REDAC / NAS Operations

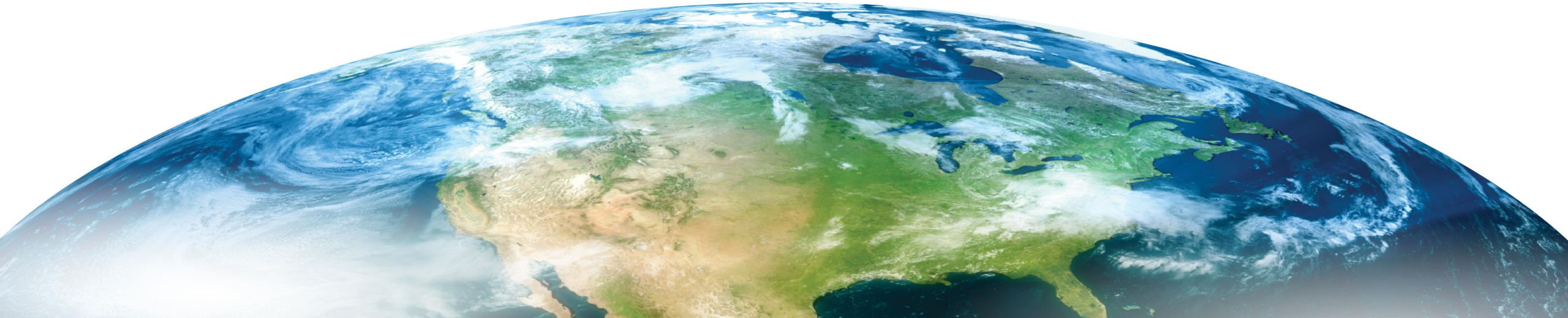
Name of Program: Weather Technology in the Cockpit (WTIC)

BLI Number: A12c

Presenter Name: Gary Pokodner

Date: August 31, 2021

Review of FY 2021 - 2023 Proposed Portfolio



WTIC Program Overview

What are the benefits to the FAA

- Enhanced safety by resolving/reducing adverse-weather safety risks before they result in an accident/incident

- Enhanced NAS efficiency and increased capacity resulting from consistent and predictable pilot adverse weather decision making due to established cockpit minimum weather service(s)
  - Reduced emissions due to enhanced efficiency
  - Reduction in flight delays
  - Enhanced flight routing in and around adverse weather

- Enhanced safety resulting from the resolution of pilot meteorological training shortfalls

WTIC Program Overview

What determines program success

- Number of standards released incorporating WTIC MinWxSvc recommendations
- Number of transitions of WTIC MinWxSvc recommendations into commercial products or operations
- Number of transitions of WTIC training materials to use in courses, textbooks, guidance, Wings Credit Courses, FAA pilot exam questions, and commercial training products
- Number of MinWxSvc recommendations incorporated by pilots and other stakeholders into practice, guidance, or endorsements by representative groups such as Aircraft Owners and Pilots Association (AOPA), Air Line Pilots Association (ALPA), and National Association of Flight Instructors (NAFI)
- Benefits analyses using model simulations and demonstration/operational data
- Tangible reduction in avoidable delays and aircraft accidents/incidents/risks due to weather

Weather Technology in the Cockpit (WTIC) Program Support

People: Program Manager: Gary Pokodner

- Subject Matter Experts: Dr. Ian Johnson (Human Factors), Eldridge Frazier (Lead Engineer)

Stakeholders and Laboratories:

Government
- FAA
  - Flight Standards Service
    - Test questions AFS-630
    - NEXRAD Online Course AFS-850
    - ASRS report AFS-430
  - Aircraft Certification
  - Small Aircraft Directorate
  - Office of Aviation Safety
  - Human Factors Research & Engineering
  - William J. Hughes Technical Center(WJHTC)
  - Civil Aerospace Medical Institute (CAMI)
  - Future Flight Services
- NASA - Ames
- NTSB
- NCAR

Airlines
- Delta
- United
- American

Publishers
- Routledge

Standards Bodies
- RTCA
- ASTM

Academia
- Embry-Riddle Aeronautical University
- Florida Institute of Technology
- Georgia Institute of Technology
- Iowa State University
- Purdue University
- Texas A&M University
- The Ohio State University
- University of Oklahoma
- Western Michigan University
- Virginia Tech

Professional Societies
- AOPA
- GAMA
- ALPA
- Others (via GAJSC)
- NAFI

Industry
- Lockheed Martin (via PEGASAS)
- Frasca (via PEGASAS)
- Mindstar Aviation (via PEGASAS)
- Fly8Ma (vis PEGASAS)
- WebManuals (via PEGASAS)
- Aspen Avionics (via PEGASAS)

