LEGACY APPROACH/LANDING SOLUTION: INSTRUMENT LANDING SYSTEMS

+ Worldwide availability at all major airports
+ Established/trusted technology
+ Nearly 100% penetration of air equipment
+ Enables Safe, All-weather precision approach capabilities down to CAT III
  - Little flexibility of approach design after initial installation
  - Highly Sensitive to Interference
  - Requires periodic regulatory flight check
  - One ILS for each Runway end, with one approach
  - Expensive to maintain ($150K+/yr/runway)
  - Requires large amount of real estate; inflexible siting criteria
  - Would likely not be certifiable under today’s airworthiness requirements

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**GBAS BASICS—WHERE DID WE COME FROM?**

- Satellite Positioning Systems were first envisioned as replacement for terrestrial based systems (Decca, Loran-C, VOR, DME, ADF, etc.) for surface applications (land and sea)
- 1st Gen system—Transit Satnav (1964 U.S. Navy)
  - Too few satellites for aviation use (need full time access to satellites)
- US and USSR Systems (1970’s)
  - Global Positioning System (GPS)
  - Global Navigation Satellite System (GLONASS)
- Adopted as Global Navigation Satellite Systems (GNSS)
- International Interoperability Standards came in to being
- Early airborne applications were primarily aimed at aircraft trans-oceanic navigation, communication and surveillance
- Future Air Navigation System (ICAO 1983)
- Technological developments (combining satellite receivers with navigation computers) resulted in expansion of the uses of satellite based systems for higher levels of accuracy and functionality
GNSS* FOR AIRBORNE NAVIGATION

GPS (USA)    GLONASS (Russia)    Galileo (Europe)    北斗 (China)

*Additional Global Navigation Satellite Systems continue to be developed.
**HONEYWELL’S SMARTPATH® GROUND-BASED AUGMENTATION SYSTEM (GBAS)**

<table>
<thead>
<tr>
<th>SCAT I</th>
<th>Portable</th>
<th>CAT I</th>
<th>CAT II/III</th>
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<tr>
<td>SCAT-I</td>
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<td>SLS-1000/2000</td>
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<td>Oct 2015</td>
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**World’s First DGPS Cert**

**World’s Only FAA-Approved**

**Leading the Industry in Satellite Landings Systems for > 20 Years**
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)
HOW DOES GBAS WORK?

GBAS Avionics
- Cockpit Displays
- Pilot Interface
- GBAS Ground System
- MMR
- GPS Antenna
- Autopilot
- Aircraft Surfaces
- GBAS Avionics
- GPS error corrections, integrity, and path points
- DATALINK – VHF Data Broadcast (VDB)
- 24+ GPS Satellites
- 4 GPS Antennas
- Differential GPS Control & VDB Cabinet
- VHF Data Broadcast (VDB) Antenna

Honeywell Uniquely Provides Both Air and Ground GBAS Equipment
Numerous Near-Term Opportunities for Network Expansion

SMARTPATH® GBAS DEPLOYMENT EXPANDING GLOBALLY
KEY GBAS BENEFITS OVER LEGACY ILS

Flexible, Digital Approach Paths

- ILS: Single defined slope, same touchdown point on runway
- SmartPath GBAS: Multiple touchdown points and glide slope combinations

Requires No “Clear Zones”

Increases Capacity; Reduces Delays

Create Spacing; Mitigate Noise; Avoid Runway Construction

Enables Efficient Flight Path

RNP Approach:
- curved final approach
- begins on the downwind leg
- lateral and vertical guidance to the runway or to a GLS intercept

4 NM final can save up to 10.6 NM Approach
- 3 minutes of flight time
- 82.7 kilograms of fuel
- 104 liters of fuel

Reduce Fuel Consumption; Minimize Emissions; Avoid Terrain

Serves All Runway Ends

Reduce Maintenance Costs; Increase Precision Approaches

CO2 emission reductions of 1.42431kg per each 1kg of fuel saved

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Create Spacing; Mitigate Noise; Avoid Runway Construction

Reduce Maintenance Costs; Increase Precision Approaches

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NEXT GENERATION LANDING SYSTEM- AVAILABLE NOW

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
SMARTPATH ® CERTIFICATIONS

• FAA : 2009
• BAF (Germany) : December 2011
• FAA : Block 1 September 2012
• ASA ( Australia) : May 2014
• AENA ( Spain): May 2014
• BAF (Germany-Frankfurt); September 2014
• Switzerland: October 2014
• FAA : Block II November 2015*
• ASA : Block II 2017
• BAF (Germany): Block II May 2019
• China: (In Process)

