GBAS Approval Process

Honeywell, Precision Landing Systems
Agenda

• FAA System Design Approval
  – Integrity Panel
• Ionosphere Mitigation
• Facility Approval
• Service Approval
• GBAS Approval by Country
Purpose

• Provide aircraft with a precision approach

1. Variable Geometry, using FMS/GPS
2. Transition to approach path
3. Precision approach path generated by GBAS
   TCH = Threshold crossing Height (ft or m)
   LRP = Landing Reference Point (lat, lon, alt)
   FPAP = Flight Path Alignment Point (lat, lon)
4. Missed approach guidance

Reference Receivers (4)
VDB Antenna
Shelter

FPAP

TCH

LRP
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

FAA approved 2009
BAF approved 2011

- Bremen, Germany
- Newark, New Jersey
- Houston, Texas
- Malaga, Spain
- Sydney, Australia
- Frankfurt, Germany
- Zurich, Switzerland
Process to Certification

- Need early involvement from all stakeholders
  - Airport
    - Installation
    - Operation
    - Maintenance
  - Approval Agency
  - Airlines
  - Civil construction
  - Approach procedure designers
  - Flight Inspection
  - Air Traffic Control
  - NavAid Inspectors
  - NOTAM process

A successful project requires involvement from everyone
Honeywell, Precision Landing Systems

FAA System Design Approval

Honeywell
GBAS CAT I Approval Steps

• 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

SYSTEM DESIGN APPROVAL

- System Safety
- System Engineering
- Software Design Assurance
- Hardware Design Assurance
- System Verification
- Commercial Instruction Book
- Training Material
- System SRMD
- Operational Evaluation

FACILITY APPROVAL

- Operations
- Maintenance
- Installation
- Flight Procedures
- Flight Inspection
- Spectrum Management
- Training
- Safety Management

SERVICE APPROVAL

- Aircraft Approval
- ATC Training
- Pilot Training
- Instrument Flight Criteria
**Customer Requirements**

- **LGF/ Customer**
- **System Reqs**
- **Arch**
- **Detailed Reqs**
- **Code**
- **Test**

**Requirements**
- ICAO SARPS
- FAA Specification 3017

**Secondary Requirements**
- DO-246C, GBAS Signal in Space
- DO-245A, MASPS for GBAS
- Mil-Std-461E, Electromagnetic Interference
- Mil-Std-810F, Environmental Tests
- FAA-G-2100G, Electronic Equipment
- ED-114, MOPS for GBAS

**Process Requirements**
- ARP-4754, Certification Considerations
- ARP-4761, Safety Process
- DO-278/DO-178, Software
- DO-254, Hardware
GBAS CAT I Approval Plan

- GBAS Approval Plan
  - Provides the FAA with Honeywell’s plan to achieve design approval for the GBAS system
  - Approval basis includes
    - Requirements
    - Compliance method
    - Data
    - Schedule
    - Responsibilities
FAA Approval Process

• System Design Approval Plan CAT I Local Area Augmentation System (LAAS)
  – Provides top-level SDA plans and activities for use by FAA personnel
• System Design Approval Process And Procedures for The CAT I Local Area Augmentation System
  – Defines the evaluation criteria for all reviews necessary to accomplish System Design Approval
• These documents describe the objectives, activities and documentation to:
  – Verify compliance to the requirements
  – Define design data that substantiates compliance
  – Document accepted configuration
FAA System Design Approval

System Design Approval

- System Safety Assessment
- Functional Hazard Assessment
- Preliminary System Safety Assessment
- Algorithm Description Document
- Training Material Review
- Commercial Instruction Book Review
- Systems Engineering Review
- System Level Verification
- SW Design Assurance Reviews
- Complex HW Design Assurance Reviews
- HMI Analysis/Report
- SRMD (System Design Aspects)
- FMEA/FMES
Safety Definitions

- **Integrity** – The probability of transmitting out-of-tolerance navigation data for 3-seconds or longer in any 150-second interval.

- **Continuity** – The probability of an unscheduled interruption of the VHF transmission for 3-seconds or longer in any 15 second interval.

