ADS-B Weather Update

Presented to: Friends and Partners in Aviation Weather

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Federal Aviation Administration

Weather and NAS Safety and Efficiency

- **Weather is the leading cause of:**
  - Part 121 Air Carrier Accidents
  - Fatal General Aviation Accidents
  - Flight Delays and Lost Aircraft Utility
- **Aircraft-based Observations (ABO) are the critical enabler of high resolution, rapid refresh weather forecasting and improved weather forecast model performance**

Q. Why ADS-B Wx?
A. Aviation Safety, Efficiency, and Utility…

AIREP (Air Reports) Benefits

More rapid, more accurate weather awareness

More accurate, precise, and frequent forecasts & nowcasts

More efficient aircraft operations

Improved awareness & avoidance of adverse and hazardous weather and hazardous wake turbulence

Better access to more ABO data

Increased aircraft utility

PIREP (Pilot Reports) Benefits

More effective pilot decisions

AIREP impacts where PIREPs are submitted

More PIREPs with fewer errors

Relieve ATC/FSS collection and transcription by fully automating:

PIREP data submission

Encoded PIREP creation

ADS-B PIREP dissemination via existing networks, including FIS-B
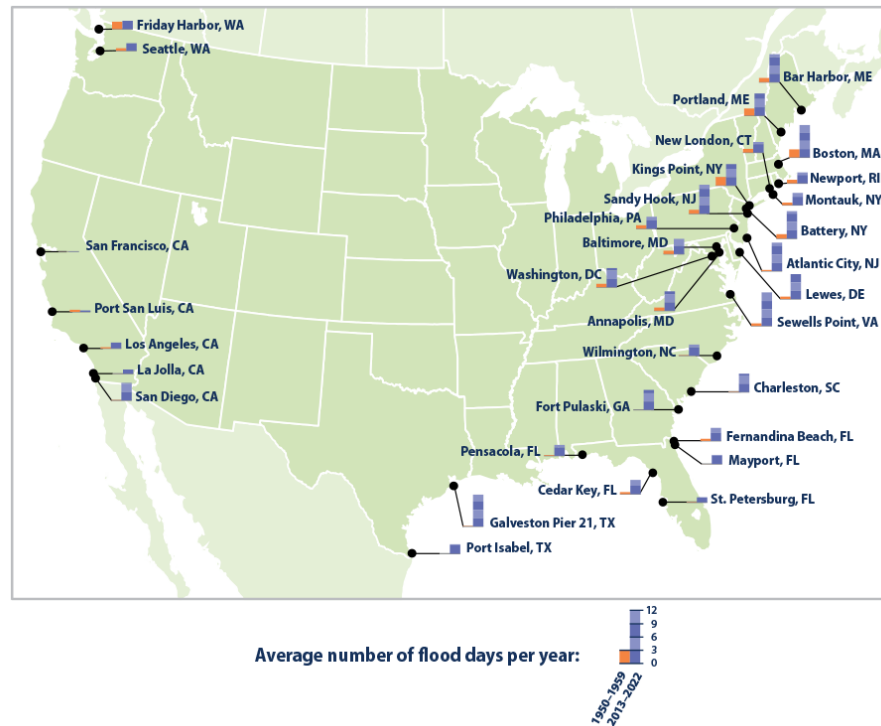
Increased aircraft utility

Automated wake encounter reporting
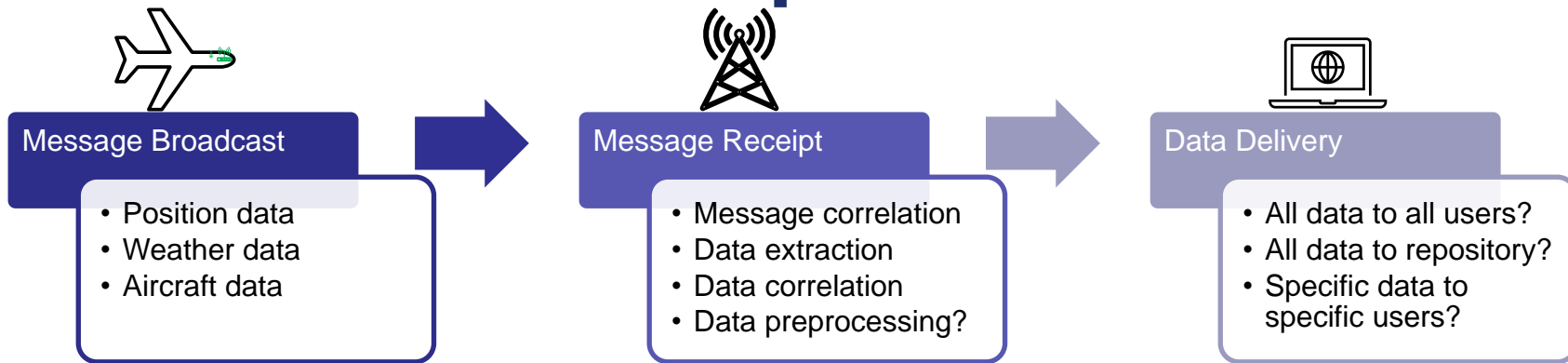
Q. Why ADS-B Wx?
A. Impacts Beyond Aviation…

