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PROSPECTS FOR USING SOVIET DSN ANTENNAS FOR SETI

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ABSTRACT To optimize SETI searches, large radio antennas are desirable. The parameters and availability of large Soviet Deep Space Network (DSN) radiotelescopes for such searches are described.

INTRODUCTION

One of the main problems that has become evident over the last 30 years in the search for radio signals from extraterrestrials is the difficulty of obtaining adequate observing time on large telescopes (Papagiannis 1979, 1984; Ambartsumian *et al.* 1981). The search philosophy has hardly changed since the early 60s and 70s when research was carried out with distributed dipole arrays and small dishes (Tarter, 1985) in parallel with large dishes. Drake and Gulkis (1985) estimated that the probability of succeeding in a SETI search was contingent upon obtaining time on large telescopes, noting that "a large telescope can always be used to produce a higher probability of success than a smaller telescope."

SETI search strategies have been based upon two different assumptions: (1) we are searching for signals which have been emitted by civilizations wanting to be heard, or (2) we can eavesdrop on radio signals, even if unintentionally sent our way. The first assumption is based upon the idea that extraterrestrials think like humans. This postulate has led to strategies based on "magic frequencies," "magic locations," very narrow bandwidth signals, or signals with strong polarizations. The second assumption has fewer constraints on the types of signals to be searched, but is, of course, limited by our current level of technology.

Both types of search strategies are skewed towards the use of the largest antennas. In the second case (eavesdropping) the amplitude of the signals is expected to be several orders smaller than in the first case, assuming that the extraterrestrial transmission facility is similar to those existing here on Earth.

The principal SETI efforts rely on the NASA program which will be in operation in the 90s. This project will use many of the largest telescopes including Arecibo, Bonn, and the NASA DSN. It is estimated that the total telescope time required for this work in the two operational modes (Targeted Search and Sky Survey) is about 10 years (Seeger *et al.* 1985; Klein *et al.* 1985). It also appears that it is unreasonable to expect that these large telescopes will be 100% dedicated to SETI.

The situation will certainly improve if we can include in the list of antennas available for SETI observations the large Soviet telescopes – the antennas of the Soviet DSN 70 m dishes in Ussuriisk and Evpatoria, the 64 m dish at Bear Lakes near Moscow, and the 70 m telescope in Suffa (currently under construction in central Asia). Also, an efficient use of the large telescopes would be to analyse radio telescope data obtained by other projects for SETI evidence. This SETI strategy is best described as *S*upport by *E*xisting *T*elescopes *I*n Search.

SOVIET DSN ANTENNAS

Two 70 m and one 64 m Soviet DSN antennas are currently in operation. Figure 1 shows the antenna in Evpatoria; the antenna at Ussuriisk is shown in Figure 2. Antenna locations and some technical parameters related to scheduling are included in Table 1. These antennas were designed to work at wavelengths longer than 3 cm. Surface accuracy is good enough to work at 1.35 cm and 0.8 cm but pointing is a problem. The measured parameters of the antennas are given in Table 2.

Table 1. Soviet Deep Space Antennas

Characteristics	Evpatoria	Ussuriisk	Bear Lakes
Designation	Evp-70	Uss-70	BL-70
Diameter	70 m	70 m	64 m
Mount	azim-elev	azim-elev	azim-elev
Longitude	33°11′19″	131°45′22″	37°57′17″
Latitude	45°11′22″	44°00′57″	55°51′57″
Min. Elev. Angle	0 to 5°	0 to 5°	0 to 5°
Azim. Limit	±270°	±270°	±270°
Pointing Accuracy	0.003°	0.003°	0.003°
Pointing Type	Auto, Man.	Auto, Man.	Auto, Man.
Tracking Speed Range			
a) Auto			
–Azim (°/*sec*)	$6 - 700\ 10^{-4}$	$6 - 700\ 10^{-4}$	$6 - 700\ 10^{-4}$
–Elev (°/*sec*)	$6 - 200\ 10^{-4}$	$6 - 200\ 10^{-4}$	$6 - 200\ 10^{-4}$
b) Man			
–Azim (°/*sec*)	0.5	0.5	0.5
–Elev (°/*sec*)	0.25	0.25	0.25
Max. Tracking Accel. (°/*sec*)	0.5	0.5	

Fig. 1. The 70 m DSN antenna in Evpatoria.

