Weather Technology in the Cockpit: Cognitive Assistant Tools (CAT) for the Cockpit

Presented to: *Fall 2023 Friends and Partners in Aviation Weather(FPAW) Meeting*

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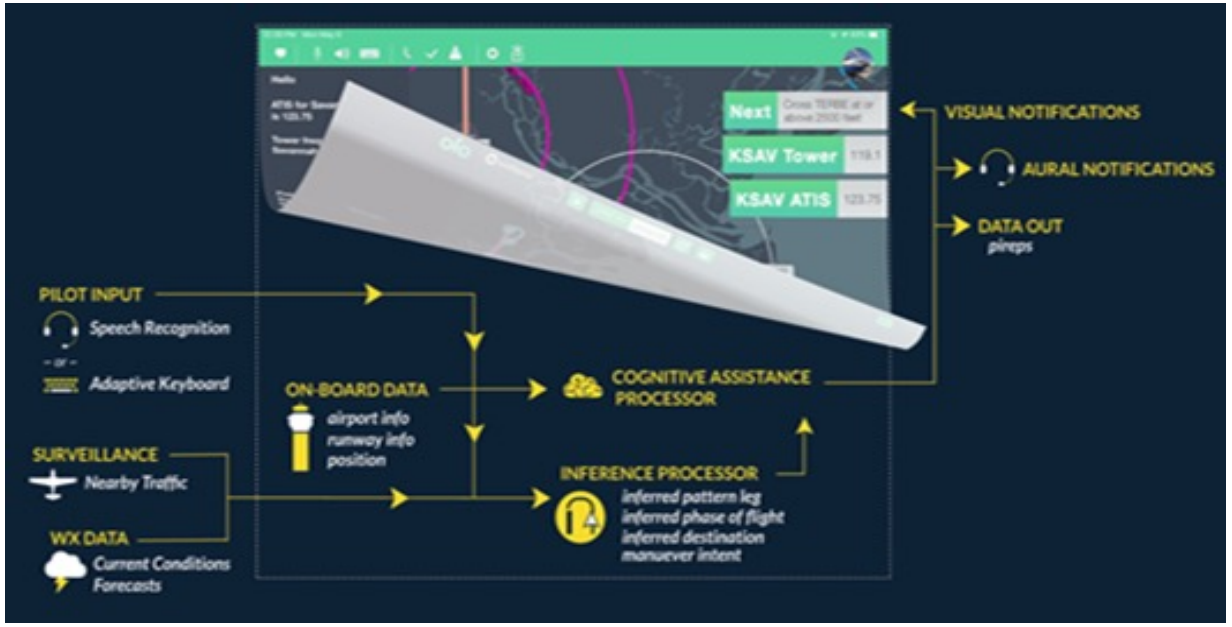
Date*: November 16, 2023*

