Ground Based Augmentation System (GBAS)

Why augment GPS for precision approach?

How do we augment GPS for precision approach?
Honeywell’s SmartPath® Ground-Based Augmentation System (GBAS)

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<tr>
<th>SCAT I</th>
<th>Portable</th>
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<th>CAT II/III</th>
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World’s Only FAA-Approved

Leading the Industry in Satellite Landings Systems for > 20 Years

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**Honeywell SmartPath GBAS**

**Reference Receivers**
- Multipath Limiting Antenna (MLA)
- Narrow Correlator GPS Receiver
- 2 Hz Measurements
- 4 GPS Receivers

**Dual Processor Channels**
- Differential Corrections
- Overall System Integrity
- Approach Database
- Redundant Channel

**VHF Broadcast**
- Corrections, Integrity, Approaches
- Horizontally Polarized, Omni-Directional
- 108-118 MHz
- 2 TDMA Time Slots (typ.)
- 2 Hz Corrections
- Redundant Radio

**Maintenance Data Terminal**
- System Status, Mode, Control
- System Alerts, Alarms
- Approach Control

**Air Traffic Status Unit**
- System Mode
- System Availability

**TDMA – Time Division Multiple Access**

**Hz – Hertz**

**LAN – Local Area Network (typ. Ethernet)**

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Next Generation Landing System- Available Now

• Today’s presentation focuses on the next generation of landing system (GBAS) that provides:

  - **Enhanced Safety:**
    • Multiple ANSP Certification Pedigree
    • Signal Stability (immune to signal bends inherent in ILS)
    • Wake Vortex Mitigation – Customizable Glide Paths/Approaches

  - **Increased Airport Capacity:**
    • Offers precision approach where ILS cannot due to geography
    • Enables flexible approaches (48), improved accuracy versus ILS
    • Airport benefits from increased revenue (landings fees, concessions, etc.) and cost avoidance (capacity increase without adding runways)

  - **Lower Life-cycle Costs:**
    • One SmartPath GBAS Station serves all runways/runway ends at any airport
    • Lower maintenance costs/lower flight inspection costs

  - **Environmental Friendliness:**
    • Variable Glide Slopes, RNAV/RNP to GLS Finals
    • Airline fuel & emission savings, increased schedule flexibility, avoid noise violations
    • Airports increased capacity and schedule flexibility, improved community relations
Airlines
Lowers operational cost, and increases schedule reliability

ANSP
Enhances safety, environmental impacts, ATM modernization

Airports
Improves capacity, lowers cost, future proof to CAT III

Stakeholder Involvement Throughout the Whole Project = Successful Implementation
Numerous Near-Term Opportunities for Network Expansion

SmartPath® GBAS Deployment Expanding Globally

- Deployed
- Near-Term Opportunity

Examples:
- Dubai
- Delhi
- Heathrow
- Krakow
- Frankfurt International Airport
- Mexico City
- Brisbane
- Bangkok
- Krakow
- Singapore
- Shanghai
- Gimpo
- Sydney International Airport

Additional locations:
- Anoka County-Blaine Airport MN
- Grant County International Airport WA
- Olathe-Johnson County Executive Airport, Olathe KS
- Charleston SC
- Puerto Plata Punta Cans
- Newark Liberty International Airport NJ
- FAA Tech Center Atlantic City NJ
- Bremen International Airport
- Zurich
- Malaga
- Dubai
- Delhi
- St. Helena
- Galeao Antonio Carlos Jobim International Airport
- Melbourne International Airport
SLS-4000 Block II SW – What Improves?

