Potential Use of ADS-B 1090 Extended Squitter Message Set For Wake Turbulence Avoidance Applications

Briefing to RTCA SC 186 WG 3 - ADS-B 1090 MHz Extended Squitter MOPS

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Wake Turbulence Impacts on NextGen and SESAR Operational Concepts

- **Wake turbulence avoidance is a primary constraint on the NAS**
  - Reduced separation distances can not be implemented unless safety from hazardous wake turbulence is assured
  - NextGen and SESAR concepts required significant reductions in separations to achieve capacity goals
- **More than 30 JPDO operational improvements (OIs) and SESAR lines of change (LoC) could be impacted by wake considerations**
  - 10 are specific to wake avoidance applications
  - 23 involve reduced separation where wake considerations may be a factor
- **Wake turbulence separation standards significantly limit the capacity of the NAS**
  - Especially when Instrument Flight Rules (IFR) operations are in effect
  - A380 wake safety concerns resulted in increased separation distances
  - Safe wake separations for emerging aircraft types (e.g. VLJs) are TBD

Ambient Atmospheric Conditions Critically Impact Wake Vortex Lifetimes

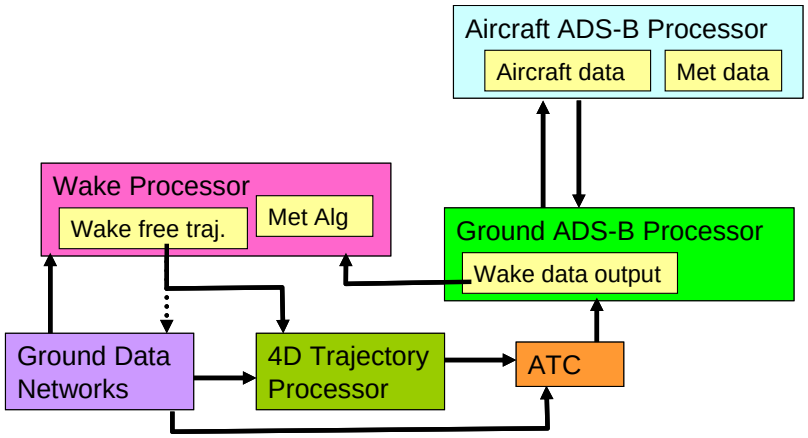
- **The temporal and spatial scales of hazardous aircraft wake turbulence are critically dependent on ambient atmospheric conditions**
  - Highly turbulent atmospheres - hazardous wake turbulence may persist only 40-60 seconds
  - Stable atmospheric conditions - heavy aircraft may generate hazardous wake turbulence that persists more than 2 minutes
  - Spatial extent of wake hazard related to phase of flight (e.g. aircraft in cruise travel ~ 8 miles/min)
- **Mid-term & far-term wake avoidance applications will require atmospheric profile information**
- **ADS-B equipped aircraft have the potential to measure and report meteorological data at a high resolution, under all weather conditions, over regions of operational interest**

Broadcast Data Link Requirement

- **Broadcast link of relevant atmospheric and aircraft data is required to accommodate the wide range of temporal and spatial scales associated with hazardous wake turbulence.**
- **To provide data when wake vortices are short-lived and during ascent and descent flight operations, a data broadcast frequency on the order of 15 seconds is desired.**
  - Terminal environment, 15 second update frequency provides a high likelihood of receiving broadcast data:
    - Every 1-2 miles traveled by the generating aircraft
    - Every 1000 ft or less during departure and arrival phases of flight
    - Less than 1000 ft vertically on approach where wake turbulence encounters can be most hazardous
  - Represents a report once every 2 miles typical at cruise speeds
    - High likelihood of receiving broadcast data on temporal and spatial scales consistent with the current separation en route separation standards (5 miles and +- 1000 ft)
- **Request-reply and other addressed data links appear inappropriate for transmission of data to multiple aircraft and ground stations at this frequency**
- **Previous RTCA and FAA studies produced recommendations for a broadcast data link of meteorological and aircraft data**

Proposed Wake Avoidance System

- **FAA Wake Turbulence Program proposes an initial ground-based wake turbulence avoidance application**
  - Application will be crosswind-based and will not rely on any wake decay mechanisms
  - First step in the development of a series of ADS-B supported wake avoidance applications enabling the transition to long-term NextGen and SESAR operational concepts
- **Set of data elements proposed is sufficiently robust to support envisioned NextGen and SESAR ground-based and airborne wake avoidance applications**
- **Has a high potential to produce early benefits for NAS users**
- **Follow on ground-based and airborne applications can use the same data elements**



Data Elements

- **General scientific agreement that real-time predictions of the movement and decay of aircraft wake vortices can be developed from a list of data elements that includes:**
  - Wind speed
  - Wind direction
  - Local temperature
  - Local barometric pressure
  - Aircraft type
  - Aircraft position
  - Aircraft speed and heading
  - Aircraft weight (previous results based on percentage of max landing weight)
  - Local atmospheric turbulence (normally eddy dissipation rate but total kinetic energy has also been used)

- **Additional utility for potential future applications may be gained if the list above is supplemented with:**
  - Aircraft configuration data (e.g. flap setting)

Most Required Data Elements in Existing ICAO & RTCA Message Sets

Data elements	ICAO report
Wind speed & direction Static Temperature Static Pressure Turbulence	Meteorological routine air report
Aircraft Type Wake Turbulence Category	Extended squitter aircraft ident. & category Aircraft Type
Aircraft Position	Extended squitter airborne position report Position report coarse Position report fine
Aircraft velocity	Extended squitter airborne velocity(Subtypes 1 and 2: Velocity over ground) Extended squitter airborne velocity report Air-referenced state vector
(vertical aircraft velocity)	Air/air state information 2 (aircraft intent)
Aircraft track & ground speed	Air/air state information 1 (aircraft state)

Similar Reports are Included in RTCA documents (e.g. RTCA/DO-260A)

Suggested Data Priorities for Wake Applications

Cumulative Capabilities →

Data Elements

- Wind speed
- Wind direction
- Local temperature
- Local barometric pressure
- Aircraft position
- Aircraft speed & heading

- Aircraft type
- Aircraft weight
- Atmos.turbulence

- Aircraft configuration data (e.g. flap setting)

1st Priority

Ground-based system extracts aircraft type & weight estimates from ground-based networks (based on Mode S Ident). Generates safe trajectories for ATC DSTs

2nd Priority

Provides improved ground-based capabilities & enables airborne applications. Provides data for calculation of wake decay and more precise prediction of wake vortex movement. Provides data to enhance meteorological forecasts

3rd Priority

Provides aircraft data specific to phase of flight for highly dynamic NextGen & SESAR operational concepts. Supports precise determination of aircraft trajectory changes. Enables advanced aircraft specific prediction of wake vortex movement & decay,

Collaborative Working Arrangement Desired

- **The FAA wake turbulence program proposes to work with the SC-186 Work Group 3 team to determine:**
  - Most appropriate raw data sources for populating ADS-B registers
  - Required data update rates
  - Modifications to the planned ADS-B message elements, where required
- **A minimal set of additional message elements is required**
  - Aircraft weight
  - Aircraft configuration (for determining phase of flight for wake purposes)
- **Additional aircraft wake vortex categories are required**

Questions?