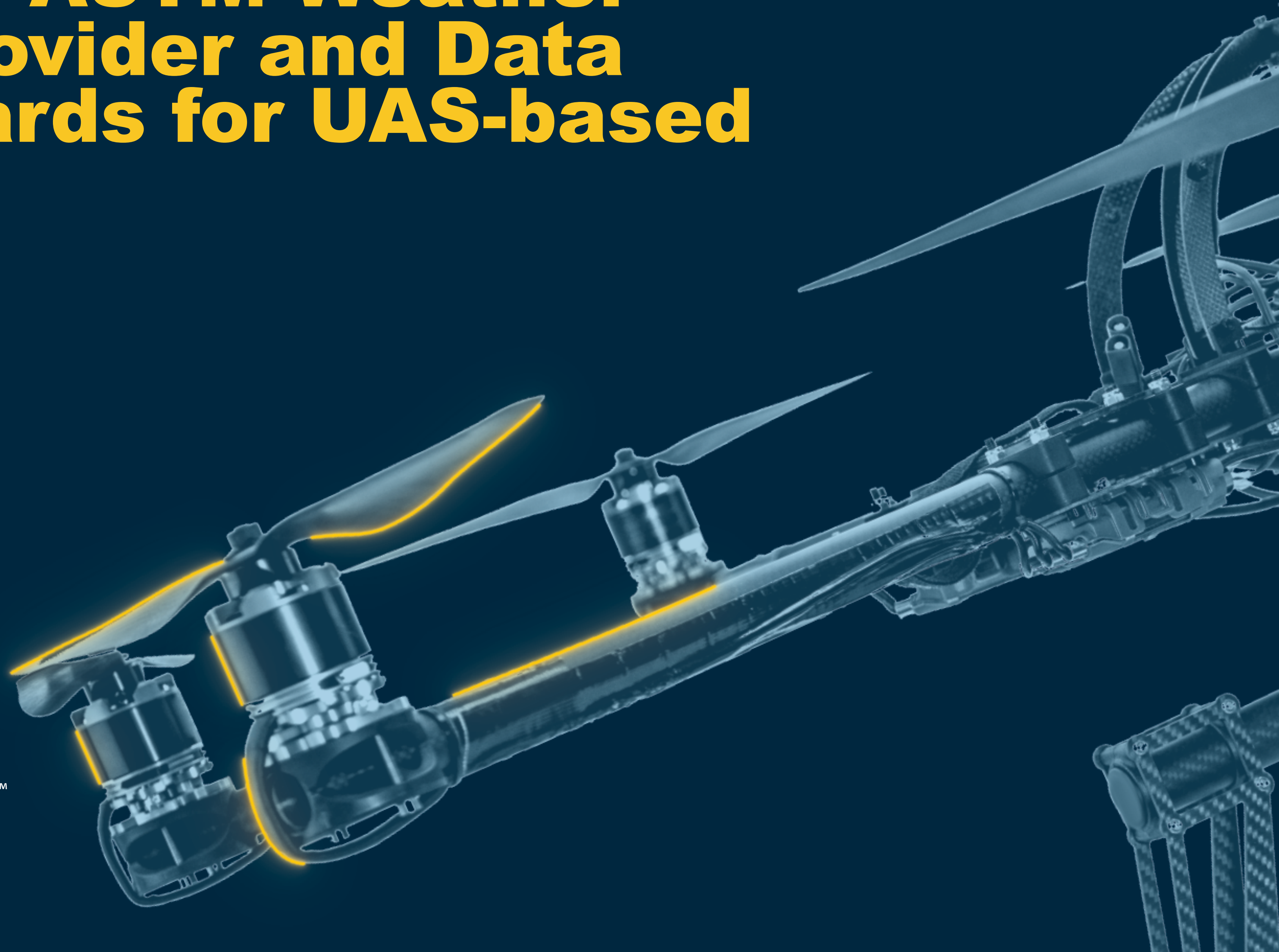
Introduction to ASTM Weather Information Provider and Data Sharing Standards for UAS-based Observations