• Honeywell Achieved System Design Approval for our 3rd Generation Block II GBAS Software in October 2015

  - Enhances Availability
    ▪ Include satellites that are currently omitted in Block I
    ▪ Change fault reactions to re-admit faulty satellites sooner
    ▪ Operate on two receivers for common masking
      - Block I requires three receivers to broadcast corrections

  - Provides Configurability Options
    ▪ Allows for a user-defined iono threat model
      - Enables improved availability in all geographies
    ▪ Allows for automatic user-defined GLS approach procedures for a specific time period
      - Motivated by low latitudes – Set up to broadcast only during specific time periods

  - Maintenance Improvements
    ▪ Enable or disable VHF broadcast without going into test mode
    ▪ Display enhancements for usability

  - Enables 48 FAS Data Blocks (from 26)
Demonstrating the Value of GBAS

- RNP to GLS with 1.4 nm short final approach
- 3.5 – 4.0 deg Glideslope approaches with up to 1000 ft displaced threshold
- CAT III “hands-off” Autoland by an airline crew
- GBAS landing in Asia Pacific (Australia excluded)
- Published RNP to GLS approaches (2016)

Shanghai Pudong GBAS Trials

Large Scale Demonstrations (2016)
Customer Testimonial – DFS, Germany

DFS embraces new precision approach technology

Honeywell SmartPath® GBAS increases airspace efficiency and capacity with the prospect to lower airport costs

Overview

With global air travel continuing to rise, airports need to find new ways to handle additional aircraft movements without incurring the costs of building more runways. GBAS has been identified by ICAO, the U.S. Federal Aviation Administration (FAA), and Eurocontrol as an enabler for improving air traffic capacity. Honeywell SmartPath is the world’s first and only certified GBAS system. DFS wanted to familiarise itself with GBAS as the organisation sees it as an eventual successor to ILS technology.

Customer results

- Reduced the chances of taxi time delay and much less impact from weather or significant sitting obstacles on the airfield, unlike ILS critical areas
- Significantly reduced maintenance effort as GBAS requires fewer checks by flight inspection than ILS systems
- Used by airlines under MCC down to CAT I decision altitude

AT A GLANCE

Customer

Names: DFS Deutsche Flugsicherung GmbH
Location: Bremen, Germany
Industry: Air navigation service provider
Website: www.dfs.de

Honeywell solution

SmartPath Ground-Based Augmentation System (GBAS)

Why DFS chose Honeywell

- GBAS identified by ICAO, FAA and Eurocontrol as an enabler for improving air traffic capacity
- Honeywell SmartPath is the world’s first and only certified GBAS system
- DFS wanted to familiarise itself with GBAS as the organisation sees it as an eventual successor to ILS technology

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GBAS AVIONICS UPDATE
Honeywell’s Integrated Multi-Mode Receiver
How Does GBAS Work?

Honeywell Uniquely Provides Both Air and Ground GBAS Equipment

GBAS Avionics

Pilot Interface

Cockpit Displays

MMR

GPS Antenna

Autopilot

Aircraft Surfaces

GPS error corrections, integrity, and path points

GBAS Ground System

DATALINK – VHF Data Broadcast (VDB)

24+ GPS Satellites

4 GPS Antennas

Differential GPS Control & VDB Cabinet

VHF Data Broadcast (VDB) Antenna

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GLS Uses Existing Aircraft Architecture

- ILS look alike
  - Glideslope
  - Localizer

Looks and Feels Like ILS. Minimal Pilot Training Required
### Aircraft GLS Capable

**Boeing**
- 737NG – GLS forward fit, retrofit
- 787 – GLS basic
- 747-8 – GLS basic

**Airbus**
- A320 – GLS option
- A330 – GLS option
- A340 – GLS option
- A350 – GLS option
- A380 – GLS option

Airbus & Boeing committed to RNP RNAV 0.1 (or less) and GLS
- FMS changes complete or planned for most models
- LPV not in current plans at Boeing or Airbus
- Over 4000 aircraft already equipped with GLS, and 700 on order

Embraer and Honeywell are developing Similar Strategic Roadmaps
- RNP-0.1 in development for Honeywell Epic platforms

