




Ground Based Augmentation and the GBAS Landing System

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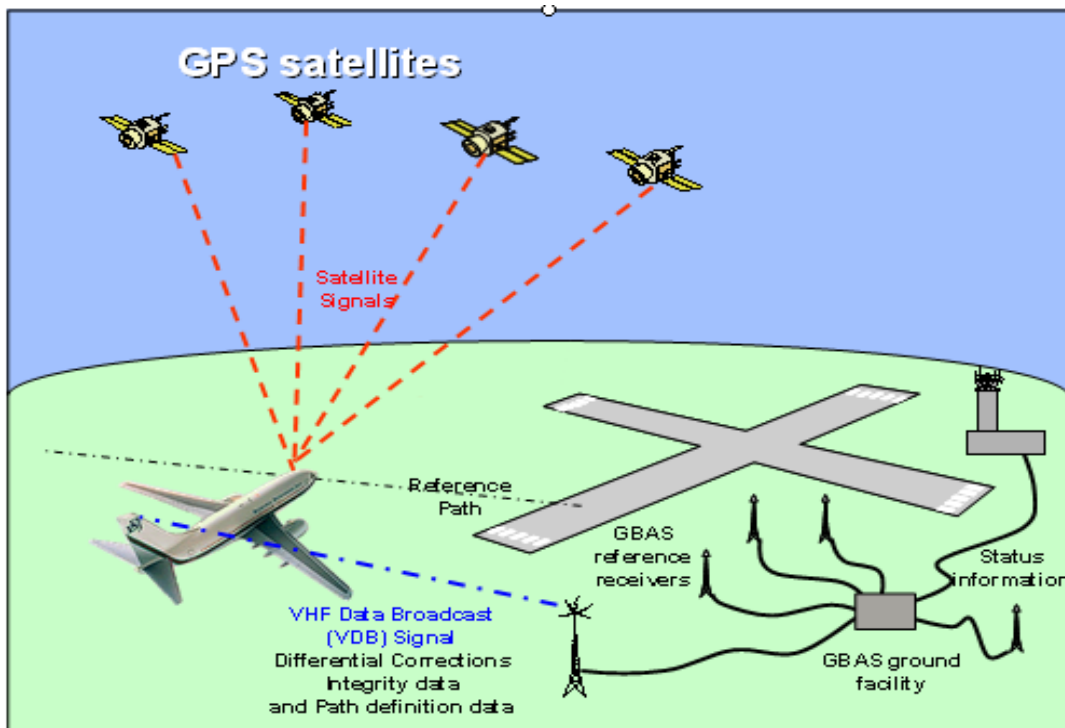
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Agenda

- 
- **GBAS/GLS Overview**
 - **Boeing GLS**
 - **Flight Trials & Operational Trials**
 - **GBAS Service Approval**
 - **Boeing Involvement in GBAS Implementation**

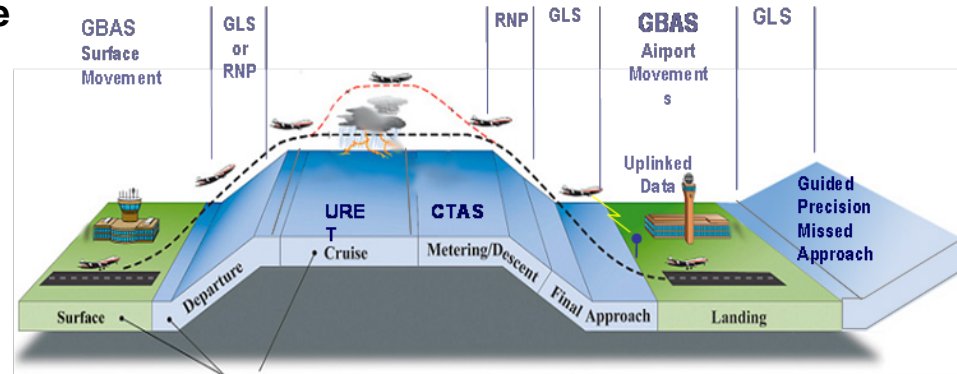
GBAS / GLS Overview – System Components

- GBAS (Ground Based Augmentation System) refers to the ground elements of the system
- GLS (GBAS Landing System) refers to the airplane function based on GBAS
- GLS
 - Translates uplinked data
 - Computes airplane position
 - Computes ILS-like deviations from selected path



GBAS / GLS Overview – Airplane/Airline Benefits

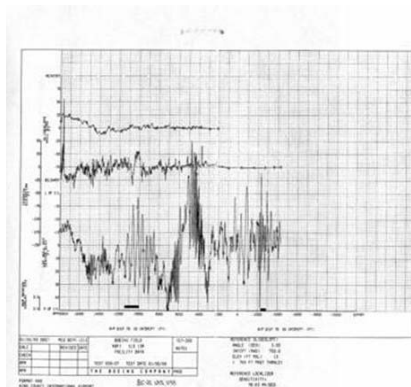
- **Precision all-weather terminal area operations are key to future Air Traffic Management, e.g.:**
 - Required Navigation Performance (RNP)
 - 4-D arrivals and departures
 - Enhanced ground operations
 - All-visibility operations on multiple runways
- **GLS is best and most ready precision navigation technology**
- **Increased Capability**
 - Multiple glide-paths, displaced thresholds, staggered touch-downs &, offset localizer paths
 - Steeper, lower noise profile glide-paths
 - Increased efficiency from reduced separation as a result of wake vortex mitigation
 - Low RNP capability in terminal area / surface
 - Precision guidance for departures
- **Cost Avoidance**
 - Fewer diversions
 - Reduced fuel reserves from improved access to ETOPS and destination alternates
 - Reduced landing fees
 - Improved Safety
 - Provide precise ILS-like guidance in places where ILS is not feasible