Better forecasts mitigate the economic impacts of weather-

- **"Every year, weather variability is estimated to cost $630 billion for the U.S. alone, or 3.5% of GDP."** Harvard Business Review, 2017

- **"Climate change and extreme weather events … have a direct impact on 70% of all economic sectors worldwide."** Forbes on Deloitte's 2021 Climate Check Survey
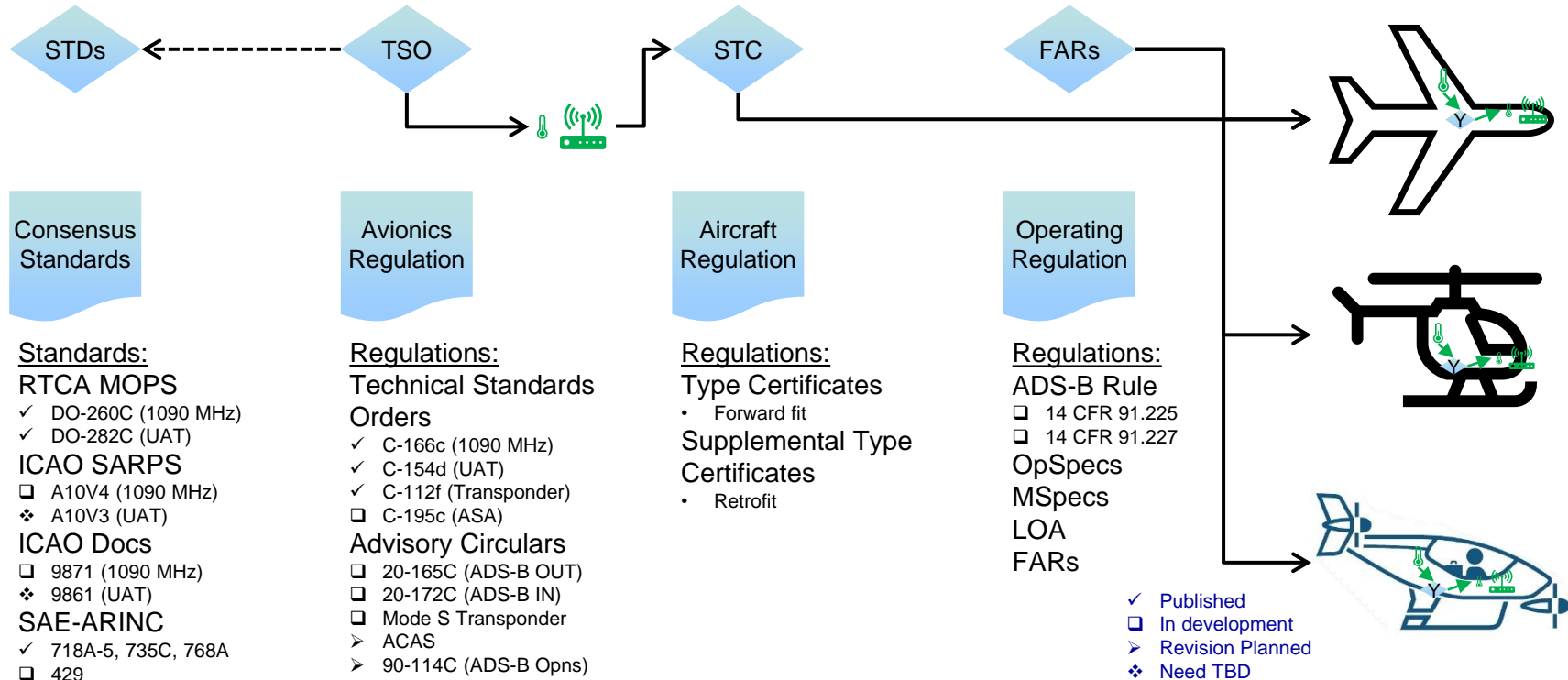

Average number of flood days per year:

https://www.epa.gov/climate-indicators/climate-change-indicators-coastal-flooding

