UAS Certification – Regulatory and Operational WX Challenges for BVLOS

Presented to the UAS WX Forum
at AUVSI XPONENTIAL 2020

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Federal Aviation Administration

Policy and Innovation – Aircraft Certification

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Topics

- Rain, Snow and Icing Hazards
- UAS Type Certification Process
- Operational WX Challenges

- Rain, Snow and Icing Hazards

Unmanned Aircraft Systems – the rain hazard

- Water Ingress
  - Loss of control event in rain investigated by Air Accidents Investigation Branch (AAIB) Bulletin 1/2020, January 9, 2020, available at http://www.aaib.gov.uk
  - Service history of events including light drizzle
  - IP (International Protection or Ingress Protection) rating defined in International Electrotechnical Commission (IEC) standard 60529 is insufficient

Unmanned Aircraft Systems – the rain hazard

- Aerodynamic
  - Low Reynolds Number
- Rain Erosion
  - Helical Tip Mach Number on sUAS can be same as on airplane propeller
- Effect on Essential Systems
  - Cameras and LiDAR don't work well with obscurants in air
  - Precipitation static (p-static) effect on communication systems?

Unmanned Aircraft Systems – the snow hazard

- Snow effects on slow moving aircraft
  - Airships
  - sUAS

Snow encounter, 10 minutes, -2C to 0C
Credit: Meteomatics

Unmanned Aircraft Systems – the snow hazard

- Limitations of Automated Surface Observation
  - Inability of to report freezing drizzle
  - Inability to report freezing precipitation when falling snow is reported
  - DOT/FAA/TC-15/39 “Current Capabilities for Icing Nowcasting and Forecasting in the Terminal Area”
  - Case study in Appendix 1 of Advisory Circular 91-74A

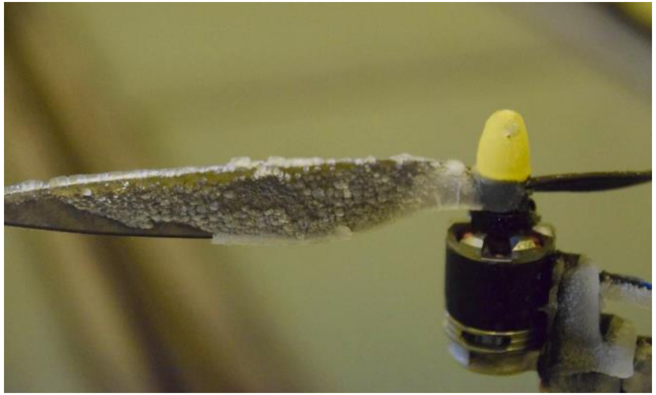
Unmanned Aircraft Systems – the icing hazard

- Icing occurs at low altitude

Unmanned Aircraft Systems – the icing hazard

- Military experience
- Icing tunnel tests (credit: Meteomatics)

