5-7-2019

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WEATHER HAZARDS IN GENERAL AVIATION: HUMAN FACTORS RESEARCH TO UNDERSTAND AND MITIGATE THE PROBLEM

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Weather-related accidents contribute to general aviation fatal accidents each year. These accidents continue to occur even with advancements in weather information technology available in cockpit display technology and mobile applications. The purpose of this session is to highlight a body of on-going human factors research addressing examining interpretability of aviation weather observations, displays, and forecasts; discussion of results from the weather information latency study; use of augmented reality to enhance aviation education, training, and weather information presentation; increasing the number and detail of GA pilot reports (PIREP's); and GA Pilot In-flight Visibility Assessments. This paper provides an abstract for each of the topic areas.

Despite enhancements in weather information and the proliferation of weather-related cockpit display technology and mobile applications by industry, weather-related accidents continue to account for the majority of general aviation (GA) fatal accidents. Previous research has shown that in many instances a contributing factor in many of these accidents was the pilot's failure to correctly interpret the weather information being depicted inside and viewed outside the cockpit, and inadvertently entering instrument meteorological conditions. (Pearson, 2002; Aarons, 2014). Fortunately, a body of on-going, human factors research exists aimed at understanding and addressing this problem.

The purpose of this session is to highlight that research. Topics will include: examining interpretability of aviation weather observations, displays, and forecasts; discussion of results from the weather information latency study; use of augmented reality to enhance aviation education, training, and weather information presentation; increasing the number and detail of GA pilot reports (PIREP's); and GA Pilot In-flight Visibility Assessments. This session is designed to foster a discussion about the complexity of interpreting aviation weather, the hazards of weather in GA operations, and the research underway to mitigate the hazards and improve GA safety**.**

Interpretability of Aviation Weather Products by GA Pilots

If a General Aviation (GA) pilot encounters hazardous weather during flight, a high likelihood of fatal accident exists (Fultz and Ashley, 2016). Fortunately, a wealth of aviation weather technology and information is available to help pilots to develop situation awareness of current and forecasted weather conditions. Little research, however, has examined the degree to which General Aviation pilots can interpret the weather observation, analysis, and forecast products* (Blickensderfer et al., 2017). If GA pilots are unable to interpret the weather products effectively, those pilots will not be able to take advantage of that technology and information to improve flight safety. To determine how well GA pilots, interpret weather products, a multidisciplinary research team including human factors specialists, meteorologists, and flight experts developed and validated a written test to assess the degree to which pilots can interpret weather products (Blickensderfer et al., 2017). The purpose of this presentation is to describe and discuss weather product interpretability based on a series of studies conducted using the Blickensderfer et al. (2017) test. Results will be discussed in terms of implications for product design and pilot training. *Observation products include Routine Meteorological Reports (METARS), Aircraft Reports (AIREPS)/Pilot Reports (PIREPS), radar, and satellite imagery. Analysis products include Ceiling and Visibility Analysis (CVA), Weather Depiction Charts, and Surface Analysis Charts. Finally, forecast products include Terminal Aerodrome Forecasts (TAFs), Prognostic (or prog) charts (e.g., surface weather charts), Graphical Airman's Meteorological (G-AIRMET) advisories, Graphical Turbulence Guidance (GTG), Significant Meteorological Information (SIGMET) advisories, and winds aloft.

Weather Information Latency Study

The inability of GA small aircraft pilots to correctly assess the actual in-flight weather situation is aggravated by the fact that most of GA aircraft are not equipped with complex and expensive airborne weather radars, like those in larger aircraft, especially in commercial aviation. Pilots of these small GA aircraft have to make in-flight weather relevant decisions based on information displayed on screens of various electronic devices capable of producing weather radar images (Pope, 2015). Unfortunately, these images show weather situations that existed some time ago. The time difference between an electronic device radar weather image and actual flight weather conditions, seen from the aircraft cockpit, can be very significant and may be as long as 20 minutes (Zimmerman, 2013; Trescott, 2012). This information discrepancy makes weather-related accidents more probable due to the degraded situational awareness of the pilots, who become predisposed to making safety-threatening decisions to continue flights into rapidly deteriorating weather conditions for which they, or their aircraft, are not certified. The purpose of this presentation is to describe and discuss weather information latency based on a study conducted at the FAA W. J. Hughes Technical Center in July 2018. Results will be discussed in terms of implications for pilot initial and recurrent training.

