Impact of Station Coordinate Accuracy on Dynamic Time Transfer

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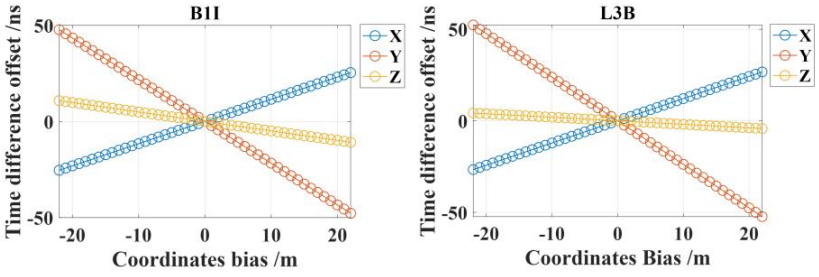
Mobile stations such as sailing ships, self-driving cars, and high-speed railway trains have put forward a demand for high-precision time synchronization. However, most of them use the one-way Global Navigation Satellite System (GNSS) time transfer to achieve time synchronization to GNSST or UTC(GNSS) (predicted Coordinated Universal Time (UTC) by GNSS), where, the timing performance, mainly including the time differences between mobile stations and reference stations, as well as between multiple mobile stations is usually unknown for users. With one way method, various uncertainty sources such as real-time changes in the position of mobile carriers have not been taken into account in terms of their impact on the performance of mobile carrier time synchronization. As of now, high precision GNSS code based time transfer, such as common view (CV) or all in-view (AV), exists between static stations, such as the time links of the International Atomic Time (TAI) computation[1][2]. For the mobile stations, the duration of measurements data used for positioning is too short to calculate accurate coordinates. If GNSS time transfer is used for mobile stations, the impact of the inaccurate coordinate should be analyzed and evaluated.

The impact of station coordinates on time transfer has been analyzed in [3]. However, factors other than the variation of geometric distance are not considered. Here, the impact of coordinate accuracy on GNSS time transfer is studied in more detail. The correction terms in the time transfer resolution equation are analyzed item by item based on the CGGTTS-V2E standard. The items related to the station coordinates are acquired and studied, such as the geometric distance delay, ionospheric delay, and tropospheric delay. The variation of geometric distance delay is three orders of magnitude greater than that of tropospheric delay and five orders of magnitude greater than that of ionospheric delay. Geometric distance delay error is the main cause of the GNSS time transfer results (REFSYS) error for single station, when there is a bias in the coordinates of the mobile station. As shown in Fig.1, for both single-frequency and dual-frequency measurements, the results error caused by coordinates bias is linear with the bias. Five meters bias may result in an error of nearly ten nanoseconds.



(a) (b)

Fig. 1: The time difference variation caused by mobile station coordinates bias (BDS B1I and L3B).

Meanwhile, the time transfer experiments were conducted based on the GNSS CV in dynamic scenes. Inaccurate standard positioning coordinates and accurate post-processing coordinates by Precise Point Positioning (PPP) are used to calculate the REFSYS value of the mobile station. Fig. 2 shows the time difference between the mobile station and the reference station. For time

transfer based on standard positioning, the standard deviation of the time difference during the stationary period of the mobile station is 2.0 ns. After moving, the time difference jitter significantly increases, and the standard deviation increases to 3.5 ns. For the time transfer results based on PPP positioning, the standard deviation of the time difference during the stationary and the moving periods is 1.5 ns and 1.7 ns separately. The results indicate that inaccurate coordinates can indeed cause a deterioration in time transfer performance.

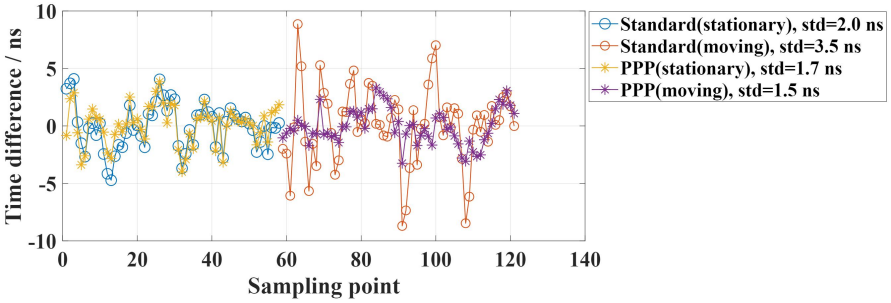


Fig. 2: The time difference between the mobile station and the reference station based on PPP and standard positioning coordinates during the stationary and the moving periods.

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