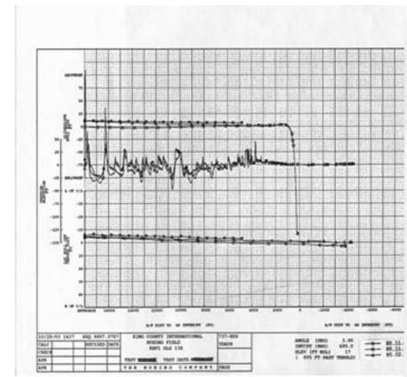
- ***The FAA is supporting development of GBAS***
- ***Prototype Ground Stations for CAT I are supporting revenue operations***
- ***Boeing and Airbus have been equipping aircrafts with GLS***
- ***Airline customers want GLS & have been purchasing it.***

GBAS / GLS Overview

ILS



Glide slope Radar Alt Localizer



GBAS



Agenda

- GBAS/GLS Overview



- Boeing GLS

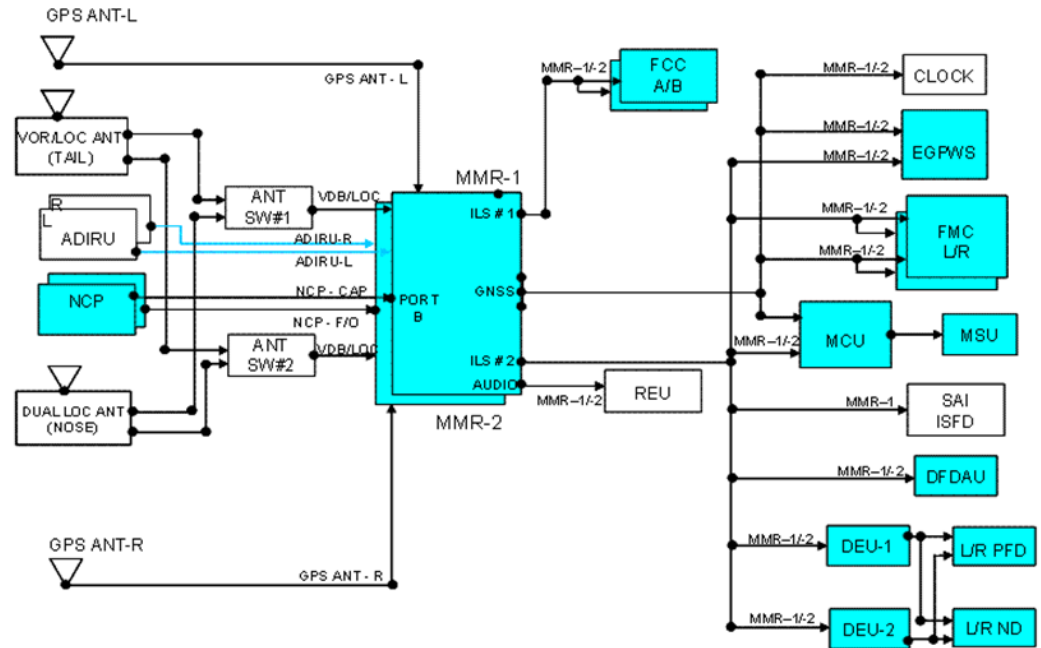
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Boeing GLS: 737NG

- For the 737NG, GLS is available as:
 - A production option
 - As a retrofit service bulletin and kit.



