Metrological traceability in dynamic scenarios timing

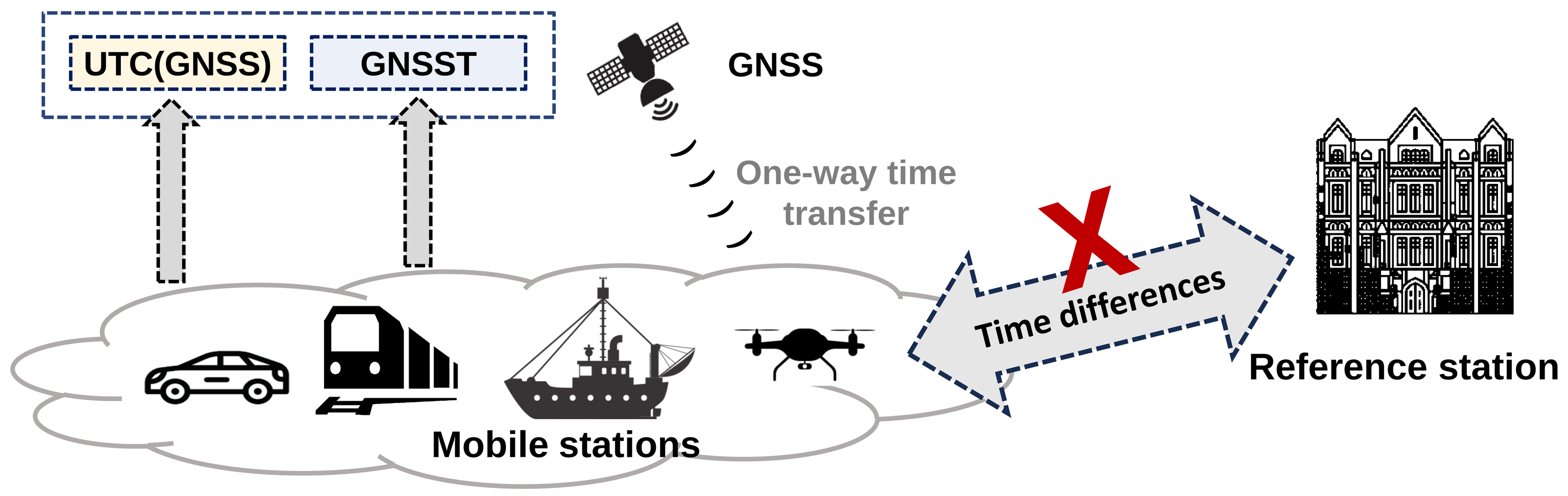
LIANG Kun, WEI Baoying

Motivation

The metrological traceability of time and frequency based on the Common-View (CV) method has been established in static stations, such as, the metrological traceability to UTC of UTC(*k*) in the frame established by CCTF key comparison: CCTF-K001.UTC. In dynamic scenarios, most mobile stations use the GNSS one-way time transfer to achieve time synchronization.

Issues with timing in dynamic scenarios :

