



GNSS System Time Scales and GNSS-GNSS Time Referencing

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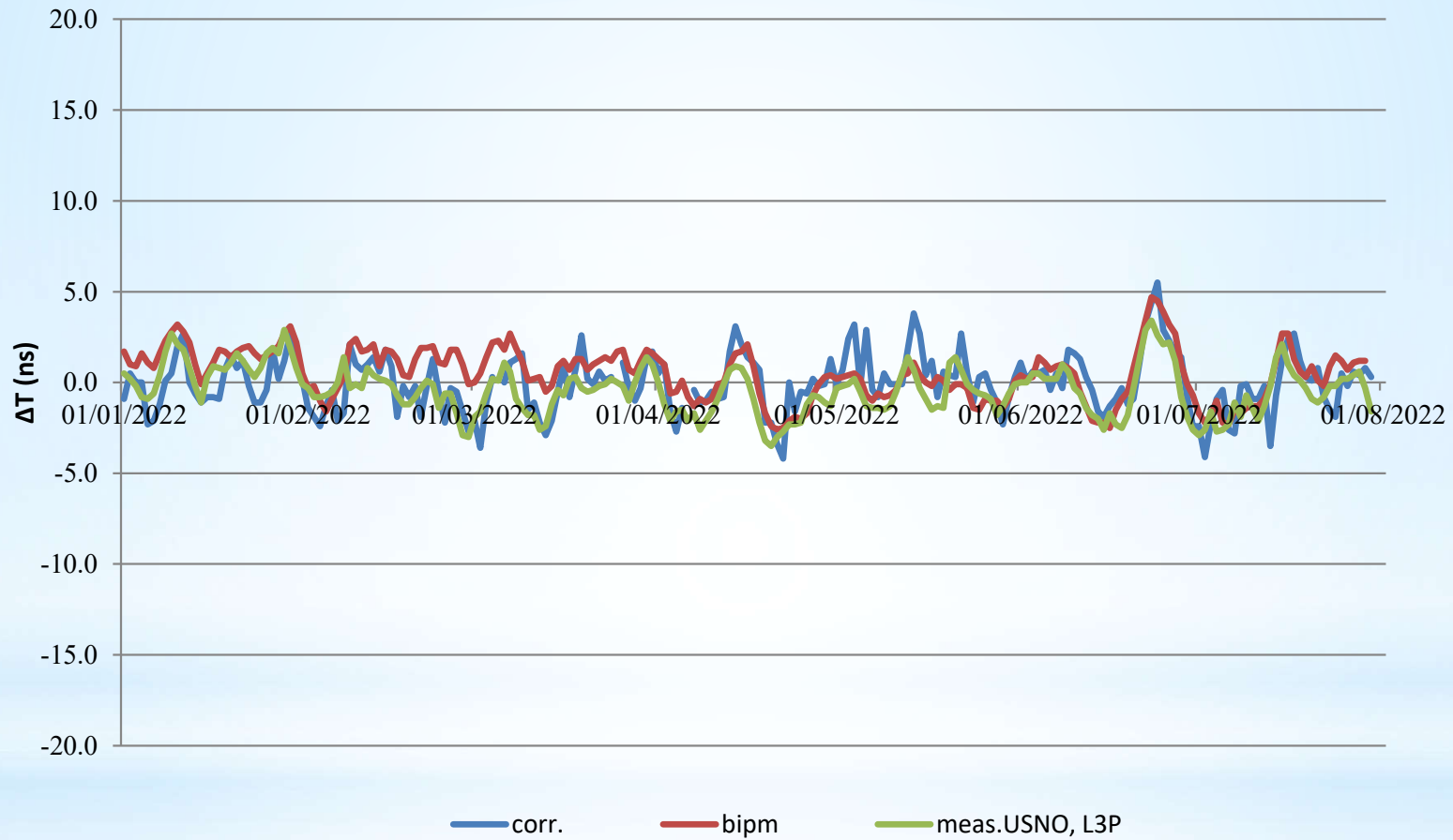
GNSS/RNSS Time Scales in 2022

To assess GNSS/RNSS Time Scales the following data were used:

- ***broadcast corrections*** to convert from GNSS/RNSS Time to Reference Time scales which are UTC(k);
- ***the data provided by BIPM*** on broadcast GNSS Time - Reference Time offsets (published for GPS and GLONASS);
- ***the results of measurements*** at Reference Time Generating Facility (if available);
- ***the results of measurements*** of the receiver located at the measuring site.

