PROSPECTIVE IDENTIFICATION OF NEXTGEN FLIGHT DECK HUMAN FACTORS ISSUES[1]

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The Human-Machine Systems Engineering Methodology (HMSEM) is a systematic method to prospectively identify relevant human fallibilities, potential errors, and general human factors issues in a complex, high-risk system, then develop design recommendations for remediations to counteract the fallibilities, avoid or mitigate the errors, and therefore resolve the issues. HMSEM uses IDEF0 functional modeling, task analysis, human fallibilities analysis, and Failure Modes and Effects Analysis, organizing the information for and from the analyses in a workbook. The results of its application to several tasks on the NextGen flight deck suggest that it can be a valuable complement to other means to anticipate and resolve human factors issues in NextGen development. The Appendix contains the complete results of the analysis.

The problem of human performance in complex, high risk systems was described concisely, accurately, and usefully by Wiener in the phrase, "fallible humans and vulnerable systems" (Wiener, 1987). Human beings are innately fallible, being subject, for example, to variable sensory thresholds, perceptual illusions, a narrow scope of attention, cognitive biases, and limited physical strength, speed, and accuracy. Engineered systems often possess characteristics that make them vulnerable to difficulties and mishaps triggered by their fallible human operators, including inscrutable displays, distracting environments, complex decision making situations, and awkward, cumbersome, difficult-to-operate tools and controls. Too often, the interactions of human fallibilities with system vulnerabilities manifest themselves as human errors that spoil the effectiveness and efficiency of the systems, damage property, and injure or kill people. Human error accounts for the majority of aircraft accidents (e.g., Boeing, 2008) and in the US alone, 100,000 may die annually due to errors by medical personnel (Kohn et al, 2000). The great challenges to human factors scientists and engineers are to understand human fallibilities and to find (or, better, anticipate) and correct system vulnerabilities to minimize the occurrence and impact of human error.

The Next Generation air transportation system (NextGen) threatens to be a system highly vulnerable to the errors of its fallible human operators unless these challenges are met in advance. From the documentation available at this time (e.g., JPDO, 2007a, 2007b), NextGen appears to be a technology-driven system, not a human-centered system, and we know from past experience that technology-driven systems can be particularly vulnerable to human error (e.g., Wiener, 1987, 1989; Billings, 1996; Funk et al, 1999). Already, some NextGen human factors issues have been identified. For example, studies of the human factors of Automatic Dependent Surveillance – Broadcast (ADS-B), a core NextGen technology, point to the potential distraction from critical aircraft control tasks caused by compelling traffic displays on the flight deck (Williams et al, 2002; MITRE, 2006). Sheridan et al (2006a, 2006b) surveyed aviation human factors experts and found, among others, concerns about the process of NextGen flight plan negotiation, plan representation, and the ability of flight crews to detect and deal with NextGen automation failures. Funk, Mauro, and Barshi (2009) reviewed the small but growing NextGen human factors literature and conducted preliminary analyses themselves to identify and organize a large list of issues.

These early efforts start to raise NextGen human factors issues and thereby begin the prospective identification and correction of NextGen system vulnerabilities to human error, but much remains to be done. The aviation human factors/psychology community can make a valuable contribution to the development and implementation of NextGen through the thorough and systematic identification of human factors issues, but those issues must be identified, organized, and presented in such a way as to be understandable by and useful to NextGen system architects and engineers. Given the timetable proposed by the Federal Aviation Administration for NextGen development and implementation, the community must move quickly. Methods and tools are needed soon.

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Funk, K., "A Methodology and Tools for the Prospective Identification of NextGen Human Factors Issues," *Proceedings of the 15th International Symposium on Aviation Psychology*, Dayton, OH, April 27 – 30, 2009, 106-111.

Objectives

The first objective of this project was to develop and test a systematic, analytical methodology to prospectively identify human factors issues, organize them by system functions, and from them present preliminary recommendations to inform and guide system development. The second objective was to apply the methodology to the NextGen flight deck.

Human-Machine Systems Engineering Methodology, Tools, and Application to NextGen

The Human-Machine Systems Engineering Methodology (HMSEM) is a formal, systematic methodology to identify important human fallibilities relevant to a system, identify specific errors likely to arise from the interactions of those fallibilities with characteristics of the system, identify general human factors issues arising from the potential errors, develop remediations to counteract the fallibilities, reduce the likelihood of the errors, and resolve the issues, and organize the findings in a way useful to analysts, Subject Matter Experts (SMEs), system architects, and system engineers. HMSEM includes the following stages:

1. Formal functional modeling using IDEF0
2. Task Analysis
3. Human Fallibilities Identification
4. Failure Modes and Effects Analysis
5. Issue Identification
6. Requirements Development

The following tools, most of them presently in prototype form, are used in HMSEM.

- KBSI, Inc.'s AI0Win, for IDEF0 modeling
- IDEF0 Navigator (INav) to facilitate use of complex IDEF0 models (a prototype)
- The Human Fallibilities Identification and Remediation Database (a prototype)
- an OpenOffice.org Calc HMSEM Workbook

These tools and HMSEM were applied, as a test case, to the NextGen flight deck. HMSEM, the tools, and the application are described and discussed in the remainder of this paper.

IDEF0 Modeling

Many human factors methodologies begin with some form of hierarchical task analysis (HTA, Kirwan & Ainsworth, 1992), but HMSEM requires a richer and more detailed representation of system processes (activities, functions, tasks) than HTA typically provides. This requirement is met by modeling the system with IDEF0, a graphical language for modeling system functions (NIST, 1993). The Oregon NextGen Flight Deck Functional Model (ONFDFM) is an IDEF0 model of a generic NextGen commercial flight deck based on NextGen literature available at this time (see above) and knowledge of present-day commercial flight deck operations. Figure 1 shows ONFDFM's top-level diagram, its most general representation of flight deck functions.

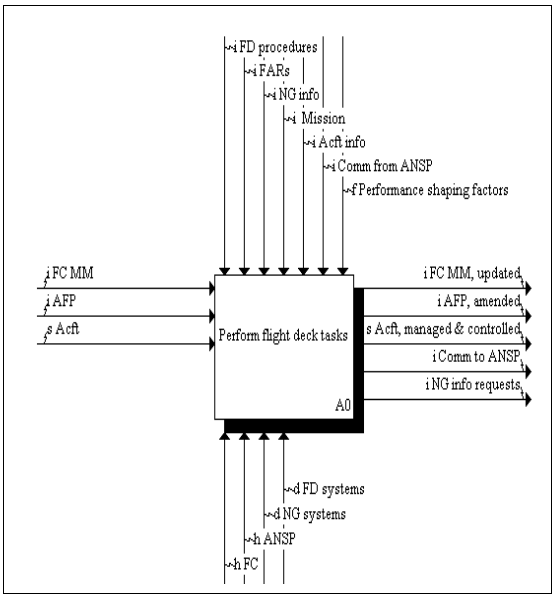

Figure 1. Top-level IDEF0 diagram of the Oregon NextGen Flight Deck Functional Model.

In IDEF0, a function is a process, performed by mechanisms (humans, devices), that transforms inputs (matter, energy, information, systems) to outputs (matter, energy, information, systems), subject to controls (information, factors) that guide, facilitate, or constrain the process. IDEF0 uses boxes labeled with verb phrases to represent functions and arrows labeled with noun phrases to represent mechanisms, inputs, outputs, and controls. So, omitting some details, Figure 1 represents that the human flight crew [h FC] and flight deck systems (devices) [d FD systems] perform flight deck tasks [Perform flight deck tasks] to transform the aircraft system [s Acft] to a managed and controlled aircraft system [s Acft, managed & controlled]. The performance of flight deck tasks is guided (controlled) by information in flight deck procedures [i FD procedures] and Federal Aviation Regulations [i FARs] and influenced (controlled) by performance shaping

factors [f Performance shaping factors], like the aircraft's performance limitations and the flight crew's decision biases. To perform flight deck tasks also transforms the flight crew's mental model [i FC MM] to an updated mental model [i FC MM, updated], utilizes NextGen systems [s NG systems] and the Air Navigation Service Provider [h ANSP], and is controlled by information received from the NextGen system [i NG info] and the ANSP [i Comm from ANSP].

In IDEF0, general functions are detailed or decomposed into more specific functions, those functions are further detailed, and the modeling process continues until a representation sufficiently detailed for further analysis is produced. For example, in the ONFDFM, the function [Perform flight deck tasks] is detailed into [Collaboratively manage FP (flight plan)], [Manage 4DT (4-dimensional trajectory)], [Manage acft (aircraft) systems], and [Control acft]. Those are in turn detailed, and so on. Table 1 shows a portion of the function hierarchy of the ONFDFM, elaborating part of the [Manage 4DT] branch. A-numbers (A#s) define a function's place in the hierarchy ("A" for "Activity" being inherited from IDEF0's precursor, SADT). The hierarchy is, effectively, the task hierarchy resulting from a typical HTA, but the detailed IDEF0 diagrams underlying the hierarchy bear much more information than does the typical HTA. As shown in Table 1, the detailing of [Manage 4DT] ultimately yields [Get traffic info using HSI/CDTI (Horizontal Situation Indicator/Cockpit Display of Traffic Information)], part of whose IDEF0 diagram is shown in Figure 2.

Table 1. A portion of the ONFDFM function hierarchy, elaborating the [Manage 4DT] branch.

A#	Function
A0:	Perform flight deck tasks
A1:	Collaboratively manage FP
A2:	Manage 4DT
A21:	Receive ANSP clearances
A22:	Assess 4DT WRT AFP & clearances
A23:	Assess 4DT WRT terrain
A24:	Assess 4DT WRT obstacles
A25:	Assess 4DT WRT traffic
A251:	Get traffic info from ANSP advisories
A252:	Get traffic info from FD alerts
A253:	**Get traffic info using HSI/CDTI**
A2531:	Configure HSI to display traffic
A2532:	Locate traffic symbols on CDTI
A2533:	Select traffic for detailed info
A2534:	Determine traffic IDs, bearings, ..., from CDTI
A2535:	Estimate traffic trajectories from CDTI info
A254:	Get traffic info visually
A255:	Integrate traffic info
A256:	Assess integrated traffic picture
A26:	Adjust 4DT
A3:	Manage acft systems
A4:	Control acft

ONFDFM was developed using KBSI Inc.'s AI0Win IDEF0 modeling software. An HTML version of the full model, generated by AI0Win, is accessible at http://flightdeck.ie.orst.edu/NextGen/Models/ONFDFM1.0/.

IDEF0 diagrams and the glossary of model elements underlying them provide a very rich representation of the functions performed in and by a complex system. An important benefit over HTA is that IDEF0 explicitly models not only functions (or tasks), but relationships among functions via mechanisms, inputs, outputs, and controls. Those relationships can be identified in the IDEF0 model by examining related diagrams and tracing arrows. However, a complex IDEF0 model may have many diagrams, and navigating them to identify relationships, although in principle straightforward, is in practice difficult and prone to error. As in any reductionist method, it is tempting for the analysts to focus on a small part of the IDEF0 model and ignore its context, thus to "lose the big picture" or "miss the forest for the trees". HMSEM uses the prototype IDEF0 Navigator (INav) to avoid that. INav operates on an IDEF0 model, providing an alternative representation to the IDEF0 diagrams. An arrow entering an IDEF0 diagram can come from another part of the model outside the immediate diagram or from outside the system itself. The INav representation abstracts out some of the details of the IDEF0 diagrams to show from where each arrow (or each group of related arrows) comes or where it goes, allowing analysts to explore details in the context of the entire model in a single view. Figure 3 depicts an example of INav's representation of [A2564:Assess spacing in flow corridor operations], showing upstream flows of inputs and controls to A2564 from other parts of the model.

Task Analysis

In HMSEM, task analysis is used to further analyze the most detailed IDEF0 functions – referred to as tasks – to compile, from the model and elsewhere, information needed for human fallibilities identification. The analysts enter, for example, task location and timing information into the HMSEM workbook. Table 2 shows the results of task analysis of [A2534: Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI].

