Ground Based Augmentation and the GBAS Landing System

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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
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

**GBAS**

Instrument Landing System
glideslope and localizer

Glide slope
Radar Alt
Localizer
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Boeing GLS: 737NG

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

- Display shows approach details, including course, speed, and deviation
- Annunciators indicate active modes and auto-flight status
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
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.
Runway 08 BJNU:
4 degree Glide Slope and 1000 ft. Displaced Threshold

Challenge #1: Avoid Pedersen Hill!

Elevations enhanced x3
Runway 26 GJNU:
3 degree Glide Slope and 2000 ft. Displaced Threshold

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

Elevations enhanced x3
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
Fully integrated on Primary Flight Display

RNP RF leg

- GLS Final
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
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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:
  - 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
- **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

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!