The 70 m antenna is a Gregorian-type antenna with feeds and receivers located at the secondary focus. The main reflector structure uses a "homologous deformation" design. As a result, the change in the effective area with elevation angle is small. For rapid band changing, there is an additional two-mirror switching system located on the top of a focal cabin. The diameter of these additional mirrors is about 1 m. On the top of the focal cabin are 6 locations for different feeds. To change the feed, small mirrors must rotate around the focal point. The usual band configuration in the receiving mode of the Soviet DSN antennas is 32 cm, 18 cm, and 5 cm.

Fig 2. The 70 m DSN antenna at Ussuriisk.

All of the front–end amplifiers are low noise and cryogenically cooled. All of the receiver Local Oscillators (LO) are synchronized with a high stability hydrogen maser.

RADIOASTRON REQUIREMENTS FOR THE SOVIET DSN

The Space VLBI mission RADIOASTRON will be in operation in the mid–90s and will include a Space Radio Telescope (SRT) on a one day

Table 2. Measured Parameters of the 70 m Antenna in Ussuriisk

Three Frequency Band Ring Feed

Parameter	18 cm	6 cm	1.35 cm
Effective area (m^2)	2100	2020	1100
Antenna Noise Temp. (°K)	50-60	40-60	20-35

One Frequency Band Horn Feed

Parameter	18 cm	6 cm	1.35 cm
Effective area (m^2)	2400	2800	1100
Antenna Noise Temp. (°K)	17	16	20-35

Earth orbit and many Ground Radio Telescopes which will co–observe with the SRT at 92, 18, 6, and 1.35 cm wavelengths.

As a part of the ground support of the RADIOASTRON mission, Soviet DSN antennas will be fitted with receiving systems at 92, 18, 6 and 1.35 cm, using dual channel circular polarization feeds and having the capacity for simultaneous operations. Moreover, the telescopes will have VLBA (U.S.) and/or S-2 (Canada) recording systems for recording of the interferometric signal in two channels simultaneously, with a bandwidth of 32 MHz. It is also planned to place a diagnostic correlator at the Ussuriisk station, having a 70 m radiotelescope and 32 m tracking station, to receive part of the signal from the SRT. The diagnostic correlator will correlate a part of the science data flow from the GRT and the SRT (one data channel is 4 MHz) for fringe verification of the Earth-space interferometer in a near-real-time mode (data processing within one day of the observations).

Figure 3 shows a block diagram of a radiotelescope developed for RADIOASTRON. The complete system consists of the radiotelescope, low-noise receivers, VLBA and/or S-2 high-speed recording system, hydrogen maser, and diagnostic correlator.

The front-end amplifiers on the 18/6/1.35 cm band receivers are designed as an integral cryogenically cooled block. A specially designed SRT feed also will be included in the dewar. There are two levels of cooling in this device: the physical temperature of the low noise amplifiers should be 20°K and the temperature of the feed should be 80°K. The feed is an unusual design. Its combination of flat rings at 18 and 6 cm and feed horn at 1.35 cm can provide outputs in both LCP and RCP simultaneously. The prototype of this feed for 4 wavelengths (92, 18, 6, and 1.35 cm) was completed and tested at the radiotelescope in Ussuriisk. Good efficiency was

