ATOP-R&D

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Technical Note: Advanced Weather Information for TRACON Controllers. Ulf Ahlstrom, William J. Hughes Technical Center, ACB-220

Introduction

Hazardous weather conditions affect the National Airspace System (NAS) in many ways including flight safety and system effectiveness. From a safety perspective, hazardous weather conditions contribute to aircraft accidents and fatalities (NTSB, 1999a; 1999b). From a NAS operations perspective, hazardous weather conditions are very costly. In 1995, weather related delays cost airlines $4.1 billion, and costs are only increasing ("Weather reports should be higher priority," 1995).

In an effort to mitigate these effects, the FAA is improving the availability of advanced weather products at selected Terminal Radar Approach Control (TRACON) facilities. In essence, these weather products provide detailed information about the presence of microbursts, wind shear, gust fronts, as well as the direction and speed of storm cells. However, the bulk of this weather information is only available to traffic management and supervisors for *strategic* use (Ahlstrom, 2004). TRACON controllers, on the other hand, maintain their Weather Situation Awareness (WSA) by receiving weather briefings from supervisors and by viewing six independent levels of precipitation on the Standard Terminal Automation Replacement System (STARS) Terminal Controller Workstation (TCW) or the ARTS Color Display. If the controller uses older

TRACON display systems, he/she can only display two precipitation levels simultaneously (out of six possible). In addition, controllers receive reports of hazardous weather conditions that pilots encounter during flight.

Providing controllers with the capability to display advanced weather information could be one way to improve the ability of NAS to deal with adverse weather. However, although accurate and timely weather information is of utmost importance for the mitigation of delays and safety risks, it is not clear what types of information would be most useful for TRACON operations (Ahlstrom & Della Rocco, 2003). Furthermore, we know very little about the optimal display of this information as well as the human factors issues associated with tactical operations (Ahlstrom, Keen, & Mieskolainen, 2004). Too much weather information could actually interfere with the perception of traffic data by providing redundant information and causing display clutter. On the other hand, if immediate access to enhanced weather information contributes to increased controller efficiency, we could potentially see a number of benefits like increased traffic throughput, improved weather advisories to pilots, and reduced workload associated with controlling traffic during adverse weather conditions.

Method

In the present high-fidelity simulation, we investigated the impact of advanced weather information on controllers' *tactical* operations. We manipulated the display of advanced weather information and compared this to a control condition where controllers had no weather information (current field operations). The advanced weather information consisted of pre-recorded Integrated Terminal Weather System (ITWS) data from the Dallas Forth Worth (DFW) TRACON. During the human-in-the-loop simulation, we presented the weather information on the TRACON controller workstation (TCW) or on an auxiliary weather display system (WIDS). Eleven non-supervisory, full-performance level TRACON controllers volunteered as participants. We used a generic TRACON airspace with two adjacent sectors and employed standard operating procedures (SOP) developed for the simulation airspace. To allow an examination of the effects of advanced weather information, we included a procedure that assigned responsibility for separating aircraft from weather levels 4, 5, and 6, to the controller. During simulation runs, two controllers operated traffic within the TRACON airspace. One controller was responsible for West operations, while the other controller was responsible for East operations. Controllers issued commands to simulation pilots and received additional information from an experimenter serving as a supervisor and subject matter expert (SME). The simulation pilots maneuvered aircraft using keyboard commands and communicated with the controllers using proper ATC phraseology and procedures. Because controllers rely heavily on pilot reports (PIREPs) during adverse weather conditions, we displayed weather information on simulation pilots' workstations. By providing the same precipitation information to controllers and simulation pilots, we enhanced the WSA and allowed for feedback that is more realistic during controller/pilot communications. To measure the workload associated with the use of advanced weather tools, controllers provided real-time workload ratings using the Air Traffic Workload Input Technique (ATWIT).

