SAI–VNIIFTRI VLBI Analysis Center 2015–2016 Report

Vladimir Zharov [1], Sergey Pasynok [2], Andrey Sinev [2]

Abstract This report presents an overview of the SAI–VNIIFTRI VLBI Analysis Center activities during 2015–2016 and the plans for 2017. The AC analyzes all IVS sessions for computations of the Earth orientation parameters (EOP), time series of the ICRF source positions, and performs research and software development aimed at improving the VLBI technique.

1 General Information

The SAI–VNIIFTRI VLBI Analysis Center is located at Sternberg State Astronomical Institute (SAI) of Lomonosov Moscow State University in Moscow and at the National Research Institute of Physicotechnical and Radio Engineering Measurements (VNIIFTRI), Mendeleevo, Russia. The Analysis Center participates in geodetic and astrometric VLBI analysis, software development, and research aimed at improving the VLBI technique, and especially for support of the ASC correlator during the Radioastron mission [1].

2 Activities during the Past Two Years

The SAI–VNIIFTRI AC performs data processing of all kinds of VLBI observation sessions. For VLBI data analysis we use the ARIADNA software package developed by V. Zharov [2]. Version 4 of this software was finished and tested in 2015. All reductions are performed in agreement with the IERS Conventions (2010). The software package uses files in NGS format as input data.

ARIADNA (v. 4) is the base of the ORBITA software installed on the correlator of the AstroSpace Center at the Lebedev Physical Institute. It is used for correlation of the ground–space interferometer data during the Radmoastron mission.

Staff of the joint AC are:

- Vladimir Zharov, Prof.: development of the ARIADNA software, development of the methods of parameter estimation (SAI);
- Sergey Pasynok, scientific researcher: global solution (VNIIFTRI);
- Andrey Sinev, engineer: VLBI data processing (VNIIFTRI); and
- Natalya Shmeleva, engineer: VLBI data processing (SAI).

3 Current Status

- **Software development for VLBI processing**
  The ARIADNA software is being developed to provide contributions to IVS products. The software is used for calculating all types of IVS products. The main features of version 4 are: all reductions are performed in agreement with the IERS Conventions (2010), the automatic generation of the SINEX files, and the combination of some of the SINEX files to stabilize the solution.

1. Sternberg State Astronomical Institute (SAI) of Lomonosov Moscow State University
2. National Research Institute of Physicotechnical and Radio Engineering Measurements (VNIIFTRI)

SAI–VNIIFTRI Analysis Center

IVS 2015+2016 Biennial Report

The used version of software was corrected in 2015; now it is possible to use the CIO-based transformation matrix. A new set of EOP series was obtained from observations that were made in 2015–2016.

The method that uses calculation of the equinox-based transformation matrix for precession-nutation was kept to compare the new series with the old ones. The equinox-based matrix $Q(t)$ that transforms from the true equinox and equator of date system to the GCRS composed of the classical nutation matrix, the precession matrix including four rotations, and a separate rotation matrix for the frame biases. The new series of nutation angles will be used for preparation of our suggestion to improve the nutation theory.

- **Routine analysis**

During 2015–2016 the routine data processing was performed with the ARIADNA software using the least-squares method with rigid constraints.

The SAI–VNIIFTRI AC operationally processed the 24-hour and Intensive VLBI sessions. The forming of databases of the VLBI sessions and processing of all sessions is fully automated. The EOP series vnf_2015.eoxy, vnf_2016.eoxy, vnf_2015.eopi, and vnf_2016.eopi were calculated. These series were computed with the catalog VTRF2015 of station positions and velocities. SINEX files were generated for all 24-hour sessions.

The weighted mean (WM) and weighted root mean square (WRMS) UT1 differences between SAI–VNIIFTRI and BKG, IAA, USNO estimates from all Intensives sessions are shown in Figure 1 and from 24-hour solutions are shown at Figure 2.

They were calculated using the formulas:

$$WM_j = \sum_{i=1}^{N} \frac{(\mathrm{UT1}_{AC_{j,i}} - \mathrm{UT1}_{AC_{SV,i}})p_{j,i}}{\sum_{i=1}^{N} p_{j,i}}$$

$$WRMS_j = \sqrt{\frac{\sum_{i=1}^{N}\left(\mathrm{UT1}_{AC_{j,i}} - \mathrm{UT1}_{AC_{SV,i}} - WM_j\right)^2 p_{j,i}}{\sum_{i=1}^{N} p_{j,i}}}$$

where

$$p_{j,i} = \frac{1}{\sigma^2_{AC_{j,i}} + \sigma^2_{AC_{SV,i}}}$$

are the weights of UT1 differences. $\mathrm{UT1}_{AC_{j,i}}$ are the estimates of the UT1 from AC_j, where $j =$ BKG, IAA, USNO and $\mathrm{UT1}_{AC_{SV}}$ the same from AC SAI-VNIIFTRI, respectively, and $\sigma_{AC_{j,i}}$ and $\sigma_{AC_{SV,i}}$ denote their formal uncertainties.

