Did You Notice Your Destination Airport Just Went IFR?

How to more effectively convey weather information to pilots

By David Hughes, FAA NextGen Performance and Outreach

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It is all too easy for general aviation pilots to overlook key cockpit-displayed weather information if the presentation isn't obvious enough. FAA human factors engineers are trying to shed light on how cockpit or portable display technologies might convey vital weather information more effectively to pilots.

Ian Johnson is a human factors researcher in the FAA's NextGen Aviation Weather Division's Weather Technology in the Cockpit (WTIC) program. Johnson, who began working on the program one year after its 2008 launch, flies a simulator at the FAA William J. Hughes Technical Center (WJHTC) in Atlantic City, N.J., to show how this research is being conducted. He sees the same weather displays in the cockpit encountered by the 60 to 90 private pilot volunteers who participate in the WTIC simulator studies.

Accurate, high resolution, rapidly updated weather reporting is now a reality in the cockpit for general aviation pilots, but how effectively can a pilot absorb and use this information? This is one of the research questions being addressed by the FAA's NextGen WTIC program, now in its fourth phase. The research aims to recommend, but not require, a minimum performance for weather displays so that pilots have sufficient, accurate information that is effectively displayed to support consistent and safe weather-related decision making.

The WTIC program does not seek to establish standards but aims to provide guidance on the best ways to highlight changing METARs to improve pilot recognition. The METAR acronym roughly translates from the French as Aviation Routine Weather Report; it is an ICAO format for reporting weather observations and comes from an airport or a weather observation station. The program will outline a number of ways to reduce any information gaps in the cockpit and thus achieve the desired level of performance so pilots will be more likely to recognize when key weather information is changing. Still, there is no one size fits all solution.

Weather Information That is Easy to Miss

Today, Johnson, who is also a general aviation pilot, is cruising along at 3,500 feet, demonstrating how a VFR pilot sees important weather information on glass cockpit displays. The focus is on METAR symbols that change color when the destination airport goes from VFR to IFR conditions. This is vital information for a VFR-only pilot who doesn't want to fly into clouds or fog on the way to his or her destination, which could result in a fatal loss of control of the aircraft. The displays used in the simulator studies are those currently on the market, and the manner in which they present weather information to the pilot vary a great deal.

METAR symbols also show what the weather is like at alternate airports. During Johnson's short flight, the symbols start to change from blue to yellow, alerting him to which airports now have IFR rather than VFR weather. It is all too easy to miss the change in color depending on the presentation. This is particularly true for a single pilot who is multi-tasking, scanning for other traffic out the window while also checking for other information, not just weather information, when glancing down to scan the instrument panel.

Ian Johnson flies a Beech 350 simulator at the Cockpit Simulation Center at the William J. Hughes Technical Center in Atlantic City, N.J. Johnson is a human factors researcher in the FAA's NextGen Aviation Weather Division's Weather Technology in the Cockpit program.

During the WTIC experiments, many of the volunteer pilots do miss the changes and continue on when they should be thinking about heading for an alternate airport or making a decision to turn around and fly another day. These lost decision-making windows point to gaps in displays that FAA researchers plan to highlight in reports on these simulator sessions. The findings will provide guidance to both the FAA safety organization and private sector cockpit display designers on how to make the presentation of weather information more consistent and effective.

Doing this type of research is exactly what Johnson had in mind when he graduated from Embry-Riddle Aeronautical University with a master's degree in aeronautical science focused on human factors in aviation systems. He also earned his bachelor's at Embry-Riddle in human factors psychology and a second Master of Aeronautical Science degree in aviation/aerospace safety systems.

These degrees provide a perfect foundation for what Johnson is doing now on WTIC. The WTIC program is part of a wide-ranging effort by the FAA's NextGen Aviation Weather Division to ensure critical weather information is ready for the NextGen era.

Identifying targets for NextGen weather research is a matter of finding gaps in the flow and use of information and making a determination on whether fixing the gap will improve operational efficiency, safety, or reduce environmental impact in the NAS. The benefits will help commercial, general aviation, or business aviation aircraft operators. Helping VFR pilots avoid flying into IFR conditions by having the right weather information is a high priority.

"Half of general aviation weather-related accidents that result in fatalities are due to limited visibility," said Gary Pokodner, WTIC program manager. "If we can show that pilots have a lack of the right weather information, we can fill that gap." Since graduating from Lehigh University as an electrical engineer, Pokodner worked in design, reliability, development, testing, and acquisition of avionics at ARINC for 25 years before joining the FAA in 2011 to work on aviation weather research.

One significant issue that the NextGen WTIC team is addressing is the misunderstanding among pilots about the capabilities and limitations of Next Generation

WTIC Phases 1 to 4

Three phases of research have already been conducted in the FAA's WTIC program as part of the FAA's NextGen modernization of the air traffic control system, and a fourth is in the works. A key part of this modernization is what happens in the cockpit. Phase 4 is just beginning this year. Each phase has a different focus:

- WTIC Phase I (2014): This simulator study at WJHTC involved 24 volunteer, instrument-rated, private pilots, and focused on weather display symbols and their effects on pilot decision making. This research showed that different symbols and colors caused differences in pilot behavior and decisions. As a result of these findings, the WTIC team postulated that cockpit apps could be developed to track hazardous weather conditions and alert pilots to them.
- WTIC Phase 2 (2015): This simulator study involved 60 volunteer, instrument-rated pilots, and assessed general aviation pilots' perceptions of changes in aviation routine weather report (METAR) symbols. The research showed that different symbols used to present weather information affects pilots' perceptions of any changes and in turn influences pilots' reactions.
- WTIC Phase 3 (2015): This simulator study involved 70 volunteer, private pilots, and examined how pilot behavior is affected by using portable weather applications. The research showed that portable weather displays can be used by pilots without degrading decisions and actions related to the safety of flight. It also showed that improved situational awareness of weather doesn't always improve pilot performance relative to weather challenges.
- WTIC Phase 4 (2016): This simulator study will be designed to build on what is reported in Phase 3. This phase started in July 2016.