Certified GLS Category I Functionality

Boeing GLS: 737NG Crew Interface

Navigation Control Panel

Moves Standby Selection to Active

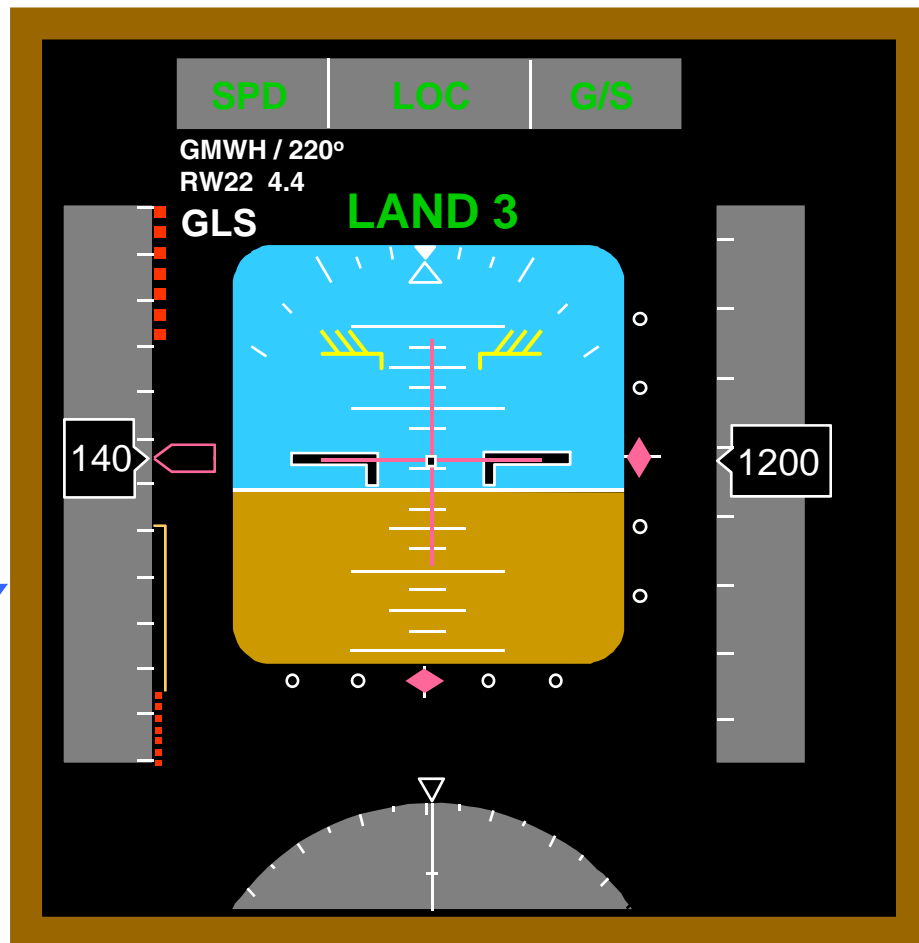


Cycles through
Modes: ILS, VOR, GLS

Keypad data
entry

- Common Flight Mode Annunciator and auto-flight annunciations
- Data block indicates approach data and type
- Common deviation display “ILS – like”
- Common crew procedure

Primary Flight Display



Boeing GLS: 787, 747-8, 777, Other

- **787: GLS is a basic capability (2010)**
- **747-8: GLS is a basic capability (provisioned for Category III) (2010)**
- **777: evaluating the potential incorporation of GLS Category III capability**
- **Other Boeing models: subject to customer demand.**



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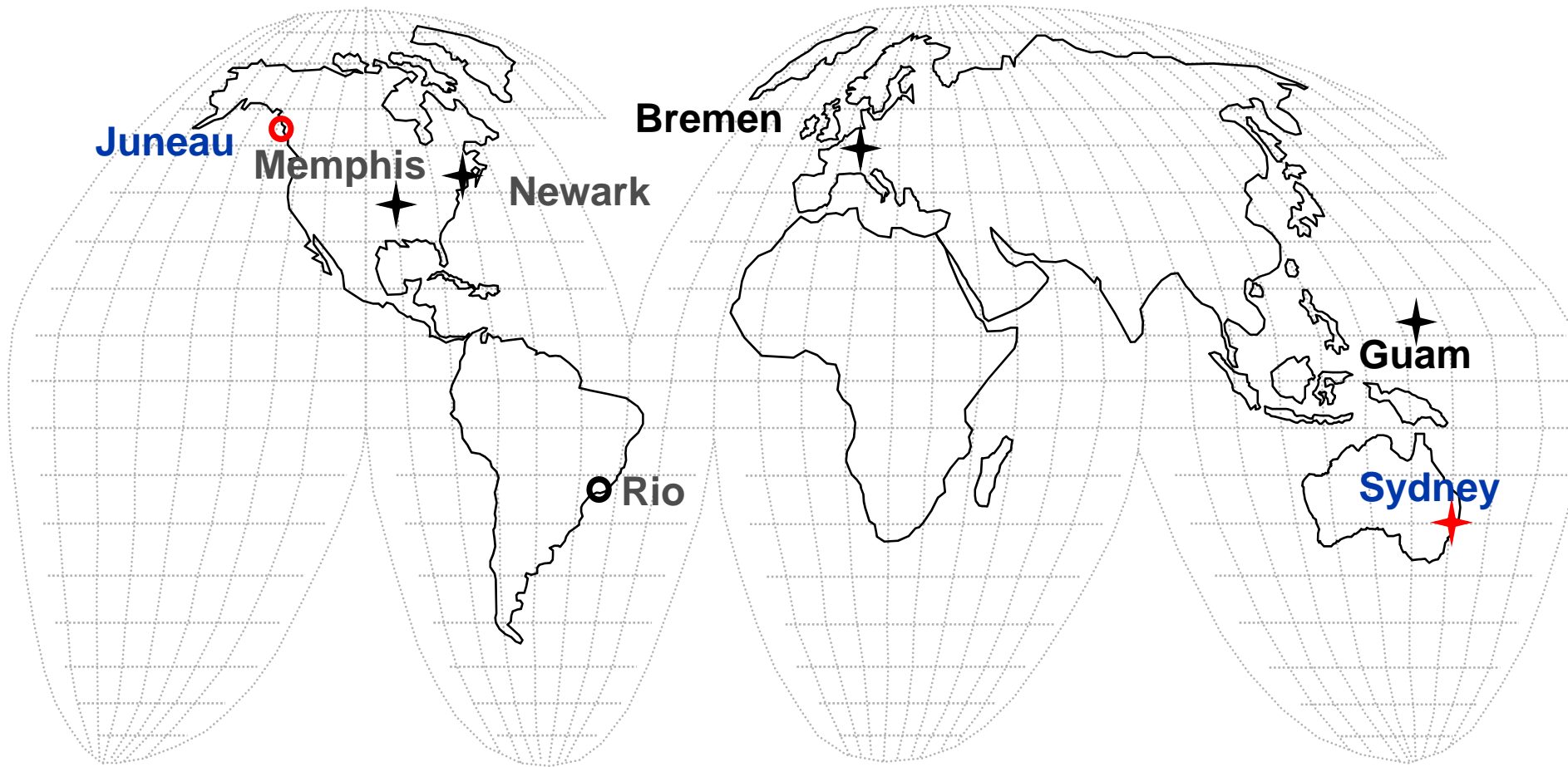