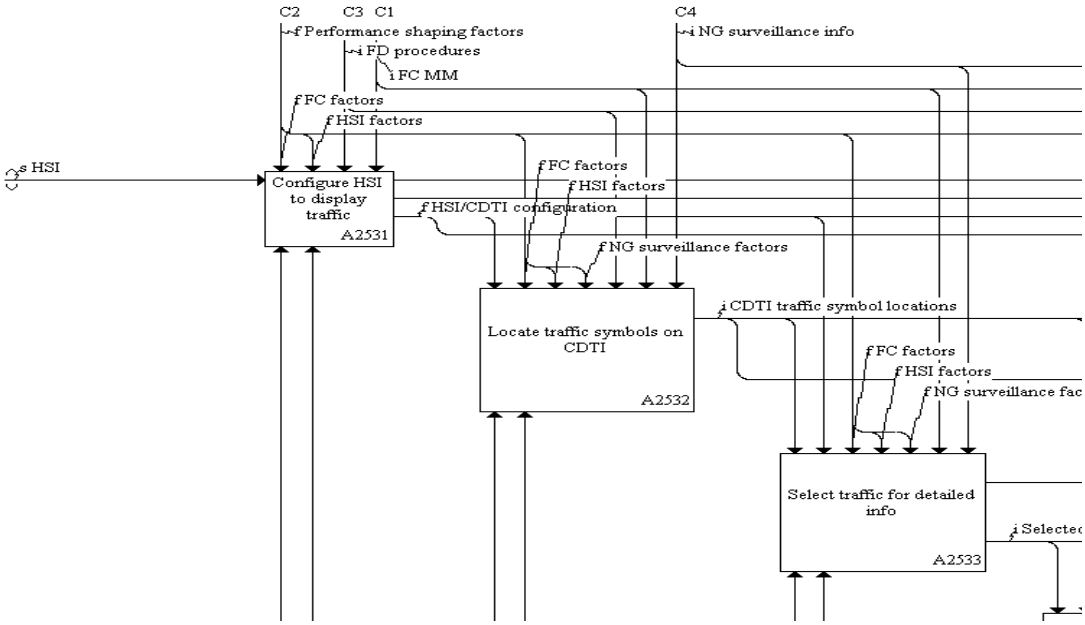

Figure 2: Detail from the IDEF0 diagram of the [Get traffic info using HSI/CDTI] function from the ONFDFM.

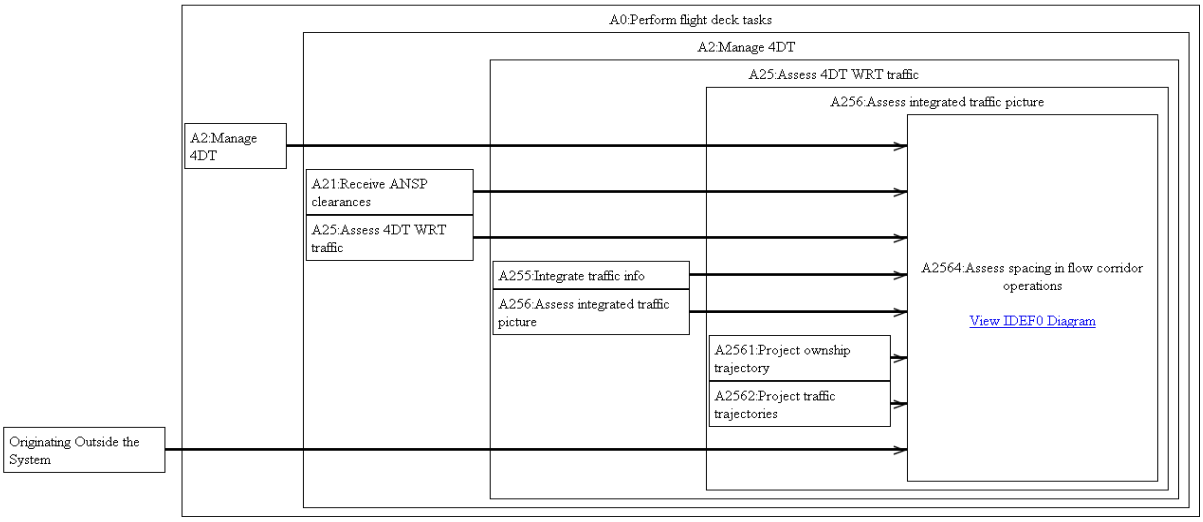

Figure 3: INav representation of [A2564:Assess spacing in flow corridor operations], showing upstream flows of inputs and controls from other parts of the model. Downstream flows are not shown here.

Table 2. Results of the task analysis of [A2534: Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI].

Task Analysis Attribute	Value
Purpose / Value Added	Necessary to detect conflicts and determine if separation and spacing is appropriate.
Location	Flight deck
Frequency & Timing	Continuous, intermittent
Environmental Conditions	Darkness (red illum) to direct sunlight, glare, etc.; Noise; Vibration (low, high freq.)
Information Requirements	i Selected traffic; i CDTI traffic symbol locations; f HSI/CDTI configuration; i FD procedures; i FC MM; i NG surveillance info
Sensory/Cognitive/Motor Actions	View CDTI; Identify traffic; Estimate bearings, ranges, relative altitudes, and probable trajectories

Human Fallibilities Identification

Human factors analysis sometimes employs a Human Error Identification (HEI) technique like SHERPA (Embrey, 1986) to identify errors that could occur in a system. HEI techniques typically start with a functional representation of the system (often from HTA) and analysts and SMEs, referring to that representation, use their knowledge and experience to hypothesize potential errors that could occur in specific tasks. HEI techniques rely heavily on analyst and SME memory and judgment (and, one could say luck) to compile a comprehensive list of likely errors and are, therefore, subject to the same kinds of limitations that affect human performance in systems like the one they are studying. Rather than to attempt to identify errors directly, HMSEM first identifies the human fallibilities likely to be significant in each task and, from system and task information from the IDEF0 model and task analysis, proceeds to project errors that could occur as a result of those fallibilities interacting with system and task characteristics. See the Appendix for the complete results of Human Fallibilities Identification.

HMSEM uses the Human Fallibilities Identification and Remediation Database (HFIRDB) for fallibilities identification. The HFIRDB is a database consisting of human fallibilities and remediations for them compiled from Wickens' and Hollands' *Engineering Psychology and Human Performance* (Wickens & Hollands, 2000). The user interface leads the analysts through a series of questions about each task to be analyzed for fallibilities and errors and the analysts refer to the IDEF0 model and the task analysis to answer them. The HFIRDB first asks the analysts to select from among seven information processing stages (i.e., sensory registration, perception, attention allocation, working memory, long-term memory, decision-making, and response control) those employed in the task under consideration. Next the user is asked to choose general human fallibility categories (e.g., visual display processing or working memory limitations) that apply to the selected information processing stages. Then HFIRDB asks the analysts to choose from a list of possibilities just those conditions that exist in the task under consideration. For example, that operators must appropriately allocate attention to concurrently process or selectively attend to visual stimuli presented in displays is a condition necessary for visual display processing fallibilities to be relevant. The HFIRDB uses a set of queries to produce a list of human fallibilities that may manifest themselves in performance of the task, such as the sensitivity-related vigilance decrement, the tendency for operator performance to degrade during vigilance tasks as a result of a decrease in sensitivity level. The HFIRDB then asks the analysts to confirm task conditions that enable manifestation of the fallibilities and a complete list of relevant fallibilities is generated, which may be copied into the HMSEM workbook for Failure Modes and Effects Analysis (FMEA).

Failure Modes and Effects Analysis

Failure Modes and Effects Analysis (FMEA) is an analytic technique used to prospectively identify the ways in which a system can fail (DOD, 1980; Crow, 2002). FMEA begins with a process or functional description of the system to be analyzed. For each function, the analysts use their knowledge of the function to identify failure modes, that is, ways in which it could fail to achieve its intended outcome. For each failure mode, the analysts identify the causes of or contributing factors to the failure mode, and try to predict its consequences. To prioritize the failure modes for further study or remediation, the analysts assign numeric ratings as to the severity of the consequences of the failure mode, the probability or expected frequency of its occurrence, and the likelihood that it would not be detected in time to avoid the consequences. These three ratings are multiplied to give a Risk Priority Number (RPN) for each failure mode and the RPNs are used to prioritize the failure modes for further analysis or remediation.

In HMSEM, FMEA is used to identify potential operator errors as failure modes. The analysts use the IDEF0 model, operator fallibilities identified with the help of the HFIRDB, and general domain and human factors knowledge to identify specific failure modes – i.e., operator errors – that could occur in performing the task as a result of the interaction of system and task characteristics with those fallibilities. These are entered into the HMSEM workbook. Table 3 presents some results from FMEA applied to the task [A2534: Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI]. All identified failure modes are included in the Appendix.

Issue Identification

At this point, HMSEM may proceed directly to the development of recommendations or design requirements for remediations to prevent or mitigate errors identified in FMEA (see below), but the purpose of this application of HMSEM was to prospectively identify NextGen flight deck human factors issues. To identify issues, the HMSEM analysts collect similar failure modes and those related by common fallibilities and task characteristics. For each such collection, the analysts compose a statement which, if it is or should become true in the implementation and

Table 3. Excerpts from the Failure Modes and Effects Analysis of the task, [A2534: Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI].

Human_Fallibility	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetect.	RPN
Perceptual competition	High symbol density on HSI/CDTI	MM error: FC confuses two CDTI traffic symbols, mis-estimates bearing/range/altitude/trajectory of one or both.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	5	100
Negative skill transfer	CDTI display format, symbology differ from those of similar equipment.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80
Strategic task-management bias	Other high-priority, concurrent tasks/stimuli.	TM error: FC fixates on CDTI, fails to perform other high-priority tasks.	Other tasks ignored or performed poorly.	4	5	4	80

operation of the system, describes a condition or situation related to system operations where natural human characteristics, capabilities, limitations, and tendencies are very likely to to lead to significant problems with system effectiveness, efficiency, or safety. These issues are added to the HMSEM workbook. Table 4 presents some NextGen flight deck failure modes and general issues arising from them. See Appendix.

Table 4. Some general issues identified by analysis of the NextGen flight deck.

Related Failure Modes	In Task(s)	Resulting General Issue
Miss: FC misses traffic on CDTI.	A2532	The flight crew's CDTI traffic detection performance decreases over long periods of self-separation authority.
Delay: CDTI scan is prolonged. Miss: FC fixates on one region of CDTI, misses other traffic.	A2532	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.
mistake: FC chooses and sets HSI/CDTI to inappropriate config.	A2531	Complex device configuration procedures induce pilots to select suboptimal configurations, leading to diminished performance when the devices are used.
slip: FC sets HSI/CDTI to unintended config. lapse: FC omits step to properly configure HSI/CDTI. MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	A2531, A2534	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,

Requirements Development

Perhaps hundreds of human factors issues related to the NextGen flight deck may be identified in this and other ways, but unless guidance is given to avert the potential effectiveness, efficiency, and safety problems they raise, merely citing them is of little value. Here is an opportunity for aviation human factors scientists and practitioners to go the next step toward solution. In addition to human fallibilities information, the HFIRDB contains general guidance information for remediations to reduce the likelihood that human fallibilities will interact with system and task characteristics to manifest themselves as errors. With fallibility, failure mode, error, and issue information from the HMSEM workbook, the analysts may turn again to the HFIRDB to retrieve countermeasures suggested to counteract the fallibilities. Table 5 presents some preliminary, suggested requirements for the NextGen flight deck. Following requirements engineering convention, terms and phrases enclosed in asterisks (* ... *) are, for the time being, ambiguous and unverifiable. Further analysis, and possibly research, would be required to refine them. See Appendix.

Table 5: Some preliminary NextGen flight deck requirements to address issues identified in HMSEM analysis. Asterisks (* ... *) denote as-yet unverifiable terms.