Chris Zarzar, TruWeather Solutions



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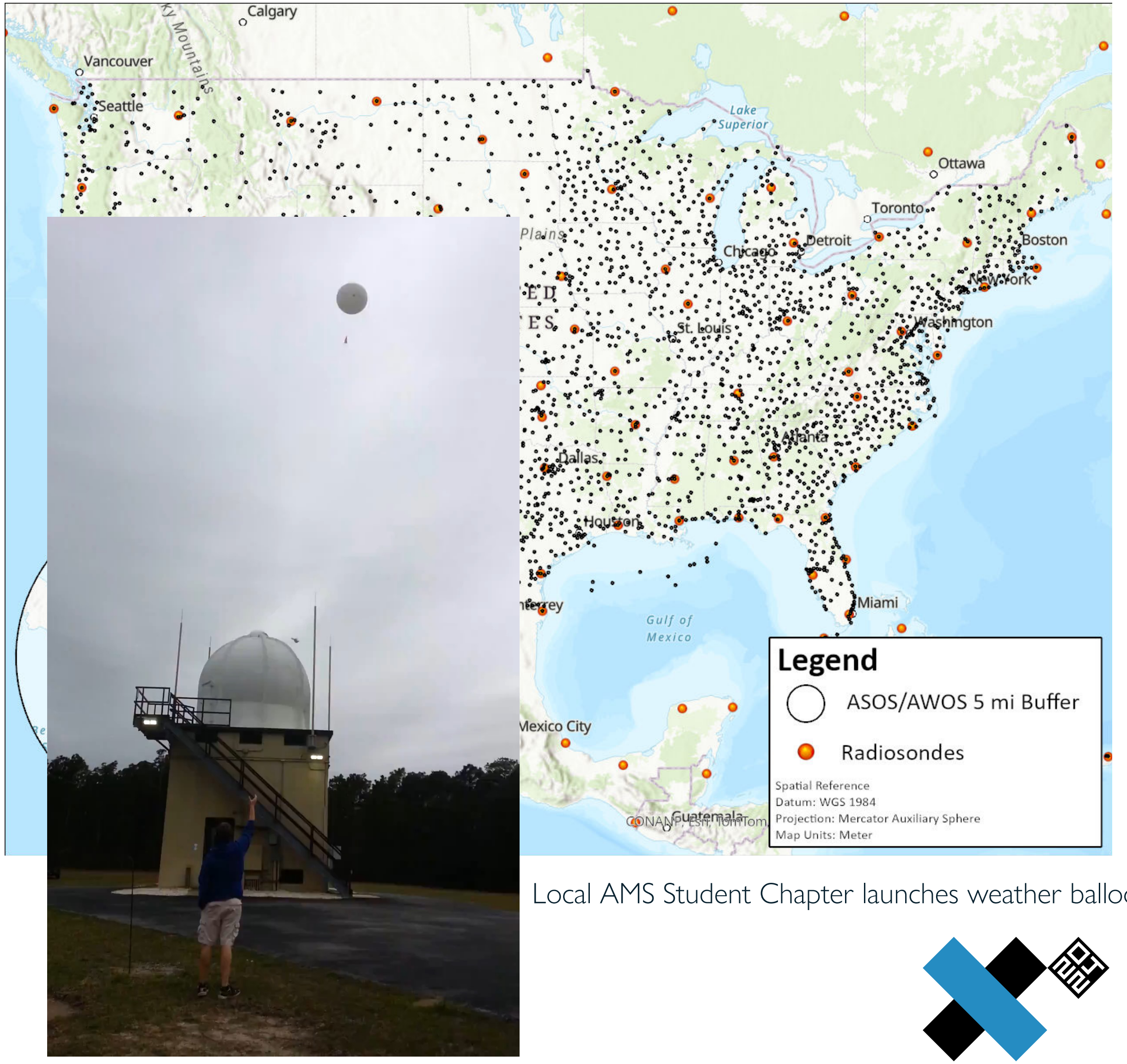
Current State

The current aviation weather observation network lacks data granular enough **from the surface to 5,000 feet AGL.**