FY21 Accomplishments

- FY21 Accomplishment Slides Only Addressing a Few Selected Projects with Significant Updates Since Spring 2021 Presentation
- Selected Projects Have Plans for Follow-On Research
- More Details Provided for Selected Projects as Backup for FY22-FY24 Plans
- Highlights of Accomplishments For All WTIC Projects Will be Provided in Spring 2022 REDAC
- Briefing Covers Research Planning for FY22 – FY24

Current FY21 Accomplishments

- **Remote Oceanic Meteorological Information Oceanic (ROMIO)**
  - Fully created the technical transfer package (TTP) and improved multiple files
  - Completed draft of TTP documentation and submitted for FAA review
  - Completed successful testing of the TTP on multiple operating system architectures

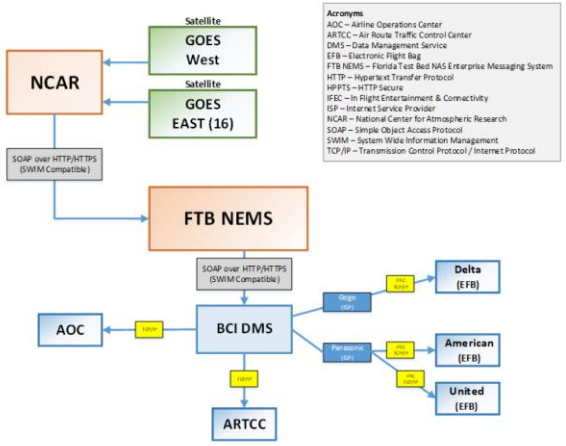


Figure 2. The ROMIO system architecture is illustrated from data ingest at NCAR to final transmission of the CTH and CDO polygons to the airlines, the AOC and to the ARTCC.

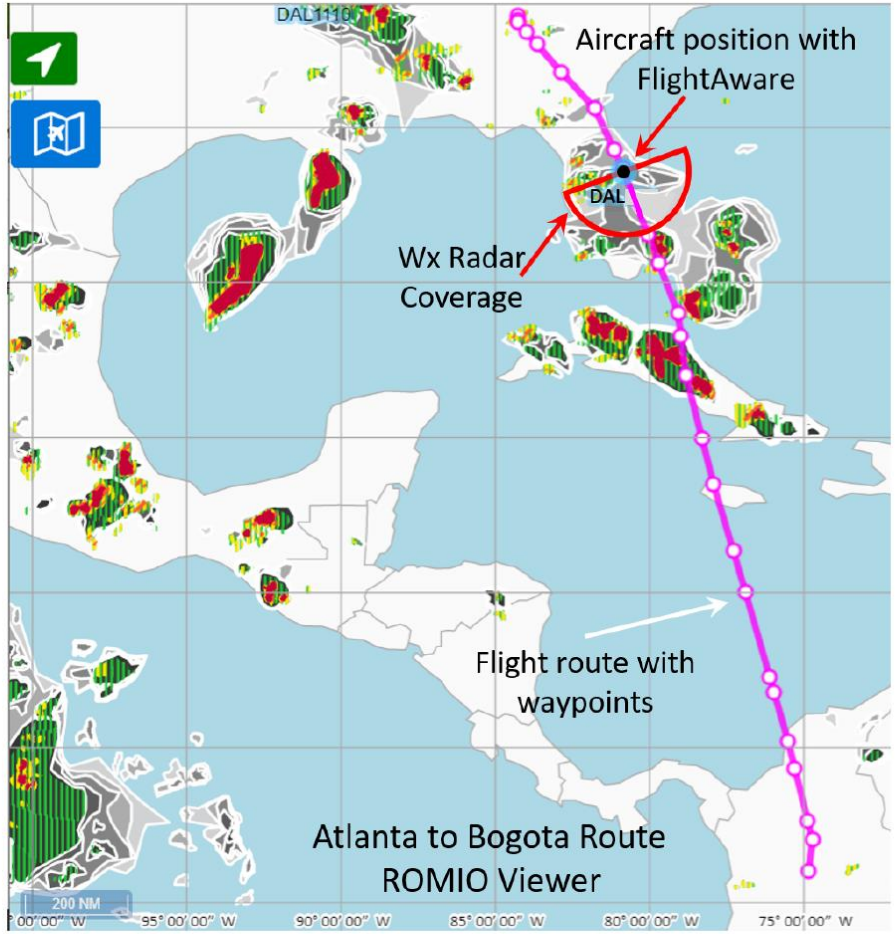
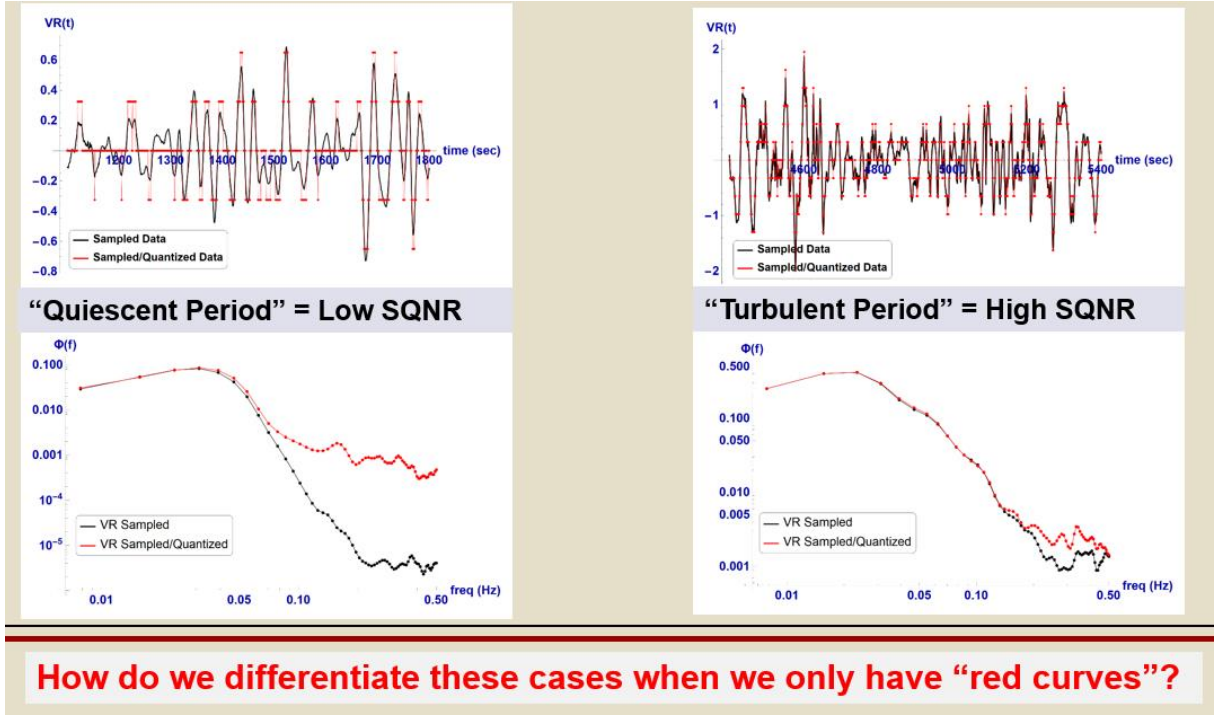