A#	Requirement	Type
A0	NextGen flight crews shall receive concurrent task management training, including *topics TBD*.	Training
A253	CDTI traffic symbol visual coding, for whatever purpose, shall *manifest* exactly three levels of salience corresponding to the three levels of traffic priority: low for the symbols of normal priority traffic, medium for symbols of intermediate priority traffic, and high for symbols of high priority traffic.	Equipment
A2532	CDTI procedures shall *recommend or specify* a *systematic* display scan pattern that covers the entire display each cycle and which cycle is completed in no more than *C* seconds.	Procedures

Discussion

HMSEM is prospective, systematic, and is based on validated human factors knowledge. Moreover, its use of a rich functional modeling formalism provides a framework to organize human fallibilities, potential errors, human factors issues, and recommendations or requirements in a way compatible with the functional models used by system architects and engineers. It thus offers a natural way for human factors scientists and engineers to collaborate with system designers in the critical early stages of system development. Important to this research, the application of HMSEM to the NextGen flight deck identified potentially important human factors issues not specifically found in the literature. But HMSEM has important limitations. In its present form, it is a time-consuming process. Most HMSEM tools are presently in the prototype stage, with technical and content limitations. Despite its attempt to be systematic, its application is still subject to analyst biases and analyst knowledge and cognitive limitations. Its application to NextGen, described in this paper, is limited in scope to a few tasks related to CDTI-based traffic awareness. The functional model itself is limited in scope and based on as-yet very limited documentation on the envisioned NextGen flight deck.

Conclusions and Recommendations

HMSEM is a systematic methodology for the prospective identification of human fallibilities, likely errors, and general human factors issues in complex, high-risk systems, and the development of remediations. It has been successfully applied to a limited number of tasks on the NextGen flight deck. Although the methodology itself seems sound, most of its tools are prototypes and these prototypes must be refined. In particular, the knowledge base of the HFIRDB should be expanded to address more dimensions of human performance and the HMSEM workbook should be converted to a more robust software tool that integrates the other tools, provides a repository for findings, and generates publishable reports. A team of human factors analysts, SMEs, and engineers should be assembled to continue applying HMSEM to NextGen. They should refine and expand the ONFDFM to incorporate the most recent plans for NextGen implementation, modeling, in detail, the full scope of flight deck functions. They should use the model and refined tools to identify human fallibilities, potential errors, and human factors issues, and make recommendations for engineering requirements to guide NextGen system design. Throughout this process, the team should work with NextGen system architects and engineers to make the ONFDFM consistent with functional models used for NextGen development, to utilize the latest NextGen plans in their analyses, and to organize and present their findings in a way compatible with NextGen design documents. In this way, human factors analysis and recommendations will be more likely to have greater impact on the implemented system.

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APPENDIX: NEXTGEN FLIGHT DECK HUMAN FACTORS ANALYSIS

This appendix contains the results of Human Fallibilities Identification, Failure Modes and Effects Analysis, Issue Identification, and Requirements Development

NextGen Flight Deck Human Factors Analysis

9 December 2008 Oregon NextGen Flight Deck Functional Model 2.0 Node A253 (submodel used for this analysis): http://flightdeck.ie.orst.edu/NextGen/Models/ONFDFM1.0/dgm-actuse.htm?3947,3967

Full Oregon NextGen Flight Deck Functional Model 2.0: http://flightdeck.ie.orst.edu/NextGen/Models/ONFDFM1.0/index.htm

Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Working memory code limitations	Tendency for tasks that employ the same type of working memory resources to be time-shared less effectively than task that employ different working memory codes.	Similar, concurrent task.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	Train FC to understand value and choice of optimal CDTI configuration. CTM training.	Flight crews shall be trained to determine and select *optimal* CDTI configurations for *representative* situations.
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	Train FC to understand value and choice of optimal CDTI configuration. CTM training.	Flight crews shall be trained to determine and select *optimal* CDTI configurations for *representative* situations.
A2531	Configure HSI to display traffic	Implementation cost bias	Operators tend to avoid solutions and plans which are difficult or effortful to implement.		mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Complex device configuration procedures induce pilots to select suboptimal configurations, leading to diminished performance when the devices are used.	Train FC to understand value and choice of optimal CDTI configuration. Simple, straightforward CDTI configuration procedures.	(covered)
A2531	Configure HSI to display traffic	Knowledge-in-the-world effect	Tendency for system designs that make knowledge available "in the world" to be more error tolerant and higher performing than systems that rely on "knowledge in the head"	HSI/CDTI config options not clearly visible to FC.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Device configuration options are not clearly presented to the flight crew as part of the device interface, which leads to delays and suboptimal or inappropriate configurations and subsequent performance problems.	CDTI should present FC with easily discriminable CDTI config options.	The CDTI flight crew interface shall give positive indication of available CDTI configuration parameters, possible parameter values, and how to set them.
A2531	Configure HSI to display traffic	Risk calibration bias	Tendency for operators to better calibrate risks when risk data is presented pictorially rather than in numerical or verbal statements.	Risk information unknown and not displayed.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Flight crews are not aware of the risk associated with suboptimal or inappropriate configurations of critical flight deck equipment, which leads to inappropriate configurations and errors in use.	Train FC to understand value and choice of optimal CDTI configuration. Simple, straightforward CDTI configuration procedures.	(covered)
A2531	Configure HSI to display traffic	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Concurrent tasks, pacing, & other stressors induce high levels of perceived workload.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	High levels of workload diminish flight crew performance.		

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Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Retroactive memory interference	Tendency for information received after the target stimuli to disrupt the recall of the target stimuli.	Other task interrupts HSI/CDTI config.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Lengthy, complex, and critical flight deck equipment configuration procedures are particularly susceptible to distraction and interruption, leading to poor configurations and subsequent errors in use.		
A2531	Configure HSI to display traffic	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	Task poorly designed.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Lengthy, complex, and poorly designed flight deck equipment configuration procedures lead to configuration delays and errors and to subsequent delays and errors in use.		
A2531	Configure HSI to display traffic	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Concurrent tasks require similar processing codes.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Working memory code disruption	Environmental stimuli is more likely to degrade task performance if it is the same code (phonetic or spatial) as the task being performed.	Environmental (i.e., task-irrelevant) stimuli of same code present.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Concurrent task(s) of same/similar modality.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	Tasks that are commonly performed concurrently tend to overload one modality, especially visual or auditory, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		

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A2531	Configure HSI to display traffic	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.	Poorly integrated HSI/CDTI config interface.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The design of flight deck equipment interfaces does not map well to the flight deck task procedures which use that equipment and therefore leads to delays and errors.		
A2531	Configure HSI to display traffic	Web disorientation	Tendency for operators to become disoriented when navigating through web pages.	Complex HSI (/CDTI) page architecture.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The flight crew can become disoriented when navigating complex flight deck equipment information/control structures, e.g., databases, pages, menus, etc., consequently losing situation awareness or incurring delays or errors.		
A2531	Configure HSI to display traffic	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	HSI/CDTI config interface differs from that of similar systems (lack of standardization).	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2531	Configure HSI to display traffic	Strategic task-management bias	Tendency for operators to utilize suboptimal planning strategies for concurrent task management, especially when workload is high.	FC distracted by other task.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The necessity for the flight crew to configure two or more complex flight deck devices concurrently will lead to configuration errors in one or both and, consequently, errors in using them.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2531	Configure HSI to display traffic	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.		mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The necessity for the flight crew to configure two or more complex flight deck devices concurrently will lead to configuration errors in one or both and, consequently, errors in using them.		
A2531	Configure HSI to display traffic	Bottleneck effect	Inability of operators to perform two action-selection or decision-making tasks concurrently, and for performance to decrease when resource-intensive tasks must be time-shared.	FC concurrently tries to configure another device.	mistake: FC chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	4	80	The necessity for the flight crew to configure two or more complex flight deck devices concurrently will lead to configuration errors in one or both and, consequently, errors in using them.		

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A2531	Configure HSI to display traffic	Representativeness heuristic	Tendency for operators to choose a hypothesis or diagnose a situation by comparing the available evidence to characteristics that are representative of familiar hypotheses.	Current traffic situation different from but deceptively similar to a representative situation.	mistake: FC misjudges situation, chooses and implements inappropriate HSI/CDTI config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	3	4	60	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,		
A2531	Configure HSI to display traffic	Working memory code limitations	Tendency for tasks that employ the same type of working memory resources to be time-shared less effectively than task that employ different working memory codes.	Similar, concurrent task.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,		
A2531	Configure HSI to display traffic	Knowledge-in-the-world effect	Tendency for system designs that make knowledge available "in the world" to be more error tolerant and higher performing than systems that rely on "knowledge in the head"	HSI/CDTI config options not clearly visible to FC.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Device configuration options are not clearly presented to the flight crew as part of the device interface, which leads to delays and suboptimal or inappropriate configurations and subsequent performance problems.		
A2531	Configure HSI to display traffic	Risk perception bias	Tendency for operators to overestimate the risk involved in a course of action or situation relative to the true objective risk.	Risk information unknown and not displayed.	mistake: FC sets CDTI display range too large	FC fails to detect separation violation.	5	5	2	50	Flight crews are not aware of the risk associated with suboptimal or inappropriate configurations of critical flight deck equipment, which leads to inappropriate configurations and errors in use.		

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A2531	Configure HSI to display traffic	Stimulus-response consistency effect	Tendency for lack of consistency in the level of compatibility between stimulus and response to degrade performance efficiency	Inconsistent S-R compatibility in HSI/CDTI config interface.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Stimulus-response compatibility effect	Tendency for compatible stimulus-response pairs to result in faster reaction times and lower error rates.	Poor HSI/CDTI config interface S-R compatibility.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Movement compatibility	Tendency for operator performance efficiency to increase when systems respond to control activities (operator actions) in ways that are consistent with operator expectations.	HSI/CDTI config interface violates population stereotypes.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Population stereotype effect	Tendency for population stereotypes to influence how operators map stimuli to responses.	HSI/CDTI config interface violates population stereotypes.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Modality stimulus-response compatibility effect	Tendency for the modality of the stimulus and the response to affect reaction time.	Poor HSI/CDTI config interface S-R mapping.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		

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A2531	Configure HSI to display traffic	Stimulus-response consistency effect	Tendency for lack of consistency in the level of compatibility between stimulus and response to degrade performance efficiency	HSI/CDTI S-R compatibility inconsistent with rest of flight deck.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Location compatibility	Tendency for operator performance efficiency to increase when stimulus-response pairs are collocated and spatially congruent.	HSI/CDTI controls lack location compatibility.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Concurrent tasks, pacing, & other stressors induce high levels of perceived workload.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	High levels of workload diminish flight crew performance.		
A2531	Configure HSI to display traffic	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	Task poorly designed.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2531	Configure HSI to display traffic	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Concurrent task(s) of same/similar modality.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Tasks that are commonly performed concurrently often rely predominantly on one sensory modality, visual or auditory, leading to diminished task performance.		

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A2531	Configure HSI to display traffic	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Concurrent tasks require similar processing codes.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Working memory capacity	The normal maximum capacity of working memory is 5 to 9 chunks of information when attention is fully allocated.	HSI/CDTI config interface requires FC to transfer info from one part to another.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		

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A2531	Configure HSI to display traffic	Working memory duration	Operators usually retain little information in working memory after 10 to 15 seconds if they are not able to continually rehearse the information.	HSI/CDTI config interface requires FC to transfer info from one part to another.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2531	Configure HSI to display traffic	Speed-accuracy trade-off	Tendency for operators to make more errors as they try to execute tasks more quickly.		slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The complexity of flight deck interfaces makes the flight crew especially susceptible to the speed-accuracy trade-off, leading to delays and/or errors.		
A2531	Configure HSI to display traffic	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.	Poorly integrated HSI/CDTI config interface.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The design of flight deck equipment interfaces does not map well to the flight deck task procedures which use that equipment and therefore leads to delays and errors.		
A2531	Configure HSI to display traffic	Web disorientation	Tendency for operators to become disoriented when navigating through web pages.	Complex HSI (/CDTI) page architecture.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The flight crew can become disoriented when navigating complex flight deck equipment information/control structures, e.g., databases, pages, menus, etc., consequently losing situation awareness or incurring delays or errors.		
A2531	Configure HSI to display traffic	Information visualization disorientation	Tendency for operators to become disoriented or lost when navigating through the databases or computer menu hierarchies in information visualization and scientific visualization environments.	Complex HSI (/CDTI) page architecture.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The flight crew can become disoriented when navigating complex flight deck equipment information/control structures, e.g., databases, pages, menus, etc., consequently losing situation awareness or incurring delays or errors.		

