Weather Technology in the Cockpit (WTIC) Program—Minimum Weather Services

Friends/Partners of Aviation Weather (FPAW)

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Presented by

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WTIC Program Overview

- Portfolio of research projects to develop, verify, and validate requirements recommendations to incorporate into Minimum Weather Service (MinWxSvc) standards and guidance documents
- We define MinWxSvc as:
  - Minimum cockpit meteorological (MET) information
  - Minimum performance standards/characteristics of the MET information
  - Minimum information rendering standards
  - Enhanced MET training

WTIC Program Objectives

- Enhance General Aviation (GA) safety by identifying and resolving risks before they become accidents
- Incorporate MinWxSvc recommendations into standards and other guidance documents
  - Enables NextGen operations and benefits, and pilot roles
- Resolve operational (current and NextGen) inefficiencies associated with adverse weather
- Enhance pilot MET-training to enable effective and consistent adverse weather decision-making

WTIC is not building cockpit applications so outreach to industry is necessary for implementing MinWxSvc(s).

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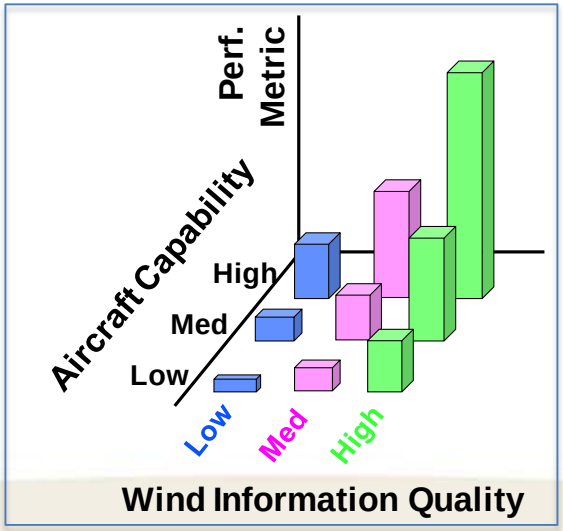
Wind Study - Wind Information Analyses with Publically Available Models

- **Wind Study Project Overview**
  - Develop trade spaces of wind accuracy impacts on selected NextGen operational scenarios (Time of Arrival, Interval Management, etc.) to support requirements development
    - Phase 4 of research project

Sample Generic Trade Space



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Wind Study - Wind Information Analyses with Publically Available Models

- **Task Purpose**
  - Perform wind model performance analyses to determine accuracy of “truth” wind information
    - Previous trade studies used HRRR analysis winds as truth
    - Future studies planning to use MDCRS data for truth
  - Assess predictability of wind model performance/accuracy for HRRR and GFS
    - Identify indicators to predict forecast accuracy

Wind Study - Wind Information Analyses with Publically Available Models

Source	Pros	Cons
NWS Radiosonde 	• Most accurate • No cost • Lost of samples • Easy access • Input "Truth" for forecasts	• Not correlated to flights • Only two sample times (0/12Z) • Spatially limited • Very-low frequency
Model 0-hour	• Volumetric • No cost • Easy access	• Heavy filtering (meso-scale) • Low Frequency • Accuracy is in question
MDCRS	• No cost • Lots of samples • Easy access • In-situ • Input "Truth" for forecasts	• Highly subject to A/C dynamics • ~~Not associated with flight ID~~ • Phase lag (non-parallel winds) • Erroneous reporting
Mode-S EHS Lincoln ASR 	• Similar to MDCRS • Samples all EHS equipped A/C in 60 NM radius • Correlated to particular flight • Sees down to surface at KBOS	• Highly subject to A/C dynamics • Erroneous reporting • No temperature data • Requires some devel & implementation
Mode-S EHS (Long-range) Elwood, NJ (FAA)	• Similar to MDCRS • Samples all EHS equipped A/C in region with 200 NM radius • Correlated to particular flight • LL has data archives	• Highly subject to A/C dynamics • Erroneous reporting • No temperature data • Some process work to generate wind estimates
Custom E550 flights 	• Can control sampling locations* • Easy data collection • Can minimize sampling error - Control over A/C dynamics	• Must pay for sampling on custom flights • Orchestrate with Boston Center • Phase lag (non-parallel winds)

