Transportation Applications: Now and Future

Session 1: Overview: GNSS-Based Application Areas


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Augmentations Overview

• GPS is an Open Architecture service
  – Where GPS by itself does not fulfill user needs, it can be augmented

• Public Augmentations
  – Nationwide Differential GPS (Nationwide DGPS)
  – Space Based Augmentation Systems (e.g. WAAS)
  – Continuously Operating Reference Stations (CORS), International GNSS Service (IGS), Global Differential GPS (GDGPS)

• Commercial Augmentations
  – Differential GPS, Sensor Integration (e.g. inertial), Cellular, etc.

• Distinct from Value-Added Services
  – Integration of GPS with other data or services (e.g. Location-Based Services)
Nationwide DGPS Status

• Built upon Maritime Differential GPS network
• Operational Since March 1999
• Key Characteristics
  – Local differential corrections
  – Low frequency correction broadcast (good for surface reception)
• User Base
  – Maritime, rail, survey, precision agriculture, weather forecasting, and resource management
• International standard in over 50 countries
International Coverage
GNSS Aviation Integrity

• Availability of GNSS accuracy with continuity and integrity essential to International Civil Aviation Organization Modernization Planning

• Key to future implementation of required surveillance, communications as well as navigation performance

• GPS Aviation Use Approved for Over a Decade
  – Aircraft Based Augmentation Systems (ABAS) – (e.g. RAIM)

• Space Based Augmentation System (SBAS) since ‘03
  – U.S. Wide Area Augmentation System (WAAS); Others soon

• Increases air traffic while maintaining safety standards

• GPS type signals - requires no additional hardware
GPS (ABAS) Aviation Receivers

- Aviation navigation services assured to Safety of Life integrity standards
- Over 16,000 * commercial air carrier Instrument Flight Rated (IFR) GPS receivers sold (as of 2003)
- Additional 70,000 – 80,000 * General Aviation IFR GPS receivers sold

* U.S. manufacturer sales only (does not include units limited to visual situational awareness)
GPS Aviation Ops Approvals

42 Nations; many others pending
Space Based Augmentation System (e.g. WAAS/EGNOS/GAGAN)

- Provides integrity for all phases of flight
- Vertically guided approaches enhance safety
- Permits operations at airports without navigation aids
  - No ground hardware required at airport
- Operations to all runways at all airports*
- Expanding Globally; Can augment multiple satellite navigation constellations
- Ranging and improved algorithm/mask angle increases availability for all applications
- Provides Safety of Life Integrity Services today

* Must meet other instrument flight requirements
WAAS Modernization

• Expansion/Availability Improvements (through 2008)
  – Two new geostationary satellites
    • On orbit (Telesat and PanAmSat)
    • L1 and L5 signals; Operational fall 2006
  – Ground network expansion in Alaska, Canada and Mexico
  – Software upgrades

• Performance and Robustness Improvements
  – Augment GPS L5 signals for redundant service
  – Improved accuracy and integrity
  – Better ops during periods of severe solar storm activity
  – Additional security against interference
  – Enables decommission of large number of ground-based aids
  – Possibility to monitor and augment Galileo Open Service
International SBAS Coverage

- Japanese MSAS
- U.S. WAAS
- E.U. EGNOS
- Indian GAGAN

![Map showing international SBAS coverage](image-url)
WAAS APPROVED FOR NEW, LOWER MINIMUMS (March 2006)

• In 2007, WAAS procedures will provide precision approaches down to 200 feet above airport surface
  – Same as Category I Instrument Landing System (ILS)

• Since WAAS requires no equipment at the airport, it provides a cost-effective alternative to Category I ILS

• Increases capacity at thousands of airports without ILS

* Many airports currently use ILS that is costly to install and maintain
SBAS Equipment

- Garmin GNS-480/CNX-80 - 4000 sold
  - 430/530: 50,000 upgradeable units
- Free Flight Aviation
  - Panel Mount Receiver and sensor
- Rockwell Collins Unit
  - High end users
- Others include: Avidyne, Chelton, CMC, Universal, Thales, and Honeywell
- No equipment changes required to get lower minima
- Non aviation receivers now provide SBAS at no additional cost
  - Over 6 Million receivers (U.S. manufacturers)
Ground Based Augmentation System (GBAS)