- **Availability** – The proportion of time during which service is provided, computed over a long period (typically a year).
LAAS Integrity Panel

- **Purpose**
  - Ensure GBAS integrity monitors address defined GPS threats

- **Team**
  - Honeywell, FAA (10), Subject Matter Experts (11 Key Technical Advisors)

- **Process**
  - 10 years development
  - 20 Technical Interchange Meetings
  - Review development of integrity monitors
  - Approve integrity monitors
## Integrity Algorithms

<table>
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<tr>
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<tr>
<td>Broadcast Msg Type 1, 2 &amp; 4</td>
<td>Broadcast Msg Type 1, 2 &amp; 4</td>
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<table>
<thead>
<tr>
<th>SCAT I</th>
<th>GAST-C</th>
<th>GAST-D</th>
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<tr>
<td>Sigma PR Ground</td>
<td>Sigma PR Ground</td>
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<tr>
<td>Phase Center Non-Zero Mean</td>
<td>Phase Center Non-Zero Mean</td>
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<td>Ground System Sigma Monitor</td>
<td>Ground System Sigma Monitor</td>
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<tr>
<td>Ionosphere Anomaly Monitor</td>
<td>Ionosphere Anomaly Monitor</td>
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<tr>
<td>Troposphere Anomaly Monitor</td>
<td>Troposphere Anomaly Monitor</td>
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<tr>
<td>Ephemeris Monitor</td>
<td>Ephemeris Monitor</td>
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<td>Signal Deformation Monitor</td>
<td>Signal Deformation Monitor</td>
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<td>Low Satellite Signal Power Monitor</td>
<td>Low Satellite Signal Power Monitor</td>
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<td>Code Carrier Divergence Monitor</td>
<td>Code Carrier Divergence Monitor</td>
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<tr>
<td>Excessive Acceleration Monitor</td>
<td>Excessive Acceleration Monitor</td>
<td>Excessive Acceleration Monitor</td>
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<td>Executive Monitor</td>
<td>Executive Monitor</td>
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<td>RFI Above the Mask</td>
<td>RFI Above the Mask</td>
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<tr>
<td>Iono Screening Real Time Inflation</td>
<td>Iono Screening Real Time Inflation</td>
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<tr>
<td>Constellation Alerts</td>
<td>Constellation Alerts</td>
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<tr>
<td>Broadband RFI Monitor</td>
<td>Broadband RFI Monitor</td>
<td>Cross Correlation Monitor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iono Gradient Monitor</td>
</tr>
</tbody>
</table>

**GAST-C provides foundation for GAST-D**

**CAT III monitors developed**
Honeywell, Precision Landing Systems

Ionosphere Mitigation

Honeywell
Ionosphere Threat Model

- Independent ionosphere analysis performed by following countries
  - United States
  - Germany
  - Spain
  - Australia
  - Switzerland
  - Brazil
- Approved Honeywell GBAS addresses mid-latitude iono
- Honeywell has developed an update to address low-latitude iono
Rare Anomalous Iono

\[ D = w g \]

\[ \text{Front Speed} (v) \]

\[ \text{Nominal Iono Width} (w) \]

\[ \text{Iono Front Slope} (g) \]

Results in integrity/position error

• Gradient = Slope (g)
Iono Error at Decision Height

200 ft DH

< 6 km
Iono Scintillation

Impacts availability of GBAS
Equatorial Scintillation

- Amplitude and phase of GPS signals change rapidly
- Degradation of measurements
  - Enhanced error
- Loss-of-lock of satellite signals
  - Degradation of geometry, less accuracy, availability issue
- Occurs local sunset to local midnight
Facility Approval

Honeywell, Precision Landing Systems
GBAS CAT I Approval Steps

- Facility Approval ensures that the system as installed meets the performance requirements

**SYSTEM DESIGN APPROVAL**
- System Safety
- System Engineering
- Software Design Assurance
- Hardware Design Assurance
- System Verification
- Commercial Instruction Book
- Training Material
- System SRMD
- Operational Evaluation

**FACILITY APPROVAL**
- Operations
- Maintenance
- Installation
- Flight Procedures
- Flight Inspection
- Spectrum Management
- Training
- Safety Management

