



GLONASS Time: Current Status and Monitoring Results

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*11th Meeting of International Committee on Global Navigation Satellite Systems
6-11 November 2016, Sochi, Russian Federation*



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GLONASS Time Forming

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

$\Delta T_{GL}(t)$ – 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

The core of CS is frequency/time keeping facility based on 4 active hydrogen frequency/time standards with daily frequency instability below $2 \cdot 10^{-15}$.



GLONASS Time Synchronization to UTC(SU)

GLONASS Time is referenced 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.

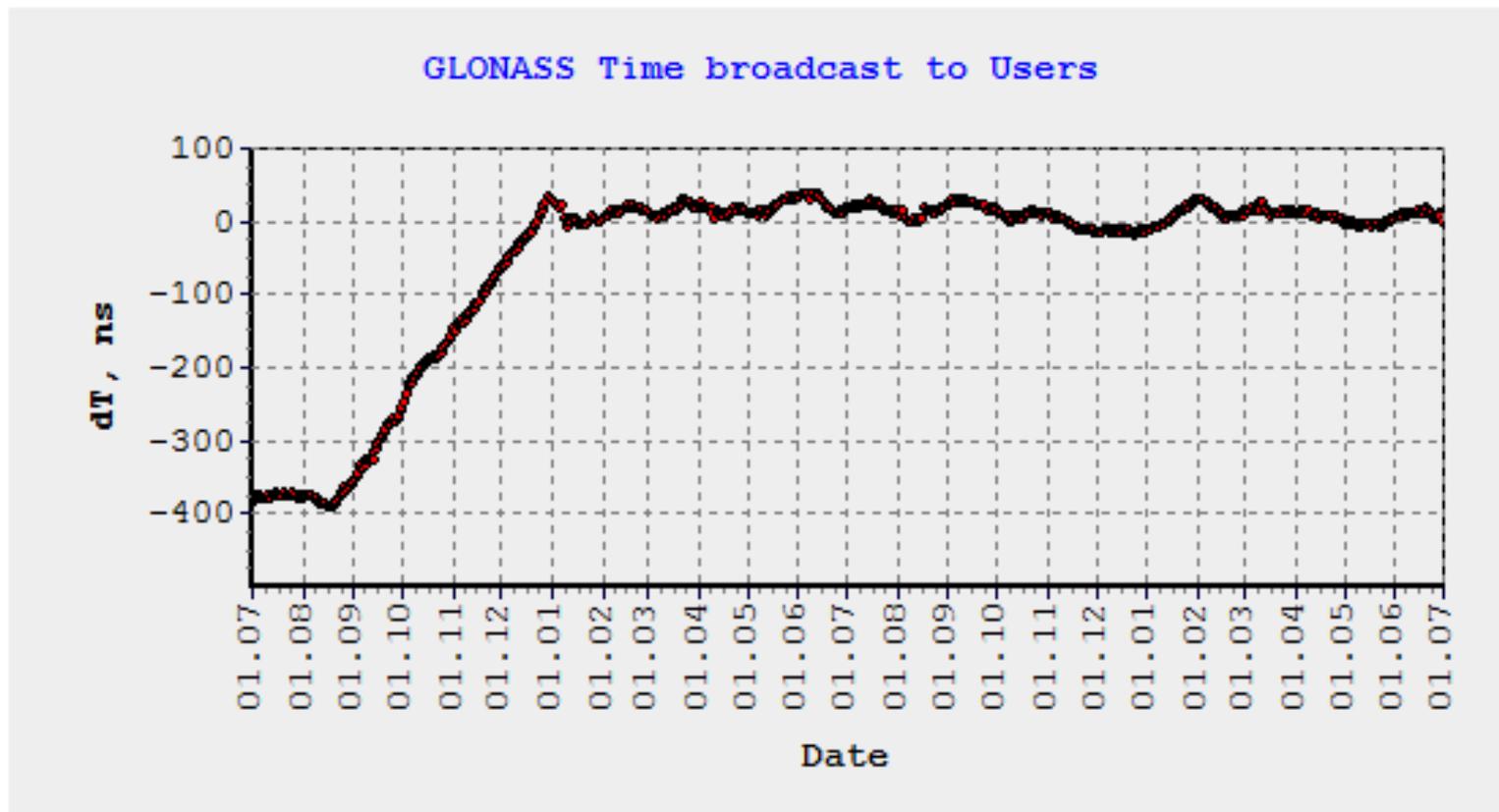
As a result of the correction procedure, GLONASS Time offset relative to UTC(SU) changed to 29.4 ns at the end of 2014.

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



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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.

