ATOP-R&D

Human Factors Newsletter # 05-06

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13th Annual International Symposium on Aviation Psychology (ISAP): The 13th ISAP will be held in Oklahoma City at the Oklahoma City Convention Center April 18-21, 2005. The FAA Civil Aerospace Medical Institute (CAMI) will be the local host. Wright State University and General Dynamics Advanced Information Systems will handle the technical details of the meeting including conference registration. Major sponsors are expected to be General Dynamics, the U.S. Air Force Research Laboratory, FAA, NASA and others.

Aviation Psychology is the field of study concerned with the role of human operators in aviation systems. First convened by the Aviation Psychology Laboratory in 1981, this symposium series is offered for the purposes of:

- presenting the latest research on human performance problems and opportunities created by changes in aviation systems and technology
- envisioning design solutions that best utilize human capabilities for creating safe and efficient aviation systems

- bringing together scientists, research sponsors, and operators in an effort to bridge the gap between research and application

While the symposium is aerospace safety oriented, anyone with an interest in human performance and behavior will find the experience invaluable. The objective is to provide a forum for critical examination of the impact of high technology on the role, responsibility, authority, and performance of human operations in modern aircraft and air traffic control systems all over the world.

Last week's "Special Edition" Human Factors Newsletter provided information on FAA-funded research to be presented at the symposium. Two additional FAA-funded presentations are listed below. Copies of the papers are attached to this newsletter.

- Assessing Human Factors Risks in Air Traffic Management Research
- Building an Interlocking Human Factors Research and Development Program

Management Note: Next Generation Air Transportation System (NGATS) Institute: The JPDO is currently in the process of standing up the NGATS Institute. The NGATS Institute is an alliance among organizations representing major aviation stakeholder communities, who will support the NGATS mission by recruiting, selecting, and assigning private sector experts and technical resources to participate on IPTs, and perform technical work for the IPTs/JPDO. The Institute will operate under guidelines set forth in the funding agreement between the FAA/JPDO and the host organization, the National Center for Advanced Technologies (NCAT). A sixteen member Institute Management Council (IMC) will govern the Institute. Chaired by the Air Traffic Control Association (ATCA) and the Air Transport Association (ATA), the IMC includes representatives of regional commercial airline operations, business aircraft operations, helicopter operations; small aircraft general aviation, commercial pilots, air traffic controllers, airport operators, manufacturers of air vehicles, manufacturers of air and space-borne and ground-based equipment, federal advisory committees, universities, and nonprofit research organizations. Day-to-day operations of the NGATS Institute will be managed by an Executive Director, selected by an Executive Committee of the IMC and employed by NCAT. For more information in the Institute, see http://www.jpdo.aero/site_content/NGATS_Institute.html.

Phased-Array Radar: William J. Hughes Technical Center personnel participated in the Phased-Array Radar project Joint Action Group meeting at the National Severe Storm Laboratory in Norman, OK on March 28 and 29, 2005. The meeting was coordinated by the Inter-Departmental Committee for Meteorological Services and Supporting Research. Participants included personnel from the following agencies: National Oceanic and Atmospheric Administration /National Severe Storms Laboratory, US Air Force, US Navy, Office of Naval Research, National Science Foundation Engineering Research Center, and Massachusetts Institute of Technology Lincoln Laboratory. Discussions focused on multi-agency needs and requirements for a multi-functional Phased Array Radar. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 7: Enhance the safety of FAA's air traffic systems* (E. Stein, WJHTC)

Flight Attendant Fatigue: On March 30th**,** David Schroeder and Thomas Nesthus participated in a Flight Attendant Fatigue Summit in Dallas/Fort Worth, TX. The meeting was hosted by the Association of Professional Flight Attendants and Transport Workers Union Local 556, and provided a forum for flight attendant union principals and safety representatives to discuss the issue of fatigue in regard to its impact on operational performance and safety. A presentation was made to the 62 attendees describing the status of the NASA-Ames Fatigue Countermeasures Team effort that was initiated this year in support of congressional direction and funding provided in the FY 2005 appropriation "…to better understand the impact of minimum rest requirements…". A contractor who supports the union provided information regarding research on flight attendant workload in long-haul operations. Information was also provided regarding the application of scheduling tools to typical flight attendant duty schedules. A request was made for additional scheduling information to support planned research activities. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 1: Reduce the commercial fatal accident rate.* (D. Schroeder, CAMI)

Information Technology Security: Engineering research psychologists from the William J. Hughes Technical Center's NAS Human Factors Group visited six FAA facilities in the Atlanta, GA area to interview Airway Facilities/Technical Operations personnel regarding use of passwords, smartcards, and other information technology security techniques. Over 20 personnel were interviewed regarding human factors topics such as the number of passwords each user maintains, the requirements and guidelines for creating complex passwords, methods for resetting forgotten passwords, experiences in being "locked out" of systems due to forgotten passwords, and "tricks" employed to remember passwords. Researchers also collected information about users' experiences and attitudes regarding biometric techniques such as fingerprint scanners. This information will be combined with data from other field visits to develop recommendations for technologies and procedures that make it easier for the workforce to follow good security practices, reduce impact on operations, and improve the overall security of FAA information technology systems. *This research supports the Administrator's Flight Plan Goal for Organizational Excellence, Objective 3: Make decisions based on reliable data to improve our overall performance and customer satisfaction.* (K. Allendoerfer, WJHTC)

ERAM: Two research psychologists from the William J. Hughes Technical Center's NAS Human Factors Group are supporting a meeting of the En Route Automation Modernization (ERAM) Technical Operations User Team. Part of the meeting is being devoted to learning about maintainer aspects of the En Route Information Display System and how it relates to ERAM. The researchers are focusing on usability of the user interfaces and issues such as consistency and interoperability with ERAM and other existing systems. The remainder of the meeting will focus on a discussion of ongoing ERAM monitor and control development. *This research supports the Administrator's Flight Plan Goal for Greater Capacity, Objective 3: Increase on-time performance of scheduled carriers.* (T. Yuditsky, WJHTC)

En Route Information Display: Researchers from the William J. Hughes Technical Center's NAS Human Factors Group attended a demonstration of the En Route Information Display System Monitor and Control Workstation. Together with a team of Technical Operations Specialists from the field, they provided feedback on the usability of the workstation. The recommendations include criteria for an appropriate audible alarm, display of state and status,

and use of color to represent alarms and alerts. *This research supports the Administrator's Flight Plan Goal for Greater Capacity, Objective 1: Increase capacity to meet projected demand.* (T. Yuditsky, WJHTC)

STARS: William J. Hughes Technical Center personnel conducted Standard Terminal Automation Replacement System (STARS) procedure dry-runs in advance of the April 4-8, 2005 operational test. These activities are necessary to prepare for formal testing that will determine the Operational Suitability of Full STARS-2 + Life Cycle Maintenance Build Release 10. This software build will add 14 new Air Traffic and Airway Facilities functionality features. It will also incorporate enhancements to conflict alert, flight plan processing, hand-off processing and consolidation, Area Navigation, Airport Surveillance Radar- 9, monitor and control, and situation display. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 7: Enhance the safety of FAA's air traffic systems.* (E. Stein, WJHTC)

