ANG The Future of the NAS Starts Here

FAA Office of NextGen (ANG)

REDAC / NAS Ops

Review of FY2023 – 2025 Proposed Portfolio

Name of Program: Weather Program

BLI Number: A11.k

Presenter Name: Randy Bass

Date: March 15, 2023

Weather Program A11.K Overview

What are the benefits to the FAA

- Enhanced National Airspace System (NAS) safety via reduction of accidents associated with hazardous weather
- Improved NAS capacity/efficiency via reduced delays and cancellations and increased capacity in high traffic areas
- Reduction in environmental impact (i.e., lower fuel consumption via improved accuracy and accessibility of observed and forecast weather information)
- Enhanced General Aviation (GA) safety via improved accuracy and accessibility of observed and forecast weather information

What determines program success

- Transition of research capabilities into evolving Air Traffic Management (ATM) decision support processes
- Research capabilities align with NextGen Segment Implementation Plan and NextGen emerging solution sets
- Incorporation by National Weather Service (NWS) of research capabilities to improve delivery of FAA required services
  - Weather Program funding of High-Resolution Rapid Refresh weather model while resulting in NAS benefits, has also provided high resolution severe weather 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/Global Systems Lab – 18 Jan 2022]
- Incorporation by NWS or commercial industry of research capabilities into weather information that enhances GA safety
- Tangible reduction in avoidable delays and aircraft accidents due to weather
  - Transition of successful weather research capabilities into operations have contributed to a reduction in NAS delays due to weather from 66% in 2007 to 57% in 2019

Weather Program A11.K Support

People:

- Program Manager
- 14 Subject Matter Experts

Laboratories:

• NOAA GSL	Model Development & Enhancement (MDE); Quality Assessment (QA)
• NOAA NSSL	Advanced Wx 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 Storms (CS)
• NWS MDL	C&V
• MIT/LL	CS; C&V
• NCAR	IFI; MDE; C&V; TRB; CS; TAIWIN, High Ice Water Content (HIWC); Weather Observations (Wx Obs)
• WJHTC	Aviation Weather Demonstration and Evaluation (AWDE); Wx Obs; TAIWIN; HIWC
• MITRE CAASD	Unmanned Aircraft System Weather (UAS Wx); Space Weather Aviation (SWxA); TRB
• NRC	TAIWIN
• ECCC	TAIWIN
• Diakon	TAIWIN
• NASA	TAIWIN; HIWC

Highlights of Significant Accomplishments & Plans

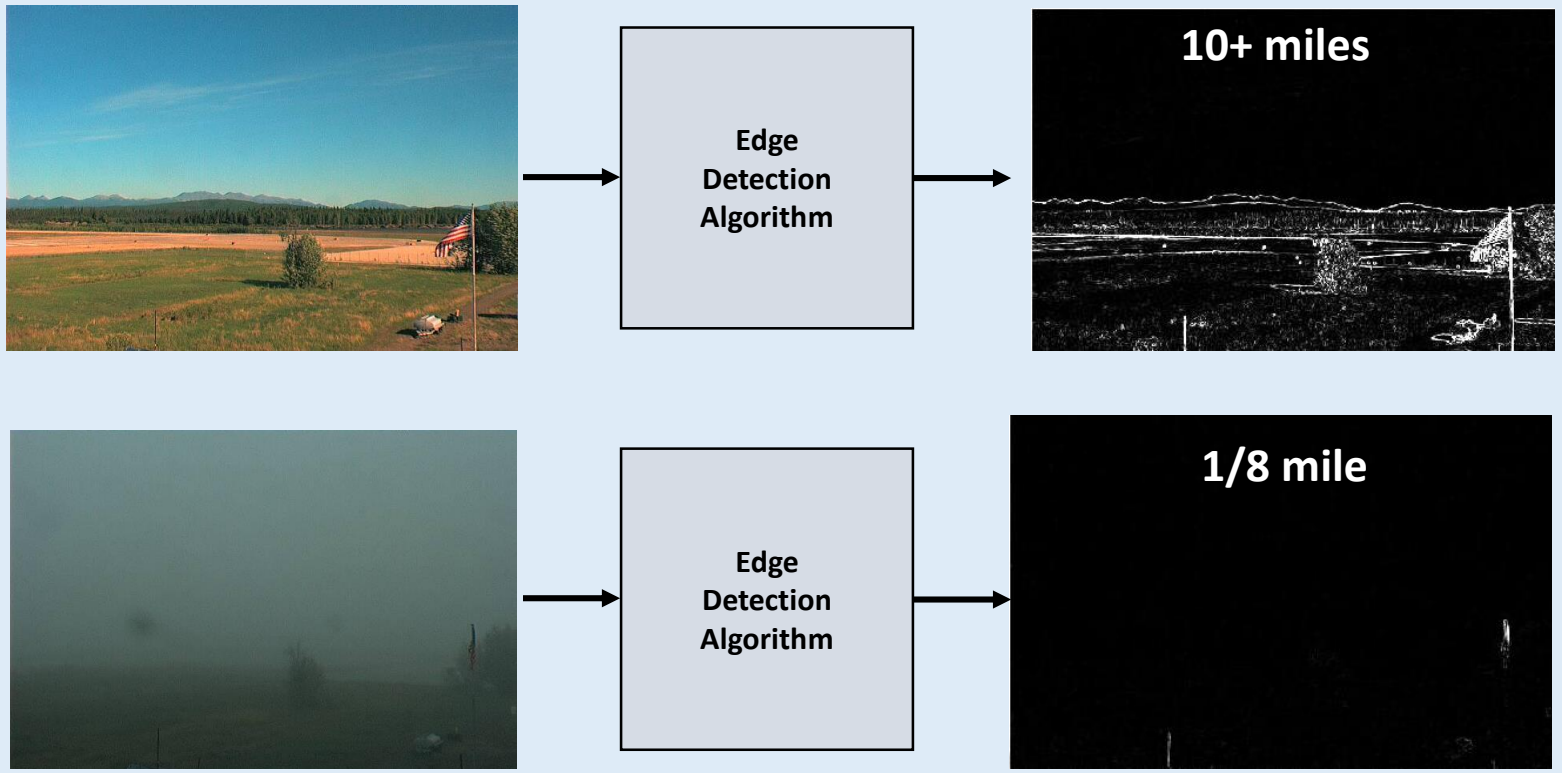
- Visibility Estimation through Image Analysis (VEIA)
- Research to Operations (R2O), Collaborative Process with NWS
- Space Weather Aviation (SWxA)
- Volcanic Ash Detection (VAD)

Visibility Information Derived from Weather Cameras will Increase Aviation Safety

2016 – Began Development of VEIA

2022 – Completed testing & evaluation to prove:

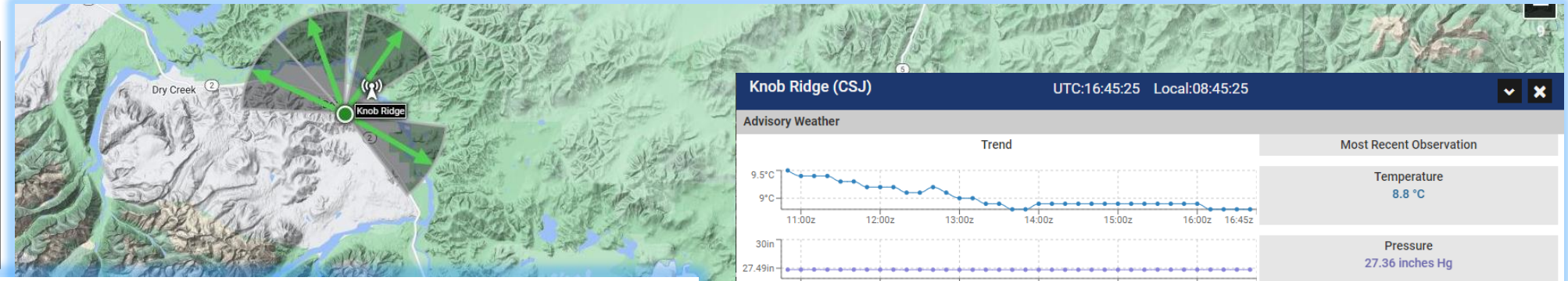
- Meteorological accuracy
- Value added to aviation users
- Safety in an operational environment