**SERVICE APPROVAL**
- Aircraft Approval
- ATC Training
- Pilot Training
- Instrument Flight Criteria
Facility Approval Activities

- Installation, Site Acceptance Test
  - Installation checklists
  - Installation drawings
  - System configuration
    - Software
      - Operational software
      - Adaptation file
      - Measured Site Data file
      - FAS Data file
  - Security/Access
  - VHF broadcast license
  - Maintenance log
  - Ground Equipment Manual
  - Input power
  - Lightning protection
  - Antenna locations
Facility Approval Activities

- **Installation, Site Acceptance Test**
  - Installation testing
    - Calibrated test equipment
    - RF power
    - RF frequency
    - RF line loss/VSWR
    - Cavity filter tuning
  - Installation analysis
    - 14 day stability test
  - Remote monitoring
Facility Approval Activities

- **Spectrum Management**
  - Submit required documentation to obtain a VHF frequency
  - Evaluate spectrum compatibility with all existing NAS, Government, and non-Government equipment at each location
  - Have all frequency management requirements been satisfied IAW FAA Order 6050.32, Manual of Regulations and Procedures for FAA Spectrum Management?
Facility Approval Activities

- Training
  - Have all types of training been identified for affected organizations
    - Operations
    - Maintenance
  - Have training requirements (i.e. number personnel per site) been identified
  - Will training development and conduct of training support the program deployment schedule
  - Have the training materials been developed and approved
  - Have all Commercial Instruction Books, (CIBs) which are required for training, been identified
  - Approved manuals available to support training development and conduct
Maintenance Training

• Course content
  – Provide an overview of GPS and how it is used to provide guidance to the runway for approaching aircraft
  – Give you a solid understanding of proper system operation – (subsystems, user interface, inputs and outputs)
  – Recognizing system status and performance
  – Provide operational procedures (software loading, viewing status and fault displays, etc.)
  – Provide requirements for periodic maintenance
  – Give guidance on troubleshooting and repair of the system when it breaks
  – Return to service requirements
# Maintenance Training

## Class schedule

<table>
<thead>
<tr>
<th>MIN</th>
<th>MODULE 1 Day 1</th>
<th>MODULE 2 Day 2</th>
<th>MODULE 3 Day 3</th>
<th>MODULE 4 Day 4</th>
<th>MODULE 5 Day 5</th>
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<tbody>
<tr>
<td>50</td>
<td>Module 2A - Block Diagrams</td>
<td>Module 3A - Software and Tools</td>
<td>Module 4A - General Maintenance</td>
<td>Module 5 - Performance Examination</td>
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<tr>
<td>50</td>
<td>Module 2B - Theory RSMU/DCP</td>
<td>Module 3A - Software and Tools - Continued</td>
<td>Module 4B - Power and Frequency Measurement</td>
<td>Module 5 - Performance Examination</td>
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<tr>
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<td>Module 2C - Theory VDB</td>
<td>Module 3B - Fault analysis</td>
<td>Module 4C - Power and Frequency Measurement - Continued</td>
<td>Module 5 - Performance Examination</td>
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<tr>
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<tr>
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<td>Module 2D - Theory Power/Sensors/MDT</td>
<td>Module 3B - Fault analysis - Continued</td>
<td>Module 4D - Periodic maintenance</td>
<td>Module 5 - Performance Examination</td>
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<td>60</td>
<td>LUNCH</td>
<td>LUNCH</td>
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<tr>
<td>50</td>
<td>Module 1A - Orientation, Basics of GPS</td>
<td>Module 2D - Theory Power/Sensors/MDT - Continued</td>
<td>LAB - (MDT commands and operation)</td>
<td>Module 4D - Periodic maintenance - Continued</td>
<td>Module 5 - Performance Examination (If required)</td>
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<tr>
<td>10</td>
<td>Break</td>
<td>LUNCH</td>
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<td>Break</td>
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<tr>
<td>50</td>
<td>Module 1A - Basics of GPS - Continued</td>
<td>LAB - (GBAS Power up, Modes, Status, MDT operation)</td>
<td>LAB - (MDT commands and operation - Continued)</td>
<td>LAB - Fault Insertion</td>
<td>Module 5 - Performance Examination (If required)</td>
</tr>
<tr>
<td>10</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
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<tr>
<td>50</td>
<td>Module 1B - GBAS Operation</td>
<td>LAB - Lab (GBAS Power up, Modes, Status, MDT operation)</td>
<td>LAB - Changing Approach Status/ FAS Block Tool use, Return-to-Service/QUIZ)</td>
<td>LAB - Fault Insertion - Continued</td>
<td>Wrap-up, Certificates, and send off</td>
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<td>Break</td>
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<tr>
<td>50</td>
<td>Module 1B - GBAS Operation - Continued</td>
<td>LAB - Lab (GBAS Power up, Modes, Status, MDT operation)</td>
<td>LAB - Changing Approach Status/ FAS Block Tool use, Return-to-Service - Continued</td>
<td>LAB - Fault Insertion - Continued</td>
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<td>Break</td>
<td>Break</td>
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<td>30</td>
<td>LAB - GBAS Hardware Walk-around</td>
<td>QUIZ</td>
<td>QUIZ</td>
<td>Open discussion - Review Performance Test requirements</td>
<td></td>
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<tr>
<td>30</td>
<td>QUIZ</td>
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</tbody>
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Total Instruction = 36 hours 40 minutes