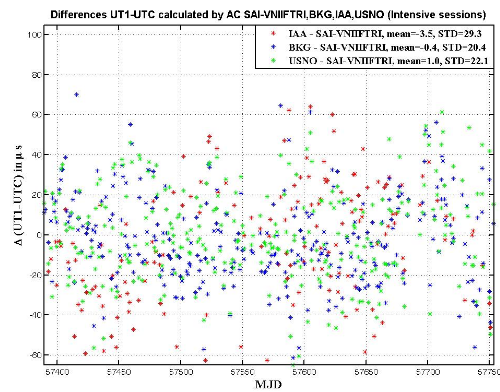

Fig. 1 Differences of the BKG, IAA, and USNO with the SAI–VNIIFTRI estimates of UT1 based on the solutions for the Intensive sessions.

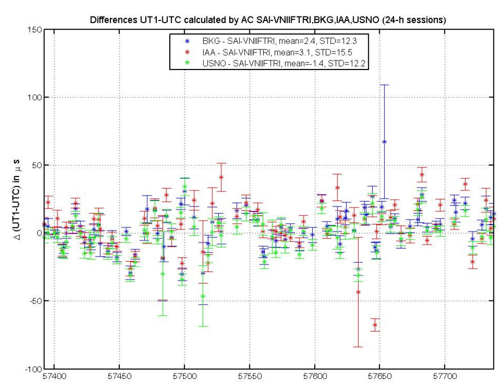

Fig. 2 Differences of the BKG, IAA, and USNO with the SAI–VNIIFTRI estimates of UT1 based on the solutions for the 24-hour sessions.

In processing 24-hour sessions, ARIADNA normally uses the a priori station coordinates from the catalog VTRF2015. If they are the estimation parameters then no-net-translation and no-net-rotation constraints are applied for selected stations. Solution for the TSUKUB32 antenna gives very large correction for the catalog position: $\Delta x = 0.047 \pm 0.013, \Delta y = -0.031 \pm 0.010, \Delta z = -0.030 \pm 0.022$. The TSUKUB32 antenna is used for UT1 estimation from the Intensive sessions. To avoid shift of the UT1 estimates from incorrect the TSUKUB32 antenna position the last was corrected for the above values.

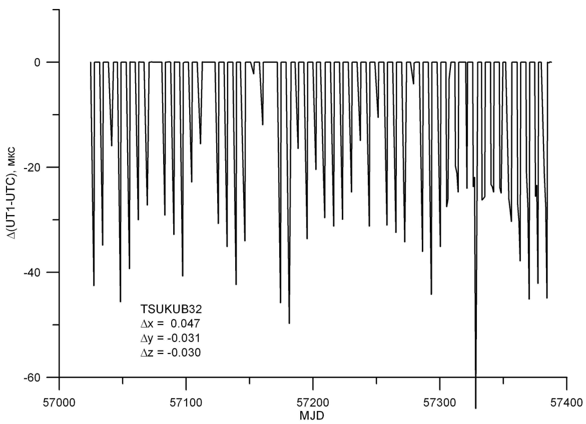

Fig. 3 Difference between UT1–UTC from two solutions (with catalog and corrected positions of the TSUKUB32 antenna) from the Intensive sessions.

Difference between UT1–UTC from two solutions (with catalog and corrected positions of the TSUKUB32 antenna) is shown in Figure 3. There is a systematic shift in the calculated value of UT1–UTC of the order of 20 μs.

4 Future Plans

- Continuing investigations of VLBI estimation of EOP, station coordinates, source coordinates and their variability.
- Improvement of the ARIADNA software for processing of the GNSS troposphere zenith delays.

References

1. N.S. Kardashev, V.V. Khartov, V.V. Abramov et al. “RadioAstron” - A telescope with a size of 300 000 km: Main parameters and first observational results. *Astronomy Reports*, 57(3), 153–194, 2013.
2. V.E. Zharov. Osnovi radioastrometrii (in Russian). Physics department of Lomonosov MSU, 2011.