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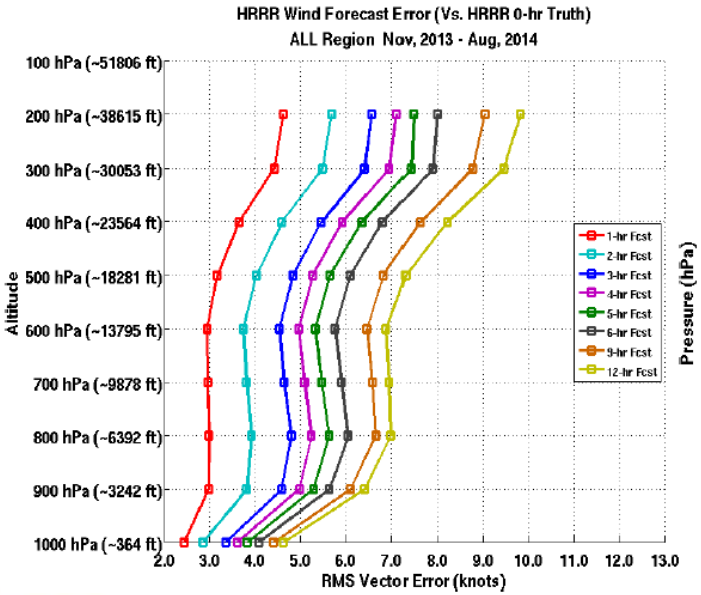
Wind Study - Wind Information Analyses with Publically Available Models

- **Recent Activities**
  - Completed HRRR zero-hour forecast vs MDCRS comparisons (4 regions)
  - Used publically available MDCRS data, but received authority to use unfiltered MDCRS data
    - Plan to use unfiltered MDCRS data for future trade studies
  - Investigated potential sources of truth wind data for HRRR accuracy comparison

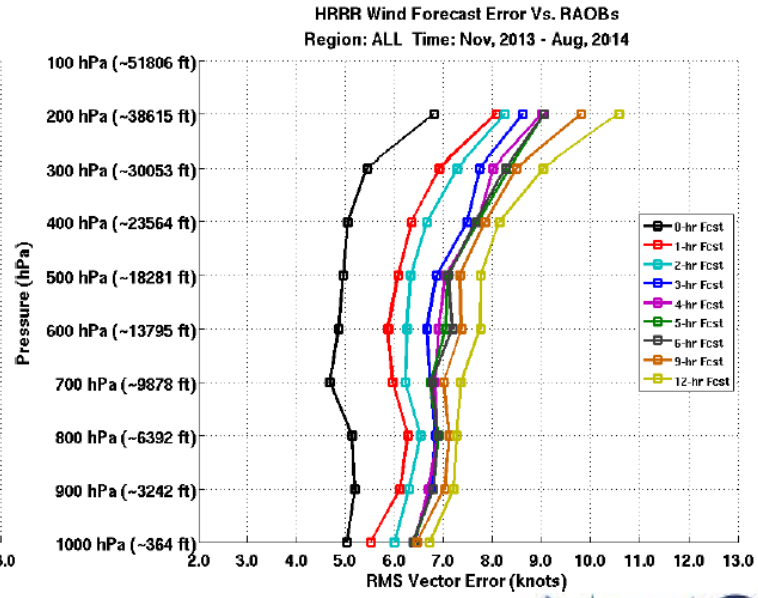
Wind Study - Wind Information Analyses with Publically Available Models

- **Interim results**
  - HRRR forecast errors vs RAOBs larger (2 to 4 knots) than vs HRRR analysis, and dependency on forecast look-ahead time reduced