Figure 1. An example of the CTH and CDO products that compares the forward-looking view of the onboard weather radar (red half circle) to the expanded view provided by ROMIO. The planned flight route is shown by the magenta line. The aircraft position was determined with FlightAware locations.

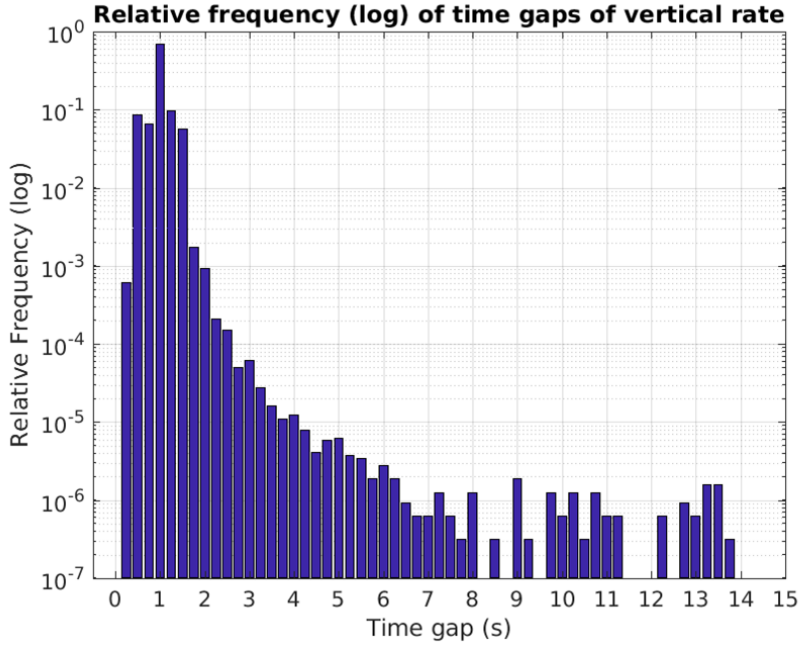
Current FY21 Accomplishments

- **ADS-B Turbulence Project**
  - General classification of events
    - Turbulence
    - Short->Long Waves
    - Maneuvers
    - Quiescent Periods
  - Second derivatives of Vertical Rate has skill in turbulence detection and maneuver/wave rejection
  - Sampling rate for ground-based receivers is not great, but adequate
  - Quantization is problematic
  - ***The combination of all these aspects leads to methodology of adaptive algorithmic processing***
    - 2nd derivative filters with differing high frequency damping



