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Applied Human Factors Research for the Technical Operations Organization of the Federal Aviation Administration

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APPLIED HUMAN FACTORS RESEARCH FOR THE TECHNICAL OPERATIONS ORGANIZATION OF THE FEDERAL AVIATION ADMINISTRATION

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The FAA is developing and implementing human factors standards within the Technical Operations domain of the Air Traffic Organization. TO personnel are responsible for installing, certifying, and maintaining NAS infrastructure and equipment. Application of standards within this domain is intended to improve human performance, contribute to the more efficient and effective maintenance of NAS systems, and facilitate the integration of human factors into operational systems. Over several decades, the FAA has independently and incrementally modernized TO systems leading to user-system interface diversity within and across systems and facilities. Based on human factors principles, TO requested that FAA human factors research develop human factors standards to create user-interface uniformity across TO systems. Based on a review of industry and academic literature from the aviation, nuclear, and communications domains, there is evidence that the application of standards may benefit training and human performance while potentially providing the Agency with noteworthy returns on investments.

The Federal Aviation Administration (FAA) Human Factors Division oversees the activities of the Air Traffic Control (ATC) / Technical Operations (TO) Human Factors Team. The Team is responsible for managing four research and development (R&D) portfolios that are driven by Destination 2025, the National Aviation Research Plan (NARP), the Air Traffic / Technical Operations Human Factors Strategic Research Plan, and the operational needs of internal FAA sponsoring organizations. Each R&D portfolio is composed of related requirements that aim towards improving a specific component of the National Airspace System (NAS). This paper details specific projects within the Advanced Technical Operations Systems (ATOS) R&D portfolio and the proposed benefits that may be achieved through the development and application of human factors standards within the TO domain of the Air Traffic Organization (ATO).

The Role of Technical Operations in the NAS and Shortfall Definition

The ATOS R&D portfolio aims to improve human factors contributions to the TO domain of the ATO. “The FAA TO Organization includes the centralized National Operations Control Center (NOCC), three regional Operations Control Centers (OCCs), Systems Operations Centers (SOCs) at Air Route Traffic Control Centers (ARTCCs) and large Terminal Radar Approach Controls (TRACON), and additional facilities at the local and regional level” (Chinoy

& Fischer, 2011). Within these facilities, TO personnel are responsible for the installation, certification, and maintenance of a wide variety of infrastructure, equipment, and systems. TO traditionally interacts with these systems through Graphical User Interfaces (GUI). When maintenance events are detected, coordination with, and prioritization of maintenance is determined by the local ATC facility prior to execution (Chinoy & Fischer, 2011).

Over several decades, the FAA has implemented independent, incremental improvements to TO systems. Documentation utilized by the FAA and system developers during those improvements addressed the incorporation of computer-human-interface design standards but did not bound a TO system developer to domain specific human factors standards—this resulted in complex and diverse graphical user interfaces within and across systems and facilities. "As a result, the likelihood of human error increased presenting the opportunity for unintended AT system outages and human performance inefficiencies" (FAA, 2012). In response to the identified shortfall, the FAA ATC/TO Human Factors Team and Technical Operations have partnered with industry to improve human factors requirements in system acquisitions. Among the products the partnership will develop and apply are the Graphical User Interface Standard, Graphical User Interface Style Guide, Technical Operations Maintenance Markings and Symbols Standard, and a Technical Operations Abbreviations Standard.

Due to the lack of uniformity and human performance data from legacy TO systems, this paper will propose human factors benefits and potential success criteria to be realized post-application of these human factors TO standards. The measures may be used to diagnose whether there is an opportunity to further improve performance, assess the effectiveness of the human factors solution, and determine whether there are opportunities for the community of practice to develop additional human factors interventions. Figure 1, below, provides a graphical overview of the proposed improvements, measures, and potential success.

The remainder of this document will further detail active research requirements for each of the aforementioned standards and corresponding literature review findings.

