ADS-Wx / Mode S Wx Development Status

Friends and Partners in Aviation Weather
October 2018
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Purpose and Outline

- Purpose:
  - Provide an update on RTCA/Eurocae Combined Surveillance Committee (CSC) activities implementing ADS-Wx / Mode S Wx
- Outline
  - Summary of ADS-Wx / Mode S Wx requirements
  - WxS SG Status and Next Steps
  - Other ADS-Wx / Mode S Wx Considerations

CSC Weather Surveillance Subgroup
ADS-Wx / Mode S Wx Approach

FPAW

- **3** Identify and resolve Aircraft-based Observations requirements & recommendations
- **3** Incorporate support provided by existing aircraft sensing and computation and communications requirements
  - As needed, develop parameter derivation requirements
- Develop ADS-B (Out) and Mode S message and ADS-B (In) report generation requirements
- Document and communicate results and status

2018 CSC WxS SG Deliverables

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3 Requirements for each ADS-Wx parameter

- Parameter Range and Resolution
- Recommended encoding and register loading requirements
- Update Interval
  - The interval at which the most demanding receiving application requires the parameter to be received
- Reception Range
  - The minimum distance between the sending aircraft and the most demanding receiving application (air-air, air-ground)

ADS-Wx / Mode S Wx
Parameter-Specific Requirement Setting

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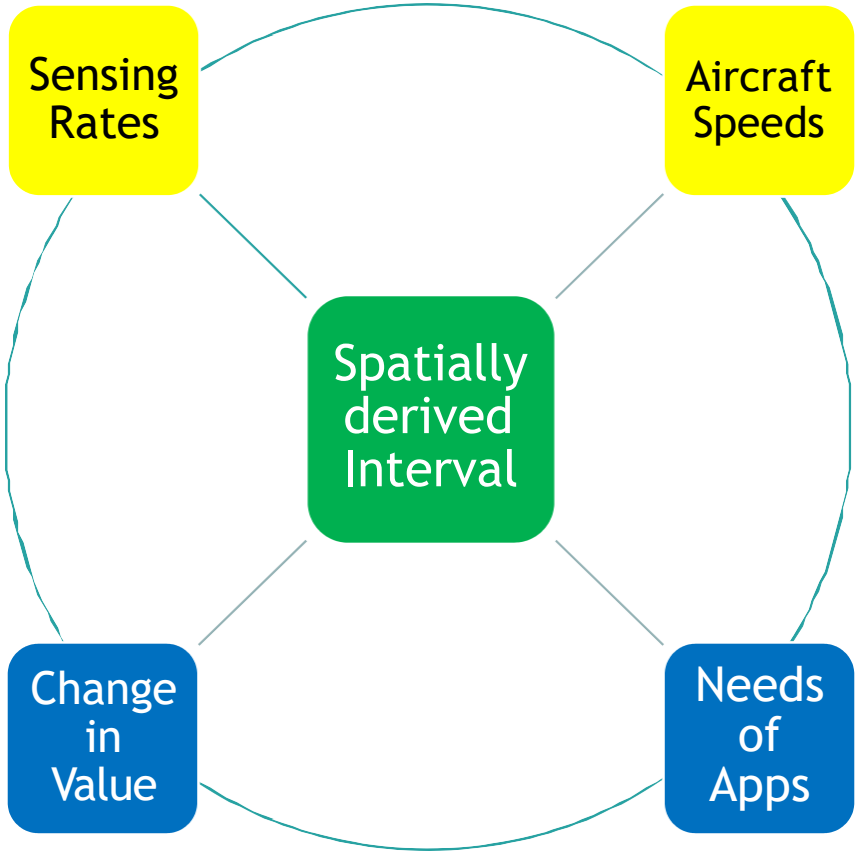
Update Interval



Reception Range

An Example:
Icing Encounter Warning

- Scenario: Icing encounter by equipped aircraft allows in-range proximate aircraft to initiate mitigations prior to entering icing volume
  - Encountering Aircraft: in icing for sufficient time to detect and transmit Ice Status received by in-range proximate aircraft
  - In-Range Proximate Aircraft: Outside of and converging on icing volume at various altitudes, at 480 knots true airspeed
  - Shape and size of Icing Volume cannot be defined and can vary from very small to very large
    - Large or convoluted icing volumes can result in Out-of-range Proximate Aircraft not receiving Ice Status prior to entering icing volume
- Determine air-to-air range requirement, given 95% probability of reception in a given time, to perform anticipated icing encounter procedures (avoidance assumed as worse case than ice protection system activation)