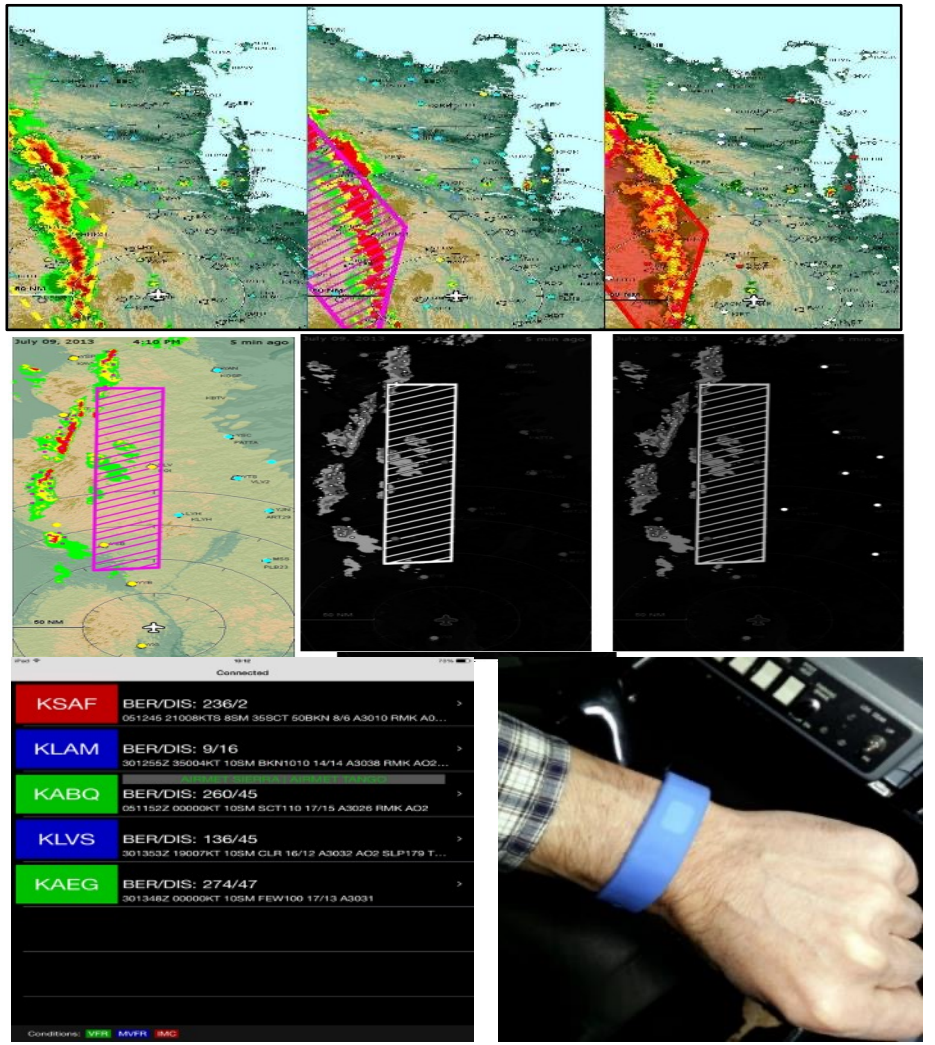


Background

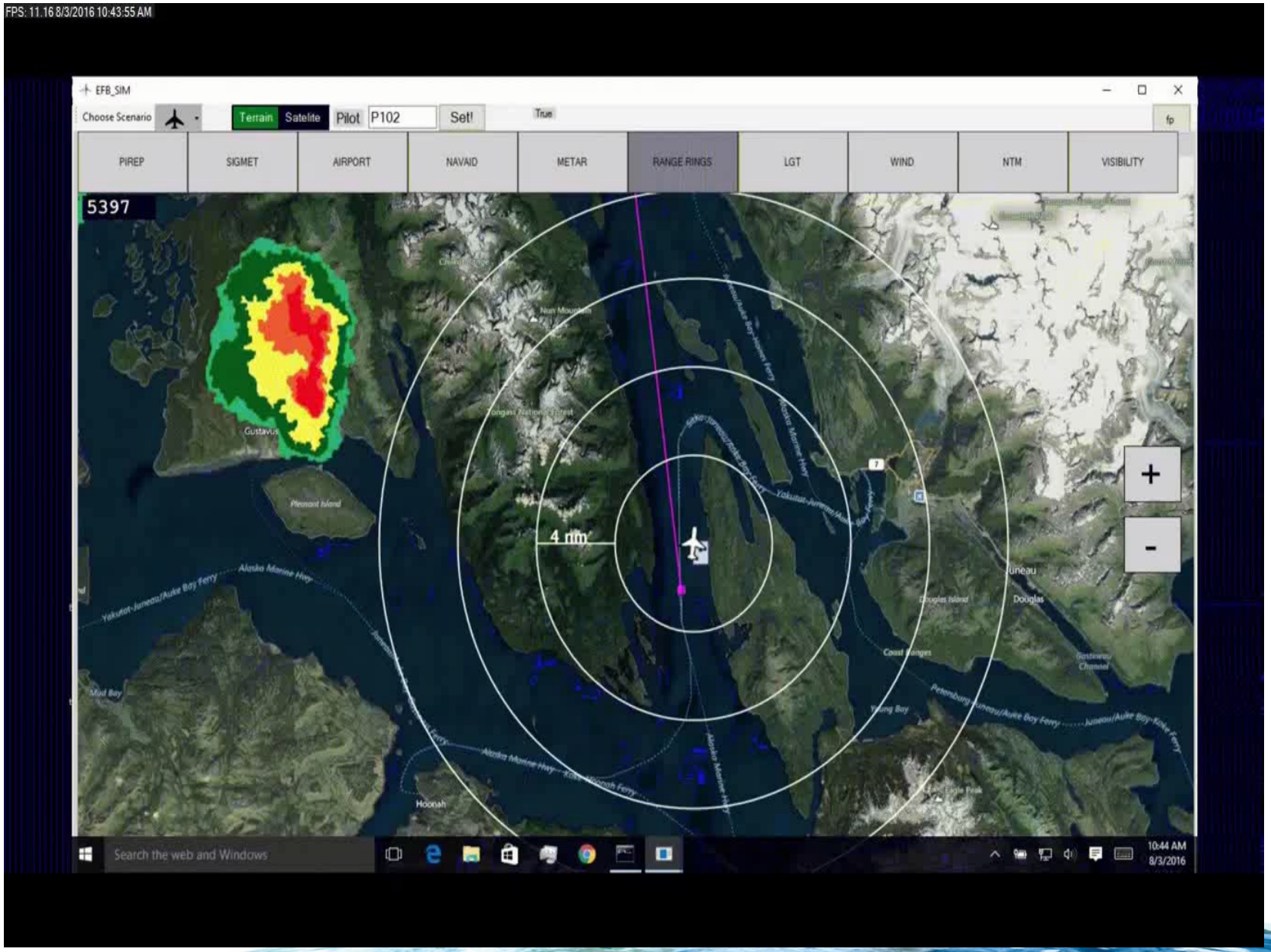
- The use of weather information on Electronic Flight Bags (EFBs), tablets, and mobile phones has become commonplace among General Aviation (GA) pilots.
- Previous (WTIC) research shows:
  - Gaps in pilot awareness of adverse weather both En route and at the destination airport.
  - Difficulty associated with identifying trends in weather data containing both spatial and temporal information.

