



GLONASS Time and UTC(SU) Broadcast by GLONASS Current Status

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GLONASS Time Forming

$$\begin{aligned}\Delta T_{GL}(t) &= \Delta T_{CSM}(t) + \Delta T_{CSM}^{ph}(t_i) + \Delta T_{CSM}^{fr}(t_j) - \Delta T^c(t) = \\ &= \Delta T_{CSR}(t) + \Delta T_{CSR}^{ph}(t_k) + \Delta T_{CSR}^{fr}(t_l) - \Delta T^c(t) - \Delta T_{M-R}(t)\end{aligned}$$

$\Delta T_{GL}(t)$ – GLONASS Time – UTC(SU) offset

$\Delta T_{CS}(t)$ – Main/Reserved CS – UTC(SU) offset

$\Delta T_{CS}^{ph}(t)$ – corrections for Main/Reserved CS phase steering

$\Delta T_{CS}^{fr}(t)$ – corrections for Main/Reserved CS frequency steering

$\Delta T^c(t)$ – correction for controlling GLONASS Time – UTC(SU) offset

$\Delta T_{M-R}(t)$ – Main–Reserved CS Time offset



GLONASS Central Synchronizers

The core of CS is frequency/time keeping facility based on active hydrogen frequency/time standards.

CS components:

- 4 Hydrogen Frequency/Time Standards (HFS);
- a system for internal comparisons;
- a system for steering frequencies and phases;
- a system for external comparisons.

CS accuracy parameters:

- relative frequency error – within $\pm 3 \cdot 10^{-14}$;
- daily frequency instability – below $2 \cdot 10^{-15}$.



GLONASS Time Synchronization to UTC(SU)

There is no whole second GLONASS Time – UTC(SU) offset as CS time is corrected by ± 1 s simultaneously with UTC leap second corrections.

There is a constant 3-hour GLONASS Time – UTC(SU) offset due to GLONASS operational principles.

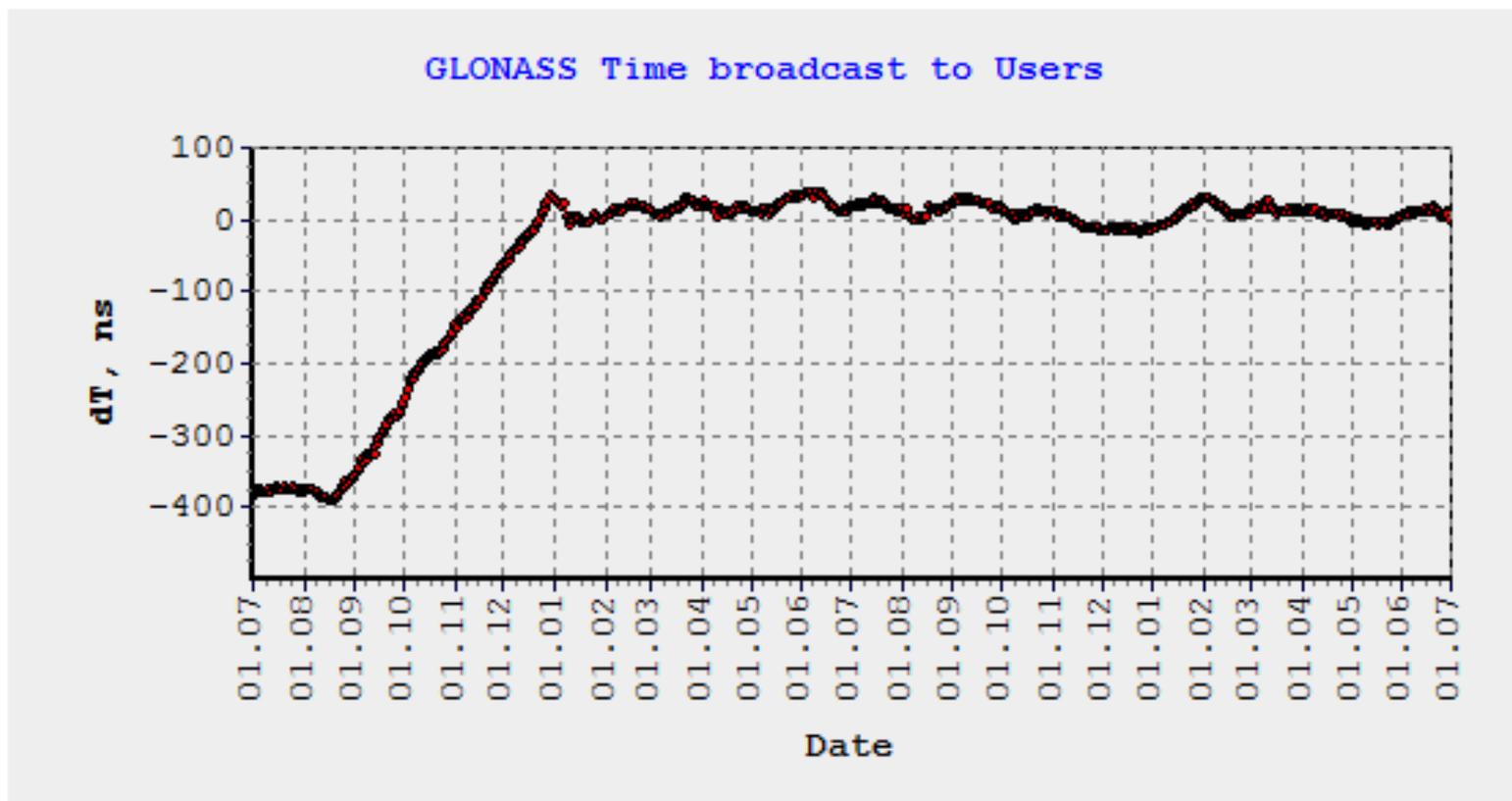
Till August 2014 GLONASS Time – UTC(SU) offset was about 400 ns. It met specified requirements but was not satisfactory for time users.