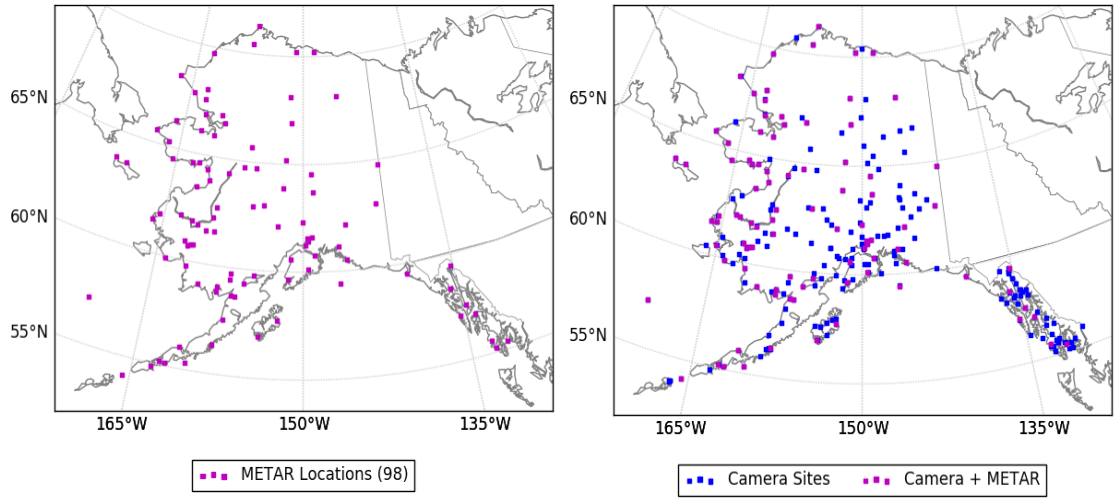
VEIA works by comparing the visible edges of permanent features and objects in the scene to a clear day reference image.

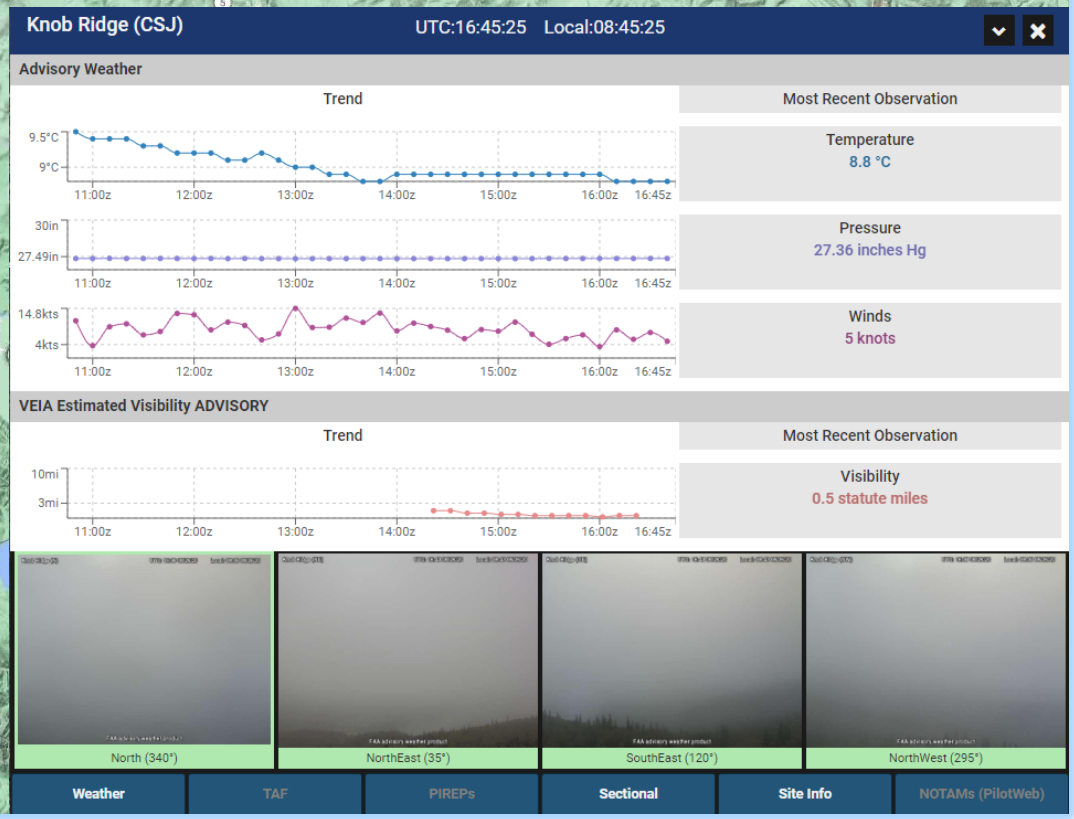
The FAA plans to deploy VEIA visibility estimates on the Weather Camera website beginning in the Fall of 2023

Alaskan METAR observation density (left panel) compared to the camera density (right panel).



VEIA will greatly increasing the observation density in Alaska by leveraging the FAA Weather Camera Network.



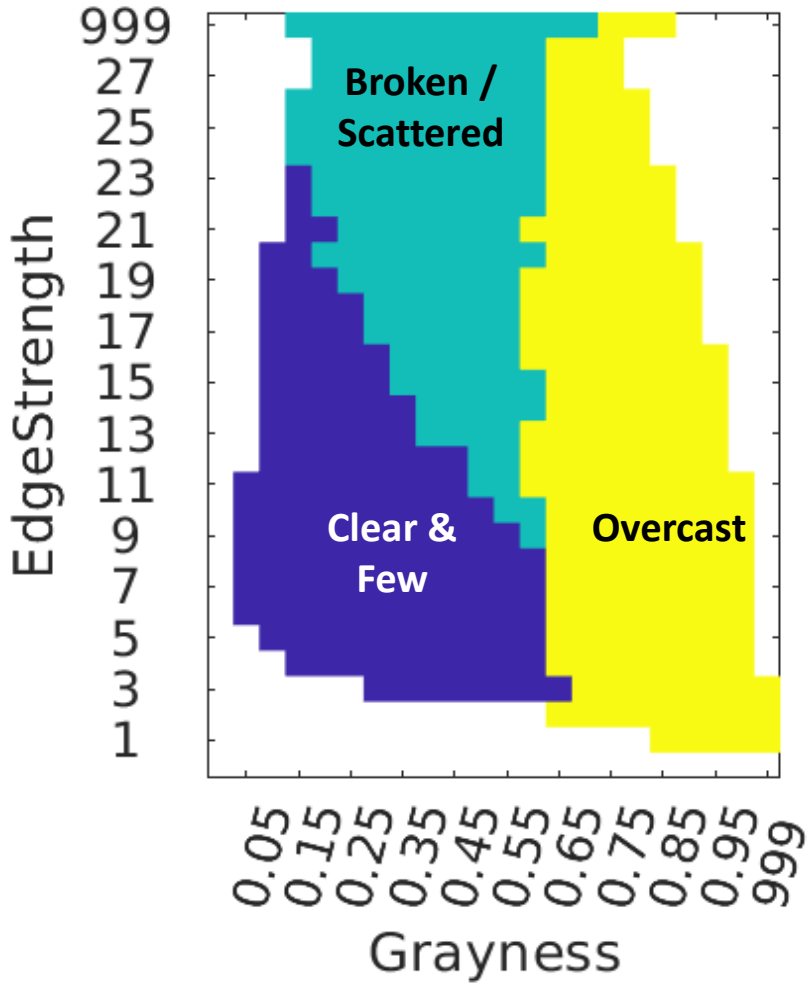


Example of VEIA visibility estimates displayed on the FAA Weather Camera website from Knob Ridge site on 8-26-2020

VEIA - What's next for Image Analytics?