GLS equipped aircraft are in service
Summary

• CAT III GBAS is no longer a question of if, it is **who**, **where** and **how soon** for each airport and airline operator

• By working together with airlines, national regulators, air navigation service providers, key airports, and aircraft OEMs, Honeywell is uniquely positioned to support, both in the air and on the ground, with CAT I/II/III GBAS and eventually Multi-Constellation GNSS
  - We **can** influence the results and expedite the benefits to all stakeholders

• We want your business
  - Honeywell provides the optimal path to not only equip, but also **achieve the value** out of this game-changing technology

• Partnering on GBAS deployment
  - Proactive communications between Airlines, Airports, OEMs, and the regulatory authorities will expedite GBAS deployment and value realization by all stakeholders
SMARTPATH CERTIFICATION
OVERVIEW
GBAS Approval Categories

- To be approved the system must meet ICAO, FAA and/or other recognized standard
- The standard for SmartPath is the FAA LAAS Specification 3017 which also traces to the ICAO requirements

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<th>FACILITY APPROVAL</th>
<th>SERVICE APPROVAL</th>
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<td>Operations</td>
<td>Aircraft Approval</td>
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<td>System Engineering</td>
<td>Maintenance</td>
<td>ATC Training</td>
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<td>Software Design Assurance</td>
<td>Installation</td>
<td>Pilot Training</td>
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<td>System Verification</td>
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<td>Commercial Instruction Book</td>
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<td>Operational Evaluation</td>
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GBAS Certification Phases

- **System Design Approval (SDA) – Manufacturer**
  - Ground station system design meets requirements
  - Developed to appropriate design assurance levels
  - Accuracy, integrity, availability requirements satisfied

- **Facility Approval – Owner/ANSP/Airport**
  - Ground station installed properly, safely
  - Approach plates/procedures developed
  - Signal-in-space, coverage volume verified, approaches verified
  - Maintenance technicians trained, certified

- **Service Approval – Operator/Airline**
  - Aircraft equipped
  - Pilot crews trained
  - Control tower personnel trained
Approval Outside the USA
International Civil Aviation Organization

ICAO is a standards organization. Each country can adopt ICAO into their aviation regulations.

For example, Australia ratified ICAO standards through *Air Navigation Act 1920*.

*GBAS is specified under ICAO SARPS Annex 10, Attachment D*
Germany

• Country requirements for type certification
• Top level requirements: ICAO, EUROCAE
• Honeywell obtained type certification with BAF
Germany - Requirements

- **NfL II-51/08, Notification concerning the requirements for type-certification of GBAS ground facilities as aeronautical radionavigation stations**
  - System safety and security
    - ICAO Annex 10, Volume 1
    - ARP4761, Safety Assessment Process
  - Software requirements
    - Developed according to EUROCAE ED-109
  - Technical functional requirements
    - ICAO Annex 10, Volume 1
    - Tests per EUROCAE ED-114
    - Ground and Flight inspections per ICAO Doc 8071 chapter 4
    - All weather operations, NfL I-1/99
    - Remote monitoring
  - Environmental requirements
    - ED-114
    - NfL I-328/01, Guidelines Concerning Obstacle Clearance for Instrument Runways
Germany - Requirements

- NfL II-51/08, Notification concerning the requirements for type-certification of GBAS ground facilities as aeronautical radionavigation stations
  - Facility Documentation
    - Installation manual
    - Technical system description
    - Operators manual
    - Maintenance manual
  - Legal telecommunication requirements
    - Declaration of conformity to radio equipment and telecommunications standards
  - Applicable to Cat I operations
  - Independent audit of Honeywell’s FAA SDA data package
Spain

- Top level requirements: FAA specification
- Aena prepared approval package for certification authority

Malaga
Australia

• Top level requirements: FAA, ICAO
• Airservices Australia prepared approval package for certification authority CASA
• CASA participated in FAA audits
Questions?
Thank You!

Honeywell