Human Factors On-Line Training Course: The March 31, 2005 GovExec.Com Today includes an article describing the FAA's on-line human factors training course. For more on the article, point to http://www.govexec.com/dailyfed/0305/033005b1.htm
The human factors training course can be accessed at: www.hf.faa.gov/webtraining/index.htm. *This research supports the Administrator's Flight Plan Goal for Organizational Excellence, Objective 1: Make the organization more effective with stronger leadership, increased commitment of individual workers to fulfill organization-wide goals, and a better prepared, better trained, safer, diverse workforce.* (G. Hewitt, ATO-P R&D)

ATM 2005 Seminar: On April 6-8, 2005, Paul Krois attended a review meeting in Amsterdam in preparation for the FAA/EUROCONTROL Air Traffic Management (ATM) Seminar scheduled for Baltimore, MD in June 2005. The purpose of the review meeting was to select final papers and develop the agenda. Attendees included representatives from ATO, EUROCONTROL, NASA, Mitre Corporation, academia, and member states. The objective of the ATM 2005 Seminar is to foster a realization of harmonized ATM systems. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objectives 4 and 7: Reduce the risk of runway incursions; Enhance the safety of FAA's air traffic systems* (P. Krois, ATO-P R&D)

Safety Management: On April 11, 2005, Paul Krois met with EUROCONTROL representatives to discuss a new FAA/EUROCONTROL Action Plan addressing human factors and safety management. The meeting will focus on planning of "terms of reference" to be incorporated into the Action Plan. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objectives 4 and 7: Reduce the risk of runway incursions; Enhance the safety of FAA's air traffic systems* (P. Krois, ATO-P R&D)

RNP: On April 14th**,** ATO-P researchers at the William J. Hughes Technical center will conduct a "Quick Look" briefing of preliminary results from the Human Factors Study of San Francisco International Runway 28R Required Navigation Procedure (RNP) Converging Approach Procedure. This is the first of two deliverables for the ongoing project (the other deliverable will be the final report). Jeff Williams and Janettarose Greene from the ATO-R RNP Program Office will receive the briefing. The presentation summarizes findings from the December 2004 human

factors study conducted at the Northern California TRACON. Sixteen ATCTs from Area B participated in the study. Each participant completed a reaction time task and four operational scenarios. One primary goal of the study was to determine controllers' ability to accurately distinguish between standard track errors and "blunders" using an ARTS Color Display showing ASR-9 radar data. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 7: Enhance the safety of FAA's air traffic systems* (P. Dellarocco, WJHTC)

NTML: ATO-P Research Psychologists from the William J. Hughes Technical Center are supporting phase two of Operational Testing and Evaluation of Version 3.05 of the National Traffic Management Log (NTML). As part of the test team, they are validating that system requirements were implemented in a manner that is consistent with human factors design guidelines, and that the capabilities work as expected. The NTML is a tool that provides automated logging and dissemination of traffic management initiatives between, as well as within, Air Traffic Control facilities. It is currently used in all Air Route Traffic Control Centers, many Terminal Radar Approach Controls and Air Traffic Control Towers, and at the FAA Command Center. *This research supports the Administrator's Flight Plan Goal for Greater Capacity, Objective 3: Increase on-time performance of scheduled carriers.* (T. Yuditsky, WJHTC)

Information Technology Security: William J. Hughes Technical Center personnel visited three FAA facilities in northern California to interview Airway Facilities (AF)/Technical Operations (TO) personnel regarding their use of passwords, smartcards, and other information technology (IT) security techniques. Fifteen AF/TO personnel were interviewed regarding human factors topics such as the number of passwords each person has, the requirements for creating complex passwords, methods for resetting forgotten passwords, experiences in being locked out of systems, and "tricks" employed to remember passwords. They also collected information about employees' experiences and attitudes regarding biometric techniques such as fingerprint scanners. These data will be combined with information from other field visits to support a project examining human factors issues affecting passwords and other IT security techniques. Researchers seek to develop recommendations for technologies and procedures that make it easier for the AF/TO workforce to follow good security practices, reduce the impact of security measures on the primary mission, and improve the overall security of FAA systems. *This research supports the Administrator's Flight Plan Goal for Organizational Excellence, Objective 3: Make decisions based on reliable data to improve our overall performance and customer satisfaction.* (K. Allendorfer, WJHTC)

More information on human factors research can be found at the FAA Human Factors (ATO-P R&D) web site: http://www.hf.faa.gov

Paul Krois
FAA (ATO-P R&D Human Factors)

CALENDAR

April 11-14, 2005 – SAE 100th Anniversary World Congress, Cobo Hall, Detroit, MI *http://www.sae.org/congress/about/news/congressdates.htm*

April 12-13, 2005 – R,E&D Advisory Committee Meeting, Bessie Coleman Auditorium, FAA Headquarters, Wash., DC Gloria.dunderman@faa.gov

April 12-18, 2005 – Sun 'n Fun 2005, Lakeland, FL http://www.sun-n-fun.org/

April 13 - 16, 2005 - Society for Behavioral Medicine Annual Meeting and Scientific Sessions, Boston, MA http://www.sbm.org/

April 15 - 17, 2005 - Annual Conference: Society for Industrial/Organizational Psychology (SIOP), Los Angeles, CA lhakel@siop.bgsu.edu , http://www.siop.org

April 17-22, 2005 – International Federation of Air Traffic Controller's Associations, Melbourne, Australia *http://www.ifatca.org/conferences/annual_conference.htm*

April 18-21, 2005 – 13th International Symposium on Aviation Psychology (ISAP), Cox Convention Center, Oklahoma City, OK http://www.wright.edu/isap/

April 26-28, 2005 – Flight Safety Foundation 50th Annual Corporate Aviation Safety Seminar, Orlando, FL http://www.flightsafety.org/cass05_preagenda.html

April 27-30, 2005 - Aircraft Electronics Association Convention & Trade Show, Gaylord Texan Resort, Grapevine, Texas www.aea.net

April 28-29, 2005- Mini-Conference on Human Factors in Complex Sociotechnical Systems, hosted by HFES South Jersey Chapter, Atlantic City, NJ, http://www.sjhfes.org/

May 9-12, 2005 - 76th Annual Scientific Meeting of the Aerospace Medical Association, Kansas City, MO *http://www.asma.org/*

May 14-15, 2005 – 8th Alaska State Aviation Trade Show and Conference, Anchorage International Airport, Anchorage, AK http://www.alaskaairmen.com/

May 17-18. 2005 – Aviation Maintenance & Human Factors Workshop & Symposium, Crowne Plaza, Arlington, TX exhibitions@sae.org

May 18-20, 2005 - International Applied Reliability Symposium, Catamaran Resort on Mission Bay in San Diego, California. Symposium Theme: "Sharing applications, success stories and lessons learned in reliability and maintainability engineering." Visit the Web site http://www.ARSymposium.org/ for detailed information on topics, presenters and registration. You can also download the brochure at: http://www.ARSymposium.org/2005/ars2005_brochure.pdf

