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AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST WILL TRANSFORM AIR TRAFFIC CONTROL

A white paper on DO-260 mandates, Honeywell solutions, and expected benefits

Table of contents

Abstract:
Automatic Dependent Surveillance-Broadcast is one of the key enablers of airspace modernization across the globe. It will bring a variety of new capabilities to Air Navigation Service Providers (ANSP) and aircraft operators alike. Operators need to begin planning to meet various regional DO-260 mandates on their fleets.

1.0 Background

With commercial airspace becoming increasingly crowded, safety and efficiency upgrades mandated by international regulatory agencies are a fact of aviation life.

Clearly, expected increases in air traffic levels worldwide - ICAO estimates increases of 3.15 percent per year - inevitably require corresponding increases in air traffic control capacity.

However, necessary as the mandated systems are, the benefits and ultimate cost savings in lives and faster routing may not be seen right away. In fact, the ultimate beneficiaries, the flying public, may not even be aware that the system is being quietly and rigorously overhauled.

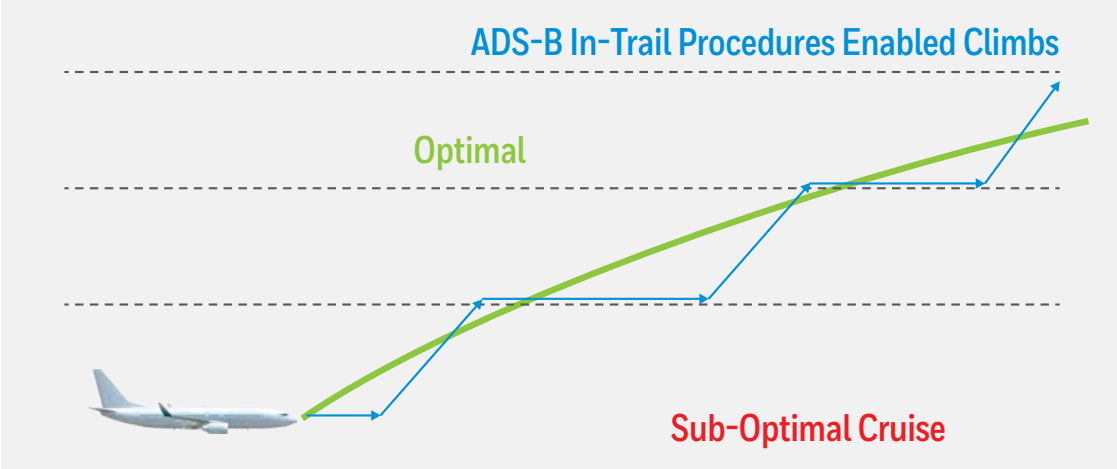
Nevertheless, there is no question within the international aviation community that Automatic Dependent Surveillance-Broadcast (ADS-B) will transform air traffic control and bring both safety and significant cost efficiencies to operators, and, ultimately, travelers in every segment of the aviation spectrum.

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 (ANSP) and aircraft operators alike.

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.[1]

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.

1. http://www.raytheon.com/newsroom/technology_today/2012_i2/airtraffic.html.



This is where ADS-B technology comes to the front as an onboard surveillance technology for tracking aircraft anywhere in the world. The aircraft determines its own position via satellite navigation and periodically broadcasts this information which can be received by air traffic control ground stations as a replacement for secondary radar or by other aircraft to provide situational awareness and allow self-separation. ADS-B refers to this general technology whereas DO-260, DO-260A, and DO-260B refer to specific RTCA minimum operating performance standards (MOPS) for an ADS-B system.

There are two commonly recognized types of Automatic Dependent Surveillance for aircraft applications.

- **ADS-B *Out* - Surveillance technology that *transmits* GPS-based position and other aircraft information.**
- **ADS-B *In* - Technology that *receives* other aircraft's transmitted ADS-B Out signals.**

As the name implies, ADS-B *Out* periodically broadcasts information about each aircraft, 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 information.

The basic ADS-B surveillance architecture consists of a Mode S transponder and GPS position source 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. 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 the 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 "broadcast" implementations, 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 issues a periodic report - typically every five or ten minutes - of aircraft position over ACARS (and SATCOM) from the aircraft to ATC.

1. FANS-2 is Boeing's name for highly integrated, seamless FANS-1 and PM-CPDLC ATM systems. Airbus uses FANS-B+ to signify PM-CPDLC ATM.

2.0 Benefits of ADS-B Out/In

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.

