Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09669, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09669
EGU General Assembly 2008

Relative positioning of LEO satellites at different baselines using GPS

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Relative positioning of LEO satellites using GPS has been studied a lot in the past decade, which not only provides the necessary relative position information for the configuration maintenance maneuvers of satellite formations but also is an important weigh factor in the system design of some missions, such as the baseline design of GRACE. However, most of the researches have been focused on the relative positioning of LEO satellites over a short baseline (not more than several hundred kilometres). For the long-baseline LEO satellites, whether GPS relative positioning can be used and what the accuracy is still lack a clear answer. If an overall view on the GPS relative positioning of LEO satellites at various baselines is obtained, it can not only help decide the application potential of GPS in the autonomous constellation maintenance of the recently booming LEO satellite constellations but also be useful to the future mission design of GRACE-alike satellite formations.

This paper presents the change of the relative positioning accuracy of two LEO satellites with the increase of the intersatellite separation using single-differential GPS (SDGPS). The two LEO satellites are in the same near-circular orbit, the separation between which varies from 100m to 10000km.

Single-differential GPS (SDGPS) is used in the paper to compute the baseline vector between the two LEO satellites with GPS receivers onboard. Because the absolute position of the reference receiver is needed in the relative navigation, a least squares estimator has been developed for the stand-alone positioning of one LEO satellite using GPS pseudoranges. Accordant with the error analysis equation of relative posi-

tioning, the absolute positioning error, whether tens of meters or several centimetres, nearly has no effect on the result of SDGPS relative positioning. GPS measurements used in the paper are generated by the signal simulator of the IESSG. A simplification is adopted: given a measurement noise of 0.005m, P1 pseudoranges are used as a substitute of phase measurements to avoid the ambiguity resolution and to get a quick initial result.

Simulation results indicate that for two coplanar LEO satellites at the altitude of 600km inclined at 89º, when the intersatellite separation increases from 100m to 10000km, the relative position accuracy decreases from less than 1mm to around 6m, while the absolute position accuracy remains about 3.4m.