8 hours 20 minutes 8 hours 20 minutes 8 hours 20 minutes 6 hours 40 minutes
Facility Approval Activities

• **Operations**
  – How will system be monitored
    • Air Traffic Status Unit
    • Maintenance Data Terminal
  – Define process for when system is unavailable
    • Air Traffic Control
    • NOTAM
    • Maintenance notification
ATC Operation

- Monitor GBAS status
- NOTAM process
ATC Operation

- Constellation Alert (30 minute look ahead)

- GBAS Mode: NORMAL
- GLS Approach: PREDICTED OUTAGE
  - Predicted Outage:
    - Estimated Start Time: 14:49:00
    - Estimated End Time: > 45 min
    - Countdown: 00:30:00

- GBAS Mode: NORMAL
- GLS Approach: NOT AVAILABLE
  - Service Outage:
    - Estimated Start Time: 15:49:00
    - Estimated End Time: 15:49:00
    - Countdown: 00:45:00

UTC
- 12-Jun-2010 14:19:00
- 12-Jun-2010 15:04:00
GBAS MODE:
1. LOOK FOR SOLID GREEN “NORMAL” (NO FLASHING)
2. NO OTHER LIGHTS ON
3. REPORT ANY OTHER LIGHTS ON OR IF “NORMAL” IS FLASHING

ALARM DISPLAY AREA:
1. LOOK FOR NO MESSAGES
2. REPORT ANY MESSAGES TO HONEYWELL

ALERT DISPLAY AREA:
1. LOOK FOR NO MESSAGES
2. REPORT ANY MESSAGES TO HONEYWELL
Facility Approval Activities

• Maintenance
  – Maintenance and logistics support plan
  – Approved maintainers
  – Spare parts
  – Support equipment
Facility Approval Activities

- **Flight Procedures**
  - Published approaches
  - FAS data blocks defined for each approach
  - VHF coverage volume test procedure
  - Approach validation test procedure
  - Test system defined
    - Aircraft
    - Flight test equipment
Facility Approval Activities

- **Flight Inspection**
  - Is new flight inspection equipment required? If so, has it been identified?
  - Have modifications to the flight check aircraft been completed?
  - Need to schedule sufficient airport time to test VHF coverage volume and each approach.
  - Approved flight procedures.
  - Perform flight test and generate report.
Facility Approval Activities

• Safety Management
  – System Risk Management Document
  – Have the Safety Risk Management Document(s) (SRMD) been developed, approved and accepted
  – Were high risk hazard(s) identified? If yes, were the mitigations and controls approved
  – Were system safety requirements derived from the control(s) to mitigate medium residual risks documented on the SRMD
Facility Approval Checklist