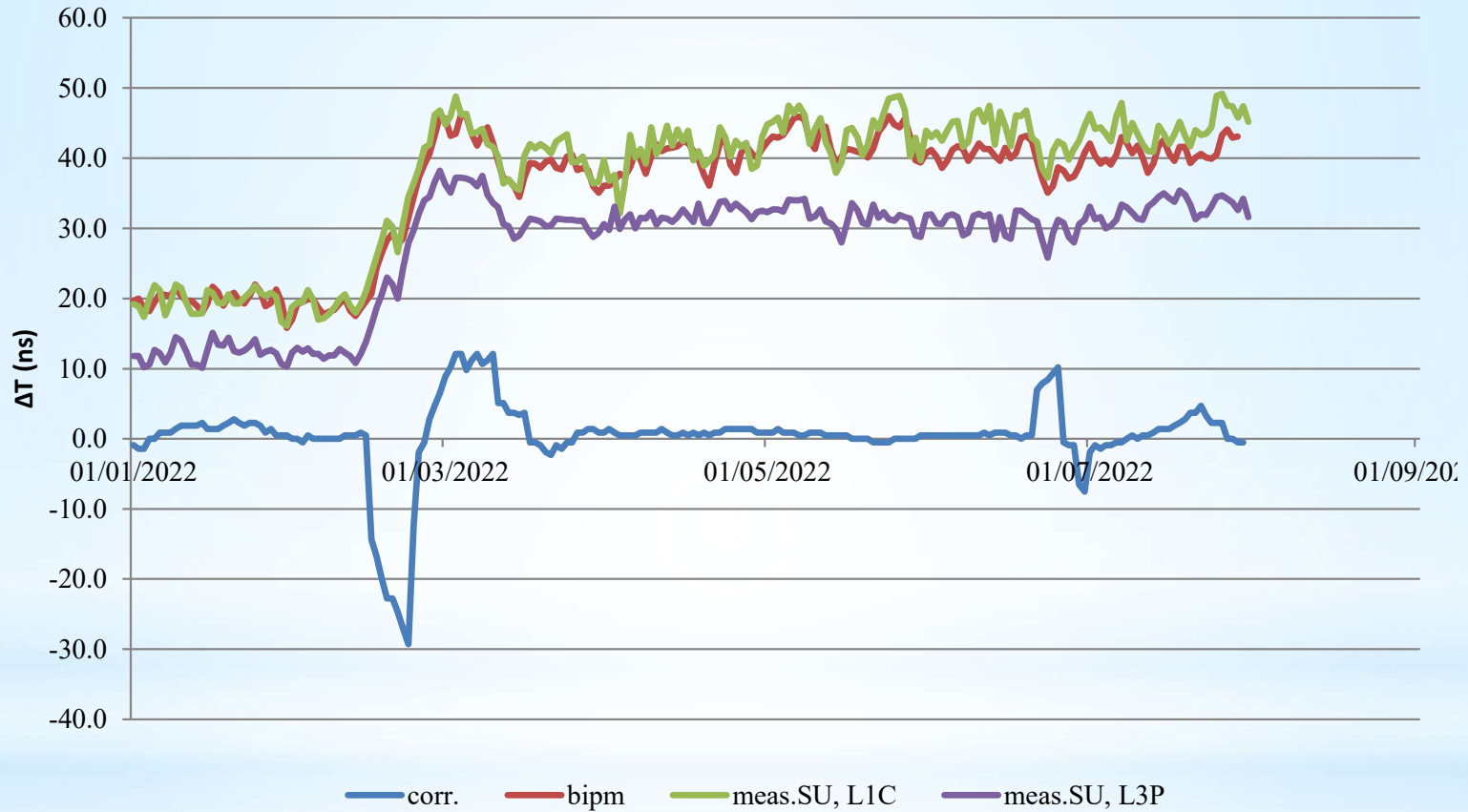


GPS Time - UTC(USNO) Offset





GLONASS Time - UTC(SU) Offset



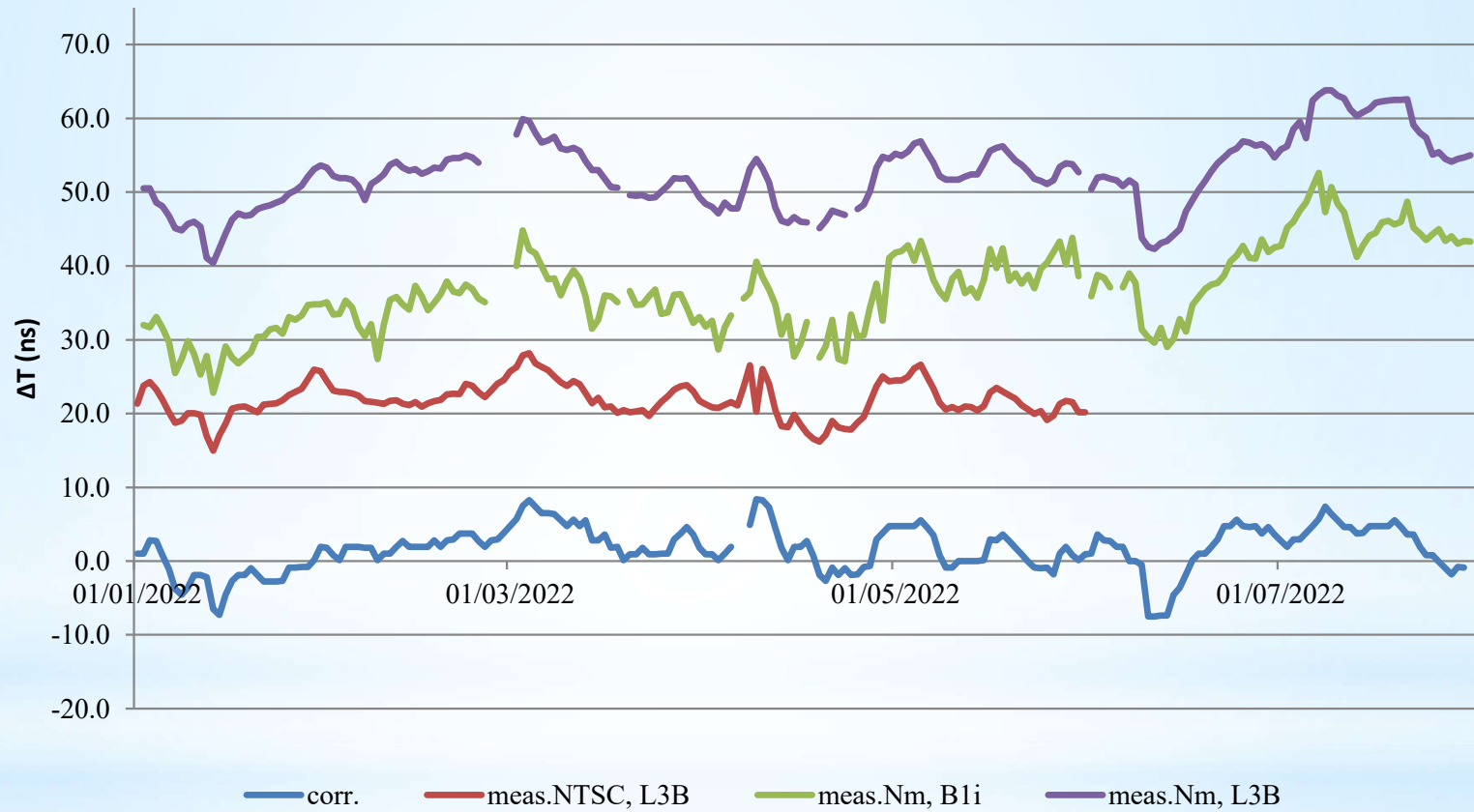


Galileo Time - UTC(EU) Offset





BeiDou Time – Reference Time Offset



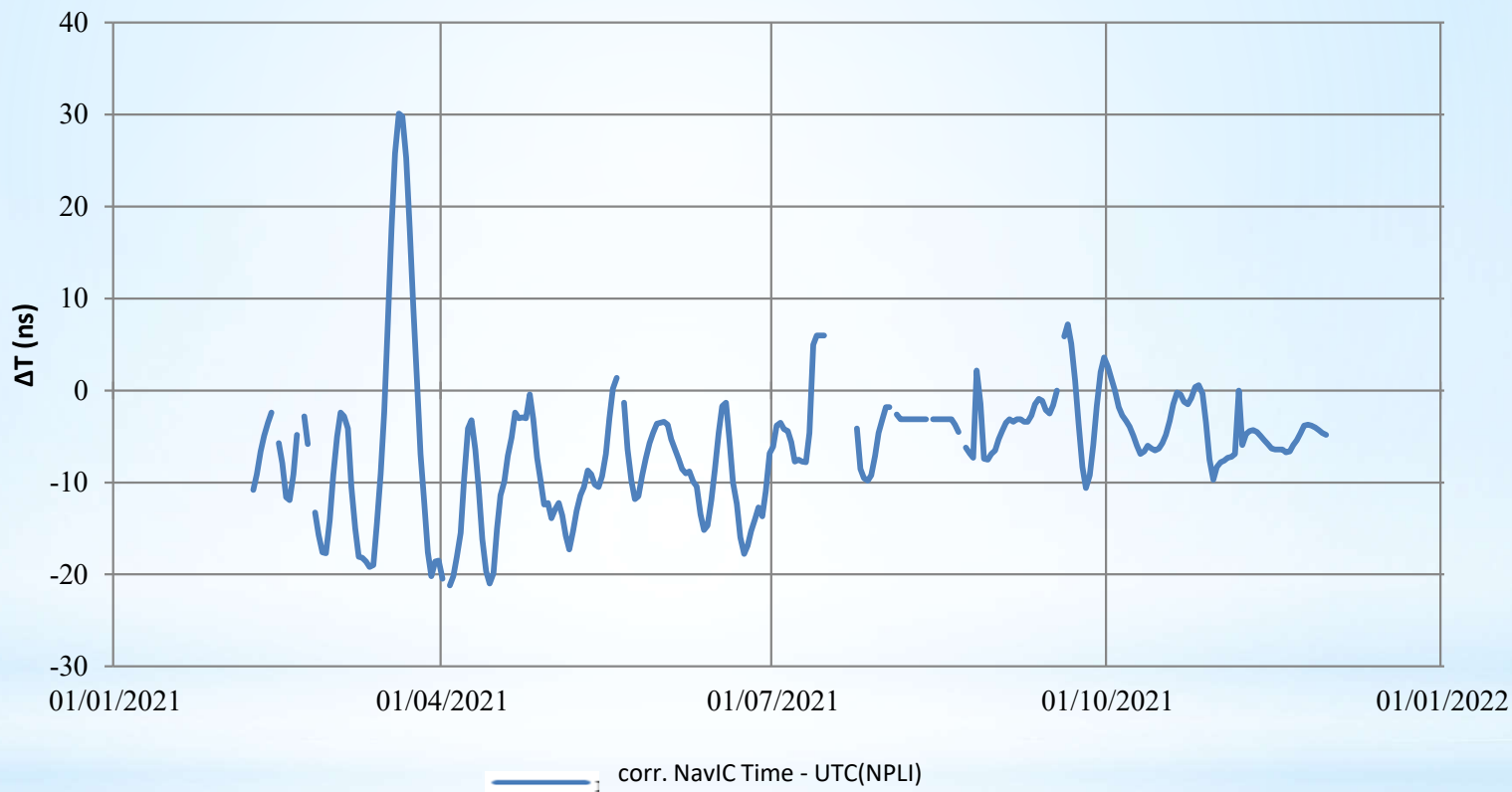


QZSS Time - UTC(NICT) Offset





NavIC Time - UTC(NPLI) Offset





GNSS-GNSS Time Referencing Methods

GNSS-GNSS Time referencing is necessary for GNSS Time interoperability.

