CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Short and Long-Term Planning Considerations

The Atmosphere and its Effect on GNSS Systems

14 to 16 April 2008

Santiago, Chile

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Migration to a GNSS Service

- **Major GNSS services extend beyond national boundaries**
  - **Core constellations offer worldwide service**
  - **SBAS covers continental areas**
- **A regional approach to migrating from ground NAVAIDs to GNSS appears most effective**
  - **Implementation *and* research, development and planning**
- **GNSS is still an evolving technology**
  - **Dual frequency applications will dramatically improve service in South America**
    - **Only a few years away**

General Considerations

1 of 2

- **Implementing a GNSS augmentation is a relatively long process**
  - **Minimum of 5 years, and could be longer**
- **Planning should give due consideration to GNSS modernization and other technological advancements**
  - **According to current schedule GALILEO and dual-frequency GPS should be available in the 2013 to 2015 timeframe**
  - **Unfortunately, the schedule for GNSS modernization has shown to be somewhat elastic**
- **FAA has started exploring potential GNSS architectures in the GPS-III, Block C timeframe (2030 and beyond)**
  - **Study aims at a level of service equivalent to LPV-200 worldwide**
- **Multi-frequency, multi-constellation solutions are also being investigated in Europe**

General Considerations

2 of 2

- **Based on current state of the art, the programmatic risk of a potential single-frequency SBAS implementation to provide APV in all but the southern-most part of South America appears to be very high**
  - **SBAS monitoring of GPS satellites could contribute a much improved availability of ER/NPA service**
- **Dual frequency SBAS (with GPS and/or GALILEO) would require fewer monitoring assets and should provide APV everywhere**
- **GBAS should provide adequate Category I precision approach service**
  - **Serve as a stepping stone toward future GBAS Cat II/III service**
  - **Risks (impact on service) associated with localized ionospheric effects need to be carefully evaluated**

Considerations Related to Ionospheric Effects

1 of 2

- **Ionospheric effects in South America have not yet been characterized as extensively as in mid-latitudes**
- **A large depository of data and analyses are needed to support GNSS-based approach and landing services**
- **If an SBAS implementation is considered, a good characterization will be needed for**
  - **Variations in ionospheric delays over wide areas**
    - **Requires a network of reference receivers distributed over the entire service area (300 to 600 km apart)**
  - **Errors induced by the thin shell model**
    - **Particularly in equatorial anomaly region**
  - **Ability to detect depletions (misdetection and false alert risks)**
    - **And impact on service associated with detections**

Considerations Related to Ionospheric Effects

2 of 2

- **Wherever a GBAS implementation is considered, a good characterization will be needed for**
  - **Variations in ionospheric delays over the local area**
    - **Requires a few closely space receivers (5 to 10 km) in area of interest to evaluate gradients in East-West and North-South directions over 10 to 15 km (final approach distances)**
  - **Characterization will depend on magnetic latitude**

- **For all types of GNSS implementation**
  - **Probability of loss of service due to scintillation induced losses of lock**
    - **Probability will depend on the navigation service**
    - **On the number of satellites in view, and**
    - **On the level of ionospheric scintillation**