- Flight Trials & Operational Trials

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Flight Trials & Operational Trials Boeing Participation



Boeing supports our valued customers as they seek to make aviation history with initial implementation.

Flight Trials & Operational Trials

737NG, Juneau, Alaska, USA (2008)

- **Performed demonstration of GLS with Head-Up Display (HUD)**
 - Participants included: Boeing, Alaska Airlines, Qantas Airways & FAA
 - Trial flown in Visual Flight Rule conditions
 - Performed approaches to automatic landing to both runway ends (first ever autolands at Juneau Airport)
- **Special operations illustrate the potential flexibility of GBAS**
 - RNP procedure transitioned to capture short GLS final
 - Demonstrated both 3 & 4 degree glide-paths
 - GLS approaches included offset thresholds



Note: the particular approaches flown are probably not practical for regular revenue service use: for capability demonstration only

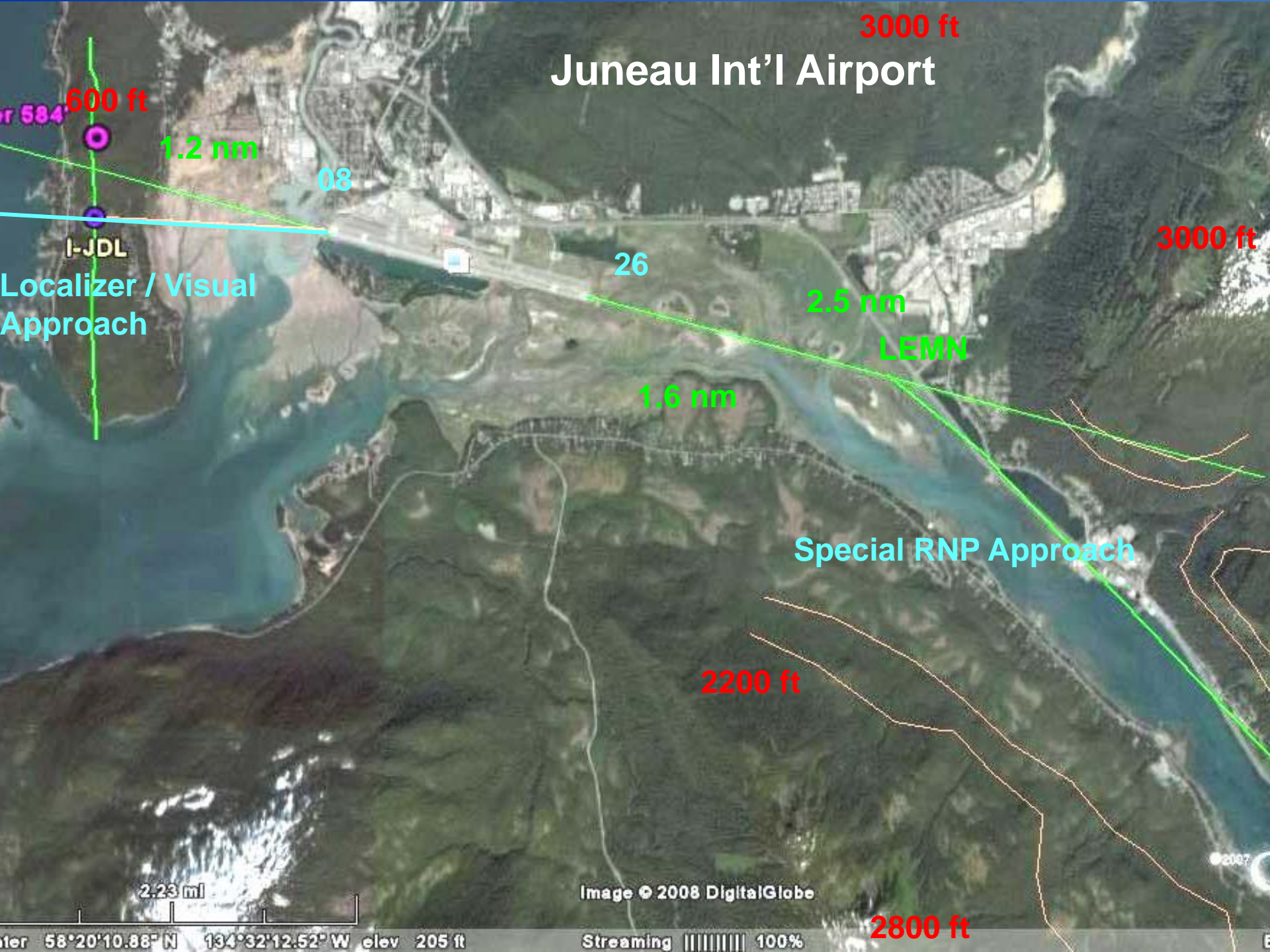
Flight Trials & Operational Trials

Why Juneau Airport?

- An ILS installation is not possible due to geographic limitations.
- Alaska Airlines RNP Approach minimums are:
