Integration of surveillance in the ACC automation system

ICAO Seminar on the Implementation of Aeronautical Surveillance and Automation Systems in the SAM Region

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Outline

- Surveillance Categories
- Example of Integration & processing of ADS-B in ACC
- Surveillance tracker
- Surveillance impact
Surveillance Categories

2 broad surveillance categories: Hi-surveillance and Lo-surveillance.

**Hi-surveillance:**
- Surveillance technologies with frequent updates to aircraft position (typically between 1-12 seconds) and that are used for the provision of “radar like” separation.
  - Primary Radar.
  - Secondary Radar: SSR Modes A/C, SSR Mode-S.
  - Automatic Dependent Surveillance: ADS-B (Broadcast).
  - Multi-Lateration: Wide-Area (WAM) or Airport.

**Lo-surveillance:**
- Either no surveillance or surveillance technologies with less frequent updates of position (for example several minutes out to 20-30 minutes) and that support the provision of procedural separation.
  - Automatic Dependent Surveillance: ADS-C (Contract) for FANS and ATN, which downlinks a wide range of ADD and other information such as intent data or MET data.
  - No surveillance data (FPL based position data only).

Surveillance data is also the source data for **Safety-Net processing and supports conformance monitoring.**
Example of integration & processing of ADS-B in ACC
ADS-B Processing By ATM Systems

ADS-B Front Processing
- Collects ADS-B reports from ground stations
  - Asterix CAT 21
- Filters and distributes tracks to ADS-B Track Processor.

ADS-B Processing
- Receives ADS-B data from Front Processor
- Updates ADS-B system tracks.
  - Track Reception
  - System Track Synchronization
  - Vertical rate processing
  - Track Quality Processing
  - Track Extrapolation
  - Track Coasting
  - QNH correction of barometric flight levels
  - Dual node switchover management
  - System Track Distribution

Core ADS-B data
- Airframe identifier (ICAO 24-bit address)
- Position: Latitude and Longitude
- Altitude: Barometric and Geometric
- Figure of Merit
- Aircraft Identification (Callsign)
- Emitter category

Additional ADS-B data
- Ground vector: Ground Track, Ground Speed and Vertical Rate
- Air vector: Heading, Indicated Air Speed, and Vertical Rate
- Short term trajectory intent
- Rate of turn
- Aircraft type
A track is created based on the ICAO-24 bit identifier.

- A received report is considered to be matching if the ICAO 24-bit identifier exists in ADS-B-FP and the position reported is within a specific range of the other track.

Flight plan correlation is based on Callsign and ICAO-24 bit identifier matching.

A track is updated when a received report matches an existing ADS-B track.
Navigation Integrity Category (NIC) is a measure of confidence in the transmitted position data determined by the avionics:

- A high NIC indicates a high integrity position data from avionics source (GPS)

When received and re-forwarded by ADS-B ground stations, NIC is (improperly) re-named Figure Of Merit

Confidence Filtering:

- Checks the figure of merit (FOM) against an offline defined threshold
- Disregards the message if FOM does not meet the threshold

Ground stations are offline defined as reliable or unreliable:

- If a track is received by a reliable ground station then the track shall be flagged as reliable.
- If a track is received by an unreliable ground station then the track shall be flagged as unreliable.
- If the track is received by more than 1 ground station then the track shall be flagged as reliable irrespective of the individual station definition.
If the Track is Reliable and the FOM is above a threshold, then the track quality is High.

If the Track is Unreliable or the FOM is below the defined threshold then the quality is Low.

Track transition from Low Quality to High Quality and vice versa is dependent on receiving consecutive updates.

Track quality is a determinant of the operational services that can be provided.
ADS-B and Multi-Sensor Symbol Concepts

Hi-Surveillance Tracks

- Multi-Sensor: Hi-LOS
  - Use of 3NM/5NM

- Multi-Sensor: Lo-LOS
  - Use larger Surv Sep

Lo-Surveillance Tracks

- ADS-C: Hi-LOS
  - ADS Distance allowed
  - High ADS FOM

- ADS-C: Lo-LOS
  - ADS Distance not allowed
  - Low ADS FOM

Other symbols seen in particular circumstances

- Primary Only
- ADS-B Lo-Quality Only
- Last Surveillance Position

ADS-B track symbology must fit within a coherent concept in a Multi-Sensor Tracking environment: for example Level-Of-Service (LOS) concepts.
Surveillance tracker
Different Surveillance Technologies

Radar, ADS-B, WAM Fused System Tracks

- Single system track for all sensors
- Fusion of all relevant downlinked data
- More accurate tracking

Surveillance Processor

ACARS Network

CPDLC Communication

ADS-C Surveillance

Radar Surveillance

WAM Surveillance

ADS-B Network

ADS-B Surveillance

WAM Network

Radar Coverage

WAM Coverage

Radar, ADS-B, WAM Coverage

Fusion of all relevant data

More accurate tracking
Combined Surveillance

All surveillance sources combined into a single track

- ADS-B tracks
- WAM tracks
- Radar Tracks
- ADS-C tracks
- (datalink)
- Flight Plan tracks

Combined Tracks
One key component impacted by the addition of new surveillance means is the surveillance tracker.