An Example:
Warning Time Required = 47 Seconds

Hazard Detection (15 seconds)

+ Register Loading to Transmit Time (10 seconds)

+ 95% PoR of ADS-B message (50 seconds)

= Time in icing (75 seconds)

= 10 NM horizontal at 480 knots
= 2500 ft vertical at 2000 ft/minute vertical speed

Process ADS-B data and display alert (2 seconds)

+ Detect alert and decide to initiate mitigation (5 seconds)

+ Coordination with ATC (10 seconds)

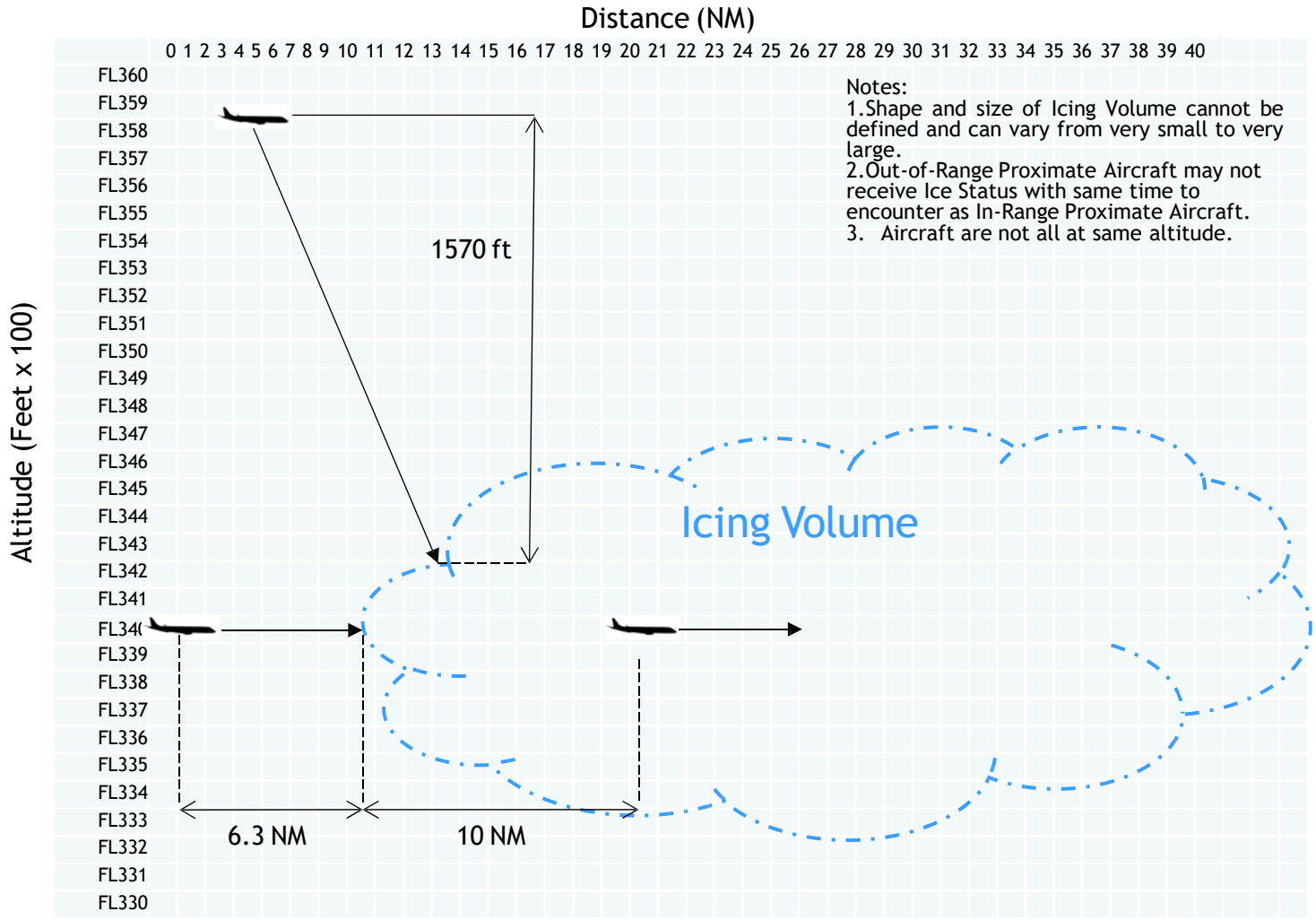
+ Time to mitigation effectiveness (90 degree turn ~30 seconds)