 - 336 feet for Runway 26
 - 1800 feet for Runway 08
- Nearest alternate is Anchorage (800 miles away)
- GLS is ideally suited for this application
- Analysis of the geography indicated that the trials could incorporate GLS autolands.



Juneau Int'l Airport



Runway 08 BJNU: 4 degree Glide Slope and 1000 ft. Displaced Threshold



Elevations enhanced x3

Challenge #1: Avoid Pedersen Hill!

Runway 26 GJNU:

3 degree Glide Slope and 2000 ft. Displaced Threshold



LEMN
600'

Challenge #1: Turn the corner
Challenge #2: Time to FLARE Engage
While you're at it – avoid the mountains!

Elevations enhanced x3

Image © 2008 TerraMetrics
Image NASA
Image © 2008 DigitalGlobe

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1624 ft

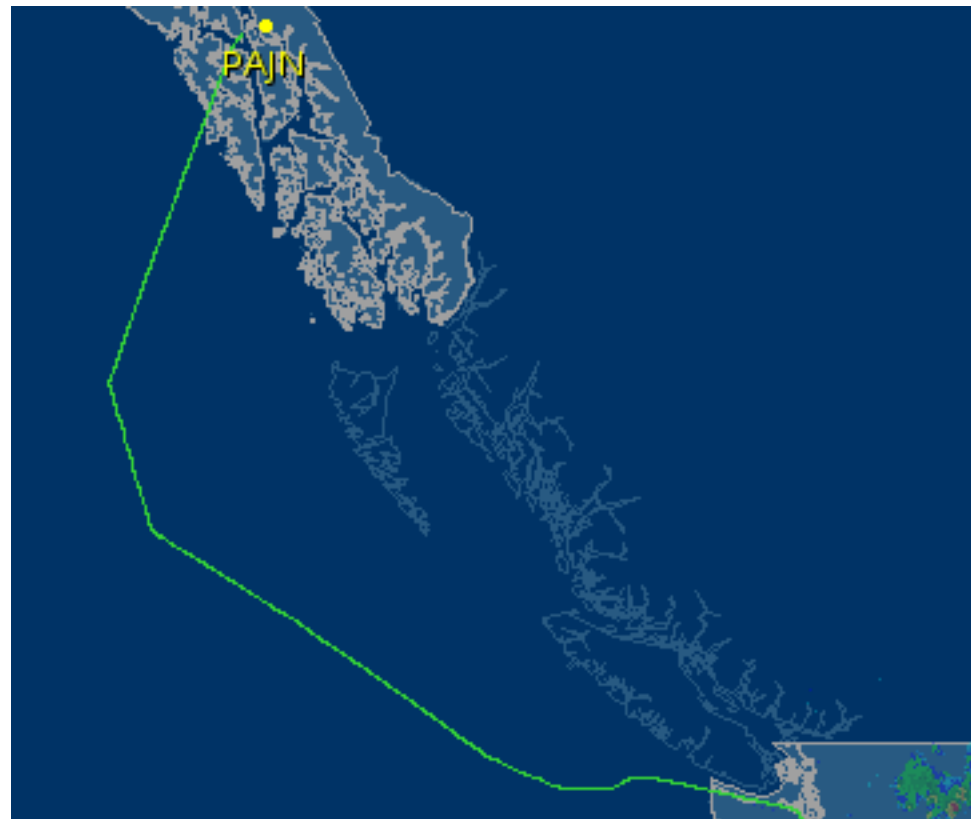
Pointer 58°20'40.09" N 134°30'53.81" W elev 4 ft Streaming 100%

Eye alt 4818 ft

Flight Trials & Operational Trials

Juneau GLS Flight Trial Results

- Showcased the potential for GBAS in a terrain constrained location.
- Demonstrated unique GBAS capabilities
 - Offset thresholds
 - Steep Approach Paths
 - Transition from RNP to GLS final
- Confirmed that autolands can be accomplished at Juneau Airport.