- FY 23
  - Testing of a VEIA enhancement that uses scene-type designations (e.g., mountainous or flat terrain) to adjust VEIA configuration & improve overall performance
  - Testing & Evaluation of **Cloud Estimation through Image Analytics (CEIA)**
    - New capability that estimates the cloud cover from weather cameras
    - User Evaluation planned for summer 2023
- FY24 - Third party quality assessment & safety assessment of CEIA technology
- FY25 - Assimilation of camera-based observation into weather models

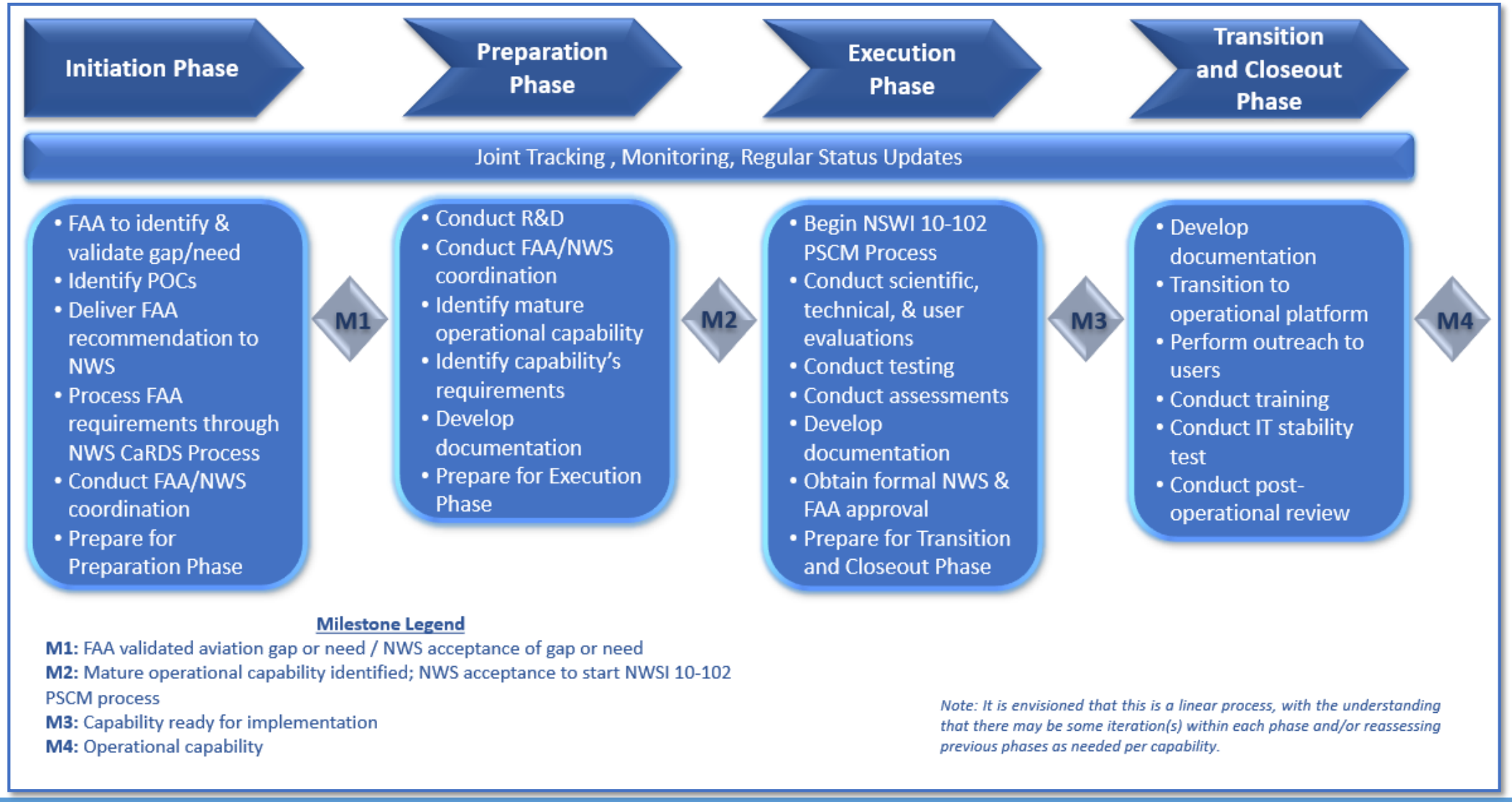
CEIA uses the texture & grayness of the sky to estimate the cloud cover. Sky texture is measured in the Edge Strength of sky pixels (i.e., cloud structures)



Research to Operations (R2O) - Purpose

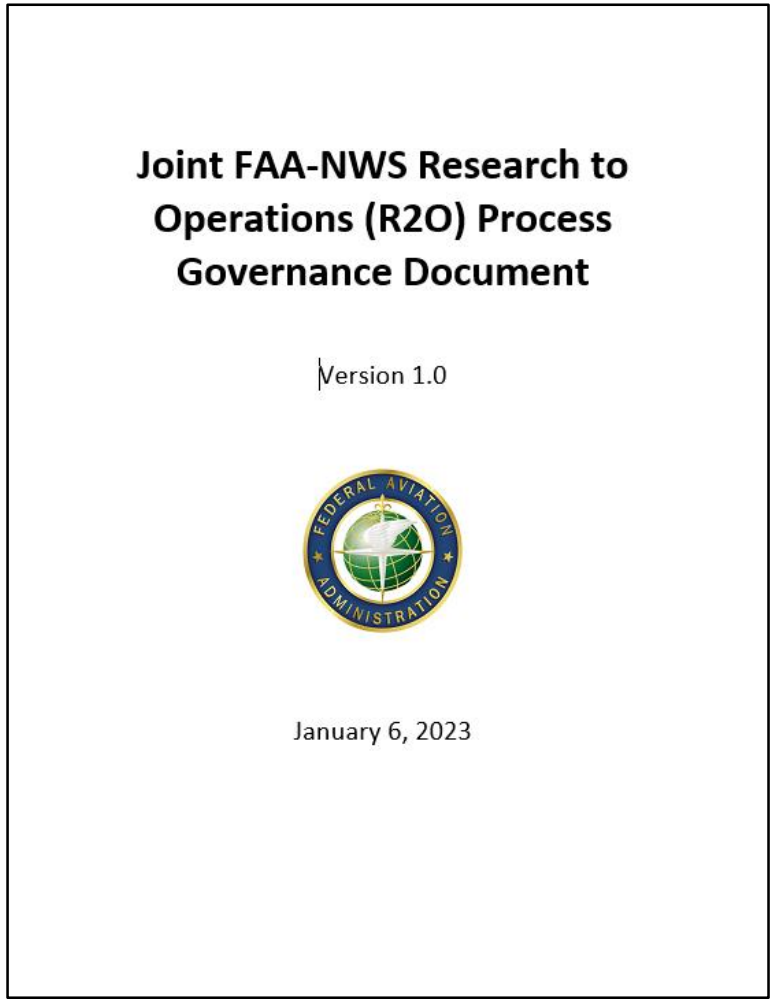
- Memorandum of Understanding (MOU) defines policy agreement between FAA and NWS including the area of R2O
  - New MOU currently being routed through FAA & NWS channels for signature – first update since 2004
  - “The NWS & the FAA shall approve a joint research to operations process & conduct recurring joint research to operations meetings”
- R2O process document developed in coordination with NWS
  - Defines a high-level process for transitioning from FAA research and development to an NWS-established process for the transfer of a capability into operational use
  - Four phases with milestones:
    - Initiation
    - Preparation
    - Execution
    - Transition and Closeout
  - Defines roles & responsibilities
  - Involves multiple NWS organizations

Research to Operations (R2O) - Process



Research to Operations (R2O) - Status

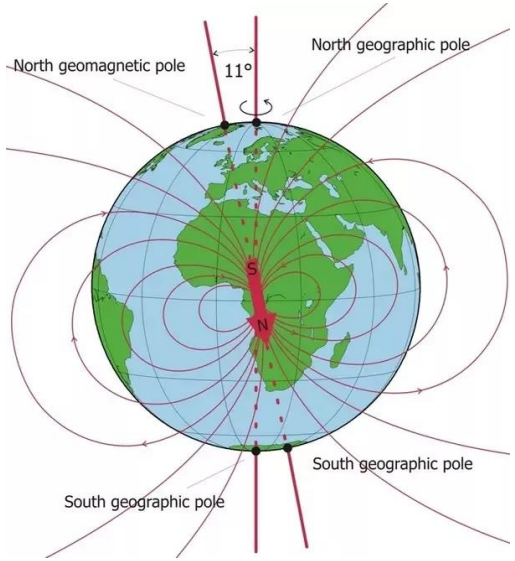
- Final document in January 2023
- Will reside with Memorandum of Understanding
- Quarterly meetings being conducted
  - Currently tracking 6 distinct capabilities
  - More to be added
- Document will serve as a template for separate R2O processes to FAA systems and to industry
  - Modifications to be done as needed



Space Weather Aviation (SWxA)

Space Weather (SW) refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space and ground-based technological systems, as well as endanger human health

SW can have a greater hindrance on operations at high latitudes (>50°N) and polar regions (>78°N) due to limited magnetic shielding in polar regions (‘open’ field lines)



Impacts
High-frequency communication disruptions
Satellite navigation system (GNSS) and precision location errors
Increased radiation dose exposure (SEPs and GCRs) and avionic damage

SWxA goal is to increase data collection during SW events to improve capacity of the NAS through validated models that enhance forecasting & warning lead times/confidence. Provide additional communication capabilities for reporting SW activity and threat level. Identify areas at risk & mitigate harmful impacts to avionic, navigation/communication, and aircrew/passenger health