May 23-24, 2005 – PROP Europe 2005, Frankfurt, Germany
http://www.turbineair.com/prop.html

May 23-26, 2005 – DoD TAG (Human Factors Engineering Technical Advisory Group), Marriott Bay Point Resort Golf and Yacht Club, Panama City, FL
http://hfetag.dtic.mil/meetschl.html

May 25-26, 2005 – Military Aviation Repair & Maintenance 2005, One Whitehall Place, London, UK http://www.iqpc.co.uk/GB-2361/1010

May 26-29, 2005 – American Psychological Society 17th Annual Convention, Westin Century Plaza Hotel, Los Angeles, CA http://www.psychologicalscience.org/convention/

June 2005 – 6th USA/Europe ATM Seminar, Baltimore, MD (note: call for papers deadline is January 28, 2005) http://atmseminar.eurocontrol.fr/

June 4, 2005 – AOPA Fly-in and Open House, Frederick, MD http://www.aopa.org/

June 13-19, 2005 - Paris Air Show 2005, Parc des expositions de Paris Nord - Le Bourget, 93350, France. www.paris-air-show.com

June 20-22, 2005 – 3rd Human System Integration Symposium, Sheraton National Hotel, Arlington, VA http://www.navalengineers.org/Events/HSIS2005/HSIS05Index.html

June 27-30, 2005 – TRB 3rd International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Rockport, Maine

June 28-30, 2005 – AAMI Human Factors, Ergonomics, and Patient Safety for Medical Devices, Capital Hilton, Washington, DC http://www.aami.org/meetings/hf/

July 22-28, 2005 – HCI International 2005, 11th International Conference on Human-Computer Interaction, Caesars Palace, Las Vegas, NV hcii2005@ecn.purdue.edu

July 25-31, 2005 – EAA AirVenture Oshkosh 2005, Oshkosh, WI http://www.airventure.org

August 15-18, 2005 - 43rd AIAA Aerospace Sciences Meeting and Exhibit, Hyatt Regency San Francisco at Embarcadero Center, San Francisco, CA http://www.aiaa.org/

August 18-21, 2005 - 113th Convention of the American Psychological Association, Wash, DC http://www.apa.org/convention

August 22-26, 2005 – SAE G-10 (Behavioral Engineering Technology Committee Meeting, Washington, DC http://forums.sae.org/access/dispatch.cgi/TEAG10_pf

September 12-16, 2005 – Interact 2005, Tenth IFIP TC13 International Conference on Human-Computer Interaction, Rome, Italy http://www.interact2005.org/

September 19-23, 2005 – ANA 2005 Aviation Conference and Exhibition, Connecticut Convention Center, Hartford. CN *http://www.aerospace-na.com/ace2005.asp*

September 20-21, 2005 - R,E&D Advisory Committee Meeting (joint meeting with NASA's Aerospace Research Advisory Committee), Bessie Coleman Auditorium, FAA Headquarters, Wash., DC Gloria.dunderman@faa.gov

September 21-23, 2005 - Cargo Facts 2005- 11th Annual Aircraft Symposium, Sheraton Hotel & Towers, Seattle, Washington ashoemaker@cargofacts.com

September 25-28, 2005 - 11th Ka and Broadband Communications Conference and 23rd AIAA International Communications Satellite Systems Conference 2005 (organized by IIC), Aurelia Convention Center, Rome, Italy http://www.aiaa.org/

September 26-28, 2005 - AIAA 5th Aviation, Technology, Integration, and Operations Forum (ATIO), Hyatt Regency Crystal City, Arlington, VA http://www.aiaa.org/

September 26-28, 2005 - AIAA 2nd Intelligent Systems Conference (IS), Hyatt Regency Crystal City, Arlington, VA http://www.aiaa.org/

September 26-30, 2005 – Human Factors and Ergonomics Society 49th Annual Meeting, Royal Pacific Resort at Universal Orlando, Orlando, FL *http://hfes.org/meetings/menu.html*

October 3-6, 2005 – SAE 2005 AeroTech Congress and Exhibition, Gaylord Texan Resort and Convention Center, Dallas/Fort Worth Airport Area, Texas *http://www.sae.org/events/conferences/aerospace/*

October 6-9, 2005 – Aviation North Expo Conference, Fairbanks Princess Riverside Lodge, Fairbanks, AK *www.AviationNorth.org*

October 24-25, 2005 – National Academies Institute of Medicine Annual Meeting, National Academy of Sciences, Washington, *DC http://wwwsearch.nationalacademies.org/*

October 24-26, 2005 – 43rd SAFE Symposium,Grand America Hotel, Salt Lake City, UT http://www.safeassociation.org/symposium.htm

October 30-November 7, 2005 – ATCA 50th Annual Conference and Exposition, Dallas, TX http://www.atca.org/event_items.asp.

October 30—November 3, 2005 – 24th Digital Avionics Systems Conference, Hyatt Regency Crystal City, Wash., DC http://www.dasconline.org

November, 2005 – DoD TAG (Human Factors Engineering Technical Advisory Group) Meeting, Baltimore, MD http://hfetag.dtic.mil/meetschl.html

November 3-5, 2005 - AOPA Expo, Tampa, Florida www.aopa.org

November 6-9, 2005 - ACI World / Pacific Conference and Exhibition, Auckland, New Zealand. www.auckland-airport.co.nz

November 7-10, 2005 – Flight Safety Foundation 58th Annual International Air Safety Seminar, Moscow, Russia http://www.flightsafety.org/iass05_cfp.html

November 8-10, 2005 – Aerospace Testing Expo, North America: Scientific Conference and Technology Forum, Long Beach Convention Center, Long Beach, CA http://www.aerospacetesting-expo.com/northamerica/conf+forum.html

November 10, 2005 - 34th Annual Meeting of the Society for Computers in Psychology, Toronto, Ontario, Canada http://www.scip.ws

November 10 - 13, 2005 - 46th Psychonomic Society Annual Meeting, Toronto, Ontario, Canada http://www.psychonomic.org/meet.htm

November 15-17, 2005 - National Business Aviation Association's 58th Annual Meeting & Convention, New Orleans, LA www.nbaa.org

January 9-12, 2006 - 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno Hilton, Reno, NV http://www.aiaa.org/

January 22-26, 2006 – TRB 85th Annual Meeting, Washington, DC http://trb.org/calendar/
May 14-18, 2006 - 77th Annual Scientific Meeting of the Aerospace Medical Association, Orlando, FL http://www.asma.org/

March 22 - 25, 2006 - Society for Behavioral Medicine Annual Meeting and Scientific Sessions, San Francisco, CA www.sbm.org/annualmeeting/index.html

March 23-25, 2006 - 17th Annual International Women in Aviation Conference, Opryland Hotel Nashville, TN http://www.wai.org/