• For Federal Installation/implementation an (ISR) In Service checklist Review is used
• GBAS Team used that checklist for the non-Fed facility approval checklist
  – Eliminated Fed procurement specific items
  – Cross checked with 6720A Non-Fed order
• Checklist was reviewed against
  – SDA
  – Honeywell CIB and installation document
  – Draft siting order
Facility Approval Checklist

• Are interdependencies with other NAS products identified and incorporated into project schedules and plans?
• Will product require rulemaking changes?
• If the new product interfaces to an existing NAS product, is the specification for that interface in compliance with NAS-SS-1000, NAS System Specification, as well as the product specification (baseline) for the existing NAS system?
GBAS CAT I Approval Steps

- Service approval ensures that GBAS is ready for unrestricted operations

**SYSTEM DESIGN APPROVAL**
- System Safety
- System Engineering
- Software Design Assurance
- Hardware Design Assurance
- System Verification
- Commercial Instruction Book
- Training Material
- System SRMD
- Operational Evaluation

**FACILITY APPROVAL**
- Operations
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- Spectrum Management
- Training
- Safety Management

**SERVICE APPROVAL**
- Aircraft Approval
- ATC Training
- Pilot Training
- Instrument Flight Criteria
Service Approval

• Aircraft Approval
  – Aircraft equipment designs approved via FAA Technical Standard Orders (TSOs)
    • TSO-C161 (GBAS equipment)
    • TSO-C162 (GBAS VHF Receiver)
    • TSO-C190 (Active Antenna)
  – Aircraft installations approved via existing FAA processes (e.g., TC, STC, etc)
Service Approval

• ATC Training
  – GBAS technology
  – Phraseology
  – Procedures
  – Operation
NOTAM Process

- FAA provides NOTAM notification for next two days
- Airport is expected to create NOTAM for current day outages when Protection Level is expected to be above Alert Limit
Pilot Training

- Airbus and Boeing provide GLS operations in their Flight Manual
- Coordinating Approval with FAA Flight Standards POI (Principle Operations Inspector) assigned to an air carrier certificate holder and responsible for the approval of this training
GLS approach procedures and techniques are identical to those of an ILS approach. GLS approaches are extraordinarily steady and smooth when compared with the current ILS system, even when critical areas necessary for the ILS approaches are unprotected during GLS approaches. There is no beam bending, no FM frequency interference, no interference from preceding aircraft, and no ground areas near the runway that need to be protected from surface traffic.

GLS approaches are certified to Category 1 approach minimums and have also been demonstrated through autoland and rollout.
Pilot Training (Boeing)

Approach and Missed Approach

737 Flight Crew Training Manual

Approach

MCP mode selection requires the same pilot actions for ILS and GLS approaches. The approach selection for GLS is accomplished by selecting the GLS approach in the FMC and tuning a GLS channel versus selecting the ILS approach and tuning an ILS frequency.

GLS annunciations are identical to those used for ILS except that GLS is shown as the navigation reference on the PFD.

Crew actions while flying a GLS approach are just like those when flying an ILS approach. Note that both the Normal and Non-Normal Operations for GLS approaches are aligned with the Normal and Non-Normal Operations for an ILS approach.
Pilot Operation
Pilot Operation

- Autopilot mode selection requires the same pilot actions for ILS and GLS approaches
- GLS annunciations are identical to those used for ILS
- Normal and Non-normal operations for GLS approaches are aligned with ILS Approaches
Pilot Operation

• GLS versus ILS
Service Approval

- Instrument Flight Criteria
  - Current GLS approaches equivalent to ILS
GBAS Approval by Country

Honeywell, Precision Landing Systems
Germany

- Country requirements for type certification
- Top level requirements: ICAO
- Honeywell responsible to obtain 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
Australia

- Top level requirements: FAA specification
- Airservices Australia prepared approval package for certification authority
- Certification authority CASA participated in FAA audits

Sydney
Switzerland

• Switzerland approval agency stated that they don’t approve NAVAIDS. It is the responsibility of the ANSP to purchase an approved system.
• Switzerland approval agency is interested to see safety case for how the new NAVAID is integrated into the airport’s operation
• Honeywell provided a documentation package that defines the SmartPath system