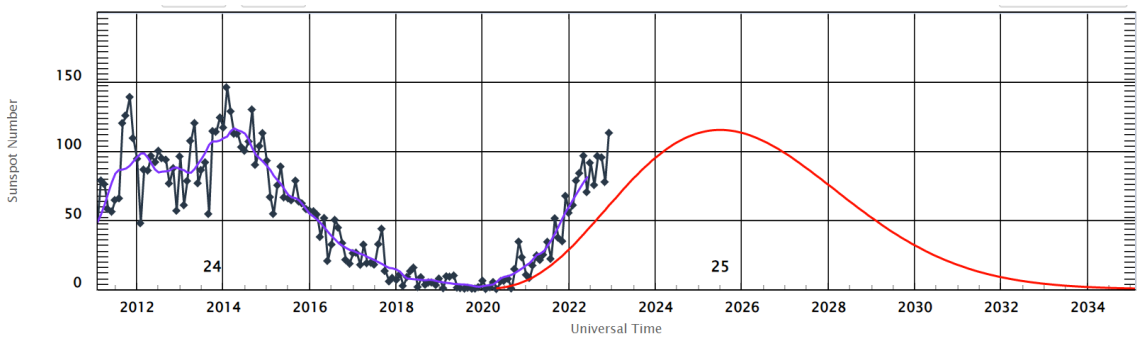
Space Weather Aviation (SWxA)

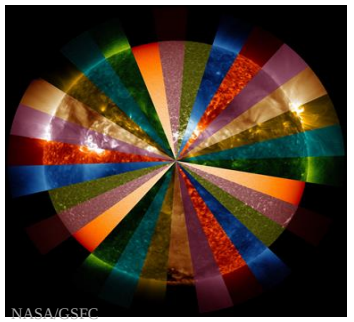
Research Requirements

- As Solar Cycle 25 ramps up towards maximum, peaking between 2024-2025, the solar magnetic field complexity drastically increases providing opportunity for more frequent and enhanced solar storming events
- Governmental entities recognized the issues of SW, including those directed towards aviation, through various executive acts, orders, and plans

Prospective Taskings

- Continue to investigate the viability of a data assimilative cutoff rigidity approach utilizing US Space Force REACH payload data
- Complete NAS infrastructure SW vulnerability assessment highlighting priorities for SW resiliency
- Conduct a simulated Observing System Experiment (OSSE) to identify an optimal, cost-effective ground-based neutron monitor network to support aviation radiation models
- Ensure the collection of SW observations & measurements for enhanced forecasting support to provide increased accuracy and lead times, making the NAS safer & more efficient
- Utilize Citizen Science (scientific research with public participation) to further develop and validate SW aviation-based models

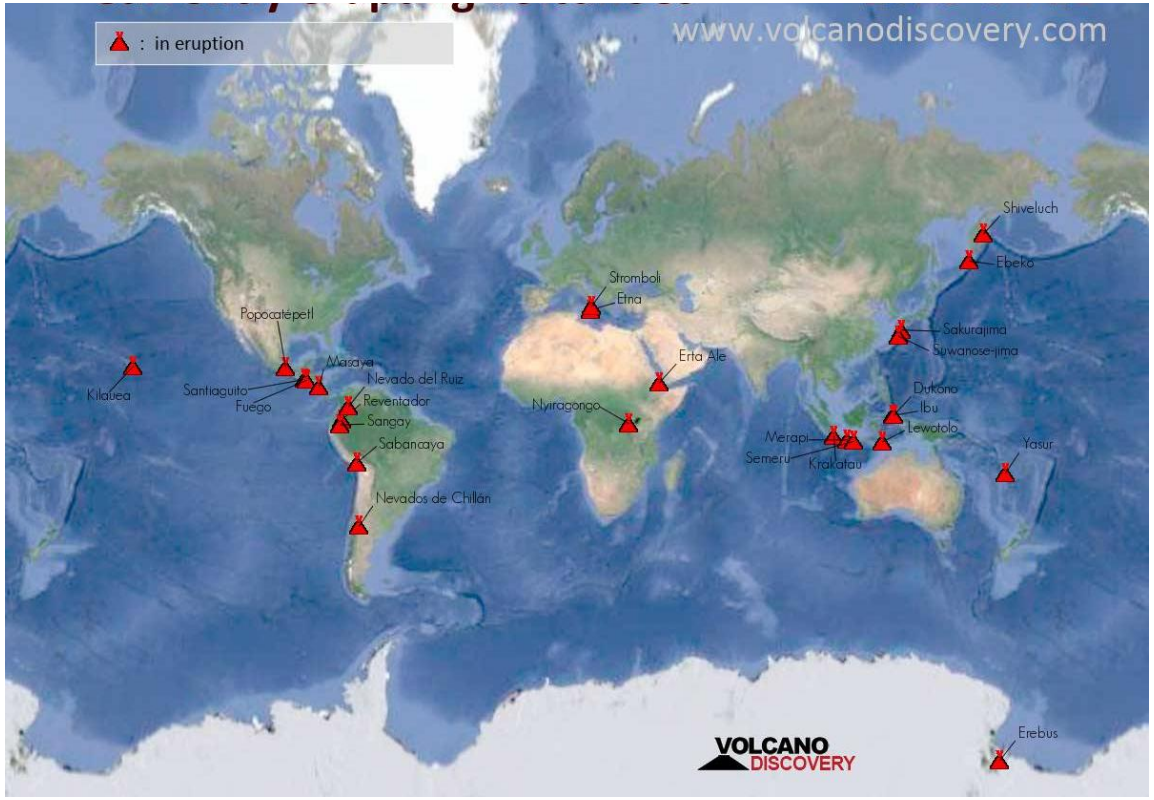




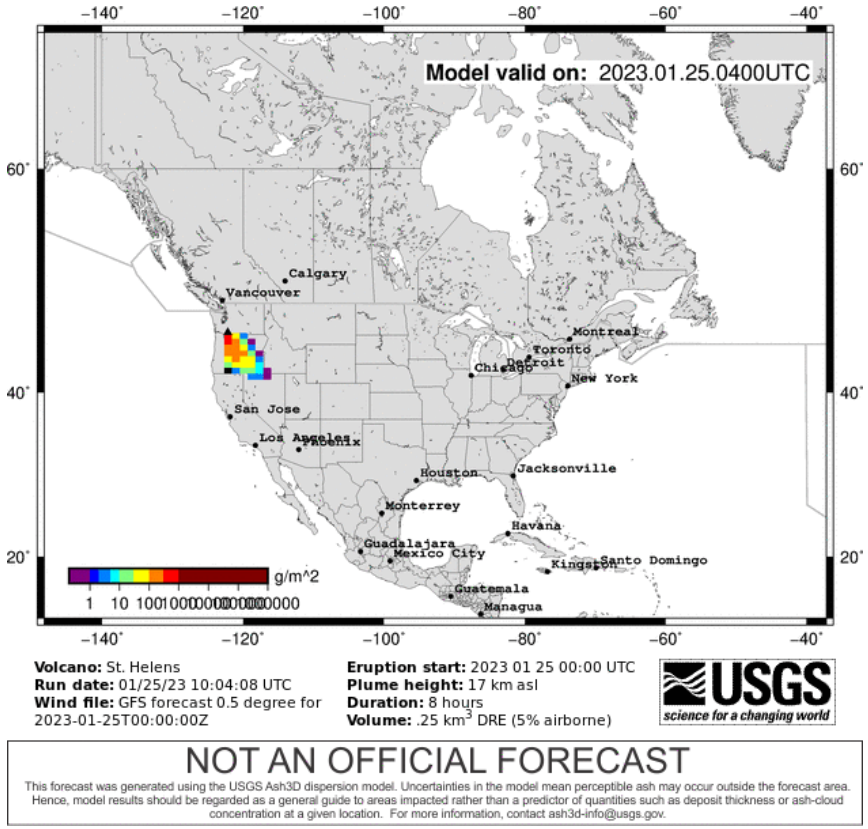
Volcanic Ash Detection (VAD)

Currently Active Volcanoes and Potential Impacts

World Map of currently Erupting Volcanoes as of 1/25/23



Ash 3d VA Cloud Simulation of Mt St Helens; courtesy of the U.S. Geological Survey



VAD utilizing Airborne (Aircraft) Radar

Volcanic Ash Airborne Detection Mitigation Efforts

- Improve capacity of the NAS
- Reduce accidents/injuries related to VA encounters
- Develop new capability for aircraft/aircrew to avoid encounters with VA

