

June 3, 2019

HONEYWELL **GBAS SYSTEM** **DEVELOPMENT**

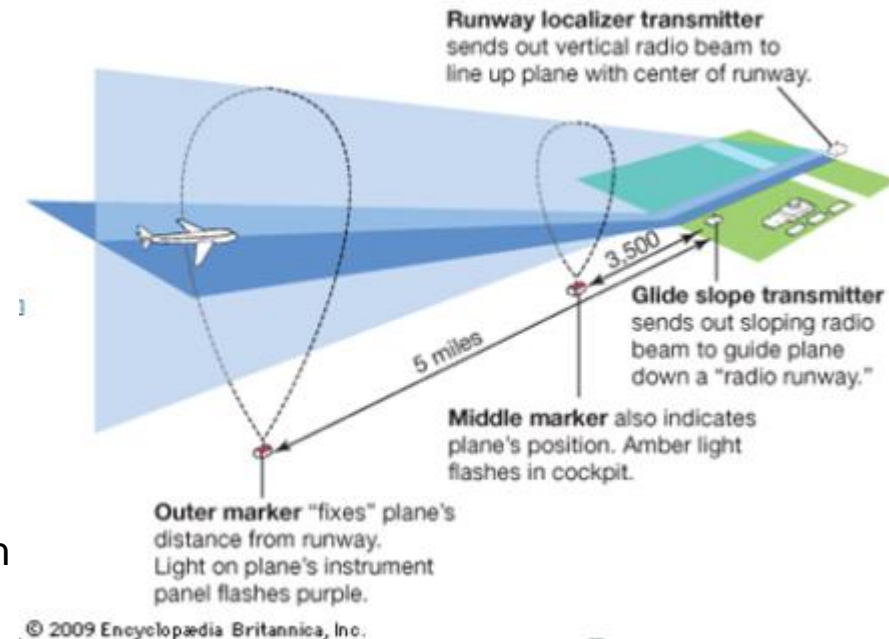
PAUL NEF
DIRECTOR ATM INITIATIVES APAC

Honeywell



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



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)



~2021 (Satellites)

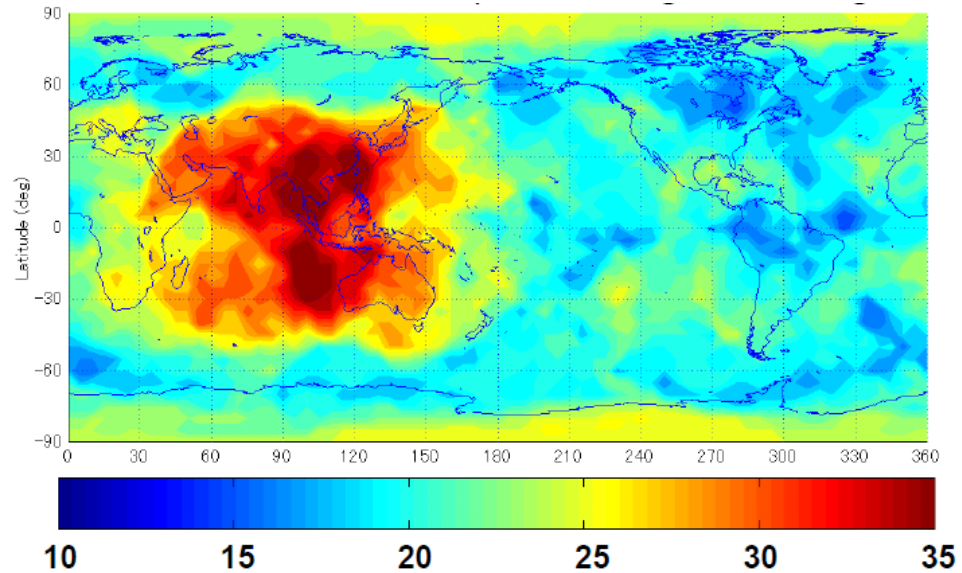
GPS (27)

Glonass (24)

Galileo (30)

北斗 (35)