Results

Our result showed a significant impact of advanced weather information on controller efficiency. With advanced weather information at the workstation, controllers increased the average sector throughput (completed flights) by 6-10% compared to control conditions where no weather information was available. Although some types of weather information provide more benefits for tactical operations than others do, *we want to emphasize that any advanced weather information not currently at the workstation could benefit controllers*. By providing enhanced weather information at the workstation, we enhanced controllers' ability to detect approaching weather, monitor its movement, and understand its effect on future operations. This increased controllers' efficiency for timing of arrivals, for vectoring and adjustment of flow and sequencing, and for runway selection. We also find a positive transfer from these effects on controllers' tactical execution of aircraft holds. Controllers held more aircraft within the terminal airspace in weather tool conditions compared to the control condition. In control conditions, controllers were less able to pre-plan arrivals to runways affected by weather, thereby allowing less aircraft into the terminal airspace. Because controllers using advanced weather information held aircraft closer to the runways, it allowed aircraft a quicker approach that increased the efficiency and traffic throughput.

In addition to increased sector throughput, our results also show benefits for pilots when controllers have access to enhanced weather information. During the simulation, controllers issued weather sequences as they became available, reported storm intensity and movements, delivered reports about changing conditions, and explained reasons for approach changes to pilots when they were necessary. In short, pilots could benefit from increased controller WSA and the corresponding improvements in weather advisories. Increased WSA also has a positive effect on controller working conditions. Although controllers rated their instantaneous workload as low during all simulation runs, controllers' post-scenario ratings showed a significant reduction in overall workload during weather tool conditions as compared to control conditions.

Discussion

Although our findings indicated that weather information on both the WIDS and TCW was beneficial to controllers, we did see differences in the simulation data that could possibly be due to presentation mode idiosyncrasies. For example, both presentation modes differed with respect to the spatial and temporal presentation of traffic and weather data, and in the potential for creating display clutter. During WIDS conditions, we found that controllers performed significantly more heading commands compared to TCW conditions. This could possibly have been due to the spatial separation of weather and traffic data, and resulted in a larger number of corrective heading commands by controllers during WIDS operations. Another issue related to the spatial separation of data is the amount of 'heads-up' time for controllers using the WIDS display. Potentially, controllers could have spent a large amount of time looking up at the WIDS, time not spent focusing on the traffic data. However, this did not seem to be the case during our simulation. Using point-of-gaze (POG) data from oculometer recordings, we found that controllers had an average total viewing time on the WIDS display of 1.61 min during weather scenario 1, and 4.52 min during weather scenario 2. There was, however, a tendency for controllers to display advanced weather products for longer durations during WIDS conditions when compared to TCW conditions. This interaction pattern was likely the result of increased display clutter that would have resulted from superimposing traffic and weather data on the TCW. Despite these idiosyncratic effects, it seems like controllers can safely and effectively use both presentation modes for tactical operations. Based on subjective reports from controllers, we identified no clear preference for either presentation mode. Both the weather presentation on

WIDS and TCW were clearly preferred over receiving information from the supervisor. Controllers who reported preferring WIDS stated that they liked WIDS because weather information was instantly available but did not interfere with the traffic display. Those controllers who preferred receiving weather information on the TCW felt that on the TCW, there was less work involved in correlating weather information with current aircraft positions, and that there was no need to divert attention away from the traffic when viewing weather information.

Conclusion

The purpose of the present study was to evaluate the impact of advanced weather information on TRACON controller's tactical operations. We found that providing controllers with the capability to display advanced weather information increased controllers' efficiency for timing of arrivals, for vectoring and adjustment of flow and sequencing, runway selection, and improved their weather advisories to pilots. By reducing the uncertainty about weather conditions, controllers can make better decisions that will positively affect safety and efficiency of terminal operations. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objectives 1, 2 and 7: Reduce the commercial fatal accident rate; Reduce the number of fatal accidents in general aviation; Enhance the safety of FAA's air traffic systems.*

Point of Contact: E. Stein, WJHTC

Technical Note: Collocation of Systems

Sollenberger, R.L., Willems, B., Della Rocco, P. S., Koros, A., and Truitt, T. (2004). *Human-in-the-Loop Simulation Evaluating the Collocation of the User Request Evaluation Tool, Traffic Management Advisor, and Controller-Pilot Data Link Communications: Experiment 1 - Tool Combinations* (DOT/FAA/CT-TN04/28). Atlantic City International Airport, NJ: DOT/FAA William J. Hughes Technical Center