NOW	
Enhanced Traffic Situational Awareness During Flight Operations (AIRB)	Flight crew awareness of airborne traffic by adding aircraft ID, ground speed, and a wake vortex category to the traditional TCAS target report display.
In-Trail Procedures (ITP)	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.
SOON	
Flight Deck Interval Management (FIM)	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.
Enhanced Visual Separation on Approach (VSA)	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.
Enhanced Traffic Situational Awareness on the Airport Surface (SURF)	Cockpit display of traffic overlaid on an airport moving map.
FUTURE	
Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF IA)	Flight crew alerting of potentially hazardous traffic on and near the airport surface; Operator safety benefits include reduced collisions and reduced runway incursions.
Traffic Situation Awareness with Alerts (TSAA)	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.

3.0 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, will be required for ADS-B *Out* capability in the U.S. and Europe. [See timelines, Appendix].

4.0 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

5.0 Updated Timeline for Mandates

The European Union Single Sky Committee has amended the previous ADS-B *Out* mandate timelines with the following changes to the DO 260B ADS-B *Out* mandate.

June 7, 2020

Forward fit moved to **June 7, 2020** to align with retrofit.

Retrofit moved to **June 7, 2020**

These date changes were made by the European Commission to address the implementation problems of Europe's ADS-B Out rule and general lack of readiness in the industry for both the air and ground based elements of the solutions.

[See ADS-B chart in Appendix for country-by-country timelines.]

6.0 Bringing Aircraft into DO-260B Compliance

Honeywell has 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. All aircraft solutions consist of 3 pieces: DO-260B compliant transponder, GPS position source, and aircraft updates.

6.1 Transponders

Transponders designed to meet DO-260B include changes to the way position accuracy and uncertainty are reported along with additional transmitted information on the length and width of the aircraft. Honeywell already has certified transponders to meet the new DO-260B requirements resulting in a full suite of transponders to support all aircraft types.

6.2 GPS Position Sources

ADS-B Out relies on the GPS avionics for the aircraft's location, groundspeed and other data. Today there are three generations of GPS equipment installed and available but the third generation is just beginning to be seen on airline transport aircraft.

The first generation which is still widely installed today on commercial aircraft were designed when the GPS signals were intentionally degraded for national security purposes with a technique referred to as Selective Availability (SA). So-called SA-On GPS receivers operate as if the SA intentional degradation is still present despite SA being turned off. These GPS systems will calculate a more accurate position solution now that SA is turned off, but they don't know that so they report a pessimistic accuracy estimate (NIC, NAC, and SIL).

The second generation, referred to as "SA-Aware" know that Selective Availability is turned off and are able to both calculate a more accurate solution and also report the correct accuracy estimates.

Lastly, the third-generation of GPS receivers implements the Satellite-based Augmentation System (SBAS) to improve accuracy and integrity. In systems such as the Wide Area Augmentation System that has been operational in the US for many years now, SBAS systems use additional satellites and ground stations to detect errors and send messages that contain information that allow airborne SBAS GPS receivers to remove these errors in the GPS signal, allowing for a significant increase in location accuracy and reliability. Actual performance measurements of the U.S. WAAS system at specific locations have shown it typically provides better than 1.0 meter (3 ft 3 in) laterally and 1.5 meters (4 ft 11 in) vertically throughout most of the contiguous United States and large parts of Canada and Alaska. SBAS GPS equipment is slowly becoming available on airline transport aircraft, with retrofit solutions for virtually all platforms becoming widely available from Honeywell by 2018. Currently however, SBAS systems that allow airborne SBAS GPS to attain the accuracy and integrity improvements outlined earlier are operational in the U.S. (WAAS), Europe (EGNOS) and Japan (MSAS), but other systems will become operational within the decade.

Countries and regions that are implementing ADS-B Out rules have taken different approaches regarding the GPS position source requirements. The E.U. ADS-B Out rule does not require SA-Aware, so first generation SA-On GPS equipment that satisfy the requirements in CS-ACNS will meet the mandate for GPS position source. Australia on the other hand has required SA-Aware GPS to meet its ADS-B Out mandate. Currently, only the FAA DO-260B mandate requires a third generation GPS source that is both SA-Aware GPS and uses SBAS corrections.

Since the necessary SBAS capable GPS systems have limited availability until 2018, the FAA has created a temporary exemption option for GPS requirements from January 1, 2020 through December 31, 2024.

Operators must apply for this exemption by August 1, 2018 and applications must include a plan to update their fleet to be in full DO-260B compliance by January 1, 2025. Transponder requirements for DO-260B are not changed by this exemption and still must be fully met by January 1, 2020. Exemption 12555 allows operation between January 2020 until January 2025 with either:

(a) SA Aware GPS and no additional requirements for SBAS or preflight checks.

or

(b) SA ON GPS with the pre-flight check as described in AC 90-114A CHG 1 via the Service Availability Prediction Tool (SAPT – see http://sapt.faa.gov for more details)..