ADS-B Wx Development

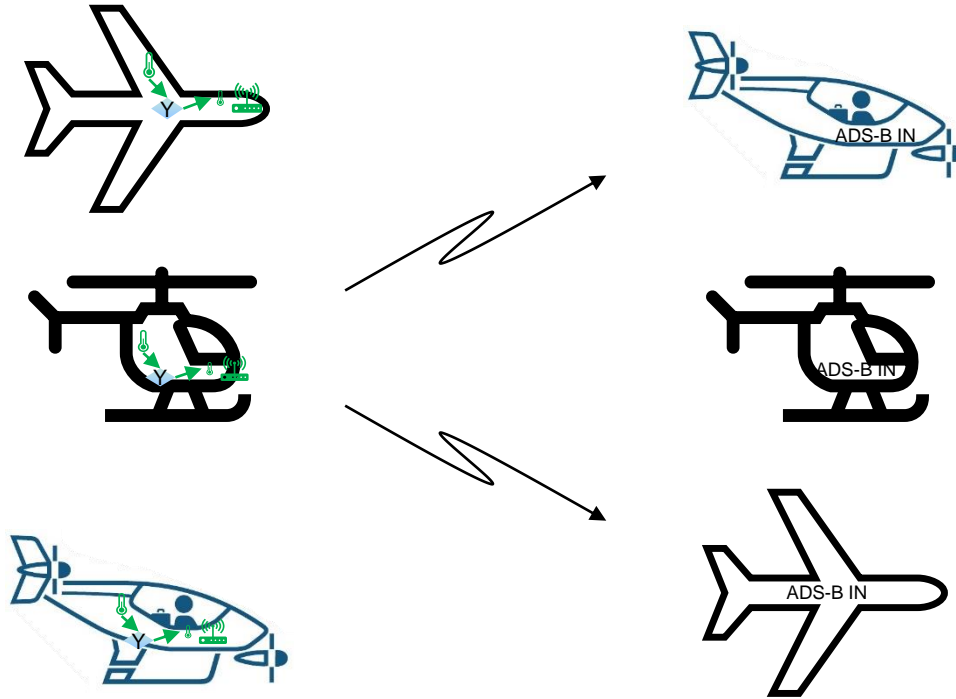| Message Broadcast	Message Receipt	Data Delivery
• Position data • Weather data • Aircraft data	• Message correlation • Data extraction • Data correlation • Data preprocessing?	• All data to all users? • All data to repository? • Specific data to specific users?

- **Ensuring stakeholders are involved in the message broadcast, receipt, and data delivery planning**
  - Specific uses considered; e.g., flight deck applications and ground-based decision support tools need data in real time, climatology can work from historical archives

Progress towards Signal-in-Space

STDs ← **TSO** → **STC** → **FARs**

Consensus Standards

Standards:
RTCA MOPS
- ✓ DO-260C (1090 MHz)
- ✓ DO-282C (UAT)

ICAO SARPS
- ❑ A10V4 (1090 MHz)
- ❖ A10V3 (UAT)

ICAO Docs
- ❑ 9871 (1090 MHz)
- ❖ 9861 (UAT)

SAE-ARINC
- ✓ 718A-5, 735C, 768A
- ❑ 429

Avionics Regulation

Regulations:
Technical Standards Orders
- ✓ C-166c (1090 MHz)
- ✓ C-154d (UAT)
- ✓ C-112f (Transponder)
- ❑ C-195c (ASA)

Advisory Circulars
- ❑ 20-165C (ADS-B OUT)
- ❑ 20-172C (ADS-B IN)
- ❑ Mode S Transponder
- ➢ ACAS
- ➢ 90-114C (ADS-B Opns)

Aircraft Regulation

Regulations:
Type Certificates
- • Forward fit

Supplemental Type Certificates
- • Retrofit

Operating Regulation

Regulations:
ADS-B Rule
- ❑ 14 CFR 91.225
- ❑ 14 CFR 91.227

OpSpecs
MSpecs
LOA
FARs

- ✓ Published
- ❑ In development
- ➢ Revision Planned
- ❖ Need TBD

Progress towards Air-to-Air Receipt

ADS-B IN

ADS-B IN

ADS-B IN

Consensus Standards

Operating Regulation

Standards:
RTCA MOPS
❖ DO-317 (ASA)
✓ DO-361 (FIM)
ICAO SARPS
❑ A10V4 (1090 MHz)
❖ A10V3 (UAT)
ICAO Docs
❑ 9924 (Aero Surv)
❖ 9994 (Airb Surv)