- Less than 5% of US has good cloud height and visibility data
- Even less data coverage for winds and icing conditions above ground level
  - Sparse aircraft observations and weather balloon data.
- This introduces weather risk for decision makers
- Need more low-altitude weather observation data to replace the loss of the best weather sensor on an aircraft today—the pilot



Local AMS Student Chapter launches weather balloon

ASOS – Automated Surface Observation System
AWOS – Automated Weather Observation System

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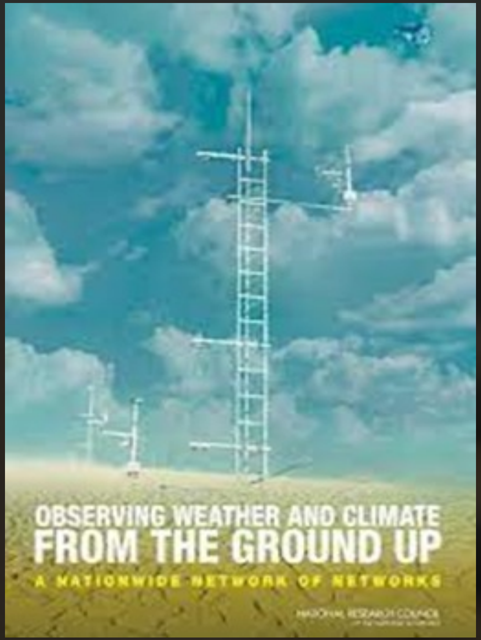
Infrastructure and Technology Development

- Satellites-oriented approach will not resolve low altitude and local weather challenges
- A **ground-up augmented** approach is required
- Advancements in machine learning weather prediction requires robust training/testing data
- Targeted low-altitude aviation weather solutions will come from private sector
- Need policy to unlock full potential of innovative weather observation technology



["Observing Weather and Climate from the Ground Up"]

Anemoment
Surface Wind

NRG Wind Lidar
Low-altitude Winds

Barani
Surface Weather Data

Tempest
Surface Weather Data

Intellisense MWS
Surface Weather, Ceiling, Visibility

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ASTM Standard Specification for Performance for Weather Information Reports, Data Interfaces, and Weather Information Providers (WIPs)

A performance-based standard, that includes **weather data error rates and metadata**, will allow for use of lower cost, novel science and technology to collect more ubiquitous weather data.

- Will move from requiring instrument certifications to performance-based qualification
- Incentivizes private sector investment and access to reliable weather data
- Better supports risk-based decisions
- Standardizes JSON/GeoJSON data format requirement
- Provides a structured 3PWP path to approval
- Is a work in progress—requires Metadata, and API annexes, and expansion into predictions, including probabilistic data.

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TABLE 1 Tiered Weather Data Categories and Thresholds[A]

Observed Element	Tier 1			Tier 2			Tier 3		
	Range	Accuracy	Confidence Level	Range	Accuracy	Confidence Level	Range	Accuracy	Confidence Level
Ceiling/Cloud Height	Surface to 800 ft	-200 ft/+300 ft	90 %	Surface to 800 ft	-100 ft/+200 ft	90 %	Surface to 2000 ft	±100 ft	90 %
	>800 ft to 3000 ft	-300 ft/+500 ft		> 800 ft to 3000 ft	-200 ft/+400 ft		>2000 ft to 12 500 ft	5 %	
	> 3000 ft to unlimited	-700 ft /+1200 ft		> 3000 ft to unlimited	-500 ft/+1000 ft				
Visibility	0 miles to 1 mile	±¼ mile	90 %	0 miles to 1 mile	±¼ mile	90 %	0 miles to 1¼ miles	±¼ mile	90 %
	>1 mile to 3 miles	-½ mile to +1 mile		>1 mile to 3 miles	±½ mile		1½ miles to 1¾ miles	+¼ mile to -½ mile	
	>3 miles to unlimited miles	±1.5 miles		>3 miles to unlimited miles	± 1 mile		2 miles to 2½ miles 3 miles to 3½ miles 4 miles to 10 miles	±½ mile +½ mile to -1 mile ±1 mile	
Temperature	-40 °C to 50 °C	± 2 °C	90 %	-40 °C to 50 °C	± 1 °C	90 %	-50 °C to 50 °C	± 0.6 °C	90 %
Wind Speed	2 knots to 10 knots	±3 knots	90 %	2 to 10 knots	± 2 knots	90 %	2 knots to 10 knots	±1 knots	90 %
	>10 knots to 20 knots	±4 knots		>10 to 20 knots	± 3 knots		>10 knots to 20 knots	±2 knots	
	>20 knots to 40 knots	±6 knots		>20 to 40 knots	± 5 knots		>20 knots to 40 knots	±2 knots	
	>40 knots to 85 knots	±8 knots		>40 to 85 knots	± 6 knots		>40 knots to 85 knots	RMSE ± 5 %	
Wind Direction	45° increments	±20°	90 %	45° increments	±10°	90 %	10° increments	± 5° when wind is greater than or equal to 5 knots	90 %
Pressure	28.5 in. to 31.5 in. of mercury	±0.2 in. of mercury	90 %	28.5 in. to 31.5 in. of mercury	±0.1 in. of mercury	90 %	16.9 in. Hg to 31.5 in. Hg	± 0.02 in. of mercury	90 %
Dew Point	-40 °C to 50 °C	±3 °C	90 %	-40 °C to 50 °C	± 2 °C	90 %	-34 °C to -24 °C	±2.2 °C	90 %
							-24 °C to -01 °C	±1.7 °C	
							-01 °C to +30 [illegible]	[illegible]1.1 °C	