Abstract: The FAA Free Flight Program successfully deployed the User Request Evaluation Tool (URET), Traffic Management Advisor (TMA), and Controller-Pilot Data Link Communications (CPDLC) to a limited number of Air Route Traffic Control Centers (ARTCCs). As deployment expands nationwide, several facilities may eventually receive all three tools. Before this occurs, it is important to identify any potential human factors issues that may arise due to the collocation of these tools at the controller's workstation. In this report, we present the first of three high fidelity human-in-the-loop simulation experiments conducted to evaluate the impact of URET, TMA, and CPDLC collocation on controller workload, situational awareness, and teamwork. We examined collocation issues with a "stovepipe" independent configuration where none of the tools were integrated or directly communicated with each other. In this first experiment, twelve Air Traffic Control Specialists (ATCSs) participated as R-side/D-side controller teams operating a high altitude generic sector using all combinations of the three tools. The most important collocation issue identified was that controllers had difficulty accessing important information on the D-side display when URET and CPDLC were both operational (i.e., display clutter). Although neither tool alone caused display clutter, both tools in combination made it difficult for D-side controllers to find the information they needed quickly. This was especially true for

accessing CPDLC windows, which became covered when controllers used URET. Another collocation issue was that D-side controllers had to access TMA delay time information from the R-side display. Controllers thought it was important to have TMA information available on the D-side display where it could be easily accessed by D-side controllers. However, controllers were concerned that simply showing the TMA List on the D-side might add to the D-side display clutter. Good human factors design principles prescribe that users must have immediate access to important information and that critical information should never be covered. A "stovepipe" independent deployment of these tools will result in impaired access to timely information. The results of this study indicated that better efforts should be made towards integrating the information from URET, TMA, and CPDLC on the D-side monitor prior to deployment. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 7: Enhance the safety of FAA's air traffic systems.*

Point of Contact: E. Stein, WJHTC

HFACS: On February 5-6, 2005, CAMI researcher Albert Boquet participated in the annual HeliExpo in Anaheim, CA. He made a presentation entitled "An HFACS Analysis of Rotorcraft Accidents in the US". As information, the Human Factors Analysis and Classification System (HFACS) facilitates reliable identification, classification, and analysis of human error in complex, high-risk systems such as rotorcraft. The HFACS framework comprehensively addresses the myriad of active and latent failures known to influence operator performance. In doing so, it allows safety professionals to identity factors that influence performance and cause operator error. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objectives 1, 2 and 7: Reduce the commercial fatal accident rate; Reduce the number of fatal accidents in general aviation; Enhance the safety of FAA's air traffic systems.*
(A. Boquet, CAMI)

RRJSIT: Kevin Williams attended a meeting of the Remaining Risk Joint Safety Implementation Team (RRJSIT) in San Diego, CA, January 31 – February 4, 2005. The team is divided into three subgroups: icing, mechanical problems, and cargo/mid-air. Current work on cargo/mid-air accidents involves reviewing the recommendations that have been made for reducing these accidents and providing ratings for each recommendation regarding its potential to eliminate such accidents in the future. Recommendations include the addition of training, regulation changes, and equipment development/installation. Final disposition of the recommendations will be made in March 2005. One final meeting of the RRJSIT is scheduled for March 2005 at the Airlines Pilots Association in Herndon, VA. *This research supports the Administrator's Flight Plan Goal for Increased Safety, Objective 1: Reduce the commercial fatal accident rate.* (K. Williams, CAMI)