Requirement Basis

- Between 1954 & 2009, the USGS identified 94 confirmed ash encounters: 79 of those having various degrees of airframe or engine damage (high severity) & 15 encounters where severity was not able to be determined. Additionally, there were 20 suspected (not verified) low-severity encounters that may have involved volcanic ash or volcanic gases (s02 clouds)
- The 2010 eruption of an Icelandic volcano (Eyjafjallajokull), in combination with upper-level winds, rapidly spread ash over large distances at aviation altitudes. The eruption lasted for 8 days, shutdown all European and Atlantic airspace, & cost $4.7 billion in economic losses
- A U.S. Geological Survey simulation of major eruption from Mt St Helens shows entire NAS could be impacted in 8 hours
- The FAA policy is to avoid VA; therefore, closing the NAS for a number of days; this is unsustainable
- Without means of detection, aircraft can unknowingly fly into volcanic ash clouds resulting in engine damage & power loss

VAD utilizing Airborne Radar

Year 1 (FY23): Feasibility study related to airborne radar detection of VA Clouds (NASA LaRC)

- Review best practices & outcome from aircraft radar detection of HIWC flight/Saharan dust campaign
- Determine if a similar approach for volcanic ash measurement & detection of volcanic ash concentrations (Very low to high) can be done

Year 2 (FY25): Conduct wind tunnel tests using modified radar algorithm

- Software development & testing of identified radar algorithm approaches for detection of VA

Years 3-4 (FY25-26): Airborne flight campaign to verify/validate modified radar algorithm

- Use modified aircraft radar algorithm to investigate and discern VA from very low to high (0.2 – 10mg/m^3) concentrations from varying range & flight altitudes

Year 5 (FY27): RTCA Minimum Operational Performance Standards (MOPS) for airborne radar systems

Cancellation of UAS Weather Research Projects

On 14 Feb 2023, AUS 300 announced that a list of UAS projects previously approved were being cancelled due to a change in priorities

- Initiated on Emerging Entrants Executive (-1's/-2's) review based on new criteria & their respective responsibilities/priorities for UAS & AAM integration
- Directed Program Managers to close out affected projects immediately with remaining funding to be repurposed for projects the executives identified as a priority
- Some projects already started; Stop Work orders required and contracts to be cancelled
- All future UAS & AAM research requirements are required to flow to AUS from executive leadership
- Three weather-related projects are affected that were being led by Flight Safety (briefed to the REDAC in Sep 2022)

	Research Title	**CA#**	**Sponsor**
AIR.16	Develop icing, snow, and rain means of compliance for UAS.	A11L.UAS.80	Paul Pellicano
FS.25	Identify Weather Research and Knowledge Gaps in the Boundary Layer for UAS	A11L.UAS.81	Gordon Rother and John Steventon
FS.26	Identify Unmanned Aircraft System (UAS) Weather Hazards	A11L.UAS.82	Gordon Rother and John Steventon

Current FY23 Accomplishments

- **Convective Storms (CS)**
  - Commenced implementing AJV-S research guidance for Offshore Precipitation Capability (OPC) enhancements
  - Collaborated with AWDE on Traffic Flow Management Survey Convective Forecast (TCF); 184 responses received from industry, NWS, & FAA Air Traffic Controllers
  - Finalizing code to transition Ensemble Prediction of Oceanic Convective Hazards (EPOCH) to NWS to support international weather requirements; transition expected to be completed by Q3 in FY23
- **Inflight Icing (IFI)**
  - Updated internal processes to prototype scenarios & enhanced satellite upgrades to prototype IFI products to improve performance of diagnosing large drop conditions
  - Developed plan for calibration of IFI probability & severity
- **Model Development & Enhancement (MDE)**
  - Conducted Rapid Refresh Forecast System (RRFS) data assimilation experiments to demonstrate improvements, including improved wind forecasts
  - Upgraded RRFS microphysics to address convective weather shortfalls
- **Turbulence (TRB)**
  - Provided overview on Graphical Turbulence Guidance Version 4 (GTG4) transition efforts to Acting NextGen Administrator & new National Weather Service Director
  - On-going transition discussions with NWS for transfer of GTG Nowcast (GTGN) model - short-term, rapidly updated tactical product – National Transportation Safety Board (NTSB) Recommendation

Current FY23 Accomplishments (Contd.)

- **Clouds, Cloud Ceiling, & Visibility (C&V)**
  - Completed initial testing of CEIA algorithm & determined technology shows promise for estimating cloud cover from weather cameras. Began preparations for a live user evaluation
  - Completed initial testing of an enhancement to VEIA that uses scene-type designations (e.g., mountainous or flat terrain) to adjust the VEIA configuration & improve overall performance of the visibility estimates
  - Completed data collection & final report for field study at CVG airport to assess the impact of meteorological observations from drones on the prediction of fog events
- **Quality Assessment (QA)**
  - The continuous improvement through verification services have been updated with the latest icing & turbulence model data which can be used for current model development comparison
  - Completed turbulence & inflight icing cases & interview questions for an AWDE user evaluation. The goal of the User (GA Pilots) Evaluation is to understand if the different model outputs of icing & turbulence information have an impact on decision-making
- **Aviation Weather Demonstration & Evaluation (AWDE) Services**
  - Coordinated with FAA Weather Evaluation Team (WET) & Industry leads to develop survey to determine how users, including Air Traffic Controllers, Mets, Dispatchers, & ATM, use & interpret the TCF; results summary forthcoming
  - Coordinated with Quality Assessment Team, to collect data from GA pilots to determine how different icing & turbulence model outputs impacts decision making; results summary forthcoming
- **Terminal Area Icing Weather Information for NextGen (TAIWIN)**
  - Completed TAIWIN capability user demo & eval activity in coordination with AWDE Services
  - Initiated an output evaluation of the development version of the TAIWIN capability

Current FY23 Accomplishments (Contd.)

- **High Ice Water Content (HIWC)**
  - Completed the preliminary particle size distribution analysis of the data collected in the 2022 HIWC high aerosol flight campaign
  - Completed a preliminary particle size distribution dataset
- **Unmanned Aircraft System Weather (UAS Wx)**
  - Updated report on ongoing UAS research efforts that may be candidates for technology transfer
  - Completed urban micro-scale weather (wind) sensitivity study for UAS integration advancement
    - Simulations at 6-meter resolution to show how landscape & buildings affect wind flow & turbulence below 400 feet for different wind speeds & directions
- **Weather Observations (Wx OBS)**
  - Initiated Research & Development program with NCAR to streamline weather sensor research across all product development teams
- **Volcanic Ash Detection (VAD)**

  (Anticipated accomplishments FY23 Q3-Q4)
  - Review best practices & outcome from aircraft radar detection of HIWC flight/Saharan dust campaign
  - Determine if a similar approach for measurement & detection of volcanic ash concentrations (very low to high) can be done
  - Develop a feasibility with a test plan/roadmap to outline the steps needed to modify the radar algorithm, the type of testing needed, including the type of VA medium that will be used to simulate VA particles

Anticipated Research in FY24

Planned Research Activities

- **CS**
  - Commence planning & development of “proof of concept” forecast metrics for near-term TFM requirement, with focus on NAS high traffic sectors
  - Collaborate with Weather Evaluation Team (WET) to explore possible convective weather tasking to support Collaborative Decision Making (CDM)
  - Coordinate with Weather Information Migration & Transition (WIMAT) team to explore streamlining the number of convective weather products; “modernize” convective weather products by digitizing those that are currently textual and/or graphical
  - Commence research & development efforts on any remaining initial OPC requirements for En Route Automation Modernization (ERAM)
- **IFI**
  - Development of initial drop size output capability
  - Prepare initial Current Icing Product (CIP) version 2.0 for transition to NWS
  - Finalize Forecast Icing Product (FIP) for use over Alaska
- **MDE**
  - RRFS version 2 research & development to address aviation weather hazards
- **TRB**
  - GTG4 transition to operational status at NWS; Commence GTGN2 transition to NWS
  - Begin global GTGN product development, Turbulence Avoidance Model (TAM) Phase 3 prototype evaluation

Anticipated Research in FY24 (Contd.)

Planned Research Activities (contd.)