Current FY21 Accomplishments

- **ADS-B Turbulence Project (continued)**
  - Data Quality Assessment of Terrestrial (SBS) and Space Based (SBA) data
    - Assessments to date mostly focused on SBS data and time gaps
    - SBA has slightly different fields and different formats for the same field
    - Data analyzed found, **on average**, about 1 sec intervals, with moment-to-moment variations (70% about 1 sec, most within +/- 0.5 sec), but larger gaps seen
    - Time gaps above 2 seconds rare, but occur
    - Plan to look at other quality issues (e.g. spikes)
    - Plan to obtain more SBS and SBA data to assess



Current FY21 Accomplishments

- **Hands Free/Minimized Pilot Reports (PIREPs)**

Project Area AWIP.2
Develop and evaluate capabilities for automated PIREP generation and dissemination, including "Store and Forward" geo-referencing

Project Area AWIP.3
Evaluate opportunities for "speech-recognition" or "hands-minimized" PIREP generation support

Development of hands-minimized PIREP submittal tool

Develop machine learning models to automate PIREP submission process

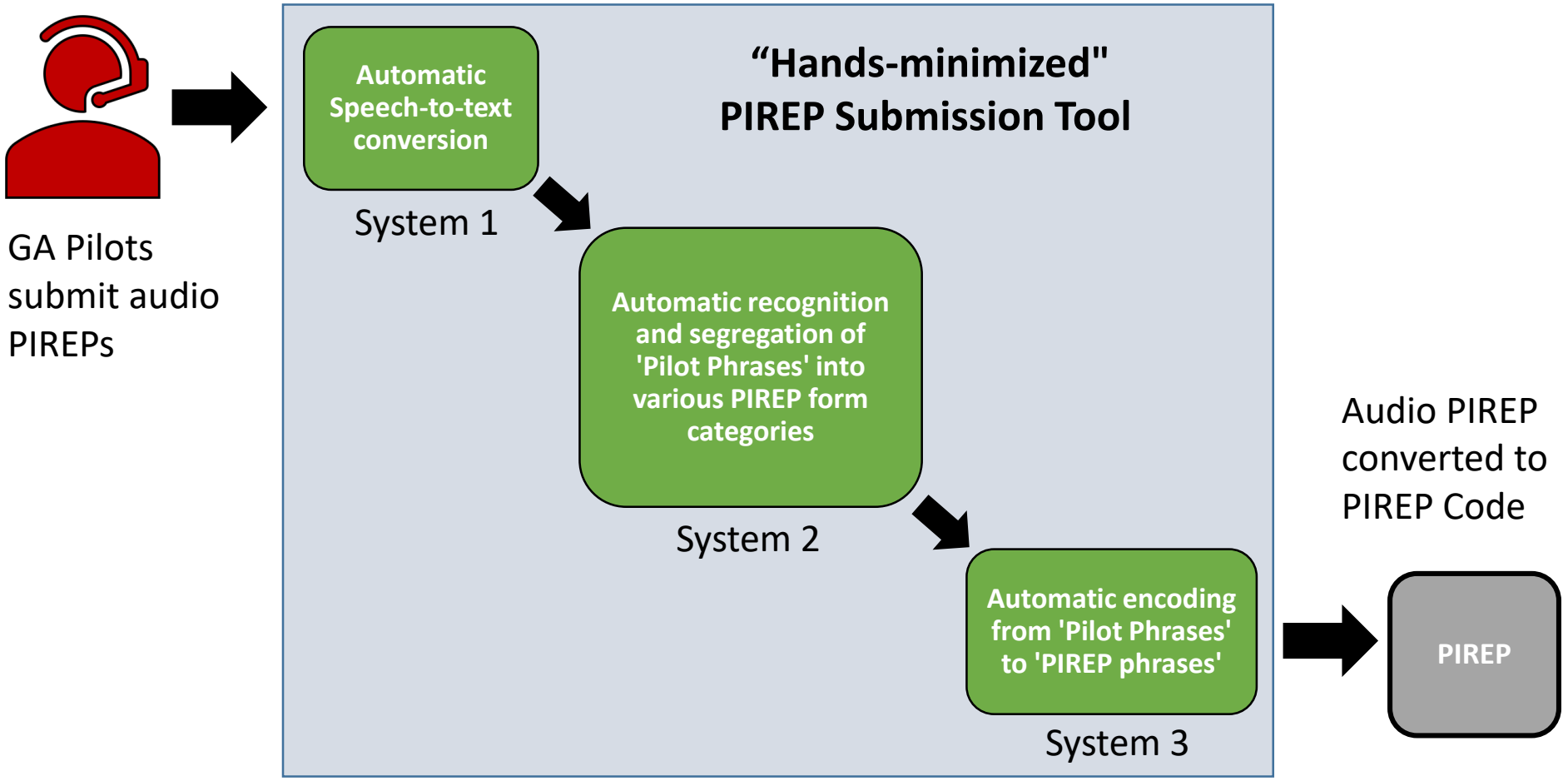
Objective is spoken PIREP to Encoded PIREP