[A] 1 ft = 0.3 m, 1 knot = 0.5 m/s, and 1 mile = 1.6 km.

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3PWP – 3rd Party Weather Provider
WIP – Weather Information Provider

Aviation Weather Advancement through PPPs

Ushering in a new paradigm of low-altitude aviation weather requires **transparent and agile public-private partnerships.**

- PPPs should receive input from diverse set of low-altitude aviation operators
- PPPs must engage in **deliberate collaboration with communities**
- Data sharing will support methods and means of compliance R&D
- Shared data must be secure and reliable with known uncertainty to maintain levels of aviation safety and ensure digital flight data integrity
- Aviation Authorities will determine rule-making if standard is adopted

Climavision

FOR IMMEDIATE RELEASE

National Weather Service gains access to Climavision's supplemental radar network

Weather tech pioneer will provide data through National Mesonet Program

LOUISVILLE, KY (September 21, 2023) – NOAA's National Weather Service (NWS) has a new set of "eyes" on severe weather, where and when they need to see the most.

Since early last year, Climavision has been cooperating with NOAA's National Severe Storms Laboratory (NSSL). Now, for the first time, the National Weather Service has entered into a short-term arrangement to access Climavision's supplementary radar data through the National Mesonet Program (NMP). The NWS will use this opportunity to enhance research and development while further informing any decision by the agency to enter into a longer-term contracting/data-buy commitment.

The National Mesonet Program is a "network of networks," which combines data from public and private weather sensor networks across the country, greatly expanding the amount of information accessible to the National Weather Service and its forecasters.

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PPP (or P3) – Public-Private Partnerships
CAA – Civil Air Authority

US Approach to Implementation

What is the 3PWPs path to provide reliable, secure weather data and services?

- Part 135 exemptions and/or Part 107 waivers while Part 108 is under development
- NTAP – Near Term Approval Process
- Test and improve ASTM F38 Weather Standard
- Safety Risk Management Panel
- R&D required to determine methods to validate and quantify the Tier of weather information accuracy and determine how to "approve" 3PWPs for weather services
- Inform development of Advisory Circular
- Publish Advisory Circular

Food for thought

- How can aviation authorities test and demonstrate the standard for potential adoption?
- What methods and means of compliance are required for rulemaking consideration?
- How is data collected and analyzed (who, what, where, how) to understand the value proposition for the 3PWP and users?
- What are potential Public/Private/University Partnership business models?