= Total Warning Time Required (~47 seconds)

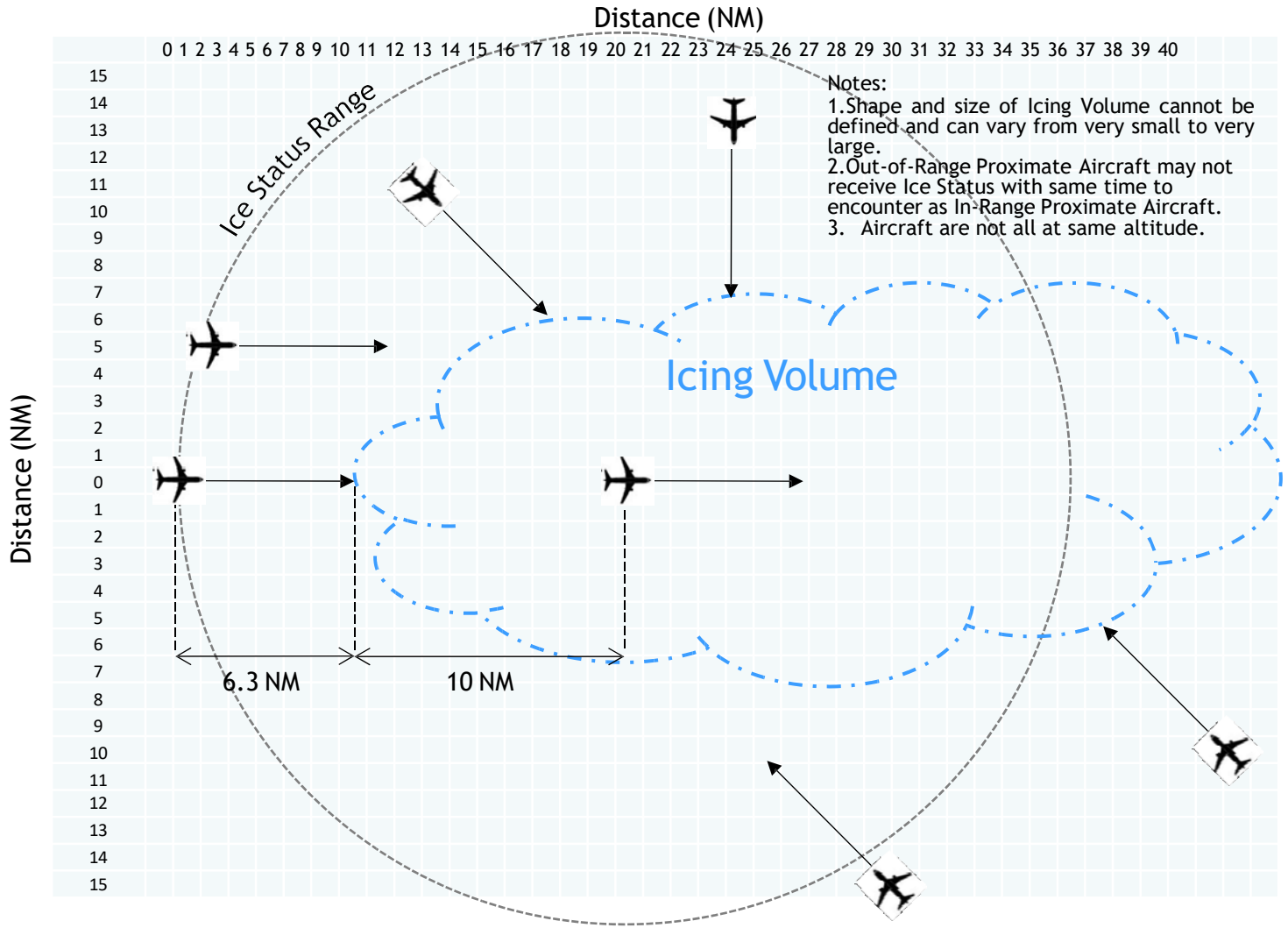
Total Warning Distance from Icing Air Volume