Changes in Weather: WTIC Research

- Assessed GA pilots' perception of changes in METAR symbology and airport visibility conditions
  - Depending on the symbol shape and color, pilots varied considerably in their overall detection of METAR symbol change during flight.
- Assessed symbology salience and its effect on symbology recognition
  - Enhancing display symbols increases the discriminability accuracy and reduces the response time
- Assessed weather notification function to notify GA pilots of state changes in weather
  - Weather state-change notifications (via tactile feedback) improved pilot weather situation awareness and reduced cognitive workload



Active Reminder (AR) Demonstration Video

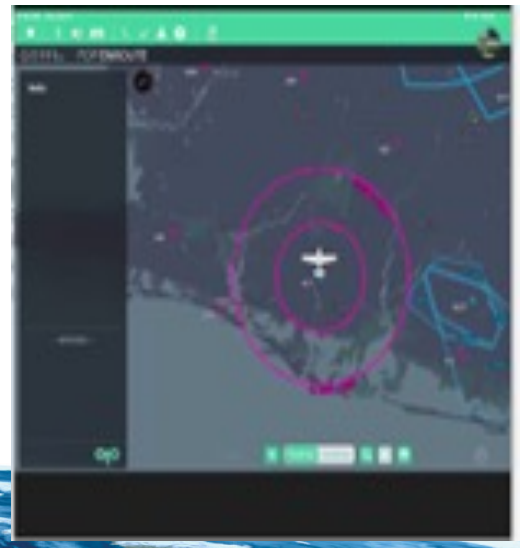


First video segment –Convection: Active Reminder (AR) blue line pops up at 20 nmi from 30 dBz areas (Yellow)

Second video segment – Visibility; AR pops up when **20 nmi from 1-3** nmi visibility (Red)

Study Question

- Can we develop a set of Cognitive Assistance tools that only use presently available data:
  - to aggregate weather data,
  - develop insights from the weather data,
  - and present these insights to pilots in such a way as to enhance pilot decision-making, enhance operational safety, and reduce cognitive workload?