*New Standard
LATEST SLS-4000 BLOCK II APPROVAL

System Design Approval for 3rd Generation Block II GBAS Software

Enhances Availability

- Include satellites that were 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 in Block I)

Enables SBAS Integration to Support:

- CAT II on CAT I with no change to existing GAST C avionics
- CAT I Autoland
- Extended Service Volumes
HONEYWELL CONTINUES TO DEVELOP

29 April 2015 China Eastern A321 & Shandong Airlines B737 successfully flew the most Complex PBN to GLS procedures to date
• RF Curved Path to 2.5 and 4.0 NM Finals
• 2.8-3.2 Degrees Variable Glidepaths
• Displaced Threshold Operations (1075m)
HONEYWELL CONTINUES TO DEVELOP

Augmented approaches to land 2

WP2: GBAS CAT II with CAT I airborne and ground equipment

- Enabling lower decision heights to CAT II minima (DH 100ft);
- Addresses hubs and medium size airports

Airports:
Bremen, Newark

Demonstrations:
Lufthansa, Ryanair

Q2 - Q3 2019

> 150 approaches planned with mainline revenue aircraft.

With Honeywell GBAS Ground station – SLS-4000.

Detailed Presentation of AAL2 – Wednesday in Working Session 2
CAT I post approval/implementation activities.
Honeywell GBAS Involvement in SESAR & SESAR2020

- **GBAS CAT II/III L1 Validation**
  - SESAR 9.12 GBAS CAT II/III Airborne
  - SESAR 15.3.7 MCMF GBAS System & Ground
  - Validation of airborne GBAS GAST D TRL6 – large number of validation flights,
    US/ EU interoperability
  - Inputs to MOPS and SARPS

- **Advanced Procedures with GBAS**
  - SESAR 6.8.8 Enhanced Arrival Procedures
  - LSD 02.02 AAL – Augmented Approaches to Land
  - Received SES Award for Innovation
  - Over 200 RNP to GLS approaches flown

- **Work towards MCMF GBAS**
  - S2020 PJ14-3-1 GBAS
    - GBAS CATII/III GPS L1 & MCMF GBAS
  - Very early stages of concept development

- **Surface Operations with GBAS**
  - S2020 PJ03a-03 Surface Operations
  - Exploring surface operation concepts and how GBAS can support them

- **Advanced Procedures with GBAS**
  - S2020 PJ02-02 and PJ02-06
  - Continues work on advanced procedures to bring GBAS benefits.
Honeywell Safety & Connectivity

GBAS AVIONICS UPDATE
Honeywell’s Integrated Multi-Mode Receiver
HONEYWELL INTEGRATED MULTI-MODE RECEIVER (IMMR)

Today

IMMR Approach

Today

IMMR

Approach

New Nav Receiver Supporting all Current and Future Needs
NEW SBAS/GBAS Products

- CMA-5024 GLSSU
- CMA-6024 GBAS GLSSU

- All in-production CMC GPS receivers can be software upgraded to GBAS TSO-161A and DAL-A

- Timetable:
  - GBAS GAST-C software load by end of 2017
  - GBAS GAST-D software load planned (2018/2019)

- The CMA-6024 GLSSU is a GPS/SBAS/GBAS receiver + a state-of-the-art built-in VDB receiver

Result: a totally self-contained, drop-in solution.
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, aircraft OEMs, and the regulatory authorities will expedite GBAS deployment and value realization by all stakeholders.
SLS-5000 CAT III SMARTPATH® GBAS

Road to CAT III is Paved...

SDA Approval Plan submitted and acknowledged by FAA
FAA CAT III validation project completed
- Substantially de-risked CAT III development
FAA formally supporting CAT III development
Heavy Re-use of Block II baseline
- 100% re-use of 13 integrity monitors from Block II
- Adding 2 new monitors; Updating 2 others
Minimal HW changes from CAT I (ex: Copper Cables to Fiber)
SDA … Market Driven Delivery

CAT III Schedule

<table>
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<td>Minimal HW changes from CAT I (ex: Copper Cables to Fiber)</td>
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<tr>
<td>SDA … Market Driven Delivery</td>
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</table>

**CAT III Schedule**

- Approval Plan
- System Description
- System Requirements
- Security Plan
- Human Factors
- Algorithm Description
- Documents
- Preliminary System Safety Assessment

**CAT I and CAT III Integrity Monitors**

<table>
<thead>
<tr>
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<tr>
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Thank You