- **C&V**
  - Prepare Localized Aviation Model Output Statistics (MOS) Program (LAMP) & Gridded LAMP (GLMP) 15-min forecasts of C&V for transition to operational implementation
  - Continue to improve the visibility & cloud estimates from weather cameras & conduct third party quality assessment & user assessment of CEIA technology for implementation on the FAA Weather Camera website
  - Conduct a cost-benefit analysis for the use of fully-autonomous drone-based weather sensing systems near airports with high C&V impacts & complex terrain features
- **AWRT**
  - Evaluate benefits of adding a 3D mosaic of Terminal Doppler Weather Radar data into the Multi-Radar/Multi-Sensor System (MRMS) domain (NTSB Recommendation)
  - Develop probabilistic tools to be incorporated into the MRMS product suite
- **QA**
  - Assessments of GTG4, & FIP v2 re: RRFS-based
  - Assessment of RRFS-based FIP2 vs IPA over Alaska Domain

Anticipated Research in FY24 (Contd.)

Planned Research Activities (contd.)

- **AWDE**
  - Conduct User Assessment of the CEIA to determine how cloud information will be used to support decision making when used in conjunction with Alaska camera images
  - Conduct User Assessment of the LAMP Onset/Cessation of Flight Categories (FC) to determine which solution is most suitable for use, provides the best information for determining the onset & cessation of the FCs, & evaluate user benefits
- **TAIWIN**
  - Continue development of TAIWIN capability to provide a horizontal and vertical icing diagnosis & forecast throughout the terminal area at high spatial & temporal resolutions
  - Evaluate capabilities met vs. required for a final TAIWIN capability
  - Prepare for flight campaign to collect data for validation & verification of high-resolution TAIWIN capability
- **HIWC**
  - Complete the evaluation of ice crystal icing environments for the Appendix D certification envelope
  - If operational pathway for Algorithm for Predicting HIWC Areas (ALPHA) has been identified, commence efforts to deploy ALPHA as an operational HIWC weather avoidance tool
- **UAS Wx**
  - Evaluate use of airport & off-airport observations to provide analyzed local information
  - Investigate hazardous weather alerting concepts for UAS operations
  - Complete urban/sub-urban micro-scale wind sensitivity study for UAS integration advancement for Winston-Salem, NC

Anticipated Research in FY24 (Contd.)

Planned Research Activities (contd.)

- **Wx OBS**
  - Continue exploration of new sensor technology to determine if sensor capabilities can be consolidated for future iterations of surface observing systems
  - Explore how various Liquid Water Equivalent (LWE) measurements during mixed-phase precipitation can be used to develop more robust determinations of LWE
  - Continue exploring automation of ground truth techniques for evaluating surface sensor capabilities to better distinguish obstructions to visibility such as fog and/or mist from moderate to heavy precipitation events
- **SWxA**
  - Investigate the viability of a data assimilative cutoff rigidity approach utilizing US Space Force REACH payload data
  - Complete NAS infrastructure space weather vulnerability assessment highlighting priorities for space weather resiliency
  - Conduct a simulated OSSE to identify optimal, cost-effective ground-based neutron monitor network to support aviation radiation models
  - Analyze existing datasets of radiation observations & develop a plan to collect measurements of radiation at aviation operating altitudes
- **VAD**
  - Identify & collaborate with US Geological Survey personnel & other SMEs knowledgeable in volcanic ash characteristics/properties to support determination of VA requirements
    - Identify common volcanic ash cloud particles found at aircraft altitudes & recommend the VA medium (simulated or real VA)
  - Review, analyze, & determine wind tunnel test facility requirements & aircraft radar system/instrument requirements

Anticipated Research in FY24

Expected Research Products

- **CS**
  - Additional functionality, output & information from OPC
- **IFI**
  - Enhanced FIP running in NWS operations
  - Enhanced CIP transitioned to NWS
  - Developmental CIP & FIP drop size information to provide aircraft certification criteria guidance (performance-based standards)
- **MDE**
  - Prototype RRFS version 2
  - Prepare for RRFS Operational Implementation (slipped to Q1, FY25)
- **TRB**
  - Initial GTGN2 code ready to transfer to NWS
  - EDR Correlation Study Final Report & Recommendations; Prototype TAM evaluations Status Report
- **C&V**
  - Gridded & station-based forecasts of high impact C&V & flight categories for CONUS every 15 minutes out 3-6 hours
  - Report containing user feedback, research status, & test results for GLMP analysis of ceiling observations over the SFO domain
  - Cost-benefit analysis report for the use of fully-autonomous drone-based weather sensing systems near airports with high C&V impacts and complex terrain features

Anticipated Research in FY24 (Contd.)

Expected Research Products (contd.)

- **AWRT**
  - Winter weather & convective products implemented into the developmental MRMS system for performance monitoring
  - Automated first-guess output of convective SIGMETs for forecaster & end-user evaluation
- **QA**
  - New verification techniques for analyses of gridded weather products, & probabilistic ensemble forecasts
  - Analysis of how users interpret forecast information
- **Wx OBS**
  - Identify candidate sensor & system requirements for better discrimination of present weather & obstructions
  - Industry demonstration & evaluation of weather obstruction capabilities

Emerging FY25 Focal Areas

- **CS**
  - Implement prototype metrics into select convective weather products that can be focused on NAS high traffic sectors
  - Research alternatives to streamline the convective weather product suite; begin developing convective weather end-to-end prototype
  - Continue operational transition of OPC; begin development on OPC version 2 to capture any remaining requirements
  - Complete “baseline/legacy” Convective Weather Avoidance Model (CWAM) research requirements for transition
- **IFI**
  - Refine drop-size capability in icing products to meet aircraft certification envelopes
  - Development of initial, prototype capability for low-level UAS operations
- **MDE**
  - Finalization of RRFS version 2 with enhanced model physics and data assimilation for NWS implementation
- **TRB**
  - Turbulence mitigation for UAS/AAM environment
  - Studies of climate change effects on turbulence patterns & air traffic routes
- **C&V**
  - Improved C&V forecasts due to the assimilation of camera-based observation & other novel datasets
  - Assessment of the impact of C&V on new NAS entrants (UAS, Urban Mobility, etc.)

Emerging FY25 Focal Areas (Contd.)

- **AWRT**
  - 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
- **QA**
  - Assessment of Probabilistic Turbulence Forecasts, C&V capabilities for CONUS and AK
  - Assessments of enhancements to: IFI for CONUS, AK, global, and UAS Wx
- **AWDE**
  - 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
- **TAIWIN***
  - Validation & verification flight program for TAIWIN capability
- **HIWC***
  - Operational implementation of ALPHA as an operational HIWC weather avoidance tool

***TAIWIN and HIWC will be transitioning to the Aircraft Icing BLI beginning in FY25*

Emerging FY25 Focal Areas (Contd.)

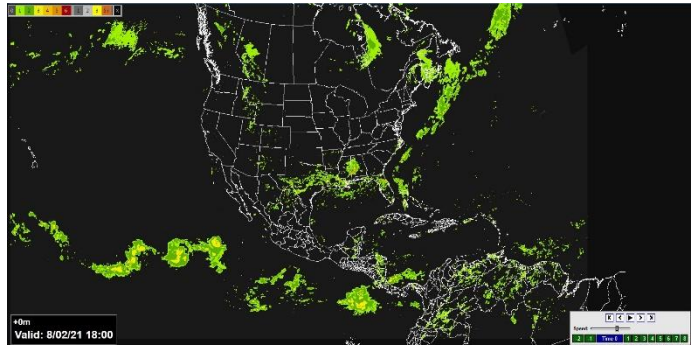
- **UAS Wx**
  - Continue collaboration with industry UAS organizations for understanding weather needs for Advanced Air Mobility & UAM operations
  - Validation of forecast performance of numerical models in UAS domains
- **WXOBS**
  - Optimization of present weather sensor technologies to include one-to-one intensity/present weather reporting
  - Improved discrimination of present weather (snow) & weather obstructions (fog/mist)
- **SWxA**
  - Enhance space weather observations & modeling from the surface to Low Earth Orbit (LEO) to improve safe operations for aviation with better accuracy and lead-time forecasting and nowcasting
- **VAD**
  - Development & testing of radar algorithm approaches for detection of VA
  - Perform series of existing aircraft radar systems wind tunnel tests using modified radar algorithm for detection of VA.
  - Review, analyze, & determine aircraft requirements for an airborne flight campaign including agreements
- **Wind Detection & Forecast (WDF)**
  - Conduct initial sensor study to assess the benefits & impacts of including Light Detection & Ranging (LIDAR) sensed wind observations
  - TFM near-term wind requirements

Convective Storms (CS)

Research Requirements

- Improve observations & forecasts of convective storms. Create & improve standards & techniques for integration into Decision Support Processes (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
- POC: Jason Baker, ANG-C61, 202-267-1625

Outputs/Outcomes



- OPC: Blend lightning data, satellite imagery & weather 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
- CWAM: Redesign the model to incorporate AI techniques and optimize use in strategic time frames (2–8-hours)
- EPOCH: Transfer to NWS to improve forecast for oceanic airspace
- TCF: More accurate forecast with infusion of high-resolution data & AI