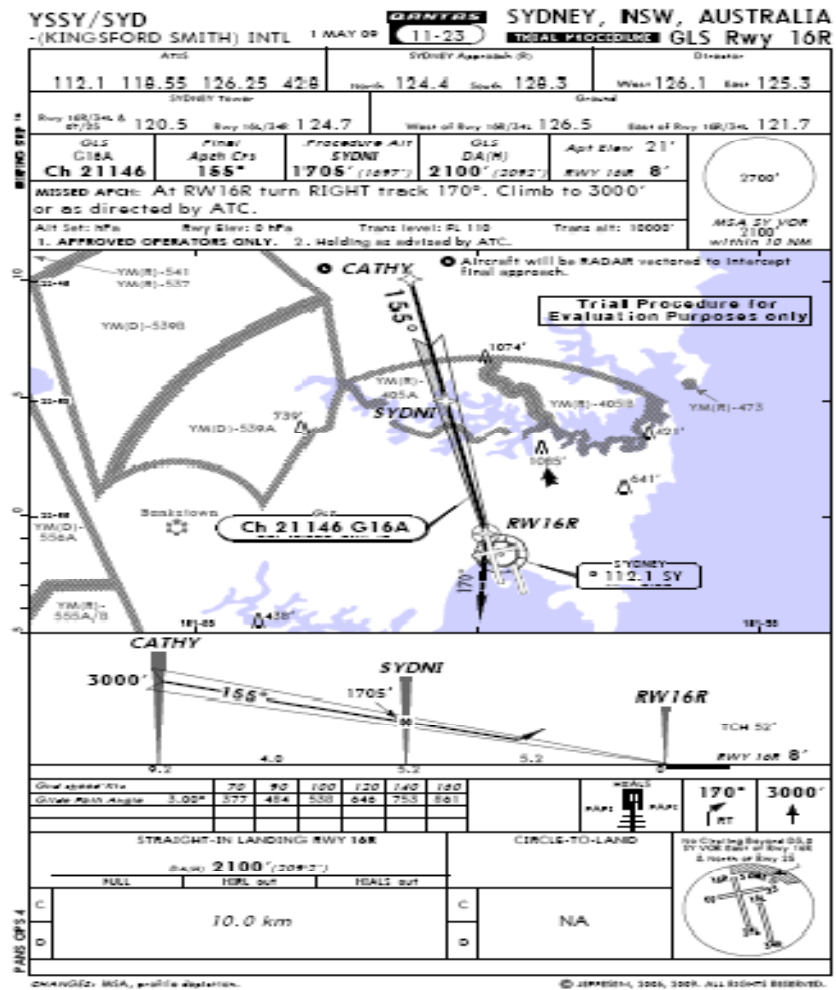
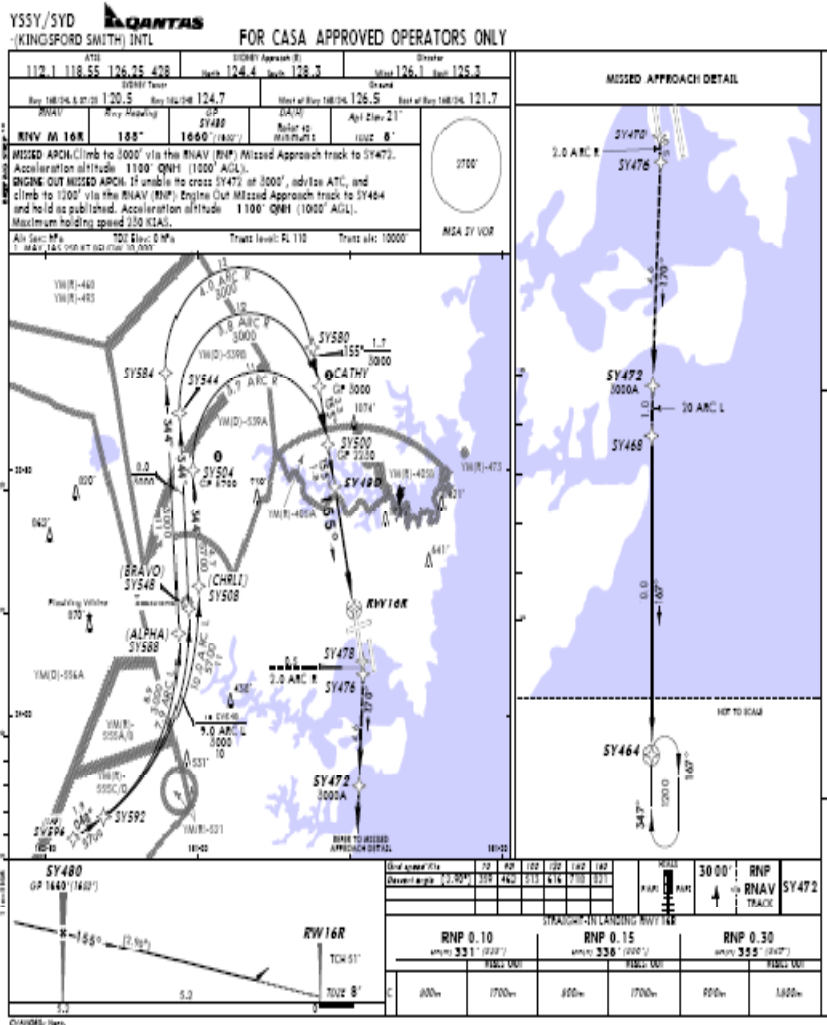