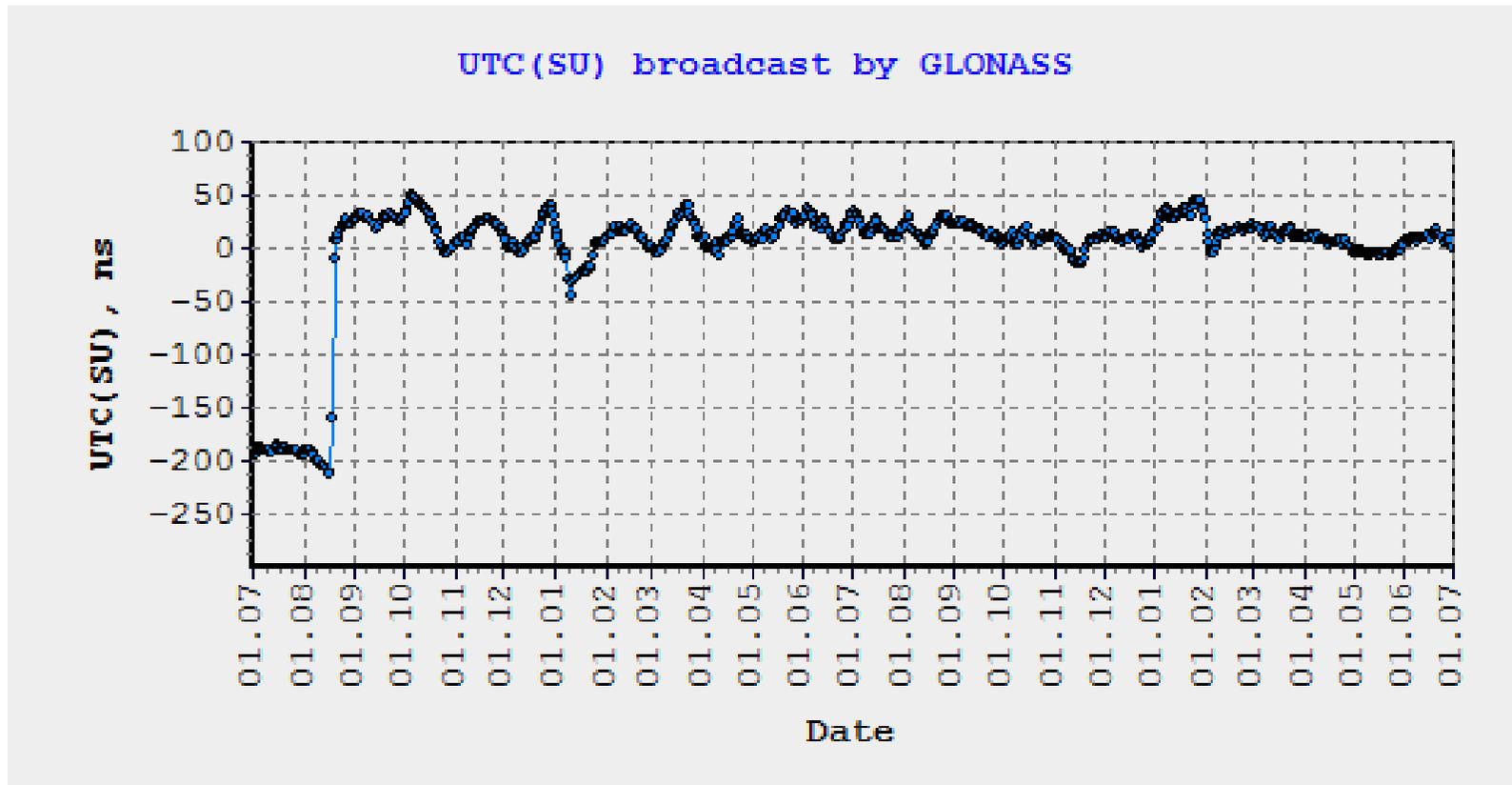
On 18th August, 2014 the calculation of corrections to GLONASS Time was also changed.