Operators interested in operating under Exemption 12555 should become familiar with the details. Refer to Exemption 12555 on http://www.faa.gov/nextgen/equipadsb/.

6.3 Aircraft Updates

Aircraft wiring updates may be needed to provide a connection between the GPS and transponder for older aircraft installations. In many cases redundancy is also added by cross wiring each GPS position source to each transponder. Specific wiring updates to support GPS will vary for each platform and upgrade solution. Program pin wiring updates at the transponder are also needed to determine the aircraft length/width, aircraft code, and antenna offset for the new ADS-B transponder data. Finally, aircraft updates are needed to provide a method for indicating loss of ADS-B operation to the pilot. In some cases this will be a wiring update from the transponder to drive a lamp in the cockpit, and in other cases it will be an updated transponder fail message which may require a software update to the displays.

7.0 Looking to the Future: Reduction or Elimination of Ground-Based Radar

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 in 2018, an Iridium subsidiary, Aireon, will relay signals seamlessly to air traffic controllers on the ground, providing the first opportunity for global air traffic monitoring.

8.0 Appendix

1. ADS-B global mandate summary

2. Mandates by country/region

3. Timeline graph

4. Product applications: DO-260 through DO-260B

5. TRA-100B specification highlights

6. Glossary

8. 1 Global ADS-B Out mandate summary

Mode S Transponders with Extended Squitter capability in accordance with RTCA DO-260 or DO-260B:	
Australia mandate for retrofit aircraft	12-Dec-2013
Singapore mandate for all aircraft	12-Dec-2013
Indonesia mandate for all aircraft	01-Jan-2018
Hong Kong mandate for all HKG-registered aircraft - Flying PBN routes L642 or M771 between FL290 and FL410 - Flying within HKG FIR between FL290 and FL410	 31-Dec-2013 31-Dec-2014
Australia mandate for SA Aware GNSS (new a/c)	08-Dec-2016
Mexico - SBAS GPS required as per FAA guidelines	January 1, 2020 (Pending)
Colombia - SA-ON acceptable	January 1, 2020 (Pending)
U.S. FAA mandate for 100% equipage - Class A, Class B and Class C airspace - 1090 ES (Extended Squitter) for FL180 and above - 1090 ES or UAT (Universal Access Transceiver) below FL180 - Must be compliant with TSO C166b (Mode S) or C154a (UAT)	01-Jan-2020
EASA mandate for *forward-fit and retrofit* aircraft	07-June-2020
China mandate for all aircraft	31-Dec-2022

8. 2 ADS-B Mandates by Country/Region

Australia (CASA)

- ADS-B Out for FL 290 and Above: DO-260 Equipage by 12-DEC-2013
  - SA aware GNSSU or MMR data source for new aircraft by 8-DEC-2016

Canada (Transport Canada)

- ADS-B Out for Hudson Bay Access, FL 350 to 400
  - DO-260 access benefits began JAN-2009, with access penalties if no ADS-B by 18-NOV-2010

EASA (via EUROCONTROL)

- ADS-B Out proposal:
  - Forward fit and Retrofit by 07-JUN-2020
  - DO-260B ADS-B Out on all aircraft exceeding 5700 kg or cruising true airspeed capability greater than 250 kts
  - Applicable to all IFR flights operated in Africa-Indian Ocean and European Regions

Hong Kong (CAD)

- ADS-B Out for FL 290 to FL410 DO-260 or DO-260A Equipage by 12-DEC-2013
  - Limited to HKG-Registered aircraft operating on PBN Routes L6642 and M771 in HKG FIR
- ADS-B OUT FOR FL 290 TO FL410 DO-260 OR DO-260A EQUIPAGE BY 12-DEC-2014
  - Limited to HKG-Registered aircraft operating in the HKG FIR

Indonesia (DGCA)

- ADS-B Out for FL 290 and Above DO-260 Equipage by 01-JAN-2018

Singapore (CAAS)

- ADS-B OUT FOR FL 290 AND ABOVE DO-260 EQUIPAGE BY 12-DEC-2013
  - Limited to specific Airways in the Singapore FIR