HRRR Forecasts Vs HRRR 0-Hr Analysis (Prior LL Study)



HRRR Forecasts Vs RRS RAOBs



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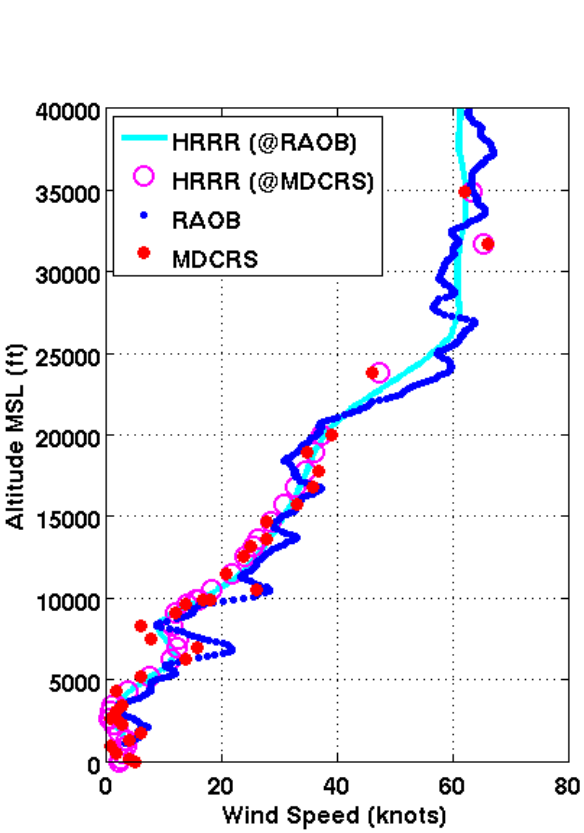
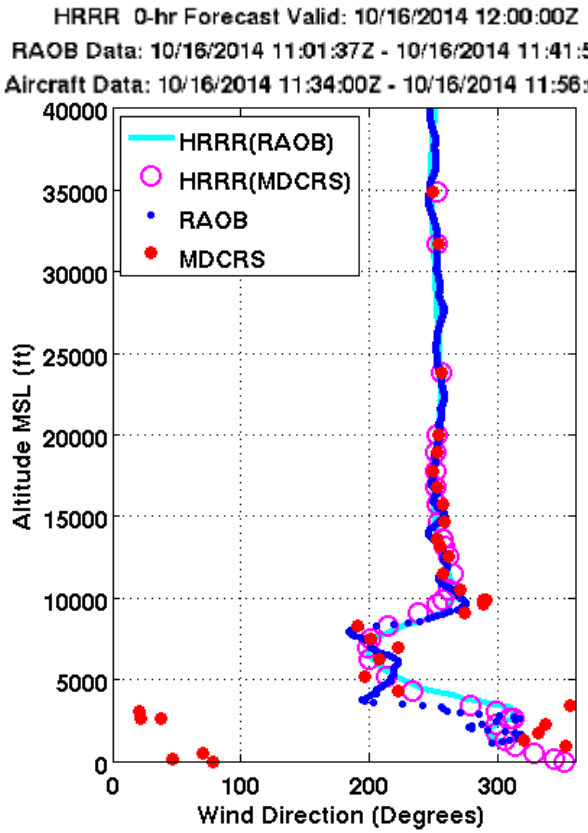
Wind Study - Wind Information Analyses with Publically Available Models

