Weather Program A11.k Overview

What are the benefits to the FAA

- Enhanced National Airspace (NAS) safety via reduction of accidents associated with hazardous weather (wx) and resolving adverse-wx safety risks before they result in an accident/incident
- Improved NAS capacity/efficiency via reduced delays & cancellations, & increased capacity in high traffic areas; and consistent and predictable adverse wx decision-making due to established cockpit minimum weather service(s)
- Reduction in environmental impact (i.e., lower fuel consumption via improved accuracy and accessibility of observed & forecast wx info)
- Enhanced GA safety via improved accuracy and accessibility of observed and forecast wx info
- Enhanced NAS safety resulting from resolution of pilot MET-training shortfalls
- Identification of essential pilot wx-related tasks & roles to ensure they are safely incorporated into autonomous vehicles, and potential to mature wx-related automation functions with pilots in the loop

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Weather Program A11.k Overview (cont'd)

What determines program success

- Transition of research capabilities into evolving ATM decision support processes
- Research capabilities align with NextGen Segment Implementation Plan (NSIP) and NextGen emerging solution sets
- Incorporation by NWS of research capabilities to improve delivery of FAA required services
  - Weather Program funding of High-Resolution Rapid Refresh wx model while resulting in NAS benefits, has also provided high resolution severe wx forecasting; benefits to the energy community, est. $200M/yr. (enhanced wind prediction); improved freeze forecasts for specialty crops, est. $12.3M/yr.; 12-hour precipitation forecasts (commuter benefit minimizing late arrivals to work) [Evaluating the Economic Impacts of Improvements to Weather Models – NOAA/GSL – 18 Jan 2022]
- Incorporation by NWS or commercial industry of research capabilities into wx information that enhances GA safety
- Tangible reduction in avoidable delays and aircraft accidents due to wx
  - Transition of successful wx research capabilities into operations have contributed to a reduction in NAS delays due to wx from 66% in 2007 to 57% in 2019
- Number of standards released incorporating Weather Technology in the Cockpit (WTIC) MinWxSvc recommendations
- Number of transitions of: (1) WTIC MinWxSvc recommendations into commercial products or operations; (2) WTIC training materials to use in courses, textbooks, guidance, Wings Credit Courses, FAA pilot exam questions, & commercial training products
- Number of MinWxSvc recommendations incorporated by pilots & other stakeholders into practice, guidance, or endorsements by representative groups such as AOPA, ALPA, & NAFI
- Benefits analyses using model simulations and demonstration/operational data
- Tangible reduction in avoidable delays & aircraft accidents/incidents/risks due to wx

Weather Program A11.k Support - AWRP

People:

- 1 Program Manager
- 14 Subject Matter Experts

Laboratories supporting Aviation Weather Research Program (AWRP):

NOAA GSL	Model Development & Enhancement (MDE); Quality Assessment (QA)
NOAA NSSL	Advanced Weather Radar Techniques (AWRT); Terminal Area Icing Weather Information for NextGen (TAIWIN)
NOAA NCEP	MDE; Clouds, Cloud Ceiling, and Visibility (C&V); In-Flight Icing (IFI); Turbulence; (TRB); Convective Weather (CW)
NCAR	IFI; MDE; C&V; TRB; CS; TAIWIN, High Ice Water Content (HIWC); Weather Observations Research (WOR)
WJHTC	Aviation Weather Demonstration & Evaluation (AWDE); WOR; TAIWIN; HIWC
MITRE CAASD	Unmanned Aircraft System Weather (UAS Wx); Space Weather Aviation (SWxA); TRB
NASA Langley	HIWC; Volcanic Ash Detection (VAD)
NWS MDL	C&V
MIT/LL	CS; C&V
NRC	TAIWIN
Diakon	TAIWIN
AvMet Applications	TAIWIN, C&V
The Aerospace Corporation	SWxA
NASA/LaRC	VAD

Convective Weather (CW)

- **Current FY24 Accomplishments**
  - Continued OPC enhancements research per AJV-S guidance (broadening domain, improving refresh-time, & making outputs customizable)
  - EPOCH transitioned to NWS to support international wx requirements

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Begin prototyping metrics into select CW products to focus on NAS high traffic areas
    - Continue operational transition of OPC
    - Commence exploring AI / ML concepts

- **Emerging FY26 Focal Areas**
  - Implement prototype metrics into CW products with focus on NAS high traffic sectors
  - Continue operational transition of OPC

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In-Flight Icing (IFI)

- **Current FY24 Accomplishments**
  - Enhanced FIP version 2.0 running in pseudo-operational status at NCEP EMC
  - Enhanced CIP version 2.0 beta code transferred to NCEP AWC for evaluation set up on pseudo-operations infrastructure

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Finalization and implementation of FIP v2.0 and CIP v2.0 into NCEP operations
    - Continued development and refinement of forecasting drop size categories relevant to aircraft certification categories
    - Development of tactical, low-level capability with higher update and output rates
  - **Expected Research Products**
    - Prototype FIP and CIP (P-FIP & P-CIP) with initial drop size categories and higher update and output rates

- **Emerging FY26 Focal Areas**
  - Initial drop-size capability in icing products to meet aircraft certification envelopes
  - Further refinement and evaluation of prototype capability for low-level operations

Model Development & Enhancement (MDE)

- **Current FY24 Accomplishments**
  - Initial aviation-oriented assessments of Rapid Refresh Forecast System (RRFS) version 1
  - Enhanced data assimilation and physics into prototype RRFS for improved convective wx and cloud forecasts

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Finalization and implementation of RRFS v1 into NCEP operations
    - Incorporation of improved data assimilation and physics to improve forecasts of aviation wx hazards by prototype RRFS v2
  - **Expected Research Products**
    - Prototype RRFS v2 with improved forecasts of aviation wx hazards

- **Emerging FY26 Focal Areas**
  - Preparation of RRFS v2 with enhanced data assimilation and model physics for implementation into NCEP operations
  - Begin development of RRFS v3 with enhanced aviation specific capabilities including application to low-level operations

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Turbulence (TRB)

- **Current FY24 Accomplishments**
  - Began transition of GTG Nowcast (GTGN) model (short-term, rapidly updated tactical product) to NWS in response to NTSB recommendation
  - Concluded Year 1 (data collection) of EDR Correlation Study and began Year 2 (analysis) in response to NTSB recommendation
  - Initiated studies determining climate change impact on global AT routes; Completed study "Expected Changes in TRB in a Changing Climate"

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - GTG4 transition to NWS for operational implementation
    - Turbulence mitigation for UAS / AAM environment;
    - Studies of climate change effects on turbulence patterns & air traffic routes; research improving forecasts of persistent contrails
  - **Expected Research Products**
    - Calibration of GTG4 model to the new RRFS v1 underlying model
    - GTG4 quality assessment, technical review panel, safety risk management panel, and implementation at NWS
    - Transition activities for GTGN implementation at NWS

- **Emerging FY26 Focal Areas**
  - GTGN (RRFS v1-based) operational implementation at NWS; Begin adaptation of GTG and GTGN to RRFS-v2
  - GTG enhancements – Outside cloud convectively-induced turbulence forecasts, global probabilistic turbulence forecasts, global "Nowcasts" with rapid updates (15 minutes) and high resolution (3 km), and addition of machine learning for tuning the GTG model
  - Turbulence mitigation for UAS / AAM environment
  - Studies of climate change effects on turbulence patterns & air traffic routes; research improving forecasts of persistent contrails

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Clouds, Cloud Ceiling, & Visibility (C&V)

- **Current FY24 Accomplishments**
  - Provided a System Authorization Briefing for visibility estimations derived from FAA wx cameras to the Cybersecurity Review Board. The Board found no significant concern with implementing the visibility display on the WCAMS operational website
  - Gridded & station-based C&V forecasts for CONUS every 15 minutes out 6 hours were made available experimentally on a website to facilitate a 30-day user evaluation prior to code handoff to operations
  - Completed the selection and analysis of fog cases for experiment to determine the optimal weather-sensing UAS configuration needed to improve the accuracy of fog predictions at airports

