REDAC / NAS Ops

Review of FY 2021 Proposed Portfolio

Weather Program

BLI Number: A11.j

Randy Bass, ANG-C6

September 5, 2018

Weather Program
A11.j

What are the benefits to the FAA

- Enhanced 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 GA safety via improved accuracy and accessibility of observed and forecast weather information

What determines program success

- Transition of research capabilities into evolving ATM decision support tools
- Research capabilities align with NSIP and NextGen emerging solution sets
- Incorporation by NWS of research capabilities to improve delivery of FAA required services
- Incorporation by NWS of research capabilities into weather information that is enhancing GA safety

Weather Program / A11.j Overview Capabilities

People:

- Program Manager and 6 Project Leads/Subject Matter Experts

Laboratories:

- NOAA ESRL – Numerical Modeling, Quality Assessment, TAIWIN
- NOAA NSSL – Wx Radar Techniques, TAIWIN
- NOAA NCEP – Numerical Modeling, Ceiling & Visibility
- NWS MDL – Ceiling & Visibility
- NCAR – In-flight Icing, Turbulence, Convective Storms, Ceiling & Visibility, TAIWIN, HIWC
- MIT/LL – Convective Storms, Ceiling & Visibility
- FAA Tech Center – AWDE
- Volpe NTSC – Weather Requirements for Wake Mitigation
- NRC - TAIWIN
- ECCC – TAIWIN, HIWC
- Diakon - TAIWIN
- NASA Armstrong, Glenn, & Langley – HIWC
- Australian BoM - HIWC

Weather Program – Accomplishments FY18

- **Convective Weather:** Integration of Geostationary Orbiting Environmental Satellite (GOES)-16 satellite data into the Offshore Precipitation Capability (OPC); Collaboration with Air Force Weather on developing a global version of OPC, as well as a 0-12 hour Offshore Forecast Capability; Delivery of Blending code to AJM that smooths the transition between CIWS and CoSPA forecasts in the NextGen Weather Processor, also improves convective initiation forecasts in the model
- **Turbulence:** Graphical Turbulence Guidance (GTG) Nowcast (rapidly updated [every 15 minutes], valid for the next 15 minutes) short term turbulence forecast: Running in real-time at the National Center for Atmospheric Research and undergoing user evaluations in Delta Air Lines flight operations and on the National Weather Service Aviation Weather Center (NWS/AWC) test bed. Transition of adapted Graphical Turbulence Guidance – Global (GTG-G) code accommodating model upgrades to the NWS
- **Ceiling and Visibility (C&V):** Real Time Mesoscale Analysis – Rapid Update (RTMA-RU), with 15 minute updates implemented into operations; Revised LAMP with 15 minute update of C&V three hour forecasts implemented into operations; Integrated satellite cloud-mask data into the Ceiling and Visibility Analysis for Alaska (CVA-AK) prototype
- **In-flight Icing:** Transferred code for Icing Product Alaska diagnosis (IPA-D) to experimental use at Aviation Weather Center (AWC) and Alaska Aviation Weather Unit (AAWU); Adapted new GOES data into the Current Icing Product (CIP)

Weather Program – Accomplishments FY18 (cont'd)

- **Advanced Weather Radar Techniques (AWRT):** Belize radar system added to the MRMS Caribbean radar domain; Implemented data from 15 TDWRs into MRMS developmental system; developed QC protocol for the TDWRs
- **Modeling Development and Enhancement (MDE):** Northern Hemisphere Rapid Refresh (RAP v4) implemented into operations by NWS; CONUS and Alaska versions of the High Resolution Rapid Refresh (HRRR v3) implemented into operations by NWS
- **Quality Assessment (QA):** Initial assessment of Ensemble Prediction of Oceanic Convective Hazards (EPOCH); CVA assessment; core research on ensemble techniques, probabilistic forecasts, convectively induced turbulence techniques, and new satellite data
- **Aviation Weather Demonstration and Evaluation (AWDE) Services:** Probabilistic C&V User Assessment; IPA User Evaluation; Participated in the NOAA AWC Testbed Winter Experiment; Conduct turbulence nowcast forecast group; Conduct HEMS user evaluation
- **Terminal Aviation Icing Weather Information for Nextgen (TAIWIN):** Completed the Freezing Precipitation Algorithm for research use with the Automated Surface Observation System (ASOS); Completed frozen and freezing precipitation spatial variability studies; Completed initial preparation for ICICLE flight campaign
- **High Ice Water Content (HIWC):** Prepared and conducted HIWC Airborne Weather Radar II flight campaign; Commenced HIWC Nowcasting Trial between FAA, NCAR, and Australian BoM using the Algorithm for the Prediction of HIWC Areas (ALPHA)