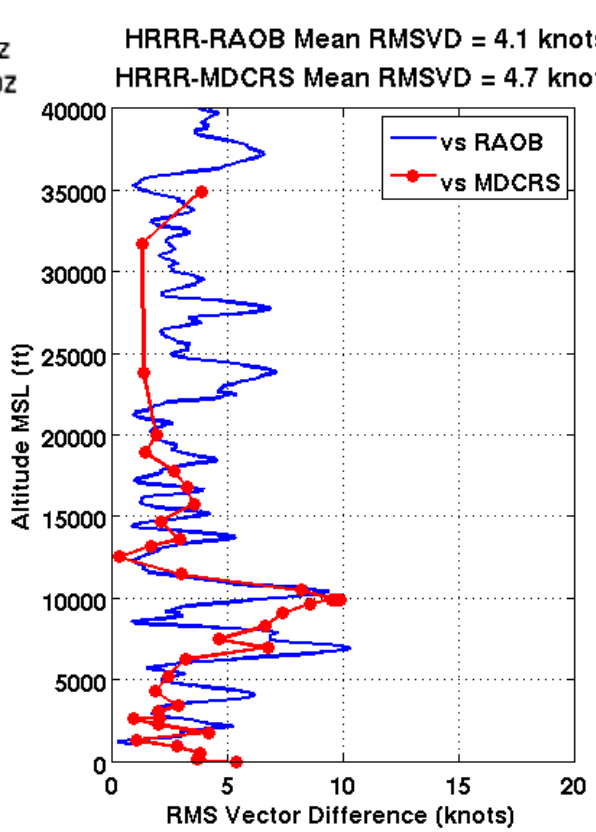
- **Interim results**
  - Generally good agreement seen between both RAOB and Aircraft (MDCRS) and HRRR analysis winds for initial case of a single descent profile
    - Wind shears get filtered in HRRR but are typically captured by RAOB
    - MDCRS captures more of the shears than HRRR
    - Plan to use MDCRS as truth over HRRR analysis winds for future trade studies

Wind Study - Wind Information Analyses with Publically Available Models

- Interim results







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Wind Study - Wind Information Analyses with Publically Available Models

- **Next Steps**
  - Obtain tail number correlation lists for MDCRS reports
    - Enables correlation to flown routes for simulations
  - Improve MDCRS data quality checks
    - Enhance filtering for future trade studies based on errors observed in post-MADIS filtered MDCRS data
  - Explore predictability of wind model performance
  - Evaluate model data as a function of aircraft trajectory
    - Identify error in headwind component on given trajectory
  - May perform controlled flight tests to validate MDCRS data