Assessment of GNSS-GNSS Time offsets by the user can be provided:

*- **autonomously** in the receiver by processing navigation signals from different GNSS constellations (can't be implemented in challenging environment);*

*- **based on broadcast corrections:***

- corrections to convert from GNSS Time to Reference Time UTC(k) which is steered to UTC with maximum possible accuracy;

- GNSS-GNSS Time Offset Corrections (GGTO).



GNSS-GNSS Time Referencing Methods

GNSS Time - Reference Time Offset Corrections are broadcast by all operational GNSS and RNSS.

GGTO corrections are broadcast by:

- *GLONASS - corrections for GLONASS-GPS time offset;*
- *Galileo – corrections for Galileo-GPS time offset;*
- *NavIC – corrections for NavIC-GPS and NavIC-GLONASS time offsets.*



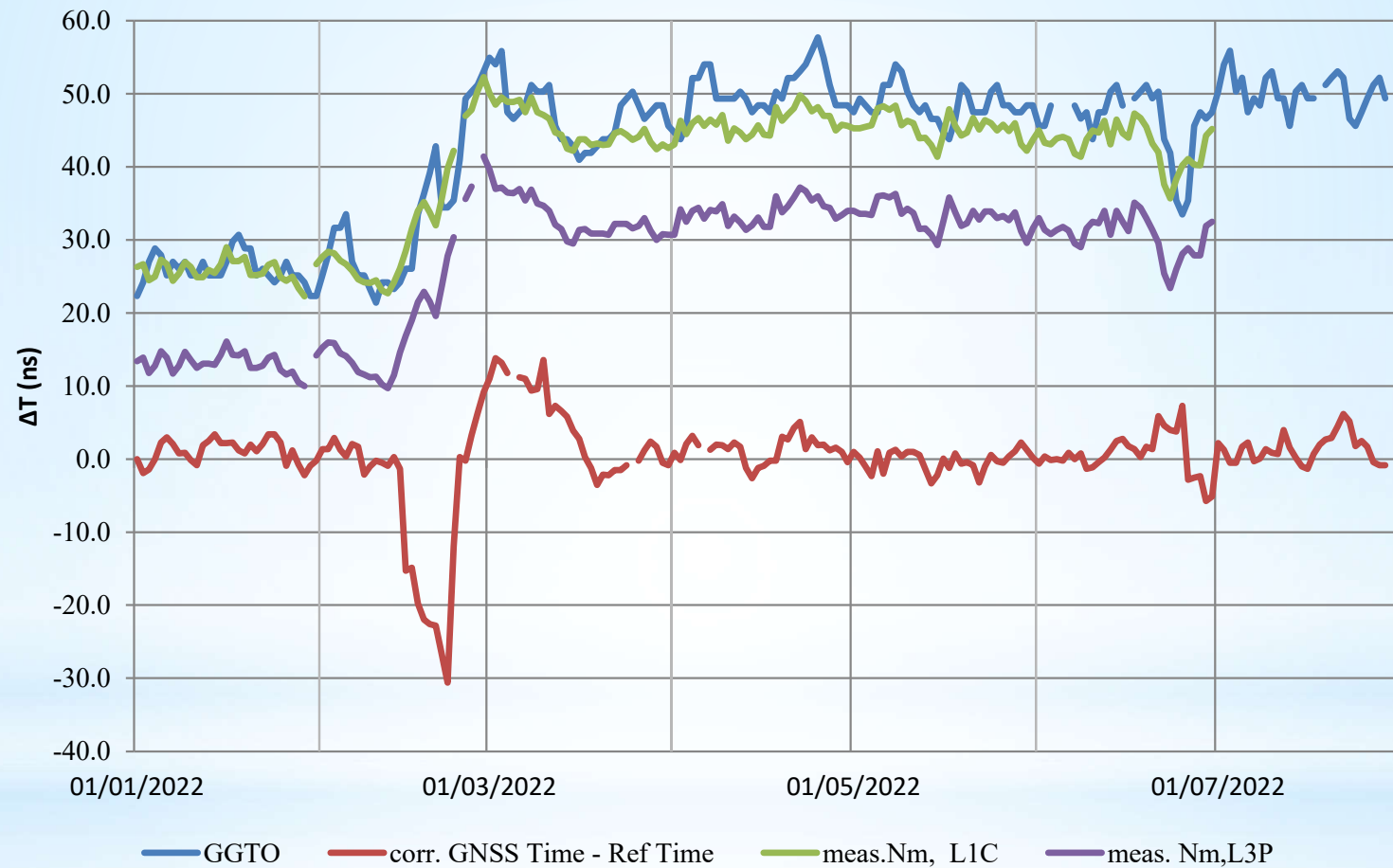
Results of GNSS-GNSS Time Offset Assessment