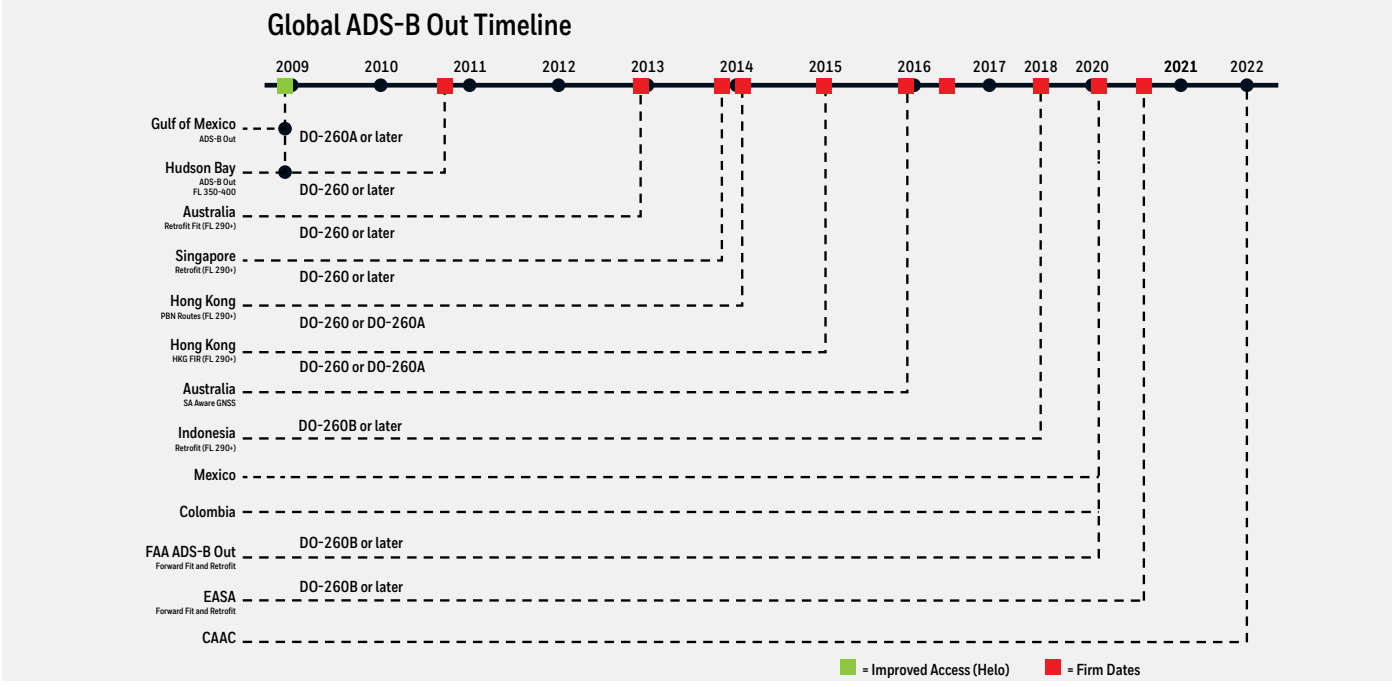
USA (FAA)

- ADS-B OUT FOR GULF OF MEXICO ACCESS DO-260A BENEFITS ON 1-JAN-2010
- ADS-B OUT FOR CLASS A, B, C AIRSPACE DO-260B EQUIPAGE BY 1-JAN-2020

China (CAAC)

- ADS-B OUT FOR FL 290 AND ABOVE DO-260B EQUIPAGE BY 31-DEC-2022

8.3 Timeline Graph



8.4 Honeywell Prodcut Application Updates: DO-260 through DO-260B

PRODUCT	APPLICATION	DO-260	DO-260A	DO-260B
AESS (A380/A350)	Air Transport	--	Available	Available
TRA-67A	Air Transport	Available	--	Replace with TRA-100B
TRA-100B	Air Transport	-	-	Available
Epic	Regional, Helicopter Business Aviation	--	Available	Available
Primus II	Regional Business Aviation	--	--	Available
MST-67	Regional Business Aviation	--	--	Replace with MST-70B
MST-70B	Regional Business Aviation	_	_	Available

8.5 Honeywell's Air Transport Solutions for DO-260B

Honeywell has a number of products to meet the DO-260B mandate requirements with the growth capacity to meet future operator needs for ADS-B, navigation, and precision approaches. The newly developed TRA-100B is the transponder solution for air transport aircraft with reduced weight, improved reliability and dataloading capability for cost effective updates. The MST-70B is available from Honeywell to replace the TRA-67A. These two transponders are drop-in replacements for the current TRA-67A and MST-67A, respectively.

Honeywell also has two new GPS solutions to meet DO-260B requirements for air transport in all regions. The IMMR is designed for both forward and retrofit of multi-mode receiver (MMR) installations. It is backwards compatible to existing MMR installations while also containing optional integrated VOR and marker beacon capability.

