Abstract: Automatic Dependent Surveillance-Broadcast is a mandated technology that will transform the global surveillance infrastructure over the next 15 years. It introduces a variety of new capabilities for Air Navigation Service Providers (ANSPs), pilots and aircraft operations.

Background

With airspace becoming increasingly crowded, safety and efficiency upgrades – especially those involving situational awareness and pilot resource management – mandated by global international regulatory agencies are a fact of aviation life.

Clearly, expected increases in air traffic levels worldwide – ICAO estimates increases of 3 to 15 percent per year depending on region – inevitably require corresponding increases in air traffic control capacity.

Nevertheless, there is no question within the international aviation community that Automatic Dependent Surveillance-Broadcast (ADS-B) will transform air traffic control and bring both safety and significant cost efficiencies to operators, pilots and, ultimately, travelers in every segment of the aviation spectrum. ADS-B mandates have been adopted globally along with more specific dual frequency mandates in the USA.

This emerging technology holds the promise of revolutionizing the global surveillance infrastructure over the next 15 years. It will bring a variety of new capabilities to Air Navigation Service Providers (ANSPs) and aircraft operators alike.

ADS-B mandates have been adopted globally along with expanded dual frequency services for general aviation in the U.S. This new global ADS-B airspace surveillance system will overcome limitations associated with the current surveillance systems that rely on interrogations from traditional radar systems. The transition to ADS-B based surveillance will allow more accuracy and efficiency, enhanced coverage and reduced installation and maintenance costs.

Today, most air traffic control radar systems fall into two categories: Primary Surveillance Radars (PSRs) that transmit electromagnetic pulses and detect the echoes to identify targets in the surveillance area, and Secondary Surveillance Radars (SSRs) that transmit coded messages and receive replies from transponder-equipped aircraft. The data collected by PSRs and SSRs is usually combined in an automation system that generates an airspace picture used by controllers to maintain separation between aircraft.
However, PSRs have difficulty discriminating airplanes from migratory birds and rain “clutter.” In addition, these radar signals tend to degrade with range. Furthermore, any ground-based radar offers no help for oceanic flights where there is great potential for improved routing and in-trail procedures.

ADS-B technology using onboard position reporting becomes an enabler for improved surveillance, to more accurately track aircraft anywhere in the world. The aircraft determines its own satellite-based position. This information (along with identification, category, velocity, status and other important data) is broadcast every second and can be received by air traffic control ground stations as a supplement to secondary radar or used by other aircraft to provide better situational awareness.

In the US, Automatic Dependent Surveillance-Broadcast (ADS-B) technology provides four distinct services:

- Automatic Dependent Surveillance-Broadcast (ADS-B)
- Automatic Dependent Surveillance-Rebroadcast (ADS-R)
- Traffic Information Service-Broadcast (TIS-B)
- Flight Information Service-Broadcast (FIS-B)

These ADS-B services are aircraft class specific, but work together to support critical air traffic control surveillance applications. ADS-B services are organized under two “umbrellas”: ADS-B Out and ADS-B In.

- **ADS-B Out** – The broadcast of GPS-based position and other aircraft information.
- **ADS-B In** – The reception of ADS-B Out broadcasts to be received by aircraft.

As the name implies, aircraft equipped for ADS-B Out periodically broadcast information about themselves, such as identification, current position, altitude, and velocity, through an onboard transmitter. ADS-B Out thus provides air traffic controllers and any other suitably equipped aircraft with real-time position and intent information.

The basic ADS-B surveillance architecture consists of a Mode S transponder with extended squitter capability (for ADS-B Out) and a TCAS traffic computer (for ADS-B In).

Implementation of ADS-B In is already in use by several airlines and general aviation operators. While there are no current mandates for ADS-B In, there are significant benefits for aircraft so equipped. At present, aircraft crossing the ocean at altitudes commonly used by most airlines are required to stay in a track at a given flight level with defined time-based separation “in-trail,” an approximately 80-nautical-mile buffer, between aircraft. However, what happens when one aircraft is able to transition to a more fuel-efficient altitude, but is blocked by nearby aircraft?

ADS-B In reduces that buffer to less than 15 nm, allowing airlines to utilize In-Trail Procedures (ITP), enabling an aircraft to safely move to a more optimum altitude thus reducing fuel costs, improving ride quality or both. In this way, more aircraft will be able to fly at the most optimum altitudes for overall fuel savings.