Anticipated Research in FY19 and FY20

Planned Research Activities

- **Convective Weather:** Complete independent Quality Assessment on global EPOCH output; Improve regional calibrations of weather forecasts in EPOCH; Integrate GOES-17 data, including the Geostationary Lightning Mapper data, into OPC; Conduct feasibility study for using OPC to fill in weather radar gaps over the Rockies; Develop new and improved Convective Weather Avoidance Model (CWAM) that uses machine learning
- **Turbulence:** Complete GTG High resolution (HRRR-based) development; Transition GTG Nowcast (15 min update rate) to NWS for implementation
- **Ceiling & Visibility:** Development of prototype RTMA-3D; Integrate camera visibility data into CVA-AK; RTMA-3D transition to operations
- **QA:** Plan, coordinate, and conduct scientific meteorological assessments of enhancements to aviation weather hazard forecast capabilities for CONUS and AK; Conduct scientific meteorological assessments of enhancements to oceanic convection forecasts, C&V forecasts, and high-resolution turbulence forecasts for CONUS

Anticipated Research in FY19 and FY20 (cont'd)

Planned Research Activities

- **AWDE:** Conduct an assessment to determine the suitability and usability of the CIWS/CoSPA blended model; Conduct research to determine how Ensemble Forecasts are used, how to visually display the forecasts, and information requirements needed from Ensemble Forecasts; Participate in the AWC winter and summer experiments; Conduct assessments of diagnosis and forecasting products including ceiling and visibility analysis and graphical guidance
- **UAS Wx:** Collaborate with FAA UAS community to develop strategy for weather research to meet operational needs
- **Terminal Aviation Icing Weather Information for Nextgen (TAIWIN):** Capability that identifies and distinguishes between App C and App O icing conditions in the terminal area; Complete final preparation for and conduct ICICLE flight campaign; Process aircraft and ground sensor data for use in analyses; Conduct analysis of ICICLE case study events and initial flight test results to begin to quantify the ability to diagnose and forecast the detection/ discrimination of freezing drizzle from freezing rain aloft; Use available results from analysis of ICICLE flight campaign data to begin improving model microphysics and icing weather tools with emphasis on supercooled large drops

Anticipated Research in FY19 and FY20 (cont'd)

Planned Research Activities

- **High Ice Water Content (HIWC):** Conduct analyses of flight test results to determine ability of modified airborne weather radar to identify hazardous HIWC conditions; Complete HIWC Nowcasting Trial between FAA, NCAR, and Australian BoM using ALPHA; Evaluate ALPHA with results from HIWC Radar II campaign and initial results from HIWC Nowcasting Trial. Coordinate and plan additional flight research focusing on continental engine ice crystal icing; Complete formal study for HIWC Nowcasting Trial between FAA, NCAR, and Australian BoM using ALPHA

Anticipated Research in FY19 and FY20

Expected Research Products

- **Convective Weather:** EPOCH forecast capability with higher Probability of Detection and lower False Alarm Rate; Enhanced CWAM tool for incorporation into NWP
- **Turbulence:** High Resolution GTG; High Resolution GTG Nowcast
- **Ceiling & Visibility:** Enhanced C&V information in the HEMS tool
- **Terminal Aviation Icing Weather Information for Nextgen (TAIWIN):** Demonstrate a TAIWIN capability that identifies and distinguishes between App C and App O icing conditions in the terminal area; Report on ICICLE campaign
- **High Ice Water Content (HIWC):** Report on flight test campaign, including analysis of results; ALPHA product ready for operational testing

Emerging FY21 Focal Areas

- **Convective Weather:** Transition of OPC and EPOCH to NWS; Transition of CWAM to NWP; High resolution, nowcasts (0-2 hour) of convection for UAS and Commercial Space
- **Turbulence:** Adapt GTGN to the High Resolution Rapid Refresh model; Ensemble-based/probabilistic GTG
- **Ceiling & Visibility:** RTMA-3D prototype for Alaska; Improvements to gridded C&V analysis
- **QA:** Investigation of new techniques and data sources; GTG ensemble & probabilistic assessment
- **AWDE:** Assessments of diagnosis and forecasting products, including ceiling and visibility analysis and graphical guidance; Advance the AWDE Concept and Product Capability for the integration, evaluation and demonstration of future NextGen weather concepts and technologies.
- **Terminal Aviation Icing Weather Information for Nextgen (TAIWIN):** Assess and validate meteorological data from NWP models, weather radars, and other data sources with ICICLE research flight data collected for TAIWIN capability
- **High Ice Water Content (HIWC):** Flight test campaign close to industrial area, where “non-pristine” environments exist, containing a larger variety and concentration of aerosols