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Assess performance of forecasts for the timing of onset-cessation of high impact C&V conditions at Core 30 airports
    - Explore techniques to improve the performance of visibility and cloud property estimates from wx cameras
    - Complete experiment to determine the optimal weather-sensing UAS configuration needed to improve the accuracy of fog predictions at airports. Finalize the report and submit to peer-reviewed journal for publication
    - Participate in World Meteorological Organization weather-UAS demonstration campaign

- **Emerging FY26 Focal Areas**
  - Extend UAS observation studies to assess the value of symbiotic UAS observations (observations obtained during flights with some other primary mission, like package delivery) in prediction of fog and low ceilings
  - Prepare for demonstration of targeted UAS-based technologies to support the FAA's new Innovate-28 which targets AAM solutions for the summer 2028 Olympics in Los Angeles

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Advanced Weather Radar Techniques (AWRT)

- **Current FY24 Accomplishments**
  - Recreate dual-pol mosaics for select time periods during the ICICLE field campaign; disseminate the resulting mosaics to NCAR
  - Converted the HEMS output to grib2, and set up a live feed of the HEMS mosaic on the NSSL LDM server for AWC evaluations

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Evaluate benefits of adding 3D mosaic of TDWR data into MRMS domain (NTSB Recommendation)
    - Monitor algorithm performance in developmental MRMS system (winter precipitation, TDWRs, convective polygons)
    - Improve QC algorithm for light winter precipitation
  - **Expected Research Products**
    - Winter wx & convective products implemented into the developmental MRMS for performance monitoring
    - Automated first-guess output of convective SIGMETs for forecaster & end-user evaluation

- **Emerging FY26 Focal Areas**
  - Advance AI designed to automatically detect convection that poses a threat to aviation in MRMS and NextGen Weather Processor radar mosaics
  - Test & evaluate real-time performance of aviation threat-specific products through the MRMS platform
  - Evaluate the WSR-88D capability to provide required wind shear detection performance
  - Evaluate modified quality control algorithm that removes echoes of light precipitation, which can allow for improved situational awareness of terminal-area icing

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Quality Assessment (QA)

- **Current FY24 Accomplishments**
  - New verification techniques for analysis of gridded wx products and for analysis of probabilistic ensemble forecasts
  - Core Research: C&V Flight Category Climatology; JPSS Satellite Investigation – benefits AK & CONUS icing evals as well as C&V event duration evals

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - GTG4 and FIP2 assessments – RRFS v1 Update;
    - Impact-based Assessment of RRFS v1 implementation
    - RRFS v1- based FIP2 vs IPA over the Alaska Domain
    - Current Icing Product version 2, RRFS v1 Implementation
    - CEIA Assessment

- **Emerging FY26 Focal Areas**
  - RRFS v1 upgrade and its impacts to the CW forecast
  - Probabilistic Turbulence Forecasts assessments
  - Continuous Improvement through Verification for modeling, turbulence, convection, and icing
  - Assessment of C&V capabilities for CONUS and Alaska; assessment of enhancements to UAS Wx
  - LAMP C&V Forecast
  - Comparison of TCF and CoSPA in the Context of TFM Decision Making

Aviation Weather Demonstration & Evaluation (AWDE) Services

- **Current FY24 Accomplishments**
  - Conducted a CEIA Assessment by collecting feedback from GA, Helicopter, Part 121 Pilots, Part 121 Dispatchers, & Mets
  - WIMAT survey to Part 91 Pilots, Part 135 Pilots/Dispatchers, Part 121 Pilots/Dispatchers, TMs, & FAA Flight Service participants. Feedback will aid determining preference of CW products, info requirements needed to support decision making, & which products not being used & possibly retired
  - Coordinated with AWT on the User Assessment for the LAMP FC Onset and Cessation. Objectives of the assessment are to determine if the text & graphic solutions support decision-making & are easy to use
  - Coordinated with AWRP icing lead & NOAA GSL to begin planning for an assessment focused on determining if current operational FIP information when compared to upscaled icing information impacts decision-making

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Conduct assessment(s) of advanced wx diagnosis and forecast products and features such as:
      - Enhanced IFI Diagnosis and Forecast; CIP / FIP Numerical Severity Scale; Upscaling the FIP
    - WIMAT - conduct exploratory research to identify convective wx products available to the aviation community
    - Provide a laboratory capability to perform HITLs and other technical evaluations

- **Emerging FY26 Focal Areas**
  - Continue conducting user assessments for newly developed and/or redesigned weather products to ensure capabilities are usable and suitable for operational use
  - Continue to conduct research to identify weather product information requirements to support decision making

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Terminal Area Icing Weather Information for NextGen (TAIWIN)

- **Current FY24 Accomplishments**
  - Re-ran the capability using the latest version for the ICICLE, Northeast demonstration, and Marshall Field, CO domains and dates covering associated data collection efforts
  - Initiated analyses on components of the capability, including radar, satellite, surface observations, wx forecast model, and intermediate fields generated within the capability

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Prepare TAIWIN Capability for a validation and verification activity in ~FY27, addressing remaining shortfalls and evaluations
    - Prepare for a program in ~FY27 to collect data for TAIWIN capability validation/verification efforts

- **Emerging FY26 Focal Areas**
  - Prepare real-time capability version for validation and verification effort in ~FY27
  - Prepare for ~FY27 validation & verification data collection program for TAIWIN capability
  - Define next steps for operational transition activities

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High Ice Water Content (HIWC)

- **Current FY24 Accomplishments**
  - Completed particle size distribution analysis of data collected in 2022 HIWC high aerosol flight campaign; Completed particle size distribution dataset (comparison to previous flight program and Appendix D certification envelope)
  - Completed the first HIWC workshop on the 2022 flight program cloud measurements and towering cumulus data analysis results to-date, with follow-up meetings to be held
  - Completed the assessment of the processing techniques used in the HIWC studies (i.e. use of "equivalent diameter" for diameter, focus corrections, etc.) compared to techniques used in the broader cloud physics community

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Begin transition of Algorithm for Predicting HIWC Areas (ALPHA) to an operational HIWC wx avoidance tool

- **Emerging FY26 Focal Areas**
  - Continue transitioning ALPHA to an operational HIWC wx avoidance tool

Unmanned Aircraft System Weather (UAS Wx)

- **Current FY24 Accomplishments**
  - Commenced defining process & demonstrate development/application of forecast UAS micro-weather hazard information for Winston-Salem & discrete UAS mission scenarios

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Research use developed concepts to support and enable operations with limited observational data; feasibility to support EWINS type operational approvals with AFS
    - Develop Concepts of Use for high resolution modeled urban wind information
    - Research Non-std wx obs for supporting Urban UAS Operations including DOT roadside wx obs & traffic monitoring cams

- **Emerging FY26 Focal Areas**
  - Non-Standard/Federal wx observation data sets
  - Non-traditional derived in-situ wx data sets supporting UAS Ops; power line fluctuations due to wind
  - Further development of hi-res urban modeling DSPs

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Weather Observations Research (WOR)

- **Current FY24 Accomplishments**
  - Continued winter wx data collection at sites in Colorado and NJ
  - Relocation of laboratory facilities at the WJHTC. Moved all equipment from ACY Hangar facility to WJHTC facility. Packaged and shipped numerous present wx and weighing precipitation accumulation gauges to NCAR for deployment at Marshal Field

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Optimization of present wx sensor technologies to include one-to-one intensity/present wx reporting
    - Improved discrimination of present wx (snow) & wx obstructions (fog/mist)
    - Initial investigation into automated smoke detection opportunities within existing observing equipment
  - **Expected Research Products**
    - Continued one-to-one intensity/present wx reporting, dependent on and reactive to near-term NWS present wx sensor procurement activities

- **Emerging FY26 Focal Areas**
  - Research addition of smoke detection and reporting capabilities within the ASWON program
  - Gap and shortfall analysis

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Space Weather Aviation (SWxA)

- **Current FY24 Accomplishments**
  - Received first deliverable from MITRE detailing the needs and path to success for NSIP OIs 103119-09 and 103123-09.
  - Establishing IAA with The Aerospace Corporation to fund research focused on leveraging the REACH satellite constellation network for delivering near real-time cutoff rigidity values to enhance operational radiation dose models supporting ICAO advisories