April 4-10, 2006 – Sun 'n Fun, Lakeland, FL http://www.sun-n-fun.org/content/

May 25-28, 2006 – American Psychological Society 18th Annual Convention, New York Marriott Marquis, New York City, NY http://www.psychologicalscience.org/convention/

July, 2006 - 26th International Congress of Applied Psychology, Athens, Greece dgeorgas@dp.uoa.gr , http://www.erasmus.gr/dynamic/conventions.asp?conv_id=21r/dynamic/conventions.asp?conv_id=21

July 24-30, 2006 – EAA AirVenture, Oshkosh, WI http://www.airventure.org/

August 10-13, 2006 – American Psychological Association Annual Meeting, New Orleans, LA
http://www.apa.org/convention05/future.html

October 23-25, 2006 – 44th Annual SAFE Symposium, Reno Hilton Hotel, Reno, NV
http://www.safeassociation.org/symposium.htm

Note: Calendar events in Italics are new since the last Newsletter

Comments or questions regarding this newsletter?
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13th Annual International Symposium on Aviation Psychology

ASSESSING HUMAN FACTORS RISKS IN AIR TRAFFIC MANAGEMENT RESEARCH

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This paper describes guidance for assessing human factors risks of research capabilities. The risk scales in the present study were used to assess concepts of the FAA Target System Description, part of the National Airspace System architecture. Results help identify areas where human factors analyses are needed and strengthen the business case for human factors assessments. Repeated high risk ratings provide R&D managers with additional information about whether or not to proceed with specific capabilities.

Introduction

The Federal Aviation Administration (FAA) System Engineering Manual defines risk as "a future event or situation with a realistic (non-zero nor 100 per cent) likelihood of occurring and an *unfavorable consequence/impact* to the successful accomplishment of the well-defined program goals if it occurs" (2004a). Relative to the FAA's definition, a consistent and more quantitative approach to human factors risk management is needed for application to research and development (R&D) on air traffic management. This paper describes the guidance developed for assessing human factors risks of R&D capabilities.

Previous research (Krois, Mogford, and Rehmann, 2003) posed that select human factors study areas

should be incrementally addressed as an R&D prototype matures. That research also validated the need to consider all human factors study areas defined in the FAA Job Aid (2003a) by the time a research prototype is tested in a laboratory with representative users. These findings provided programmatic guidance for early, realistic assessments of innovative concepts and emerging technologies for use in an integrated National Airspace System (NAS). The research described in this paper poses that from a risk standpoint, the same human factors study areas could be assessed to better gauge and understand potential program impacts of research capabilities.

The human factors study areas pose potential risks in relation to the conceptual service improvements comprising the FAA Target System Description (TSD), which is part of the NAS architecture (FAA, 2004b). Researchers need help to strengthen the business case for human factors studies that resolve risks. This includes assessments that use complex human in the loop (HITL) simulation. Resolution of high risk areas provide R&D managers with additional information about whether or not to continue with development of specific capabilities.

Technical Readiness Levels

One approach for assessing the maturation of capabilities from laboratory to field implementation is the Technology Readiness Level (TRLs) model. TRLs are described in the FAA/NASA Integrated Plan for Air Traffic Management Research and Technology Development, Version 7.0 (FAA, 2003b). The TRL model intends an orderly transfer process from R&D to deployment and has been used by NASA and FAA to define transitions between stages of R&D leading to NAS implementation. FAA recognizes the need to manage more efficiently the transition of R&D capabilities, promote understanding of human factors risks, and make informed program decisions. The TRL model helps researchers from different organizations coordinate objectives and outputs and assess research maturation.

TRLs 1-6 pertain to concept exploration and concept development phases and consist of the following. TRL 1 Basic Principles Observed/Reported is the stage at which a capability is initially identified and described. In TRL 2 Technology Concept and/or Application Formulated a research plan is developed that defines the technical solution to the deficiency identified in TRL 1. This plan identifies activities, schedule, and resources necessary to address issues with the capability. In TRL 3 Analytical/ Experimental Critical Functions or Characteristic Proof of Concept, a conceptual prototype of the capability is developed and initial requirements are defined. The use of metrics to assess benefits should show an improvement over the baseline. TRL 4 Component or Integrated Components Tested in a Laboratory Environment is the stage where a research prototype of the capability is developed and evaluated by representative users. The laboratory real time simulation environment is at a higher fidelity level than at TRL 3. In TRL 5 Components/Subsystems Verified in a Relevant Environment, a pre-development prototype is prepared and evaluated. The evaluation environment should be at a high fidelity. The FAA assumes "ownership" of the operational concept and initiates activities to transition the capability to the acquisition product team. In TRL 6 System Demonstrated/ Verified in a Relevant Environment, an operational demonstration of the pre-production prototype system is conducted in an FAA field facility.

Human-System Interaction Research

Human factors research addresses human-system interaction (HSI) as R&D capabilities mature. This is shown through technical reviews of ATC modernization improvements planned in different operational environments, lower-fidelity assessments such as cognitive walkthroughs, and complex HITL simulations including integrated air-ground simulations.

As one example, "allocation of function" is one of the earliest human factors considerations effecting successful HSI. Inadequate consideration of allocation of function was evidenced in an operational evaluation of a controller decision support tool called passive Final Approach Spacing Tool (pFAST). In the evaluation, controllers found some advisories problematic but were instructed to use them anyway unless the non-use was approved by supervisors. Unfortunately, pFAST was found to work best when all controllers followed all advisories, i.e., pFAST performance degraded when advisories were not used. With pFAST the flexibility in decision making that controllers routinely exercised became constrained (Cardosi, 2002).

Trends suggest that information management demands associated with effective HSI are changing from being based on procedural requirements to controller workload impacts. Automation poses the risk of tunneling the attention resources of the controller and molding the application of those

resources so as to be opaque to unforeseen and subtle events and incidents. Experience with another controller decision support tool called URET indicates that controllers make decreased use of trial planning as workload increases, and that use of the traffic management advisor (TMA) metering list decreases when workload is high. Such "automation shedding" moves the controller into a manual control mode that poses a hysteresis effect for returning to use of automated tools, e.g., the controller has to restart building a new mental picture of the traffic situation and not reverting to a previous mental state.

Human Factors Study Areas

Human factors study areas used to assess research risks are taken directly from the FAA Human Factors Job Aid and consist of the following.

