understanding of tasks and improve coordination activities between En-Route and Terminal for Trafiic Flow efficiency gains
- Systems designers will use the functional commonality assessments to predict the kinds of overarching changes that will need to be ultimately implemented, and use the human factors analysis to inform the design process.
- Program managers will use the analysis to inform the rollout plan.

Recent Success: Air Traffic

HUMAN-SYSTEM RESILIENCY

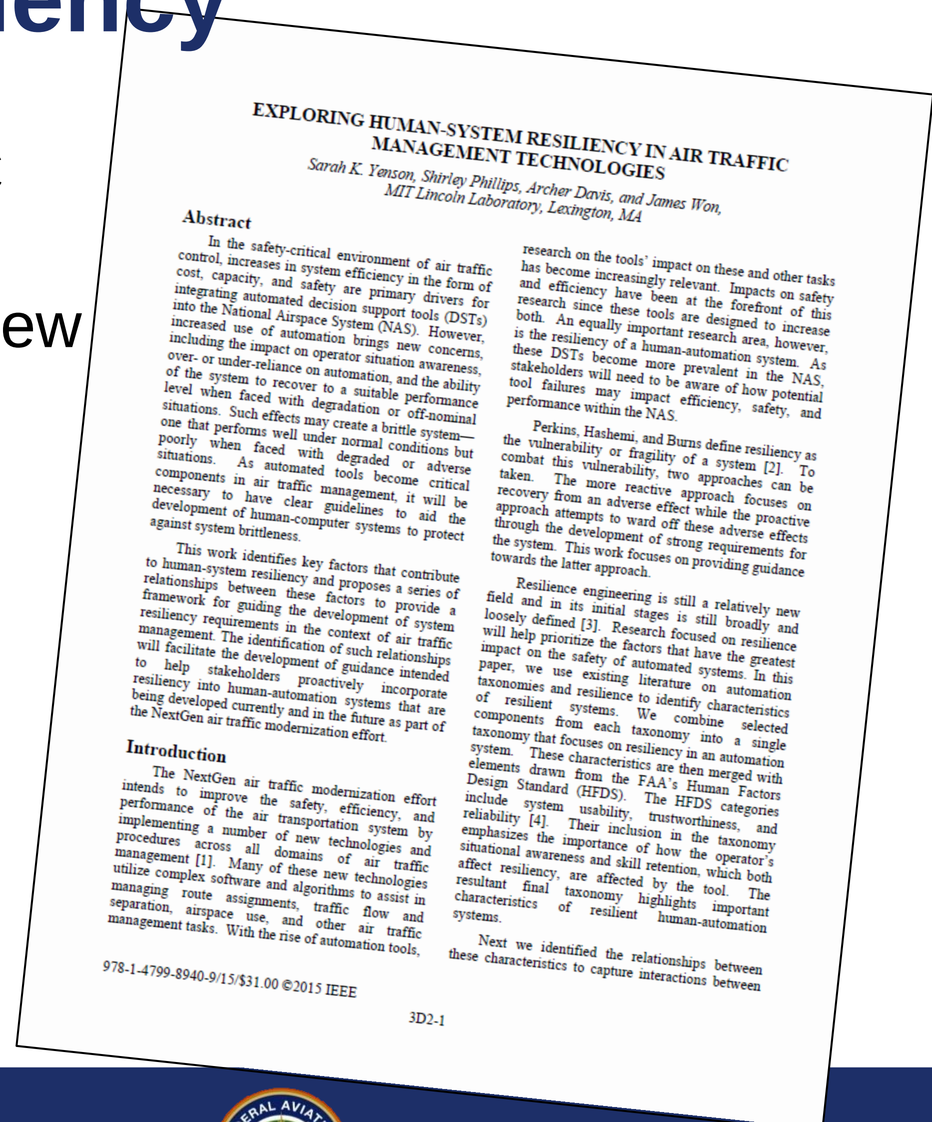
Description: Human-System Resiliency

- **Purpose**
  - This project examines how NextGen system and capabilities may correlate to negatively impacting controller performance by introducing weaknesses in the overall system resulting in a more “brittle” (fragile or more sensitive to unplanned events) NAS



Accomplishments: Human-System Resiliency

- Published paper in 34th DASC 2015, received NextGen DST catalog, targeted literature review on levels of automation and resiliency, system resiliency evaluation criteria and metrics definition.



