Russian VLBI Network “Quasar”: from 2006 to 2011

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This paper describes Russian VLBI Network “Quasar”. The VLBI Network “Quasar” consists of three 32-m antennas and involves the control and data processing center. A brief review of upgrade and development of the VLBI Network “Quasar” up to 2011 is presented.

The 9th European VLBI Network Symposium on
The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting
Bologna, Italy
September 23-26, 2008

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PoS(IX EVN Symposium)053

1. The VLBI Network “Quasar”: 2006–2008

Three Russian radio astronomical observatories “Svetloe” (Sv), “Zelenchukskaya” (Zc) and “Badary” (Bd) make up the three-element VLBI Network “Quasar” with baselines of about 2015×4282×4404 km assembling with the Control and Processing Center in St. Petersburg. The guideline of the Russian VLBI Network “Quasar” is to carry out astrometrical and geodynamical investigations [1]. The VLBI Network “Quasar” uses as much as possible powerful advantage of longitudinal and latitudinal extention of Russian territory, which allows us to acieve wide enough mutual visibility of radio sources with different declinations (Fig. 1).

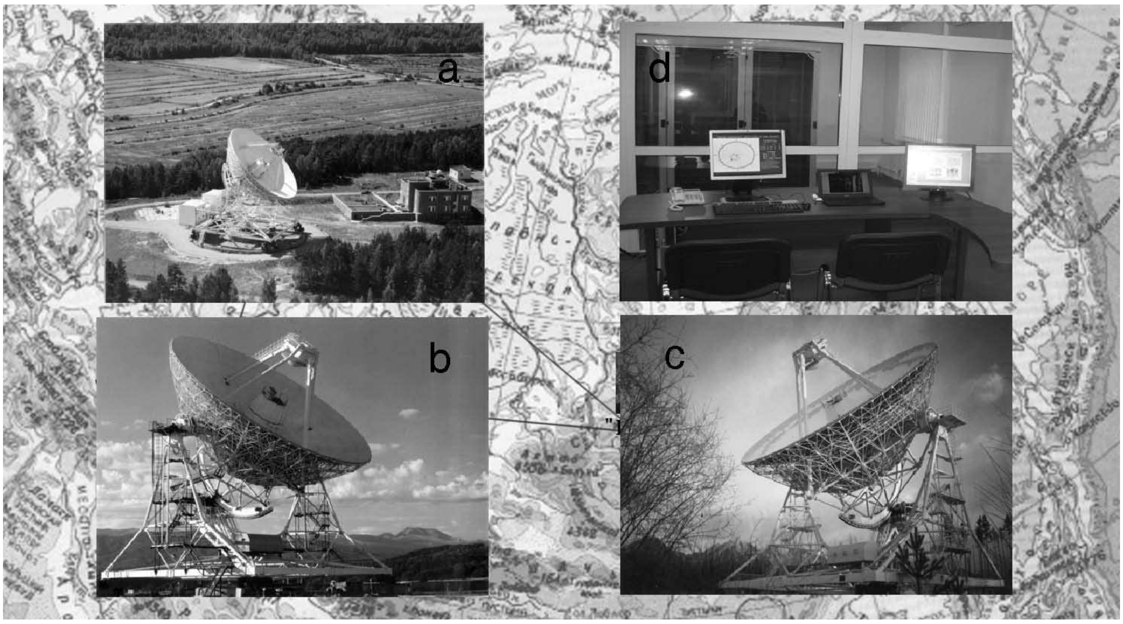

Figure 1: VLBI Network “Quasar” (a — “Svetloe”, b — “Zelenchukskaya”, c — “Badary”, d — Control and Processing Center, St. Petersburg).

The basic element of each observatory is a fully steerable 32 meters radio telescope. The antenna was designed on the basis of modified Cassegrain scheme with a main quasi-parabolic reflector with focal distance of about 11.4 meters and the secondary quasi-hyperbolic mirror of 4 meters in diameter. The asymmetric secondary mirror focuses the emission of radio sources aside of the main dish axis and the focal point draws the circle while the rotation of the secondary reflector. Fast transfer from one wavelength to another is performed by the rotation of the secondary mirror to a given angle (Fig. 2).