-2°C OAT



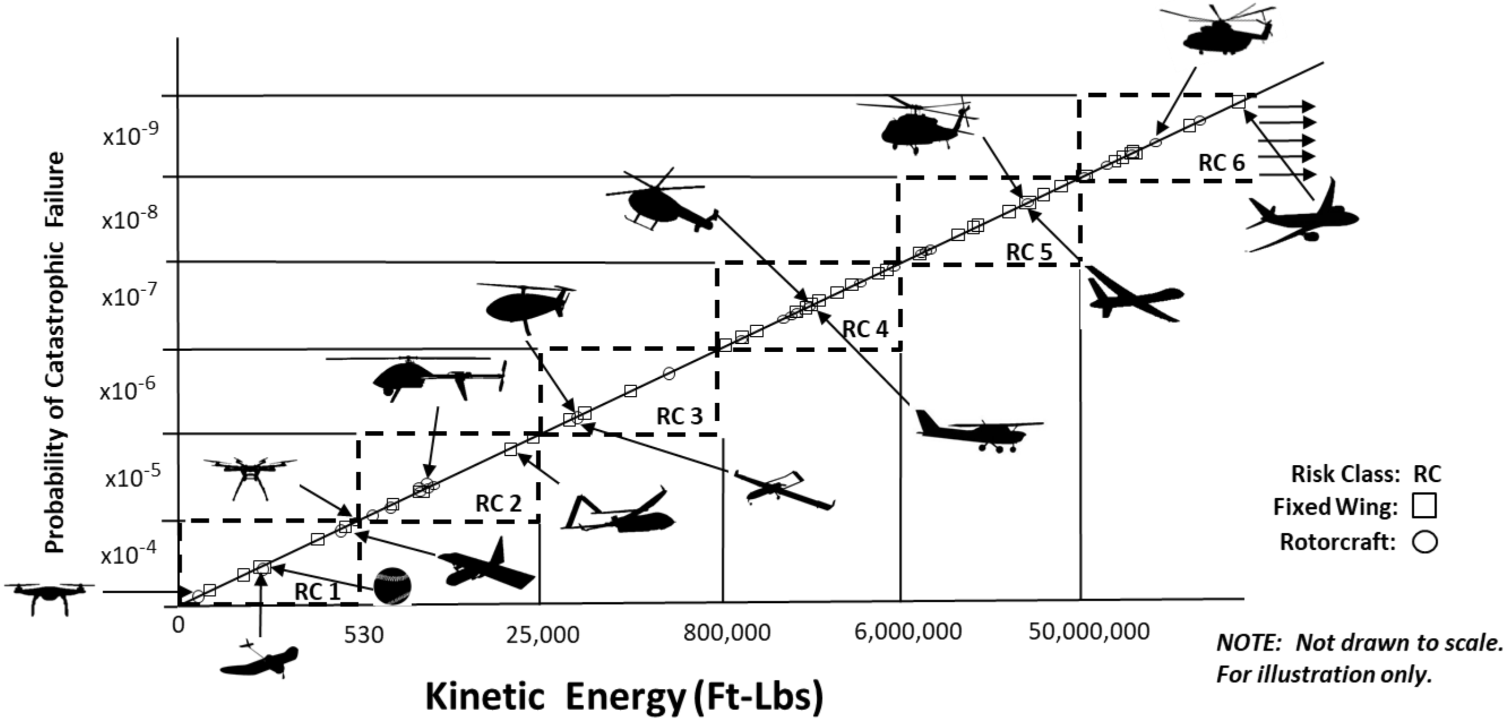
-5°C OAT

- UAS Type Certification Process

Unmanned Aircraft Systems Rulemaking

- MOSAIC (Modernization of Special Airworthiness Certification)
- SUITE (Streamlined UAS Integration Type Certification Enaction)
  - Target goal of TC issuance within 90 days of application
  - Limited to:
    - no icing
    - Class 1-2 and possible population density limitations
    - <400 ft. AGL
    - electric only

Risk Classification for UAS



Proposed Certification Basis for Low Risk UAS

UAS.130 Adverse Weather Conditions:

(a) For purposes of this section, adverse weather conditions means rain, snow, and icing.

(b) Except as provided in paragraph (c) of this section, the UAS must have design characteristics that will allow the UAS to operate within the adverse weather conditions specified in the CONOPS without loss of flight or loss of control.

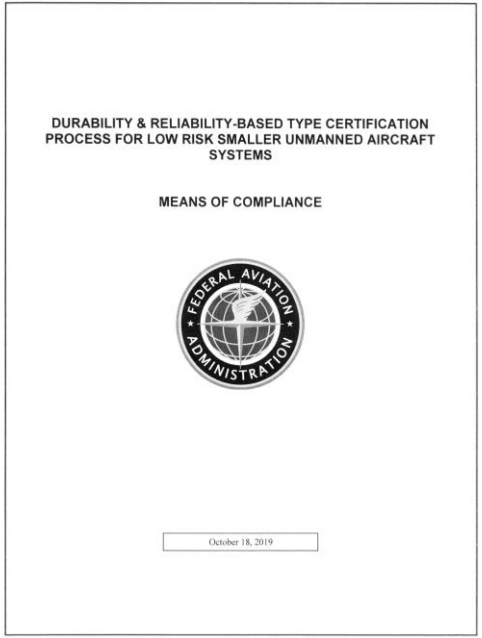
(c) For adverse weather conditions for which the UAS is not approved to operate, the applicant must develop operating limitations to prohibit flight into known adverse weather conditions and comply with one of the following:

(1) Develop operating limitations to prevent inadvertent flight into adverse weather conditions; or

(2) Provide a means to detect any adverse weather conditions for which the UAS is not certified to operate and show the UAS's ability to avoid or exit those conditions.