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Identify the optimal sensors for generating near real-time cutoff rigidity values, essential for integration into operational radiation models like SWPC's CARI-7 model. Detail the ingestion process of these values into CARI-7 and clarify their operational utilization to enhance radiation dose model outputs
    - Create a systematic framework enabling operational users to report space weather-related issues and record corresponding events. This initiative will play a pivotal role in model validation and the enhancement of forecasting capabilities

- **Emerging FY26 Focal Areas**
  - Support the development of an improved neutron monitor network. An experiment utilizing OSSE is imperative to ascertain the extent of scientific research that can be achieved with a specific quantity of instruments, distributed in numerous locations, and to also establish a corresponding price point
  - Development of an AI system inspired by physics-based models, which will enable us to anticipate a significant space wx occurrence and safeguard ourselves against its impact
  - Craft a highly specialized training package that clarifies the complexities of space wx, its effects on aviation operations, and proactive strategies for navigating its challenges

Volcanic Ash Detection (VAD)

- **Current FY24 Accomplishments**
  - TIM with NASA/LaRC on Doppler Weather Radar detection/identification of Volcanic Ash Clouds from Hydrometeor Clouds
    - Limited case study performed to assess potential of the NASA Swerling algorithm to detect/ distinguish VA from benign hydrometeor clouds
    - Data analyzed was collected during 2022 NASA flight campaign during which regions of SAL were observed
    - SAL dust particles are similar in size and concentrations to some Volcanic Ash conditions. SAL conditions were utilized because they are more common and far easier to locate than actual Volcanic Ash plumes that stay aloft for days to months
    - "Truth" for these cases came from a NASA nadir-looking LIDAR and its DMR
    - NASA/LaRC conclusion: feasibility is enough to warrant a more thorough assessment, technology development/maturation, and potential for follow on flight assessments/demonstrations

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Development of test plan for modification and testing of radar algorithm
    - Continued software development and testing of radar algorithm (Swerling) for detection and distinguishment of volcanic ash
    - Review, analyze, and determine wind tunnel test facility requirements and aircraft radar system/instrument requirements
    - Wind tunnel testing and test plan development

- **Emerging FY26 Focal Areas**
  - Review, analyze, and determine requirements for airborne flight campaign
    - Determination of in-situ probing/measurements; Airframe; Agreements

Wind Detection & Forecast (WDF)

- **Anticipated Research in FY25**
  - **Planned Research Activities**
    - Sensor Enhancements LIDAR Winds: Conduct initial sensor study to assess the benefits/impact of including LIDAR sensed wind observations; determine benefit of adding LIDAR observations in the terminal airspace
    - JAWS Modernization: Begin study to determine if JAWS or a JAWS like system would be beneficial at other airports in the NAS and investigate if output could be provided solely by high resolution modelling
    - TFM Near-Term Wind Requirements: Compare RRFS model output of wind forecast at select, high demand, airports to TFM Wind Requirements; establish baseline

- **Emerging FY26 Focal Areas**
  - Sensor Enhancements LIDAR Winds: Conduct initial sensor study to assess the benefits/impact of including LIDAR sensed wind observations; determine benefit of adding LIDAR observations in the terminal airspace
  - JAWS Modernization: Extend JAWS Warning Thresholds for various aircrafts types
  - TFM Near-Term Wind Requirements: Compare RRFS model output of wind forecast at select, high demand, airports to TFM Wind Requirements

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Convective Weather (CW)

Research Requirements

- Improve observations & forecasts of convective storms. Create & improve standards & techniques for integration into DSPs to mitigate impacts on & improve efficiency of the NAS

- Improve accuracy over legacy systems; higher spatial & temporal resolution; well-defined probabilistic & gridded information; guidelines & strategies for developing capabilities for integration into DSPs that meet users' requirements & are applicable to their needs

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC: Jason Baker, ANG-C61, 202-267-1625

Outputs/Outcomes

- OPC: Blend lightning data, satellite imagery & wx model data to produce an estimate of precipitation for areas that lack radar coverage, merged seamlessly with existing radar mosaic to provide controllers with better situational awareness for offshore sectors

- TCF: More accurate forecast with infusion of high-resolution data & AI
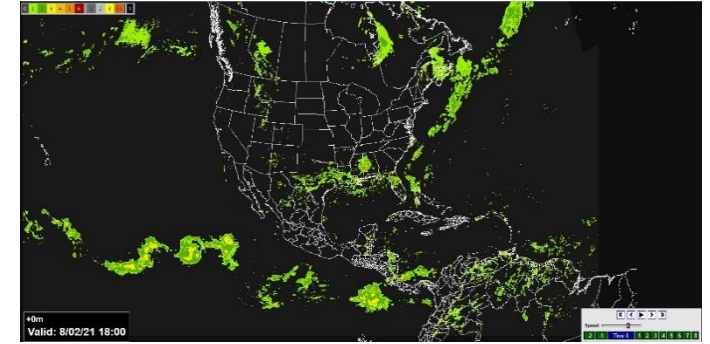
FY 2026 Planned Research

- Implement prototype metrics; focus on NAS high traffic sectors
- Forecast comparison to TFM Weather Requirements
- Explore blending convective wx forecast based on AI / ML
- Continue to prepare OPC for operational transition
  - Faster (5 min -> 2.5 min approx.) refresh rate
  - Create flexible/center selectable altitude layers
  - Broader domain to include Central and Western Pacific

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$1.M	$ 1.8M	$ 2.1M

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In-Flight Icing (IFI)
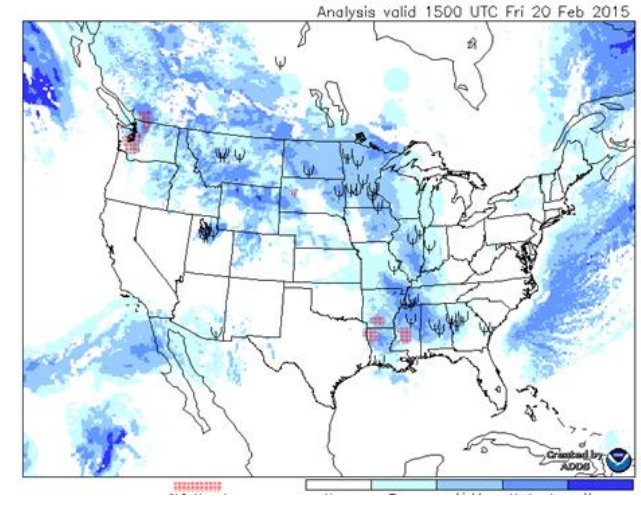
Research Requirements

- Improve operationally-available diagnoses & forecasts of aircraft icing conditions that can be used by aviation users to make decisions on icing threat areas, optimum routings, & areas to avoid in compliance with recently updated regulations & aircraft certification envelopes

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC: Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

- Diagnostic & forecasts up to & beyond 18 hours over the CONUS & Alaska for operational use by ATM, dispatchers, & pilots to enhance capacity & safety

FY 2026 Planned Research

- Initial drop-size capability in icing products to meet aircraft certification envelopes
- Further refinement and evaluation of prototype capability for low-level operations

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 1.3M	$ 1.3M	$ 1.4M

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Model Development & Enhancement (MDE)

Research Requirements

- Weather prediction models are the basis for aviation wx hazard forecasts beyond 2 hours; enhancements to forecasts of aviation wx hazards including clouds & visibility, inflight icing, turbulence, and CW require wx prediction model enhancements

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC: Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

- 0-60-hour high resolution rapid refresh over North America to support aviation forecast products

- Enhanced NAS safety & capacity/efficiency from improved forecasts of aviation specific wx hazards

FY 2026 Planned Research

- Preparation of RRFS v2 with enhanced data assimilation and model physics for implementation into NCEP operations
- Development of RRFS v3 with enhanced aviation specific capabilities including application to low-level operations

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 1.2M	$ 1.2M	$ 1.3M

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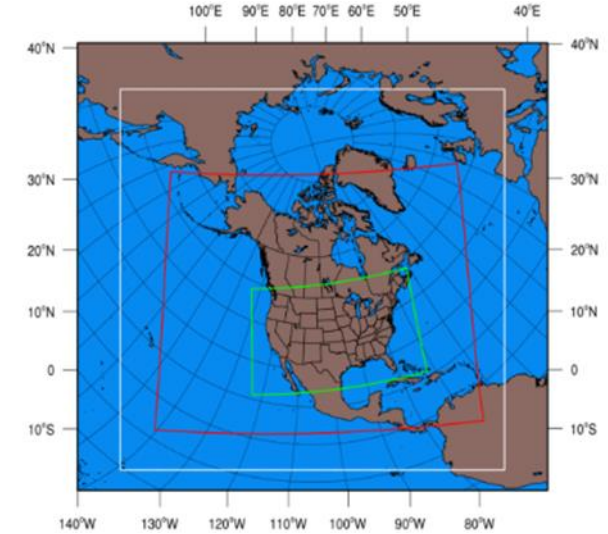
Turbulence (TRB)