In addition to the ADS-B “broadcast” implementations that utilize the aircraft Mode S transponder, Automatic Dependent Surveillance-Contract (FANS ADS-C) is used primarily in oceanic and remote airspace, taking advantage of both satellite communication and satellite navigation (GPS) to effectively create a virtual radar environment for safe passage of aircraft. ADS-C equipped aircraft issue a periodic report – typically every five or ten minutes – of aircraft position over ACARS (and SATCOM) datalinks from the aircraft to ATC.
**ADS-B provides more accurate and consistent aircraft positioning, inexpensive traffic awareness service for other nearby aircraft, and a more cost-effective solution for deployment than ground-based radar systems.**

**Benefits of ADS-B Out**

In the broadest view, the major benefits of ADS-B Out/In are to increase airspace capacity for a given airport or in oceanic regions at the same or higher level of safety.

Many current or upcoming mandates add functionality for the operator resulting in a variety of safety and cost efficiencies.

<table>
<thead>
<tr>
<th>Capability</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Traffic Situational Awareness During Flight Operations (AIRB)</td>
<td>NOW</td>
</tr>
<tr>
<td>Flight crew awareness of airborne traffic by adding aircraft ID, ground speed, and a wake vortex category to the traditional TCAS target report display</td>
<td></td>
</tr>
<tr>
<td>In-Trail Procedures (ITP)</td>
<td>NOW</td>
</tr>
<tr>
<td>Enables flight level changes in non-radar airspace with reduced separation standards. With the latest ADS-B upgrades, airlines can take advantage of in-trail procedures that will allow the lower aircraft to transition to a more efficient altitude. Operator benefits include reduced fuel consumption and increased cargo payload</td>
<td></td>
</tr>
<tr>
<td>Flight Deck Interval Management (FIM)</td>
<td>SOON</td>
</tr>
<tr>
<td>Provides flight crew with the ability to adjust space with respect to another aircraft; operator benefits include increased airport arrival rates and reduced fuel use</td>
<td></td>
</tr>
<tr>
<td>Enhanced Visual Separation on Approach (VSA)</td>
<td>SOON</td>
</tr>
<tr>
<td>Use of cockpit display of airborne traffic to assist in acquiring target for visual approaches, allowing increased airport arrival rates through broader use of visual approaches</td>
<td></td>
</tr>
<tr>
<td>Enhanced Traffic Situational Awareness on the Airport Surface (SURF)</td>
<td>SOON</td>
</tr>
<tr>
<td>Cockpit display of traffic overlaid on an airport moving map</td>
<td></td>
</tr>
<tr>
<td>Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF IA)</td>
<td>FUTURE</td>
</tr>
<tr>
<td>Flight crew alerting of potentially hazardous traffic on and near the airport surface; Operator safety benefits include reduced collisions and reduced runway incursions</td>
<td></td>
</tr>
<tr>
<td>Traffic Situation Awareness with Alerts (TSAA)</td>
<td>FUTURE</td>
</tr>
<tr>
<td>Airborne collision avoidance for non-TCAS II-equipped aircraft, though no resolution advisory provided and will not be mandated. Operational benefit: reduced mid-air collision risk through increased traffic situational awareness</td>
<td></td>
</tr>
</tbody>
</table>
Honeywell continues to play a key role in integrating ADS-B technologies and participates globally with both the FAA NextGen and SESAR ATM implementation programs.

RTCA DO-260 Evolution to DO-260A/B

RTCA, Inc. is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. In September 2000, RTCA Special Committee 186 issued Document (DO) 260 containing Minimum Operational Performance Standards (MOPS) for airborne equipment for Automatic Dependent Surveillance. This evolving document was superseded by DO-260A and by the current version, DO-260B, in December 2009. Further revisions and updates are expected as technologies develop.

A brief technical review of the differences in the standard may be helpful in understanding its evolution.

Transponders designed to the original DO-260 standard transmit “Navigation Uncertainty Category” (NUC) which might be based on Horizontal Protection Limit (HPL) or Horizontal Figure of Merit (HFOM) – but the receiving system does not know which is being transmitted.

DO-260A and DO-260B transponders remove the ambiguity by transmitting Navigation Integrity Category (NIC), Navigation Accuracy Category (NAC) and Source Integrity Level (SIL) in place of NUC. Thus, HPL is used to format NIC integrity bounds, HFOM is used to format NAC accuracy bounds and SIL indicates integrity level, that is, the probability of being out of NIC radius.