PIREP Transcription

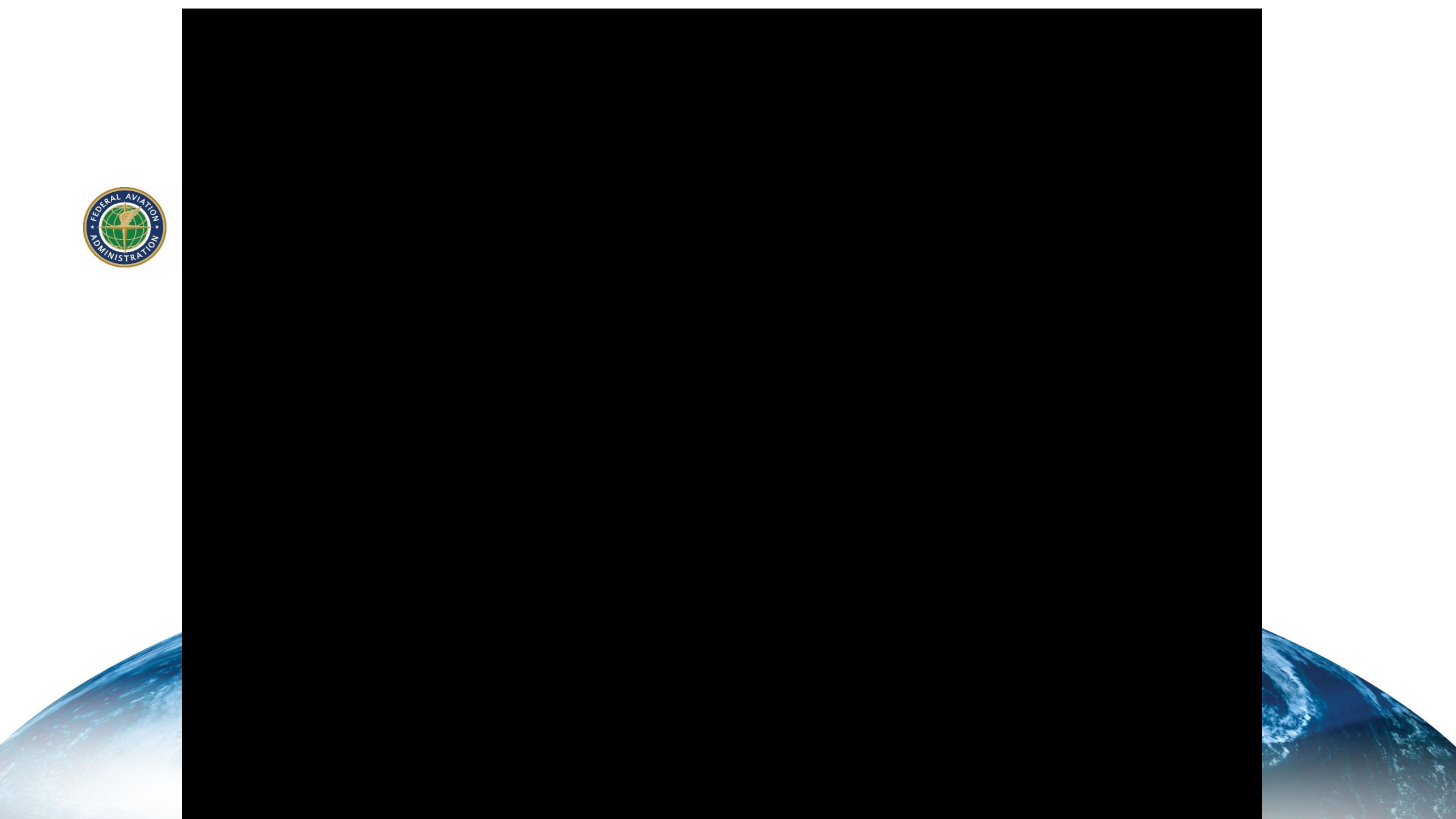
We are approximately twenty miles from the Roanoke VOR on the three-twenty-one radial. We are climbing out and during climb Beech Baron fifty-eight. Sky condition sky is overcast at five thousand with tops at seven thousand. Temperature is minus one during the climb. No turbulence and we had picked up rime ice between five thousand and seven thousand feet. The rime ice was light in intensity. And its remarks are clear above seven thousand.