Research Requirements

- Improve turbulence observation & forecasting capabilities throughout the NAS to accurately identify & predict time, locations, & intensity of turbulence; improving safety, capacity, & efficiency in the NAS

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S , AFS-400

- POC: Tammy Flowe, ANG-C61, 202-267-2796

Outputs/Outcomes

- High resolution, gridded, global detection & probabilistic forecasts of turbulence (clear-air, mountain wave & convectively-induced) to support ATM DSPs, dispatchers & pilots resulting in improved safety, increased capacity & reduced atmospheric emissions within the NAS
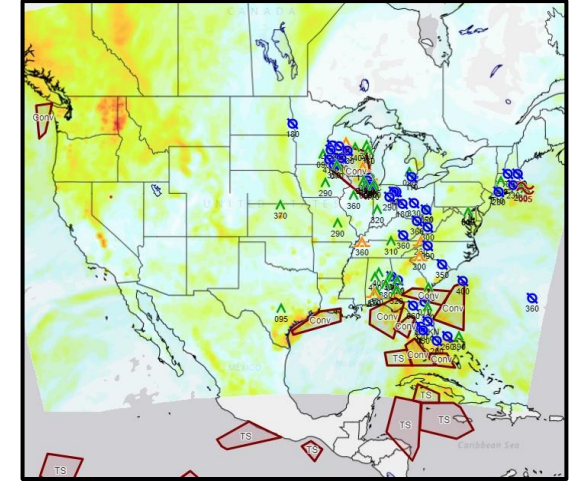
FY 2026 Planned Research

- GTGN (RRFS v1-based) operational implementation at NWS

- Turbulence mitigation for UAS/AAM environment

- Studies of climate change effects on turbulence patterns & air traffic routes

- GTG enhancements – Outside cloud convectively-induced turbulence forecasts, global probabilistic turbulence forecasts, global "Nowcasts" with rapid updates (15 minutes) and high resolution (3 km), and addition of machine learning for tuning the GTG model

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 1.5M	$ 1.5M	$ 1.5M

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Clouds, Cloud Ceiling, & Visibility (C&V)

Research Requirements

- Improve C&V detection & prediction with the goal of reducing GA accidents/incidents & improving airport efficiency

- Sponsored by ANG-C6, ANG-C7, AJM- 3, AJR-B, AJV-S , AFS-400

- POC: Jenny Colavito, ANG-C61, 202-267-2787

Outputs/Outcomes

- Improvements to C&V guidance at airports leads to greater efficiency
- Improvements to & expansion of C&V gridded guidance
- New sources for C&V observations: camera-based & drone-based
- Enhanced safety for GA & new NAS entrants
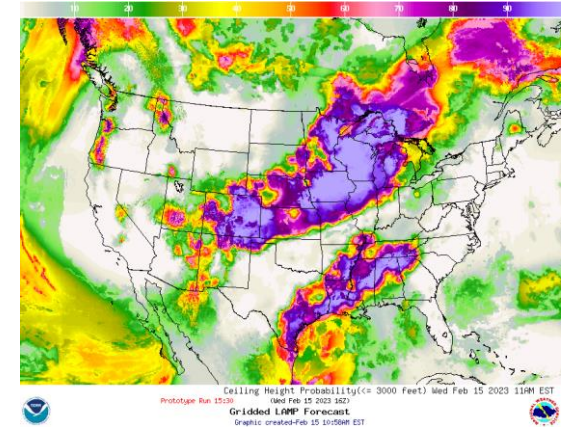
FY 2026 Planned Research

- Usability and suitability assessment of AWC display of gridded C&V forecasts with 15-minute resolution
- Improve gridded forecasts of C&V using novel observation data sets (e.g. from wx cameras and satellites)
- Continue development of image analysis technology to extract wx elements (including existence of precipitation)
- Extend UAS observation studies
- Assess the impact of C&V on new NAS entrants

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 0.9 M	$ 0.9 M	$ 1.0 M

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# Advanced Weather Radar Techniques (AWRT)

Research Requirement

- Conduct & implement research toward a high-resolution, high quality, three-dimensional (3D) wx radar data analysis from national & international radar networks

- Provide improved detection & forecasting for hazardous phenomena such as turbulence, icing & convection, & deliver these products & services in a manner that allows for their rapid & effective use by NAS decision-makers

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC: Randy Bass, ANG-C61, 202-267-2800

Outputs/Outcomes

- Aviation threat-specific information provided through the MRMS platform

- Reflectivity at specific flight levels beneficial to aviation users

- Improved diagnosis & depiction of icing conditions of interest to aircraft operations

- Improved validation techniques to ensure that MRMS data can be used effectively & reliably for operational decision-making

- Improved wx radar diagnosis & depiction of turbulence conditions of interest to aircraft operations

3D HCA & mPING obs at 1800 UTC 07/02/2019

FY 2026 Planned Research

- Monitor performance of new products & algorithms on the developmental MRMS system, including winter precipitation algorithms & convective polygons

- Complete integration & testing of TDWR data into MRMS

- Investigate wx radar capability requirements for NWP & develop strategies for research opportunities in support of these requirements
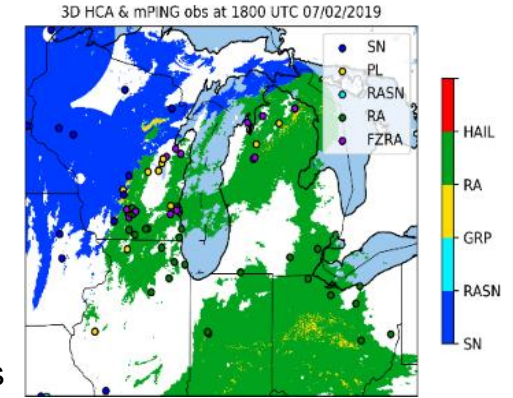
Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 500K	$ 600K	$ 600K

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Quality Assessment (QA)

Research Requirements

- Improved observations & enhanced forecasts must have effective & reliable verification prior to becoming operational to ensure the accuracy, performance, and value of these products for NAS users
- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400
- POC: ANG-C63 Sean Whelan 609-485-4838; ANG-C63 Steve Maciejewski 609-485-5950

Outputs/Outcomes

- Verification/assessment of aviation impact wx forecasts and analyses
- Data provided supports transition of research wx forecast products based on forecast accuracy, quality, and operational meaningfulness to ATM, dispatchers, and pilots

3-km Native Grid

Max: 0.16
Median: 0.14
Nearest: 0.14
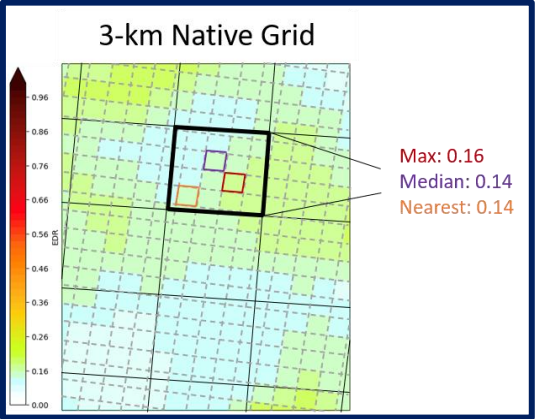
FY 2026 Planned Research

- Assessments:
  - RRFS upgrade and its impacts to the CW forecast
  - Probabilistic Turbulence Forecasts
  - Continuous Improvement through Verification for modeling, turbulence, convection, and icing
  - C&V capabilities for CONUS and Alaska
  - Enhancements to UAS Wx
  - LAMP C&V Forecast
  - Comparison of TCF and CoSPA in the Context of TFM Decision Making

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 1.15 M	$ 1.2 M	$ 1.3 M

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Aviation Weather Demonstration and Evaluation (AWDE)

Research Requirements

- NextGen Implementation Plan (Reduce Weather Impact & Validating Concepts) states human factors, human-in-the-loop testing, & demonstrations are essential tools for validating NextGen concepts

- Demonstration & evaluation services are required to assess wx research maturity & concept readiness for transition

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC Sonia Alvidrez, ANG-C63; 609-485-7613

Outputs/Outcomes

- Enhanced demonstration & evaluation services with subject matter expertise, improved data resources including live aircraft situation data, & metrics capability

- Data & analysis to reduce programmatic risk, aid in definition & validation of requirements & inform AMS lifecycle management activities to improve the delivery of research capabilities developed

FY 2026 Planned Research

- Continue conducting user assessments for newly developed and/or redesigned wx products to ensure capabilities are usable and suitable for operational use.