On 18th August, 2014 the procedure of minimizing the offset by changing the value of controlling correction was started. To keep the specified accuracy of SV-GLONASS Time offset the daily change of controlling correction was 3 ns.

As a result of the correction procedure, GLONASS Time offset relative to UTC(SU) changed to 29.4 ns at the end of 2014.

In 2015 GLONASS Time – UTC(SU) offset was kept within ± 35 ns, and in the first half of 2016 within ± 25 ns.

UTC(SU)–GLONASS Time offset from 01.01.2014 to 01.07.2016





Corrections to GLONASS Time

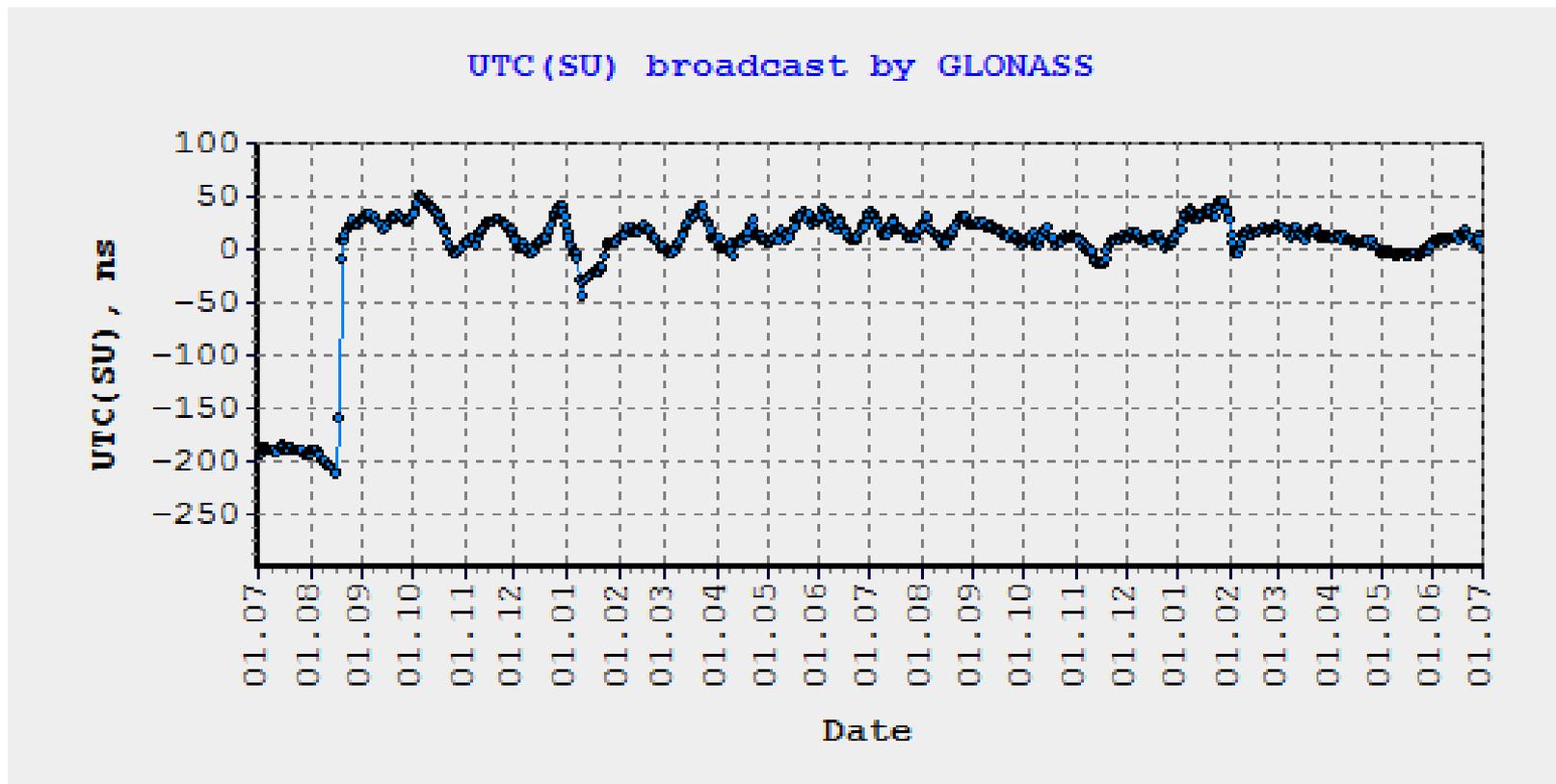
Corrections to GLONASS Time relative to UTC(SU) τ_c are broadcast in the navigation message.

Till August 2014 the error of broadcast corrections to GLONASS Time relative to UTC(SU) contained a systematic component of ~ 200 ns.

On 18th August, 2014 the calculation of corrections to GLONASS Time was also changed.