Flight Trials & Operational Trials Sydney Airport with Qantas Airways

- GLS operations initiated late 2006 with Honeywell GBAS prototype.
- Participating aircraft: 737-800 & A380
- Initial operations include (visual conditions):
 - Parallel runway operations
 - Autoland operations
- Flight crew reports are extremely positive
- As of January 2009, Qantas completed over 2000 GLS approaches in revenue service.
- This trial highlights the benefits of GBAS insusceptibility to beam disturbances from aircraft surface movements.
- Airservices Australia is pursuing SmartPath™ installation (1st Quarter 2010).
- Next phase of GLS trials (mid-2010) planned to include:
 - RNP to GLS transitions
 - Simultaneous GLS approaches to parallel runways
 - Displaced threshold operations
 - Low visibility operations (including takeoff)



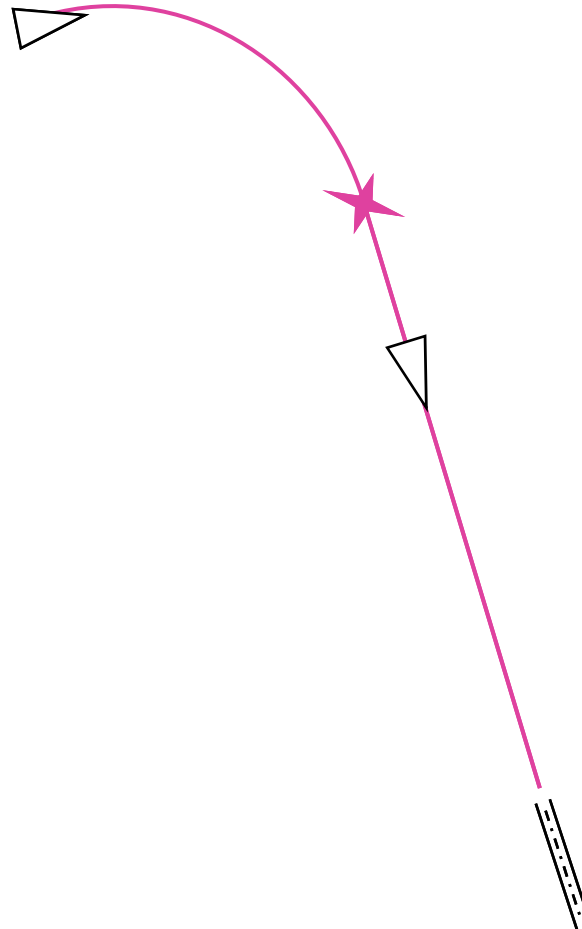
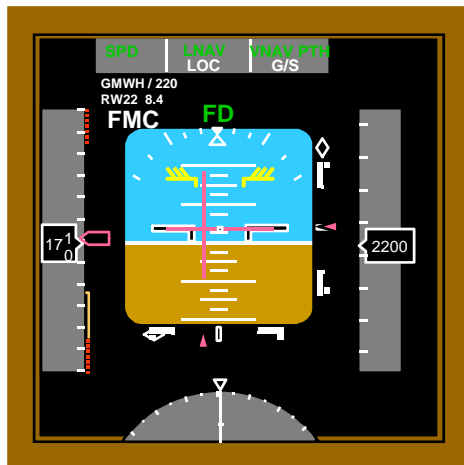
Flight Trials & Operational Trials Sydney Airport - RNP to GLS Procedures



Flight Trials & Operational Trials

Fully integrated on Primary Flight Display

RNP RF leg



■ GLS Final



Flight Trials & Operational Trials

Qantas Airways - RNP to GLS Transitions

- **First RNP to GLS operation in revenue service involving 737NG in May 2009**
 - Extremely smooth transition
 - Radar & ADS-B data confirm track conformance
 - Fuel saving of 140 kg (168 litres) per flight over conventional radar vectoring to ILS
 - Emission reduction of 440 kg CO₂
 - Noise reductions



Agenda

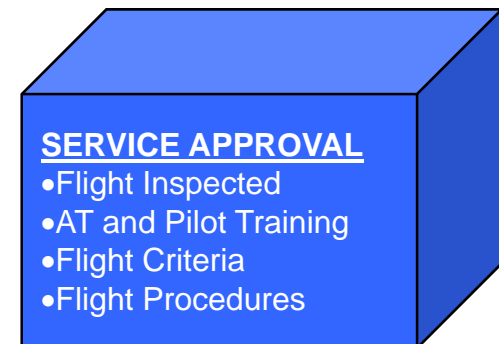
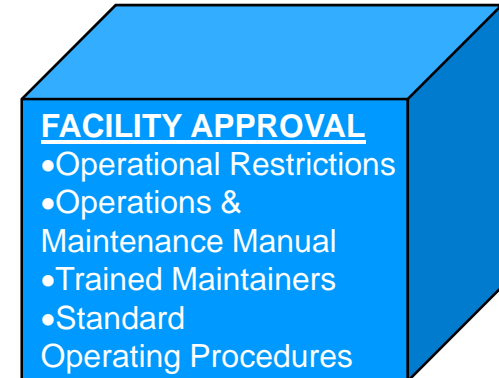
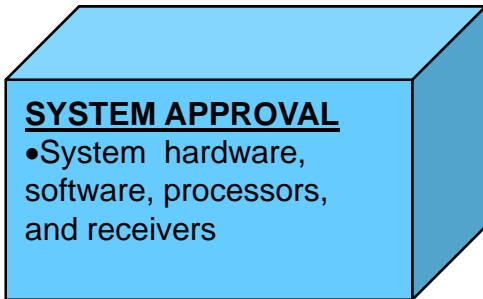
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GBAS Service Approval