- Participate/support the AWC Testbed Summer & Winter Experiments

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 550k	$ 550K	$ 550K

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Terminal Area Icing Weather Information for NextGen (TAIWIN)*
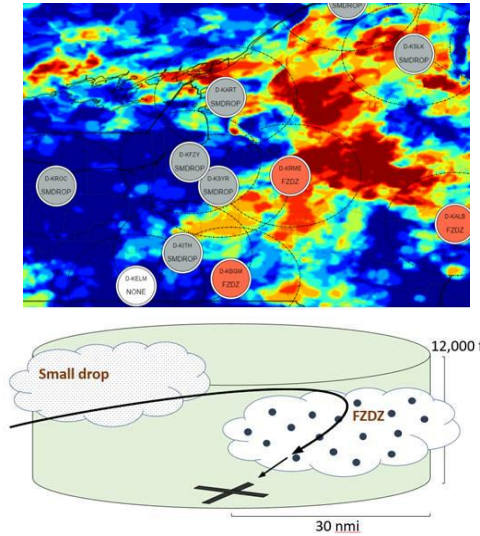
Research Requirements

- Responds to operational needs - new SLD Rule 25.1420 & NextGen *Reduce Weather Impact* capacity & throughput requirements in freezing precipitation
- Develop capability/technology to manage impact of new certification SLD rule on terminal area operations; research on automated reporting systems & improved wx diagnostic/forecast tools
- Sponsored by: AFS-200, AFS-400
- POC Stephanie DiVito, ANG-E2; 609-485-7152

Outputs/Outcomes

- Improved icing wx information including SLD in terminal area
- Maintain/improve efficiency & safety in icing conditions under new SLD rules in terminal area, facilitating smooth transition to new operational rules and/or guidance anticipated from Flight Standards corresponding to new SLD certification rule

FY 2026 Planned Research

- Prepare real-time capability version for validation and verification effort in ~FY27
- Prepare for ~FY27 validation & verification data collection program for TAIWIN capability
- Define next steps for operational transition activities

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 1.6M	*$220K	*TBD

*TAIWIN will be transitioning from A11.k to A11.da, Aircraft Icing BLI, and funded/managed by ANG-E2

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# High Ice Water Content (HIWC)*

Research Requirements

- NTSB: A-96-54, -56, & -58
- Characterization of HIWC ice crystal environments that can be a threat to turbine engines
- Diagnosis and forecasting of HIWC ice crystal environments
- Sponsored by AIR-624, AFS-400
- POC Stephanie DiVito, ANG-E2; 609-485-7152

Outputs/Outcomes

- Atmospheric HIWC ice crystal data set sufficient for assessment of certification envelopes, development of test facilities, onboard detection for avoidance, & diagnosis & forecasting for avoidance
- Enhanced avoidance of HIWC conditions

FY 2026 Planned Research

- Given an operational pathway for ALPHA has been identified, perform efforts to deploy ALPHA as an operational HIWC wx avoidance tool
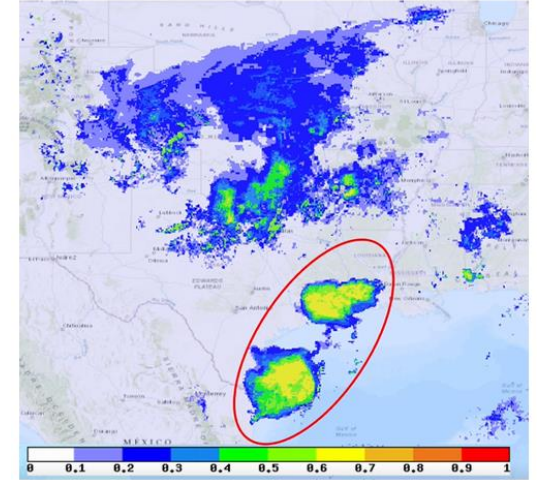
Out Year Funding Requirements

RE&D	FY24	FY25	FY26
	$250K	*$50K	*TBD

*HIWC will be transitioning from A11.k to A11.da, Aircraft Icing BLI and funded/managed by ANG-E2

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Unmanned Aircraft System Weather (UAS Wx)

Research Requirements

- Assess & improve wx observation & forecast needs for UAS operations (Boundary layer (just above earth's surface; urban environment)
- New & refined wx information; observation & forecast, & decision support processes need defined standards to ensure continued high-level operational safety for the NAS
- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400, AUS-300
- POC Pat Murphy, ANG-C61; 202-267-2788

Outputs/Outcomes

- Conduct research to identify how to improve wx observational networks and wx forecast models for low-altitude (below 400 feet) UAS operations

FY2026 Planned Research

- Urban/Suburban Microscale Modeling for UAS & UAM Operational Concepts Development
- UAS Weather Research in the Boundary Layer
- Standard Specification for Wx Data Performance, Interfaces, & Interoperability
- UAS/AAM Integration Plan (UIRP)
  - FAA UIRP development & improvement
  - NASA-FAA UIRP development & improvement

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 700K	$ 800K	$ 1M

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Weather Observations Research (WOR)

Research Requirements

- Conduct & transition research that enhances or increases wx observations on the surface with the goal of improving capacity & surface operations

- Evaluation of emerging observing technologies are required to validate user needs & assess readiness for formal concept demonstration & transition into operations

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC Victor Passetti, ANG-C63; 609-485-6260

Outputs/Outcomes

- Affirmation of automated wx detection capabilities synchronized to new or emerging wx observation requirements

- Reinforce the safety risk management process via early user interactions with new observing technologies to clarify desired needs & harmonize transition of new capabilities into existing wx observing platforms

FY 2026 Planned Research

- *Continue optimization of present wx sensor technologies to include one-to-one intensity/present wx reporting

- Continue improved discrimination of present wx (snow) & wx obstructions (fog/mist)

- Research addition of smoke detection and reporting capabilities within the ASWON program

- Gap and shortfall analysis

* Dependent on upcoming NWS PRSENT wx sensor procurement decision

Out Year Funding Requirements

RE&D	FY24	FY25	FY26
	$ 750K	$ 675K	$700K

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Space Weather Aviation (SWxA)

Research Requirements

- Space wx services will provide information for space wx events that may adversely affect the performance of aircraft communications, navigation, & surveillance systems.
- Improved space wx information for aviation will consist of more accurate depictions & forecasts of the areas & altitudes affected by the space wx event
- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400
- POC: Samantha Carlson, ANG-C61, 202-267-8990

Outputs/Outcomes

- Increased lead times for preflight planning & enroute diversions to save fuel, time, & limit radiation dosages to passengers & avionics
- Enhanced operator understanding of space wx, its aviation impacts, and proactive measures for sustaining operations
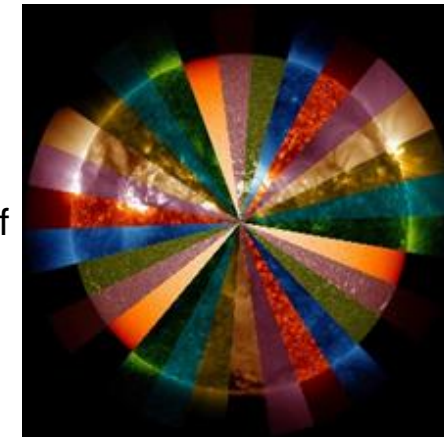
FY 2026 Planned Research

- Facilitate enhancing neutron monitor network via crucial OSSE experiment to determine research potential and cost-effectiveness
- Creation of an AI system based on physics models to predict and mitigate major space wx events
- Develop tailored training on space weather's impact on aviation operations and proactive strategies

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 500k	$500k	$500k

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Volcanic Ash Detection (VAD)

Research Requirements

- Develop capability/technology to detect concentration of volcanic ash particles within 60nm using an airborne radar
- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-2, AFS-400
- POC: Karen Shelton-Mur, ANG-C64, 202-267-7985

Outputs/Outcomes

- Demonstration of detection of volcanic ash using a modified aircraft radar algorithm.