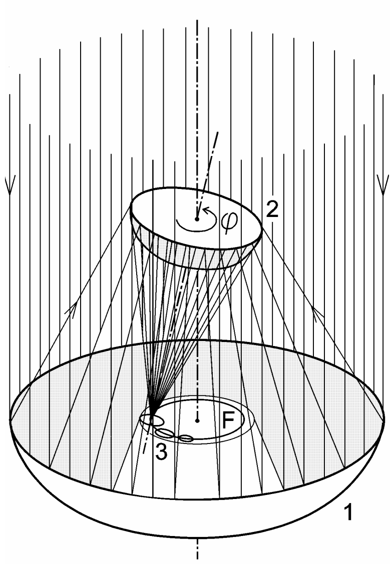

Figure 2: Focusing system of radio telescope
(1 — main dish, 2 — subreflector, 3 — horns, F — focal plane).

The slewing velocities are of about 1.6°/s and 1.0°/s along azimuth and elevation angle correspondingly. The accuracy of pointing and guiding the radio source is less than 10". Each telescope of the VLBI Network "Quasar" is equipped with similar receiving facilities — the low-noise multi-wave receiving SHF-system which consists of 1.35, 6, 18–21, 3.5 and 13 centimeter double-channels (left and right polarization) cryogenic radiometers (Table 1), the last two being used for joint reception in S/X range.

Wavelength, cm	Frequency band, GHz	T_r, K	T_{sys}, K	SEFD, Jy
21/1	1.38–1.72	8	43	240
13	2.15–2.50	10	48	330
6	4.60–5.10	8	27	140
3.5	8.18–9.08	11	34	200
1.35	22.02–22.52	20	80	710

Table 1: Parameters of the VLBI Network "Quasar" radio telescopes.

The time-keeping complex of each observatory is developed on the basis of hydrogen masers with 3×10^{-15} instability for 1000 s time of averaging. Site clocks are synchronized by the GPS/GLONASS signals with better than 50 nanosecond accuracy. The system of transforming, formatting and receiving signal for radiometric and VLBI modes operates in the 100–1000 MHz basic range of intermediate frequencies. Different systems of formatting radio signals are connected to the outputs of receivers by wideband coaxial link.

Nowadays the observatories of the VLBI Network "Quasar" have different data acquisition systems: Mark IV DAS with Mark 5A recorder in observatory "Svetloe", VLBA 4 DAS with Mark 5A terminal in "Zelenchukskaya", and P 1000 DAS [2] with Mark 5A recorder in "Badary" observatory. Recorder S2 is to be used up to the end of 2008 in the frame of domestic geodetic programs only.

All observatories of the VLBI Network “Quasar” are linked to the Control and Processing Center by optical fiber lines and equipped with working stations of x86 architecture and network facilities providing data transmission with 100 Mbps rate.

Domestic observational programs were started in 2006 and the main goal of the programs is to determine the Earth orientation parameters. There are two domestic programs: Ru-E — diurnal observations on 3-baselines interferometer for determining all Earth orientation parameters (polar motion, Universal Time and celestial pole coordinates) and Ru-U — observations of 8-hour duration for obtaining Universal Time. Preliminary processing the VLBI observational data recorded in S2 format is carried out using 2-stations MicroParsec correlator [3].

The domestic astrometrical, geodynamical, geodetic and astrophysical observational sessions are planned using program package developed in the IAA RAS on the basis of NASA SKED system [4].

Observational activity of the VLBI Network “Quasar” observatories “Svetloe”, “Zelenchukskaya” and “Badary” in both international and domestic VLBI programs is presented in Table 2.

Programs	2006			2007			2008		
	Sv	Zc	Bd	Sv	Zc	Bd	Sv	Zc	Bd
IVS	46	63	–	44	37	12	71	69	36
Ru-E	9	9	9	9	9	9	24	24	24
Ru-U	5	5	–	7	8	16	–	24	24

Table 2: Activities of the Network “Quasar” stations “Svetloe”, “Zelenchukskaya” and “Badary” in international and domestic observational programs.

The results of obtaining EOP from the all available domestic observational programs are presented in Table 3.

Program		Nsess	RMS
Ru-E	X_p	27	0.82 mas
	Y_p	27	0.97 mas
	UT	27	44 µs
	X_c	27	0.75 mas
	Y_c	27	0.72 mas
Ru-U	UT	30	132 µs

Table 3: RMS differences between EOP obtained within the domestic programs and EOP IERS 05 C04 series.