EXPLORING HUMAN-SYSTEM RESILIENCY IN AIR TRAFFIC MANAGEMENT TECHNOLOGIES

Sarah K. Yenson, Shirley Phillips, Archer Davis, and James Won,
MIT Lincoln Laboratory, Lexington, MA

Abstract

In the safety-critical environment of air traffic control, increases in system efficiency in the form of cost, capacity, and safety are primary drivers for integrating automated decision support tools (DSTs) into the National Airspace System (NAS). However, increased use of automation brings new concerns, including the impact on operator situation awareness, over- or under-reliance on automation, and the ability of the system to recover to a suitable performance level when faced with degradation or off-nominal situations. Such effects may create a brittle system—one that performs well under normal conditions but poorly when faced with degraded or adverse situations. As automated tools become critical components in air traffic management, it will be necessary to have clear guidelines to aid the development of human-computer systems to protect against system brittleness.

This work identifies key factors that contribute to human-system resiliency and proposes a series of relationships between these factors to provide a framework for guiding the development of system resiliency requirements in the context of air traffic management. The identification of such relationships will facilitate the development of guidance intended to help stakeholders proactively incorporate resiliency into human-automation systems that are being developed currently and in the future as part of the NextGen air traffic modernization effort.

Introduction

The NextGen air traffic modernization effort intends to improve the safety, efficiency, and performance of the air transportation system by implementing a number of new technologies and procedures across all domains of air traffic management [1]. Many of these new technologies utilize complex software and algorithms to assist in managing route assignments, traffic flow and separation, airspace use, and other air traffic management tasks. With the rise of automation tools, research on the tools' impact on these and other tasks has become increasingly relevant. Impacts on safety and efficiency have been at the forefront of this research since these tools are designed to increase both. An equally important research area, however, is the resiliency of a human-automation system. As these DSTs become more prevalent in the NAS, stakeholders will need to be aware of how potential tool failures may impact efficiency, safety, and performance within the NAS.

Perkins, Hashemi, and Burns define resiliency as the vulnerability or fragility of a system [2]. To combat this vulnerability, two approaches can be taken. The more reactive approach focuses on recovery from an adverse effect while the proactive approach attempts to ward off these adverse effects through the development of strong requirements for the system. This work focuses on providing guidance towards the latter approach.

Resilience engineering is still a relatively new field and in its initial stages is still broadly and loosely defined [3]. Research focused on resilience will help prioritize the factors that have the greatest impact on the safety of automated systems. In this paper, we use existing literature on automation taxonomies and resilience to identify characteristics of resilient systems. We combine selected components from each taxonomy into a single taxonomy that focuses on resiliency in an automation system. These characteristics are then merged with elements drawn from the FAA's Human Factors Design Standard (HFDS). The HFDS categories include system usability, trustworthiness, and reliability [4]. Their inclusion in the taxonomy emphasizes the importance of how the operator's situational awareness and skill retention, which both affect resiliency, are affected by the tool. The resultant final taxonomy highlights important characteristics of resilient human-automation systems.

Next we identified the relationships between these characteristics to capture interactions between

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Outcomes: Human-System Resiliency

- This project will assist NextGen system engineers in considering the context of existing tasks, procedures, and systems, recovery procedures, and other tools as new automation and DSTs are developed. Most importantly, this project will provide NextGen system engineers information about automated systems and DSTs with guidance that will help them build safe, reliable, and resilient systems.