- Allocation of Function: Assigning those roles/functions/tasks for which the human or equipment performs better while enabling the human to maintain awareness of the operational situation.
- Anthropometrics and Biomechanics: Accommodating the physical attributes of its user population (e.g., from the 1st through 99th percentile levels).
- Computer-Human Interaction (CHI): Employing effective and consistent user dialogues, interfaces, and procedures across system functions.
- Communications and Teamwork: Applying system design considerations to enhance required user communications and teamwork.
- Culture: Addressing the organizational and sociological environment into which any change, including new technologies and procedures, will be introduced.
- Displays and Controls: Designing and arranging displays and controls to be consistent with the operator's and maintainer's tasks and actions.
- Documentation: Preparing user documentation and technical manuals in a suitable format of information presentation, at the appropriate reading level, and with the required degree of technical sophistication and clarity.
- Environment: Accommodating environmental factors (including extremes) to which the system will be subjected and understanding the associated effects on human-system performance.
- Functional Design: Applying human-centered design for usability and compatibility with operational and maintenance concepts.
- Human Error: Examining design and contextual conditions (including supervisory and organizational influences) as causal factors contributing to human error, and consideration of objectives for error tolerance, error prevention, and error correction/recovery.
- Information Presentation: Enhancing operator and maintainer performance through the use of effective and consistent labels, symbols, colors, terms, acronyms, abbreviations, formats, and data fields.
- Information Requirements: Ensuring the availability and usability of information needed by the operator and maintainer for a specific task when it is needed, and in a form that is directly usable.
- Input/Output (I/O) Devices: Selecting I/O methods and devices that allow operators or maintainers to perform tasks, especially critical tasks, quickly and accurately.
- Knowledge, Skills and Abilities (KSAs): Measuring the KSAs required to perform job-related tasks, and determining appropriate selection requirements for users.
- Operational Suitability: Ensuring that the system appropriately supports the user in performing intended functions while maintaining interoperability and consistency with other system elements or support systems.
- Procedures: Designing operation and maintenance procedures for simplicity, consistency, and ease of use.
- Safety and Health: Preventing/reducing operator and maintainer exposure to safety and health hazards.
- Situational Awareness: Enabling operators or maintainers to perceive and understand elements of the current situation, and project them to future operational situations.
- Special Skills and Tools: Minimizing the need for special or unique operator or maintainer skills, abilities, tools, or characteristics.
- Staffing: Accommodating constraints and efficiencies for staffing levels and organizational structures.
- Training: Applying methods to enhance operator or maintainer acquisition of the knowledge and skills needed to interface with the system, and designing that system so that these skills are easily learned and retained.
- Visual/Auditory Alerts: Designing visual and auditory alerts (including error messages) to invoke the necessary operator and maintainer response.
- Workload: Assessing the net demands or impacts upon the physical, cognitive, and decision-making resources of an operator or maintainer using objective and subjective performance measures.
- Work Space: Designing adequate work space for personnel and their tools or equipment, and providing sufficient space for the movements and actions that personnel perform during operational and maintenance tasks under normal, adverse, and emergency conditions.

FAA Target System Description (TSD)

FAA is modernizing the NAS, nominally to achieve the Joint Concept of Operations (CONOPS) as described by the RTCA (2002). The TSD describes improvements to NAS service capabilities expected by 2015. It includes descriptions of systems to be implemented, services provided, and operational capabilities that will be achieved. Together the NAS Architecture and the TSD provide a roadmap to guide the evolution of automation, surveillance, navigation, and communication systems to ensure NAS modernization is achieved.

The TSD, like the NAS architecture, is organized into 9 service areas including flight planning; separation assurance; tactical traffic flow; strategic flow; advisory services; emergency and alerting; navigation; airspace management; and infrastructure and information management. These are further decomposed into service improvement areas identified later in this paper.

Key HSI characteristics of TSD operational improvements consist of the following.
- A system wide information management system (SWIM) will serve as the central depository for all NAS information.
- Wide-spread, real-time distribution of NAS data.
- A standard automation platform (SAP) will be used by both terminal and en route controllers.
- Decision support systems (DSS) and intelligent agents will be common.
- Maximum use of digital communications.
- Maximum use of ADS-B for surveillance.
- Traffic managed gate to gate.
- Integrated ATM/CNS provides seamless airspace (Surface, Terminal, En Route and Ocean).
- Flexible airspace to match the dynamics of demand.
- Three mile separation used throughout the airspace.
- Pilots participate in managing aircraft separation.
- Airborne and ground conflict alerting.
- Auto-negotiations to develop flight profiles.

Methodology

We conducted an analysis to assess the viability of using specially developed scales for the 24 human factors study areas in helping to gauge risks associated with the TSDs. The resultant risk ratings reflect an average response as determined by human factors subject matter experts who participated in the analysis.

Human Factors Risk Scales

Risk scales used a five point scale based upon similar scales in the FAA System Engineering Manual (FAA, 2004a) and a safety risk assessment approach developed for military product improvements (Naylor, 2000). A low risk associated with the human factors study area is assigned a numerical value of 1; accordingly, if there is a minor risk, the value assigned is 2; a moderate risk is assigned a value of 3; a significant risk was assigned a value of 4; and a high risk associated was assigned a value of 5. A sample risk scale is as follows.

Allocation of Function: System design reflects assignment of operational roles, functions, tasks to humans or equipment while maintaining the human's awareness of the operational situation.
Low: Allocation of function of the proposed R&D capability does not change the current roles, functions, and tasks presently assigned to humans or equipment nor changes the operator's situation awareness.
Minor: Integration of the R&D capability into the present work environment may result in limited changes to current roles, functions, and tasks presently assigned to humans or equipment and may slightly alter the operator's situation awareness.
Moderate: Integration of the R&D capability into the present work environment alters current roles, functions, and tasks presently assigned to humans or equipment, and impacts the operator's situation awareness.
Significant: Integration of the R&D capability into the present work environment significantly alters current roles, functions, and tasks presently assigned to humans or equipment, and significantly impacts the operator's situation awareness.
High: Allocation of function of the proposed R&D capability alters completely the current roles, functions, and tasks presently assigned to humans or equipment and changes completely the operator's situation awareness such that how an operator's 'mental picture' is formed no longer exists.

Results

It should be noted that the data and its analysis are notional and illustrate one approach to help identify human factors risks. Average scores for the 24 human factors study areas are shown in Figure 1, based on ratings across the 19 service improvement areas. Results showed the topmost risks as Allocation of Function, Communication and Teamwork, Procedures, Information Requirements, Workload, Human Error, Culture, Information Presentation, and Situation Awareness.

The average scores for the 19 service improvement areas are shown in Figure 2. Results suggest a clustering of a small number of areas posing the highest total human factors risk consisting of Aircraft-Aircraft Separation and Flight Data Management. Another cluster with a large number of areas of high risk included Airspace Management, Traffic Advisories, Surface Separation, Monitoring and Maintenance, Flight Plan Support, Airborne Synchronization, Airspace Design, Alerting Support, Aircraft-Terrain Separation, Surface Synchronization, and Weather Advisories.

In the course of assessing the service improvement areas, questions, issues, and potential interdependencies influencing human factors risk were identified to help clarify the basis for ratings.

Several questions/concerns raised by human factors experts help clarify ratings of 4 or 5. For example, for the aircraft/aircraft separation service improvement, human factors questions include the following considerations:

- Communications and Teamwork: What is the impact associated with changing roles and responsibilities and how will separation authority transition between controller and pilot?
- Culture: What is the impact from divergence of operating norms and business cultures between FAA air traffic controllers and multiple unique airlines?
- Functional Design: How compatible are the alerting logic algorithms among airborne and ground systems and what will be the impact on pilot and controller decision making?
- Human Error: What is the potential for pilot and air traffic controller task performance error during critical operations?
- Information Presentation: How will information be displayed?
- Information Requirements: What information is needed?
- Procedures: How will tasks and procedures change?
- Situation Awareness: What are the impacts on controllers' situation awareness?
- Special Skills and Tools: What human performance considerations are associated with reduced separation?
- Visual/Auditory Alerts: Will air and ground trajectory models and conflict prediction algorithms be integrated?
- Workload: What are the workload impacts on air traffic controllers of using new automation and decision support tools for reduced separation tasks?