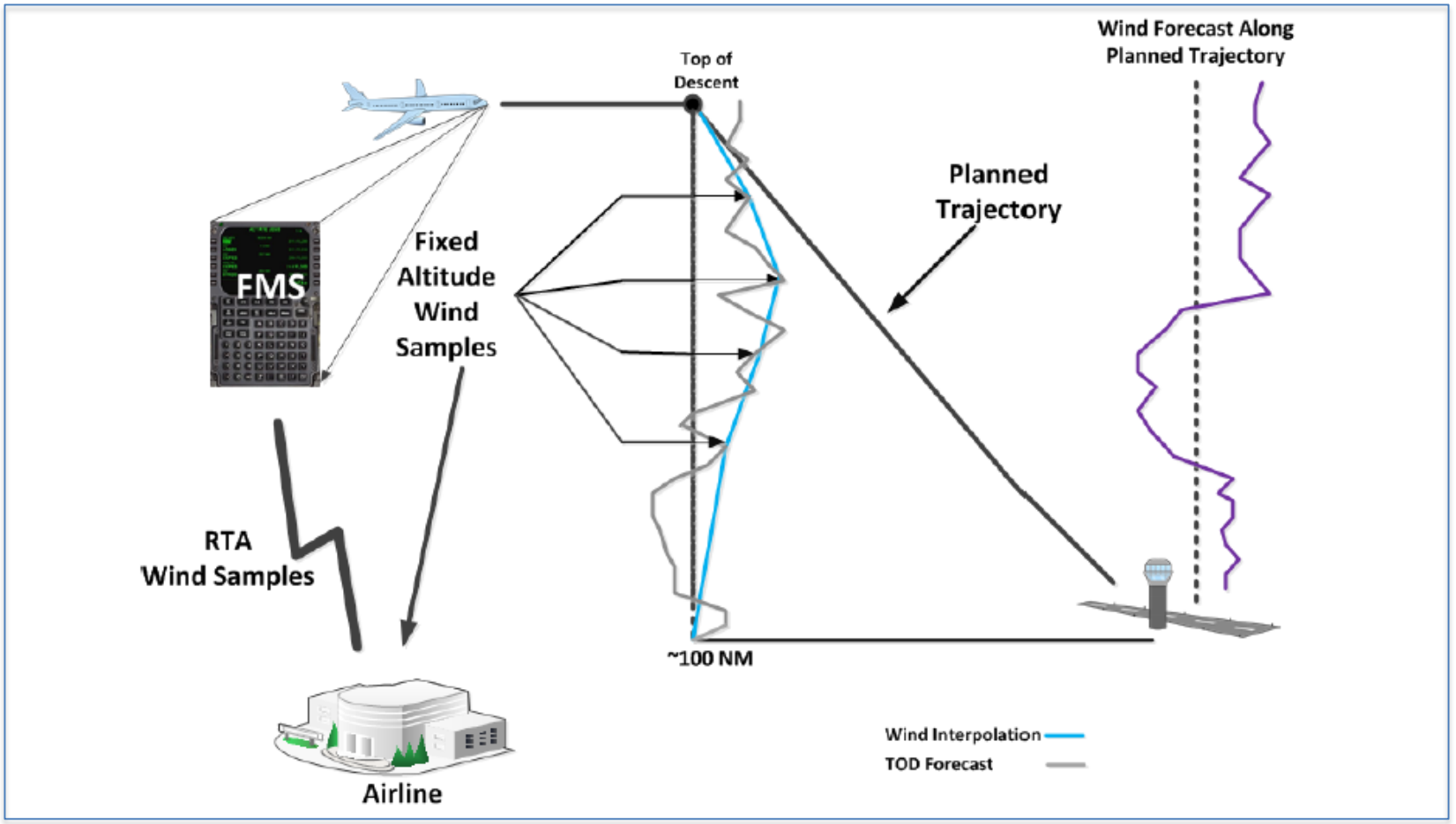
Wind Study – 4DTBO Trade-Spaces with Future FMS Capability

- **Task Purpose**
  - Evaluate whether 9 descent winds at set altitudes versus 4 descent winds “optimally” chosen provide no significant improvement in meeting Required Time of Arrival requirements
    - Supports RTCA SC-206

