Geophysical Research Abstracts
Vol. 14, EGU2012-6850, 2012
EGU General Assembly 2012

Characterizing GPS Block IIA Shadow and Post-Shadow Maneuvers

J. Weiss, Y. Bar-Sever, W. Bertiger, S. Desai, B. Haines, N. Harvey, and A. Sibthorpe
Jet Propulsion Laboratory, California Institute of Technology

We characterize GPS Block IIA shadow and post-shadow maneuvers by way of "reverse" precise point positioning (PPP). This technique takes advantage of the non-zero antenna phase center offset, representing the vector from the satellites' center of gravity (CG) to the antenna phase center, to estimate the spacecraft yaw attitude.

We begin with a standard GIPSY-based precise orbit determination (POD) solution for the GPS constellation, and use the ground station troposphere, clock, and position estimates, as well as the reduced-dynamic GPS orbit solution as input to a follow-up estimation where the spacecraft body-fixed x, y, and z antenna phase center offsets relative the CG are estimated as unconstrained stochastic white noise parameters every 30 seconds. These estimates directly provide yaw attitude because the spacecraft attitude in the follow-up estimation is set to follow the "velocity frame," where the body-fixed z points towards the Earth, x points along the velocity vector, and y completes the right-handed coordinate system. The estimated antenna offsets absorb errors in the velocity frame attitude model, which does not perform noon and shadow maneuvers, and in turn directly measure spacecraft yaw attitude.

In this presentation we utilize the outlined approach to characterize both shadow and post-shadow maneuvers of the GPS Block IIA spacecraft over a period of three years. We fit linear models to the yaw angle estimates during shadow (when the spacecraft traverses umbra) and compare the resulting yaw rate to estimates from standard POD solutions. We particularly focus on changes in yaw rate over time, and on using estimates from reverse PPP to improve nominal yaw rate values. We additionally characterize post-shadow maneuvers for which data are typically removed in POD solutions because the direction and duration of the yaw maneuver to recover nominal attitude are not straightforward to model. We analyze post-shadow maneuvers in terms of yaw angle versus time, the turn direction, and factors such as the angle between the GPS orbital plane and the plane of the Earth's revolution around the sun ("beta" angle). Initial results indicate that the reverse PPP yaw angle estimates are determined with an accuracy of a few degrees, with significant potential for smoothing to improve precision. Comparisons of empirical yaw to the standard model (e.g., Bar-Sever, 1996) furthermore show excellent agreement in the timing of noon and shadow maneuvers. Finally, based on the empirical results we discuss workable improvements to the GPS Block IIA attitude model and possible approaches for including post-shadow data in future orbit reprocessing campaigns.