Means of Compliance for Low Risk UAS

- Means of Compliance
  - Design checklist (simple yes/no questions)
  - Endurance/Durability testing
    - Hours depend on ground risk, including whether design incorporates a flight termination system
  - Specific demonstration tests


DURABILITY & RELIABILITY-BASED TYPE CERTIFICATION PROCESS FOR LOW RISK SMALLER UNMANNED AIRCRAFT SYSTEMS

MEANS OF COMPLIANCE

FEDERAL AVIATION ADMINISTRATION

October 18, 2019

Proposed Means of Compliance for Low Risk UAS

APPENDIX B – ICING, SNOW AND RAIN MEANS OF COMPLIANCE

The standard D&R-based means of compliance in this document do not currently accommodate operation in any precipitation or potential icing conditions. If applicants seek certification in any of these adverse weather conditions, coordinate with the FAA ACO Branch and Standards Branch for acceptable means of compliance for approval to operate in icing, snow or rain.

Acceptable Means of Compliance

The UAS Flight Manual shall incorporate the following limitations:

Takeoff is prohibited with any frost, snow, or ice on any surface of the UAS, including rotors and propellers.

Operations, including takeoff and landing, are prohibited in:

- **Any precipitation (including drizzle, rain, snow, ice pellets); and**
- **Potential icing conditions (any moisture including clouds, precipitation, mist, fog, below an ambient temperature of +5°C)**

Proposed Means of Compliance for Low Risk UAS

- Draft MOC Issue Paper presented to applicants
  - Moderate Rain
    - Waterproofness test of DO-160G, Category R
    - Flight tests
  - Snow
    - Simulated or natural snow tests
  - UFM (UAS Flight Manual)
  - ICA (Instructions for Continued Airworthiness)

Proposed Certification Basis for Larger UAS

- Based on part 23, Amendment 23-64
  - Effective August 30, 2017
  - Replaced prescriptive design requirements with performance based airworthiness standards
    - Requirements moved to ASTM standards
    - ASTM F3120 “Standard Specification for Ice Protection for general Aviation Aircraft” is an acceptable MOC for part 23 airplanes
    - Supplemental MOCs
      - Ice detection
      - SLD detection
      - Flight tests maneuevers such as stall protection evaluation

Areas needing additional research or investment from the icing community

- Weather products
- Ice detection systems
- Ice protection systems
- Ice accretion on rotors – performance, vibration, shedding
- Development of codes for rotor blade ice accretion
- Validation of codes at low speeds

Questions?

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UAS Certification:
Regulatory and Operational Weather Challenges for BVLOS Operations

Presented to: UAS Weather Forum: AUVSI XPONENTIAL

By: Marilyn Pearson; FAA General Aviation and Commercial Division; marilyn.pearson@faa.gov

Date: October 5, 2020

Current UAS Requirements for Operations by CFR Part

- Certificate holders, parts 91, 107, 135, and 137 must use specific sources or facilities for obtaining weather reports and forecasts
  - Some weather sources are specified by regulation
  - Other weather sources approved at the discretion of the Administrator (EWINS)
- Required weather information includes:
  - Preflight planning
  - Departure
  - En route
  - Arrival

See and Avoid

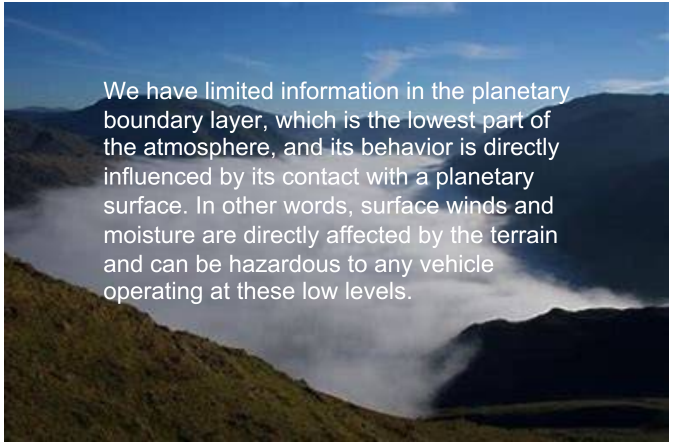
§ 91.113(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to **see and avoid other aircraft**. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

Will BVLOS operations deviate from current regulatory requirements?