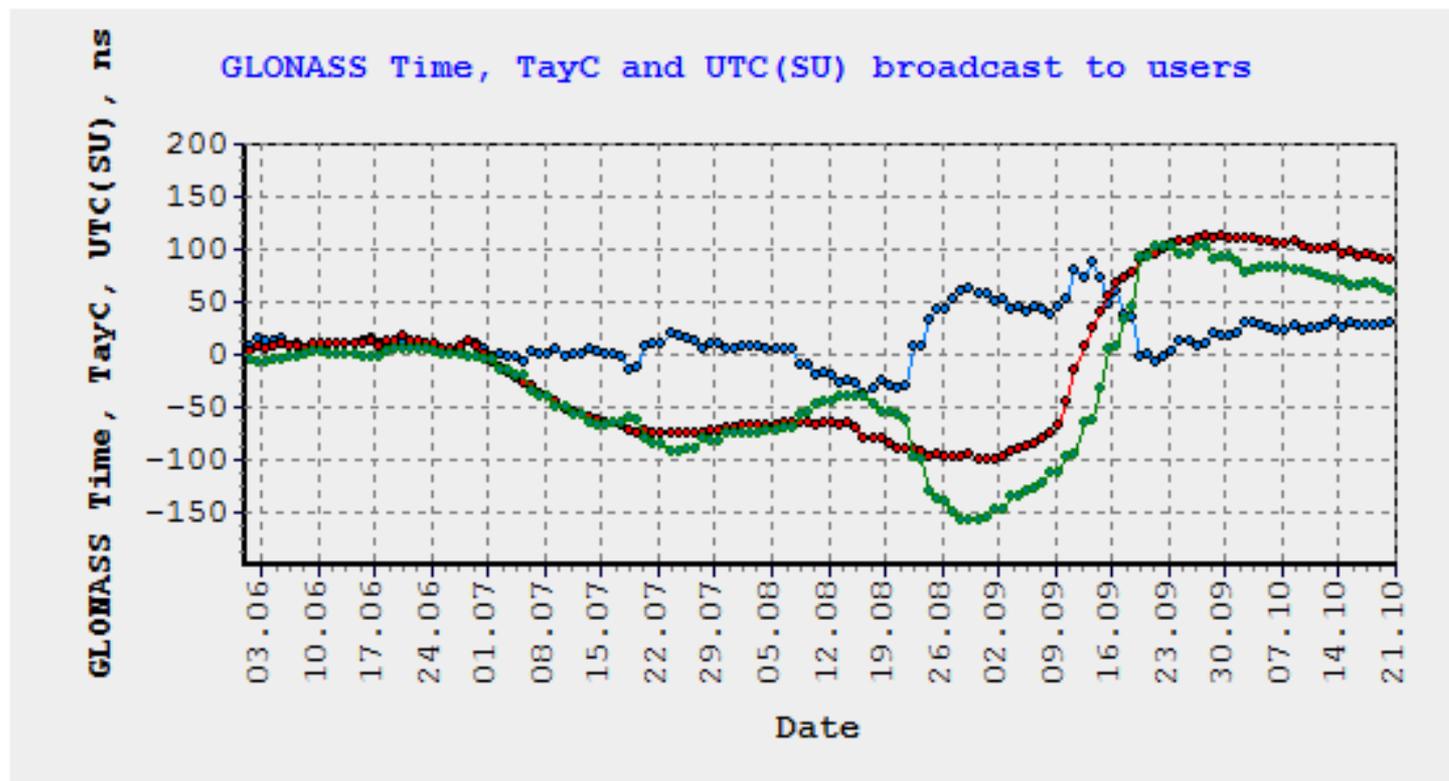
As a result, the error of broadcast corrections to GLONASS Time relative to UTC(SU) became below 10 ns.

UTC(SU) broadcast by GLONASS from 01.01.2014 to 01.07.2016





GLONASS Time, Corrections to GLONASS Time and UTC(SU) Broadcast by GLONASS in May-October 2016





Procedures to minimize GLONASS Time–UTC(SU) offset

To improve the situation now GLONASS Time is being changed by ~2 ns daily by means of changing the value of the controlling correction .

The small value of the controlling correction allows to maintain the specified accuracy of GLONASS Space Vehicles time offset relative to GLONASS Time and, as a result, to maintain the accuracy of navigation.

The preliminary evaluation showed that as a result of the procedure mentioned above the accuracy of broadcast GLONASS Time and UTC(SU) will be achieved by the end of the year.



Improvement of GLONASS Time

The main approaches to increase the accuracy of GLONASS Time forming and synchronizing to UTC(SU) are:

- increasing CS accuracy parameters;
- increase the accuracy of GLONASS Time referencing to UTC(SU);
- decreasing the error of broadcast corrections to GLONASS Time relative to UTC(SU).

By 2020, the following accuracy parameters are planned to be achieved:

- GLONASS Time - UTC(SU) offset below 4 ns;
- the error of broadcast corrections to GLONASS Time relative to UTC(SU) below 2 ns.



Thank you for your attention!