GNSS Coverage Map Circa 2021



**Additional Global Navigation Satellite Systems continue to be developed*

HONEYWELL'S SMARTPATH® GROUND-BASED AUGMENTATION SYSTEM (GBAS)

SCAT I

World's First
DGPS Cert



SCAT-I
Certified
Sep 1998

SLS-1000/2000

Portable

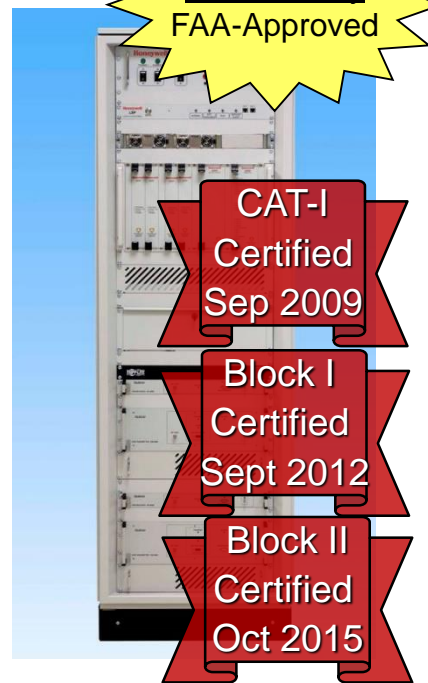


Migrated to
Portable Unit

SLS-3000

CAT I

World's Only
FAA-Approved



CAT-I
Certified
Sep 2009

Block I
Certified
Sept 2012

Block II
Certified
Oct 2015

SLS-4000

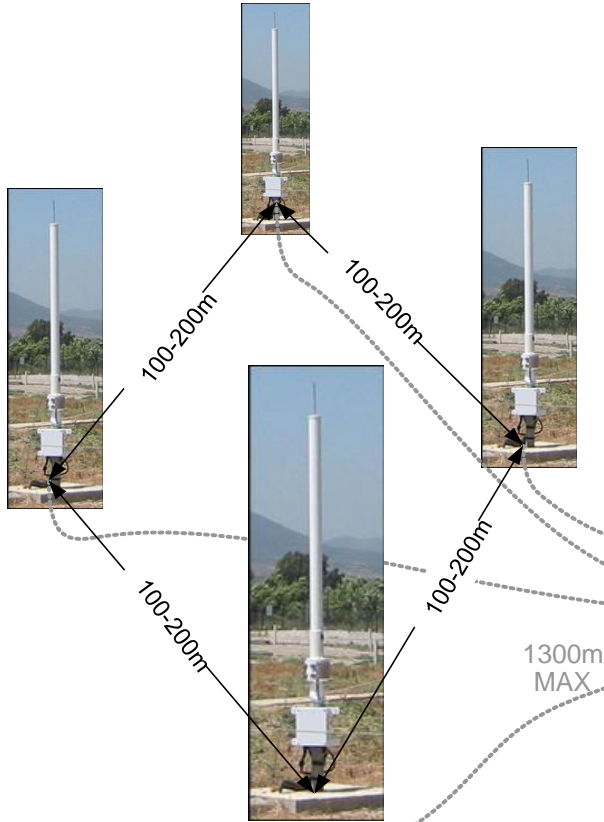