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A2531	Configure HSI to display traffic	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	HSI/CDTI config interface differs from that of similar systems (lack of standardization).	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2531	Configure HSI to display traffic	Strategic task-management bias	Tendency for operators to utilize suboptimal planning strategies for concurrent task management, especially when workload is high.	FC distracted by other task.	slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.		slip: FC sets HSI/CDTI to unintended config.	FC misunderstands resulting HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	5	5	2	50	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,		
A2531	Configure HSI to display traffic	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.		lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,		

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A2531	Configure HSI to display traffic	Knowledge-in-the-world effect	Tendency for system designs that make knowledge available "in the world" to be more error tolerant and higher performing than systems that rely on "knowledge in the head"	HSI/CDTI config options not clearly visible to FC.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Device configuration options are not clearly presented to the flight crew as part of the device interface, which leads to delays and suboptimal or inappropriate configurations and subsequent performance problems.		
A2531	Configure HSI to display traffic	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Concurrent tasks, pacing, & other stressors induce high levels of perceived workload.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	High levels of workload diminish flight crew performance.		
A2531	Configure HSI to display traffic	Compliance cost bias	Tendency for the tangible cost of compliance with safety regulations to be overestimated in relationship to the abstract risks of non-compliance.	Complex HSI/CDTI config interface design.	mistake: FC hastily chooses and sets HSI/CDTI to inappropriate config.	FC misinterprets traffic picture, violates separation/spacing reqts.	5	4	2	40	Lengthy, complex, and poorly designed flight deck equipment configuration procedures lead flight crews to choose suboptimal configurations and subsequent delays and errors in use.		
A2531	Configure HSI to display traffic	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	Task poorly designed.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2531	Configure HSI to display traffic	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Concurrent task(s) of same/similar modality.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Tasks that are commonly performed concurrently often rely predominantly on one sensory modality, visual or auditory, leading to diminished task performance.		

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Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Concurrent tasks require similar processing codes.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		

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Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Strategic task-management bias	Tendency for operators to utilize suboptimal planning strategies for concurrent task management, especially when workload is high.	FC distracted by other task.	lapse: FC omits step to properly configure HSI/CDTI.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	5	4	2	40	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Decision complexity reaction delay	Tendency for increases in the number of stimulus-response alternatives to increase reaction time.	Complex HSI/CDTI config interface design.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Complex flight deck decision problems lead to delays in decision making.		
A2531	Configure HSI to display traffic	Menu distance effect	Tendency for increased distance between menu (or spreadsheet) items to both increase the time necessary to navigate the information and to reduce the ability of operators to perform concurrent tasks.	HSI/CDTI config menu items too far apart.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Complex, poorly designed menu systems of flight deck equipment increase the time needed and the errors in making menu selections.		
A2531	Configure HSI to display traffic	Knowledge-in-the-world effect	Tendency for system designs that make knowledge available "in the world" to be more error tolerant and higher performing than systems that rely on "knowledge in the head"	HSI/CDTI config options not clearly visible to FC.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Device configuration options are not clearly presented to the flight crew as part of the device interface, which leads to delays and suboptimal or inappropriate configurations and subsequent performance problems.		
A2531	Configure HSI to display traffic	Skilled memory advantage	Tendency for experts to use long-term working memory to quickly encode information in a durable and easily accessible form.	FC inexperienced with HSI/CDTI.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Flight crew experience with flight deck equipment is often inadequate to produce satisfactory performance.		
A2531	Configure HSI to display traffic	Practice effect	Tendency for practice executing a response in reaction to a stimulus to decrease reaction time and increase information transmission rate.	Little FC experience with HSI/CDTI.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Flight crew experience with flight deck equipment is often inadequate to produce satisfactory performance.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Location compatibility	Tendency for operator performance efficiency to increase when stimulus-response pairs are collocated and spatially congruent.	HSI/CDTI controls lack location compatibility.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Concurrent tasks, pacing, & other stressors induce high levels of perceived workload.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	High levels of workload diminish flight crew performance.		
A2531	Configure HSI to display traffic	Retroactive memory interference	Tendency for information received after the target stimuli to disrupt the recall of the target stimuli.	Other task interrupts HSI/CDTI config.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Lengthy, complex, and critical flight deck equipment configuration procedures are particularly susceptible to distraction and interruption, leading to poor configurations and subsequent errors in use.		
A2531	Configure HSI to display traffic	Response complexity effect	Tendency for the discriminability and complexity of a response to increase reaction time.	complex HSI/CDTI control design, complex configuration protocol	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Lengthy, complex, and poorly designed flight deck equipment configuration procedures lead to configuration delays and errors and to subsequent delays and errors in use.		
A2531	Configure HSI to display traffic	Stress-induced perceptual tunneling	Tendency for stress to cause operators to process a smaller range of information, effectively narrowing their attention.	Stressors present.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Some flight deck displays are not designed so as to offset the performance effects of stress, so flight crews are susceptible to them.		
A2531	Configure HSI to display traffic	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	Task poorly designed.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2531	Configure HSI to display traffic	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Concurrent task(s) of same/similar modality.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Tasks that are commonly performed concurrently often rely predominantly on one sensory modality, visual or auditory, leading to diminished task performance.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Concurrent tasks require similar processing codes.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Stress-induced perceptual tunneling	Tendency for stress to cause operators to process a smaller range of information, effectively narrowing their attention.	Stressors present.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Stimulus discriminability effect	Tendency for reaction time to increase as stimulus discriminability decreases.	HSI/CDTI configs/modes not readily discriminable.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The complexity of flight deck interfaces makes the flight crew especially susceptible to the speed-accuracy trade-off, leading to delays and/or errors.		
A2531	Configure HSI to display traffic	Involuntary speed-accuracy performance shifting	Tendency for certain design features to automatically shift the speed-accuracy trade-off towards one extreme.	Complex, opaque HSI/CDTI config interface design induces FC to be overly cautious about correct config.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The complexity of flight deck interfaces makes the flight crew especially susceptible to the speed-accuracy trade-off, leading to delays and/or errors.		
A2531	Configure HSI to display traffic	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.	Poorly integrated HSI/CDTI config interface.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The design of flight deck equipment interfaces does not map well to the flight deck task procedures which use that equipment and therefore leads to delays and errors.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Web disorientation	Tendency for operators to become disoriented when navigating through web pages.	Complex HSI (/CDTI) page architecture.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The flight crew can become disoriented when navigating complex flight deck equipment information/control structures, e.g., databases, pages, menus, etc., consequently losing situation awareness or incurring delays or errors.		
A2531	Configure HSI to display traffic	Information visualization disorientation	Tendency for operators to become disoriented or lost when navigating through the databases or computer menu hierarchies in information visualization and scientific visualization environments.	Complex HSI (/CDTI) page architecture.	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The flight crew can become disoriented when navigating complex flight deck equipment information/control structures, e.g., databases, pages, menus, etc., consequently losing situation awareness or incurring delays or errors.		
A2531	Configure HSI to display traffic	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	HSI/CDTI config interface differs from that of similar systems (lack of standardization).	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Inertia effect	Tendency for operators to continue performing a task longer than optimal in order to delay incurring mental cost of switching attention between tasks.		delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		

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A2531	Configure HSI to display traffic	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.		delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Perseveration	Tendency for operators to continue with the same plans or actions longer than optimal under stressful conditions.		delay: HSI/CDTI configured slowly.	Delays performance of other critical task.	3	4	2	24	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Confirmation bias	Tendency for operators to seek information that confirms their current hypothesis and to disregard or undervalue information that does not confirm the hypothesis.		mistake: FC fails to understand that/why particular HSI/CDTI config is optimal.	FC sets inappropriate HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	2	3	3	18	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Recency bias	Tendency for operators to overvalue information that they received recently when choosing and evaluating hypotheses.		mistake: FC fails to understand that/why particular HSI/CDTI config is optimal.	FC sets inappropriate HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	2	3	3	18	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Overconfidence bias	Tendency for operators to be overconfident in their state of knowledge or the accuracy of their beliefs.		mistake: FC fails to understand that/why particular HSI/CDTI config is optimal.	FC sets inappropriate HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	2	3	3	18	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		

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A2531	Configure HSI to display traffic	Satisficing	Tendency for problem solvers to select the best plan that is currently available, despite the fact that it might not ultimately be the best plan.		mistake: FC fails to understand that/why particular HSI/CDTI config is optimal.	FC sets inappropriate HSI/CDTI config, misinterprets traffic picture, violates separation/spacing reqts.	2	3	3	18	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Color automaticity	Tendency for color to be processed automatically or concurrently with other stimuli.	HSI/CDTI config interface non-standard color coding.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	Flight deck displays that are not designed to circumvent perceptual biases lead pilots to commit errors.		
A2531	Configure HSI to display traffic	Color stereotypes	Tendency for colors to be strongly associated with symbolic meanings, impairing display interpretation if colors in the display are not coded consistently with operators' expectations of their meaning.	HSI/CDTI config interface non-standard color coding.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2531	Configure HSI to display traffic	Cognitive overload decision failures	Tendency for operators to make suboptimal decisions because their capacity to aggregate evidence, evaluate hypotheses, and choose actions is overburdened.	complex HSI/CDTI config display design.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	High levels of workload diminish flight crew performance.		
A2531	Configure HSI to display traffic	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Concurrent tasks, pacing, & other stressors induce high levels of perceived workload.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	High levels of workload diminish flight crew performance.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	Task poorly designed.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2531	Configure HSI to display traffic	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Concurrent task(s) of same/similar modality.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	Tasks that are commonly performed concurrently often rely predominantly on one sensory modality, visual or auditory, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Concurrent tasks require similar processing codes.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.		
A2531	Configure HSI to display traffic	Saliency bias	Tendency for the salience of a cue to influence the extent to which operators attend to and weigh the information it contains during decision making.	Irrelevant element in HSI/CDTI is overly salient.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The attention of flight crews is drawn from important by non-salient information to unimportant but salient information.		
A2531	Configure HSI to display traffic	Anchoring Heuristic	Tendency for operators to favor their original hypotheses, and to undervalue subsequent information that may support other hypotheses.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands, config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Confirmation bias	Tendency for operators to seek information that confirms their current hypothesis and to disregard or undervalue information that does not confirm the hypothesis.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Saliency bias	Tendency for the salience of a cue to influence the extent to which operators attend to and weigh the information it contains during decision making.	Irrelevant element in HSI/CDTI is overly salient.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Availability heuristic	Tendency for operators to consider the hypothesis which can be most easily accessed in memory.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Cue weighting heuristic	Tendency for operators to weigh all of the informational cues that they process equally when evaluating evidence.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2531	Configure HSI to display traffic	Overconfidence bias	Tendency for operators to be overconfident in their state of knowledge or the accuracy of their beliefs.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		

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Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.		
A2531	Configure HSI to display traffic	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	HSI/CDTI config interface differs from that of similar systems (lack of standardization).	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2531	Configure HSI to display traffic	Recognition-prime decision making heuristic	Tendency for experts to recognize patterns of cues, and to make fast and relatively automatic diagnoses based on these familiar patterns.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Perceptual competition	Tendency for spatial proximity between stimuli to increase both the competition for processing resources and the probability of failures in focused attention.	Cluttered HSI/CDTI config display.	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.	Make CDTI bigger. Provide declutter function. Train FCs to prioritize HSI info to minimize clutter. Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	1) The visual angles subtended by the traffic display area of the CDTI, when viewed from the flight crew's most distant eye reference point, shall be at least *X* degrees horizontal by *Y* degrees vertical. 2) The HSI/CDTI shall provide the flight crew with a “declutter” option that removes from the traffic display, or *significantly* reduces the salience of, all *non-traffic-related* symbology for a period of *P* seconds. 3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.
A2531	Configure HSI to display traffic	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Concurrent task(s).	MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		

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A2531	Configure HSI to display traffic	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.		MM error: FC misinterprets current HSI/CDTI config.	FC sets HSI/CDTI to inappropriate config, misunderstands config, misinterprets traffic picture.	3	3	1	9	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2531	Configure HSI to display traffic	Central executive limitations	Tendency for tasks that employ the central executive component of working memory to be time-shared less effectively than tasks that employ different working memory codes.		???					0	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,		
A2531	Configure HSI to display traffic	Decision-making improvement failure	Tendency for general practice in decision-making to have no consistent effect on decision-making performance.		NA					0			
A2531	Configure HSI to display traffic	Task-response dichotomy	Tendency for performance to improve when different working memory codes underlie task and response.		???					0			
A2531	Configure HSI to display traffic	Color continuum ambiguity	Tendency for people to disagree in their interpretation of how color should be ordered in a continuum.		NA					0			
A2531	Configure HSI to display traffic	Expertise-based stress coping	Tendency for more experienced and skilled operators to perform better under stressful conditions than less skilled operators.		NA					0			
A2531	Configure HSI to display traffic	Ideomotor compatibility effect	Tendency for reaction time to be fast and relatively automatic when a stimulus matches the sensory feedback produced by the response, e.g. spoken response to a heard letter.		???					0			