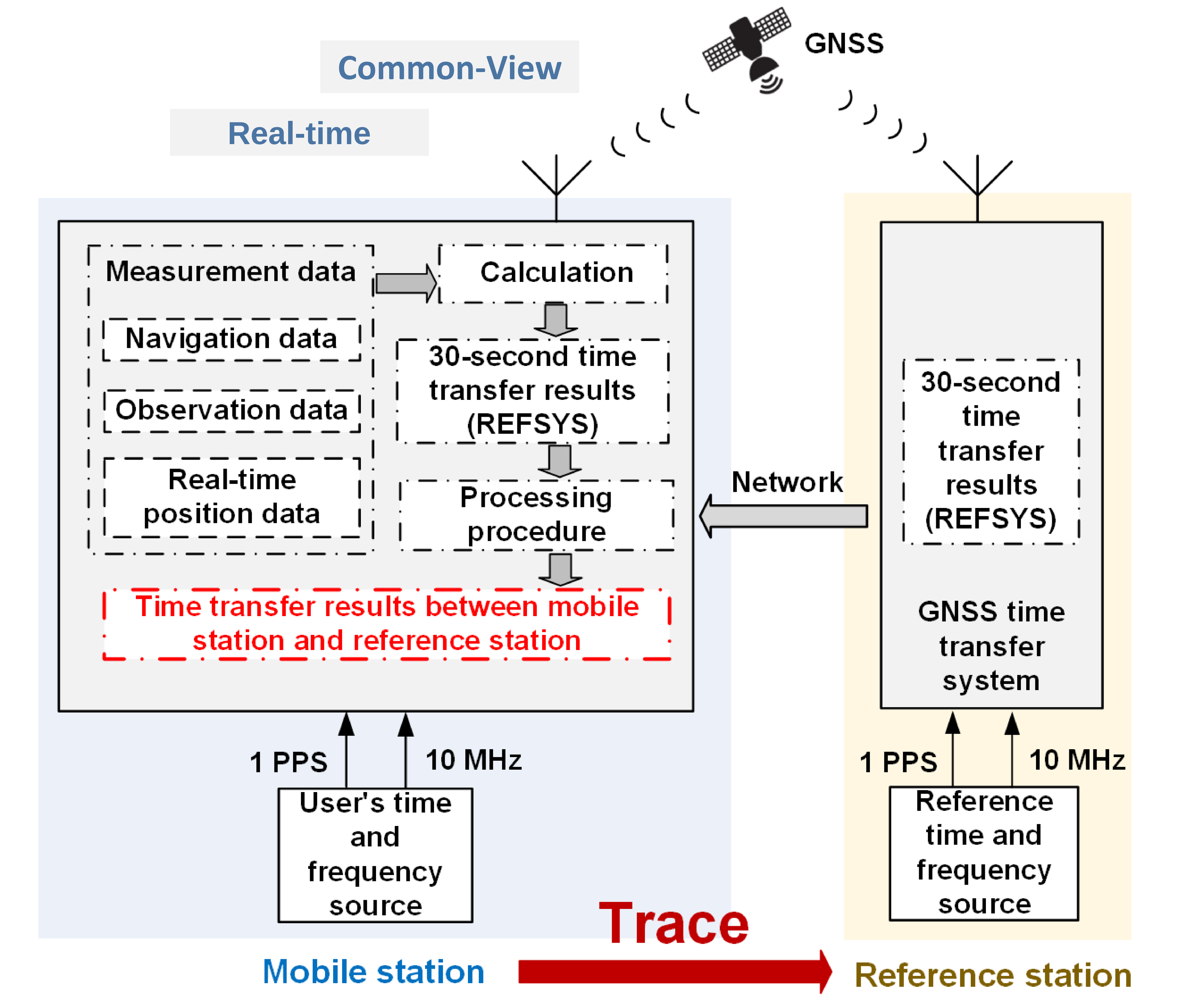
- The time differences between the mobile stations and the reference station cannot be known.
- The CV method, suitable for static stations, is not applicable to dynamic scenarios.



To ensure the metrological traceability of the time and frequency values obtained by the mobile stations, a study on time transfer in dynamic scenarios should be conducted.