Wind Study – 4DTBO Trade-Spaces with Future FMS Capability

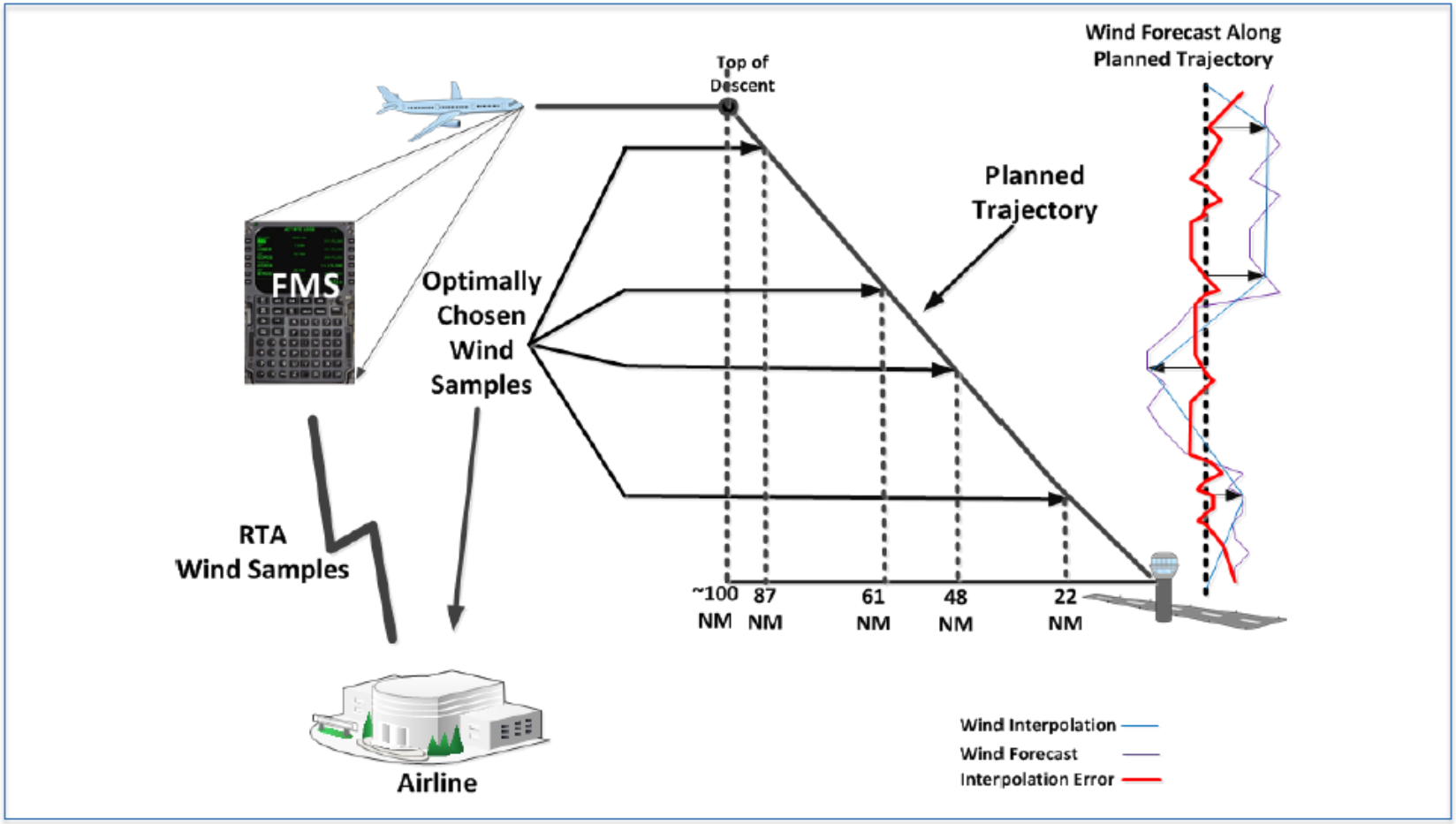
- **Task Plan**
  - Use “simulated annealing” algorithm to optimize selection of four wind altitudes
    - Selected minimize fuel consumption across the predicted cruise and descent segments of flight based on the pre-flight forecast conditions as the optimize criteria
  - Run simulations for 10 airports
  - Use a variant of Honeywell Pegasus FMS software (has closed loop speed control for RTA implementation)
  - Assess RTA performance
    - Optimized wind samples at 4 altitudes for one group
    - 9 wind samples at fixed altitudes for second group

Wind Study – 4DTBO Trade-Spaces with Future FMS Capability



Fixed Altitude Sampling

Wind Study – 4DTBO Trade-Spaces with Future FMS Capability



GA MET Presentation—
Adverse Weather Notifications

- **Purpose**
  - Assess feasibility and utility of agile, low latency cockpit notifications to enhance pilot identification of hazardous weather
    - Evaluated existing weather notifications to determine effects of key qualities (such as latency) on weather-related decisions
    - Performed demonstrations with detailed scenarios to assess pilot performance with selected notifications
  - Develop MinWxSvc recommendations for adverse weather notifications

GA MET Presentation—Adverse Weather Notifications

- **Method**
  - Fly scenarios with various adverse weather conditions to assess the impacts of five variants of adverse weather notifications
  - Parameters measured included: Reaction Time, Correctness % (situation and response), Source % (extent use of notification)