At present, DO-260-compliant transponders are acceptable for ADS-B Out usage near term for Non-Radar Area (NRA) applications such as the vicinity of Canada’s Hudson Bay.

DO-260B-compliant transponders, such as Honeywell’s TRA-100B, MST-100B, KT-74 and KXP-2290A will be required for ADS-B Out capability in the U.S. and/or Europe. [See timelines, Appendix].

Global industry cooperation

Honeywell participates with a number of regulatory organizations throughout the world which are focused on establishment of ADS-B plans, standards and infrastructure:

- RTCA SC-186
- Joint U.S./European Requirements Focus Group
- FAA ADS-B Aviation Rulemaking Committee
- FAA Merging and Spacing Working Group
- NavCanada ADS-B Hudson Bay Implementation planning
- SESAR Joint Undertaking
- Air Services Australia ADS-B Trials

Bringing transponders into DO-260B compliance

All new ADS-B Out requirements are being written to the DO-260B standard. Fortunately, there are a broad range of products and solutions with ADS-B Out capabilities available today or in the final stages of development to ensure compliance with various mandates.

A key feature of the new generation of transponders, such as the Honeywell TRA-100B, is that they are provided through a simple software-loadable upgrade on the aircraft (“loadable “on wing”). This will allow airlines to address any future mandate changes in a fast and cost effective way.

Looking to the future: Reduction or elimination of ground-based radar

ADS-B is an enabler for Nextgen / SESAR systems infrastructure that will facilitate the evolution from a ground-based system of air traffic control to a satellite-based system of air traffic management.

To meet the challenges of space-based air traffic monitoring, ADS-B receivers on board Iridium NEXT satellites – Iridium’s second-generation global satellite constellation – will detect signals from next-generation-equipped commercial aircraft all over the world, including airways over oceans, mountains, remote areas and polar regions. Starting as early as 2017, an Iridium subsidiary, Aireon, will relay signals seamlessly to air traffic controllers on the ground, providing the first opportunity for global air traffic monitoring.

In short, ADS-B is an important enabler that will help to avoid gridlock in the sky and throughout the world’s airports.
Global ADS-B Out equipage mandate summary

<table>
<thead>
<tr>
<th>Aircraft registered in these countries require Mode S transponders with Extended Squitter capability in accordance with RTCA DO-260 or DO-260B:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Singapore</strong> mandate for all aircraft</td>
</tr>
<tr>
<td><strong>Australia</strong> mandate for forward-fit aircraft</td>
</tr>
<tr>
<td><strong>EASA (EU) mandate for forward-fit aircraft</strong></td>
</tr>
<tr>
<td><strong>Australia</strong> mandate for retrofit aircraft</td>
</tr>
<tr>
<td><strong>Indonesia</strong> mandate for all aircraft</td>
</tr>
<tr>
<td><strong>EASA (EU) mandate for retrofit aircraft</strong></td>
</tr>
<tr>
<td><strong>U.S. FAA mandate for all aircraft</strong></td>
</tr>
</tbody>
</table>

**ADS-B Out airspace mandates by country/region**

**Australia**
- Access to airspace at/above FL290
- Mandate 2 (GNSS) GC6 Aircraft first placed on the Australian Aircraft Register on/after 6 Feb 2014, must be equipped for IFR GNSS navigation in accordance with the standards meeting TSO-C145/-146/GG0196 or be approved by CASA as a RNP capable aircraft.
- Mandate 3 (Mode-S) GC6 Aircraft first placed on the Australian Civil Aircraft Register on/after 6 February 2014 must be Mode S transponder equipped for flight in airspace classifications A, B, C or E or for flight above 10000FT in Class G airspace.
- Mandate 4 (Mode-S): For any retrofit installation, it is mandatory to install a Mode S transponder with ADS-B capability, not a Mode A/C transponder, although the associated GNSS unit is not necessarily required to be installed at that time of retrofit.
- Mandate 5 (Mode-S): Any aircraft undertaking flight under the IFR in airspace classes A, B, C or E within an area 500NM from the North of Perth Airport to 500NM East of Perth Airport must be equipped to transmit ADS-B.
- Mandate 6 (ADS-B Out) GC5 Aircraft placed on the Australian Civil Aircraft Register before 6 February 2014 undertaking any flight under the IFR must be equipped to transmit ADS-B.
- Mandate 7 (ADS-B Out) GC5 Aircraft placed on the Australian Civil Aircraft Register on/after 6 February 2014 undertaking any flight under the IFR must be equipped to transmit ADS-B.
- Mandate 8 (ADS-B Out) GC5 Aircraft placed on the Australian Civil Aircraft Register before 6 February 2014 undertaking any flight under the IFR must be equipped to transmit ADS-B.