Augmented Reality to Enhance Aviation Education and Training: Bridging the Digital Gap

Interpreting and understanding aviation weather is critical to hazardous weather avoidance, and previous studies have indicated that improving understanding of weather phenomena and weather products can improve pilot decision making (King, et.al, 2017). One of the main challenges faced by pilots is the ability to correlate weather knowledge to real-life situations and decision-making. This may be due to a lack of weather knowledge, the usability of the weather information available, or both. Previous research suggests increasing the usability and understanding of weather products can improve pilot situational awareness and decisions making and, in turn, increase flight safety (Latorella & Chamberlain, 2002). Specific tasks such as encountering possible adverse weather conditions require an understanding of several interrelated human and machine components requiring practice and immersion. To meet these challenges, we can harness 3D simulated environments using Augmented Reality (AR) human interfaces to provide adaptive learning methodologies to meet the learning styles of changing generations and improve effectiveness and efficiency of training methods. These AR enhancements can include interactive 3D models, experiential learning modules and assessments, engaging real-life video, scenario-based training or links to additional URL information to provide more in-depth knowledge of the weather product or phenomena and engage a new generation learner. AR technology, allows the pilot, instructor or student to escape the limitations of traditional printed materials enabling them to truly visualize the objects or weather phenomena in full 3D.

General Aviation (GA) Pilot In-flight Visibility Assessments

One of the causes behind Visual Flight Rules (VFR) into Instrument Meteorological Conditions (IMC) flights is GA pilot difficulty to assess in-flight visibility distances (Coyne, Baldwin, & Latorella, 2008; Goh & Wiegmann, 2001; Wiggins & O'Hare, 2003). During cockpit simulation flights, we investigated the ability of GA pilots to estimate the forward visibility by providing visibility estimates at various route locations where the visibilities ranged from 30 nmi to less than 3 nmi. Using three different pilot groups, we provided two of the groups with specific training (i.e., Slant-range rule of thumb and sectional map distance training) and compared their visibility assessments with a third pilot group that did not receive any training (i.e., Control group). The result showed that the visibility estimate errors for the Slant-range group were on average half the size compared to the visibility estimate errors for the Control and the Map distance training groups. Furthermore, for large simulated visibilities (10 to 30 nmi) pilots severely underestimated the visibility. For simulated visibilities below 10 nmi, the analysis showed that pilots were overestimating the forward visibility. For pilots who decided to turn around at the end of the scenario, 42% were in violation of the VFR rules due to insufficient forward visibility. We believe that with training on the Slant-range rule of thumb, coupled with a set of decision-making rules, pilots would be in a much better position to assess the out-the-window visibility and make more informed flight decisions rather than continue flight into IMC.

Increasing the Number and Detail of GA Pilot Reports (PIREP)

A Pilot Report (PIREP) provides vital information on weather conditions experienced at certain flight altitudes in specific locations. Turbulence, icing, outside air temperature, and cloud layers are a few examples of weather conditions that may be reported. Pilots may use PIREPs when doing flight planning. PIREPs are used by air traffic controllers and flight services when communicating with pilots about weather conditions aloft. PIREPs are currently the only source of icing information for pilots (NTSB, 2017). However, many general aviation (GA) pilots submit few PIREPs per year (AOPA, 2016; Casner, 2010). PIREPs have other uses beyond immediate navigation. For instance, PIREPs may be used by aviation weather professionals to modify the area encompassed in a SIGMET or to update weather forecasting models (NTSB, 2017). This presentation discusses the need for more GA PIREPs, barriers to PIREP submission, existing submission tools, and the need for more accurate and timely reports. An exploratory study is presented and discussed that examined six potential features of a digital PIREP submission tool

Acknowledgements and Disclaimer

The views expressed in this paper and associated panel presentation are those of the authors and do not necessarily represent the views of the organizations with which they are affiliated.

