Dynamic Two Way Time Transfer (DTWTT)

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Time transfer is a scheme where two or more systems share a precise reference time. Wireless time transfer over long distances is a very important aspect for individual platforms in networks to make critical data exchange possible with high accuracy for time critical applications. The technically simple one way time transfer can be used to serve multiple sites at the same time. It is however limited in its accuracy due to the inability to precisely determine the propagation delay. The two way time transfer (TWTT) method involves signals that travel both ways between the two clocks or oscillators that are being compared. If the simultaneous data of the time interval between the local clock and the received signal from the remote clock are exchanged in both directions and the two data sets are differenced, it turns out that the propagation delay cancels almost exactly, thus resulting in high accuracy of the time transfer. Two way Satellite Time and Frequency Transfer (TWSTFT) is a special case that involves the use of a geostationary satellite transponder to relay the signals between two remote stations. This technique, with an accuracy of 1-2ns has become the primary means of time transfer between timekeeping laboratories contributing to the BIPM time scale [1].

An important generalization of the TWTT is a situation where the participating clocks at the respective platforms are not stationary but are moving relative to each other. This would be the case, for instance, for time transfer (a) between a ground station and an aircraft or an orbiting satellite or (b) between two aircrafts or satellites. The exact cancellation of the propagation delay terms on differencing the time interval measurements at both ends does not hold true due to the relative motion between the stations. Special correction terms based on the station trajectories of are needed. Studies of DTWTT have been tried out earlier by Celano et al [2] for a specific case between aircrafts and ground, via geo stationary satellites using Ku band links. They incorporated two additional terms, which refer to the changes in the propagation delay and the Sagnac correction over the measurement interval.

In the present paper, we have made a general study of the DTWTT between different combinations of the participating platform motions. Extensive MATLAB simulations have been performed to estimate the accuracy achievable under different dynamical situations. We have specifically considered two types of cases where (a) the communication link is direct line of sight; or (b) the link is via a geostationary satellite.

[1]. D. W. Hanson, *"Fundamentals of Two-Way Time Transfers by Satellite,* IEEE 89CH2690-6), pp. 174-178. (1989).
[2]. T. Celano, J. Warriner, S. Francis, A. Gifford, P. Howe, and R. Beckman, *et al.*, 34th PTTI. pp. 353-366. (2004).