Principle & Experiments & Results

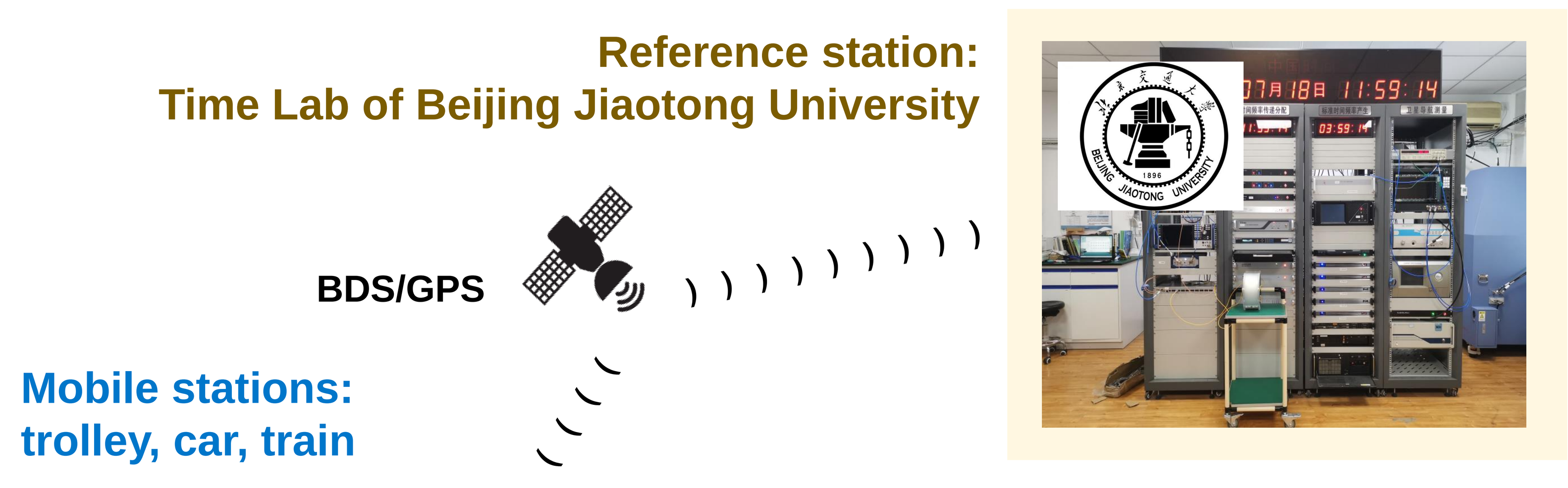
Principle

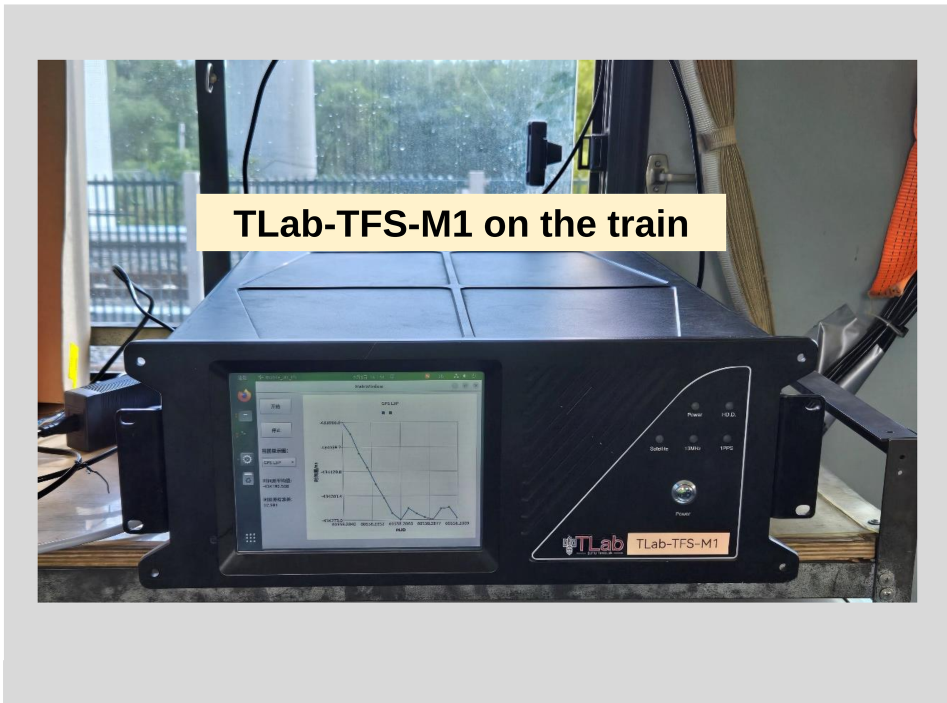


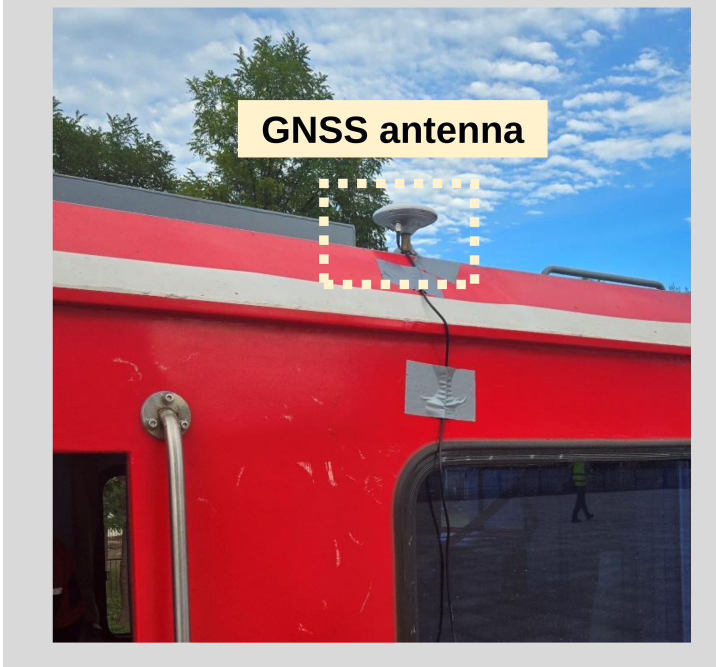
GNSS measurement data of the mobile station, which includes the navigation data, the observation data, and the real-time position data, is used to calculate and generate the 30-second time transfer results (REFSYS). The real-time position data is calculated by the standard Single Point Positioning technology. The reference station performs the solution of the 30-second time transfer results as well, which are transmitted to the mobile station via