~ 6.3 NM horizontal at 480 knots
~ 1570 ft vertical at 2000 ft/minute vertical speed

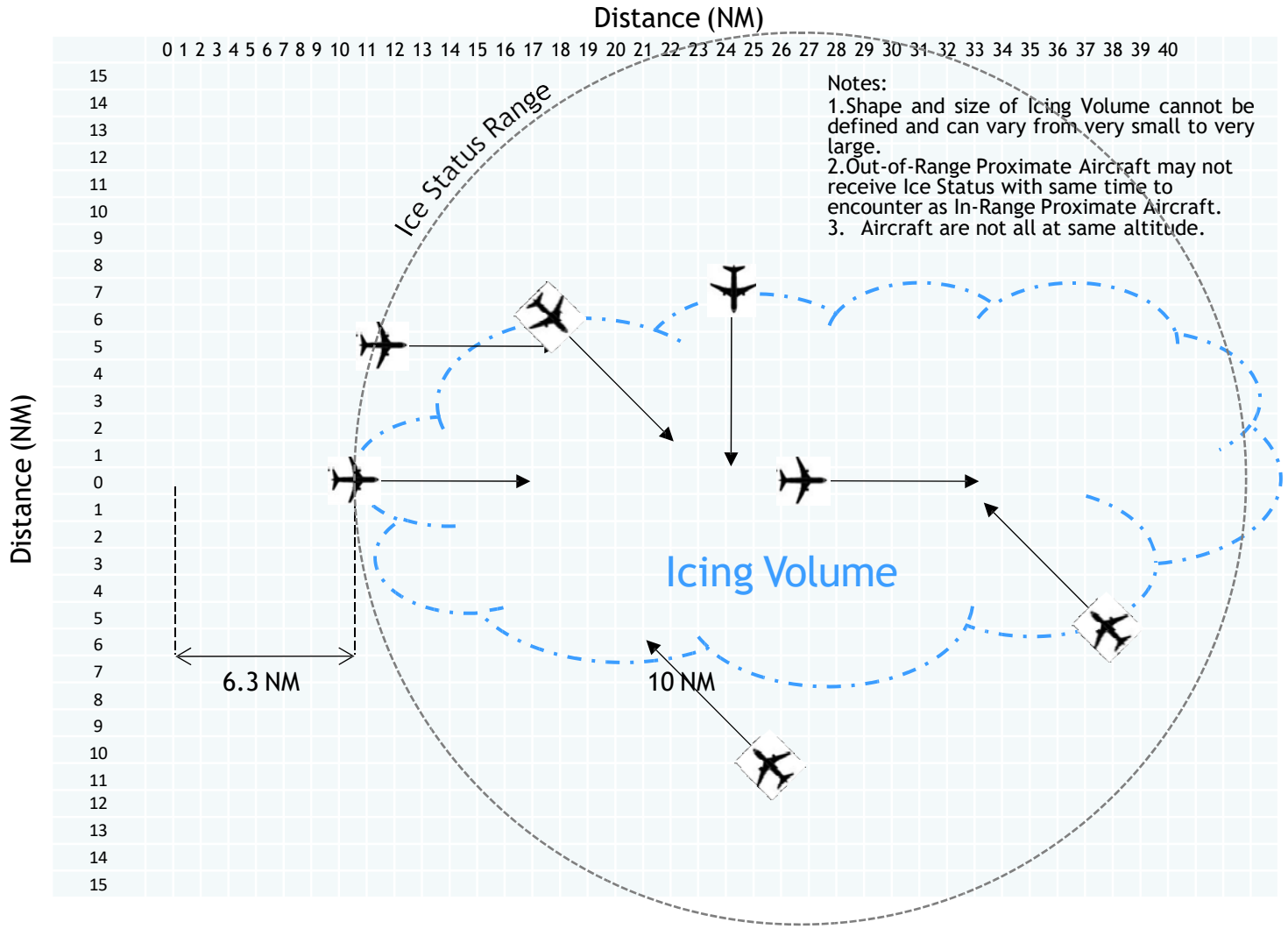
An Example:
Ice Status Spatial Requirement