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3PWP – 3rd Party Weather Provider

Metadata Considerations

"Today's metadata in support of mesoscale observations are incomplete at best and, in the case of surface observations, woefully inadequate for the great majority of them." – From the Ground Up (2009)

- Effective metadata allows for efficient data monitoring, utility, and dissemination
- 3PWP weather observations and reports will require metadata to contribute as a shared data source
- Metadata should be carefully defined and standardized
    - What existing metadata standards can be leveraged?
- A national database of metadata should be maintained and accessible to all
- Reviews and updates should be conducted frequently

What is some information you think should be required in weather observation metadata?

Weather Observations Metadata

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Weather Observations Metadata (microsoft.com)

UAS-Based Weather Data

Research has demonstrated that WxUAS can provide insights into boundary layer processes which, in turn, improve NWS meteorologists forecast skill and improve NWP representation of moisture, low level wind patterns, and storm development.

- WxUAS are comparable to radiosondes
  - Advantages of being on-demand, retrievable, and consistent position throughout profile
- Additional research will elucidate questions such as:
  - What are the best flight configuration to profile the atmosphere?
  - What WxUAS network configurations will significantly improve NWP performance?
  - What are the business models of regional or nationwide WxUAS profiling network?
  - How do we validate consistent data certainty tiers?

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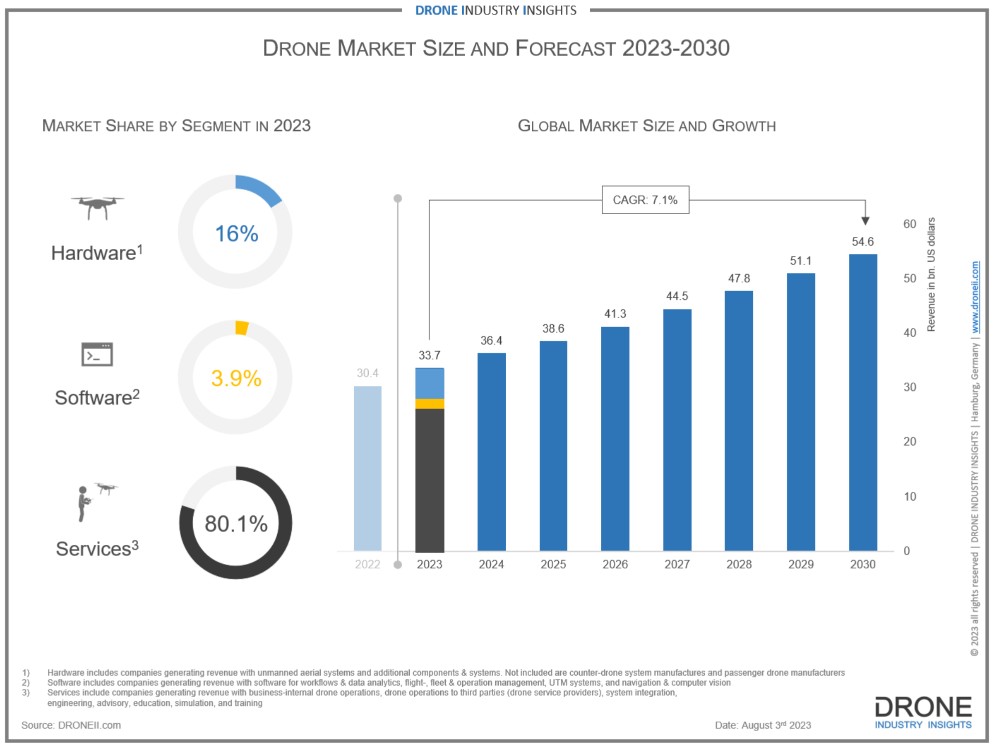
Weather from "Working" Drones

A "working" UAS is any novel uncrewed (or crewed in near term) platform including middle-mile cargo and last-mile parcel delivery, inspection and surveillance sUAS, "Air taxis", and Drone as First Responder (DFR).