Prior to approved GLS operations

There are several different approvals that are needed, which can happen in sequence or in parallel:

1. System Design Approval (applicant is designer of ground system)
2. Facility Approval (applicant is the system installer)
3. Operational Approval (applicant is user/air carrier)
4. Special Instrument Approach Procedure Approval (applicant is user/air carrier)
5. Airworthiness Approval (applicant is airframe manufacturer)
6. Service Approval (applicant is who will install/operate system).
Note, approval occurs after other approvals are complete
7. Required documents review/audit and approval
8. System Notices to Airmen (NOTAM) establishment approval
9. Spectrum and Federal Communication Commission (FCC) license approval
10. Conduct system operational assessment
 - Flight operational evaluations
 - Hazardous Misleading Information (HMI) tests
 - Maintenance tests
11. Review / audit Air Traffic Control (ATC) supportability



GBAS Service Approval

U.S. FAA Regulatory Basis for GBAS Approvals

- **GBAS installation** must be in accordance with:
 - Paragraph 171.49 of Code of Federal Regulations 14 CFR Part 171 Non-Federal Navigation Facilities, Chapter 2
 - FAA Order 6700.20A Non-Federal Navigational Aids and Air Traffic Control Facilities
 - Chapter 3, Section 3.7, ICAO Standards (Annex 10), Volume 1 for Radio Navigation Aids
- **GBAS sites** must comply with:
 - FAA 6970.1 Temperature / Humidity Control Of FAA Facilities.
 - FAA-G-2100 Revision H, Electronic Equipment, General Requirements
 - FAA Order 6700.20A Non-Federal Navigational Aids and Air Traffic Control Facilities
 - Initial FAA On-Site Inspection of the GBAS prior to commissioning flight inspections
 - Training guidance in FAA Order 6700.20A, Chapter 5 and FAA Order 3400.3, Airway Facilities Maintenance Personnel Certification.
- **Maintenance and operations** must comply with:
 - Subpart C 14 CFR Part 171 (171.51) Non-Federal Navigation Facilities
 - FAA Order 6700.20A, Non-Federal Navigational Aids and Air Traffic Control Facilities.
 - 14 CFR 171.51 requires Operations and Maintenance Manual



- **Airborne avionics** comply with:
 - TSO-C161, Ground Based Augmentation System Positioning and Navigation Equipment
 - TSO-C162, Ground Based Augmentation System Very High Frequency Data Broadcast Equipment
 - These TSO's reference RTCA Documents: DO-253C (LAAS MOPS) & DO-246C (LAAS ICD).

GBAS Service Approval Additional Regulations

- **Airworthiness approvals to date are by Issue Paper and Certification Review Items**
 - State compliance with certain elements of FAA Advisory Circular 120-29A
- **The FAA is drafting a new Advisory Circular combining portions of Advisory Circulars 120-29A and 120-28D:**
 - Address xLS systems for Category I, II and III operations.
 - Include comprehensive criteria for GLS Category I capability

The FAA is updating OpsSpec C052 (by combining C052, C053, C074)

- C052 – Types of approaches authorized
- C053 – Requirements for non-precision operations
- C074 – Requirements for CAT I precision operations (will now include GLS and LPV)



- **The FAA is updating Order 8400.13C to include ground equipment requirements for:**
 - Runway Visual Range (RVR) 800 feet (550m) without Touch Down Zone and Runway Center Line lights
 - Special Authorization (SA) CAT I – RVR 1400 (400m)
 - Standard CAT II
 - Special Authorization (SA) CAT II (CAT II on Type I)
 - CAT II to RVR 1000 (300m)
 - Standard CAT III
 - GBAS Category I service

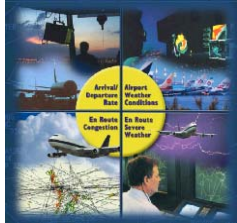
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Boeing Involvement in GBAS Implementation

Assisted in flight and op trials around the world

Regulatory Capability



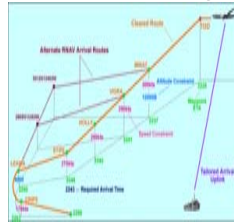
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Airport & Facility Capability



+

Air Traffic Capability



+

Airline Capability



+

Airplane Capability



Develop the regulatory basis for GBAS & GLS

Approve GBAS Design

Install & Commission GBAS Facility

Equip Aircraft with GLS

Train Flight Crews

Train ATC

Approve Operations

Introduce GLS Operations



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GLS equipped aircraft are coming to India



Thank you very much!