GPS Integrity
RAIM, WAAS, and LAAS:
Concepts and Status

Presentation to: CAAC
October 19, 2010

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Overview

• GPS Basics
• GPS with Receiver Autonomous Integrity Monitoring
• FAA GPS Augmentation Systems
• Wide Area Augmentation System
• Local Area Augmentation System
• Summary
Global Positioning System Basics

- **Space Segment**
  - 24 Satellites
  - 6 Orbital Planes
  - 4 Satellites per Plane
  - SVs Orbit at approximately 20 million meters above the earth
  - Each SV Orbits the earth twice a day

- **Ground Control Segment**
  - Master Control Station, Colorado Springs
  - Monitor Stations; Hawaii, Ascension Island, Diego Garcia, and Kwajalein
Non-Augmented GPS Operations

10-20 Meters SA Off
Atmospheric Errors, Ephemeris Errors, Multipath

Protection Level = 7
GPS Operations and RAIM

- Receiver Autonomous Integrity Monitoring (RAIM) provides GPS solution integrity without additional augmentation.

- RAIM functions include Fault Detection (FD) and Fault Detection and Exclusion (FDE):
  - Fault detection algorithms determine if there is an error in the GPS solution.
  - Fault detection and exclusion algorithms determine if there is an error in the solution and can isolate and exclude satellites from the solution.
RAIM Information

- RAIM Prediction Link

http://www.raimprediction.net/ac90-100/

Current Status: There is at least one Enroute or Terminal TSO-C129 outage
Satellite Navigation
WAAS / LAAS Implementation
Space-Based Augmentation System (SBAS)
Ground-Based Augmentation System (GBAS)
How WAAS Works

Reference Station

Reference Station

Reference Station

Master Station

Uplink Station
How LAAS Works

4 Meter Accuracy
Category I

Protection Level=10 m CAT I

Ground Processor
Ground Data Radio
Data Link Radio
Local Area Augmentation System (LAAS) Service

• Provides Precision Approach Capability, CAT I/II/III Service.
  • Performance equivalent to existing Instrument Flight Rules (IFR) radionavigation landing aids.
  • Complements the Wide Area Augmentation System (WAAS)
    • Provides CAT I where WAAS is not available.
    • Uses WAAS integrity information when in coverage of a WAAS GEO.
  • Requirements were coordinated internationally to support harmonization efforts.

• CAT I/II/III Architectures Have Common Baseline Configuration and are fully interoperable.
LAAS CAT I Approval Status

• SLS-4000 was installed at the FAA Technical Center in September 2008
  • Being used as a platform to support FAA review of Honeywell design artifacts, Integrity Monitor Verification, and a CAT III development system

• Hazardously Misleading Information (HMI) Report was completed December 2008
  • Fully describes the integrity safety case for the SLS-4000

• CAT I System Design Approval
  • NonFed Approval Completed! September 3, 2009

• SLS-4000 was installed at Newark Liberty International Airport (EWR) in November 2009
  • FAA is working to resolve environmental interference at EWR
LAAS CAT I Approval/Test Activities

• Install / Siting Process Review
• Training and Documentation Review
• Test Case and Procedures Review
• 24/7 Signal in Space (SIS) monitoring
• Stability and Integrity Monitor Testing
LAAS Information

- LAAS Team Web page
Summary

• Discussion of GPS, RAIM, WAAS, and LAAS
  • High-level concepts and overview
• Provided links for additional information
• Contact Information at the FAA Technical Center
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