**Canada**
- Access to airspace

**China**
- Access to Airspace – B330 (JTG-P142), B213 (Chengdu GC6 Lhasa), B215 (Yinchuan GC6 Purpa), M771 (Dosut GC6 Dongra), L642 (Epkal GC6 Exoto), N892 (Migug GC6 Monbo), A1 (Bunta GC6 Lenko)
- Access to Airspace – L888 (Kuqa GC6 Sanli) H15 (Lanzhou GC6 Lhasa), Z1 (Xining GC6 Yushu)
- Pilot areas of the national lower-airspace management reforms in Northeast China, Central South China and Southwest China.
- Access to Airspace – B345 (Lhasa GC6 Nonim), A460 (Kuqa GC6 Rulad), H66 (Kuqa GC6 Kash), B206 (Fukang GC6 GOPTO), A368 (Urumchi GC6 Sarin), W112 (Jiayuguan GC6 Purpa), H72 (Dunhuang GC6 P242)
- Demonstrative operation of ADS-B in the total controlled airspaces of Xinjiang.
- Access to Airport: ADS-B in operation for Golmud, Jiayuguan, Zhangye, Yushu, Jinchang, Tianshui, Xiahe, Guyuan, Guoluo, Huutogou and other feeder airports in Shaanxi, Ganshu, Ningxia and Qinghai.
- ADS-B surveillance services in pilot areas of the national lower-airspace management reforms in Northeast China, Central South China and Southwest China.
- Provide ADS-B surveillance services for the aviation teaching and training work of Civil Aviation Flight University of China and Chaoyang Flight University as well as marine petroleum services and aerial forest protection work.
- Pilot ADS-B surveillance services for aerial fertilizer spraying in Heilongjiang declaration area.
- Access to Airport: ADS-B in operation for feeder airports in Yunnan, Sichuan, Northeast China and other regions.
- Access to Airspace: ADS-B in operation for upper air routes and airlines nationwide.
- Access to Airport: ADS-B surveillance services for airport towers nationwide.
- ADS-B surveillance services for terminal (approaching) controlled areas nationwide.
- GA: ADS-B in operation for controlled airspaces and monitored airspaces.
- GA: ADS-B surveillance coverage for the reporting airspaces with enormous demand for surveillance service data.

**Hong Kong**
- Aircraft flying over PBN routes L642 or M771 at or above FL290 within Hong Kong FIR.
- All aircraft flying within Hong Kong FIR at or above FL290.

**Indonesia**
- All aircraft operations at or above FL290

**Singapore**
- Access to Airspace - aircraft operating on Airways L642, M771, N891, M753, L644 and N892 bounded within Singapore FIR Boundary to 070000N 1080000E All airspace at or above FL290.

**Sri Lanka**
- Access to Airspace – aircraft operating within Colombo TMA at or above FL 290.

**Taiwan**
- All aircraft flying over routes B576 or B591 at or above FL290.
- All aircraft flying at or above FL290 within Taipei FIR, shall carry ADS-B Out equipage.

**Viet Nam**
- Authorization is required for all aircraft flying over ATS routes L625, M771, N892, L642, M765, M768, N500 and L628 at or above FL290 within the Ho Chi Minh FIR.
Global ADS-B Out Timeline

- **Gulf of Mexico**
  - ADS-B Out
  - DO-260A or later

- **Hudson Bay**
  - ADS-B Out (FL 350–400)
  - DO-260 or later

- **Australia**
  - Retrofitt Fit (FL 290+)
  - DO-260 or later

- **Singapore**
  - Retrofit (FL 290+)
  - DO-260 or later

- **Indonesia**
  - Retrofit (FL 290+)
  - DO-260 or later

- **Hong Kong**
  - PBN Routes (FL 290+)
  - DO-260 or DO-260A

- **EASA**
  - SA Aware GNSS

- **Hong Kong**
  - HKG FIR (FL 290+)
  - DO-260 or DO-260A

- **EASA**
  - Forward Fit
  - DO-260B or later

- **FAA ADS-B Out**
  - Forward Fit and Retrofit
  - DO-260B or later

- **EASA ADS-B Out**
  - Retrofit
  - DO-260B or later

**ADS-B In**
- No known rules (US Senate FAA Reauthorization Bill states 2018 for ADS-B In)

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**Product application updates: DO-260 through DO-260B**