FY 2025 Planned Research

- Research possible alternatives to modernize TCF; begin developing convective weather end-to-end prototype
- Implement prototype metrics into CW products with focus on NAS high traffic sectors
- Continue operational transition of OPC; begin development on OPC version 2 to capture any remaining requirements
- Complete "baseline/legacy" CWAM research requirements for transition

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$1.6M	$ 1.6M	$ 2.1M

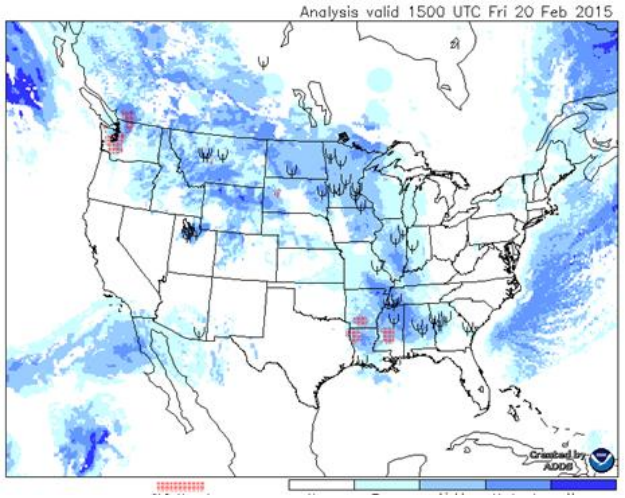
Inflight Icing (IFI)

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, AFS
- 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 2025 Planned Research

- Refine drop-size capability in icing products to meet aircraft certification envelopes
- Development of initial, prototype capability for low-level UAS operations

Out Year Funding Requirements

	FY23	FY24	FY25
RE&D	$ 1.0M	$ 1.2M	$ 1.5M

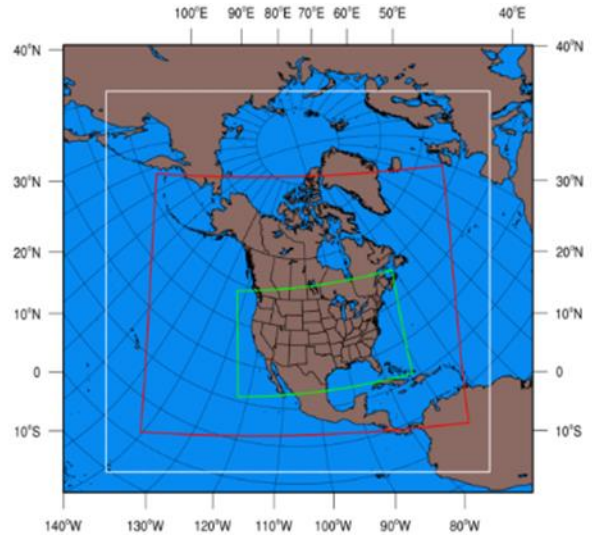
Model Development & Enhancement (MDE)

Research Requirements

- Weather prediction models are the basis for all aviation weather hazard forecasts beyond 2 hours. Improvement of operationally available numerical weather prediction models to enhance forecasts of aviation weather hazards including inflight icing, turbulence, convective weather, & ceiling & visibility will require model enhancements
- Sponsored by ANG-C6, AJM-3, AFS
- POC: Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

- 0-60-hour high resolution rapid refresh to support aviation forecast products
- Enhanced NAS safety & capacity/efficiency from improved forecasts of aviation specific weather hazards



FY 2025 Planned Research

- Enhanced RRFS version 2 data assimilation
- Enhanced RRFS version 2 model physics

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 1.0M	$ 1.2M	$ 1.2M

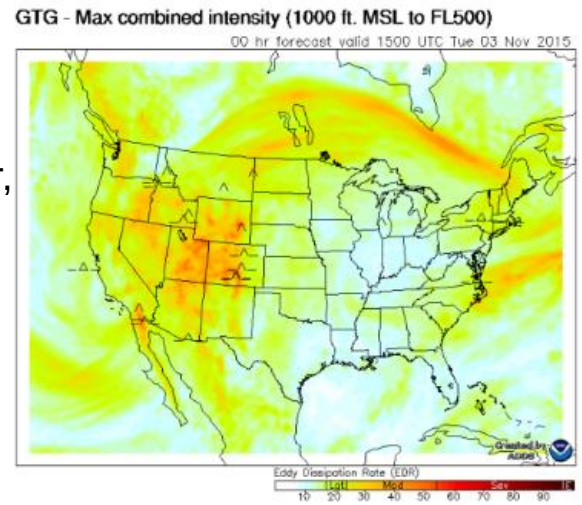
Turbulence (TRB)

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
- 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, dispatcher & pilots resulting in improved safety, increased capacity & reduced atmospheric emissions within the NAS



FY 2025 Planned Research

- 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, extremely high-altitude forecasts, rapid updates (15 minutes)

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 1.5M	$ 1.5M	$ 1.5M

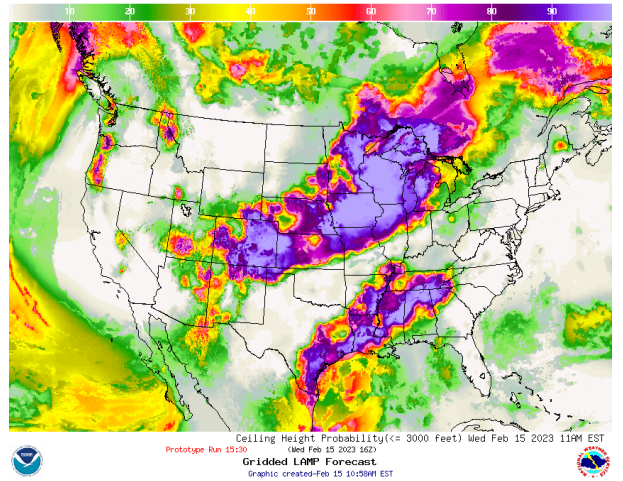
Clouds, Cloud Ceiling, & Visibility (C&V)

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
- 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 2025 Planned Research

- Improve C&V forecasts & analyses through the assimilation of camera-based observations & other novel datasets
- Enhance of cloud analysis & forecast products to include cloud layers, scattered & few coverage, & uncertainty attributes as deemed useful for aviation decision making
- Assess the impact of C&V on new NAS entrants (UAS, Urban Mobility, etc.)

Out Year Funding Requirements

RE&D

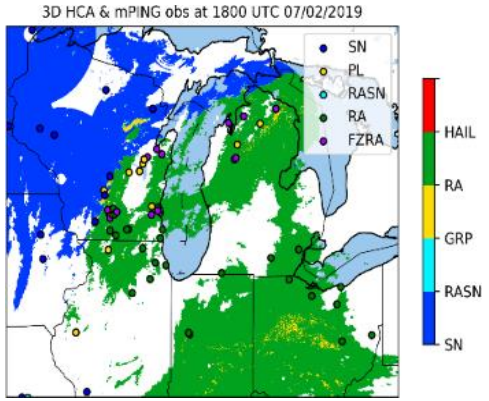
FY23	FY24	FY25
$ 1M	$ 1.5M	$ 1.5M

Advanced Weather Radar Techniques (AWRT)

Research Requirement

- Conduct & implement research toward a high-resolution, high quality, three-dimensional (3D) weather 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
- 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 weather radar diagnosis & depiction of turbulence conditions of interest to aircraft operations

FY 2025 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 weather radar capability requirements for NWP & develop strategies for research opportunities in support of these requirements

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 500K	$ 500K	$ 500K

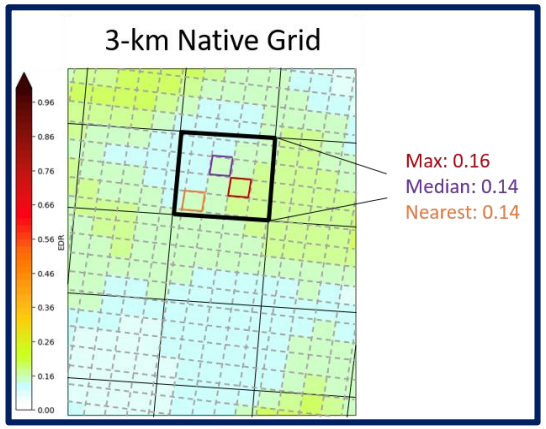
Quality Assessment (QA)