Method

Participants

- Twenty-four GA pilots participated in the study.
- Sixteen of the pilots were certified IFR pilots while the remaining eight pilots were VFR-only pilots.
- The age of the participant group had a mode of 62 years and a range of 66 years (*min*=21 and *max*=87).
- The range of total number of flight hours was between 156 and 40,000, with a mode of 11,000 hours.
- Eight pilots reported not using any kind of weather display while flying, while the remaining sixteen pilots reported using one or more of four reported weather information sources (Foreflight 64%, Garmin 26%, SiriusXM 5%, and WingXPro 5%).

Design/Setting

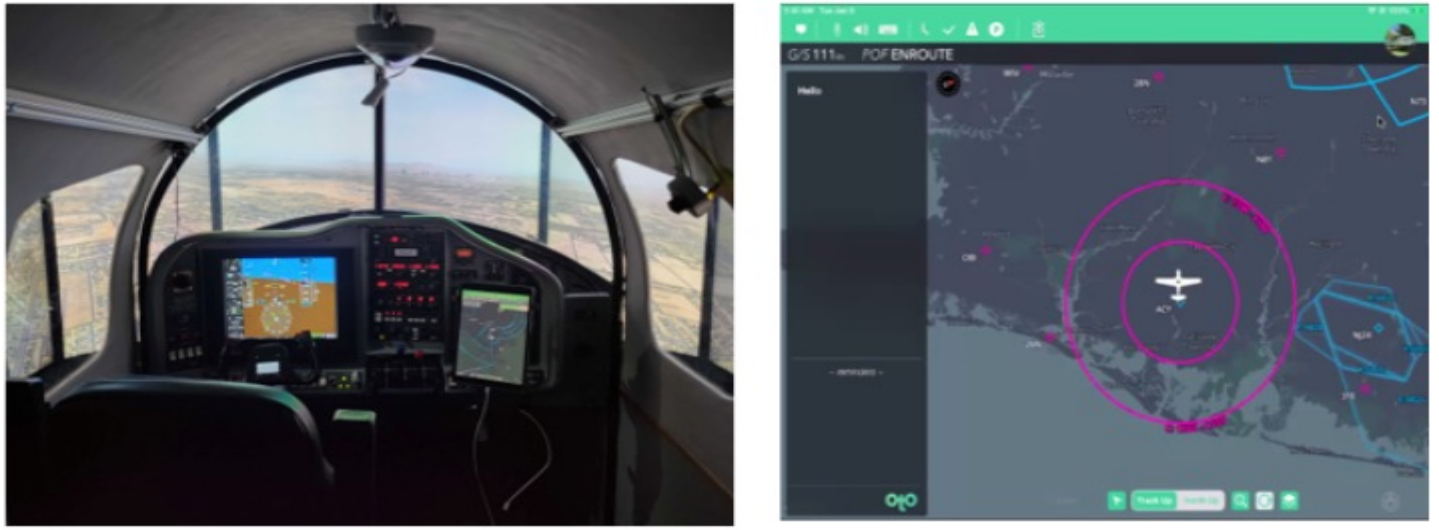
- During the evaluation pilots viewed 5 dynamic weather scenarios and answered structured questions presented on an iPad tablet.
- The 5 Scenarios were:

1. Weather at destination
2. Weather 'near', 'at', or 'below' approach minimums
3. Change in preferred runway due to weather
4. Weather changes at destination
5. Weather changes along route

- This WTIC project (Phase 1) was executed at the FAA William J. Hughes Technical Center (WJHTC) Cockpit Simulator Facility (CSF).

Equipment

- For the scenario evaluation, we used a General Aviation (GA) MicroJet simulator configured as a Cessna 172 single-engine aircraft with the G-1000 multi-function display.
- We presented information on the G1000 glass cockpit control display, the iPad display, and the 180° cockpit-out-the-window view.



