Enabling the LAAS Differentially Corrected Positioning Service (DCPS)

Young Shin Park, Sam Pullen, and Per Enge
Aero & Astro Department, Stanford University

Introduction

Local Area Augmentation System (LAAS) is primarily focused on supporting precision approach but it can also be used for a variety of other applications that are known as DCPS. DCPS includes all potential airborne uses of horizontal position and velocity that are not included in CAT I precision approach.

Airborne Geometry Screening Rules

- Limited subset geometry
- All-in-view only (M = 0)
- Drill-down to 1-satellite out (M = 1)
- Drill-down to 2-satellites out (M = 2)
  - Constellation Dependent
  - Limiting Maximum absolute value of the range-to-position scalar ($|S_{horizontal}|$
  - Combinations of airborne geometry screening rules
  - RAIM with combinations airborne geometry screening rules

Simulation Procedure

Generate all in view, all 1-SV out, all 2-SV out, etc., down to all 4-SV subset geometries

Loop through all independent individual satellites

Compute worst-case Position Error *, Protection Level *

* Horizontal component only

Screening Based on Limited Subset Geometry: Memphis

- Drill-down to 4-SV (no new screening)
- Drill-down to 2-SV out (M = 2)
- Drill-down to 1-SV out (M = 1)
- All-in-view only (M = 0)

Results

Screening Based on Maximum $|S_{horizontal}|$ Only: Memphis

| $|S_{horizontal}|$ | MUE (m) | DCPS Availability (%) |
|-------------------|--------|------------------------|
| 6.0               | 150    | 95.3                   |
| 5.2               | 130    | 94.5                   |
| 4.0               | 100    | 92.5                   |
| 3.2               | 80     | 89.8                   |
| 2.0               | 50     | 78.6                   |
| 1.2               | 30     | 48.8                   |
| 0.4               | 10     | 0.05                   |

Conclusions

Four key conclusions have been drawn from the DCPS analyses conducted in this research:

1. Changes to both the DCPS integrity requirements definition and the requirements on LAAS avionics are needed to make DCPS usable.
2. A change to the impact component of the CONUS LAAS ionospheric anomaly threat model, from 2-satellite to 1-satellite impact, is necessary when this threat model is applied to DCPS.
3. Once a non-zero value of MUE is allowed by the DCPS integrity requirement, the use of multiple screening rules and, optionally, the use of RAIM for DCPS makes it possible to achieve an MUE for DCPS of about 50 meters (for $D_{max} = 45$ km) with approximately 95% availability. Further significant reductions do not appear to be possible unless the maximum-gradient bound in the ionospheric anomaly threat model is reduced significantly. However, defining availability more conventionally, in terms of the all-in-view geometries only, would result in significantly lower MUE values at 95% availability.
4. Because performance differences among the most-helpful options are relatively small, there does not appear to be one clearly “best” choice of additional airborne screening and monitoring. Therefore, the optimal selection depends highly on the specific flight and ground operations to be supported by DCPS and the constraints imposed by existing LAAS airborne equipment.

Research is supported by the FAA LAAS Program Office and SCPNT.