PIREP FORM	Pilot Phrases	PIREP Phrases	PIREP Sentence
3-Letter Station Identifier		ROA	ROA
1. Report Type UA or UUA		UA	UA
2. Location /OV	twenty miles from the Roanoke VOR on the three-twenty-one radial	/OV ROA 321020	/OV ROA 321020
3. Time /TM			
4. Flight Level /FL	climbing out and during climb	/FL DURGC	/FL DURGC
5. Aircraft Type /TP	Beech Baron fifty-eight	/TP BE58	/TP BE58
6. Sky Cover /SK	sky is overcast at five thousand with tops at seven thousand	/SK OVC050-TOP070	/SK OVC050-TOP070
7. Flight Visibility and Weather /WX			/TA M01
8. Temperature /TA	Temperature is minus one	/TA M01	/TB NIL
9. Wind /WV			/IC LGT RIME 050-070
10. Turbulence /TB	No turbulence	/TB NIL	/RM CLR ABV 070
11. Icing /IC	rime ice between five thousand and seven thousand feet. light in intensity	/IC LGT RIME 050-070	
12. Remarks /RM	clear above 7000	/RM CLR ABV 070	

Overview of Automated PIREP Submission Tool



With this system, it is possible to change spoken PIREPs to encoded PIREPs



Current FY21 Accomplishments

- **Pilot Evaluation of Next Generation Weather Radar (NEXRAD) Valid Now (NVN)**
  - Completed final report for pilot evaluation of National Center for Atmospheric Research (NCAR) developed NVN that nulls out NEXRAD latency using short term forecasts
  - Part-task assessment of impacts of latency on pilot accuracy and speed of estimating distance to convection
  - Results showed tighter separation estimates (less variation around the mean) for NVN versus latent information
  - Tighter separation estimates meant fewer times when pilots would have flown too close to convective storms
  - Estimated time to decision had no statistically significant differences, but the decision time frequently exceeded 10 seconds so tasks were fairly challenging
- **Results indicate a benefit of NVN, but additional research is needed**
  - This part-task preliminary study had limitations and statistical analysis of the data was complex due to the number of variables
  - Exploring options to conduct a more realistic flight simulator study of the practical risks of NEXRAD latency and the use of short-term forecasting to eliminate that latency and associated risks

FY21 Accomplishments

- **Project Objectives - Increasing Weather Information Salience**
  - Perform preliminary assessment to determine if normalizing cockpit weather displays potentially provides benefits to pilot understanding of the information and improves timeliness of recognition of adverse weather