Regulations:
OpSpecs
MSpecs
LOA
FARs

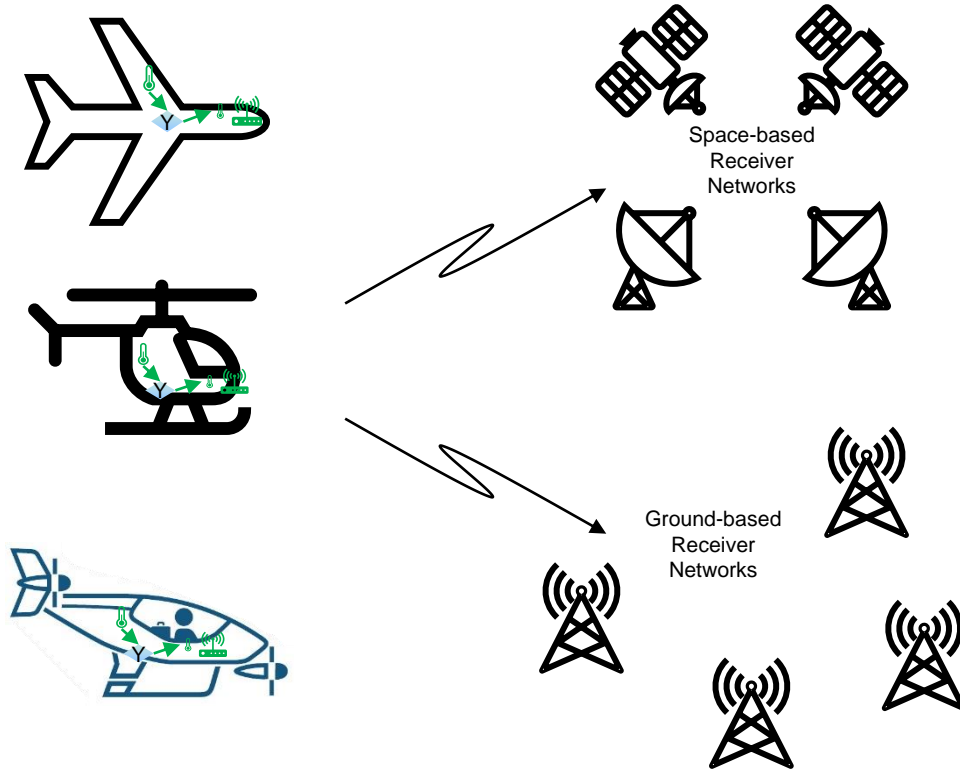✓ Published
❑ In development
➤ Revision Planned
❖ Need TBD

Progress towards Air-to-Ground Receipt

Space-based Receiver Networks

Ground-based Receiver Networks

Consensus Standards

Receiver Specs

Standards:
ICAO SARPS
- ❑ A10V4 (1090 MHz)
- ❖ A10V3 (UAT)

ICAO Docs
- ❖ 8071 Vol III
- ❑ 9924 (Aero Surv)
- ❖ 9994 (Airb Surv)

EUROCAE
- ❑ ED-129C/D (Rcvr Sys)

