DSN CO-OBSERVING OPERATIONS TO SUPPORT SPACE VLBI MISSIONS

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ABSTRACT

Reliable radio astronomy support of Space Very-Long-Baseline-Interferometry missions by ground radio telescopes is mandatory in order to achieve a high scientific return from the missions. The 70m DSN antennas along with other ground radio telescopes will perform as the ground segment of the Earth-Space interferometer.

Improvements of radio astronomy VLBI operations at the DSN to achieve higher reliability, efficiency, flexibility and lower operations costs is a major goal in preparing for radio astronomy support of SVLBI. To help realize this goal, a remote control and monitoring mode for radio astronomy operations at the DSN is been developed.

1. INTRODUCTION

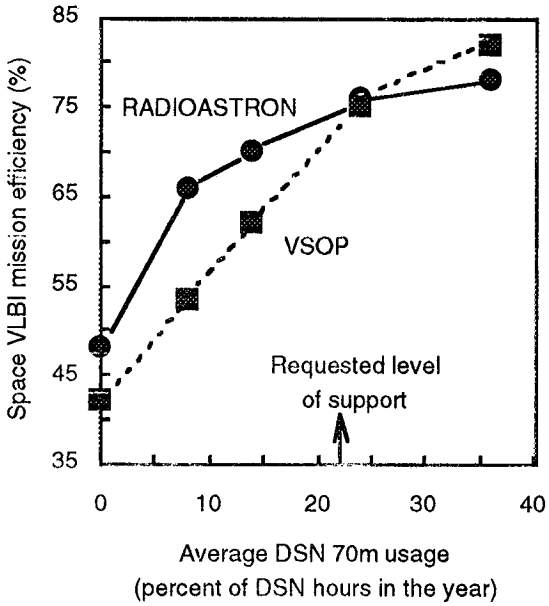
Two Space Very-Long-Baseline Interferometry (SVLBI) missions are to be operational during the second half of the 1990's. The spacecrafts and Space Radio Telescopes (SRT) will be designed, manufactured and launched by the Japanese (VSOP) and Russians (Radioastron).

In addition to the flight elements, the network of ground radio telescopes which will be performing co-observations with the SRTs are essential to the mission. Observatories in 39 locations around the world are expected to participate in the missions [1,2]. They should provide co-observing support with detection of signals from celestial sources in L,C, K-bands for VSOP and Radioastron, and additionally P-band for Radioastron, two circular polarizations at each channel and recording of signals in VLBA/MKIV compatible formats.

The 70m DSN antennas along with other ground radio telescopes will perform as the ground segment of the Earth-Space interferometer. DSN radio astronomy co-observations for future Space VLBI missions will play a special role due to the performance of the facilities (longest baselines, co-location with spacecraft data acquisition and phase link stations, 70m class of antennas with 22 GHz antenna efficiency up to 40-50%), and the inherent reliable operability of the DSN which is oriented to supporting routine operations (daily for 3-5 years).

The importance of DSN co-observing support for SVLBI missions is recognized by DSN management as evidenced by their preliminary allocation of DSN 70m

time in their long-range resource allocation plan. The value of the DSN 70m network to SVLBI missions' efficiency is illustrated by Fig1. (Courtesy of D.Meier, JPL). This figure shows an estimation of SVLBI mission efficiency (percent of time per orbit actually used for observations by a SRT) vs average DSN 70m usage for co-observing with a SRT. The change of efficiency for a SVLBI mission can be significant due to a change in the level of the DSN co-observing support [3].



Preliminary consideration of the DSN 70m co-observing requirements and cost estimates for corresponding upgrades of the DSN systems did show that upgrading the existing DSN capabilities is the only way to keep the cost upgrades at a reasonable level and satisfy minimal requirements for SVLBI mission co-observing support. Another condition is to accept a lower than is usually used for s/c operations reliability of DSN operations to maintain radio astronomy support for SVLBI.

Three main areas of activities are under development to upgrade DSN VLBI radio astronomy performance and to provide adequate and reliable co-observing support:
- improvements of the current VLBI Radio Astronomy operations;
- renovation of radio astronomy receiving systems and upgrade of the MKIII to MKIV VLBI recording system;
- testing equipment and training operations personnel.

Some of these upgrades are part of an ongoing improvement of DSN radio astronomy capabilities. Others are specific to the SVLBI missions.

The purpose of this paper is to describe ongoing improvements of the current VLBI Radio Astronomy operations at the DSN in order to meet SVLBI co-observing requirements.

2. DSN OPERATIONS CONCEPT TO SUPPORT SVLBI RADIO ASTRONOMY CO-OBSERVATIONS

Improvements in VLBI Radio Astronomy operations at the DSN to achieve higher reliability, efficiency, flexibility and lower operations cost is one of the major goals in preparing for DSN co-observing support of SVLBI. These improvements will also resuly in major advancements in the DSN's support of other radio astronomy activities.