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2531	Configure HSI to display traffic	Surprise reaction delay	Tendency for reaction times to be extremely high (several seconds) when extremely surprising events are encountered.		NA					0			
A2531	Configure HSI to display traffic	Recency bias	Tendency for operators to overvalue information that they received recently when choosing and evaluating hypotheses.		NA					0			
A2531	Configure HSI to display traffic	Global precedence bias	Tendency for response conflict to be asymmetrical in that global, holistic, or emergent aspects of stimuli interfere with the processing of local stimuli, but the reverse is not true.		???					0			
A2531	Configure HSI to display traffic	Ego-centered distortion	Tendency for ego-centered representations of three-dimensional space to distort operator perception of virtual space.		NA					0			
A2531	Configure HSI to display traffic	Stress performance influence	Tendency for stress to improve performance when arousal is low, but to decrease performance when arousal is already high.		???					0			
A2531	Configure HSI to display traffic	Excessive workload strategy	Tendency for operators to employ suboptimal task management strategies when the cognitive resources demanded by the task exceed the resources available to perform the task.		???					0			
A2531	Configure HSI to display traffic	Response conflict	Tendency for focused processing of local aspects of stimuli to be disrupted by conflicting global aspects of stimuli presented in close proximity.		???					0			

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A2531	Configure HSI to display traffic	Single-dimension judgment limitations	Tendency for operators to err when they are required to perform absolute judgment tasks that exceed their limited ability to remember different classification levels along a single physical dimension.		NA					0			
A2531	Configure HSI to display traffic	Compatibility ambiguity effect	Tendency for operators' mental models to make stimulus-response relationships ambiguous.		???					0			
A2531	Configure HSI to display traffic	Proactive memory interference	Tendency for information received before the target stimuli to disrupt the recall of the target stimuli.		NA					0			
A2531	Configure HSI to display traffic	Framing effect	Tendency for the level of risk aversion displayed by operators to be influenced by whether the risk is framed as a potential loss or a potential gain.		???					0			
A2531	Configure HSI to display traffic	Personality-based stress coping	Tendency for operator personality to influence the adaptive strategies that will be employed to cope with stress.		NA					0			
A2531	Configure HSI to display traffic	Stress interaction effects	Tendency for stressors to interact with one another in ways that either amplify or reduce their total influence on performance.		NA					0			
A2531	Configure HSI to display traffic	Error correction training effect	Tendency for practice and training in identifying and correcting errors to improve operator performance.		???					0			
A2531	Configure HSI to display traffic	Equipment design effect	Tendency for the design of equipment to influence the frequency and type of human information processing errors.		See others.					0			

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A2531	Configure HSI to display traffic	Stress training effect	Tendency for stress inoculation training and stress exposure training to improve operators performance under stress.		NA					0			
A2531	Configure HSI to display traffic	Local processing bias	Tendency for operators to utilize more cognitive resources when processing local stimuli than when processing global stimuli.		???					0			
A2531	Configure HSI to display traffic	Stage-defined resource effect	Tendency for tasks that require either perceptual processing or working memory to be more effectively time-shared with tasks that require either action selection or execution than with tasks that require the same resources.		???					0			
A2531	Configure HSI to display traffic	Stimulus-response training effect	Tendency for training to improve operators' reaction times to choice reaction-time tasks.		NA					0			
A2531	Configure HSI to display traffic	Repetition effect	Tendency for repetition of the same stimulus-response pairs to result in lower reaction time than different sequential stimulus-response pairs.		NA					0			
A2531	Configure HSI to display traffic	Speed-accuracy operating characteristic	Tendency for accuracy to increase at a decreasing rate relative to reaction time.		???					0			
A2531	Configure HSI to display traffic	Stress coping bias	Tendency for operators to select strategies to cope with stressful situations based on their subjective perception of the level of stress imposed by the situation.		???					0			
A2531	Configure HSI to display traffic	Stress-induced working memory degradation	Tendency for stress to capture operator attention, thereby decreasing the mental resources available to and disrupting the function of working memory.		???					0			

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A2531	Configure HSI to display traffic	Subjective workload disassociation	Tendency for operators' subjective evaluation of their workload to be biased by certain characteristics of the environment and/or task.		NA					0			
A2531	Configure HSI to display traffic	Similarity-based task confusion	Tendency for the concurrent performance of tasks that are similar along certain dimensions but different or incompatible along other dimensions to result in interference and confusion.		???					0			
A2531	Configure HSI to display traffic	Expertise chunking facilitation	Tendency for expertise to facilitate chunking. As a result experts can perceive and store a large quantity of information more quickly than novices.		NA					0			
A2531	Configure HSI to display traffic	Color integration	Tendency for display elements of the same color to be integrated, even if they are spatially disparate.		NA					0			
A2532	Locate traffic symbols on CDTI	Perceptual competition	Tendency for spatial proximity between stimuli to increase both the competition for processing resources and the probability of failures in focused attention.	Closely spaced traffic.	Miss: FC fixates on one region of CDTI, misses other traffic.	Loss of separation.	5	5	5	125	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.	Pilots must be aware of the tendency and danger of CDTI fixations. Pilots should employ an efficient, effective, systematic CDTI scan pattern that avoids fixations.	1) CDTI training shall *warn* the flight crew of the tendency for and dangers of fixating on one area of the CDTI. 2) CDTI procedures shall *recommend or specify* a *systematic* display scan pattern that covers the entire display each cycle and which cycle is completed in no more than *C* seconds.
A2532	Locate traffic symbols on CDTI	Stress performance influence	Tendency for stress to improve performance when arousal is low, but to decrease performance when arousal is already high.	Stressors present.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Flight crew CDTI traffic detection performance is very susceptible to stress and other factors and deteriorates as a result of their presence.	“Overdesign” CDTI to allow for effects of stress.	CDTI flight crew interface *design parameters* should exceed *minimum values* to compensate for performance effects of stress.

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Flight crew CDTI traffic detection performance is very susceptible to stress and other factors and deteriorates as a result of their presence.	“Overdesign” CDTI to allow for effects of stress.	CDTI flight crew interface *design parameters* should exceed *minimum values* to compensate for performance effects of stress.
A2532	Locate traffic symbols on CDTI	Sensitivity suboptimality	Tendency for operators to miss signals because of difficulty in discriminating signals from noise.	HSI/CDTI traffic symbols not distinct for other symbols.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Flight crew CDTI traffic detection performance is very susceptible to stress and other factors and deteriorates as a result of their presence.	Reduce HSI/CDTI noise. Train FC in the correct dynamic interpretation of traffic symbols.	Flight crews shall be formally trained to use the CDTI to *accurately* and *quickly* detect traffic in *realistic*, simulated traffic scenarios.
A2532	Locate traffic symbols on CDTI	Sluggish beta	Tendency for operators engaged in variable signal detection tasks to adjust beta (their decision response criterion) less than is required for optimal performance.	CDTI background changes due to different configs, changing conditions	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Flight crews do not adjust their CDTI traffic detection thresholds sufficiently as the HSI/CDTI display changes due to varying conditions and, as a result,performance suffers.	Train pilots to detect traffic symbols in realistic traffic & display conditions. Train FCs to adjust payoffs and probabilities, based on on circumstances (e.g., self-separation authority).	Flight crews shall be formally trained to use the CDTI to *accurately* and *quickly* detect traffic in *realistic*, simulated traffic scenarios.
A2532	Locate traffic symbols on CDTI	Sampling Bias (Unexpected events)	Tendency for the scanning behavior of operators to be driven by their expectations, causing unexpected events to be missed.	Pop-up traffic appears.	Miss: FC scan diverted to one area of CDTI, misses traffic in another.	Loss of separation.	5	4	5	100	Flight crews' CDTI scanning strategies are ineffective and inefficient.	Provide CDTI cue for traffic (especially fast-closing, co-altitude) that is about to come into display range when display range is small.	The CDTI shall present a cue of *intermediate salience* to call the flight crew's attention to traffic on a *persistently converging* path with ownship that is about to enter the traffic display area when the CDTI display range is *small*.
A2532	Locate traffic symbols on CDTI	Equipment design effect	Tendency for the design of equipment to influence the frequency and type of human information processing errors.	Poor HSI/CDTI design.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Poorly designed situation displays make it difficult for flight crews to locate information quickly and accurately.	When CDTI is not active, alert FC to nearby, fast-closing, co-altitude traffic.	When the CDTI is not being displayed to the flight crew, other means shall be provided to advise the flight crew of intermediate and high priority traffic.

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	CDTI tasks poorly designed.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.	Train pilots for effective, efficient CDTI use.	Flight crews shall be formally trained to use the CDTI to *accurately* and *quickly* detect traffic in *realistic*, simulated traffic scenarios.
A2532	Locate traffic symbols on CDTI	various		HSI/CDTI configuration suboptimal.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	Suboptimal configuration of situation displays decreases flight crew performance in locating information on them.	Train FC to select optimal CDTI configuration.	Flight crews shall be trained to determine and select *optimal* CDTI configurations for *representative* situations.
A2532	Locate traffic symbols on CDTI	various		CDTI range set too large.	Miss: FC misses near traffic because its symbol is obscured by dense symbology.	Loss of separation.	5	4	5	100	Suboptimal configuration of situation displays decreases flight crew performance in locating information on them.	Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.

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	Human Fallibility	**Human Fallibility Definition**	**Other Contributing Factor(s)**	**Potential Failure Mode**	**Potential Effects of Failure Mode**	**Severity**	**Probability**	**Nondetectability**	**RPN**	**General Issues**	**Potential Remediations**	**Design Requirements**
A2532 Locate traffic symbols on CDTI	Sampling Bias (Saliency)	Tendency for visual attention to be drawn to items that are large, bright, colorful, changing, or that abruptly appear.	Salient stimulus, irrelevant to traffic, on HSI or elsewhere in visual field.	Miss: FC fixates on one region of CDTI, misses other traffic.	Loss of separation.	5	4	5	100	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.	CDTI should use salience coding sparingly and wisely. Traffic symbol coding should be designed so as not to introduce unintended salience variations.	1) CDTI traffic symbols shall be *visually coded* to represent three levels of traffic priority: normal (traffic whose trajectories are not projected to conflict with that of ownship), intermediate (traffic whose projected trajectories conflict with that of ownship, but whose estimated times to contact with ownship are at least *C* minutes), and high (traffic whose projected trajectories conflict with that of ownship and whose estimated times to contact with ownship are less than *C* minutes). 2) CDTI traffic symbol visual coding, for whatever purpose, shall manifest exactly three levels of salience corresponding to the three levels of traffic priority: low for the symbols of normal priority traffic, medium for symbols of intermediate priority traffic, and high for symbols of high priority traffic. 3) Regardless of intended meaning, CDTI traffic symbols shall be visually *coded* so as not to introduce unintended *variations* in symbol salience.

