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Transfer functions for high-rate GNSS receivers

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In recent years the development of GPS receivers with sampling rates as high as 100Hz has sparked interest in capturing high-dynamic motions and has potentially enlarged the applicability in navigation, positioning and Earth monitoring.

The additional yield of information due to increased sampling rates, however, may be counteracted by a strong correlation of the measurements in time. Unfortunately, the tracking loop filters of the receivers produce correlations exactly in the frequency range (1-100Hz) of the expected benefit of high-rate receivers. The consequences of the correlations between subsequent epochs can be demonstrated by increased amplitude and phase retrieval errors during accelerated motions. The magnitude of these deviations directly depends on the bandwidth of the used tracking loops. A minimization of tracking loop-induced errors can be achieved in two ways: (1) by the optimization of the receiver tracking loop parameters (a larger bandwidth reduces the amplitude errors at high accelerations) and (2) by inverse filtering with a pre-estimated receiver transfer function. Especially for receivers with low and fixed tracking loop bandwidths the determination of a transfer function is crucial.

In this presentation an approach to retrieve an empirical transfer function will be demonstrated. A lot of GPS coordinate time series with a broad variety of motions generated by a single-axis shake table have been produced. The discrepancies between the actual shake table motion (measured by inductive sensors) and the motions derived from the data of various GPS receivers are the basis for the determination of (receiver-specific) transfer functions.. The discrete transfer functions are modeled as an Autoregressive Moving Average (ARMA) using the least-squares method. The transfer function can be decomposed into two terms, the moving average of the input (shake table or signal simulator) and the auto-regression of the output (GPS signal). The major challenges to retrieve an empirical transfer function from real measurements are the measurement noise and the time-dependent parameters (e.g. changes in the tracking loop bandwidths dependent on the signal strength).