The IMMR meets the latest 3rd generation GPS standards for accuracy and error/uncertainty reporting and supports advanced capability for both satellite and ground based augmentation systems (SBAS, GBAS) to support precision approaches. The KGS-200 is the GPS retrofit solution for aircraft with an existing GPSSU/GNSSU installation or no GPS at all. The KGS-200 meets all the same 3rd generation GPS performance requirements as the IMMR and supports modern GPS-based operations such as RNP, LPV, RNAV/LNAV and is on-board dataloadable. Several other existing Honeywell GPS products such as the RMA-55B and some GNSSUs are sufficient to meet some of the regional mandates such as EASA which require a 1st generation GPS solutions, but they do not meet the 3rd generation GPS requirements needed for the FAA.

Honeywell's integrated products such as the AESS for A380/A350 and the Primus Epic cockpit systems can all be upgraded to support full 3rd generation GPS and transponder capability to meet all DO-260B mandates.

8.5.1 Transponder: TRA-100B

- Weight : 13% weight reduction from TRA-67A (12.3 lbs. max.)
- Power consumption: 30W (115VAC -380/420Hz)
- Meets latest DO160G environmental qualification standards
- Data-loadable
- Meets all Airbus and Boeing OEM requirements
- Ensured compatibility with Honeywell TCAS for future evolutions to both systems

8.5.2 GPS Solution: IMMR

- Designed for forward and retrofit multi-mode receiver applications
- 3 MCU, ARINC 755 Compatible LRU
- Instrument Landing System (ILS) Receiver for precision approach/auto-land (Category IIIb ILS)
- SA-Aware Global Navigation Satellite System (GNSS) Receiver with En-route GNSS position, velocity and time (PVT) outputs (ADS-B / RNP-AR)
- GNSS Landing System (GLS) with ILS 'look-alike' deviation outputs during precision approach/autoland (Category I GLS)
- SBAS (WAAS) /LPV/EGNOS
- Integrated VHF Omnidirectional Range (VOR) & Marker Beacon receivers
- Integrated VOR increases VDB availability for GLS performance
- Hardware designed for growth to GLS Category II/III and Multi-Constellation GNSS

8.5.3 GPS Solution: KGS-200 GNSSU

- Retrofit solution for aircraft with standalone GPSSU/GNSSU or no GPS today
- Supports all modern GPS-based operations: RNP, LPV, RNAV/LNAV
- Simple Integration with standard ARINC 429 I/O
- Standard ARINC 743a form factor and much smaller than alternatives at only 42 in3
- Compatible with all DO-229 compliant SBAS systems, including WAAS, EGNOS, MSAS, and GAGAN
- SW Upgradeable to GBAS CAT I

8.6 Glossary

ADLP	Aircraft Data Link Processor
ADS-B	Automatic Dependent Surveillance – Broadcast
AIRB	Airborne (situational awareness during flight operations)
ACARS	Aircraft Communications Addressing and Reporting System
ANSP	Air Navigation Service Providers
ATC	Air Traffic Control
ATSA	Air Traffic Situational Awareness
ATSA-AIRB	Airborne ATSA
ATSA-AIRB IA	ATSA-AIRB Indicating & Alerting
ATSA-ITP	In-Trail Procedure
ATSA-SURF	Surface ATSA
ATSA-SURF IA	ATSA-SURF Indicating & Alerting
CDTI	Cockpit Display of Traffic Information
EASA	European Aviation Safety Agency
EFB	Electronic Flight Bag
ELM	Extended Length Message
FIM	Flight Deck Interval Management
FMS	Flight Management System
ICAO	International Civil Aviation Organization - UN agency, created in 1944
IM	Interval Management
ITP	In-Trail Procedures
M&S	Merging & Spacing
MCDU	Multifunction Control Display Unit
NAC	Navigation Accuracy Category
NIC	Navigation Integrity Category
NRA	Non-Radar Area
SDA	System Design Assurance
SES	Single European Sky
SESAR	Single European Sky ATM Research
SIL	Source Integrity Level
SURF	Basic Surface Situation Awareness (airport runway situational awareness)
SURF IA	Surface Indications and Alerts
TSAA	Traffic Situation Awareness with Alerts
UAT	Universal Access Transceiver
VSA	Visual Separation on Approach

For more information
aerospace.honeywell.com/mandates

Honeywell Aerospace
1944 East Sky Harbor Circle
Phoenix, Arizona 85034
+1 (800) 601 3099
www.honeywell.com

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