Research Requirements

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

Outputs/Outcomes

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



FY 2025 Planned Research

- Assessment of the RRFS upgrade & its impacts to the convective weather
- Assessment of Probabilistic Turbulence Forecasts, & C&V for CONUS & AK
- Assessments of enchantments to: In-flight Icing (IFI) for CONUS, Alaska, & global capabilities, & UAS Wx
- Continuous Improvement through Verification for modeling, turbulence, convection, & icing

Out Year Funding Requirements

	FY23	FY24	FY25
RE&D	$1.15 M	$1.15 M	$1.15 M

Aviation Weather Demonstration & Evaluation (AWDE) Services

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 weather research maturity & concept readiness for transition
- Sponsored by ANG-C6, ANG-C7, AJM-3, AJR-B, AJV-S
- 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 2025 Planned Research

- Conduct user assessments for Icing, Convective Storms, Turbulence, and C&V to ensure existing & emerging weather products enhance user decision making & support decision making
- Participate/support the AWC Testbed Summer & Winter Experiments

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 550K	$ 550K	$ 500K

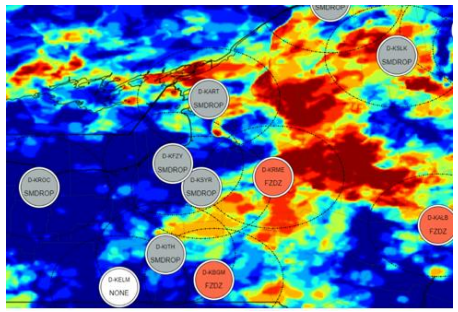
Terminal Area Icing Weather Information for NextGen (TAIWIN)

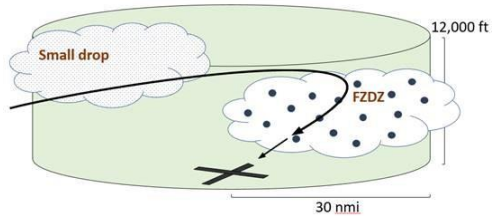
Research Requirements

- 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 Supercooled Large Drops (SLD) rule on terminal area operations; research on automated reporting systems & improved weather diagnostic/forecast tools
- Sponsored by: AFS-200, AFS-400
- POC Stephanie DiVito, ANG-E2; 609-485-7152

Outputs/Outcomes

- Improved icing weather 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 2025 Planned Research

- Conduct flight campaign to collect data for TAIWIN capability validation/verification efforts
- Define next steps for operational transition activities

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$1.6M	$1.6M	*$1.5M

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

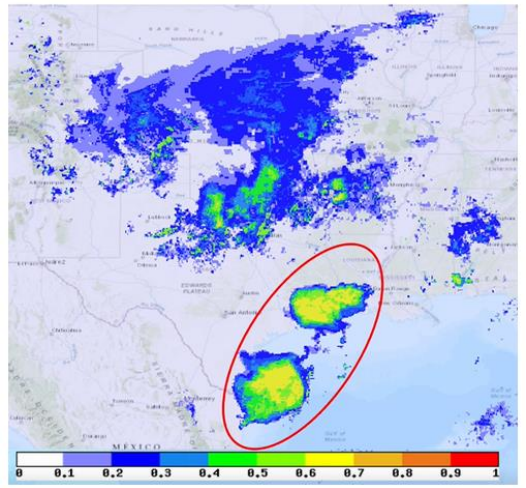
High Ice Water Content (HIWC)

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 2025 Planned Research

- Given an operational pathway for ALPHA has been identified, perform efforts to deploy ALPHA as an operational HIWC weather avoidance tool

Out Year Funding Requirements

	FY23	FY24	FY25
RE&D	$700K	$500K	*$500K

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

Unmanned Aircraft System Weather (UAS Wx)

Research Requirements

- Assess & improve wx observation & forecast needs for UAS operations
- Boundary layer (just above the Earth's surface)
- Urban Environment
- New & refined weather information; observation & forecast, & decision support products 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
- POC Pat Murphy, ANG-C61; 202-267-2788

Outputs/Outcomes

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

FY 2025 Planned Research

- Urban/Suburban Microscale Modeling for UAS & UAM Applications
- 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

RE&D

FY23	FY24	FY25
$ 250K	$ 500K	$ 500K

Weather Observations (Wx Obs)

Research Requirements

- Conduct & transition research that enhances or increases weather 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
- POC Victor Passetti, ANG-C63; 609-485-6260

Outputs/Outcomes

- Affirmation of automated weather detection capabilities synchronized to new or emerging weather 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 weather observing platforms

FY 2025 Planned Research

- Continue assessment of various LWE measurements during mixed-phase precipitation to determine which can be used to develop more robust determinations of LWE
- Continue to explore automation of ground truth techniques to evaluate sensor capabilities to better distinguish obstructions to visibility such as fog and/or mist from moderate to heavy precipitation events
- Continue to explore the sensitivity of measuring false accretions during “wet” snow events to develop a method for determining wet snow conditions utilizing the existing ASOS sensors (This is a potential shortfall in observations for UAS)
- Facilitate pre-concept demonstration activities for dual AWOS & ASOS baselines, such as tailored mission analysis & shortfall analysis

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 600K	$ 500K	$550K

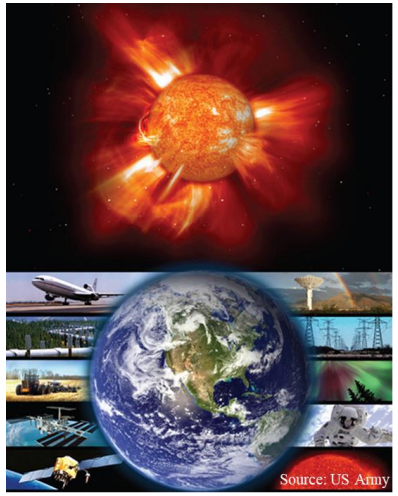
Space Weather Aviation (SWxA)

Research Requirements

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

Outputs/Outcomes

- Dosimeters on commercial, private, & governmental aircraft collecting in-flight data readily available to researchers to conduct forecast model validation
- Operational satellite mission supporting space weather forecasting for aviation needs
- Increased lead-times for preflight planning & enroute diversions to save fuel, time, & limit radiation dosages to passengers & avionics
- Developed platform for citizen engagement/input allowing input for single-point radiation exposure & communication issues



FY 2025 Planned Research

- Ensure the collection of space weather observations & measurements for enhanced forecasting support to provide increased accuracy & lead times making the NAS safer & more efficient.
- Utilize Citizen Science (scientific research with public participation) to further develop & validate space weather aviation-based models

Out Year Funding Requirements

	FY23	FY24	FY25
RE&D	$500K	$400K	$500K

Volcanic Ash Detection (VAD)

Research Requirements

- Develop capability/technology to detect concentration of Volcanic Ash particles 60nm using an airborne radar
- Sponsored by AFS-200
- POC Karen Shelton-Mur, ANG-C64, 202-267-7985

Outputs/Outcomes

- Demonstration of detection of Volcanic Ash using a modified aircraft radar algorithm

FY 2025 Planned Research

- Software development & testing of radar algorithm approaches for detection of VA
- Wind tunnel testing of modified radar algorithm using aircraft radar & instrumentation

Out Year Funding Requirements

RE&D

FY23	FY24	FY25
$ 150K	$300K	$500K

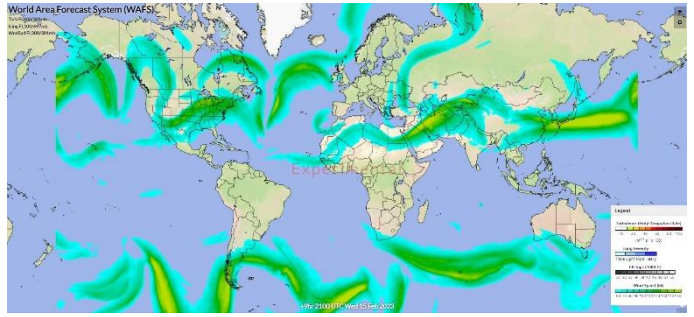
Wind Detection & Forecast (WDF)

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
- POC Pat Murphy, ANG-C61; 202-267-2788

Outputs/Outcomes

- Conduct initial sensor study to assess the benefits & impacts of including LIDAR sensed wind observations



- Investigate the performance benefit of including LIDAR data into Numerical Models

FY 2025 Planned Research

- Use a temporarily deployed LIDAR to evaluate optimal sensor siting locations around an airport
- Develop concepts to increase range of current LIDAR sensors
- 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

Out Year Funding Requirements

	FY23	FY24	FY25
RE&D	$ 0	$ 0	$ 500K