BVLOS Operational Challenges

BVLOS operational needs for UAS vulnerable to meteorological conditions that legacy aircraft are not concerned with;

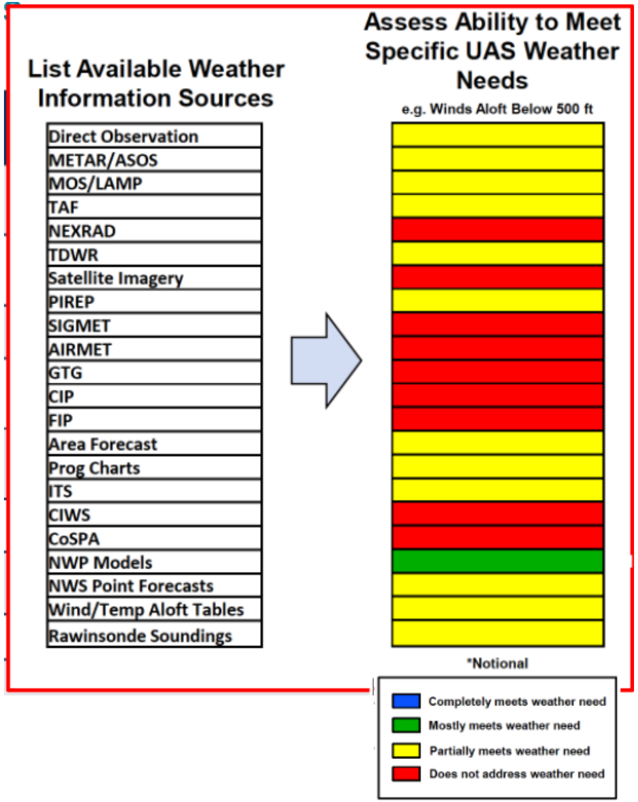
- **Surface to 400' AGL**, within small geographical areas not well served by any existing weather products;
- **Cityscapes and urban landscapes** have unique wind and turbulence around buildings;
- Proximity to oceans, mountains;
- Small UAS need the ability to depict current and forecast precipitation type and intensity, freezing precipitation - mist, drizzle, or rain,
- Winds, gusts, complex terrain and turbulence induced by man made obstructions;
- Locations of low visibilities and clouds in the 0-400' AGL layer;
- Location, direction of movement, and speed of movement of severe weather - thunderstorms, dust and sand storms and,
- Variable weather depending on time of day and season.



Identified Gaps

The research needs for characterizing the vulnerability of small unmanned aircraft to specific weather phenomenon in operating BVLOS:

- If tolerant of some kinds of meteorological phenomenon, is there a limit to how long the small unmanned aircraft can remain fully functional in those kinds of weather?
- If rain is tolerated, to what intensity and for how long?
- If icing conditions are tolerated, to what intensity and for how long?
- If winds are tolerated, to what velocity and what turbulence intensity is OK?

