Orbital Representation for the Next Generation of Space-Based Augmentation Systems

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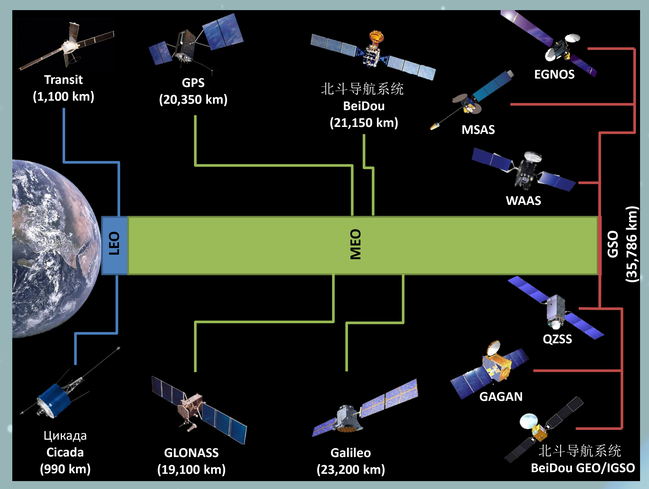
Background

The next decade will see many changes in the world of satellite navigation. There will be four fully operational global coverage constellations, namely, the current US GPS and Russian GLONASS systems as well as the European Galileo and Chinese BeiDou currently under construction. There will also be a plethora of Satellite Based Augmentation Systems (SBAS) which will further expand this combined system. This will ultimately lead to multi-constellation navigation in aviation, leaving the need for modernization of several aspects of existing systems. One such update is the in the Minimum Operational Performance Standard (MOPS) which currently can only describe the orbit of Geostationary (GEO) satellites. This limitation reduces the number of orbit classes which could be used in this applications. The goal is to design a single satellite orbit message suitable for the next generation MOPS which can encompass all of the orbital regimes employed by Global Navigation Satellite Systems (GNSS) and Satellite Based Augmentation Systems (SBAS).

GNSS & SBAS Orbit Classes

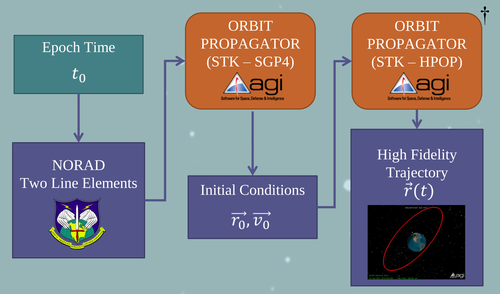


Message Structure

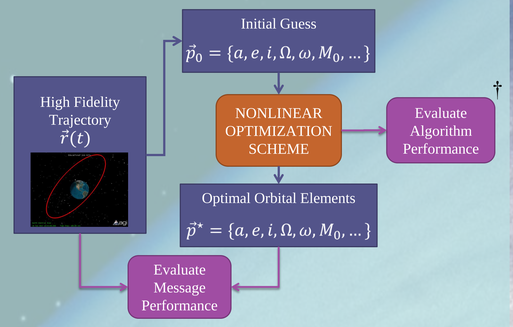
Parameter	Description	
a	Semi-major axis	6 Keplerian Elements
e	Eccentricity	
i_0	Inclination	
Ω	Right ascension of the ascending node	
ω	Argument of perigee	
M_0	Mean anomaly	
IDOT	Rate of inclination (cross-track correction)	Correction Terms
C_{us} , C_{uc}	Along-track harmonic correction terms	

Methodology

Orbit Data Generation



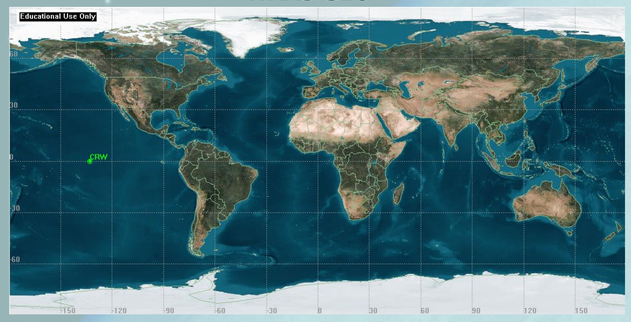
Fitting of Orbital Elements

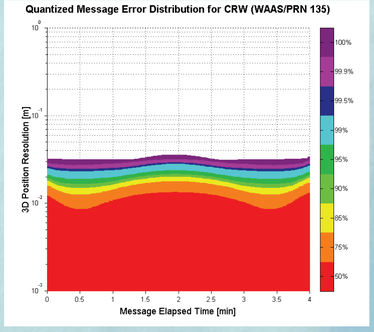


†Repeated at every 10 minute interval for a year.