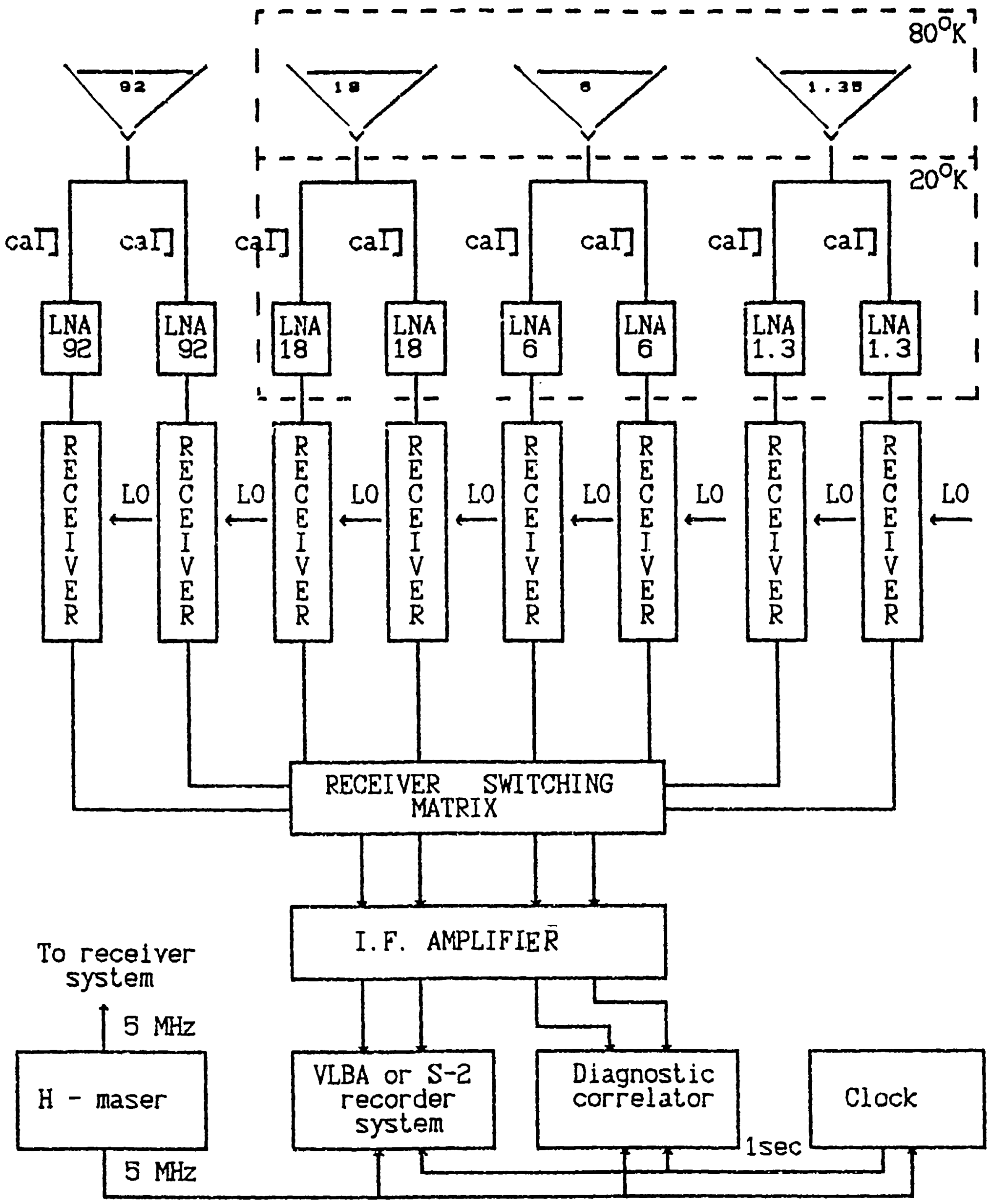

Fig 3. Block diagram of a radiotelescope as instrumented for RADIOASTRON.

shown at 18/6/1.35 cm (see Table 2). The efficiency was not good at 92 cm because the size of the mirrors in the waveband switching system (1 m) is too small. At 92 cm a cross dipole feed and low noise amplifier without cooling will be used.