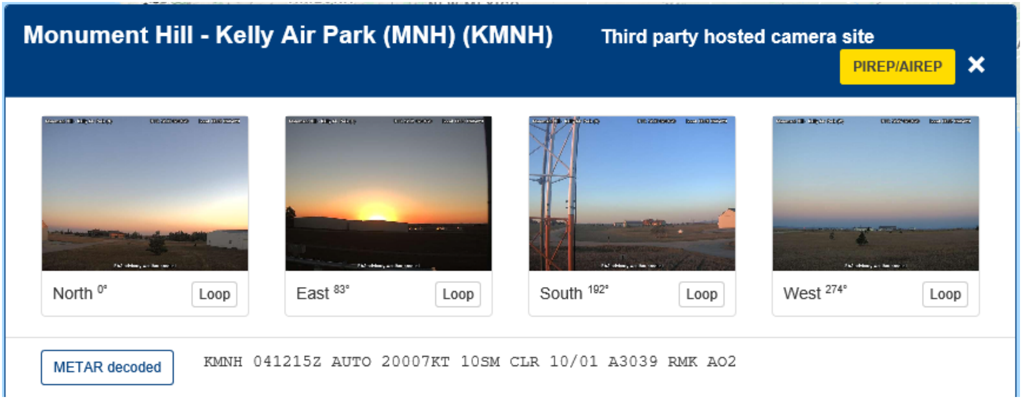


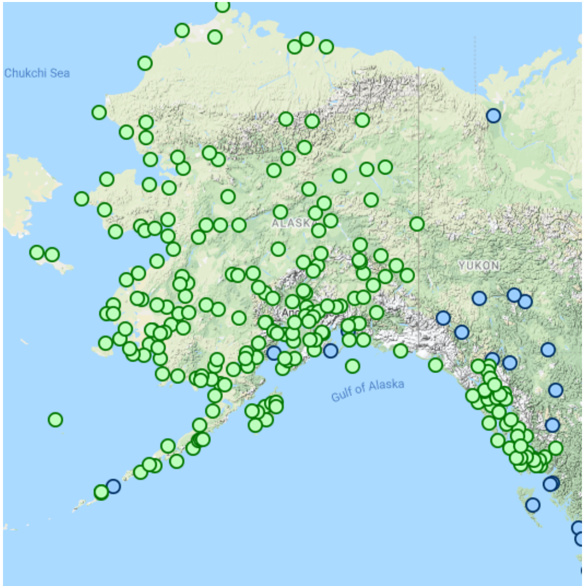
Operational Support for BVLOS

- Small UAS flight paths may be restricted to utility right of ways or railroad property. These flight paths may cross highways where existing weather information from **Road Weather Information Service (RWIS)** could provide operational support about icing conditions.
- RWIS are operated on the state level and currently exist in 40 states. These systems provide three types of road weather information: **atmospheric data, pavement data, and water level data**. Atmospheric data include air temperature and humidity, visibility distance, wind speed and direction, precipitation type and rate, cloud cover, tornado or waterspout occurrence, lightning, storm cell location and track, as well as air quality. It is possible that these system may provide data to assist UAS operators adhere to icing (and other WX limitations such as wind and rainfall rate) operating limitations. **The locations may also be used by package delivery operators.**
- **Weather radar** may be used to avoid areas of certain precipitation but there are limitations. Due to curvature of the earth, the minimum elevation coverage increases with distance from the radar. At a typical small UAS operating altitude of 400 ft. AGL, Next Generation Weather Radar (NEXRAD) may be used to detect rain. https://ops.fhwa.dot.gov/weather/index.asp

Current Resources

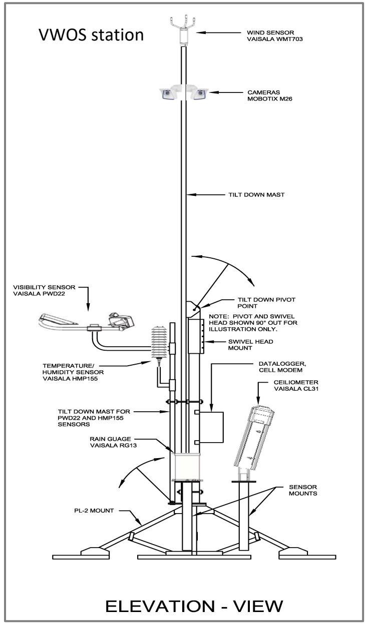
- **VWOS – Visual Weather Observation Systems**
- **FAA Weather Cameras – Currently in AK and CO, updated every 10 minutes, views from multiple angles**





New Resource Options

- Investigate accessibility of existing weather technology and data for UAS operators; **weather sensors for wind, precipitation, temperature,** etc.
- Evaluate use of airport observations and forecasts for local weather analysis
- Investigate **modification of existing products** to better address specific UAS operator concerns
- Road Weather Information Service (RWIS) could provide operational information about icing conditions. RWIS are operated on the state level and currently exist in 40 states.
- Mobile Global Reporting Format for Takeoff and Landing Performance Assessment (**GRF/TALPA**) uses RWIS technology to measure frost, ice, snow, slush on runways to provide a runway condition report that **may be adapted for UAS.**
- **National Digital Forecast Database (NDFD)** The National Digital Forecast Database (NDFD) is a suite of gridded forecasts of sensible weather elements (e.g., cloud cover, maximum temperature). NWS field offices working in collaboration with the National Centers for Environmental Prediction (NCEP) are combined in the NDFD to create a seamless mosaic of digital forecasts



BVLOS Operational Needs

- If adverse weather conditions (wind, rain, ice, snow) are not tolerated, **what weather products (observations, models, forecasts) are needed** to AVOID these conditions?
- We need to be able to provide weather product designers and providers, and the airborne sensor/instrumentation designers and certifiers with the concerns and needs associated with larger UAM and UAS that will operate in the traditional NAS.
  - These aircraft may not be so intolerant of conditions that small UAS must avoid, but are still **lacking sensory input and on board pilots who can visually interpret and judge the possible effects of phenomenon** ahead, or that are encountered in IMC. Appropriate sensors and different weather models may be needed, this is an area that may need more exploration to be able to articulate the needs of these aircraft and their operators.