To compare the methods of assessing GNSS-GNSS Time offsets (autonomous method and based on broadcast corrections) the authors calculated GNSS-GNSS Time offsets with using the following data:

- the results of receiver measurements (dual- and single-frequency);*
- broadcast GNSS Time - Reference Time offset corrections;*
- broadcast GGTO corrections.*

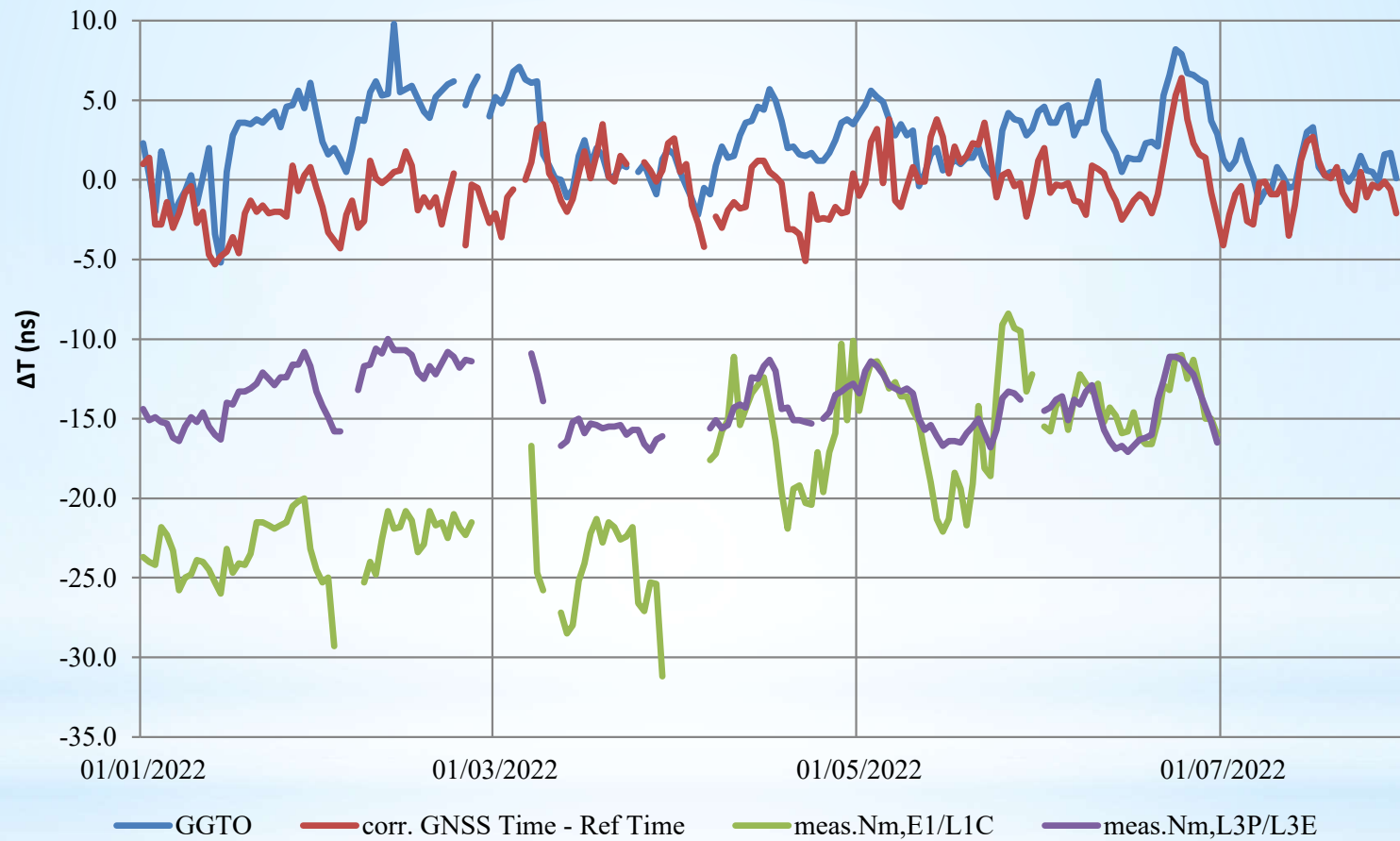


GLONASS - GPS Time Offset



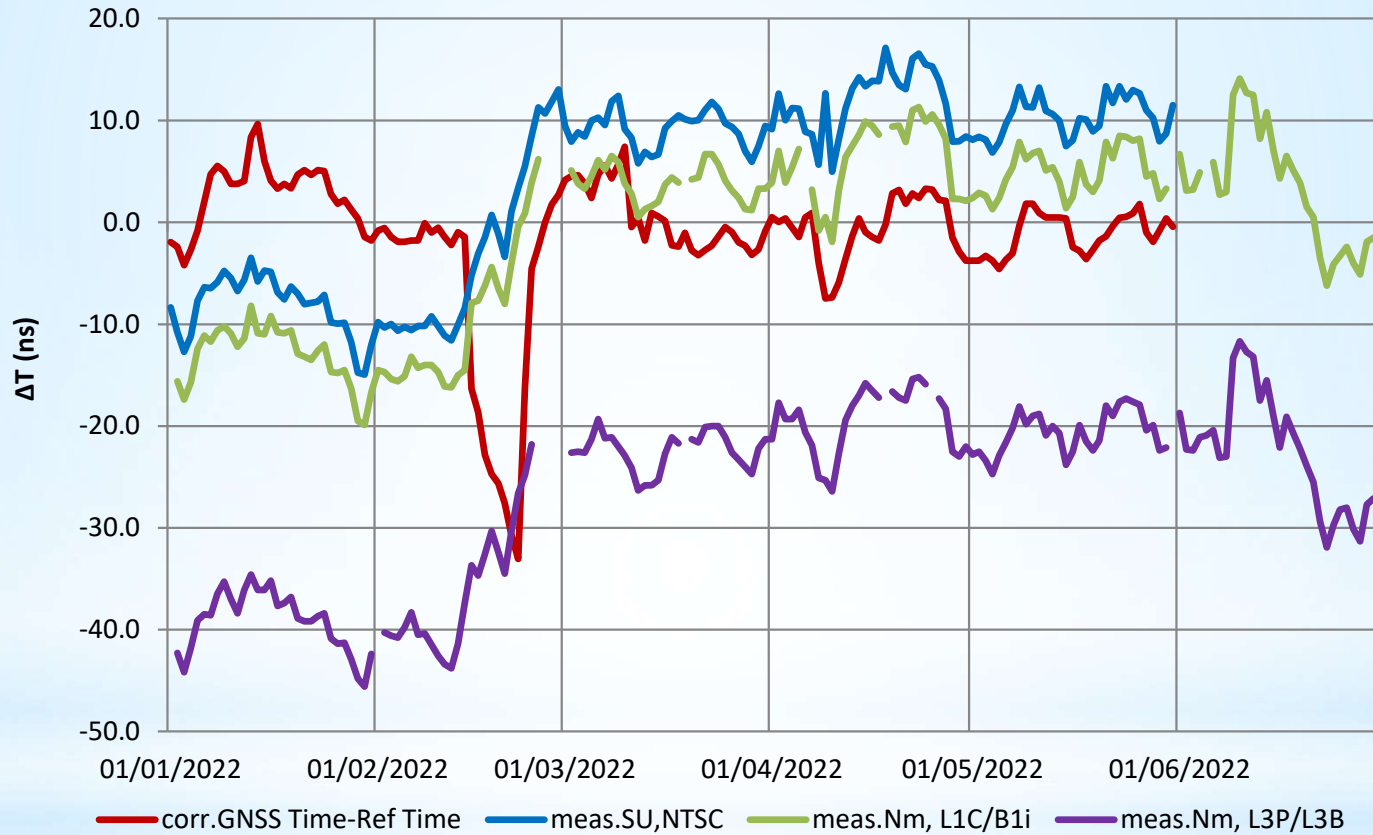


Galileo - GPS Time Offset



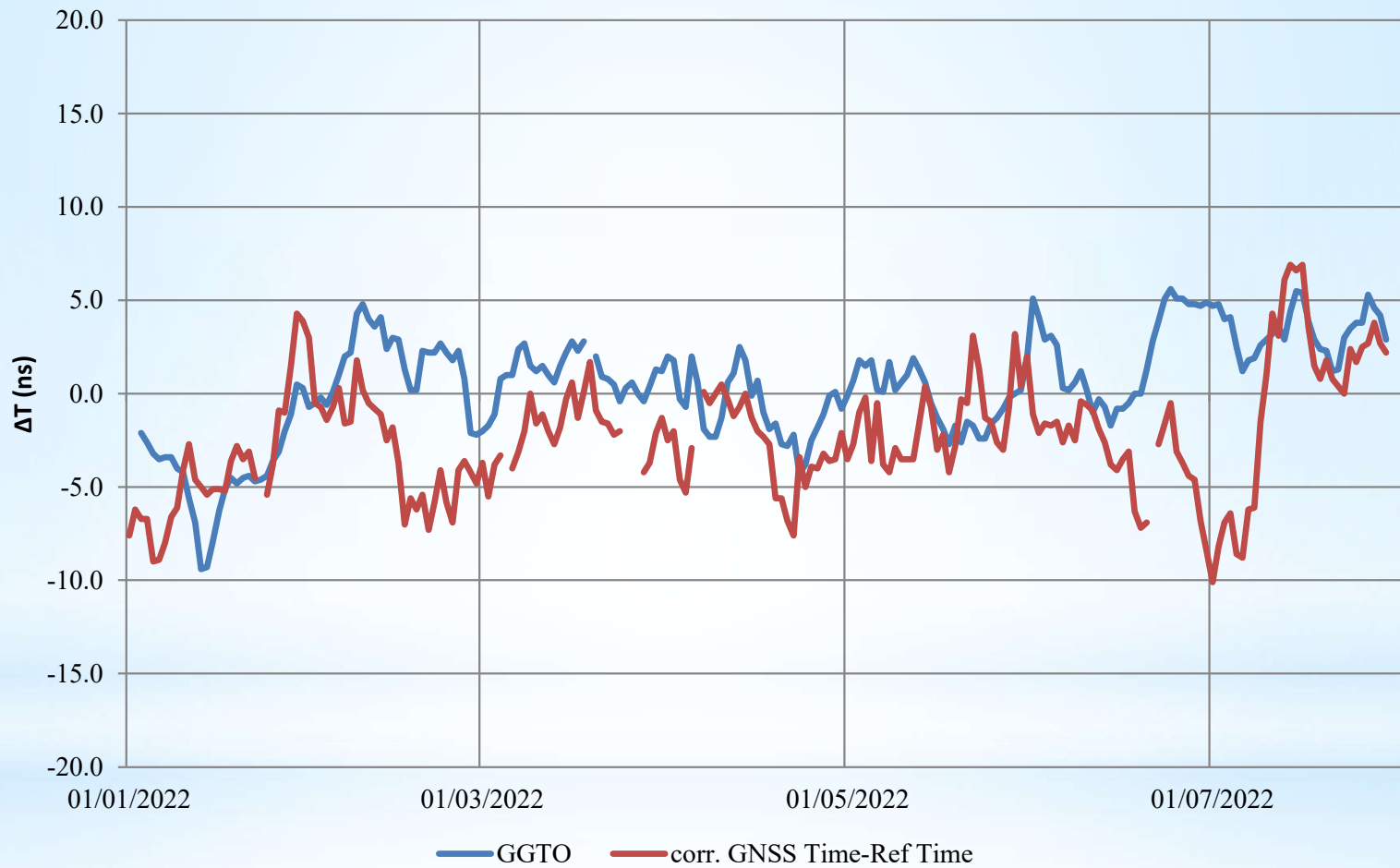


GLONASS – BeiDou Time Offset



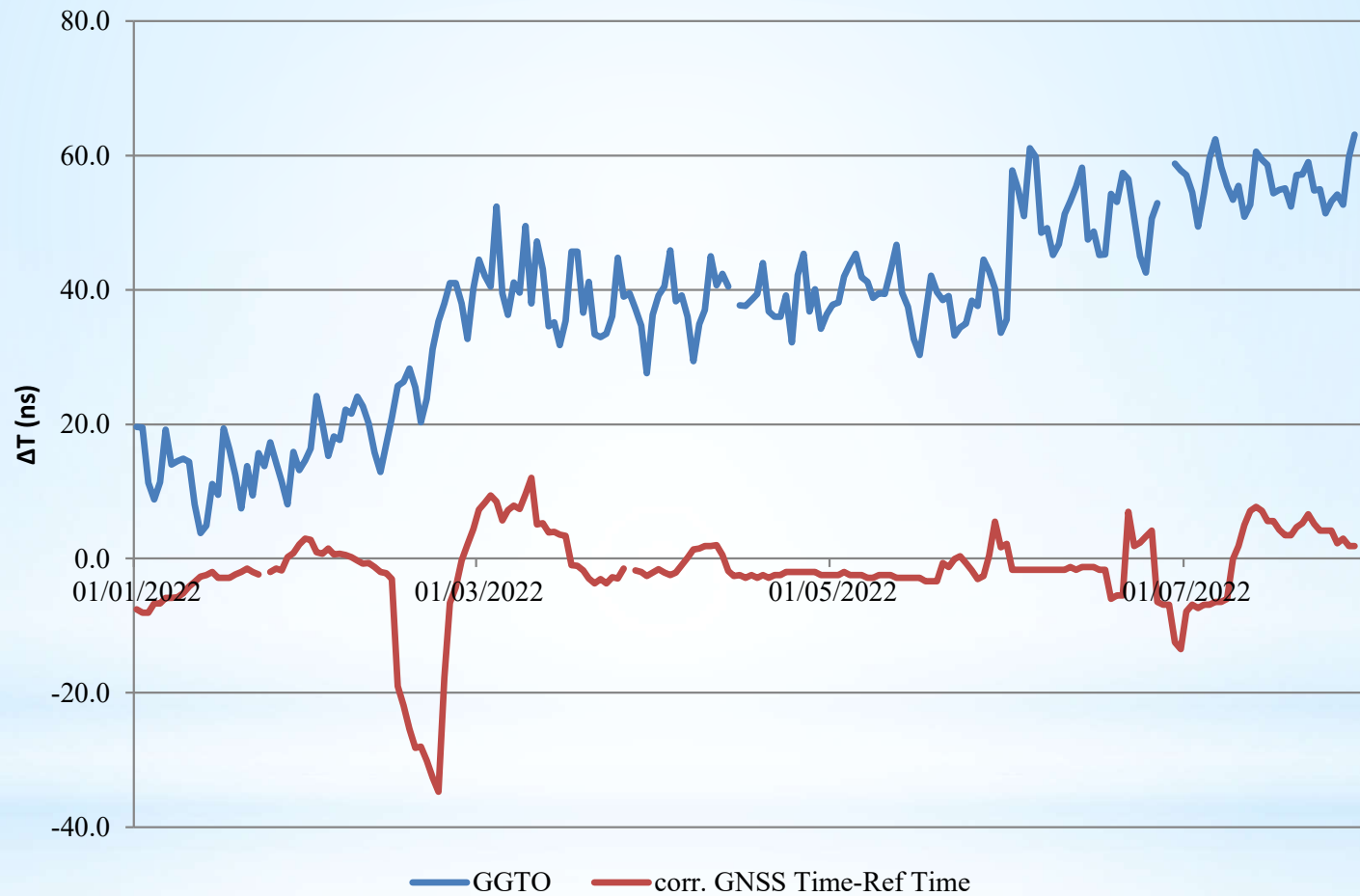