FY 2026 Planned Research

- Requirements and test plan for Airborne Campaign

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$ 150K	$ 300K	$400K

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Wind Detection & Forecast (WDF)

Research Requirements

- Improvements to wind information throughout the NAS, focusing efforts on operationally significant areas, both geographically & vertically that cause flight delays, enhancing safety, increasing capacity, & reducing environmental impacts

- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S, AFS-400

- POC Pat Murphy, ANG-C61; 202-267-2788; Jason Baker, ANG-C61, 202-267-1625

Outputs/Outcomes

- Improved wind speed/direction forecasts at/near surface including onset, cessation & dissipation of operational wind shifts

- Analyses of UAS, Comm. Space & TBFM needs
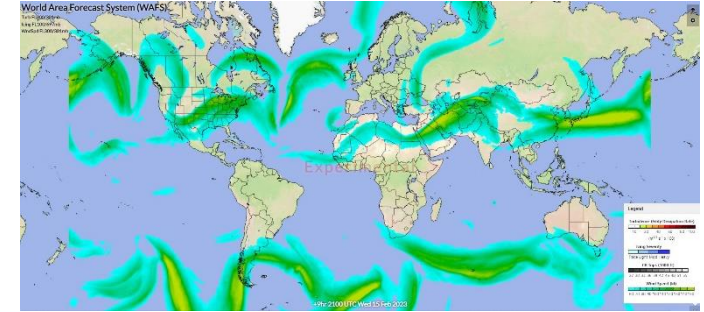
FY 2026 Planned Research

- Show benefit of adding LIDAR observations of mapping the wind flow & low-level winds aloft in the terminal airspace

- Assimilate high resolution LIDAR data into Model analysis

- JAWS Modernization

- Extend JAWS Warning Thresholds for various aircrafts types.

- Compare Rapid Refresh Forecast System (RRFS) model output of wind forecast at select, high demand, airports to TFM Wind Requirements; establish baseline

Out Year Funding Requirements

	FY24	FY25	FY26
RE&D	$0	$ 1.1M	$ 1.6M

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Weather Program A11.k Support - WTIC

People:

- 1 Program Manager
- 3 Subject Matter Experts

Collaborations with WTIC:

- **Standards Organizations**
  - RTCA, ICAO, ASTM — Advancing Global Meteorological Standards

- **Academia**
  - Embry Riddle Aeronautical University — General Aviation Interfaces, Training, and Preflight Weather Briefings
  - PEGASAS (GA Center of Excellence) — Data Fusion, PIREP enhancements, Training (Mixed Reality), AI

- **Professional Societies**
  - AOPA, GAMA — General Aviation Safety Enhancements
  - ALPA — Part 121 Pilot Studies
  - NAFI — Pilot Weather Training

- **Industry**
  - Flight Safety (and FRASCA) — General Aviation Weather Training, Mixed Reality
  - Fly8MA — Weather Training Videos and Augmented Reality Training

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Weather Technology in the Cockpit (WTIC) Projects

- **Cockpit Cognitive Assistance Tool (CAT) With Weather (*formerly Digital CoPilot*)**
  - Completed Part Task and Focus Group Assessment including a Final Report
  - Evaluated the potential benefits in decision-making using CATs that help to aggregate wx product information and automatically derive insights for the pilot
  - Ran 5 scenarios

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

  - Gathered pilot feedback on decision making, operational safety, and cognitive workload in today's operations and compared this to using CATs. Pilot impact ratings always showed higher positive ratings for the CAT conditions
  - FY24 plans are to incorporate additional CAT wx functions and perform a simulator study. Approximately 19 functions are candidates. The output will establish the initial configuration of the technical transfer package for Cockpit CATs
  - FY25 plans are to collaborate with a technical transfer partner and use a beta version for CATs for a GA flight evaluation to verify the initial technical transfer package and CATs configuration

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WTIC Projects (cont'd)

- **Automatic Dependent Surveillance–Broadcast (ADS-B) Vertical Rate (VR)**
  - Deep Dive Presentation on REDAC Agenda to cover project accomplishments and plans

- **Pilots Understanding Observation Uncertainty**
  - Received and approved final report for Phase 1
  - Results of study indicated a gap since the ***pilots had a high confidence*** in their ability to predict the wx conditions, but they ***demonstrated poor skill***
  - Experiment used 4 Zoom levels (mimicking navigational map displays per AWC), 3 regions with significant wx variability due to terrain and seasons
  - Increase in resolution reveals more of the observational variability
  - Destinations with unknown wx conditions labeled "A", "B", "C", and a departure location indicated by the yellow aircraft *(Sample on next chart)*
  - Scenarios taken from reported wx from an accident/incident
  - Pilot predicted flight conditions at destinations with a confidence rating
  - FY24 – Perform research to assess Phase 1 pilot thought processes in making decisions and confidence ratings
  - FY25 – Research resolutions to the gap(s) based on FY24 and Phase 1 and produce a final report

WTIC Projects (cont'd)

- **Pilots Understanding Observation Uncertainty (cont'd)**

Experiment Scenario Example and Results
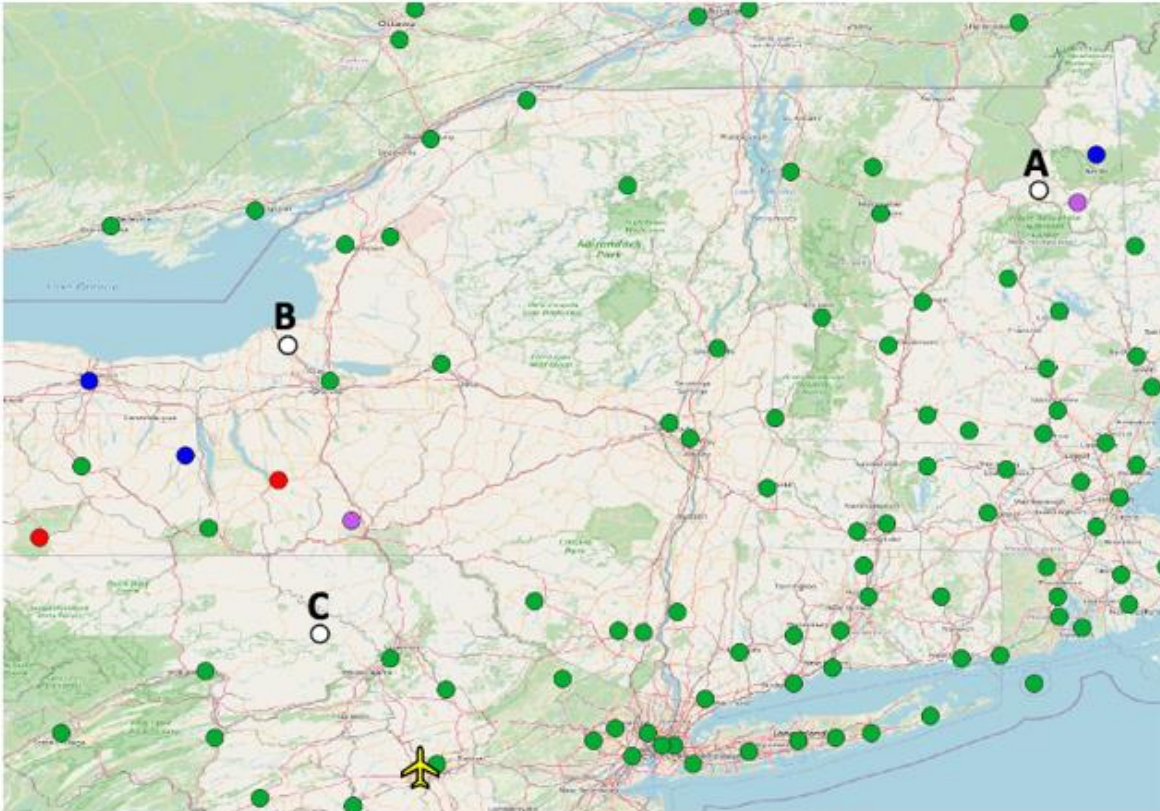
Great Lakes Region Scenario
Showing highest resolution