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Sampling Bias (Detail fixation)	Tendency for operators scanning a picture during a visual search to fixate on the areas with the most information or detail.		Miss: FC fixates on one region of CDTI, misses other traffic.	Loss of separation.	5	4	5	100	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.	Pilots must be aware of the tendency and danger of CDTI fixations. Pilots should employ an efficient, effective, systematic CDTI scan pattern that avoids fixations.	1) CDTI training shall *warn* the flight crew of the tendency for and dangers of fixating on one area of the CDTI. 2) CDTI procedures shall *recommend or specify* a *systematic* display scan pattern that covers the entire display each cycle and which cycle is completed in no more than *C* seconds.
A2532	Locate traffic symbols on CDTI	Stress-induced perceptual tunneling	Tendency for stress to cause operators to process a smaller range of information, effectively narrowing their attention.	Stressors present.	Miss: FC focuses scan on smaller area, misses traffic.	Loss of separation.	5	4	5	100	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.	Provide CDTI cue for fast-closing, co-altitude traffic that is near the periphery of the display range when display range is small.	The CDTI shall present a cue of *intermediate salience* to call the flight crew's attention to traffic near the periphery of the traffic display area that is on a *persistently converging* path with ownship when the CDTI display range is *small*.
A2532	Locate traffic symbols on CDTI	Vigilance decrement (fatigue)	Tendencyfor operator performance to degrade during vigilance tasks as a result of fatigue or reduced arousal.	Long periods of self-separation authority.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	The flight crew's CDTI traffic detection performance decreases over long periods of self-separation authority.	After long period of FC self-separation authority, ANSP should give advance warning of closing traffic.	After *long* periods of flight crew self-separation authority, the ANSP should advise flight crew of potentially conflicting traffic.
A2532	Locate traffic symbols on CDTI	Vigilance Decrement (sensitivity decrement)	Tendency for operator performance to degrade during vigilance tasks as a result of a decrease in sensitivity level.	Long periods of self-separation authority.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	The flight crew's CDTI traffic detection performance decreases over long periods of self-separation authority.	After long period of FC self-separation authority, ANSP should give advance warning of closing traffic.	After *long* periods of flight crew self-separation authority, the ANSP should advise flight crew of potentially conflicting traffic.
A2532	Locate traffic symbols on CDTI	Vigilance Decrement (shift in beta)	Tendency for operator performance to degrade during vigilance tasks as a result of a shift in the response criterion away from the optimal level.	Long periods of self-separation authority.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	4	5	100	The flight crew's CDTI traffic detection performance decreases over long periods of self-separation authority.	After long period of FC self-separation authority, ANSP should give advance warning of closing traffic.	After *long* periods of flight crew self-separation authority, the ANSP should advise flight crew of potentially conflicting traffic.

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Activity		Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Local processing bias	Tendency for operators to utilize more cognitive resources when processing local stimuli than when processing global stimuli.		Mistake: FC focuses on one traffic rather than comprehending total traffic picture.	Misses traffic, loss of separation.	5	4	4	80	???		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Visual Arrangement)	Tendency for operators to use simplified heuristics when visually sampling information channels, resulting in systematic biases in performance.	Complex traffic symbology: many different shapes, colors, etc.	Mistake: FC's CDTI scan pattern is ineffective, inefficient.	Misses traffic, loss of separation.	4	4	5	80	Flight crews' CDTI scanning strategies are ineffective and inefficient.		
A2532	Locate traffic symbols on CDTI	various		CDTI range set too small.	Miss: FC misses distant traffic because it is off-screen.	Loss of separation.	5	4	4	80	Suboptimal configuration of situation displays decreases flight crew performance in locating information on them.		
A2532	Locate traffic symbols on CDTI	Beta placement bias (individual)	Tendency for operators to be either inherently risky or conservative in the setting of their response criterion independent of the system probabilities and payoffs that determine the optimal beta.		Miss: FC misses traffic on CDTI.	Loss of separation.	5	3	5	75	???		
A2532	Locate traffic symbols on CDTI	Color integration	Tendency for display elements of the same color to be integrated, even if they are spatially disparate.	Traffic symbols same color.	Miss: FC misses traffic symbol because it is identified with a non-traffic symbol of the same color.	Loss of separation.	5	3	5	75	Situation displays are poorly color coded, leading to interpretation errors.		
A2532	Locate traffic symbols on CDTI	Fixation (single channel)	Tendency for operators (especially inexperienced operators) in high-workload situations to fixate on the information channel they perceive to be most important, potential ignoring other critical cues.	Traffic expected in specific region of CDTI.	Miss: FC fixates on one region of CDTI, misses other traffic.	Loss of separation.	5	3	5	75	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.		
A2532	Locate traffic symbols on CDTI	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	Miss: FC misses traffic due to stress distraction.	Loss of separation.	5	3	5	75	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Sampling bias (Mental Model)	Tendency for operators to sample information based on their subjective conception of the probability and importance of events occurring in each channel, and the correlation between events in different channels.	Traffic expected in specific region of CDTI.	Miss: FC fixates on one region of CDTI, misses other traffic.	Loss of separation.	5	3	5	75	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Highlighting)	Tendency for highlighting to capture operator attention.	Irrelevant highlighting of some symbols.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	3	5	75	The flight crew's CDTI traffic scan is easily disrupted by salient stimuli internal and external to the task and to other distractions, and performance can suffer as a result.		
A2532	Locate traffic symbols on CDTI	Sluggish sampling rate adjustment	Tendency for operators engaged in sampling tasks to adjust their sampling rate less than is required for optimal performance based on changes in the actual frequency of target events.	AC enters region of lower traffic density.	Mistake: FC scans CDTI more often than necessary.	Preoccupation with scan interferes with performance of other tasks.	3	4	5	60	Flight crews do not adjust their CDTI traffic detection thresholds sufficiently as the HSI/CDTI display changes due to varying conditions and, as a result,performance suffers.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Imperfect Memory)	Tendency for operators to engage in imperfect sampling because of their inability to remember the frequency with which they have sampled information sources and the status of the information source when it was last sampled.		Mistake: FC's CDTI scan pattern is ineffective, inefficient.	Misses traffic, loss of separation.	4	3	5	60	Flight crews' CDTI scanning strategies are ineffective and inefficient.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Target cueing validity)	Tendency for detection response times and misses to increase when cues are inaccurate and unexpected targets appear.	Pop-up traffic appears.	Miss: FC misses traffic on CDTI.	Loss of separation.	5	2	5	50	Flight crews do not receive enough advance warning of new traffic.		
A2532	Locate traffic symbols on CDTI	Color integration	Tendency for display elements of the same color to be integrated, even if they are spatially disparate.	Traffic symbols same color.	Miss: FC misses traffic symbol because it is identified with another of the same color.	Loss of separation.	5	2	5	50	Situation displays are poorly color coded, leading to interpretation errors.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Sluggish sampling rate adjustment	Tendency for operators engaged in sampling tasks to adjust their sampling rate less than is required for optimal performance based on changes in the actual frequency of target events.	AC enters region of higher traffic density.	Mistake: FC does not scan CDTI often enough.	Misses traffic, loss of separation.	4	3	4	48	Flight crews do not adjust their CDTI traffic detection thresholds sufficiently as the HSI/CDTI display changes due to varying conditions and, as a result,performance suffers.		
A2532	Locate traffic symbols on CDTI	Equipment design effect	Tendency for the design of equipment to influence the frequency and type of human information processing errors.	Poor HSI/CDTI design.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	4	4	48	Poorly designed situation displays make it difficult for flight crews to locate information quickly and accurately.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (dwell length)	Tendency for dwell length to increase as the information content increases and as the difficulty of information extraction increases.	CDTI presents much info with each traffic symbol and/or presents it poorly.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	4	4	48	Situation displays present too much less important information, increasing the amount of time the flight crew needs to view them to locate more important information		
A2532	Locate traffic symbols on CDTI	Sluggish beta	Tendency for operators engaged in variable signal detection tasks to adjust beta (their decision response criterion) less than is required for optimal performance.	CDTI background changes due to different configs, changing conditions	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	5	40	Flight crews do not adjust their CDTI traffic detection thresholds sufficiently as the HSI/CDTI display changes due to varying conditions and, as a result,performance suffers.		
A2532	Locate traffic symbols on CDTI	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	CDTI tasks poorly designed.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	3	4	36	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2532	Locate traffic symbols on CDTI	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	4	3	36	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.		
A2532	Locate traffic symbols on CDTI	Stress-induced perceptual tunneling	Tendency for stress to cause operators to process a smaller range of information, effectively narrowing their attention.	Stressors present.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	3	4	36	The effectiveness and efficiency of the flight crew's CDTI traffic scan is very susceptible to stress and other performance-shaping factors and performance can suffer as a result.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Sampling Bias (diminishing returns)	Tendency for inspection accuracy to increase at a decreasing rate as the search time increases.	Complex, busy, HSI/CDTI.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	4	32	???		
A2532	Locate traffic symbols on CDTI	Stress performance influence	Tendency for stress to improve performance when arousal is low, but to decrease performance when arousal is already high.	Stressors present.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	4	32	Flight crew CDTI traffic detection performance is very susceptible to stress and other factors and deteriorates as a result of their presence.		
A2532	Locate traffic symbols on CDTI	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Environmental stressors present.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	4	32	Flight crew CDTI traffic detection performance is very susceptible to stress and other factors and deteriorates as a result of their presence.		
A2532	Locate traffic symbols on CDTI	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.	CDTI tasks poorly designed.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	4	32	Some flight deck tasks are poorly designed with respect to scope, equipment, procedures, etc. and the flight crew is unable to perform them well.		
A2532	Locate traffic symbols on CDTI	Beta placement bias (individual)	Tendency for operators to be either inherently risky or conservative in the setting of their response criterion independent of the system probabilities and payoffs that determine the optimal beta.		False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	3	5	30	???		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Limited Useful Field of View-UFOV)	Tendency for the small size of the useful field of view (UFOV) to increase scan time. UFOV varies from 1 to 4 degrees.		Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	2	4	24	???		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2532	Locate traffic symbols on CDTI	Sampling Bias (Target cueing validity)	Tendency for detection response times and misses to increase when cues are inaccurate and unexpected targets appear.	Pop-up traffic appears.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	2	4	24	Flight crews do not receive enough advance warning of new traffic.		
A2532	Locate traffic symbols on CDTI	Equipment design effect	Tendency for the design of equipment to influence the frequency and type of human information processing errors.	Poor HSI/CDTI design.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	3	24	Poorly designed situation displays make it difficult for flight crews to locate information quickly and accurately.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (Singletons)	Tendency for unique stimuli to capture operator attention and increase the time it takes to find other targets.	Unique stimulus on CDTI.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	2	4	24	The flight crew's CDTI traffic scan is easily disrupted by salient stimuli internal and external to the task and to other distractions, and performance can suffer as a result.		
A2532	Locate traffic symbols on CDTI	Sampling Bias (diminishing returns)	Tendency for inspection accuracy to increase at a decreasing rate as the search time increases.	Complex, busy, HSI/CDTI.	Miss: FC misses traffic on CDTI.	Loss of separation.				0	???		
A2532	Locate traffic symbols on CDTI	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.		???					0			
A2532	Locate traffic symbols on CDTI	Sampling Bias (Cue processing)	Tendency for operators to process peripheral cues using fewer cognitive resources that central cues.		???					0			
A2532	Locate traffic symbols on CDTI	Expertise-based stress coping	Tendency for more experienced and skilled operators to perform better under stressful conditions than less skilled operators.		???					0			

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A2532	Locate traffic symbols on CDTI	Beta placement bias (expertise)	Tendency for experts to use lower response criterion settings than trainees, possibly because their expertise makes them more confident in their ability to identify a signal and take the appropriate action.		???					0			
A2532	Locate traffic symbols on CDTI	Sampling Bias (Stimulus-onset asynchrony)	Tendency for target detection accuracy to decrease as the stimulus-onset asynchrony between cues and the appearance of the target decreases.		???					0			
A2532	Locate traffic symbols on CDTI	Response conflict	Tendency for focused processing of local aspects of stimuli to be disrupted by conflicting global aspects of stimuli presented in close proximity.		???					0			
A2532	Locate traffic symbols on CDTI	Error correction training effect	Tendency for practice and training in identifying and correcting errors to improve operator performance.		???					0			
A2532	Locate traffic symbols on CDTI	Sampling Bias (Cue memory)	Tendency for the attention-directing effects of central cues to be longer lasting that those of peripheral cues.		???					0			
A2532	Locate traffic symbols on CDTI	Stress-induced working memory degradation	Tendency for stress to capture operator attention, thereby decreasing the mental resources available to and disrupting the function of working memory.	Stressors present.	???					0			
A2532	Locate traffic symbols on CDTI	Color automaticity	Tendency for color to be processed automatically or concurrently with other stimuli.		???					0			
A2532	Locate traffic symbols on CDTI	Color continuum ambiguity	Tendency for people to disagree in their interpretation of how color should be ordered in a continuum.		???					0			