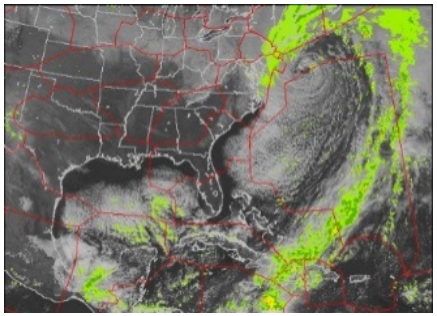
Convective Weather

Research Requirement

- Improve observations and forecasts of convective weather and create and improve standards and techniques for weather DSTs to mitigate impacts on and improve efficiency of the NAS
- Improve accuracy over legacy systems; higher spatial and temporal resolution; well-defined probabilistic and gridded information; guidelines and strategies for developing products and DSTs that meet users' requirements and are applicable to their needs
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Randy Bass, ANG-C61, 202-267-2800

Outputs/Outcomes

- OPC: Blend lightning data, satellite imagery and weather model data to produce an estimate of precipitation for areas that lack radar coverage, merged with existing radar mosaic to provide controllers with better situational awareness for offshore sectors
- CWAM: Redesign of the model to incorporate machine learning techniques and optimize use in strategic time frames (2-8 hour forecasts)



- EPOCH: Probabilistic convection guidance with lead times from 0 to 36 hours used for current operations and strategic planning of transoceanic flights

FY 2021 Planned Research

- Complete transition of the Offshore Precipitation Capability (OPC) to National Weather Service (NWS) and/or into NWP WP2
- Complete transition of new Convective Weather Avoidance Model (CWAM) to AJM for integration into NWP
- Complete transition of the EPOCH algorithm to operations at the NOAA/Environmental Modeling Center (EMC) for use by the Washington World Area Forecast Center

Out Year Funding Requirements

FY18	FY19
$1.2M	$1.2M

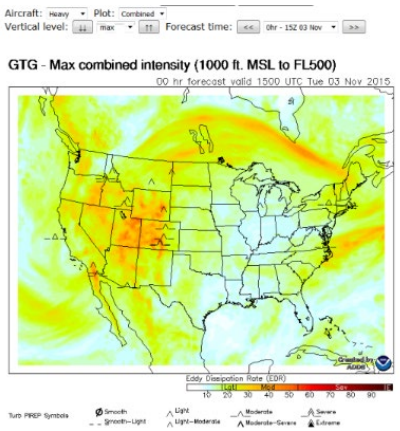
Turbulence

Research Requirement

- Improve turbulence observation and forecasting capabilities throughout the NAS to accurately identify & predict time, locations, & intensity of turbulence; improving safety, capacity, and efficiency in the NAS
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Tammy Flowe, ANG-C61, 202-267-2796

Outputs/Outcomes

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



FY 2021 Planned Research

- Graphical Turbulence Guidance (GTG) ensembles/probabilistic development commences
- Graphical Turbulence Nowcast 2 (GTGN-2) high-resolution (HRRR-based) development commences

Out Year Funding Requirements

FY18	FY19
$1M	$1M

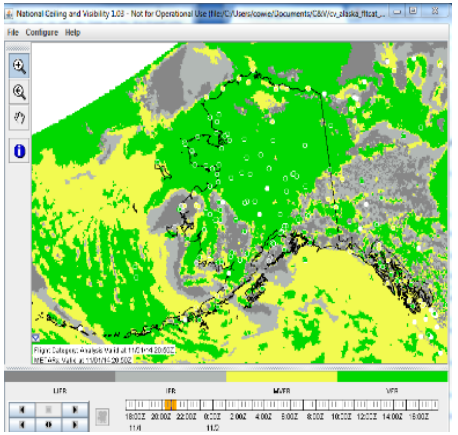
Ceiling and Visibility (C&V)