Specifications:
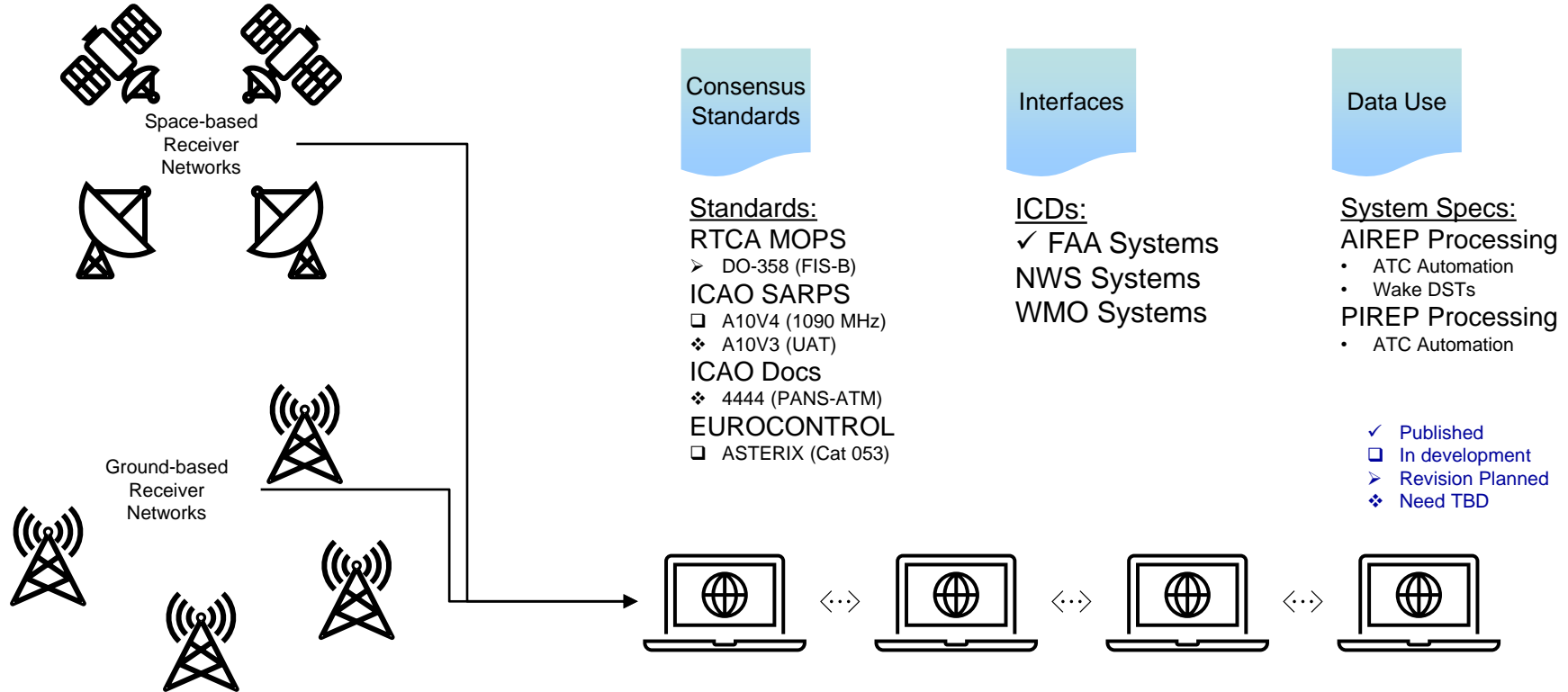SBS Program Office
Performance-based
Specifications
- ➤ 1090 MHz
- ➤ UAT

- ✓ Published
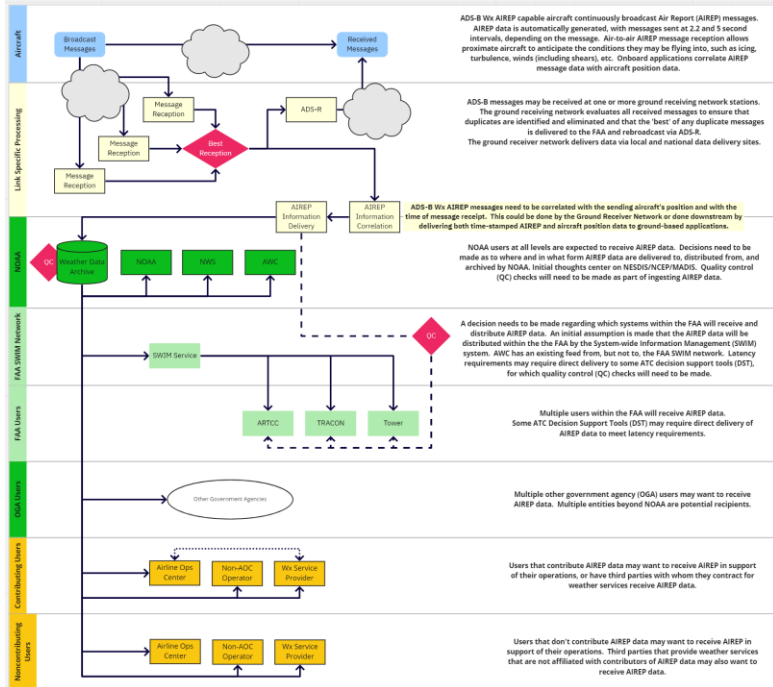- ❑ In development
- ➤ Revision Planned
- ❖ Need TBD

Progress towards Data Delivery

Space-based Receiver Networks

Ground-based Receiver Networks

Consensus Standards

Standards:
RTCA MOPS
➢ DO-358 (FIS-B)
ICAO SARPS
❑ A10V4 (1090 MHz)
❖ A10V3 (UAT)
ICAO Docs
❖ 4444 (PANS-ATM)
EUROCONTROL
❑ ASTERIX (Cat 053)

Interfaces

ICDs:
✓ FAA Systems
NWS Systems
WMO Systems

Data Use

System Specs:
AIREP Processing
• ATC Automation
• Wake DSTs
PIREP Processing
• ATC Automation