CAT II/III



In Development
SDA TBD

SLS-5000

HONEYWELL'S 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



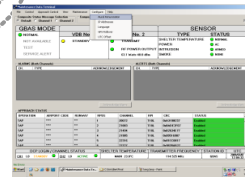
VHF Broadcast

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

200m MAX

Airport LAN

1300m MAX



Maintenance Data Terminal

- System Status, Mode, Control
- System Alerts, Alarms
- Approach Control

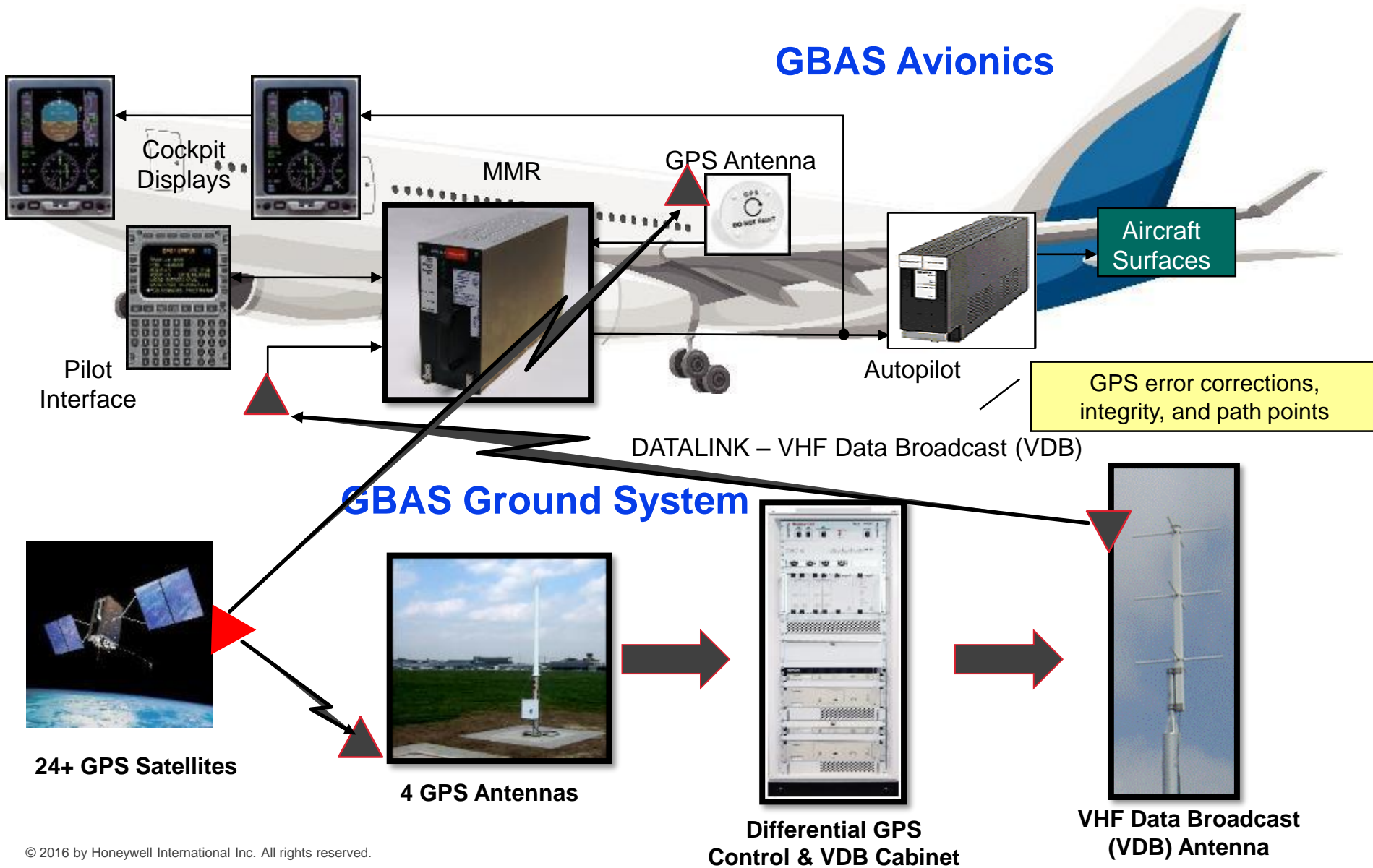
TDMA – Time Division Multiple Access
 Hz – Hertz
 LAN – Local Area Network (typ. Ethernet)