A = IFR
B = VFR
C = IFR/LIFR

Location A	VFR	MVFR	IFR	LIFR
LOW RES	14	10	0	0
MED RES	23	1	0	0
HIGH RES	0	23	1	0

Location B	VFR	MVFR	IFR	LIFR
LOW RES	20	4	0	0
MED RES	16	8	0	0
HIGH RES	2	22	0	0
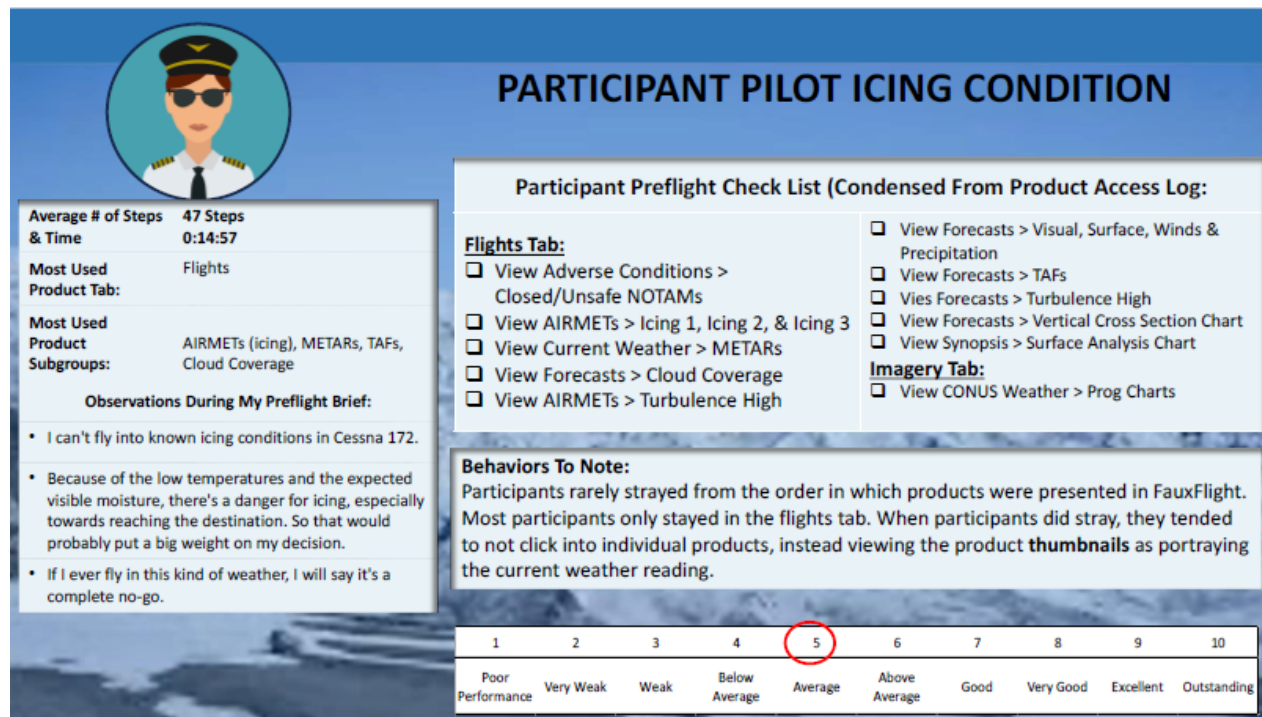
Location C	VFR	MVFR	IFR	LIFR
LOW RES	21	3	0	0
MED RES	3	17	3	1
HIGH RES	0	11	13	0

Location A	Not At All Confident	Slightly Confident	Somewhat confident	Fairly confident	Completely confident
LOW RES	0	0	8	12	4
MED RES	0	1	3	8	12
HIGH RES	0	3	8	11	2
Location B					
LOW RES	0	0	10	12	2
MED RES	0	2	7	12	3
HIGH RES	0	1	4	15	4
Location C					
LOW RES	0	0	11	7	6
MED RES	0	4	6	11	3
HIGH RES	1	0	7	13	3

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WTIC Projects (cont'd)

- **Self Briefing Versus Specialist Briefing**
  - Completed project and accepted the final report
  - Compared pilots' wx mental model after a self briefing versus a specialist briefing for two scenarios: Icing and Fog
  - Measures included questionnaires, multiple choice tests, behavioral observations, and interviews
  - Study had several limitations
  - On some measures:
    - Pilots had a higher degree of clarity of the wx with a briefing
    - Self briefings never performed higher than FSS briefing
    - Larger number of differences for the icing scenario
    - Sample report excerpt on next slide
  - FY24/25 –
    - Research enhancements to pilot self briefings
      - Output updates to guidance on self briefings.
    - Research enhancement to pilot Wx training
      - Output updated guidance for Wx training for pilots
    - Solicit inputs from Flight Services (and Leidos)
      - Use inputs to drive research and in developing updated guidance

WTIC Projects (cont'd)

- **Self Briefing Versus Specialist Briefing (cont'd)**

<u>Report Summary Excerpt</u>

WTIC Projects (cont'd)

- **Flight Profiler – Digital Twin, Preflight Briefing Tool**
  - Completed Focus Group #1 to identify wx information sources and interface design features to enhance Flight Profiler as a preflight self briefing tool
  - Participants rated the current capabilities highly and provided recommendations for enhancements (*sample results on next chart*)
  - Added 14 of 26 suggestions from Focus Group #1 for Group #2 plus a prototype AI function
  - After Focus Group #2, perform experiment like the Self Briefing versus Flight Services Briefing project to assess mental models
  - FY24/25 Develop Minimum Weather Service recommendations based on results and pursue technical transfers
  - FY25 - Use Flight Profiler as a Digital Twin to evaluate benefits of other WTIC research products, and enhance AI capabilities
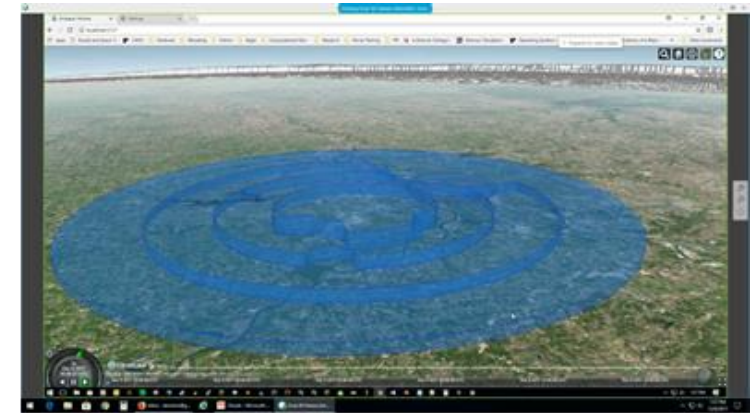
Digital Twin Kansas City/MCI Class B airspace

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WTIC Projects (cont'd)