✓ Published
❑ In development
➢ Revision Planned
❖ Need TBD

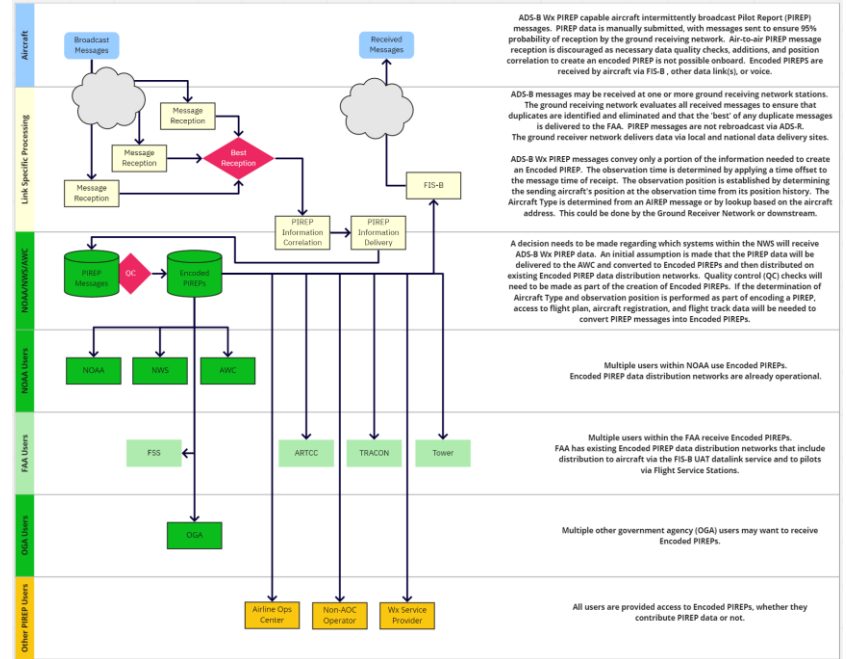# ADS-B Wx Data Flow Concepts

ADS-B Wx Development Next Steps

- **Needed capabilities in development:**
  - ADS-B V3 transponders sending ADS-B Wx messages
- **Ground distribution capabilities for ADS-B Wx information**
  - Upgrade ADS-B receiver networks to receive and distribute ADS-B V3 messages
  - Develop and coordinate ADS-B Wx data distribution ConOps
    - ICAO and WMO requirements for AbO communications and sharing are established
  - Define ASTERIX category to carry ADS-B Wx parameters
  - Specify ADS-Wx PIREP Message transcoding to Encoded PIREP format
  - Conduct segmented and end-to-end system testing and monitoring capability
- **Plan and implement integration into forecast and air traffic systems**
- **Continuing coordination with:**
  - Weather community (NOAA/NWS/AWC, FAA, WMO, FPAW, AMS)
  - Other standards bodies and regulators (EUROCAE, EUROCONTROL, FAA, ICAO)
  - Manufacturers and Operators

Recent ABO Developments

Sensing

- **Turbulence**
  - Boeing now provides EDR algorithm on all aircraft produced, and as free retrofit for earlier similar models

- **Water Vapor**
  - Boeing and Airbus are pursuing improved sensing technology supporting persistent contrail condition detection for possible EU Emissions Trading System annual Monitoring, Reporting, and Verification procedures
  - NWS issued contract for installation of a limited number of FLYHT-WVSS-II sensors on air carrier aircraft

Regulation and Standards

- **Updated Advisory Circulars for ADS-B V3 are in FAA review**
  - Will provide guidance for use of aircraft systems providing ADS-B Wx data during ADS-B device installation and operation in conjunction with MOPS recommendations

- **RTCA and EUROCAE**
  - Considering whether standards development efforts for aircraft-based meteorological observations are needed
  - Developing Minimum Aviation Systems Performance Standards for in-situ EDR computation and comparability
    - ADS-B V3 MOPS provides recommendations for reporting EDR via ADS-B