Air Traffic Flow: On February 23rd, Kenenth Allendoerfer with the William J. Hughes Technical Center's NAS Human Factors Group, will address the monthly meeting of the South Jersey Human Factors Society. The presentation is titled Playmaker: An Application of Case-Based Reasoning to Air Traffic Control Plays. When events such as severe weather or congestion interfere with the normal flow of air traffic, air traffic controllers may implement “plays” that reroute one or more traffic flows. Currently, “plays” are assessed and selected based on a controller’s experience using the National Playbook, a collection of “plays” that have worked in the past. Case-based reasoning (CBR) is an artificial intelligence technique rooted in research on how experts make decisions. CBR systems contain collections of previous situations (called cases) and methods for matching a novel situation to a previous one. The CBR technique is conceptually very similar to the Playbook. This presentation introduces PlayMaker, a CBR prototype that replicates the Playbook. It models how controllers select “plays”, describes the PlayMaker design and a model validation, and also discusses developments necessary for a full-scale CBR tool for this application. *This research supports the Administrator’s Flight Plan Goal for Increased Safety, Objective 7: Enhance the safety of FAA’s air traffic systems. This research also supports the Administrator’s Flight Plan Goal for Greater Capacity, Objective 1: Increase capacity to meet projected demand.* (K. Allendoerfer, WJHTC)

Flight Symbology: Volpe researcher Michelle Yeh gave two presentations on flight symbology research at the Society of Automotive Engineers Aerospace Behavioral Engineering Technology (SAE G-10) Meeting January 25-27 in Orlando, FL. Meeting attendees included representatives from industry, airlines, and the US Air Force. The first presentation was an invited plenary talk, which provided attendees an overview of Volpe's flight symbology research program. This research effort is concerned with the usability and comprehension of symbols that represent aeronautical navigation information on electronic displays. The second talk was given to the SAE G-10 Aeronautical Charting Subcommittee. This group is considering updating Aerospace Recommended Practice (ARP) 5289, "Electronic Chart Symbols", which provides guidance to industry on electronic charting symbology. Both talks were well received. Representatives from airlines and the Air Force offered to assist Volpe in data collection. Additionally, the Aeronautical Charting Subcommittee was especially interested in Volpe's research because of its potential implications for recommending and validating symbology. The Subcommittee believes the results of this research will assist in its effort to update ARP 5289. Dr. Yeh and representatives from the Air Force also discussed opportunities for future collaboration between Volpe and the Air Force Academy in Colorado Springs, CO. *This research supports the Administrator’s Flight Plan Goal for Increased Safety, Objective 1: Reduce the commercial fatal accident rate.* (M. Yeh, Volpe NTSC)

Human Factors Presentation: Mike McAnulty, Engineering Research Psychologist in the William J. Hughes Technical Center’s NAS Human Factors Group, gave a presentation entitled *Human Factors in Engineering FAA Systems* at a meeting of the Delaware Valley Chapter of the International Council on Systems Engineering. The presentation began with an overview of the National Airspace System (NAS) and the Technical Center. He then described the human factors discipline, the capabilities and organization of the NAS Human Factors Group and the Research Development Laboratory, and the methods used to evaluate, develop, validate, and select FAA systems. Also included were numerous examples of the different systems the group has participated in developing for the last eight years. (E. Stein, WJHTC)

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

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

CALENDAR

March 3, 2005 – Engineering and Military Psychology Symposium, George Mason University, Fairfax, VA http://www.erols..com/hfespoc

March 6-8, 2005 – Air Cargo 2005, Hotel del Coronado, San Diego, CA http://www.aircargoconference.com

March 14-16, 2005 – Centers of Excellence 4th Annual Joint Meeting, Radisson Hotel, Orlando, FL

March 14-16, 2005 – Flight Safety Foundation 17th Annual European Aviation Safety Seminar, Warsaw, Poland http://www.flightsafety.org/eass05_preagenda.html

March 17-18, 2005 – Aviation and Environment Summit, Crowne Plaza, Geneva, Switzerland http://www.iata.org

March 17-18, 2005 – FAA Aviation Forecast, Washington Convention Center, Wash, DC apo.faa.gov/Conference/welcome.htm

April 2-7, 2005 – CHI 2005, Portland, OR *chi2005-chair@acm.org*.

April 5-7, 2005 – Aviation Testing Expo 2005: Scientific Conference and Technology Forum, Europe, Messe Hamburg, Germany http://www.aerospacetesting-expo.com/northamerica/conf+forum.html

April 11-15, 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 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 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 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 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 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 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 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 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

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/

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

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

Comments or questions regarding this newsletter?
Please contact Bill Berger at (334) 271-2928
or via e-mail at bill.ctr.berger @faa.gov

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