the network every 30 seconds. By the processing procedure, the real-time time transfer results between the mobile station and the reference station are obtained.

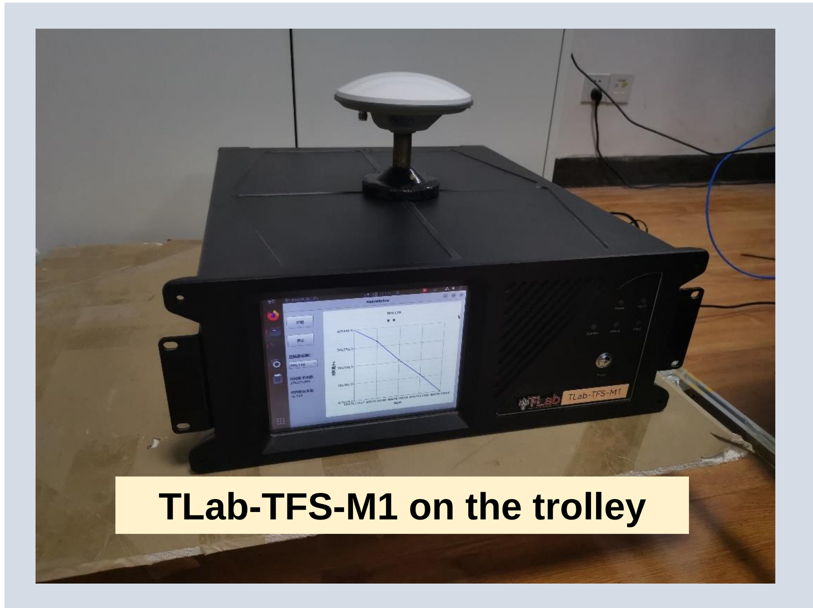
Experiment setups

A self-developed system named TLab-TFS-M1, and a calibrated GNSS time transfer system are located separately at the mobile station and the reference station. A trolley, a car, and a railway train are the mobile stations, and our lab which keeps an atomic time scale TS(BJTU) is employed as the reference station. Real-time time transfer experiments based on BDS and GPS codes are conducted.