An Example:
Relative Positions at Ice Status Range



An Example:
Relative Positions 47 seconds Later



Proposed ADS-Wx Message: Highest Rate ADS-Wx Parameters

Reported Parameter	Range and Resolution	Bits	Reception Range	Update Interval
True Airspeed	Range: 0 to > 1021.5 knots Resolution = 1 knot	2 +10	17 NM Air-Air	5 second transmit interval
Wind Speed	Range reduced to 0-255 from 0-400 Resolution = 1 knot	1+8	35 NM Air-Air	30 seconds (5 second transmit interval)
Wind Direction	Range: -180 to +179 Degrees True Resolution = 1 degree	1+9	35 NM Air-Air	30 seconds (5 second transmit interval)
Wind Quality Flag	Range: 0 to 1 (Definition in Coordination)	1	35 NM Air-Air	30 seconds (5 second transmit interval)

- CSC confirmed bits beyond Mode A code as available for ADS-Wx in Aircraft Status Message, Subtype 1
  - Recommended encoding results in 2 reserved bits
- SURV-WP06-30_A - Addition of Airspeed to Aircraft Status Message limits True Airspeed reporting to fixed wing aircraft ≥ 15,500 lbs.
  - Proposed reduction/elimination of minimum weight requirement
- Winds derived onboard are instantaneous
  - Coordinating 3-second average wind reporting requirement

Proposed ADS-Wx Message: High Rate ADS-Wx Parameters

Reported Parameter	Range and Resolution	Bits	Reception Range	Update Interval
Static Air Temp	Range: ≤ -68.5 to ≥ 57.5 °C Resolution = 1 °C	1+7	35 NM Air-Air	30 seconds
Mean EDR	Range: 0.00 to > 0.80 $m^{2/3}s^{-1}$ Resolution = 0.01 $m^{2/3}s^{-1}$	1+7	17 NM Air-Air	50 seconds
Peak EDR w/Offset	Range: 0.00 to > 0.80 $m^{2/3}s^{-1}$ Resolution = 0.01 $m^{2/3}s^{-1}$	1+7+3	17 NM Air-Air	50 seconds
Gross Weight	Range: 0 to ≥ 1,415,000 lbs. Resolution = 40 lbs.	11	17 NM Air-Air	50 seconds
Wingspan	Range: 0 to ≥ 400 feet Resolution = 0.1656 to 3.0104 feet	8	17 NM Air-Air	50 seconds
Aircraft Config	Range: 0 to 15 (discrete) Resolution = 1	4	17 NM Air-Air	50 seconds
Ice Status	Range: 0 to 30 (discrete w/ 1 reserved) Resolution = 1	5	17 NM Air-Air	50 seconds

- Recommended encoding bit counts permit population of a single XPDR register (44_{16}) with High Rate message elements
  - 1 reserved bit
- High Rate transmit interval, nominally 10 s (50 s update interval)
  - DO-339 analysis showed acceptability in congested airspace

Proposed ADS-Wx Message: Low Rate ADS-Wx Parameters

Reported Parameter	Range and Resolution	Bits	Reception Range	Update Interval
Aircraft Type	Range: 5 alphanumeric characters Resolution = NA	30	16 NM Air-Air	60 seconds
Water Vapor	Range: 0 to 38 g/kg Resolution = 0.00001 g/kg	1+12	No Air-Air requirement	300 seconds
Anti-ice Status	Range: 0 to 7 (discrete) Resolution = 1	1+3	17 NM Air-Air	60 seconds

Notes (applicable to Highest Rate, High Rate, and Low Rate ADS-Wx Parameters):
1. No reception range requirements for any ADS-Wx / Mode S Wx parameters exceed the reception range requirements for position surveillance.
2.For parameters without existing sensing and communications standards, appropriate methods of providing the data to the ADS-B Transmit Subsystem need to be developed.

