Abstract

The interest in a precise orbit determination of Low Earth Orbiters (LEOs) using GNSS observations, in order to recover the Earth's gravity field, has rapidly grown. Based on the advent of precise orbit and clock products by the IGS analysis centres and geometrical high-low Satellite to Satellite Tracking (hl-SST) observations, the point-wise Geometric Precise Orbit Determination (GPOD) of LEOs can be introduced with only a single GNSS receiver onboard LEOs. Based on a new proposed Kinematic Precise Orbit Determination (KPOD) method, the orbit is represented by a number of approximation parameters including boundary values of the LEO arc. This kind of orbit representation not only allows to determine an arbitrary functional (e.g. velocity and acceleration) of the orbit arcs but is also possible to use dynamical information for the determination of the orbit parameters. In the geometrical and kinematical POD procedures, no dynamical information is used at all. Because of the close relation of the estimated kinematical parameters with the force function model, orbit determination can be designed as a pure KPOD on the one hand and a pure Dynamical Precise Orbit Determination (DPOD) on the other hand. If only weak dynamical restrictions or full dynamical information are introduced to the estimation procedure, then a Reduced-Kinematical Precise Orbit Determination (RKPOD) is introduced. In this paper, the new concept, the various possibilities and the effect of the dynamical information in POD based on simulated data are presented for the GOCE mission.

Kinematic Precise Orbit Determination (KPOD)

In Shabanloui (2008), it was demonstrated that a LEO short arc can be kinematically represented as,

$$\mathbf{r}(\tau) = \mathbf{r}(\tau_0) + \sum_{i=0}^{\infty} \mathbf{a}_i \sin (i \tau)$$

$$\mathbf{v}(\tau) = \mathbf{v}(\tau_0) + \sum_{i=0}^{\infty} \mathbf{a}_i \tau \cos (i \tau)$$

$$\mathbf{a}(\tau) = \mathbf{a}(\tau_0) + \sum_{i=0}^{\infty} \mathbf{a}_i \tau^2 \sin (i \tau)$$

where $\mathbf{r}(\tau)$ is the normalized position at time $\tau$, $\mathbf{v}(\tau)$ is the normalized velocity at time $\tau$, and $\mathbf{a}(\tau)$ is the normalized acceleration at time $\tau$. The arc length $\tau$ as

$$\tau = \int_{\tau_0}^{\tau} \frac{ds}{a(r)}$$

Kinematic Precise Orbit Determination (KPOD) of LEOs can be introduced with only a single GNSS receiver onboard LEOs. Based on a new proposed Kinematic Precise Orbit Determination (KPOD) method, the orbit is represented by a number of approximation parameters including boundary values of the LEO arc. This kind of orbit representation not only allows to determine an arbitrary functional (e.g. velocity and acceleration) of the orbit arcs but is also possible to use dynamical information for the determination of the orbit parameters. In the geometrical and kinematical POD procedures, no dynamical information is used at all. Because of the close relation of the estimated kinematical parameters with the force function model, orbit determination can be designed as a pure KPOD on the one hand and a pure Dynamical Precise Orbit Determination (DPOD) on the other hand. If only weak dynamical restrictions or full dynamical information are introduced to the estimation procedure, then a Reduced-Kinematical Precise Orbit Determination (RKPOD) is introduced. In this paper, the new concept, the various possibilities and the effect of the dynamical information in POD based on simulated data are presented for the GOCE mission.

Numerical results