Chapter-9

Conclusion and future work

I. Scintillation and Depletions over Indian region

1. The scintillation activity at the L-band frequency of 1.5 GHz is mostly confined to the pre-midnight hours, with practically no significant scintillation activity during the post midnight and summer months of this Low Sunspot Activity years of 2004-2006.

2. The scintillation activity is significant in the equinoxal months of March, April, September & October during this LSSA period.

3. Scintillations > 10dB (S4 index = 0.45) occur more frequently around the regions of EIA (confining to 15 to 25°N geog. Lat)

4. These scintillations are often accompanied by the TEC depletions (bubbles); sometimes resulting in the loss of lock of the GPS receiver phase.

5. The occurrence of these bubbles is also found to be maximum during the equinox months peaking around the equatorial ionization anomaly region of 15° to 25° geographic latitudes.

6. The most probable bubble durations vary from 10 to 30 minutes and their amplitudes vary from 5 to 20 TEC units, which correspond to a range error of about 1 to 3.5 metres in the GPS navigation.]

7. For the days on which the TEC anomaly gradient exceeds 1.25 and post sunset vertical drifts at the equator exceeds 20 m/s, there appears to be greater probability for the occurrence of L-band scintillations as observed from the data of Indian GPS Network.

II. Validity of the IPP altitude of 350 km in the Indian Sector

1. Preliminary studies show that the variation in the effective altitude in the coversion of slant to vertical TEC did not show much of a variation, at least for elevation angles greater than 50°.

2. For low elevation angles and at local times of large TEC, the deviations appear to be significant.

III. TEC Variations over Indian Region

1. TEC varies from 5 to 50 TEC units at the equator and from 5 to 90 TEC units at the crest region which corresponds to range variations of about 1 to 8 metres at the equator to 1 to 15 metres at the crest region. These values will go up in HSSA periods.

2. The Equatorial Ionization Anomaly (EIA) maximizes during equinoxes followed by winter and insignificant in summer months in this LSSA period.

3. The location of EIA crest and its peak value in TEC increases with the increase in the IEEJ strength.

IV. Dual Shell Model

Based on the limited data available to date, it appears that modifications to the current system can provide significant LPV service to the single frequency user in equatorial regions. Some key findings include :

1. A two shell model can describe the equatorial large scale features accurately enough to support precision guidance.

2. By removing significant depletion features from the threat model. Ionospheric integrity bounds can also support precision guidance

3. A user depletion detector allows user to "coast through" depletion events when scintillation doesn't caused a loss of lock

4. Scintillation may only have a minor impact on availability

5. User RAIM allows for more reasonable integrity bounds

This new approach requires changes in the ICAO SARPS and the changes can be made in a backwards compatible fashion. It further requires some additional user processing, which necessitates a software update on the existing avionic GPS receivers. This is a significant finding for both users and civil aviation authorities contemplating SBAS usage in these regions.

More simulated and real data is needed to work out the details for the depletion detection algorithms. Potential detection modifications include taking advantage of the ground system's knowledge of the large scale ionosphere features. This may allow for a tighter slope-detector threshold without incurring a large false alarm rate. Work may also include taking a closer look at dual fault RAIM algorithms.

Some care must be paid to the correlation between scintillation events (loss-of-lock) and depletion events to establish the integrity of these algorithms. Also, close work with the safety community is needed to iron out new integrity issues that arise. The biggest issue may be obtaining sufficient data from solar max conditions to validate this approach before the next solar cycle.