How We Got This Far…

PUSH

ADS-B Wx Wagon

What We Need…

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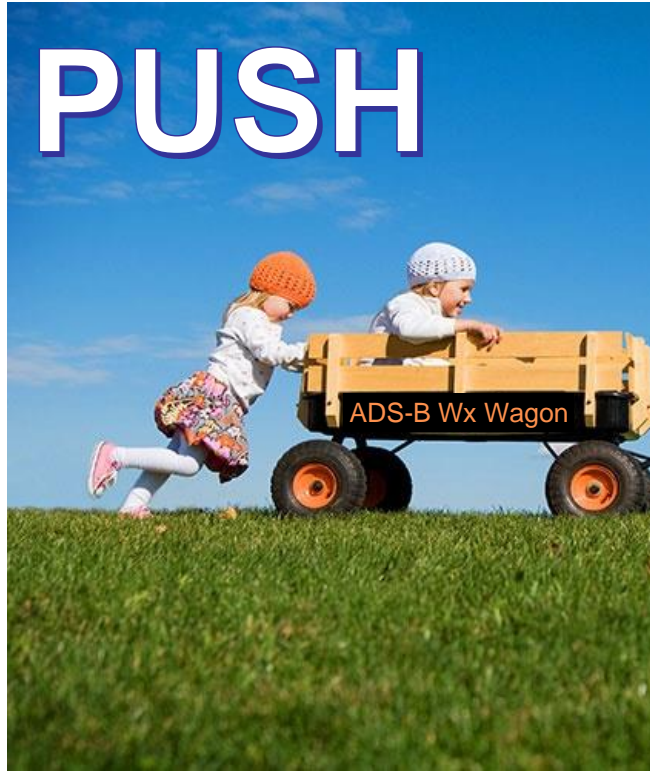
Help Answer the Question…

If You Build It, Will They Come???

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Support for ADS-B Wx Requirements

- **ALPA, AOPA, ATO Top-5, A4A, NextGen Wx Division, IATA, NTSB, NWS, WMO and others endorse ADS-B Wx AIREP & PIREP development**
- **NTSB recommended to the FAA that ADS-B Wx requirements be incorporated into the TSOs for ADS-B V3 avionics and that Part 121 air carriers be required to equip with and operate ADS-B Wx capable avionics in ADS-B rule airspace**
- **The ADS-B Wx capabilities are specified in the RTCA/EUROCAE Minimum Operational Performance Standards (MOPS) as optional capabilities**
    - During the public comment period for the ADS-B V3 TSOs (C-166c and C-154d) multiple groups recommended that ADS-B Wx be specified as a native function
    - FAA did not accept these recommendations, indicating that a rule requiring ADS-B Wx capable avionics installation and operation could be supported by optional requirements
- **The ADS-B Rule is being modified to allow the use of either V2 or V3 avionics for rule compliance.**

FPAW Support for ADS-B Wx

Position Paper Outline

- **Background**
- **BLUF (Recommendations 1 & 2)**
- **About FPAW**
- **The History of ADS-B Wx**
- **ADS-B Wx: A Deeper Dive**
- **ADS-B Wx: Current Events**
- **ADS-B Wx: Additional FPAW Recommendations (3 & 4)**
- **ADS-B Wx: FPAW POCS**
  - Elizabeth Wilson & Stephen Darr

Recommendations

1. **FPAW recommends that Automatic Dependent Surveillance – Broadcast Weather (ADS-B Wx) Air Report (AIREP) and Pilot Report (PIREP) capabilities be implemented by avionics manufacturers and commercial and general aviation operators as early and as widely as possible.**

2. **FPAW also recommends that the Federal Aviation Administration (FAA), the National Weather Service (NWS), and the weather and aviation industries be prepared to fully leverage ADS-B Wx data as soon as it becomes available.**

3. **FPAW recommends that the NWS and FAA conduct a large-scale demonstration of the potential of ADS-B Wx using funds appropriated in support of the Weather Research and Forecasting Innovation Reauthorization Act of 2023 and/or the FAA reauthorization act or other appropriations.**

4. **FPAW recommends that, if ADS-B equipage incentives are again made available, the FAA makes such incentives available only to those operators that equip with ADS-B Wx capable avionics and that the NWS and FAA integrate ADS-B Wx data provided by aircraft equipped through an incentive program into any demonstration of the potential of ADS-B Wx.**

Discussion

Backup Charts

ADS-B Overview

- **Automatic**
  - Periodically transmits information with no pilot or operator input required
- **Dependent**
  - Position and velocity vector are derived from the Global Positioning System (GPS)
- **Surveillance**
  - A method of determining position of aircraft, vehicles, or other asset
- **Broadcast**
  - Transmitted information available to anyone with the appropriate receiving equipment

ADS-B Wx AIREP Overview

- **Automatic**
  - Continuously transmits Air Report (AIREP) information with no pilot or operator input required
- **Dependent**
  - AIREP data derived from onboard sensors and systems
  - Position derived from GNSS and onboard altimetry
- **Surveillance**
  - A method of continuously determining in situ atmospheric conditions in real-time
- **Broadcast**
  - AIREP information available to anyone with the appropriate receiving equipment