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NCAR UCAR National Center for Atmospheric Research

NASA

ASTM INTERNATIONAL
Helping our world work better

Federal Aviation Administration

Operational Requirements for BVLOS

Waivers and/or Exemptions for BVLOS:

- CONOPS: Operator’s Concept of Operations, means of demonstrating safe operation in the NAS, mitigating risk:
  - Durability and Reliability
  - Means of compliance (MoC) with regulatory requirements
  - Means of avoiding inadvertent flight into adverse conditions
  - Means of detecting adverse conditions and avoiding/exiting

Aircraft Certification; if the aircraft is seeking type certification:

- Must demonstrate MoC for operations in weather; rain, snow, winds, temperature, etc.
- Flight testing to demonstrate ability to certify in specific weather conditions
- MOSAIC (Modernization of Special Airworthiness Certification)
- SUITE (Streamlined UAS Integration Type Certification Enaction)

Pilot Certification:

- Knowledge of weather, demonstrated through testing

Weather Challenges for BVLOS

- UAS operating in IMC below freezing will be operating in potential icing conditions. These aircraft will require either a **means to avoid actual icing conditions (supercooled water drops in cloud) and precipitation** at an ambient temperature below freezing, or a means to detect once in icing and show the capability to safely exit and continue flight to landing.
- Embry Riddle conducted a study, published in the April 2018 edition of the *International Journal of Aerospace Psychology,* on pilot knowledge of 23 types of weather information, from icing forecasts and turbulence reports to radar. **On average, 204 general aviation (GA) pilots were stumped by about 42 percent of the questions**. There is no reason to believe that these results would be better for the community of UAS pilots.
- **The icing weather knowledge gap also exists with small UAS manufacturers**. Most small UAS applicants for a FAA type certificate proposed that the UAS will be prohibited from flight in "known" icing, rather than potential icing as described in the previous section. These manufacturers are not aware of the definition of "known" icing. "Known" or "observed icing" includes ice accretion on the UAS itself. This requires a means of ice detection which have not been proposed in any small UAS design. It would also require the applicant to show the UAS can safely exit an inadvertent icing encounter.

Operational Tools

- Current weather products may support certain VMC operations not operating over people. Existing partnerships with industry and local governments should be utilized to evaluate these tools. **IMC operations and BVLOS operations over people will require the development of icing weather tools**.
- Some small UAS are equipped with a temperature sensor. If the temperature sensor is used to identify the potential for icing conditions, **the applicant would need to account for sensor accuracy when establishing an operating limitation.**
- Some small UAS are equipped with a humidity sensor. *Can this be used to avoid clouds?*
- Some UAS are equipped with cameras. It is not known if the capability to avoid clouds and precipitation have been demonstrated. It is also not known if the capability to detect icing in the time required to effect a safe exit has been demonstrated. **A demonstration would require all types of precipitation and night conditions if operations at night were approved**.
- METARs can provide surface temperature, cloud height, and the existence of precipitation with the exception of FZDZ at sites with no human augmentation. However, the acceptability of a **METAR observation depends on distance to the site, and topography of the UAS flight track**. For example, the UAS may operate in areas with local icing, such as orographic lifting, over bodies of water or downwind of bodies of water, and fronts.

Weather Products

- Other WX Government Products
- Other sources such as **CIP/FIP and AIRMETs/SIGMETs would not be usable for small UAS operations since they do not have the small resolution** needed or were not developed for low altitude flight. Additionally, these products infer icing aloft through several meteorological sources and do not actually detect icing. Limitations with the meteorological sources result in **missed occurrences of icing aloft. PIREPs would not be usable to avoid icing at low altitude for obvious reasons.**
- Commercial Products
- There are a number of commercial weather providers that target small UAS operators.
- https://www.uavforecast.com/#/
- https://droneweather.ch
- https://apkpure.com/uav-forecast-for-dji-quadcopter-uav-drone-pilots/com.uavforecast
- It is not known if these sources would be acceptable to observe icing operating limitations.

Weather Community of Interest

Purpose

- Resolve and/or mitigate mission-specific, information-sharing challenges
- Review problems, gaps, & shortfalls
- Increase information-sharing and best practices across FAA programs and organizations
- Leverage weather knowledge through forums to benefit stakeholders
- Foster collaboration within and across weather information users
- Identify and help resolve enterprise weather information issues
- Inform architecture and business practices within weather information domain

Questions?

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