Figure 1. Human Performance Metrics

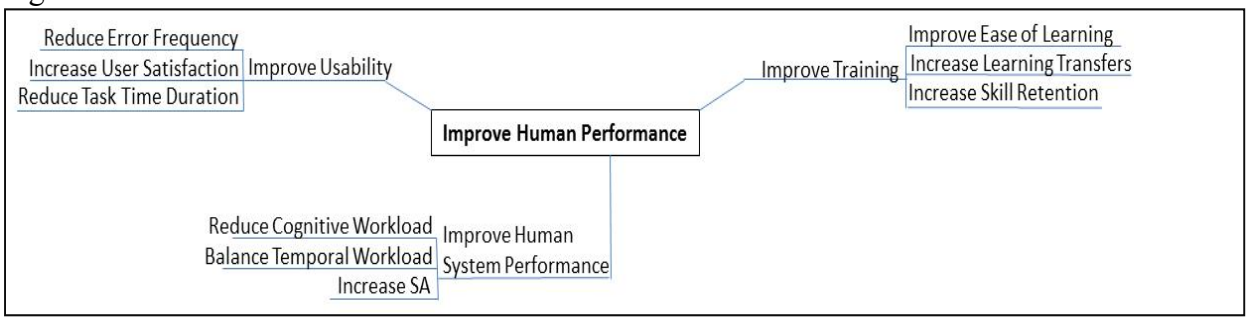

Figure 1 is a graphical overview of three main categories that support the improvement of Technical Operations human performance through the application of human factors standards. Each category (Improve Training, Improve Human System Performance, Improve Usability) are further defined by category specific measures. The measures associated with each category's success criteria are post product application goals that may be utilized to assess the need for future human factors interventions in TO. Figure 1 was adapted from the Task Performance and Human System Performance Metrics taxonomies (Pester-DeWan & Oonk, 2006).

Graphical User Interface Standard and Style Guide Requirement

Technical Operations is responsible for monitoring and controlling numerous NAS systems and equipment that directly influence air traffic system availability and NAS capacity through GUIs. TO has the ability to input information, receive information, and exert system control inputs through GUI interactions. These TO systems and their respective GUIs have been developed independently by different organizations. The independent and incremental development of these systems has created inconsistent user-system interfaces both within and across TO facilities. To prevent GUI inconsistencies during future system improvements or legacy technology replacement, the FAA has partnered with industry to develop a human factors TO GUI Standard.

Since it is critical that future system developers correctly apply the GUI Standard, the FAA has partnered with industry to develop a GUI Style Guide. The Style Guide shall link directly to the GUI Standard. The Style Guide is intended to eliminate any abstractions, ambiguity, or possible misapplication of the GUI Standard by developers. Application of both the Standard and Style Guide will ensure that future technologies in TO have a common look and feel to users.

Technical Operations Maintenance Markings and Symbol Standard

Symbols represent complex concepts in a succinct form that save space and are used to develop situational awareness in the performance of decision-making tasks. A user's understanding of the meaning of something is closely connected with the task goals of the individual. From idea to implementation, it is important that developers incorporate human factors best practices in symbol design as a barrier to unintended human performance outcomes. Designs and design trade-offs developed in the course of acquisition of information and display systems for use in the NAS must include the user's information requirements and decision-making authorities and responsibilities. Systems must not be implemented in a manner that exceeds the user's cognitive capabilities and limitations in the context of the decision-making tasks (Narkevicius, 2012).

Symbols must be crosscutting to be effective. Advances in system designs may modify the role of maintainers and reinforce the need to convey crosscutting concepts and information. Different maintenance roles will need to communicate system status and availability information across levels of the organization succinctly, accurately, and at the granularity necessary for action at each of those levels (Narkevicius, 2012).

With the intent to further integrate human factors into operations, the ATC/TO Human Factors Team is partnering with industry to develop a Technical Operations Symbol Standard. The standard will address the creation, use, structure, and content of symbols, icons, markings, legends, text, and any other constructs conveying information on TO displays. The published standard will be applied as a requirements document for FAA TO system acquisitions.