Discussion

Assessment of human factors risks shows that higher risk ratings occur in relation to the degree to which roles and responsibilities of controllers and pilots change. Our understanding of this relationship should improve as service improvements are further defined and implemented. For example, the role of the controller will drive operational requirements for information. This information is used in accordance with new procedures that pose changes in workload and communications, as well as the potential for human error.

Previous research yielded guidance that as a research capability matures and progresses from TRL-1 to TRL-6, the set of human factors issue areas increases and becomes more critical (Krois, Mogford & Rehmann, 2003). In contrast, the efficacy of research is proportional to human factors risks being addressed and attenuated as the capability progresses across the TRLs. The argument to graduate a research capability beyond TRL-6 is strengthened by the extent that human factors issues/risks are identified, assessed, and resolved within the context of interoperability with the baseline operational system.

The integration of human factors tools and techniques in the TRL model is important to the smooth transition of capabilities from research concepts to field-ready systems and procedures. FAA has found that while human performance issues may or may not impose constraints on cost and schedule, they will be the limiting factor in achieving system performance, thus impacting successful deployment. In the Standard Terminal Automation Replacement (STARS) program, for example, FAA found that system design and system development efforts can lose sight of the human-system performance impacts on end users (operators, maintainers, and support personnel), especially those related to cognitive tasks. History has taught us that if these elements are closely attended to during system development and prototyping, FAA has estimated saving a few months to up to 18 months in program development time and savings of up to 20% of program costs (FAA STARS Human Factors Evaluation, 1998).

Conclusions

It is important for research to have a risk management strategy in place to help identify mitigation strategies that may be employed. The transition from research and operational prototypes to development and fielding is complex. It is not only important to have specific criteria that define a

concept's readiness to transition from one state to the next but also to have a means of assessing potential human factors risks especially when the capabilities and technologies entail new roles for controllers and pilots. The risk scales developed for this study are intended to serve as a tool to researchers to help them better understand and quantify the impact of specific human factors risks as research progresses.

Disclaimer - The views expressed are those of the authors and do not represent the FAA.

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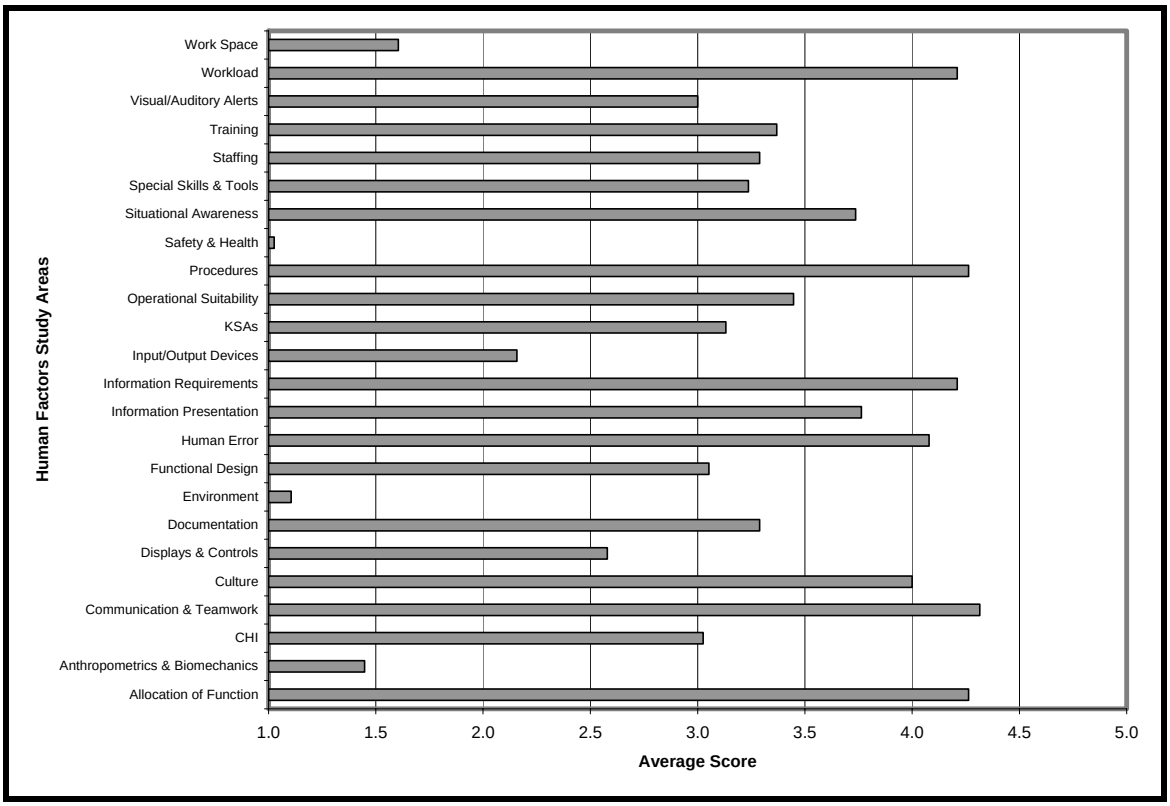

Figure 1. Average risk ratings for 24 human factors study areas.