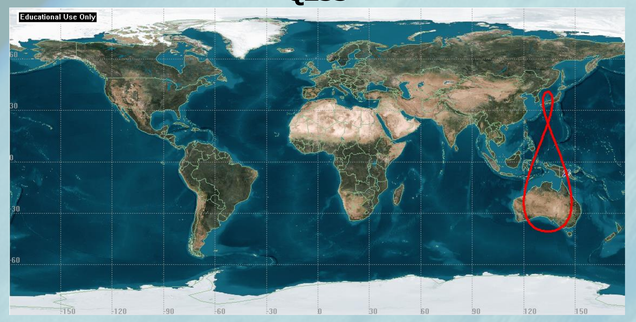
Results

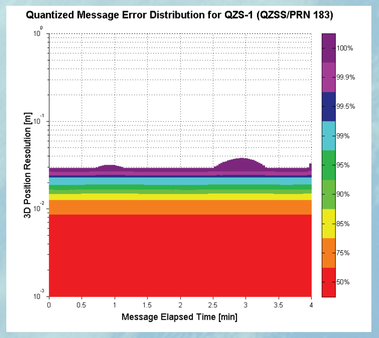
WAAS GEO



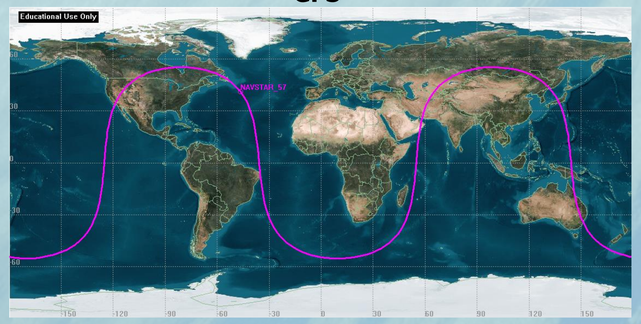


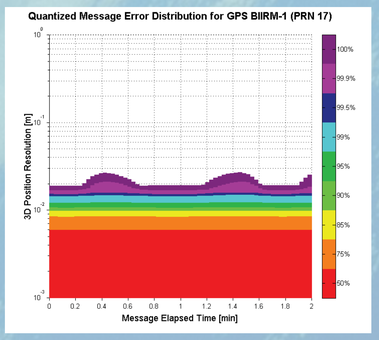
QZSS





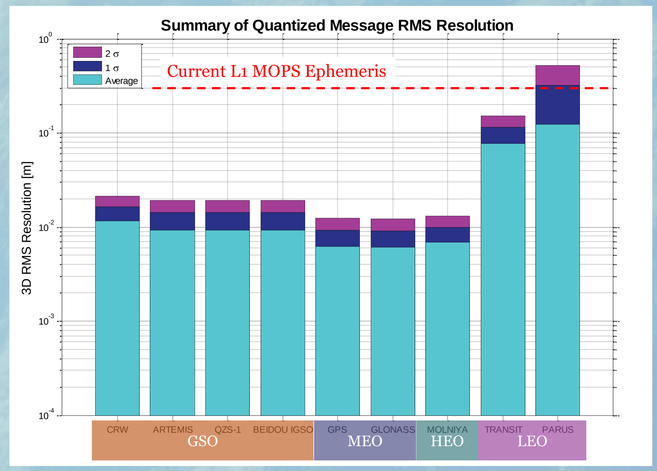
GPS





Summary of Performance

- The proposed orbit description message offers a factor 10 improvement in accuracy over that which is used in practice today for SBAS.
- The message has the additional capacity to represent Geosynchronous orbits (GSO) of both an inclined and eccentric nature, Medium Earth orbits (MEO), as well as Highly Elliptical Orbits (HEO) such as Molniya.
- The message offers limited functionality in Low Earth Orbits (LEO), but works as well or better than the message in use today which can only represent the current SBAS GEOs.
- The computational effort needed to generate the message parameters via an iterative nonlinear least squares method proved to be within the capability of existing ground equipment, further demonstrating message feasibility.



Conclusion

The proposed MOPS ephemeris message and population algorithm have been shown to function amicably as a representation method for satellites in a variety of orbit classes which are currently used by GNSS and SBAS systems and some which have been proposed for the future.

Acknowledgements

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