As future systems evolve, there may be developmental or new concepts that are not covered by the Technical Operations Symbol Standard. Therefore, it is important for consistency that the FAA have evaluative guidelines for the development and approval of new symbols within TO. The ATC/TO Human Factors Team is partnering with industry to create evidence based evaluative symbol guidelines. The guidelines will contain: best practices for symbol

design, defined criteria meriting the development of new symbols by vendors, as well as a formal vendor symbol application process and a formal approval process for TO.

Abbreviations Standard

Abbreviations are used on permanent markings, labels, and electronic displays on Technical Operations hardware and software. An abbreviation is a shortened version of a word or group of words formed by omitting one or more letters. In this paper, the authors use abbreviations as a collective term for acronyms, initialisms, contractions, and clippings. Regardless of the term used to identify the specific abbreviation, the shortened word or group of words is used on hardware and software to save space.

Lack of standardized Technical Operations abbreviations increases workload and likelihood of error. In medicine, some abbreviations are known to lead to misinterpretation and result in patient harm. To increase patient safety, there is an official "Do Not Use" list that applies to all orders and all medication-related documentation (Joint Commission, 2004).

The use of abbreviations on Technical Operations hardware and software is inconsistent. The primary reason for inconsistencies may be that a list of abbreviations to promote consistent use does not exist. For those abbreviations not appearing in the GPO Style Manual (2008), an engineer considering the use of an abbreviation must rely on his or her team's existing knowledge of over 3,000 abbreviations used in TO. Programs are unlikely to allocate a part of their very limited resources to reviewing existing TO systems for their use of abbreviations. Therefore, it is challenging to ensure that words have only one abbreviation, and abbreviations have only one definition.

Literature Review Findings

The development and application of human factors standards within Technical Operations is intended to act as a barrier for unintended designer errors leading to unintended operator outcomes (FAA, 2012). Human centric standardization across future TO system updates begins with providing industry user-friendly standards and guidance documents. Utilization and application of those documents by designers may improve end user human system performance, system usability, and training efficiencies. Additionally, there are potential program management and developer benefits to standardization—such as reduction in costs and the opportunity to reuse code (Nielsen, 1993).

User-oriented designs should allow expedient access to the status of individual components of a control system and their relationship with other components (Brookhaven National Laboratory, 2000). Implementation of soft controls is a technique that may be utilized by system developers to effectively utilize limited screen real-estate (Brookhaven National Laboratory, 2000). According to the 80-20 Rule, approximately 80% of users utilize a handful of an application's features, while only 20% use all or most of those features (Apple, 2012).

Consistent user-oriented designs, may improve a user's productivity resulting in higher throughput and a reduced number of errors due to system predictability. The smaller the number of errors and reduced learning times may also increase user satisfaction due to decreasing user frustrations (Nielsen, 1993). Interface consistency traditionally enhances a users' ability to effectively transfer user skills from one system to another, leading to ease of learning and use—thus potentially lowering training costs (Nielsen, 1993). Corroborating this statement, Polson

1988, “In several studies, consistency reduced training time to between 25-50% of that needed for inconsistent interfaces.” Application of user-centric designs will promote the ability for users to learn programs faster due to elements looking and behaving the same (Apple, 2012).

Conclusion

Application of standards within Technical Operations is intended to improve human performance, contribute to the more efficient and effective maintenance of NAS systems, and facilitate the integration of human factors into operational systems. Human factors requirements are intended to ensure that NAS equipment utilized by FAA personnel are easy to operate, maintain, and train (FAA, 2011). The aforementioned standards and proposed success criteria may be used to diagnose whether there is an opportunity to further improve performance, assess the effectiveness of human factors solutions, and determine whether there are opportunities for the community of practice to develop further interventions.

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Disclaimer

The opinions expressed are those of the authors and do not represent the Federal Aviation Administration (FAA).

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