- **Flight Profiler – Digital Twin, Preflight Briefing Tool (cont'd)**

Sample Results From Final Report

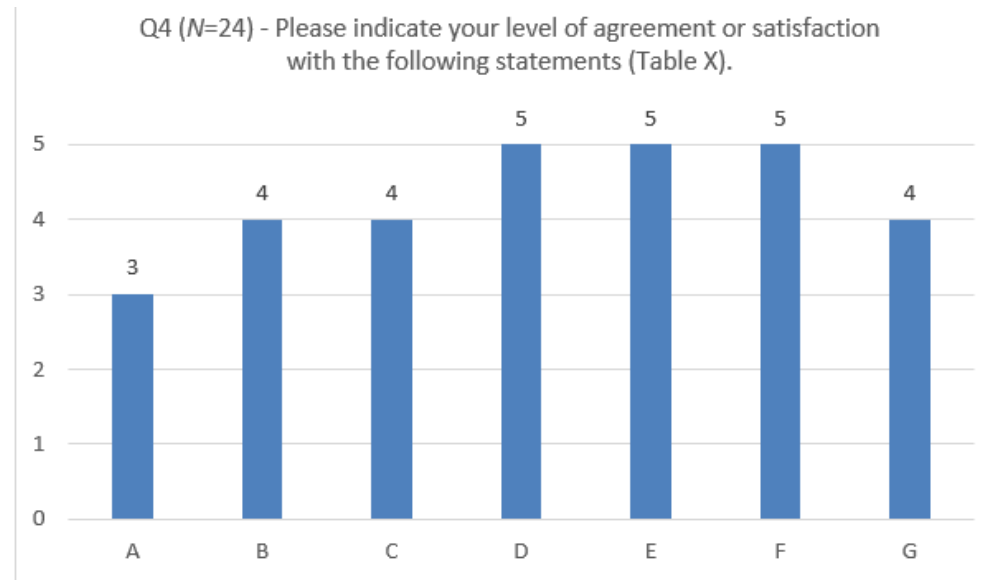|	
A	FlightProfiler's 3D Weather needs to be easier to navigate.
B	FlightProfiler's 3D Weather helps me make better decisions about flight planning and flight safety.
C	FlightProfiler's 3D Weather provides weather conditions in a way that is relevant to my preflight planning.
D	Observing the atmospheric environment in 3D adds value to my preflight planning.
E	3D weather visualizations help with mental modeling of weather conditions.
F	3D weather visualizations enable easier identification of the hazards to a planned flight.
G	The tool displays weather hazards that could impact a route (but may not be on the route).

Q4 (*N*=24) - Please indicate your level of agreement or satisfaction with the following statements (Table X).

Figure 16. Mean ratings (mode values) for statements A-G

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Other WTIC Projects (cont'd)
Quick Updates and Plans

- **Hands Free PIREP Project**
  - Draft final report and technical transfer package reviewed. FY25 incorporate with CAMI Phase 2 prototype PIREP study and outreach for technical transfer
- **Crowd Sourcing Project**
  - Developed framework for building algorithms and models for AI acceptance when lacking truth data
  - FY24-FY26 - mature models and algorithms and assess role in building stakeholder confidence and assessing operational readiness
- **Low Altitude Weather Fusion (LAWF)**
  - Awarded contract and successfully accomplished kickoff meeting. Project is a feasibility and benefits assessment. Follow-on research in FY25 and FY26 based on FY24 results
- **Global MET Standards**
  - Continued to mature DO-364A / ED – XXX, MASPS for AIS / MET Data Link Service Systems for document delivery in mid-May 2024
  - Began development of MASPS for Automated Atmospheric Turbulence Derivation Techniques
  - SC-206 / WG-76 approved ToR Revision 22 to develop a RTCA paper "Recommendation(s) Regarding Possible Standards to Support Aircraft-Based Meteorological Observation Dependent Applications" and update DO-358C

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Weather Technology in the Cockpit (WTIC)

Research Requirements

- Develop MinWxSvc recommendations for cockpit wx information and technology to enhance safety and efficiency, and reduce gaseous emissions
- Address the need for enhanced cockpit wx technology, information, and human factors principals to achieve NextGen objectives, and identify potential enhancements in a data centric national airspace system
- .

Outputs/Outcomes

- Technical reports
- Minimum wx service recommendations
- Technical transfer package(s) as applicable
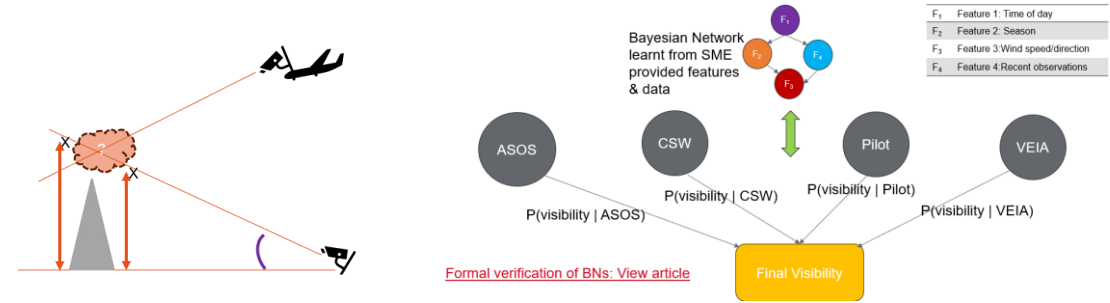
FY2026 Planned Research

- Weather Decision Support Tools and Emerging Technologies
- Integration / Fusion of Observation Weather Data
- Pilot, Automation, and Display Interfaces
- Advancement of Global Meteorological Information Standards

Out Year Funding Requirements – Estimated Totals

	FY24	FY25	FY26
RE&D	$ 3.9M*	$3.9 M*	$3.9 M*

*Estimated total funding as program under Weather Programs BLI

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List of Acronyms

- **AAM** Advanced Air Mobility
- **AI** Artificial Intelligence
- **AIS** Aeronautical Information Services
- **ADS-B** Automatic Dependent Surveillance–Broadcast
- **ALPHA** Algorithm for Predicting HIWC Areas
- **ASWON** Aviation Surface Weather Observation Network
- **ATM** Air Traffic Management
- **AWC** Aviation Weather Center
- **AWRP** Aviation Weather Research Program
- **AWT** Aviation Weather Testbed
- **CAT** Cognitive Assistance Tool
- **CEIA** Cloud Estimation through Image Analytics
- **CIP** Current Icing Product
- **CONUS** Continental U.S.
- **CoSPA** Consolidated Storm Prediction for Aviation
- **DMR** Dust Mixing Ratio
- **DSPs** Decision Support Processes
- **EDR** Eddy Dissipation Rate
- **EMC** Environmental Modeling Center
- **EPOCH** Ensemble Prediction of Oceanic Convective Hazards
- **EWINS** Enhanced Weather Information Systems
- **FIP** Forecast Icing Product
- **FC** Flight Category
- **GA** General Aviation

- **GSL** Global Systems Laboratory
- **GTG** Graphical Turbulence Guidance
- **HEMS** Helicopter Emergency Medical Services
- **HITL** Human-in-the-Loop
- **IAA** Inter-Agency Agreement
- **ICAO** The International Civil Aviation Organization
- **ICICLE** In-Cloud Icing and Large-drop Experiment
- **IPA** Icing Product Alaska
- **JAWS** Juneau Airport Wind System
- **JPSS** Joint Polar Satellite System
- **LAMP** Localized Aviation Model Output Statistics Program
- **LaRC** Langley Research Center
- **LAWF** Low Altitude Weather Fusion
- **LDM** Local Data Manager
- **LIDAR** Light Detection and Ranging
- **MASPS** Minimum Aviation System Performance Standards
- **MET** Meteorological
- **ML** Machine Learning
- **MRMS** Multi-Radar, Multi-Sensor
- **NAS** National Airspace
- **NCAR** National Center for Atmospheric Research
- **NCEP** National Centers for Environmental Prediction
- **NOAA** National Oceanic and Atmospheric Administration

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List of Acronyms (cont'd)

- **NSIP**   NAS Segment Implementation Plan
- **NSSL**   National Severe Storms Laboratory
- **NTSB**   National Transportation Safety Board
- **NWS**   National Weather Service
- **OIs**   Operational Increments
- **OPC**   Offshore Precipitation Capability
- **OSSE**   Observing System Simulation Experiment
- **PIREP**   Pilot Report
- **REACH**   Responsive Environmental Assessment Commercially Hosted
- **REDAC**   Research, Engineering and Development Advisory Committee
- **RRFS**   Rapid Refresh Forecast System
- **SAL**   Saharan Air Layer
- **SIGMET**   Significant Meteorological Information
- **SLD**   Supercooled Large Drops
- **SWPC**   Space Weather Prediction Center
- **TCF**   Traffic Flow Management Convective Forecast
- **TDWR**   Terminal Doppler Weather Radar
- **TFM**   Traffic Flow Management
- **ToR**   Terms of Reference
- **UAM**   Urban Air Mobility

- **VR**   Vertical Rate
- **WCAMS**   Weather Cameras
- **WIMAT**   Weather Information Modernization & Transition
- **WX**   Weather

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