- Lessons from current aviation industry
  - Pilot reports (PIREPs) – Significant weather reports provided at unscheduled times by pilots —difficult to benchmark quality
  - Commercial airlines -> Global Aircraft Meteorological Data Relay (AMDAR)
  - Part 135, 91, and other -> United States Tropospheric Airborne Meteorological Data Reporting (TAMDAR)
- Aircraft-based observations have been one of the most important data sets to NWP.
- More UAS in the air = more potential weather datapoints



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Weather from "Working" Drones

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Weather from "Working" Drones Considerations

Data collection approaches

- Onboard weather observation devices
- Derived weather information (e.g., winds from aircraft telemetry)

"Working" UAS data collection/sharing models

- Regulation
- Share to access
- Blockchain
- Direct sale

Data performance and metadata

- Methods for Tiering of "working" UAS weather data consistent with standard
- Ensuring data quality and security. Who is responsible?
- Descriptive metadata and reporting requirements

Sending of data and repository

- Data repository
- Latency reporting and requirements
- Security of data and "spoofing" prevention
- Fee-based curation and sales

Data from WxUAS and "working" UAS have the potential to make significant improvements in our understanding of boundary layer processes and local weather prediction capabilities. With a higher density of real-time weather observations, these platforms will provide indispensable data to life saving operations.

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Future Directions and Innovations

The NC Forsyth County Sheriff is collaborating with Duke University to initiate a UAS AED response system. Every minute that passes during a cardiac arrest event corresponds to a 10% reduction in chance of survival. Precise and accurate wind observations will be imperative to making significant improvements in cardiac arrest patient outcomes.

- Engagement with operators
- Data sharing economic modeling and business model development
- Close coordination with CAA to establish methodology a means of compliance for novel weather observations
- Continued refinement of standard to evolve with weather observation and weather modeling innovations

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Concluding Remarks

- The standard creates the pathway for the biggest transformation in collecting aviation weather data since the deployment of Doppler Weather Radar in the early 1990s.
- A new network of networks data sharing weather observation paradigm under controlled conditions
- "Working" UAS provide an opportunity to rapidly and continuously increase weather observations in the atmospheric boundary layer
- Ensuring data quality, consistency, and business models will be significant hurdles requiring additional research
- Call to action: Reach out to Don Berchoff (don.berchoff@truweathersolutions.com) to become involved with the ASTM Weather Standard committee.
  - Need committed stakeholders to "roll up sleeves" to develop an industry-consensus standard
- Expect announcement for participants for sub-working groups to work metadata and forecast standards.
- Committee will also begin developing a standard for weather forecasts. Please contact Don Berchoff if you are interested in leading the forecast standard development effort

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Supporting Science & Research Publications

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AUTONOMY

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Backup

Metadata

Metadata is data that provides information about other data. Metadata helps to understand the meaning of the data that the metadata is describing.

- Metadata requirements
  - What information will be needed to fully understand characteristics of data collected from diversified and evolving weather sensors?

Descriptive

What does it mean?

Who owns it?

What does it contain?

Structural

How is it organized?

How is it sorted?

How does it relate to other data?

Administrative

When was it created and modified?

What is the location of the data?

Who can access it?

How large is it?

What is the data format?

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Weather Standard Expected Outcomes

"A technology transfer initiative, carried out jointly and in coordination with the Director of the National Weather Service, and in cooperation with the United States weather industry and academic partners…to establish a process to sunset outdated and expensive operational methods and tools to enable cost-effective transfer of new methods and tools into operations." -Weather Research and Forecasting Innovation Act (2017)

- Leverage lower cost sensors to increase data measurements
- Augment existing observations through network of networks approach
- Reduce risk of entering hazardous winds, wind shear, turbulence, IFR ceiling and visibility, icing
- More weather data to improve short-range predictions
- Increased real-time weather certainty maximizes flight windows

Intellisense MWS
Surface Weather, Ceiling, Visibility

Barani
Surface Weather Data

Tempest
Surface Weather Data

Anemoment
Surface Wind

NRG Wind Lidar
Low-altitude Winds

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UAS Operator Pain Points

Terrain-altered winds cause excessive fuel consumption.

Pop-up and poorly forecasted precipitation can lead to hazardous conditions and reduce reliability

Reliance on METAR for visibility decision making reduces operational efficiency

Poor icing forecast results in unnecessary downtime

Low temperatures in the winter and high temperatures in summer have predictable impacts

Cloud base observations needed rather than traditional ceiling estimates.

Turbulence negatively impacts controllability and ride comfort

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