<table>
<thead>
<tr>
<th>Product</th>
<th>Application</th>
<th>DO-260</th>
<th>DO-260A</th>
<th>DO-260B</th>
<th>DO-262B</th>
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<td>Air Transport</td>
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<td>TSO 4Q, 2015</td>
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<td>Epic</td>
<td>Regional, Helicopter</td>
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<td>Business Aviation</td>
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<td>Primus II</td>
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<td>APEX, KXP-2290A</td>
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<td>General Aviation</td>
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<td>KT-73</td>
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<td>Replace with KT-74 KGX Remote mount series</td>
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<td>KGX-150/130 Remote</td>
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<td>KGX Remote mount series</td>
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<tr>
<td>Mount ADS-B In/Out</td>
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</tbody>
</table>
TRA-100B specification highlights

- Weight: 13% weight reduction from TRA-67A (12.3 lbs. max.)
- Power consumption: 30W (115VAC-380/420Hz)
- DO-160G environmental qualification
- Data-loadable (ARINC 615A Ethernet)
- Meets all Airbus and Boeing OEM requirements
- Predicted reliability: MTBF 36,000 flight hours and MTBUR 30,000 flight hours
- Wiring changes are required for DO-260B retrofit (required for any transponder supplier)
- 5-year warranty for TRA-100B at time of retrofit
- Upgradable to Level 4/5 ELM (Extended Length Message) and ADLP (Aircraft Data Link Processor)

MST-100B specification highlights

- Small and lightweight
- DO-260B-compliant and meets next gen ADS-B OUT mandate
- Replaces MST-67A transponder
- BendixKing by Honeywell supported product

Built-In air transport features:

<table>
<thead>
<tr>
<th>Item</th>
<th>Air Transport Feature</th>
<th>MST Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>ARINC 600 4MCU</td>
<td>ARINC 400 2MCU</td>
</tr>
<tr>
<td>Spec</td>
<td>RTC DO-181/ED 73E RTCA DO-260B</td>
<td>SAME</td>
</tr>
<tr>
<td>SPEC Ext</td>
<td>A-TCAS Compatibility D-Antenna Diversity E-Extended Squitter N-Enhanced Surveillance S-Surveillance Identifier Code</td>
<td>SAME + Flavor without Diversity</td>
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<td>TX &amp; xT</td>
<td>(1) A429 OUT + (1) A429 IN</td>
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<td>Air Data</td>
<td>(2) 706-575 Air Data Input A429</td>
<td>SAME</td>
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<tr>
<td>GNSS</td>
<td>(2) GNSS Data input A429 (2) GPS Time Mark Provision</td>
<td>SAME</td>
</tr>
</tbody>
</table>

KGX ADS-B specification highlights

The BendixKing by Honeywell KGX ADS-B solutions are flexible, certified and affordable. The KGX series of UAT transceivers and receivers offer an ADS-B certified solution with or without an integrated WAAS GPS.

- Environmental Compliance: DO-160G
- TSO Compliance:
  - C154c (A1H/A1S)
  - C157a (Class 1 Incomplete System C195a (Class C1)
  - C145c (B1) – P/ (KGX 150 only)
- Software: RTCA/DO-178B Level C
- Hardware: RTCA/DO-254 Level C
- Power Required: 10-40 VDC
- Weight: 0.86 lbs (364 g) [0.98 lbs (454 g) with internal GPS]
- Width: 5.0 in (127 mm)
- Height: 1.7 in (43.18 mm)
- Length: 5.5 in (139.7 mm)
- Operating Temperature: -40°C to +70°C
- Storage Temperature: -55°C to +85°C
- Altitude: 50,000 feet
- Power Requirements:
  - 10 – 40 Volts DC,
  - Typical 0.22 A (0.34 A with GPS) @ 28 VDC
  - Peak 0.72 A (0.84 A with GPS) @ 28 VDC
- Transceiver Frequency: 978 MHz
- Transmitter Power: 40 Watts max at antenna
- Receiver Sensitivity: -99 dBm
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