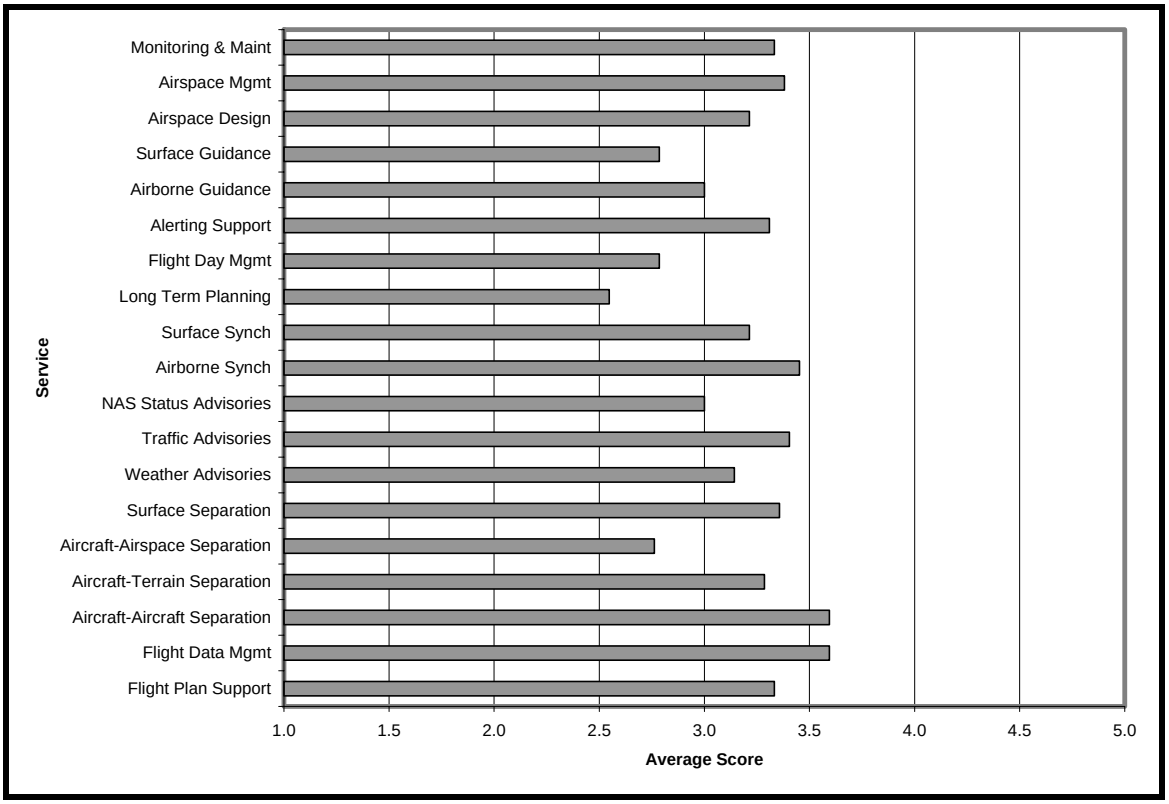

Figure 2. Average risk ratings for 19 service improvement areas.

Building an Interlocking Human Factors Research and Development Program

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The Federal Aviation Administration (FAA) partners with the National Astronautics and Space Administration (NASA) to manage and integrate research on enhanced air- and ground-based air traffic management technologies. This partnership, designed to integrate air traffic decision support tools, concepts, and procedures, was formalized in September 1995. Coordinated research initiatives are described in joint research project descriptions (JRPDs) that define objectives, approach, responsibilities, mission relevance, goals, and outcomes. JRPD 12 is unique in that, as a cross-cutting JRPD, it ensures relevant human factors research issues, methods, metrics, and findings of individual programs of both organizations are made known to, shared, and leveraged by the larger research community including FAA, NASA, aviation industry and academia. Now, FAA is challenged as never before to integrate research and development (R&D) capabilities into the National Airspace System. The lessons and challenges identified by this group are summarized and presented as recommendations for establishing an integrated and focused human factors R&D program.

Introduction

The Federal Aviation Administration (FAA) and the National Astronautics and Space Administration (NASA) have partnered through the Interagency Air Traffic Management Integrated Product Team (IAIPT). This partnership, designed to integrate research addressing air traffic management (ATM) decision support tools, concepts, and procedures, was formalized in September 1995. Oversight for IAIPT activities is provided by the FAA's Research, Engineering, and Development (R,E,&D) Advisory Committee and NASA's Aeronautics and Space Transportation Technology Advisory Committee. The IAIPT is intended to ensure that shared research provides new technologies, procedures, and concepts of use for the National Airspace System (NAS).

The FAA is responsible for the installation, operation, and maintenance of the NAS. Research organizations such as NASA, MITRE CAASD, and the Massachusetts Institute of Technology/Lincoln Laboratories generate technologies and concepts for the future NAS that are candidates for implementation. The implementation process often makes use of commercial vendors that provide the transition from research prototypes to production units that can be installed and supported at any facilities operated by the FAA. It is essential that there is an open and harmonious line of communication between the various organizations. The IAIPT provides a forum for information exchange and assures that there is a means to share the vision for the future NAS to meet capacity and safety goals and smooth the path from research to acquisition.

The IAIPT manages the pipeline for how maturing research concepts and prototypes flow into the FAA acquisition management system. The emphasis is on the maturation of capabilities from laboratory to field implementation using a model of Technology Readiness Levels (TRL) to coordinate objectives, outputs, and exit criteria for moving from one level to another. As research proceeds, the TRL model provides milestones to ensure organizations increasingly specify the capability. The TRL paradigm describes an ideal where research is matched by an orderly transfer process into implementation. In fact, this migration is not always adhered to for a variety of reasons. Now more than ever, as budget cuts and prior obligations complicate FAA's ability to incorporate research into NAS modernization, our efforts and those of our research partners need to be leveraged. As our research partners continue to dedicate resources for air traffic management research and development (R&D), the challenge is to ensure that all ATM R&D moves toward a common vision for the future NAS.

Discussion

IAIPT research initiatives are described in joint research project descriptions (JRPDs). JRPD 12 ensures that relevant human factors research issues, methods, metrics, and findings of individual programs of both organizations are shared with the larger research community. Specifically JRPD 12 is intended to provide "a framework to systematically identify, coordinate, and integrate human factors efforts in the research and development of advanced ATC/ATM/CNS automation, technologies, concepts and procedures."

For the past 6 years, human factors practitioners from FAA, NASA, and various organizations have met to exchange research findings and lessons learned. This group generally focuses on

specific research topics, and findings, issues, challenges, and lessons learned are shared. The exchange is intended to help researchers avoid the problems of the past and identify areas where future research could bear fruit. Technical information meetings are an important way for IAIPT members to exchange information and perspectives. Participants discuss the important contribution of human factors in transitioning research concepts and products through the R&D pipeline to acquisition and fielded systems. Meeting participants have generally agreed that transitioning research concepts from exploration, development, and acquisition of fielded systems should be accompanied by increasingly detailed assessments of information requirements, display management and integration, human centered automation, and human performance assessments that measure workload, situation awareness, and human error. All agree that human factors assessments are part of a larger integrated system engineering perspective encompassing operational concepts, system requirements, and system engineering methods.

More recently, discussions have focused on the need to collaborate earlier in the research cycle to address the "business case" for changes in the NAS, including an interagency review of research to provide input on research intersections and value; and data sharing for model development and verification. Human factors practitioners have a role in the Air Traffic Organization (ATO) as a member of the FAA's Development Liaison Team (DLT) to assess the human factors aspects of proposed new capabilities. Management depends on human factors input for the business case to establish the return on investment for each candidate research capability, assess the likelihood that human performance will match system demands, and determine that safety goals will be met.

The DLT performs their assessment by reviewing the proposed technology as a potential contributor to the agency's goals for capacity and safety. The FAA is acutely concerned about the safety of the NAS; especially incidents involving the loss of separation between aircraft caused by human error (i.e., operational error), and will scrutinize each proposed technology to determine if it will affect the level of safety risk in the NAS. Many technologies attempt to provide decision support capabilities for air traffic controllers in an effort to increase capacity by recommending solutions to traffic problems that controllers must manage. Other technologies have the potential to drastically alter the role of the controller by using automation in various modes. In each case, the human factors representative on the team works with System Engineering, Technology Development, and FAA Technical Center representatives to provide Air Traffic Organization (ATO) management with recommendations.