Multi-sensor tracking fuses data from several sources to produce a single system track:

- Primary and Secondary Radar (traditional surveillance);
- SSR Mode A/C, SSR Mode S
- ADS-B;
- Wide Area Multi-Lateration.

These data need to be fused together, forming one “multi-sensor system track” that represents the consolidated estimate of the physical position of the aircraft. Fusion needs to address the following:

- The update rates of the various sources of data;
- The integrity of the positional data received;
- Relevant Downlinked Aircraft Parameters (DAPs).

In addition to positional data both Mode-S and ADS-B are capable of downlinking aircraft parameters (DAP) and limited aircraft intent data.

- Note the set of DAP supported by ADS-B and Mode-S are different
Multi-Sensor Tracking - 2

Fused System Tracks
1. Single system track for all sensors
2. Fusion of relevant downlinked data
When multi-sensor tracking is not used multi-radar tracking fuses data from radar sources only to produce a single system radar track.

Other surveillance sources, if present, are used when radar is not available:

- A surveillance hierarchy concept: aircraft passing out of radar coverage transition to ADS-B/WAM.
Surveillance Hierarchy Concept

Track Hierarchy Scheme
1. Single system track based on radar.
2. ADS-B (or others) only displayed if radar not available (managed at HMI level).
3. Downlinked data according to source.
ADS-B and Track Hierarchy Symbol Concepts

Radar tracks

High Quality ADS-B track

ADS-B Symbology must be considered within the ANSP overall symbology concepts.

Separate symbol for Low Quality ADS-B tracks.
Mono-Radar tracking refers to the use of surveillance data from a single radar only. Mono-Sensor refers to the display of data from a single sensor type:

The use of data from ADS-B only (no other contributing sensor types) can occur in two prime cases:
• An operator chooses to a mono-sensor display of ADS-B.
• Only ADS-B covers the relevant area (for example in continental airspace).

• High Quality ADS-B tracks (High FOM and Reliable) can be used for the provision of hi-surveillance “radar like” separation in en-route airspace:
• Low Quality ADS-B tracks (Low FOM or Unreliable) cannot be used for the provision of hi-surveillance services including “radar like” separation.
Operationally equivalent to a FPASD track, but able to be monitored.

The use of data from WAM only (no other contributing sensor types) can occur in several cases:
• An operator chooses to a mono-sensor display of WAM.
• Only WAM covers the relevant area.
• For particular types of operation such as PRM.

• WAM is yet to be certified for the provision of hi-surveillance separation services.
• This limits its usability in the first two cases at the current time.
Surveillance Data Fusion

Test result: Accuracy improvement

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Air Operations

THALES
Surveillance impact
Surveillance impact

FDP
- Update current position,
- Prediction trajectory,
- Use additional data (e.g. rate of climb)

Safety Nets (STCA, MSAW, Area Proximity Warning, TCAS RA…)

Conformance monitoring (RAM, CLAM, FLIPCY….)

HMI
- Sensor data fusion impact on track display

Improvement of Safety Nets
More accurate Trajectory Prediction.
Elementary data fusion:

- MODE S information storing & distribution
  - Mode-S already mandated in Europe
- Plot/Track association based on ICAO 24 bits MODE S address
- Quick initialisation
- 25 feet as well as 100 feet altitude resolution capabilities handled by altitude tracking
- Code 3A direct acquisition from Mode S plot
Enhancement of surveillance data fusion: DAPS (2/3)

Advanced Data Fusion:

Downlinked Aircraft Parameters (DAPs).
- ACAS Resolution Advisories
- FMS Selected Level
- Track and turn reports
- Heading and speed reports
- Intent data
- …

Use of DAPs.
- DAPS for alerting purpose
  - Selected level / Cleared Flight level
- DAPs used for data fusion include:
  - Roll angle / true air speed
  - True track angle
  - Track angle rate
  - Barometric altitude rate
- Quality and availability of DAPs mainly depends on:
  - The on-board equipment but also on available bandwidth
  - Automation system checking DAPS to reinforce their integrity

Before DAPs can be fully trusted for critical functions, their use is required to be regulated:
- Linked to regional mandates on equipage;
- Avionics need to be certified against those mandates;
- Policies and procedures need to be put into place on the use of these data.
ADS-B and Multi-Lateration Data offers improvements over traditional Radar data in:

- Improved positional data update rate of around 1 report per second
- More accurate position
- May be used for Parallel Runway Monitoring

ADS-B Data offers additional improvements over Multi-Lateration and traditional Radar data in:

- Direct velocity vector Information
  (Radar velocity vector can be up to 7 seconds behind the actual aircraft vector)
- Rate of Turn Information
- Rate of Climb/Decent Information
- Future Intent Information