Cockpit out-the-window view (left) and the CAT display (right)

Evaluation Task

- For each of the 5 weather scenarios, we asked Pilots to evaluate and rate the weather information and how it would affect their decision-making, cognitive workload and safety for today's operations (with no CAT support) and future with operations with CAT support

1. Weather at destination
2. Weather 'near', 'at', or 'below' approach minimums
3. Change in preferred runway due to weather
4. Weather changes at destination
5. Weather changes along route

Scenario #	Rating Question	Condition
1b	Decision-making	Today
1c	Decision-making	CAT
1d	Cognitive workload	Today
1e	Cognitive workload	CAT
1f	Safety	Today
1g	Safety	CAT

- Pilots viewed the scenarios from the out-the-window display and interacted with the text and graphical information on the iPad CAT display

- Pilots also received weather information and notifications aurally from the CAT display.
- Pilots did not fly the simulator during the evaluation but observed the replay of the scenario flight

[Demonstration “1. Weather at destination.” Decision-making.] Question

- You evaluated a flight scenario that demonstrates “***weather at destination***” as provided by Cognitive Assistance Tools. Below are questions that we would like you to answer by providing a rating number from 1 to 9. The questions relate to “***weather at destination***” as it is available in today’s flight operations (i.e., by reading text and/viewing display graphics/or listening to automated weather reports) versus your prediction of using “***weather at destination***” information as provided by Cognitive Assistance Tools (as shown in the demonstration). Please put a circle around the number that corresponds to your answer.

1a. You just evaluated a Cognitive Assistance Tool demonstration that presented “***weather at destination***.” Overall, how important is information about “***weather at destination***” for *pilot operations*?

Not at All Important								Very Important
1	2	3	4	5	6	7	8	**9**

[Demonstration “1. Weather at destination.” Decision-making.] Question

- **1b**. In today’s flight operations pilots must acquire and assess information about “***weather at destination***” on their own (using available information ‘as is’). By assessing all available information, pilots must determine if the weather at the destination is below approach minimums. The outcome of this assessment will determine what decision the pilot will make with regards to the flight. When weather information is acquired in this way, how do you think it affects pilot *decision-making*? Will it have positive effects and make it easier for the pilot to make a flight decision, or will it have negative effects and make it harder for the pilot to make a flight decision?

Very Negative Effects on Decision-Making				Neutral Effects on Decision-Making				Very Positive Effects on Decision-Making
1	2	3	4	5	6	7	8	**9**

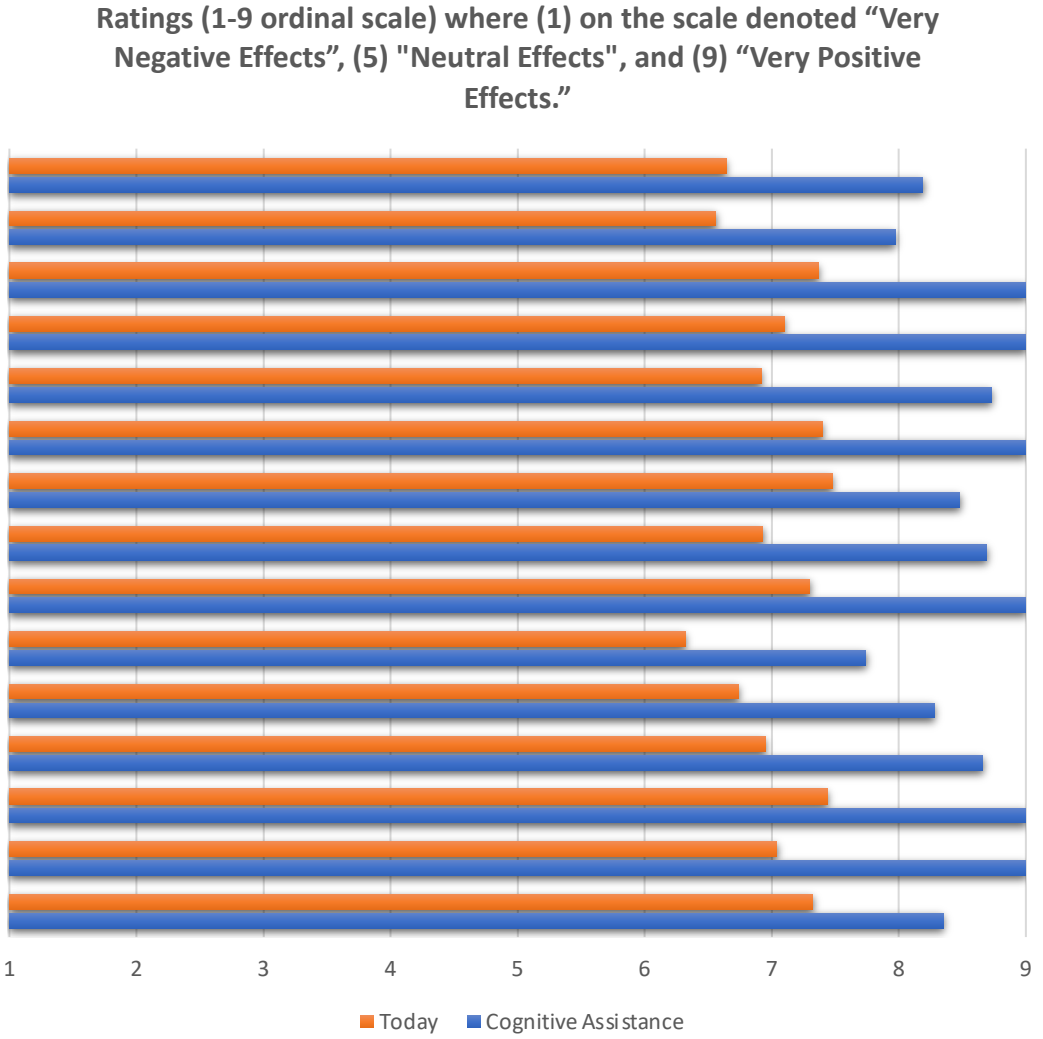
[Demonstration “1. Weather at destination.” Decision-making.] Question