2. The VLBI Network “Quasar”: 2009

In 2009 the 6-station correlator ARC [5] will be put into operation. It will provide processing input signals in VSI-H format for 16 channels with 16 MHz bandwidth and two-byte sampling for each of 15 baselines. All observatories will be equipped with Mark 5B recorders for carrying out domestic (52 sessions per year) and international IVS (60 sessions per year) programs. These facilities will be used also for domestic and international (together with EVN) programs. For observations in the frame of Radioastron space mission the RDR recorders [6] will be installed in all observatories.

In the same year e-VLBI mode will be developed for determination of UT in the frame of 1-hour domestic sessions Ru-UInt.

3. The VLBI Network "Quasar": 2010–2011

In this period the following problems will be solved:

- The RT-70 radio telescope in Ussurijsk (Far East) (Fig. 3) will be equipped with S/X receivers, P 1002 digital DAS [7] and the Mark 5B recoder for joining the VLBI Network "Quasar" to carry out both astrometric and astrophysical programs and deep space missions;
- Diurnal 1-hour session in e-VLBI mode will be started;
- The "Quasar" observatories will be equipped with Russian satellite laser ranging system "Sazhen-TM" for colocation of different space geodesy techniques (Fig. 4).

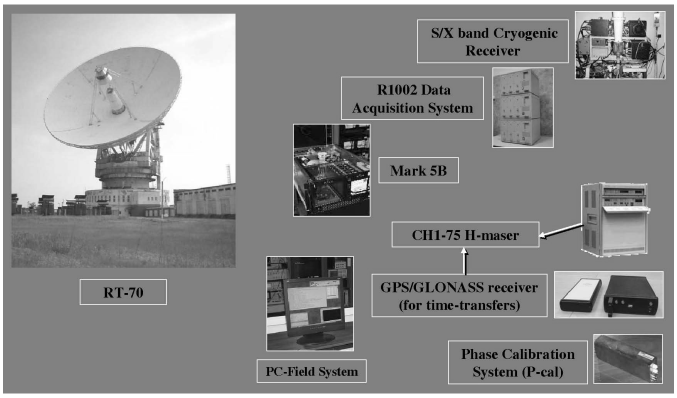

Figure 3: Upgrade of radio telescope RT-70 (Ussurijsk, Far East).

Figure 4: Satellite Laser Ranging System "Sazhen-TM". Satellite heights 400–23000 km, optical system diameter 25 cm, laser pulse frequency 300 Hz, pulse energy 2.5 mJ, mass 120 kg, normal points precision 1 cm, angular precision 1–2".

References

[1] A. Finkelstein, A. Ipatov, S. Smolentsev, *Radio Astronomy Observatories Svetloe, Zelenchukskaya and Badary of VLBI Network QUASAR*, in proceedings of *IVS 2004 General Meeting*, N.R. Vandenberg, K.D. Baver (eds.), NASA/CP-2004-212255, 2004, 161–165.

[2] L.V. Fedotov, N.E. Koltsov, *VLBI-terminal of the Nertwork "Quasar". IAA RAS Transactions*, **17**, "Nauka", St. Petersburg, 2007, 298–302 (in Russian).

[3] V.G. Grachev, L.A. Kuptsov, I.F. Surkis, *One board VLBI Correlator "MicroParsec". IAA Communications*, **162**, St. Petersburg, 2004, 22 p.

[4] A.E. Melnikov, *VLBI scheduling system of the IAA RAS based on SKED. IAA RAS Transactions*, **15**, "Nauka", St. Petersburg, 2006, 76–97 (in Russian).

[5] I. Surkis, V. Zimovsky, A. Melnikov, et al, *The IAA RAS 6-stations VLBI Correlator.* in proceedings of *the Fifth IVS General Meeting "Measuring the Future"*, A. Finkelstein, D. Behrend (eds.), "Nauka", St. Petersburg, 2008, 124–128.

[6] K.G. Belousov, S.F. Likhachev, *Digital processing of "RADIOASTRON" space mission data. Preprint PHIAN*, No 34. Moscow, 2000, 16 p. (in Russian).

[7] L.V. Fedotov, N.E. Koltsov, E.V. Nosov, *Digital signal converter for radio astronomical systems*, *Instrumental and experimental techniques*, 2009 in print (in Russian).