Research Requirement

- Improve C&V prediction models with the goal of reducing GA accidents / incidents and improving airport efficiency
- Applications for improved C&V predictions include support for current and future TAF production; production of automated TAFs in areas where no TAF exists; improvements to the accuracy & resolution of AIRMETs; improvements to forecasts in TRACON areas; updates to the C&V analysis of Helicopter Emergency Medical Services (HEMS) tool
- Done in collaboration with NWS to improve products and services the FAA requires
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Jenny Colavito, ANG-C61, 202-267-2787

Outputs/Outcomes

- Improvements to C&V information in HEMS tool and in Alaska via the RTMA and LAMP
- All C&V products generated by common weather information
- Supports enhanced GA safety & ATM based DSTs, dispatchers, and pilots resulting in improved safety



FY 2021 Planned Research

- RTMA-3D prototype for Alaska
- Improvements to gridded C&V analysis

Out Year Funding Requirements

FY18	FY19
$1M	$800K

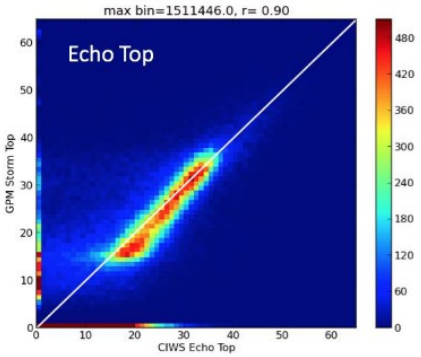
Quality Assessment (QA)

Research Requirement

- 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, AJV, AJR, AJM
- POC Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

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



FY 2021 Planned Research

- Conduct quality assessments of weather research products for Alaska ceiling and visibility using camera images, high resolution turbulence, and high resolution inflight icing

Out Year Funding Requirements

FY18	FY19
$1.3M	$912K

Aviation Weather Demonstration & Evaluation (AWDE) Services

Research Requirement

- NextGen Implementation Plan (Reduce Weather Impact & Validating Concepts) states human factors, human-in-the-loop testing and demonstrations are essential tools for validating NextGen concepts.
- Demonstration and evaluation services are required to assess weather research maturity and concept readiness for transition.
- Sponsored by ANG-C6, ANG-C7 AJV, AJR, AJM
- POC Sonia Alvidrez, ANG-C63; 609-485-7613

Outputs/Outcomes

- Enhanced demonstration and evaluation services with subject matter expertise, improved data resources including live aircraft situation data, and 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 2021 Planned Research

- Conduct assessments of diagnosis and forecasting products. Including:
  - Turbulence Forecast and Graphical Guidance
  - Ceiling and Visibility Analysis and Graphical Guidance
  - Convective Weather Forecast Statements & Graphical Guidance
  - In-flight Icing Diagnosis

Out Year Funding Requirements

FY18	FY19
$500K	$500K

UAS Weather

Research Requirement

- There are gaps between current weather capabilities and weather information needed for safe and efficient airspace management of UAS operations.
- The goals of the UAS Weather (UAS Wx) project are to further research identified gaps and explore the potential enhancement of current weather capabilities or development of new capabilities to close those gaps.
- Sponsored by ANG-C6, ANG-C7 AJV, AJR, AJM
- POC: Lyndsay Digneo, ANG-C63, 609-485-6250

Outputs/Outcomes

- Improving weather information required for safe and efficient UAS operations and integration into the NAS

FY 2021 Planned Research

- Continue collaboration with FAA UAS organizations
- Include UAS weather needs in ongoing research

Out Year Funding Requirements

FY18	FY19
-	$200K

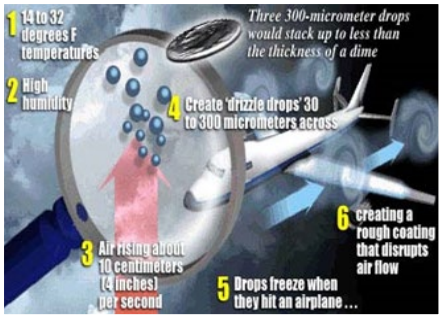
Terminal Area Icing Wx Information for NextGen (TAIWIN)

Research Requirement

- Responds to operational needs - new SLD Rule 25.1420 and NextGen *Reduce Weather Impact* capacity and 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 and improved weather diagnostic/forecast tools
- Sponsored by: ANE-100, ANM-100
- POC Stephanie DiVito, ANG-E2; 609-485-7152

Outputs/Outcomes

- Improved icing weather information including SLD in terminal area
- Maintain/improve efficiency and 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



Freezing drizzle ice accretion process

FY 2021 Planned Research

- Continue to conduct analysis of flight test results to quantify the ability to diagnose and forecast the detection/ discrimination of freezing drizzle from freezing rain aloft.
- Use available results from ICICLE flight campaign data analyses to continue improving model microphysics and icing weather tools with emphasis on supercooled large drops.

