Us of 1090 MHz Extended Squitter for ADS-B

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ADS-B: A means by which aircraft, aerodrome vehicles and other objects can automatically transmit and/or receive data such as identification, position and additional data, as appropriate, in a broadcast mode.

The digital radio that support ADS-B and standardized by ICAO are:

* 1090 MHz extended squitter (ES)
* VDL Mode 4
* UAT
Identify and altitude in SSR environment

Current ATM systems use Mode A codes associated with call-sign
ADS-B Messages

- Airborne or surface position report
- Aircraft identification - Category
- Velocity - Heading
- Emergency / Priority
- An event-driven information
- ACAS RA Broadcast
- Operational status

Not Mode A codes; an 8 character A/C ID
Contents of some registers in Mode S XPDR can be broadcasted with extended squitter hence ADS-B.

Registers (00 to FF$_{\text{HEX}}$) contain A/C information.

- Identity
- Track and Turn Report
- Heading and Speed Report

Mode S transponder

Registers enable downlinking (and broadcasting) of A/C data.
1090 MHz Extended Squitter

* Recognized as the most common element in early implementations of ADS-B (11th Air Navigation Conference, Rec.7/1)

* Standardized by ICAO (Annex 10, Volumes III and IV supplemented by a new manual (Doc 9871))

* Certified airborne equipment and ground stations (for air-to-ground ADS-B) commercially available
1090 ES transmitters

A/C in flight

ES rate is slightly randomized and varies from 2/s (for position/velocity) 0.2/s (for identification)

Obstacle

TIS-B Station

A/C on ground

Surface vehicle
Traffic Information Service - Broadcast (TIS-B)
ADS-Rebroadcast (ADS-R)

Aircraft has to be equipped with ES receiver/display to use the service

Radar
ADS-B
Other A/C Data

Broadcast of A/C Positions by ES
1090 ES Signal In Space

Same as for Mode S reply to ground interrogation

Preamble (8 uS) Data block (112 uS)

1090 MHz Carrier
ES signal can be emitted from Mode S transponders or non-transponder (NT) devices (airborne or else)

<table>
<thead>
<tr>
<th>DF 17</th>
<th>CA</th>
<th>24-Bits A/C Address</th>
<th>Parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>56 Bits</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Indicates ADS-B, TIS-B, etc

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112 Bits
The 24-bit aircraft address is essential for Mode S and ADS-B

- Annex 10, Volume III, part I shows a worldwide scheme for allocation/assignment of this address
  - Provides blocks of consecutive addresses to ICAO States for assignment to aircraft
  - 24 bits --> 16,777,216 addresses allocated among 177 States

<table>
<thead>
<tr>
<th>Country</th>
<th>Code</th>
<th>No. of Aircraft Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>0111 0000 0000</td>
<td>700₁₆, 12 bits = 4096</td>
</tr>
<tr>
<td>United States</td>
<td>1010</td>
<td>A₁₆, 20 bits = 1,048,576</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>0000 0000 0100</td>
<td>004x₁₆, 10 bits = 1024</td>
</tr>
</tbody>
</table>
ES Versions

Version 0: In Annex 10 since 2002

Version 1: Being processed

Version number only affects the message contents

The two versions are interoperable (as per SARPs)

Version 1 has more elaborate indication of accuracy and integrity.

Both versions described in Doc 9871.
The aircraft should indicate in its ADS-B messages how much trust can be placed on its reported position and velocity.

Version 0: Navigation Uncertainty (NUC)

- NUC_P (for position): From 0 to 9
- NUC_R (for velocity): From 0 to 4

Higher NUC = Higher report quality
More on Integrity, Accuracy, etc

Version 1: Navigation Accuracy Category (NAC)

Navigation Integrity Category (NIC)

Surveillance Integrity Level (SIL)

NIC: Integrity containment Radius (Rc)

Value: 0 to 11

SIL: probability that the actual position is outside the big circle

Value: 0 to 3

Higher Values = better reports

NACp: 95% bound on position accuracy

Value: 0 to 11 for P

0 to 4 for V
<table>
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<tr>
<th>56 Bits</th>
</tr>
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<tbody>
<tr>
<td><strong>Bits 1 to 5</strong></td>
</tr>
<tr>
<td><strong>TYPE Code</strong>: specifies what type of ES message is being transmitted. It also shows <strong>NUC</strong> (in Version 0) or <strong>NIC</strong> (in Version 1)</td>
</tr>
<tr>
<td><strong>Bits 11-13 in airborne velocity ES show</strong> <strong>NUCr</strong> or <strong>NACv</strong></td>
</tr>
<tr>
<td><strong>Bits 45-48 in A/C Operational Status ES shows</strong> <strong>NACp</strong></td>
</tr>
<tr>
<td><strong>Bits 51-52 in A/C Operational Status ES show</strong> <strong>SIL</strong></td>
</tr>
</tbody>
</table>
Is ADS-B as good as SSR?

Early studies suggest that minimum requirements for ADS-B to enable 5 NM separation (like for SSR) should be:

- **NAC ≥ 7** (i.e. accuracy of 0.1 NM or better)
- **NIC (or NUC) ≥ 5** (i.e. \( R_c = 0.5 \) NM)
- **SIL ≥ 2** (i.e. Prob. Of exceeding \( R_c = 10^{-5} \))
- **Latency ≤ 4 Seconds**
- **Update rate ≥ once every 12 Seconds**
Airborne equipment for ADS-B Out (using a Mode S transponder)

**Variable Data**
- Pressure altitude
- On-the-ground condition
- **Position, Velocity, Time**

**Fixed Data**
- Mode S address (24 bits)
- Maximum airspeed category
- Tail number/registration number (optional)

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**Transponder**
- **1030 MHz Receiver**
- **1090 MHz Transmitter**
- **Interrogations**
  -**Replies**
    - Short Squitters
    - Extended Squitters

**Pilot Controls**
- **Pilot-entered Variable Data**
  - Mode 3/A identification code
  - Special Position Identification (SPI)
  - Flight ID (optional)
A Navigation source (most commonly a GNSS receiver) is needed onboard to enable ADS-B ADS-B (for position and velocity information)

Alternate navigation sources are available on many large aircraft
   INS (Inertial Navigation System)
   DME / DME ranging (Distance Measuring Equipment)

For small aircraft (General Aviation), GNSS is the best navigation data source
As part of Elementary and Enhanced Surveillance mandates, most aircraft flying in/to Europe are already ES-capable. Other Mode S transponders can easily be upgraded.
A proper ground infrastructure is required to ensure timely delivery of ADS-B messages to ATS units. The system should provide proper availability, integrity, transit time and so on in order for the data to be operationally useful.
Equipage of A/C with “ADS-B Out and In” improves situational awareness in the flight deck.

ADS-B ES Coverage

Areas

(Ground Surveillance available)

Air-Air Surveillance
Related Documents

Annex 10, volume IV (Broad SARPs on ES)

Doc 9871 – Technical Provisions for Mode S Services and Extended Squitter
(In production – draft version available on the SCRSP website
www.icao.int/anb/panels/scrsp)

RTCA DO 242A – MASPS for ADS-B

RTCA DO 260 – MOPS (ES Version 0)

RTCA DO 260 A – MOPS (ES Version 1)
Thank you
Any Questions?