Radio astronomy co-observing support for SVLBI is very similar in structure and content of the

observing sessions to Radio Astronomy and Special Activities (RASA), but the volume of SVLBI co-observing activities is expected to be a few times more (yearly average) than the regular volume of RASA activities at the DSN.

Because of this, it is logical to improve the operations performance of existing DSN VLBI radio astronomy activities to meet requirements for SVLBI co-observing.

2.1. SVLBI co-observing concept

The required operations reliability for the DSN 70m antennas serving as radio telescopes in support of SVLBI is 90-95%. The SVLBI projects (VSOP and Radioastron) will provide the schedule for observations (DRUDG file) one month in advance, but in cases of "Targets of Opportunity," the telescope has to be able to change its configuration and support a new program for observations in three days.

Essential improvements in hardware to be used for co-observing are needed: use more reliable equipment, (e.g., instead of masers use HEMT LNA), provide spares, backup receivers and recorder, improve status of monitoring and calibration. Flexibility in operations can be provided through fast and simple ways to change operations configurations and modes, and through the standardization of operations procedures.

The goal of significantly improving operations performance without increasing the cost of operations can be achieved by reducing the amount of hands-on activity and automating routine activities as much as possible. Since the largest component of operations costs is the staff, by introducing automated and remote operations the costs can be lowered [4].

2.2. VLBI Radio astronomy operations functions and operations scenario

Existing VLBI Radio astronomy operations functions performed at the DSN, excluding the time allocation on the DSN, are listed in Table1.

The proposed improvements include:
(a) automatically processing DRUDG files (VLBI radio astronomy schedule files) received from the SVLBI project via Internet to DSN Predicts;
(b) remote monitoring and control of receivers (K, L, C-bands) by using dedicated Radio Astronomy computers connected with a computer at JPL via Internet at each DSN site;
(c) capability for remote monitoring of the antenna position and recorder status;

(d) station personnel will perform the initialization, calibrations (Antenna Gain Curve, Tsys) and tape logistics.

Radio Astronomy operations at the DSN are working toward an automated and remotely-controlled configuration such as is shown in Figure 1. As this capability develops, it may be an attractive resource for future SVLBI co-observing support possibilities.

VLBI radio astronomy operations functions at the DSN		
Functions		Staff
Predicts	DRUDG to Antenna predicts	NOA VLBI
	DRUDG to VLBI recorder predicts	NOA VLBI
	DRUDG to Briefing Message	Network Operations Project Engineer for RASA
Control	Antenna configuration*	Deep Space Complex operations staff
	Antenna pointing	Deep Space Complex operations staff
	VLBI Recorder	Deep Space Complex operations staff
	Receivers	Radio Astronomy engineer
Calibration	Boresighting	Deep Space Complex operations staff
	Tsys	Deep Space Complex operations staff
	Gain curve/nonlinearity	Radio Astronomy engineer
	System coherence test	Radio Astronomy engineer
Monitoring	Antenna status	Deep Space Complex operations staff
	VLBI Recorder	Deep Space Complex operations staff
	Receivers	Radio Astronomy engineer
Tape logistics	Tapes change	Deep Space Complex operations staff
	Log file	Deep Space Complex operations staff
	Shipment/Tapes label	Deep Space Complex operations staff