- Recommended encoding bit counts permit population of a single XPDR register (45_{16}) with Low Rate message elements
  - 9 reserved bits
- Low Rate transmit interval, nominally 20 s (100 s update interval)
  - DO-339 analysis showed acceptability in congested airspace

ADS-Wx / Mode S Wx Message Correlation

Reported Parameter	ADS-Wx Approach	Mode S Wx Approach
UNIQUE AIRCRAFT IDENTIFIER	Rely on inclusion of ICAO 24-bit address in all Mode S/ ADS messages- use to correlate Mode S/ ADS-Wx parameters across messages	As per ADS-Wx Approach
LATITUDE LONGITUDE	Rely on ADS-B Compact Position Report (CPR)	Rely on SSR position relative to interrogator
PRESSURE ALTITUDE	Rely on ADS-B Barometric Altitude	Rely on Mode C reporting
DATE DAY	Rely on receiver report generation function assigned time within 512 second epochs. If application needs longer scale time, it shall provide conversion	As per ADS-Wx Approach
TIME	Rely on receiver report generation function assigned time within 512 second epochs. If application needs longer scale time, it shall provide conversion	As per ADS-Wx Approach
GNSS ALTITUDE	GNSS altitude will be added to Airborne Velocity Message, making it continuously available via ADS-B, in addition to Barometric Altitude	Not reliably interrogable (optional in BDS 5,2)
Note: None of the above parameters will be changed in support of ADS-Wx / Mode S Wx implementation.		

Mode S/ ADS-Wx Non-Provisioned DO-364 Parameters

Reported Parameter	DO-364	Mode S/ ADS-Wx Approach	Status of Working Paper Development
VALID PARAMETERS INDICATOR	Mandatory	Adopt scheme used to incorporate into ADS messages	No parameter-specific WP needed
WxS MESSAGE VERSION	Mandatory	Don't provision (enforced by TSO compliance)	Non-provisioning WP: Draft presented to CSC October 2017 Final Draft delivered to CSC June 2018
DATA COMPRESSION STATE	Mandatory	Don't provision. No communication channel compression provided in ADS or Mode S. Limited data compression provided by bit encoding schema.	
DEPARTURE AIRPORT	Optional	Used by AMDAR to manage message costs- NA for Mode S/ ADS-Wx	
ARRIVAL AIRPORT	Optional	Used by AMDAR to manage message costs- NA for Mode S/ ADS-Wx	
Note: None of the parameters shown above will be implemented in ADS-Wx / Mode S Wx.			

Mode S/ ADS-Wx Non-Provisioned DO-364 Parameters

Reported Parameter	DO-364	Mode S/ ADS-Wx Approach	Status of Working Paper Development
STATIC AIR PRESSURE	Mandatory	Don't provision: report ADS-B Barometric Altitude	Non-provisioning WP: Draft presented to CSC October 2017 Final Draft delivered to CSC June 2018
FLAP POSITION	Recommended	Don't provision. Evaluation determined that A/C Configuration is sufficient.	
WINDSHEAR AIRSPEED CHANGE	Required if Equipped	To be derived from multiple wind direction and speed reports by interested applications- coordination complete	
TRUE HEADING	Recommended	Eliminated by CSC- WxS SG evaluated impact on WxS applications and alternatives to parameter, no request to implement is planned	
Note: None of the parameters shown above will be implemented in ADS-Wx / Mode S Wx.			

WxS SG NEXT STEPS
OTHER CONSIDERATIONS

WxS SG
Next Steps

- Continue ADS-Wx / Mode S Wx development
  - Determine ADS Equipment Class applicability
  - MOPS verbiage development
  - Develop ADS-B In report generation requirements
- Continue coordination with:
  - Weather community (FAA, NOAA/NWS, AMS, WMO, FPAW);
  - Other standards bodies and regulators (EUROCAE, ICAO, Eurocontrol, FAA); and,
  - Manufacturers and Operators.

ADS-Wx / Mode S Wx
Other Considerations

FPAW

- Receipt of ABO by ground systems is not addressed by MOPS
  - Integration into forecast and air traffic systems needs to be planned and implemented, including enabling receipt via ADS-B and/or interrogation via Mode S
- 2020 equipage mandate for ADS-B does not (and will not) require compliance with new DO-260 and DO-181 revisions

WxS SG Membership

Participant	Organization
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Ashutosh Sharma, Timothy Rahmes, Jesse Turner	Boeing
Frank Holzäpfel, Carsten Schwarz, Tobias Bauer, Fethi Abdelmoula	DLR
Jörg Steinleitner	Eurocontrol
Edward Johnson, Tammy Flowe, Chris Tourigny	FAA
Todd Skoog	Garmin
Anaïs Mermet	Meteo France
Clark Lunsford	MITRE
Matt Erickson	Rockwell Collins
Greg Comstock	SC-186 WG4
Curtis Marshall, Doug Body, Frank Grooters	WMO

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QUESTIONS??