All receivers will be built following a similar scheme (see Figure 3) with the possibility of LO tuning for doppler drift correction. The 18 cm receiver can be used for observations at all 4 OH lines (1612, 1665, 1667, and 1720 MHz).

The planned parameters of the RADIOASTRON receiving system are given in Table 3.

Table 3. Parameters of the 70 m Radiotelescope

Parameter	92 cm	18 cm	6 cm	1.35 cm
Frequency (MHz)	324	1,665	4,880	22,235
Bandwidth (MHz)	8	16	16	32
Diameter (m)	70	70	70	70
Eff. Aperture (m^2)	2,000	2,500	2,700	1,000
System Noise Temp. (°K)	60	20	20	35
Polarization	Rt/Lft	Rt/Lft	Rt/Lft	Rt/Lft

In the VLBA or S-2 terminals the received signal will be clipped, sampled and recorded at 64 Mbps. One terminal can record two data streams simultaneously at 64 Mbps.

The diagnostic correlator which may be located in Ussuriisk and will process the data flow at 8 Mbps in the playback mode of the VLBA can be used in principal as an autocorrelation spectrograph with a resolution of 10^{-2} Hz.

PROSPECTS FOR SETI USING THE SOVIET DSN

Although there are no current plans to use the Soviet DSN antennas directly for SETI programs, these antennas will be available since the main missions placing demands on these facilities will be RADIOASTRON and MARS 94/96, and these will not be operational until the mid–90s.

During 1991–94 the Soviet DSN antennas will be fitted for RADIOASTRON. Currently these antennas are working in the interferometric mode at 18 cm with MKII terminals. At the end of 1991, VLBA terminals will be installed at Ussuriisk and will work with 18 cm receivers. In 1992 the receiving system for 18/6/1.35 cm should be ready. In this preparatory period we hope to work on different observational programs with fully implemented facilities. When the RADIOASTRON mission is operational, we expect to have 70% of the observing time at the Ussuriisk antenna, and 10% at Evpatoria.

From the description of the RADIOASTRON ground telescope instrumentation, one can see that it is nearly optimal for SETI. Actually, the set of RADIOASTRON observing frequencies includes 3 "magic frequencies" – lines of hydroxyl (18 cm), water (1.35 cm) and formaldehyde (6 cm, see Hirabayashi, 1985), as well as the 92 cm band where the radio leakage from Earth–like civilizations is expected to be at a maximum (Sullivan, 1985; Sullivan and Knowles, 1985).

It is possible to observe at both circular polarizations and several wavelengths simultaneously.

Using a high stability hydrogen maser and by tuning the LOs of the receivers, a large integration time with the possibility of doppler drift correction can be provided.

There is also the possibility for easily switched observing frequencies.

High-speed VLBI recording terminals and near-real-time diagnostic correlators which could be implemented at the radio telescopes can provide the capability to pursue SETI observations with very high frequency resolution as described in Tarter *et al.* , 1985. The MCSA receiver could be loaned to the Soviet antennas, much like VLBA terminals, and used for a SETI program.

CONCLUSION

It appears that there exists a strong possibility to use Soviet DSN facilities for SETI. Moreover, we hope that for RADIOASTRON and for the Japanese Space VLBI mission "VSOP" (which also plans to use the same set of frequencies) many of the largest radio telescopes around the world will be similarly outfitted.

During the next several years, when RADIOASTRON and VSOP are being developed and operated, there is a good chance for organizing useful SETI observations.

Certainly these observations will be in a shared mode, but it appears that there are common observation targets for both Space VLBI and SETI. When observing programs for the future Space VLBI mission are discussed, SETI interests should be considered as well.

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Viacheslav Slysh meditates on maser sources.