*Subreflector/waveguide

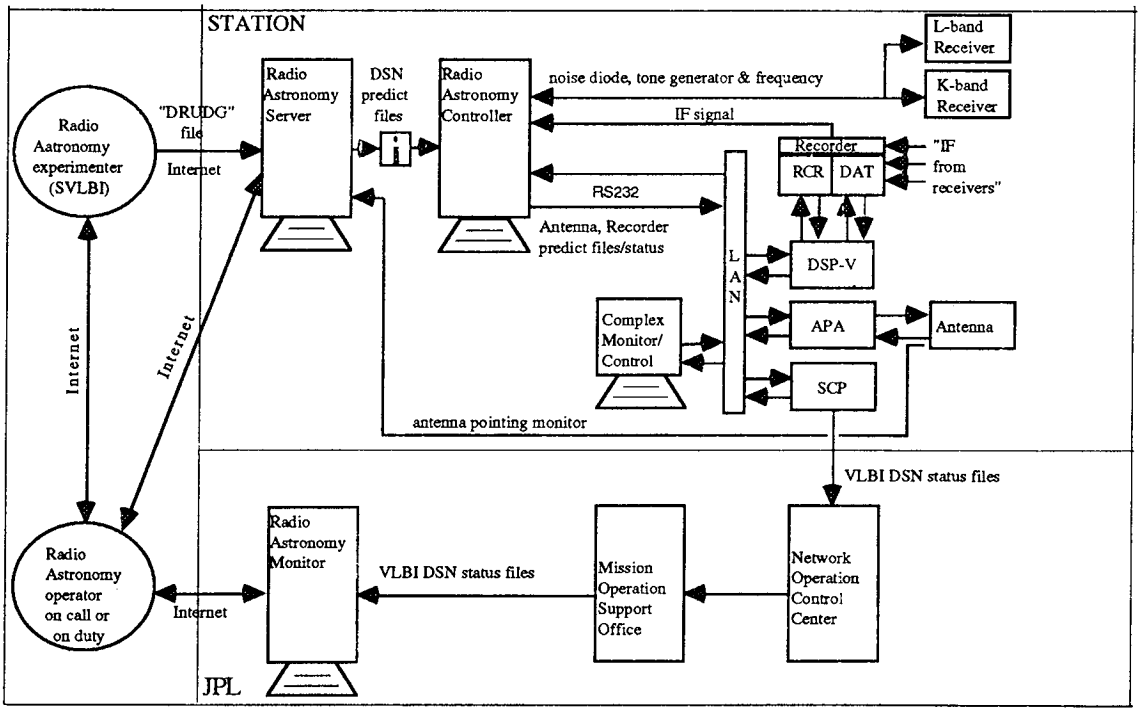


Figure 1. DSN VLBI RA operations configuration for 70m subnet

The majority of the radio astronomy community, including the SVLBI projects, in order to schedule VLBI co-observing, produce a generic scheduling file referred to as a DRUDG file. Because the DSN is used for a wider range of measurements than only VLBI radio astronomy (e.g. navigation, TM), the DSN uses its own scheduling format. DSN stations are incapable of reading DRUDG files. For this reason, someone must perform the conversion of DRUDG files to DSN predicts. SVLBI co-observing will require performing this activity much more intensively, basically every day. As result, this operation becomes very labor intensive. Automatically processing of the VLBI radio astronomy schedule files (DRUDG files), should eliminate or significantly decrease the workload to execute this function.

The Radio Astronomy Server (workstation) located at each station or in JPL, will automatically convert DRUDG files coming from the Space VLBI project to DSN predicts.

To provide security for DSN operations, it is required to have an "air gap" when information comes from outside the network it is transferred to inner network computers on diskette. The radio astronomy controller will serve as an additional filter to allow only commands which are permitted by the DSN complex. Finally, the observing program loaded on the Radio Astronomy Controller can be initiated only from the Complex Monitor and Control computer. In the future, the "air gap" may be eliminated with operations being remotely executed from the JPL control /monitor computer.

For planned SVLBI co-observations, a number of different DSN RA configurations are considered. The number of configurations is estimated to be 3 receivers x 2 polarization's x 4 recording modes = 24. An observing program may be different from day to day. An extensive automation of the control of the antenna, receivers and VLBI recorder configurations are necessary to provide reliable support without increasing of the workload of the stations personnel.

To monitor the VLBI DSN status during the observations, the necessary information will be taken from the regular flow of the DSN status information available in the Network Operation Control Center and displayed on the Radio Astronomy Monitor at JPL.

For Space VLBI co-observing, the Radio Astronomy Server and Controller may be considered as a Project resource for generating the required input files for the DSN Network Sypport System (NSS).

The station personnel will monitor activities on site during the observations for security reasons, but the automation and remote monitoring of many VLBI RA operations functions can significantly decrease the demands on the workforce thus enabling them to be shared by other projects.

Since by following the above recommendations the role of the DSN operations staff for co-observations will be minimized, more responsibility for successful observations must be assumed by the SVLBI Project. The Project

should be prepared to accept the higher probability of failures.

2.3 Implementation status

A new software for conversion of radio astronomy schedule files into DSN predicts is now under development (N.Vandenberg, Goddard SFC). The software will allow conversion of files which will arrive by the Internet to the Radio Astronomy Server atomatically and prepare the DSN predict files to use for DSN SVLBI co-observing operations.

The remote monitor control system development has been completed and its software has been successfully tested in Goldstone for 34m antenna operations (J.Leflang, JPL). The system is under development for the 70m antenna in Goldstone, and then will be implemented on other 70m DSN antennas

Dedicated RA computers (HP9000) exist at each complex. The automation of receiver control was demonstrated in Canberra DSCC. This needs to be implemented at the other complexes. It may be necessary to upgrade the computers at the other complexes to achieve full compatibility.

The monitor of data flow from DSCC via MOSO will be available on the RA computer at JPL in the near future. Software needs to be developed for the RA computer.

Antenna monitor data captured locally at each complex is available via the Radio Astronomy workstation at each complex. Software is being actively developed.

3.CONCLUSIONS
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The new Radio Astronomy VLBI observations concept is under development at the DSN to provide co-observing support for future space VLBI missions. The concept is focused on a high degree of automated operations with elements of remote monitoring and control of the VLBI radio astronomy equipment.

The upgrades will benefit not only the SVLBI project but also VLBI radio astronomy and other related VLBI activities (s/c navigation, geodesy, astrometry) at the DSN.

4. REFERENCES

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