Air Traffic Status Unit

- System Mode
- System Availability

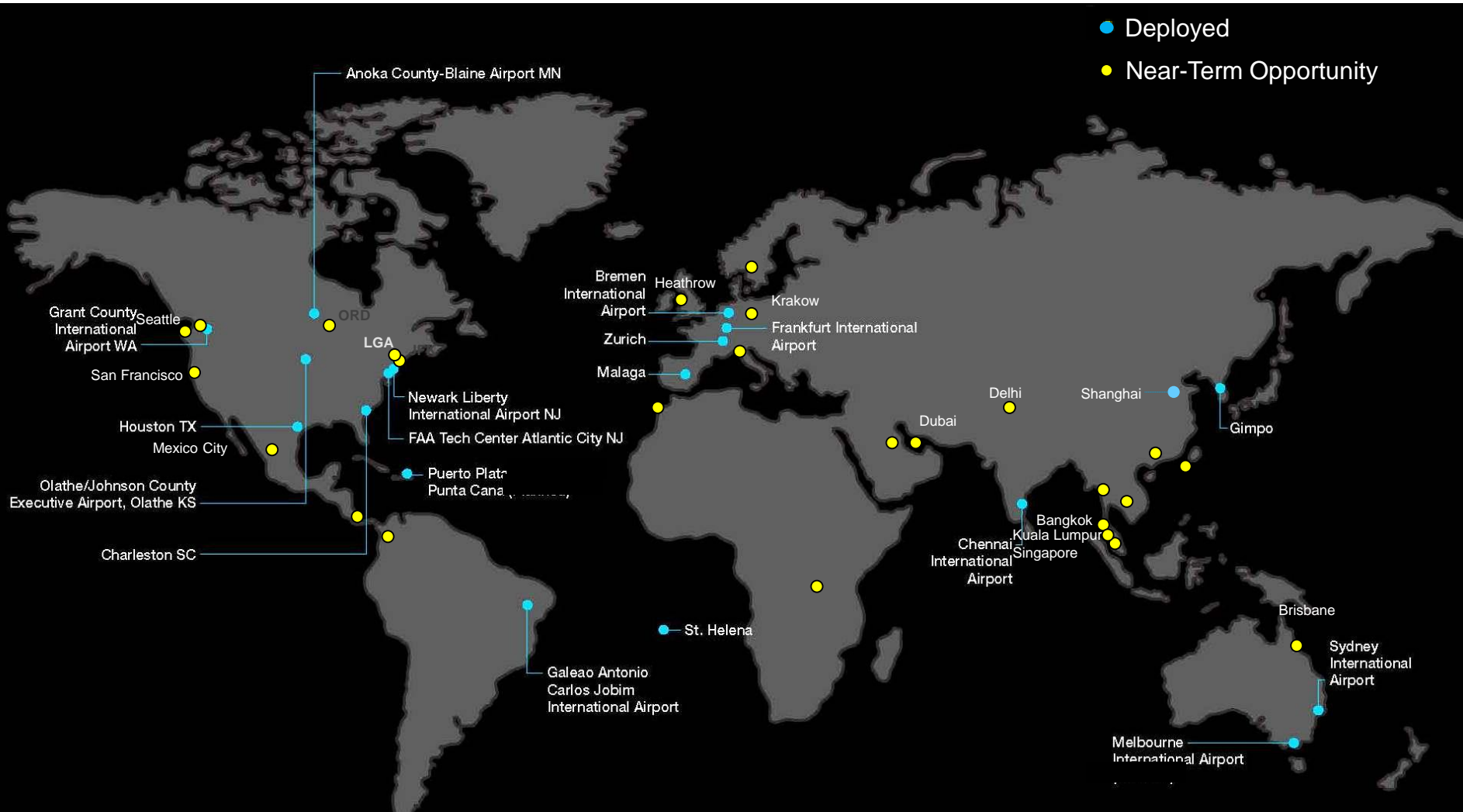
HOW DOES GBAS WORK?



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Honeywell Uniquely Provides Both Air and Ground GBAS Equipment