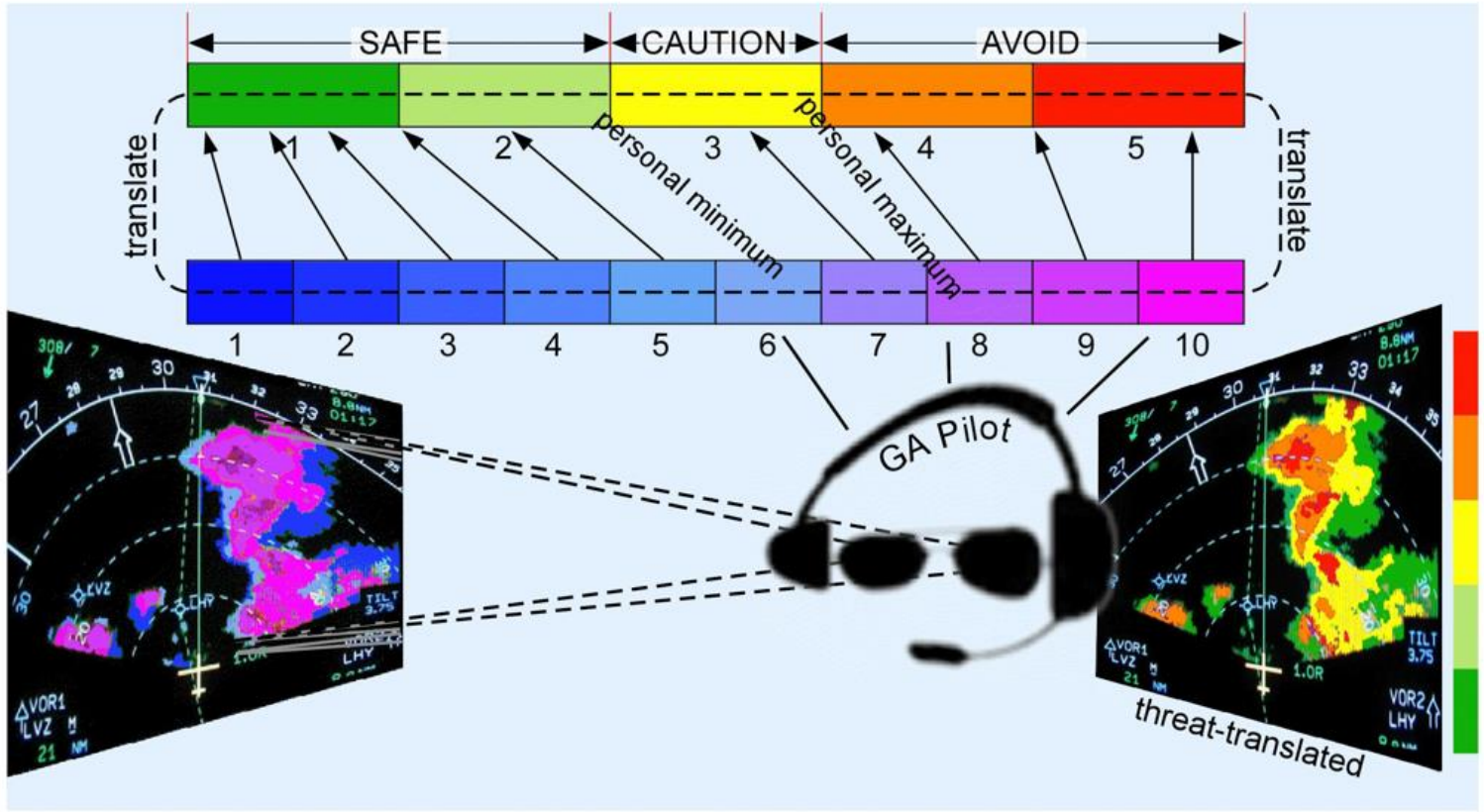
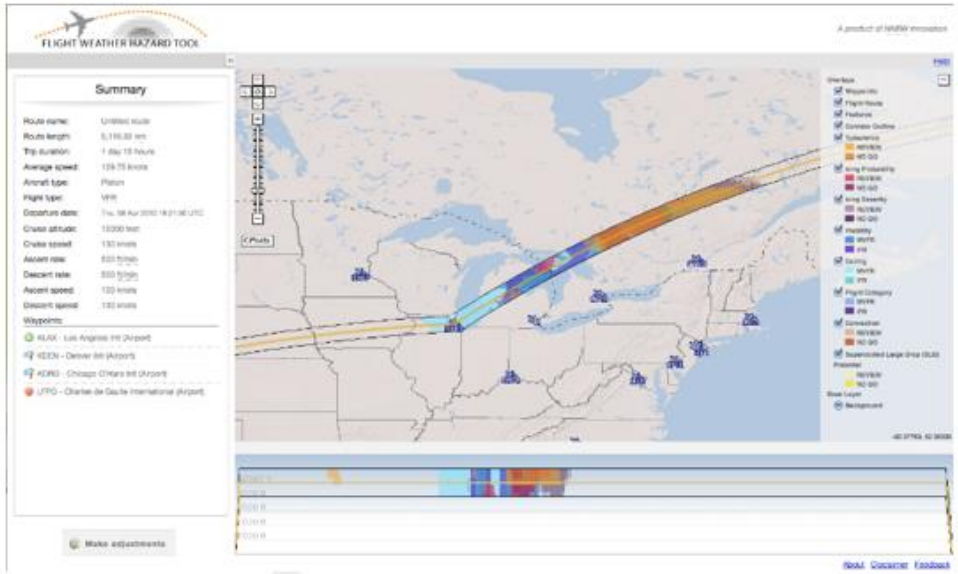


Figure 2. The "non-normalized" (regular) weather display (left) requires three processing steps, 1) perception, 2) cognitive construction, 3) (nonlinear) cognitive transformation. The "normalized" weather display requires just two steps, 1) perception, 2) cognitive construction. Pilots should therefore benefit from showing normalized scales, wherever possible.

FY21 Accomplishments

- **Project Details – Increasing Weather Information Salience**
  - Perform proof-of-concept research using an exploratory questionnaire to evaluate two methods of normalizing weather information compared to current methods
  - Weather Movie - series of images presented sequentially at a rate designed to give the impression of apparent motion
  - Forecast Corridor - path of specified width (a corridor) following the intended flight path with predicted weather intensity drawn inside according to geography and the weather expected to exist at each section at the time the aircraft is expected to arrive

WEATHER MOVIE



FORECAST CORRIDOR

FY21 Accomplishments

- **Project Results From Exploratory Questionnaire**
  - Both displays perceived as being significantly useful in hazardous-weather avoidance
  - Weather Movie was the preferred normalizing technique
  - Higher scores for Weather Movie were for the following criteria:
    1. Easier to interpret
    2. Faster to use
    3. Producing greater situational awareness
    4. More likely to keep them safely clear of hazardous weather
  - Subjectively, pilots stated they preferred the larger area covered by the Weather Movie
- Results based on first impressions of still pictures and text descriptions
- If pursued, follow-on research would use fully developed, dynamic displays under realistic situations to assess benefits

