Absolute Field Calibration of Carrier Phase Multipath

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Introduction

Carrier phase multipath is one of the most common sources of error for precise GNSS applications in active reference station networks such as the Satellite Positioning Service of the German National Survey (SA*POS*®). Depending on different factors, the effect can reach magnitudes in the order of several mm…cm. Consequently, the bias degrades speed, accuracy and reliability of ambiguity and position determination.

Fig. 1. Moving robot near SA*POS*®-station Hannover

Multipath is a highly localized error and does not cancel out in observation differences. The effect can be minimized by measuring over larger spaces of time. But due to its periodic behaviour with typical periods between 1 and 30 minutes, multipath cannot be avoided in rapid static applications. In order to mitigate multipath propagation for reference stations, one approach consists of the calibration of stations using a precise robot with a moving antenna (Fig.1.).

Absolute Multipath Calibration

The basic idea is to decorrelate the multipath on one station due to the (pseudo-) random motion of the robot. Due to identical conditions on a short baseline, atmospheric and orbit errors cancel out. Then, if precise absolute phase center variations (PCV) of the antennas are known, the multipath of a second station is accessible (Fig.2.).

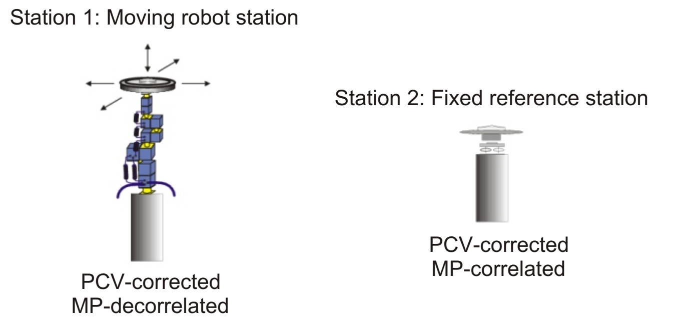

Fig. 2. Principle of multipath calibration with a moving robot

In order to also separate the multipath signal completely from the receiver clock errors, both units use the same clock. Then, single differences between both stations can be calculated, and polynoms can be used to model clock behaviour and estimate multipath signals.

Precise Clock Modeling

A prerequisite for this approach is precise receiver clock modeling. First tests showed, that the computed multipath parameters are very limited in time when using the internal quartz oscillators. Therefore, the reason can be found in varying orbital periods of the GPS satellites (Fig.3.). Applying these multipath corrections several weeks after the calibration date, remaining clock errors can no longer be estimated, and falsify the entire model.

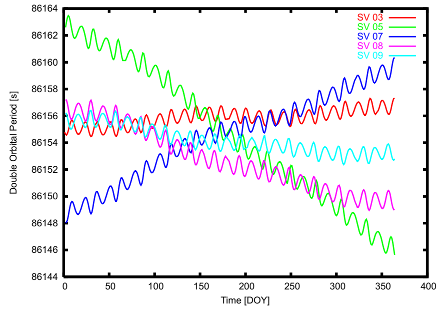

Fig. 3. Orbital periods of GPS-Satellites

In order to minimize such clock errors, investigations are currently underway connecting both receivers to the same rubidium frequency standard and using points of intersection between satellite orbits for clock modeling. Due to identical multipath error, these cross points can be used to estimate precise receiver clock information. Depending on satellite constellation und visibility, about 500-600 points per day can be determined from GPS orbits. Integrating GLONASS orbits, the number can be doubled (Fig.4.).

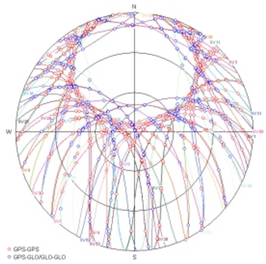

Fig. 4. Points of intersection between satellite orbits

First Results

The following standard deviations for positioning results were calculated using L1 carrier phase data with and without multipath corrections. Improvements of up to nearly 60% are very promising for further investigations.

	s (not corrected) [mm]	s (corrected) [mm]	Improvement [%]
North	2.44	1.10	54.9
East	1.93	0.99	48.7
Height	4.29	1.87	56.4

Acknowledgment

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