NavIC - GPS Time Offset





NavIC - GLONASS Time Offset





Results of GNSS-GNSS Time Offset Assessment

The previous studies of the experts from BIPM, ORB, RIRT, NTSC have shown that the highest accuracy of GNSS-GNSS Time offsets assessment by the user can be achieved based on measurements by high-precision receiver in good visibility conditions.

The error of the assessment via GNSS Time - Reference Time offset corrections depends on the error of the corrections and the difference between the Reference time scales.

The error of the assessment via GGTO corrections depends on the error of the corrections.

In both cases additional error can be caused by the difference between the mode of the user (single or dual frequency, different signal types) and the mode used for calculating corrections, as well as due to receiver calibration accuracy.



Results of GNSS-GNSS Time Offset Assessment

For multi-GNSS solution receivers need the values of GNSS-GNSS Time offsets depending on the mode of the user (single or dual frequency, different signal types).

In most of the cases the difference between the “needed” and calculated (based on corrections) offset values is systematic and can be compensated by using previously assessed by the receiver values for the special signal type.



Conclusion

The highest accuracy of GNSS-GNSS Time offset assessment by the user can be achieved based on measurements of high-precision receiver in good visibility conditions.

When autonomous GNSS-GNSS Time offset assessment in the receiver is not possible due to the lack of SVs in view, it is feasible to use GGTO corrections for calculating the offset.

It is reasonable to use GNSS-Reference Time Offset corrections for assessing GNSS-GNSS Time offsets when it is not possible to assess the offsets autonomously in the receiver or with the use of GGTO corrections.



Thank you for your attention!