Out Year Funding Requirements

FY18	FY19
$1.5M	$1.15M

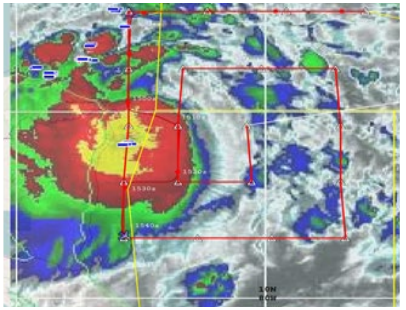
Mitigating the Ice Crystal Wx Threat to Aircraft Turbine Engines (HIWC)

Research Requirement

- NTSB: A-96-54, -56, & -58
- Characterization of High Ice Water Content (HIWC) ice crystal environments that can be a threat to turbine engines
- Diagnosis and forecasting of HIWC ice crystal environments
- Sponsored by AFS-200
- POC Jim Riley, ANG-E2; 609-485-4144

Outputs/Outcomes

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



Flight path for collection of HIWC ice crystal data

FY 2021 Planned Research

- Preparation for additional flight research focusing on continental engine ice crystal icing (ICI) if data requested by the Ice Crystal Icing Working Group (ICIWG).

Out Year Funding Requirements

FY18	FY19
$1.4M	$600K

Acronyms

- AAWU – Alaska Aviation Weather Unit
- Airmet - Airmen's Meteorological Information
- AK - Alaska
- ATM – Air Traffic Management
- BOM – Australian Bureau of Meteorology
- CIP – Current Icing Product
- CWAM - Convective Weather Avoidance Model
- DSTs – Decision Support Tools
- ECCC – Environmental and Climate Change Canada
- EPOCH - Ensemble Prediction of Oceanic Convective Hazard
- FLs – Flight Levels
- GA – General Aviation
- GTG – Graphical Turbulence Guidance
- GOES – Geostationary Operational Environmental Satellite
- HEMS - Helicopter Emergency Medical Services
- HIWC - High Ice Water Content
- HRRR - High Resolution Rapid Refresh
- ICICLE - In-Cloud Icing and Large-Drop Experiment
- MDL – Meteorological Development Laboratory
- MRMS - Multi-Radar, Multi-Sensor
- NAS - National Airspace System
- NRC – National Research Council of Canada
- NSIP - NextGen Segment Implementation Plan
- NTSC – National Transportation Systems Center
- NWP - Numerical Weather Prediction
- NWS - National Weather Service
- OPC – Offshore Precipitation Capability
- RTMA - Real-Time Mesoscale Analysis
- RU – Rapid Update
- SLD – Supercooled Large Droplet
- TAF - Terminal Area Forecast
- TAIWIN - Terminal Area Icing Wx Information for NextGen
- TDWR – Terminal Doppler Weather Radar
- TRACON - Terminal Radar Approach Control
- UAS – Unmanned Aircraft Systems
- Wx - Weather

Backup Slides

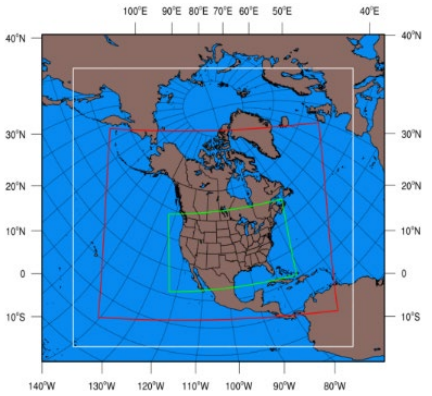
Model Development and Enhancement

Research Requirement

- Weather prediction models are the basis for all aviation weather hazard forecasts beyond 2 hours. Improve operationally available numerical weather prediction model resolution and refresh rates to enhance forecasts of aviation weather hazards including inflight icing, turbulence, convective weather, and ceiling and visibility will require model enhancements.
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

- 0-36 hour high resolution rapid refresh to include oceanic airspace to support aviation forecast products
- Global model with hourly output compatible with suite of NOAA models
- Enhanced NAS safety and capacity/efficiency from improved forecasts of aviation specific weather hazards



FY 2021 Planned Research

- Transition enhanced High Resolution Rapid Refresh (HRRR) version 4 to NWS for implementation.
- Conduct research towards hourly updated global forecasts to supplant current, regional, hourly-updated models.