SMARTPATH® GBAS DEPLOYMENT EXPANDING GLOBALLY



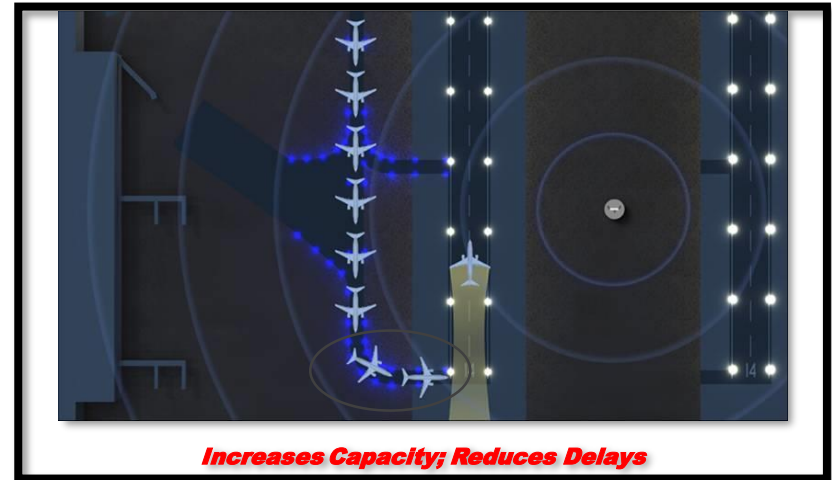
Numerous Near-Term Opportunities for Network Expansion

KEY GBAS BENEFITS OVER LEGACY ILS

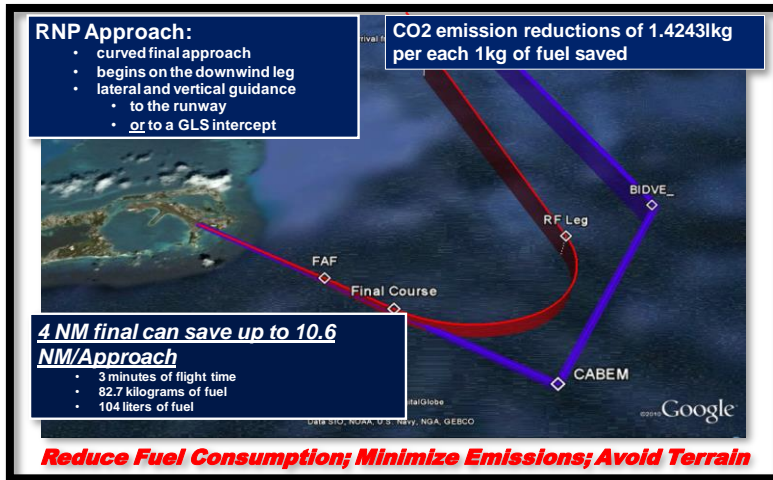
Flexible, Digital Approach Paths



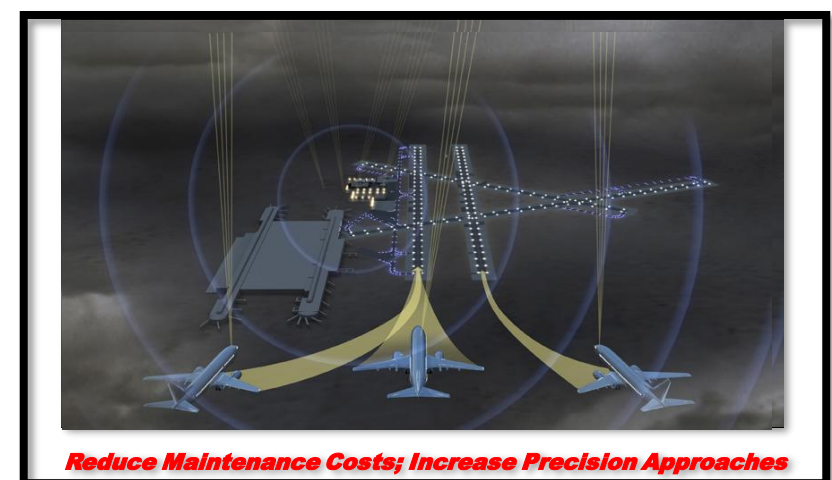
Requires No “Clear Zones”



Enables Efficient Flight Path



Serves All Runway Ends



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**Increasing Runway Capacity, Reducing Noise, Reducing Track Miles, Reducing Operating Costs
 Flexibility to Address Multitude of Operational Challenges at the Airports You Fly To**