- **1c.** In contrast to today’s flight operations, future flight operations could involve the use of Cognitive Assistance Tools that acquire and assess all available information about “***weather at destination***” automatically (without pilot involvement). This means that the Cognitive Assistance Tool will determine (based on all the data) if the weather at the destination is below approach minimums. The tool would then present this information to the pilot automatically, notifying the pilot of the status with regards to approach minimums. When weather information is acquired in this way, how do you think it affects pilot *decision-making*? Will it have positive effects and make it easier for the pilot to make a flight decision, or will it have negative effects and make it harder for the pilot to make a flight decision?

Very Negative Effects on Decision-Making				Neutral Effects on Decision-Making				Very Positive Effects on Decision-Making
1	2	3	4	5	6	7	8	**9**

Results

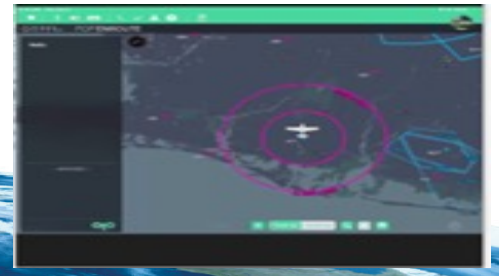
- First, Pilots provided importance ratings for the five scenarios (1=*'Not at All Important'*, 9=*'Very Important'*).
  - This information indicates how pilots perceive the relative importance of the five weather information algorithms and will inform researchers of potential candidates for use in future studies.
  - There was a consensus among pilots in their importance ratings for all five scenarios, with a rating *mode*=9 for each scenario.
- Second, pilots rated the effect on pilot operations during two conditions: "Today" (NO Cognitive Assistance tools) and "Cognitive Assistance" (The use of Cognitive Assistance tools).
  - All ratings were performed using a 1-9 ordinal scale.
  - *Main Effect*: All ratings for the 'Cognitive Assistance' are higher than the rating for 'Today' for scenario questions related to 'Decision-making', 'Cognitive workload', and 'Safety.'



Conclusion and Recommendations

- Based on the Phase I outcome WTIC should conduct a Phase II study:

- Design and conduct a human-in-the-loop simulation study to evaluate the use of Cognitive Assistance Tools:
  a. Select one or more weather scenario algorithms from the ones used in the present study.
  b. Define and develop cockpit flight scenarios.
  c. Use a between-group design with one independent variable ***Flight Condition*** (two levels: 'Cognitive Assistance' versus 'Today').
  d. Define dependent variables that are metric.
  e. Define a structured post-scenario interview that should be conducted by one or more experienced pilots.



Questions?
Thank you!

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