Out Year Funding Requirements

FY18	FY19
$1.2M	$1.2M

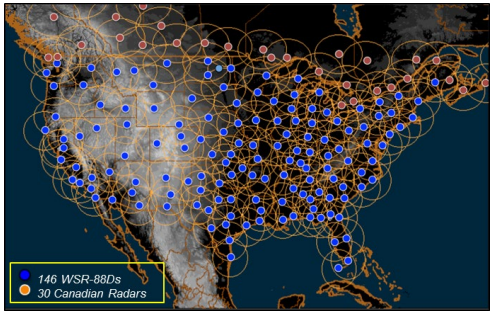
Advanced Weather Radar Techniques

Research Requirement

- Develop aviation weather applications focused on advanced radar technologies for insertion into the Multi-Radar Multi-Sensor (MRMS) system to mitigate the impact of weather on the NAS
- Improve and increase the MRMS system's detection and forecast of aviation-impacting weather conditions, and enhance the delivery of aviation weather services by the NWS
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Randy Bass, ANG-C61, 202-267-2800

Outputs/Outcomes

- Domain Expansion: Incorporate data from international radars, including those in and around the Caribbean, Gulf of Mexico and Pacific basin
- Time Stamp Mosaic: Develop capability to for users to determine data age of any pixel in a radar composite



- Improved detection and forecasting for hazardous aviation weather including turbulence, icing, and convection
- MRMS capability functions as a validation tool for high-res forecasts and DSTs

FY 2021 Planned Research

- Expand MRMS domain to include radar networks in Japan, Korea and the Philippines
- Implement/leverage turbulence and icing algorithms in MRMS for improved detection and analysis of intensities

Out Year Funding Requirements

FY18	FY19
$380K	$380K

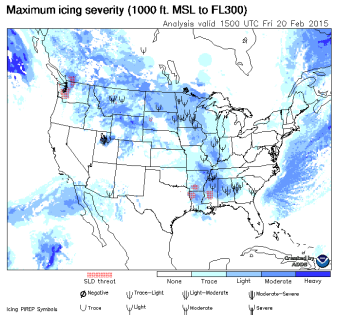
In-Flight Icing

Research Requirement

- Improve operationally-available, high-resolution, accurate diagnoses and forecasts of aircraft icing conditions that can be used by aviation users to make decisions on icing threat areas, optimum routings, and areas to avoid in compliance with recently updated regulations and aircraft certification envelopes.
- Sponsored by ANG-C6, ANG-C7, AJV, AJR, AJM
- POC: Danny Sims, ANG-C61, 202-267-2785

Outputs/Outcomes

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



In-Flight Icing Severity 1000 ft MSL – FL300

FY 2021 Planned Research

- Transition to National Weather Service CONUS and Alaska high resolution in-flight icing diagnosis and forecast capability to explicitly predict conditions associated with certification envelopes.

Out Year Funding Requirements

FY18	FY19
$900K	$900K

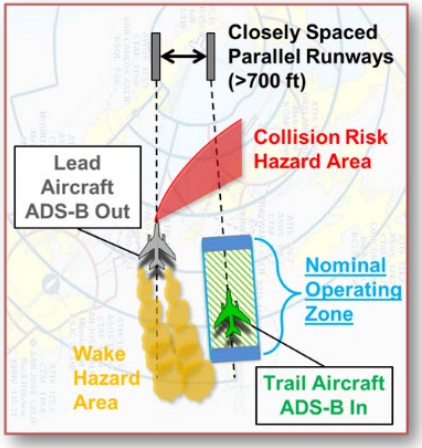
Weather Requirements for Wake Mitigation

Research Requirement

- Applications include development of the requirements for an encounter probability model to test operational concepts of wake solutions and the development of wake vortex prediction model for real-time use of establishing wake vortex separations.
- This application will incorporate weather information with its associated measurability and predictability, calculate statistical prediction bounds on the transport and decay of aircraft wake.
- Sponsored by ANG-C2, AFS
- POC: Jillian Cheng, ANG-C22, 202-267-9157

Outputs/Outcomes

- Computer modeling for Encounter Probability Model
- Development of an airport wind and weather-based wake vortex separation advisory system
- Information/Analyses to develop procedures and systems to improve NAS safety and efficiency



FY 2021 Planned Research

- Integrate wake turbulence data with higher resolution weather data to further explore wake mitigation potentials

Out Year Funding Requirements

FY18	FY19
$300K	$500K