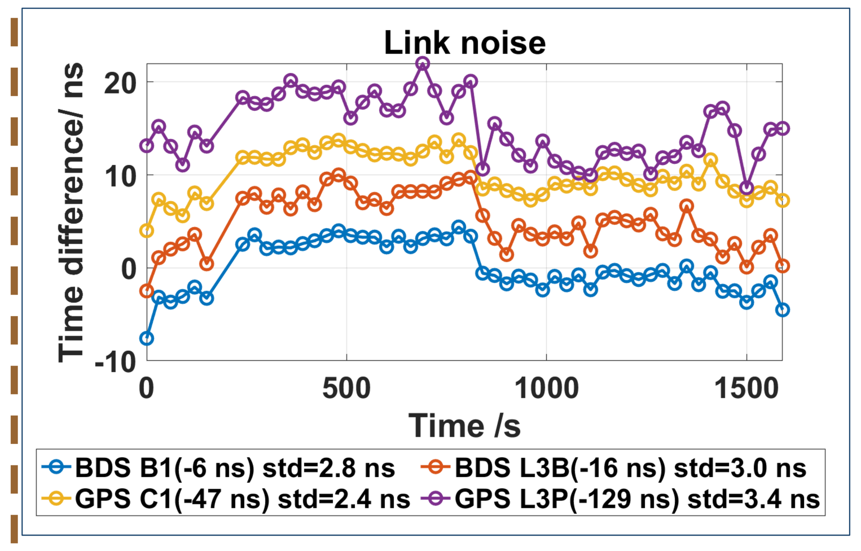


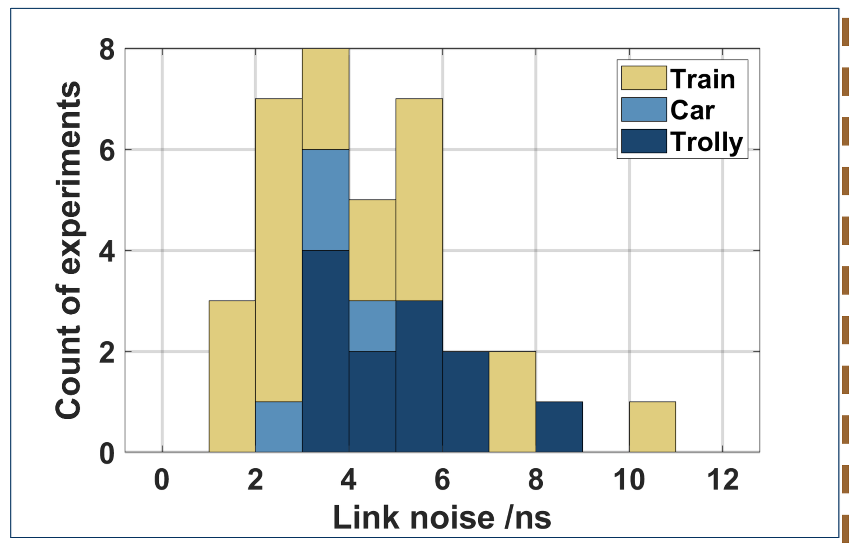


The time transfer results calculated based on the post-processing Precise Point Positioning (PPP) technology are used as the reference results for evaluation. The noise level of the time transfer link, which is the standard deviation (std) of the differences between the real-time and the reference time transfer results, is used for characterizing the performance of the time transfer.

Numerical results

The link noise of all 36 experiments is evaluated, with the results presented in the histogram. It can be observed that the link noise distributes between 2 ns and 6 ns (ratio 0.75%).





Uncertainty budget for the time transfer in dynamic scenarios is as follows:

Uncertainty component	Type	Uncertainty /ns
Calibration (mobile staion + reference station)	B	1.70
Repeatability (noise level of the time transfer link)	A	6.00
Correction of ionospheric and tropospheric effects	B	2.10
Cable connectors (mobile staion + reference station)	B	0.70
Satellite orbital	B	0.27
Multipath effect (mobile staion + reference station)	B	0.33
Total: 6.6 ns		

Conclusions & Outlook

The principle of time transfer in dynamic scenarios is proposed; a platform is constructed and real-time time transfer experiments are conducted. The noise of the time transfer link is analyzed and found to mainly distribute between 2 ns and 6 ns. The uncertainty budget of the time transfer in dynamic scenarios is presented, and the total uncertainty is evaluated as 6.6 ns. In the future, the method of construction of time traceability links in dynamic scenarios based on the GNSS carrier phase will be studied; the uncertainty of the time traceability will be further evaluated.

School of Automation and Intelligence, Beijing Jiaotong University, Beijing, China liangk@bjtu.edu.cn