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A2532	Locate traffic symbols on CDTI	Sampling bias (Cueing modality conflict)	Tendency for visual cues to dominate if the target is visual and for auditory cues to dominate if the target is auditory, when visual and auditory cues conflict.		???					0			
A2532	Locate traffic symbols on CDTI	Stress interaction effects	Tendency for stressors to interact with one another in ways that either amplify or reduce their total influence on performance.		redundant					0			
A2532	Locate traffic symbols on CDTI	Sampling Bias (Search time)	Tendency for characteristics of the targets and search environment to affect operator search time.		redundant					0			
A2532	Locate traffic symbols on CDTI	Sampling Bias (Depth cueing)	Tendency for operators to identify targets more quickly when the cue and target are presented at the same depth than when they are presented at different depths.		???					0			
A2532	Locate traffic symbols on CDTI	Stress training effect	Tendency for stress inoculation training and stress exposure training to improve operators performance under stress.		???					0			
A2532	Locate traffic symbols on CDTI	Global precedence bias	Tendency for response conflict to be asymmetrical in that global, holistic, or emergent aspects of stimuli interfere with the processing of local stimuli, but the reverse is not true.		???					0			
A2532	Locate traffic symbols on CDTI	Color stereotypes	Tendency for colors to be strongly associated with symbolic meanings, impairing display interpretation if colors in the display are not coded consistently with operators' expectations of their meaning.		???					0			

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A2533	Select traffic for detailed info	Working memory duration	Operators usually retain little information in working memory after 10 to 15 seconds if they are not able to continually rehearse the information.		lapse: FC is distracted and forgets to designate intended traffic.	Info on important traffic overlooked, loss of separation	4	4	5	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Working memory code disruption	Environmental stimuli is more likely to degrade task performance if it is the same code (phonetic or spatial) as the task being performed.		lapse: FC is distracted and forgets to designate intended traffic.	Info on important traffic overlooked, loss of separation	4	4	5	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Working memory capacity	The normal maximum capacity of working memory is 5 to 9 chunks of information when attention is fully allocated.		lapse: FC is distracted and forgets to designate intended traffic.	Info on important traffic overlooked, loss of separation	4	4	5	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Central executive limitations	Tendency for tasks that employ the central executive component of working memory to be time-shared less effectively than tasks that employ different working memory codes.		lapse: FC is distracted and forgets to designate intended traffic.	Info on important traffic overlooked, loss of separation	4	4	5	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Retroactive memory interference	Tendency for information received after the target stimuli to disrupt the recall of the target stimuli.		mistake: FC is distracted and designates wrong traffic.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	4	64	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Working memory capacity	The normal maximum capacity of working memory is 5 to 9 chunks of information when attention is fully allocated.		mistake: FC is distracted and designates wrong traffic.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	4	64	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Working memory duration	Operators usually retain little information in working memory after 10 to 15 seconds if they are not able to continually rehearse the information.		mistake: FC is distracted and designates wrong traffic.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	4	64	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.

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A2533	Select traffic for detailed info	Proactive memory interference	Tendency for information received before the target stimuli to disrupt the recall of the target stimuli.		mistake: FC is distracted and designates wrong traffic.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	4	64	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2533	Select traffic for detailed info	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	Traffic designation protocol different from that of similar devices.	mistake: FC forgets which traffic to designate, then designates another.	Info on important traffic overlooked, loss of separation	4	4	4	64	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.	If interfaces of CDTIs of different models/manufacturers are different at all, they should be distinctly different.	The means by which flight crews designate a traffic symbol for the display of detailed information on that traffic should be *standardized* across models and manufacturers.
A2533	Select traffic for detailed info	Display modality compatibility	Displays are usually more effective if they display information using the same working memory modality (verbal or spatial) that is used during the task.	Display uses verbal (alphanumeric) coding for spatial information.	slip: FC designation action goes awry and designates traffic symbol other than that intended, or non-traffic symbol.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	5	3	60	The design of flight deck equipment interfaces does not map well to the flight deck task procedures which use that equipment and therefore leads to delays and errors.	Means for selecting/designating traffic symbol for detailed info should be compatible with way symbols are displayed.	A means for designating a CDTI traffic symbol for more information on the represented traffic than is displayed by default shall be provided that is spatially compatible with the means traffic is displayed on the traffic display area.

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Activity	Human Fallibilities Identification		Failure Modes & Effects Analysis							Issues Identification	Remediation & Requirements Development	
	Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2533 Select traffic for detailed info	Perceptual competition	Tendency for spatial proximity between stimuli to increase both the competition for processing resources and the probability of failures in focused attention.		slip: FC designation action goes awry and designates traffic symbol other than that intended, or non-traffic symbol.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	3	48	High information density on flight deck displays makes it difficult for flight crews to accurately distinguish, interpret, and act on information.	Make CDTI bigger. Provide declutter function. Train FCs to prioritize HSI info to minimize clutter. Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	1) The visual angles subtended by the traffic display area of the CDTI, when viewed from the flight crew's most distant eye reference point, shall be at least *X* degrees horizontal by *Y* degrees vertical. 2) The HSI/CDTI shall provide the flight crew with a “declutter” option that removes from the traffic display, or *significantly* reduces the salience of, all *non-traffic-related* symbology for a period of *P* seconds. 3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.

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A2533	Select traffic for detailed info	Response conflict	Tendency for focused processing of local aspects of stimuli to be disrupted by conflicting global aspects of stimuli presented in close proximity.	Nearby traffic symbol draws FC focus away from intended traffic.	slip: FC designation action goes awry and designates traffic symbol other than that intended, or non-traffic symbol.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	3	48	High information density on flight deck displays makes it difficult for flight crews to accurately distinguish, interpret, and act on information.	Make CDTI bigger. Provide declutter function. Train FCs to prioritize HSI info to minimize clutter. Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	1) The visual angles subtended by the traffic display area of the CDTI, when viewed from the flight crew's most distant eye reference point, shall be at least *X* degrees horizontal by *Y* degrees vertical. 2) The HSI/CDTI shall provide the flight crew with a “declutter” option that removes from the traffic display, or *significantly* reduces the salience of, all *non-traffic-related* symbology for a period of *P* seconds. 3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.
A2533	Select traffic for detailed info	Working memory code limitations	Tendency for tasks that employ the same type of working memory resources to be time-shared less effectively than task that employ different working memory codes.		mistake: FC forgets which traffic to designate, then designates another.	Info on important traffic overlooked, loss of separation	4	3	4	48	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2533	Select traffic for detailed info	various		Vibration, acceleration due to turbulence, etc.)	slip: FC designation action goes awry and designates traffic symbol other than that intended, or non-traffic symbol.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	5	2	40	Flight deck controls are not designed to compensate for vibration and acceleration, increasing the likelihood of slips and other inadvertent operation.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2533	Select traffic for detailed info	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	Traffic designation protocol different from that of similar devices.	slip: FC designation action goes awry and designates traffic symbol other than that intended, or non-traffic symbol.	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	5	2	40	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2533	Select traffic for detailed info	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	Traffic designation protocol different from that of similar devices.	delay: FC takes too long to designate traffic.	Delays performance of other critical task.	3	4	3	36	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2533	Select traffic for detailed info	various		Vibration, acceleration due to turbulence, etc.)	slip: FC designation action is not forceful enough and fails to designate anything	FC misinterprets info, develops erroneous MM, loss of separation occurs.	4	4	2	32	Flight deck control actions do not provide adequate feedback, leading to lack of flight crew awareness and poor performance.		
A2533	Select traffic for detailed info	various		Poor control/display ratio; etc.	delay: FC takes too long to designate traffic.	Delays performance of other critical task.	3	3	3	27	Poor design of flight deck controls results in delayed flight crew inputs.		
A2533	Select traffic for detailed info	Simple reaction stimulus intensity bias	Tendency for simple reaction time (the subject has one response to make as soon as a stimulus occurs) to decrease with increases in intensity of the stimulus to an asymptotic value.	Traffic symbols not significantly more salient than background.	delay: FC takes too long to designate traffic.	Delays performance of other critical task.	3	3	3	27	The salience of information on flight deck displays is uncorrelated with its importance and urgency in context and therefore flight crews overlook high priority information and are distracted by low priority information.		
A2533	Select traffic for detailed info	Auditory display memory	Operators tend to retain visual display information in working memory less effectively than auditory information.		???					0	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.		
A2533	Select traffic for detailed info	Expertise chunking facilitation	Tendency for expertise to facilitate chunking. As a result experts can perceive and store a large quantity of information more quickly than novices.		???					0			

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A2533	Select traffic for detailed info	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.		???					0			
A2533	Select traffic for detailed info	Skilled memory advantage	Tendency for experts to use long-term working memory to quickly encode information in a durable and easily accessible form.		???					0			
A2533	Select traffic for detailed info	Temporal uncertainty reaction delay	Tendency for reaction to time to decrease as the predictability of when the stimulus will occur increases.		???					0			
A2533	Select traffic for detailed info	Local processing bias	Tendency for operators to utilize more cognitive resources when processing local stimuli than when processing global stimuli.		???					0			
A2533	Select traffic for detailed info	Global precedence bias	Tendency for response conflict to be asymmetrical in that global, holistic, or emergent aspects of stimuli interfere with the processing of local stimuli, but the reverse is not true.		???					0			
A2533	Select traffic for detailed info	Simple reaction stimuli bias	Tendency for simple reaction time (the subject has one response to make as soon as a stimulus occurs) to be 30 to 50 milliseconds faster for auditory stimuli than for visual stimuli.		???					0			
A2533	Select traffic for detailed info	Task-response dichotomy	Tendency for performance to improve when different working memory codes underlie task and response.		???					0			

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A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Saliency bias	Tendency for the salience of a cue to influence the extent to which operators attend to and weigh the information it contains during decision making.	CDTI traffic symbols differ in salience.	MM error: FC's attention drawn away from traffic symbol, fails to estimate bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	5	125	The salience of information on flight deck displays is uncorrelated with its importance and urgency in context and therefore flight crews overlook high priority information and are distracted by low priority information.	CDTI should use salience coding sparingly and wisely. Traffic symbol coding should be designed so as not to introduce unintended salience variations.	1) CDTI traffic symbols shall be *visually coded* to represent three levels of traffic priority: normal (traffic whose trajectories are not projected to conflict with that of ownship), intermediate (traffic whose projected trajectories conflict with that of ownship, but whose estimated times to contact with ownship are at least *C* minutes), and high (traffic whose projected trajectories conflict with that of ownship and whose estimated times to contact with ownship are less than *C* minutes). 2) CDTI traffic symbol visual coding, for whatever purpose, shall manifest exactly three levels of salience corresponding to the three levels of traffic priority: low for the symbols of normal priority traffic, medium for symbols of intermediate priority traffic, and high for symbols of high priority traffic. 3) Regardless of intended meaning, CDTI traffic symbols shall be visually *coded* so as not to introduce unintended *variations* in symbol salience.

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Suboptimal resource allocation	Tendency for operators to allocate too many mental resources to automatic or data-limited tasks, resulting in suboptimal performance in time-sharing environments.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	CDTI should provide more info to help FC detect threats, e.g., (relative) tracks or 0-bearing-rate cues).	In conditions of self-separation authority, the CDTI shall give the flight crew the option to display ground tracks of ownship and traffic on *converging* paths.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stage-defined resource effect	Tendency for tasks that require either perceptual processing or working memory to be more effectively time-shared with tasks that require either action selection or execution than with tasks that require the same resources.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	CDTI traffic scan should not be concurrent with other tasks requiring same resources (esp. visual). CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Bottleneck effect	Inability of operators to perform two action-selection or decision-making tasks concurrently, and for performance to decrease when resource-intensive tasks must be time-shared.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	CDTI traffic scan should not be concurrent with other tasks requiring same resources (esp. visual). CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Resource allocation trade-off	Tendency for investing more mental resources into the performance of one task to cause a performance decline in other tasks being performed concurrently.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	CDTI traffic scan should not be concurrent with other tasks requiring same resources (esp. visual). CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Intramodality performance decrement	Tendency for time-sharing performance between two tasks of the same modality (visual or auditory) to be poorer than cross-modal time-sharing.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Attempting to perform two or more tasks that require the same mental resources concurrently causes the performance of at least one of them to be diminished,	CDTI traffic scan should not be concurrent with other tasks requiring same resources (esp. visual). CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.