The human factors issues are best assessed when there is human performance data to work with. The data helps human factors representatives understand how the technology will be integrated into the workstation, how it will affect procedures, and how the roles and responsibilities of humans in the system (operators and maintainers) will change. Human performance data should support the purported improvements in the NAS for both safety and capacity. The role of human factors in this context is to help FAA make informed decisions regarding investment. Our responsibility is to assess risk and provide insights regarding the impact of technology on human error. In addition, we must determine if the proposal will provide the level of service expected by the flying public as part of a national transportation system.

The DLT will work in concert with the IAIPT to provide guidance to the air traffic research community regarding the type of data that is needed. As technology matures through the TRL process, the developing organizations should be responsible for conducting the appropriate human factors activities during each stage of technology development (Krois, Mogford, & Rehmann, 2003). Once the decision is made to consider incorporating a technology into the NAS, the FAA's Acquisition Management System (AMS) provides the structure for eventual system procurement.

The JRPD-12 meetings are an opportunity for human factors researchers and practitioners in all member organizations to share information and concerns. The information sharing takes a number of forms including traditional technical presentations, programmatic presentations, guidance for navigating the waters of research and acquisition during periods of change, and clarification of goals and objectives that may lose meaning when organizational lines are crossed.

The latest J-12 Technical Information Meeting (TIM) covered a range of topics including such provocative topics as "Air Traffic Controller Staffing and the Age 56 Rule." Other topics included Safety Management, En Route Research, NASA's Air Traffic Management (ATM) research program to date, human performance and cognitive modeling.

A portion of the TIM was spent on the human factors aspects of the transition from a research program, through acquisition, into the fielding and daily use of a system. Researchers were provided with an opportunity to understand the perspective of human factors practitioners that need human performance data to address productivity, cost/benefit, staffing, skills, training, and human error. These human performance data are needed as essential input to trade-off and investment analyses that are used to determine if a system should be allowed to proceed to the next research level, or to enter the acquisition process.

Personnel and training costs are the largest contributors to the FAA's operations budget and as new technology is introduced, there is a need to understand how productivity and staffing will be affected. In addition, the FAA is faced with a large turnover in the air traffic controller population In the next ten years. As new controllers are screened, trained, and assigned to new duties, the FAA needs a clear understanding of the number and types of individuals that will be needed to staff the air traffic system of the future. The human-system integration aspects of system design for the future NAS is a subject that requires research and analysis by the human factors community. While this was briefly discussed during the TIM, this will possibly be a topic for further discussion in a future meeting.

In addition to the topics covered, a panel of experienced human factors practitioners from several organizations was convened to consider a number of questions to help guide workshop discussions on the topic of "building an interlocking human factors ATM program." The questions were:

-*What are the obstacles to building an interlocking human factors R&D program?*
-*What are the benefits?*
-*How would we proceed?*
-*What would be the characteristics?*

-*How would we achieve true collaboration?*
-*What have we learned from the past?*

Obstacles

During the discussion, attendees agreed that "collaborative" or "interactive" would be a better term to describe our organizational relationships. The initial discussion focused on obstacles to collaboration, such as organizational "stove-piping" which has hindered our ability to exchange information. Tight budgets also create competition for scare research dollars between researchers. And often, the momentum for collaboration is lost within 2-3 months of our meetings. This is exacerbated by a lack of ongoing communication between agencies, and a lack of visibility about research taking place in other organizations. Often, there is imperfect communication between researchers and sponsors. A lack of success criteria and continuously shifting priorities of research organizations further complicate the human factors R&D landscape.

Benefits

The benefits of collaboration are many, including preventing duplication of efforts and minimizing the cost of research. Technology is bringing potentially huge changes in roles and responsibilities for humans in the NAS. This is increasing, not decreasing, the need for collaboration. Performance of the NAS hinges on effective human performance. Moreover, the future NAS is predicted to need 2 or 3 times the capacity of the current system. Thus, human factors researchers will be even more challenged to approach problems from a human-system perspective and avoid piecemeal solutions. As safety and security concerns rise, we must assess the human component from a risk standpoint for any proposed changes to the NAS.

How to Proceed

How could a collaborative human factors research program work? Participants agreed that the FAA collocation study was a good start to examine the impact of multiple tools on the controller workstation. The study assessed the collocation effects of controller decision support tools that were developed independently by FAA, NASA, and MITRE CAASD. The tools included Traffic Management Advisor (TMA-NASA), Controller-Pilot Data Link (CPDLC-FAA), and User Request Evaluation Tool (URET-MITRE CAASD). The study identified important human factors issues that were not evident until the tools were expected to work together at a single controller workstation.

Several definitive steps were taken after the TIM to ensure our discussions about collaboration became reality. Selected FAA human factors experts met with researchers at MITRE CAASD for a broad review of programs involving human factors. The teams discussed potential areas for collaboration and established specific contacts between organizations and researchers with intersecting interests. MITRE CAASD representatives attended a human factors lab research program review at the FAA Technical Center Human Factors laboratory soon after the TIM to discuss potential collaboration on air traffic control display automation.

FAA and NASA researchers likewise discussed areas for potential collaboration, including FAA participation on NASA's Human Performance and Modeling advisory committee. FAA researchers attended a NASA-sponsored intra-agency human factors symposium to highlight important NASA research.

Findings

The TIMs have been useful as a forum for getting to know members of the human factors research community, learning about the research that each organization is conducting, and sharing information about challenges researchers have faced.

Even more importantly, the intent of collaboration and information sharing is gaining momentum as a business imperative because of dwindling R&D budgets. In the present FAA environment it is imperative that the human factors community do a better job at cost-benefit analysis as well as collaborating earlier in the research cycle to ensure an understanding of full ownership costs. The human factors research community understands this and has agreed that collaboration should be continuous and worked at project levels. At the same time, strict adherence to requirements-driven research will hinder innovation and creativity. Organizations need to maintain a balance between requirements and innovation. Sharing labs and other unique facilities, including NAS simulation capabilities, would yield significant cost savings and encourage collaboration.

The lessons learned from prior R&D experiences challenge the research community to manage expectations not only within the R&D community but with the customers of R&D capabilities. Lessons learned further challenge organizations to delineate roles and responsibilities including a more balanced FAA/NASA approach; define research processes and decision points in research activities to determine what capabilities progress to field implementation and what capabilities do not; and systematically audit and inventory current and required laboratories and facilities, personnel resources, and research capabilities.

Conclusions

TIM participants agree that the transition from research to operational prototypes to development and fielding is complex and replete with human factors challenges. Moreover, they agree that FAA needs to establish an integrated and coordinated human factors R&D program that focuses on user needs, avoids duplication of effort, and leverages all research capabilities including people and laboratories. It is important to be clear about roles and responsibilities between researchers and their organizations. Fortunately, ongoing collaboration, as evidenced by post-TIM activities, is gaining momentum. Collaboration, not competition, is critical to success.

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