Weather Radar (NEXRAD) graphic displays they use in the cockpit.

NEXRAD is a great long-range, strategic planning tool that should be used by pilots only for avoiding hazardous weather areas, such as lines of thunderstorms. The mistake pilots often make is looking at NEXRAD depictions of storms neaby and assuming the picture presented is real-time. Since it takes time to process NEXRAD data and then transmit it to the cockpit, the picture a pilot sees can be 5 to 20 minutes old. This is significant because new thunderstorm cells can form in a matter of minutes to create hazardous conditions.

The WTIC program is work- ing with the Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS), an FAA sponsored Center of Excellence, to address the issue of latency in weather graphics displayed in the cockpit. The PEGASAS group is a consortium of aviation universities that performs general aviation research under an overall FAA grant.

PEGASAS is developing a latency trainer, a table top device to train pilots on this critical safety subject. The trainer will be used in the Weather Information Latency Demonstration (WILD) research project to examine how latencies in the display of weather information affect a general aviation pilot's ability to detect important weather events, plan a response, and avoid hazardous conditions. In addition, vendors that manufacture flight training devices, including flight simulators, may incorporate mo WILD concepts into their designs.

The WILD trainer has the capabili- ty to provide latency of any time interval specified to enable demonstration of the potential hazards.

Since thunderstorms can build rapidly, using NEXRAD to navigate near storms can lead to a fatal encounter with a cumulonimbus cloud. WTIC researchers have also found that few pilots can accurately judge how far they are away from that cloud even when they can see it. What can be seen out the windscreen may be a lot closer than it appears to be. In fact, pilots are often only five miles from a storm cloud when they think they are a safe 20 miles or more. "There are no markers in a cloud to tell you how far you are away from it." Johnson said.

Research Findings May Lead to Better Displays

Most VFR pilots who don't have an instrument rating know that stumbling into the clouds or a fog can lead to a potentially fatal loss of control incident. Anything in the cockpit that warns a pilot of weather changing from VFR to IFR ahead could literally be a lifesaver.

The WTIC team working is closely with Ulf Ahlstrom, an FAA NextGen engineering research psychologist who designed the VFR-into-IFR experiments. Ahlstrom, who served as principal investigator, works at the WJHTC cockpit simulator center, which has five simulators modeling general aviation, piston-powered aircraft. In all, the center has nine simulators, including one Airbus, one Boeing, one regional jet, and one corporate jet. Almost all of the research done at the center is for NextGen. Having five general aviation simulators makes it easier to conduct studies with large numbers of pilots.

In 2014, one WTIC Phase 2 study

nitored 60 instrument-rated general avi- ation pilots and assessed each pilot's ability to detect changes in METAR symbology. The simulator was frozen at three different points during a 35-minute flight to see if the pilots had noticed weather information symbols had changed on the cockpit display.

Ulf Ahlstrom, FAA NextGen engineering research psychologist, in front of a general aviation simulator

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– Gary Pokodner, Program Manager, WTIC

Photos courtesy of David Hughes

Gary Pokodner is the FAA's Weather Technology in the Cockpit program manager

In this study four types of weather information were overlaid on a moving map display – METAR, significant meteorological advisories, lightning strikes, and precipitation. Modern glass cockpits can present so much information that it can lead to pilot overload. Small, color-cod- ed symbols were used to summarize each METAR as either IFR or VFR conditions. The pilots were told to assume they were IFR-rated but had chosen to fly VFR. METAR changes were introduced at the 19, 20, and 30 minute points in each flight. At these times there were brief, temporary freezes of the simulator. Once the cockpit display was covered up, the pilots were asked what they had observed.

During the study, only 25 percent of the pilots spotted the METAR symbol change during the quiz when the simulator was frozen the first time, while 62 percent spotted it by the third time when a different symbology was used. Pilot perception varied a great deal based on the symbol presented. FAA researches believe they can use these findings to help develop concepts for more optimal presentations which display designers can leverage.

Not every symbol is a good one, and not every combination of symbols and colors produce ideal or even equally good presentations. This study revealed that more pilots spotted the change when the METAR symbol was a circle, and it changed from white to red.

Currently there are no industry standards for the display of weather information in the cockpit. This lack of a standard has resulted in a large variation of symbols used by commercial vendors, raising the question as to whether different symbols for the same weather data have an effect on pilot perception and behavior. They want to encourage designers to standardize their approaches to use the most effective symbols.

As a conclusion, the WTIC phase 2 report says it is clear from this study that pilots' perception of symbol changes while in flight is "frail," leaving many changes undetected. This "change blindness" is particularly strong during multitasking, such as during single-pilot operation. Failure to detect a METAR change means the pilots missed a valuable cue that would prompt them to ask ATC for a weather update. "The earlier a pilot recognizes the situa- tion, the more time he or she will have to make a good decision and the more time there will be to plan a different course of action," Johnson said.

At the direction of the WTIC program, PEGASAS researchers also examined whether computer apps might be able to track weather information and notify pilots of significant changes. This could assist pilots in making good decisions in the future as increasing bandwidth makes it easier for pilots to get access to the weather information they need in the air and on the ground before takeoff.

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