References

Aarons, R. N. (2014). Weather-related loss of control. *Aviation Week Network*. July 1, 2014. https://aviationweek.com/business-aviation/weather-related-loss-control

Aircraft Owners and Pilots Association. (2016). *2016 Pilot report survey*. Retrieved from http://download.aopa.org/advocacy/0417_2016_pilot_report_survey_final_report.pdf

Blickensderfer, B., Lanicci, J., Guinn, T., King, J., Ortiz, Y., & Thomas, R. (2017). Assessing general aviation pilots understanding of aviation weather products. *The International Journal of Aerospace Psychology*, 27: 3-4, 79-91, DOI:10.1080/24721840.2018.1431780.

Casner, M., S. (2010). Why don't pilots submit more pilot weather reports (PIREPs)? *The International Journal of Aviation Psychology*, 20:4, 347-374, DOI: 10.1080/10508414.2010.48701

Coyne, J. T., Baldwin, C. L., & Latorella, K. A. (2008). Pilot Weather Assessment: Implications for Visual Flight Rules Flight Into Instrument Meteorological Conditions. *International Journal of Aviation Psychology, 18*(2), 153 – 166. https://doi.org/10.1080/10508410801926756

Fultz, A. J., & Ashley, W. S. (2016). Fatal weather-related general aviation accidents in the United States. *Physical Geography*, *37*(5), 291-312.

Goh, J., & Wiegmann, D. A. (2001). Visual flight rules flight into instrument meteorological conditions: An empirical investigation of the possible causes. *International Journal of Aviation Psychology,11*, 359–379. https://doi.org/10.1518/0018720024497871

King, J., Ortiz, Y., Guinn, T., Lanicci, L. (2017). Assessing General Aviation Pilots' Interpretation of Weather Products: Traditional and New Automated Generation Products. journals.sagepub.com

Latorella, K. A., & Chambelain, J. P. (2002). Graphical weather information system evaluation: Usability, perceived utility, and preferences from general aviation pilots (No. 2002-01-1521). SAE Technical Paper. doi:10.4271/2002-01-1521.

National Transportation Safety Board. (2017). *Improving Pilot Weather Report Submission and Dissemination to Benefit Safety in the National Airspace System.* Washington DC: National Transportation Safety Board. Retrieved from https://www.ntsb.gov/safety/safety-studies/Documents/SIR1702.pdf

Pearson, D. C. (2002). VFR flight not recommended: A study of weather-related fatal aviation accidents. *Technical Attachment SR SSD*, *18*, 2443-2448.

Pope, S. (2015). 8 Offbeat Aviation Apps. - Flying magazine. Posted: May 28, 2015. Retrieved on December 13, 2015 from: http://www.flyingmag.com/avionics-gear/pilot-supplies/8-offbeat-aviation-apps

Trescott, M. (2012). NTSB Alert – In-cockpit NEXRAD weather age misleading and killing pilots. *Aviation Training, General Aviation Safety.* June 20, 2012. Retrieved from http://www.maxtrescott.com/max_trescott_on_general_a/2012/06/ntsb-alertin-cockpit-nexrad-weather-age-misleading-and-killing-pilots.html

Wiggins, M., & O'Hare, D. (2003). Weatherwise: Evaluation of a cue-based training approach for the recognition of deteriorating weather conditions during flight. *Human Factors, 45*, 337–345. https://doi.org/10.1518/hfes.45.2.337.27246

Zimmerman, J. (2013). Thunderstorm flying in the age of datalink weather. *Weather Geek*. September 8, 2013. Retrieved from http://airfactsjournal.com/2013/09/thunderstorm-flying-in -the-age-of-datalink-weather/