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	Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Perceptual competition	Tendency for spatial proximity between stimuli to increase both the competition for processing resources and the probability of failures in focused attention.	High symbol density on HSI/CDTI	MM error: FC confuses two CDTI traffic symbols, mis-estimates bearing/range/altitude/trajectory of one or both.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	5	100	High information density on flight deck displays makes it difficult for flight crews to accurately distinguish, interpret, and act on information.	Make CDTI bigger. Provide declutter function. Train FCs to prioritize HSI info to minimize clutter. Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	1) The visual angles subtended by the traffic display area of the CDTI, when viewed from the flight crew's most distant eye reference point, shall be at least *X* degrees horizontal by *Y* degrees vertical. 2) The HSI/CDTI shall provide the flight crew with a “declutter” option that removes from the traffic display, or *significantly* reduces the salience of, all *non-traffic-related* symbology for a period of *P* seconds. 3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.

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A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Data-ink distraction	Tendency for unnecessary visual elements (graphical elements that don't contain data) to reduce the accuracy and speed of judgment.	High symbol density on HSI/CDTI	MM error: FC confuses two CDTI traffic symbols, mis-estimates bearing/range/altitude/trajectory of one or both.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	5	100	High information density on flight deck displays makes it difficult for flight crews to accurately distinguish, interpret, and act on information.	Make CDTI bigger. Provide declutter function. Train FCs to prioritize HSI info to minimize clutter. Provide temporary zoom-in, or zoomed-in supplementary display) to disambiguate traffic.	1) The visual angles subtended by the traffic display area of the CDTI, when viewed from the flight crew's most distant eye reference point, shall be at least *X* degrees horizontal by *Y* degrees vertical. 2) The HSI/CDTI shall provide the flight crew with a “declutter” option that removes from the traffic display, or *significantly* reduces the salience of, all *non-traffic-related* symbology for a period of *P* seconds. 3) The CDTI shall allow the flight crew to switch to and from a a “zoomed-in” (shorter range) display scale setting by means of a single action. 4) The CDTI's “zoomed-in” (shorter range) display scale setting shall be selectable by the flight crew in-flight.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress-induced perceptual tunneling	Tendency for stress to cause operators to process a smaller range of information, effectively narrowing their attention.	Stressors present.	MM error: FC's attention focuses on subset of symbols, fails to estimate bearing/range/altitude/trajectory of others.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	5	100	Some flight deck displays are not designed so as to offset the performance effects of stress, so flight crews are susceptible to them.	Provide CDTI cue for fast-closing, co-altitude traffic that is near the periphery of the display range when display range is small.	The CDTI shall present a cue of *intermediate salience* to call the flight crew's attention to traffic near the periphery of the traffic display area that is on a *persistently converging* path with ownship when the CDTI display range is *small*.

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Processing code resource conflict	Tendency for tasks to be time shared more efficiently when they utilize different processing codes (i.e. spatial or verbal processes).	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	Tasks that are commonly performed concurrently often rely predominantly on one type of processing code, e.g., spatial or verbal, leading to diminished task performance.	CDTI traffic scan should not be concurrent with other tasks requiring same resources (esp. visual). CTM training.	NextGen flight crews shall receive concurrent task management training, including *TBD*.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Cognitive overload decision failures	Tendency for operators to make suboptimal decisions because their capacity to aggregate evidence, evaluate hypotheses, and choose actions is overburdened.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.	Train FCs to recognize susceptibility to and countermeasures for cognitive biases.	Flight crews shall be trained to recognize their susceptibility to and countermeasures for cognitive biases.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress-induced distraction	Tendency for certain stressors to divert operator attention away from the task performance.	Stressors present.	MM error: FC's attention drawn away from traffic symbol, fails to estimate bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	5	100	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to distractions and therefore prone to delays and errors.	“Overdesign” CDTI to allow for effects of stress.	CDTI flight crew interface *design parameters* should exceed *minimum values* to compensate for performance effects of stress.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress performance influence	Tendency for stress to improve performance when arousal is low, but to decrease performance when arousal is already high.	Stressors present.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.	“Overdesign” CDTI to allow for effects of stress.	CDTI flight crew interface *design parameters* should exceed *minimum values* to compensate for performance effects of stress.
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Environmental stressor effect	Tendency for environmental stressors such as noise, temperature, vibration, lighting, acceleration, and air/water pressure to degrade performance.	Stressors present.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	5	4	100	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to stressors and therefore prone to delays and errors.	“Overdesign” CDTI to allow for effects of stress.	CDTI flight crew interface *design parameters* should exceed *minimum values* to compensate for performance effects of stress.

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A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Situation awareness limitations	Maintaining accurate awareness of an evolving situation is resource intensive and can be degraded by the concurrent performance of other resource intensive working memory tasks.	Other high-priority, concurrent tasks/stimuli.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	Situation displays are poorly designed, resulting in erroneous flight crew interpretations.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Availability heuristic	Tendency for operators to consider the hypothesis which can be most easily accessed in memory.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Confirmation bias	Tendency for operators to seek information that confirms their current hypothesis and to disregard or undervalue information that does not confirm the hypothesis.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Anchoring Heuristic	Tendency for operators to favor their original hypotheses, and to undervalue subsequent information that may support other hypotheses.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Representativeness heuristic	Tendency for operators to choose a hypothesis or diagnose a situation by comparing the available evidence to characteristics that are representative of familiar hypotheses.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Framing effect	Tendency for the level of risk aversion displayed by operators to be influenced by whether the risk is framed as a potential loss or a potential gain.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Recency bias	Tendency for operators to overvalue information that they received recently when choosing and evaluating hypotheses.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Overconfidence bias	Tendency for operators to be overconfident in their state of knowledge or the accuracy of their beliefs.		MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Working memory duration	Operators usually retain little information in working memory after 10 to 15 seconds if they are not able to continually rehearse the information.	Other high-priority, concurrent tasks/stimuli.	MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress-induced working memory degradation	Tendency for stress to capture operator attention, thereby decreasing the mental resources available to and disrupting the function of working memory.	Stressors present.	MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		

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A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Working memory capacity	The normal maximum capacity of working memory is 5 to 9 chunks of information when attention is fully allocated.	Other high-priority, concurrent tasks/stimuli.	MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Negative skill transfer	Tendency for skills acquired in one domain to inhibit performance in another when both situations have similar stimulus elements but require different responses.	CDTI display format, symbology differ from those of similar equipment.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	4	4	80	The lack of standardization of flight deck equipment interfaces within and across flight decks decreases flight crew performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Perseveration	Tendency for operators to continue with the same plans or actions longer than optimal under stressful conditions.		TM error: FC fixates on CDTI, fails to perform other high-priority tasks.	Other tasks ignored or performed poorly.	4	5	4	80	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Workload effect	Tendency for the subjective workload experienced by operators to influence task performance.	Other high-priority, concurrent tasks/stimuli.	TM error: FC fixates on CDTI, fails to perform other high-priority tasks.	Other tasks ignored or performed poorly.	4	5	4	80	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Strategic task-management bias	Tendency for operators to utilize suboptimal planning strategies for concurrent task management, especially when workload is high.	Other high-priority, concurrent tasks/stimuli.	TM error: FC fixates on CDTI, fails to perform other high-priority tasks.	Other tasks ignored or performed poorly.	4	5	4	80	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Inertia effect	Tendency for operators to continue performing a task longer than optimal in order to delay incurring mental cost of switching attention between tasks.	Other high-priority, concurrent tasks/stimuli.	TM error: FC fixates on CDTI, fails to perform other high-priority tasks.	Other tasks ignored or performed poorly.	4	5	4	80	The number and complexity of concurrent flight deck tasks makes task management difficult, which leads to distractions, interruptions, misprioritizations, perseverations, and other conditions that degrade flight crew situation awareness and performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Nonlinear trend extrapolation bias	Tendency for operators to skew their estimates of nonlinear trends towards a more linear extrapolation than is justified by the data.	CDTI does not display traffic tracks.	MM error: FC mis-perceives traffic trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	5	75	Flight deck displays do not effectively present history/trend information to facilitate flight crew projection of the current situation, so future projections are inaccurate.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Skilled memory advantage	Tendency for experts to use long-term working memory to quickly encode information in a durable and easily accessible form.		MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	???		

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		Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Dependency on display compatibility	Tendency for operators to perform less effectively when displays are not compatible with their information processing needs, mental models, and/or the physical system which the interface represents.	CDTI traffic symbology/coding not consistent with FC MM.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	Flight deck interfaces often violate compatibility principles, e.g, location, movement, stimulus-response, etc., diminishing flight crew performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stroop effect	Tendency for multiple dimensions of the same object to be processed in parallel, potentially hurting performance if some dimensions are irrelevant or conflicting.	Bad combination of coding for multidimensional traffic info.	MM error: FC misinterprets CDTI traffic info, mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	Object displays often utilize poor coding methods or combinations of methods, resulting in erroneous flight crew interpretations.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Expertise chunking facilitation	Tendency for expertise to facilitate chunking. As a result experts can perceive and store a large quantity of information more quickly than novices.		MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Retroactive memory interference	Tendency for information received after the target stimuli to disrupt the recall of the target stimuli.	Other high-priority, concurrent tasks/stimuli.	MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Proactive memory interference	Tendency for information received before the target stimuli to disrupt the recall of the target stimuli.	Other high-priority, concurrent tasks/stimuli.	MM error: FC forgets previous info for specific traffic and therefore mis-estimates trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	3	4	60	The complexity of flight deck equipment, tasks, and procedures places heavy demands on flight crew working memory, resulting in poor performance.		

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A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Recognition-prime decision making heuristic	Tendency for experts to recognize patterns of cues, and to make fast and relatively automatic diagnoses based on these familiar patterns.		MM error: FC hastily interpets “familiar” traffic pattern and mis-estimates bearing/range/altitude/trajectory.	Inaccurate perception and projection of traffic bearing/range/altitude/trajectory, loss of separation/spacing.	5	2	4	40	The complexity and tempo of flight deck operations makes the flight crew especially susceptible to cognitive biases and therefore prone to suboptimization and errors.		
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Error correction training effect	Tendency for practice and training in identifying and correcting errors to improve operator performance.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Personality-based stress coping	Tendency for operator personality to influence the adaptive strategies that will be employed to cope with stress.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Task design stressor effect	Tendency for characteristics of the task and system to exert stressful influences on operators and degrade performance.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress training effect	Tendency for stress inoculation training and stress exposure training to improve operators performance under stress.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Proximity compatibility	Tendency for performance to degrade when the level of information integration in the display does not match the level of integration necessary for the task.		???					0			

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A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Expertise-based stress coping	Tendency for more experienced and skilled operators to perform better under stressful conditions than less skilled operators.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Similarity-based task confusion	Tendency for the concurrent performance of tasks that are similar along certain dimensions but different or incompatible along other dimensions to result in interference and confusion.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress interaction effects	Tendency for stressors to interact with one another in ways that either amplify or reduce their total influence on performance.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Stress coping bias	Tendency for operators to select strategies to cope with stressful situations based on their subjective perception of the level of stress imposed by the situation.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Decision-making improvement failure	Tendency for general practice in decision-making to have no consistent effect on decision-making performance.		???					0			
A2534	Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Subjective workload disassociation	Tendency for operators' subjective evaluation of their workload to be biased by certain characteristics of the environment and/or task.		???					0			

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	Human Fallibility	Human Fallibility Definition	Other Contributing Factor(s)	Potential Failure Mode	Potential Effects of Failure Mode	Severity	Probability	Nondetectability	RPN	General Issues	Potential Remediations	Design Requirements
A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Excessive workload strategy	Tendency for operators to employ suboptimal task management strategies when the cognitive resources demanded by the task exceed the resources available to perform the task.		???					0			
A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Cue weighting heuristic	Tendency for operators to weigh all of the informational cues that they process equally when evaluating evidence.		???					0			
A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Display modality compatibility	Displays are usually more effective if they display information using the same working memory modality (verbal or spatial) that is used during the task.		???					0			
A2534 Determine traffic IDs, bearings, ranges, & relative altitudes from CDTI	Auditory display memory	Operators tend to retain visual display information in working memory less effectively than auditory information.		NA					0			
	various		HSI/CDTI configuration suboptimal.	Delay: CDTI scan is prolonged.	Delays performance of other critical task.	3	4	4	48	Suboptimal configuration of situation displays decreases flight crew performance in locating information on them.		
	various		HSI/CDTI configuration suboptimal.	False Alarm: FC identifies symbol/display feature as traffic on CDTI when it is not.	Unnecessary alarm (distraction), unnecessary alteration of 4DT, loss of separation with real threat.	2	4	4	32	Suboptimal configuration of situation displays decreases flight crew performance in locating information on them.		