- Category-I through Category III (200 to zero foot Decision Height)
  - U.S. implementation: Local Area Augmentation System (LAAS)

- Boeing & Airbus Joined in Support of GBAS
  - Boeing B-737NG certified GBAS avionics; Airbus A-380 in work

- International GBAS Development Cooperation
  - Airservices Australia cooperative agreement with FAA leverages U.S. technology investment for initial ops capability
  - DFS/Germany, AENA/Spain and other service providers interested
GBAS (LAAS) Development

GBAS can support most demanding approach requirements
Performance-Based Navigation

Benefits:
- Enhanced Safety
- Increased Capacity
- Reduced Delays

- Increased Flight Efficiencies
- Increased Schedule Predictability
- Environmentally Beneficial Procedures

Efficient, Flexible Routing

Streamlined Departures

Vector-Free Arrivals

All-Weather Approaches
Performance Based Navigation Implementation

- Existing Ground Based Navigation Aids
  - DME/DME with Inertial

- GNSS (GPS)
  - ABAS (RAIM)
    - Non Precision Approach
  - ABAS With Inertial
    - RNP .1
  - SBAS (WAAS)
    - Category I
  - GBAS (LAAS)
    - Category II/III
Departure Procedures Before RNAV

• Departures voice vectored
  – Headings, altitudes and speeds issued by controllers
  – Large number of transmissions required

• Significant dispersions
  – Flight paths inconsistent and inefficient

• Dispersions limit number of departure exit points
Departure Procedures After RNAV

• Aircraft Fly RNAV tracks (not ATC vectors)
  – Headings, altitudes and speeds automated (via avionics)
  – Voice transmissions reduced (30-50%)

• Dispersions Reduced
  – Tracks more consistent and more efficient

• Additional Exit Points
Automatic Dependant Surveillance - Broadcast (ADS-B)

- **Automatic**: Periodically transmits information with no pilot or operator input required
- **Dependent**: Position and velocity derived from GNSS or Flight Management System (FMS)
- **Surveillance**: Method of determining position of aircraft, vehicles, or other assets
- **Broadcast**: Transmitted information available to anyone with appropriate receiving equipment
- **Other ADS-B services**
  - Traffic Information Service provides ADS-B equipped aircraft with position reports from surveillance radar on equipped aircraft
  - Flight Information Service transmits graphical weather, and airspace flight restrictions
GNSS Location Based Services

• **Cargo Fleet Tracking**
  – Improves safety and security

• **Fleet Control/Dispatch**
  – Fuel savings
  – Improves asset management

• **Emergency Operations**
  – Reduces response times
  – Reduces injury & property loss

• **Road Maintenance**

• **In Vehicle Navigation**
  – Accurate position determination
  – Reduces air pollution
GNSS Positive Train Control

• Situational Awareness
• Enhances safety
  – Reduces accidents
• Increases capacity and efficiency
  – Closer train spacing reduces investments
  – Reduces fuel consumption
• Rapid rail structure and condition mapping
  – Improves maintenance capability
GNSS Maritime Applications

• Large ships, fishing & recreation boats
• Harbor entrance and approach
  – Regardless of visibility
• Hydrographic Survey
• Buoy Positioning, etc.
GNSS Recreation Applications

• Explore anywhere in the world
  – Without getting lost or eaten!
• Your favorite fishing spot
  – Every time
• Try Geocaching
  – GPS treasure hunting
Summary

- GPS - Robust and operating above standards
- Augmentations (user equipment or infrastructure based) provide additional capabilities
- WAAS (SBAS) in operation today for instrument use; adding 200’ decision height in 2007
  - Benefits all users - even those not within Geo footprint
- Surface, Rail, and Maritime GNSS Services improve safety, security, and efficiency
- Performance based requirements
  - Support use of one or more GNSS solutions
  - Interoperability provides greater capability than from a single solution
- New constellations and augmentations on the way
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