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

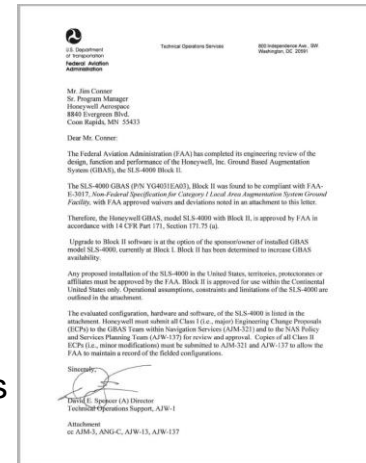
- Enable or disable VHF broadcast without going into test mode
- Display enhancements for usability

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

FAA System Design Approval



HONEYWELL CONTINUES TO DEVELOP

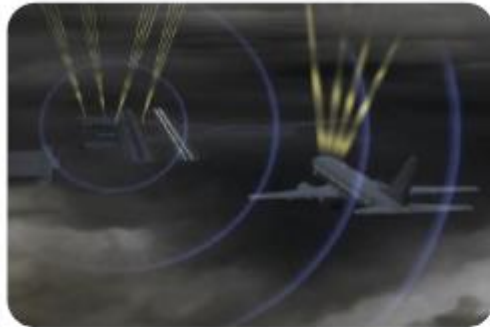
29 April 2015 China Eastern A321 & Shandong Airlines B737 successfully flew the most Complex PBN to GLS procedures to date

- 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



Lufthansa B747-8
aircraft



Ryanair Boeing
737 NG



Lead by
Honeywell



> 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**

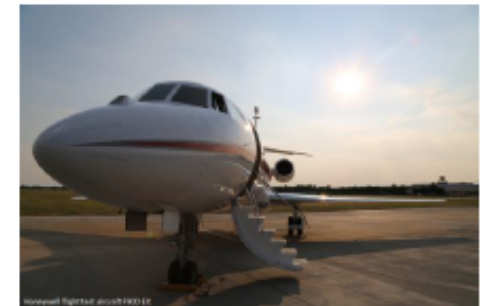
- *S2020 PJ14-3-1 GBAS*
 - GBAS CATII/III GPS L1 & MCMF GBAS
- Very early stages of concept development

- **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.



2016

2019

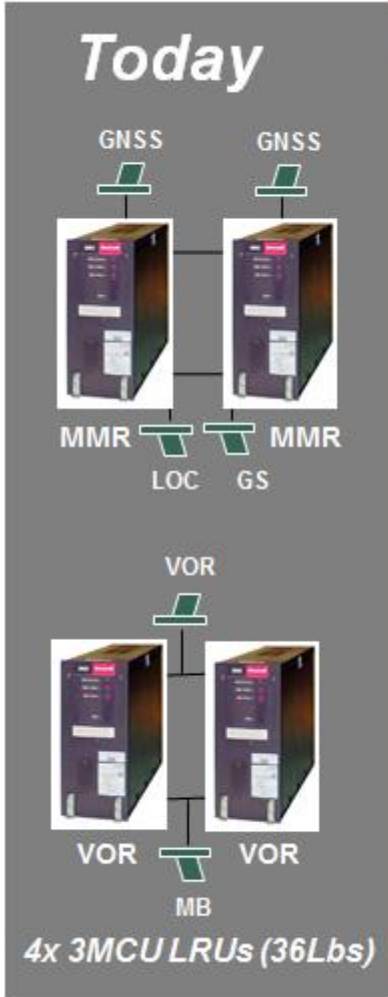


Honeywell Safety
& Connectivity

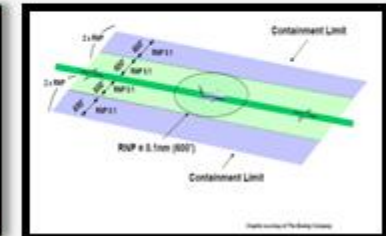
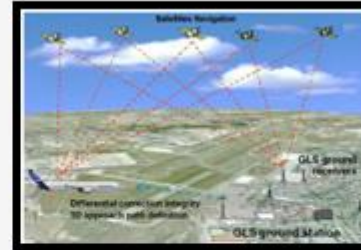
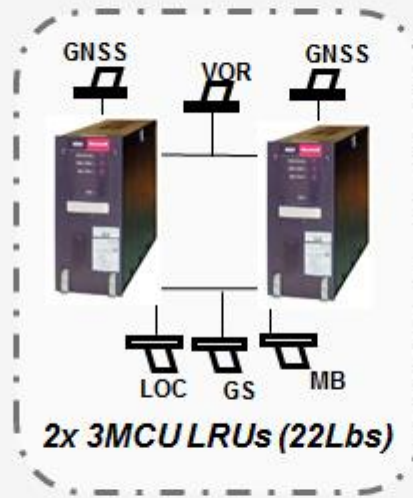
GBAS AVIONICS UPDATE

