Satellite Navigation Program

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Federal Aviation Administration
Basic GPS System

• **Space Segment**
  – 24 Satellites
  – 6 Orbital Planes
  – 4 Satellites per Plane
  – Orbit at Approximately 11,000 Nautical Miles Above the Earth
  – Orbits Every 12 Hours

• **Ground Control Segment**
  – Master Control Station, Colorado Springs
  – 5 Monitor Stations at Worldwide Locations
Satellite Navigation’s Mission
WAAS/LAAS Implementation
WAAS System Status

**Communications**
- Satellites
  - 2 of 2 on Orbit
- Terrestrial Communications Links Installation Complete

**Hardware**
- WAAS Reference Stations
  - 25 of 25 WRSs Installed/Tested (as of 6/3/98)
- WAAS Master Station
  - 2 of 2 WMSs Installed/Tested (as of 6/3/98)

**Key Issues**
- Stability
- Integrity
WAAS
Key Issues

• Stability
  – 21-Day Stability Test Completed - June 30, 2000

• Integrity
  – Meeting FAA Integrity Requirement (Safety) is Now Most Significant Schedule Driver
  – Integrity Requirements (Precision Approach)
    • $10^{-7}$/Approach
    • Time to Alarm: 6.2 Seconds for LNAV/VNAV
    • 5.2 Seconds for GLS
FAA Response to Integrity Issue

• Formed WAAS Integrity Performance Panel (WIPP)
  – FAA Established Team of Experts in January 2000 To Work Closely With Raytheon to Identify Most Cost-Effective and Expedient Solution
  – Team Includes FAA, MITRE, Stanford University, Ohio University, JPL
  – WIPP Actions:
    • Identify a Path to Achieve LNAV/VNAV Integrity
    • Identify Migration Path to GLS

• Chartered Independent Review Board (IRB)
  – Reports Directly to FAA Administrator on WIPP Products and Other Program Activities
WAAS Operational Status

• Initial Operational Capability with LNAV/VNAV in 2002
  – Vertical Guidance Down to 350 Feet Above Threshold

• Precision Approach Capability Equivalent to Category I ILS
  – Continuing Development
International Status

Canada

• Transitioning to Operational Canadian WAAS (CWAAS)

• Future Agreement Underway to Integrate WAAS and CWAAS

Mexico

• Working Cooperatively With the FAA to Install 3 WAAS Testbed Stations (NSTB Single-strand Reference Stations) in Mazatlan, Merida, and Mexico City

• Preparing to Conduct Joint Faa/mexico Tests to Define Mexico Operational WAAS Participation, Expected Benefits and Overall System Performance
South America

• The Caribbean and South American (CAR/SAM) Region is committed to a GNSS solution as a foundation for a larger CNS/ATM transition within Latin America.

• The CAR/SAM Test Bed (CSTB) will be based on WAAS Testbed Stations (NSTB Single-strand Reference Stations)
  – Will provide test capability for all of South America, Central America, and the Caribbean.

• In the future, LAAS Prototype equipment will be used to conduct tests for providing a precision approach capability to the region.
Japan/Europe

- Interoperability Working Group (IWG) Established to Discuss Critical Interoperability Issues Important to Satellite Based Augmentation Systems (SBAS) Providers

- IWG/1 Was the First Such Meeting Between All SBAS Providers, Hosted by U.S. - Aug 97

- Seven Additional Meetings Have Been Held in Europe, Canada and Most Recently in Japan (May 2000)
Local Area Augmentation System (LAAS) Architecture

LAAS Reference Station (Integrity Accuracy Availability)

Processor
GPS Receiver
VHF Transmitter

Pseudolite
L1 Differential Broadcast Capability

VHF Data Link

LAAS Reference Station (Integrity Accuracy Availability)
LAAS Background

- Government Industry Partnerships Signed (4/99)
  - Raytheon and Honeywell Teams

- LAAS Flight Tests in Atlantic City, NJ (8/99)
  - ATA, FAA, and UPS Participated

- LAAS Flight Trials in Memphis, TN (11/99)
  - ATA, FAA, and FedEx Participated
LAAS Implementation Plans

• Install 20 CAT I LAAS Beginning in 2002

• Install First CAT III LAAS in 2005

• Plan Calls For a Total of 160 LAAS
  – 46 CAT I
  – 114 CAT III
Practical Aspects of Satellite Navigation

- Routes
  - Direct
  - Independent of Ground Infrastructure

- Approaches
  - Greater Uniformity
  - More Precise / Easier to Fly
  - Vertical Guidance Available for Most Airports
• 2,353 GPS Non-precision Procedures Have Been Published

• 1,057 of the GPS NPA’s Provide New Capability to Runways that Previously Did Not Have a Straight-In IFR Approach

• 146 LNAV/VNAV Approaches Have Been Developed
GPS Today and Tomorrow

- 27 Satellites With L1 C/A Signal Today
- WAAS Initial Operational Capability LNAV/VNAV in 2002
- LAAS CAT I Commissioning 2002
- LAAS CAT III Commissioning 2005
Back Up Slides
Basic “T” Approach

**Basic “T”**

- IAF
- IF(IAF)
- FAF
- MAP

**Standard TAA**

- Straight-In Area Navigation to this fix
- Right Base Area Navigation to this fix
- Left Base Area Navigation to this fix
## WAAS Procedures Development PLAN

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* Minimum.

** LNAV (TSO-129) Procedures will be reaccomplished when overlying WAAS and LNAV/VNAV are developed.