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



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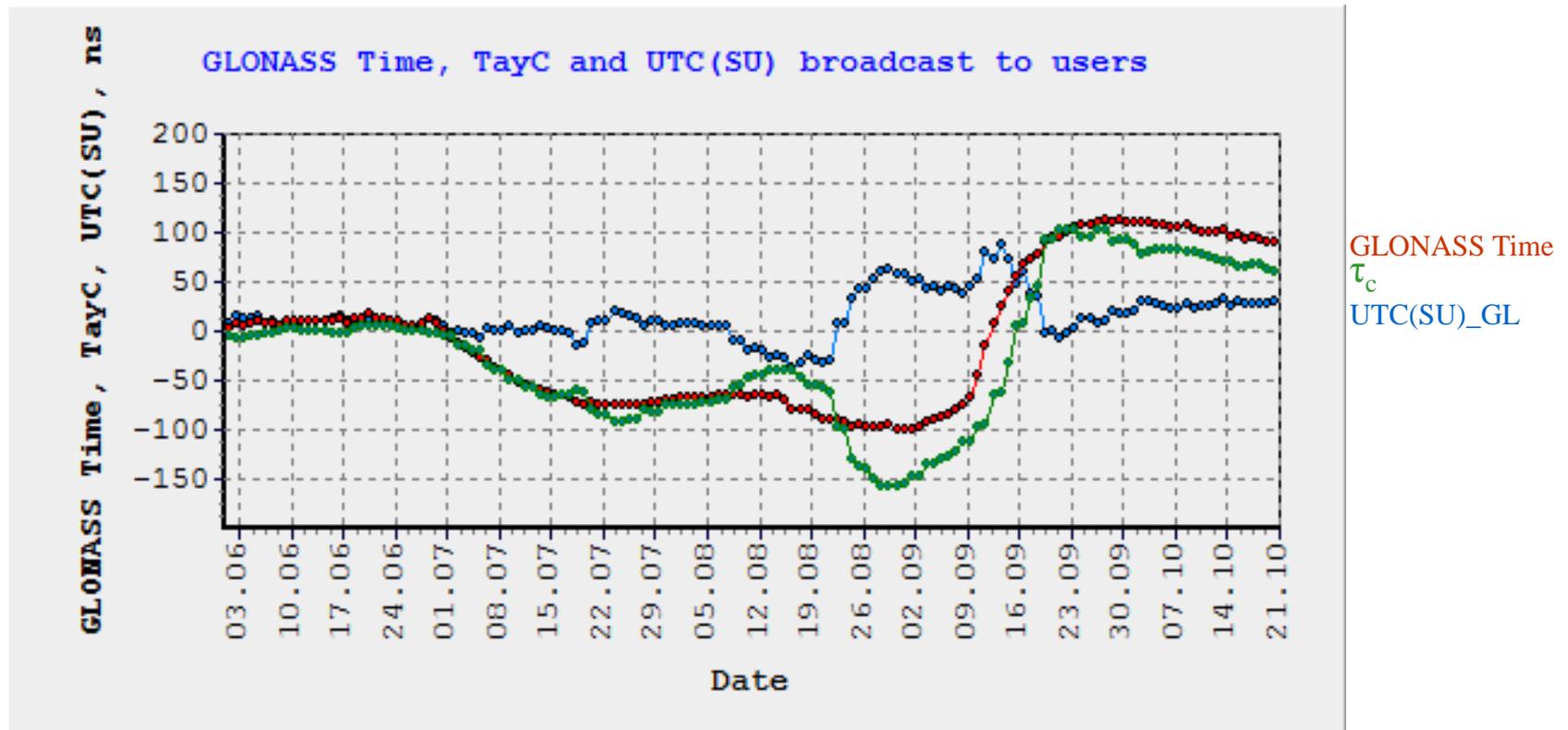
UTC(SU) broadcast by GLONASS from 01.01.2014 to 01.07.2016





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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.



Russian Monitoring Services and Facilities

In Russia monitoring of GLONASS Time and UTC(SU) broadcast by GLONASS is provided by Main Metrological Center (MMC) of Russian Time, Frequency and EOP Service:

- located in Mendeleevo, Moscow region, operated by VNIIFTRI;
- using the receivers by Pik Time System, Poland: TTS-3 (till August 2015), TTS-4 (after August 2015);
- the TTS-3 and TTS-4 receivers were calibrated absolutely with using VNIIFTRI calibrating facilities;
- results of GLONASS Time monitoring are published monthly as daily average in БЮЛЛЖЕТЕНЬ 3 on VNIIFTRI official site.



International Monitoring Services and Facilities

Monitoring of GLONASS Time and UTC(SU) broadcast by GLONASS is provided by BIPM Time department with using data from Astrogeodynamic Observatory (AOS):

- located in Borowiec, Poland;
- provides measurements by TTS-3 receivers;
- results are published monthly in CIRCULAR T on BIPM official site.

Till 2016 published monitoring results had included daily averages for:

UTC-GLONASS Time offset

UTC-UTC(SU)_by_GLONASS offset.