Alert Type	Text Summary Line Present	Audible Cue
1	No	No
2	Yes	No
3	No	Chime
3	Yes	Chime
5	Yes	Verbal summary

GA MET Presentation - Adverse Weather Notifications (Alert)

VSCL Flight Training Device, with the mounted Weather Alert Device (iPad)

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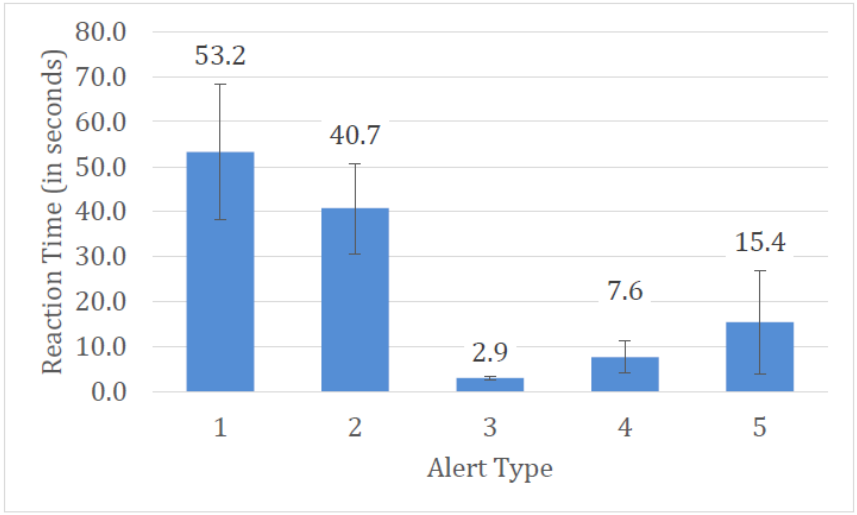
GA MET Presentation—Adverse Weather Notifications

- **High-level results summary**
  - Persistent and attention-orienting cues resulted in more consistent use of weather information sources
  - Purely auditory cues were susceptible to being missed and to an inability to quickly prioritize tasks to act on the cue (over-prioritized)
  - Textual summary line resulted in best prioritization of notification response time
  - Verbal annunciation with text summary line provided best performance and was most preferred by participants

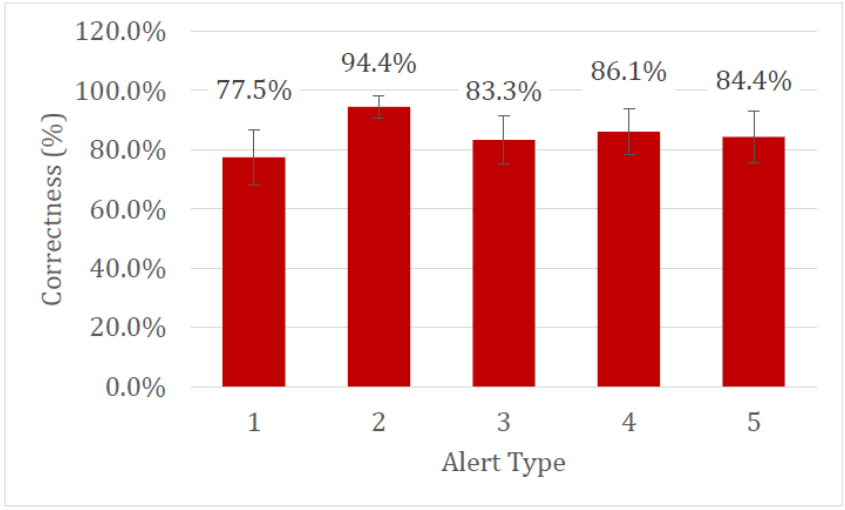
GA MET Presentation - Adverse Weather Notifications

- Results summary, sample plots

Reaction Time for Each Alert Type



Correctness of weather-related decision



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