Honeywell's Integrated Multi-Mode Receiver

HONEYWELL INTEGRATED MULTI-MODE RECEIVER (IMMR)



IMMR Approach



GLS AVIONICS FOR LEGACY AIRCRAFT

NEW SBAS/GBAS Products

On the Button Every Time.
Advanced GPS Solutions for Every Aviation Need

Integriflight™
High-Performance
Aviation GPS Receivers

- Fully Compliant ADS-B Positioning Sensor
- RNP RNAV/ SBAS/GPS Navigation Sensor
- SBAS LPV/LPV Precision Approach Sensor
- Self-Contained, Stand-Alone SBAS/LPV and GBAS/GLS Approach Solution
- GBAS/GLS in Development
- Exceptional Reliability

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Over 100 Years of Innovation



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

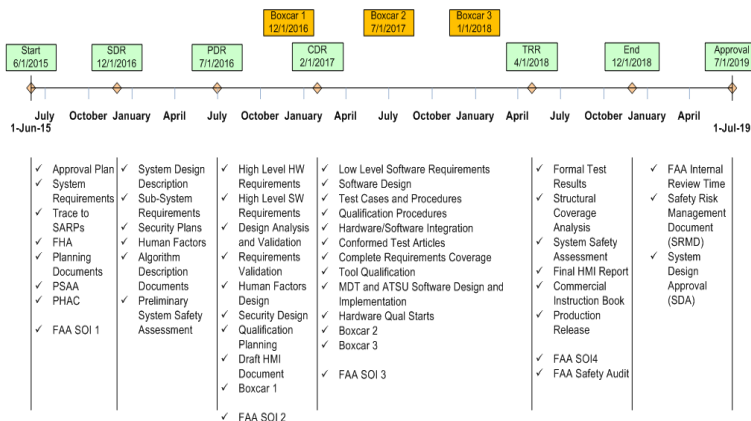
Heavy Re-use of Block II baseline

- 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



CAT I and CAT III Integrity Monitors

SCAT I	GAST-C	GAST-D	
SCAT I Operations (1998)	CAT I Operations	CAT I Operations	CAT II/III Operations
Broadcast Msg Type 1, 2 & 4	Broadcast Msg Type 1, 2 & 4	Broadcast Msg Type 1, 2 & 4	Broadcast Message Type 11
	Sigma PR Ground	Sigma PR Ground	
	Phase Center Non-Zero Mean	Phase Center Non-Zero Mean	
	Ground System Sigma Monitor	Ground System Sigma Monitor	
	Ionosphere Anomaly Monitor	Ionosphere Anomaly Monitor	
	Troposphere Anomaly Monitor	Troposphere Anomaly Monitor	
	Ephemeris Monitor	Ephemeris Monitor	
	Signal Deformation Monitor	Signal Deformation Monitor	
	Low Satellite Signal Power Monitor	Low Satellite Signal Power Monitor	
	Code Carrier Divergence Monitor	Code Carrier Divergence Monitor	
	Excessive Acceleration Monitor	Excessive Acceleration Monitor	Excessive Acceleration Monitor
	Executive Monitor	Executive Monitor	Executive Monitor
	RFI Above the Mask	RFI Above the Mask	
	Iono Screening Real Time Inflation	Iono Screening Real Time Inflation	
	Constellation Alerts	Constellation Alerts	
	Broadband RFI Monitor	Broadband RFI Monitor	
			Cross Correlation Monitor
			Iono Gradient Monitor

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Clear Path to CAT III Based on Certified Block II Baseline



Thank You