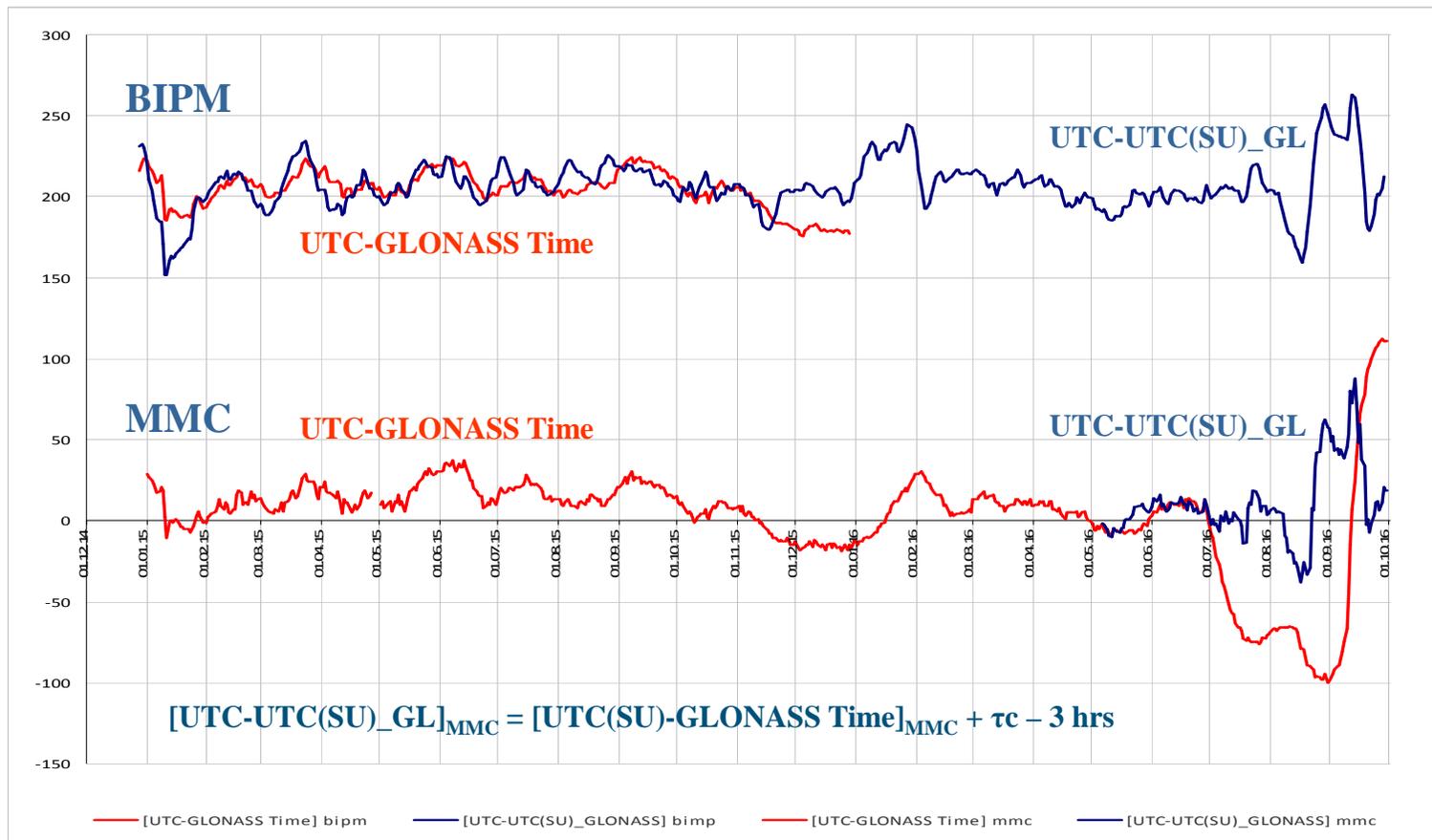
From 1 January 2016 published monitoring results include daily averages only for:

UTC-GLONASS Time offset.



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Results of GLONASS Time and UTC(SU) Monitoring by MMC and BIPM



January 2015 - September 2016



Analysis of the Results

Signal delays «**INT DLY**» in TTS-3 receivers:

AOS	Borowiec, Poland	-314.86 ns
SU	Moskva, Russia	-128.20 ns

The signal delays differ by ~200 ns. As a result, they provide measurements that differ by ~200 ns.



Conclusion

1. The accuracy of GLONASS Time and UTC(SU) broadcast by GLONASS, specified in “Federal Program on GLONASS Sustainment, Development and Use” will be achieved by the end of the year.
2. In the nearest future monitoring results for GLONASS Time and UTC(SU) broadcast by GLONASS provided by Russian and International services will coincide.



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Thank you for your attention!