Anticipated Research in FY22

WTIC Program Office Planning

- **Planned Research Activities and Expected Research Products**
- **FY22 Plan Needs Management Approval and Sufficient Funding**
- Hands Free PIREPs – Verify framework detailing methodology to resolve issues with current hands free PIREP configuration. Deliver Minimum Weather Service (MinWxSvc) recommendations and final report to enable technical transfer to 3rd parties.
- Develop and verify a framework that provides guidance and processes to create and distribute customized extended reality (XR)-enhanced weather training. Deliver framework and MinWxSvc recommendations.
- Investigate resolutions to selected gaps from the helicopter gap analyses project. Produce final report and, as applicable, MinWxSvc recommendations for gap resolution.
- Perform outreach of technical transfer conference and package for ROMIO and the Tactical Turbulence and Adverse Weather Notification, and host the transfer conference.
- Gap analysis on pilot use of “non-correlated (outside performance range)” weather information and produce a final report.

Anticipated Research in FY22

WTIC Program Office Planning

Planned Research Activities and Expected Research Products (cont)

- Continue development of ADS-B turbulence algorithms. As applicable, produce technical papers, perform a live operational demo, and perform testing on large amounts of data. Continue evaluating the potential of using SBA data.
- Technical support to RTCA SC-206 for conduct of global operational safety and global performance assessments of aeronautical and MET information services to develop data link standards requirements (e.g. DO-364). Ensure global procedures and equipage are interoperable with US operators, and global standards are harmonized.
- Perform experiment and data analysis comparing the effectiveness of weather self briefings to a specialist provided briefing, and begin drafting the final report along with recommendations.
- Mature hybrid configuration (crowd sourcing and image processing) to address user priorities and develop plans for proof of concept studies using Starlink satellite.

Anticipated Research in FY23

- Develop cockpit decision support tools to resolve pilot decision-making gaps associated with weather information decorrelation
  - Contingent on current research project on decorrelation effects and impacts
- Develop cockpit applications to enhance safety and efficiency using enhanced data produced by new and evolving cockpit weather technology
  - Holding 1-3 meetings with Collins Aerospace to discuss their 2025-2035 visions
- Use of expanding data link connectivity to enhance the generation, communication, and rendering of adverse weather information
  - Starlink project is initial research
- Use climatology, artificial intelligence, and enhanced weather forecasting to enhance classification of precipitous terrain and associated hazards
  - Coordinating with stakeholders in AVS on specific plans and needs
- Develop technical transfer package for ADS-B Turbulence to enable operational implementation
  - Contingent on success and schedule of algorithm development

Emerging FY24 Focal Areas

- Address American National Standards Institute (ANSI) Document UAS R&D Task of: *“What are the applicable ways to replicate the capability of a “flight deck display” in UAS C2 systems for the purpose of displaying meteorological information?”*
- Incorporating ADS-B Turbulence information into operational applications based on its alignment with other turbulence measures
- Virtual reality displays for cockpits to provide "visual" support for inadvertent flight into Instrument Meteorological Conditions (IMC) or other encounters with hazardous reduced visibility conditions
- Incorporating weather information from advances and proliferation of weather sensors into cockpit weather information for more efficient adverse weather avoidance

WTIC Program

Research Requirements

- Develop Part 121/135 and Part 91 MinWxSvc recommendations for cockpit weather information and technology to enhance safety and efficiency, and reduce gaseous emissions.
- Sponsored by ANG-C6, ALPA, AFS, industry, airlines, NextGen, AOPA, industry, NAFI, FAA Alaska AvCams (WCAM)
- POC: Gary Pokodner, ANG-C61, 202-267-2786

.

Outputs/Outcomes

- Recommendations and white paper on operational uses of ADS-B Turbulence outputs.
- Final report on initial research to replicate a “flight deck MET display” for UAS.
- Final report on research results for MET applications for using increasing data link connectivity.
- Plan for assessing potential applications of new weather information from technology advances.
- New and updated FAA and RTCA standards and guidance.

FY 2024 Planned Research

- Concept of operational use of ADS-B Turbulence outputs and its alignment with other turbulence measures.
- Replicate the capability of a “flight deck display” in UAS C2 systems for the purpose of displaying meteorological information.
- Continue research of applications of increasing data link connectivity to resolve gaps in cockpit weather information.
- Research applications of new weather information resulting from incorporated and planned advances in cockpit weather technology.

Out Year Funding Requirements

RE&D

FY21	FY22	FY23
$ 0.97M	$1.9M	$0.97M

FY23 budget currently reverts back to FY21 levels.

F&E

FY21	FY22	FY23	FY24	FY25	FY26
$ M	$ M	$ M	$ M	$ M	$ M