ADS-B Wx PIREP Overview

- **Automatic (On-condition)**
  - Pilot-initiated, automatic transmission of Pilot Report (PIREP) information
- **Dependent**
  - PIREP location derived from historical aircraft track and PIREP time
  - PIREP data may be manually entered or derived from sensors and systems onboard the aircraft
- **Surveillance**
  - A method of rapidly providing pilot observed weather conditions
- **Broadcast**
  - PIREP message data intended for ground-based processing

AIREP Parameters: 1090ES Messages

	Weather State Message 2.2 [s] Broadcast Interval	Alternate Weather State Message 2.2 [s] Broadcast Interval	Emergency/Priority Status Message 5.0 [s] Broadcast interval	Aircraft State Message 5.0 [s] Broadcast Interval
1	Icing Status	Icing Status (EHS Optional)	Mean EDR	Aircraft Configuration
2	Wind Quality Indicator	Roll Angle	Peak EDR	Aircraft Type
3	Wind Speed	Heading Type	Peak EDR Offset	Gross Weight
4	Wind Direction	Heading	Water Vapor	Wingspan
5	Air Temperature Type	Air Temperature Type		
6	Air Temperature	Air Temperature		
7	Airspeed Type	Airspeed Type		
8	Airspeed	Airspeed		

- **Only those parameters that the aircraft is equipped to send are sent**
- **There is no requirement for aircraft to equip to send all parameters**

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AIREP Parameters: UAT Payload Element Subtypes

	Wind and Turbulence Message 12 [s] Broadcast Interval	Water Temperature and ARV Message 12 [s] Broadcast Interval	Aircraft State Message 12 [s] Broadcast Interval
1	Wind Quality Indicator	Icing Status	Aircraft Configuration
2	Wind Speed	Air Temperature Type	Aircraft Type
3	Wind Direction	Air Temperature	Gross Weight
4	Mean EDR	Airspeed Type	Wingspan
5	Peak EDR	Airspeed	
6	Peak EDR Offset	Water Vapor	
7	Roll Angle	Heading Type	
8	Airspeed	Heading	

- **Only those parameters that the aircraft is equipped to send are sent**
- **There is no requirement for aircraft to equip to send all parameters**

PIREP Parameters: 1090ES Messages (PIREP Data, not an Encoded PIREP)

	Flight Weather Message On-condition Broadcast	Temp, Wind & Turbulence Message On-condition Broadcast	Hazardous Weather Message On-condition Broadcast
1	PIREP Time	PIREP Air Temperature	PIREP Icing
2	Flight Visibility	PIREP Air Temperature Type	Airspeed Change
3	Flight Weather 1	PIREP Wind Direction	Wind Shear Height
4	Flight Weather 2	PIREP Wind Speed	Braking Action
5	Flight Weather 3	Turbulence Duration	Runway Number
6	Layer 'A' Height	Turbulence Intensity	Runway Position
7	Layer 'A' Thickness	Turbulence Location	Layer 'C' Height
8	Layer 'A' Height Type	Layer 'B' Height	Layer 'C' Thickness
9	Layer 'A' Coverage	Layer 'B' Thickness	Layer 'C' Height Type
10		Layer 'B' Height Type	Layer 'C' Coverage
11		Layer 'B' Coverage	Flight Weather 1 Vicinity Direction
12			Flight Weather 2 Vicinity Direction
13			Turbulence Type

- **Only those parameters that the pilot chooses to send are sent, there is no requirement to send every parameter**

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PIREP Parameters: UAT PIREP Payload Frame (PIREP Data, not an Encoded PIREP)

	PIREP Payload Frame On-condition Broadcast		
1	PIREP Time	PIREP Wind Direction	Wind Shear Height
2	Flight Visibility	PIREP Wind Speed	Braking Action
3	Flight Weather 1	Turbulence Duration	Runway Number
4	Flight Weather 2	Turbulence Intensity	Runway Position
5	Flight Weather 3	Turbulence Location	Layer 'C' Height
6	Layer 'A' Height	Layer 'B' Height	Layer 'C' Thickness
7	Layer 'A' Thickness	Layer 'B' Thickness	Layer 'C' Height Type
8	Layer 'A' Height Type	Layer 'B' Height Type	Layer 'C' Coverage
9	Layer 'A' Coverage	Layer 'B' Coverage	Flight Weather 1 Vicinity Direction
10	PIREP Air Temperature	PIREP Icing	Flight Weather 2 Vicinity Direction
11	PIREP Air Temperature Type	Airspeed Change	Turbulence Type

- **Only those parameters that the pilot chooses to send are sent, there is no requirement to send every parameter**