DSN Research and Technology Support

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The activities of the Development Support Group in operating and maintaining the Venus Station (DSS 13) and the Microwave Test Facility (MTF) are discussed and progress noted. Major activities discussed include equipment modifications required for the planned automation demonstration, measurements made of radiation from the planet Jupiter and various radio sources, testing and installation of the 400-kW X-band planetary system, efficiency measurements on a DSN 20-kW transmitter, a brief summary of initial testing of microwave power transmission over a distance of 1.5 km, clock synchronization transmissions, and various interferometric observations of radio sources. Additionally, a discussion of the phased array video enhancement experiment on the Mariner 10 second Mercury encounter and DSS 13's role in that experiment is given.

During the four-month period ending October 15, 1974, the Development Support Group, in its operation of the Venus Station (DSS 13) and the Microwave Test Facility (MTF), made progress on various projects as discussed below.

I. In Support of Section 331

A. Station Automation (Pulsars)

As part of the overall DSN Station Automation Project (Research and Technology Operating Plan (RTOP) 68 "Station Monitor and Control"), a demonstration is planned using the Venus Station to perform a pulsar track under remote control from JPL in Pasadena. There are three "control" computers installed within DSS 13: a dedicated SDS-910 which operates the Clock Synchronization Transmitting System, including positioning of the 9-m antenna; another dedicated SDS-910 which positions the 26-m antenna; and a more general-purpose machine, an SDS-930, which does general control and computation work.

The two SDS-910 computers, which are internally referred to as "A" and "B," have had "intercomputer communications links," of Section 331 design, installed between them and the SDS-930 computer. Additionally, the SDS-910B (26-m control) has rewired clock and timing circuits, two modified interrupts to function with the intercomputer communications link, and has had the PIN–

POT capability expanded. In order to provide positive antenna control as well as positioning, the SDS-910B has also been interconnected with the 26-m servo/positioning system so as to *control* (1) brakes, (2) HIGH/LOW-speed switching in both azimuth and elevation, and (3) the movement warning horn mounted near the antenna. Additionally, the SDS-910B *monitors* (1) brakes ON/OFF, (2) AZ/EL drive in HIGH/LOW speed, (3) mode of computer control, (4) hydraulic pressure ON/OFF, (5) azimuth cable wrap-up warning, both left and right, and (6) AZ/EL prelimit position warnings.

The SDS-930 has also been altered for the planned demonstration. Changes include expansion of the interrupt and PIN–POT capability, expansion of central memory, and addition of a "Pulsar Data Collector" consisting of an A/D converter, timing and control logic, auxiliary memory (8192 × 24-bit words), and necessary power supply.

The current capabilities of the computers are summarized in Table 1. However, without additional wiring, additional interrupts are available by installing additional cards as follows: (1) SDS-910A–10, (2) SDS-910B–0, (3) SDS-930–6.

Testing of these various additional automated features, along with the necessary software, was performed for 54-1/4 hours, while actual observation at 2388 MHz, left-circular polarization (LCP), with the 26-m antenna was performed for 114 hours. The pulsars observed are tabulated in Table 2.

B. Phased Array Experiment on Mariner 10

In an effort to provide higher resolution picture data from the Mariner 10 second Mercury encounter, an experiment was proposed which utilized the signals from three DSN stations, in realtime, with the signals properly phased to achieve an overall signal-to-noise ratio (SNR) improvement whose absolute magnitude was a function of the individual station SNRs, but for this experiment was predicted to be 0.7 dB. The three stations chosen for arraying were DSSs 12, 13, and 14. The data were microwaved to DSS 14 for appropriate phasing and combining, where they were used as the input signal to the second (beta) telemetry detection "string" and were subsequently transmitted by high-speed data line to JPL. During pre-encounter testing, improvements within 0.1 dB of predicted were achieved; during encounter, the arrayed stations' receiving systems performed well. DSS 13 provided a total of 19-1/2 hours of pre-encounter testing and encounter data collection tracking.

Certain modifications to DSS 13 equipment were necessary for performance of this experiment. The Mod IV R&D receiver was modified for use during the Mariner 10 second Mercury encounter. The normal 2295-MHz portion of the receiver provided phased-lock-loop operation with an 8-Hz loop bandwidth. To provide for subcarrier detection, an additional channel was implemented. This was comprised of a phase detector along with appropriate bandwidth, gain, and phasing components (Fig. 1). The first conversion intermediate frequency (30 MHz) of the Mod IV receiver was fed through a bandpass amplifier to the input of a phase detector. The reference input for the phase detector was obtained from the station central frequency synthesizer. The phase shifter in the reference line provided phasing capability to optimize phase detection of the subcarrier (177.6 kHz). The output of the phase detector was fed through an amplifier, for level setting, to the signal combiner equipment at DSS 14 via the microwave link.

Tracking predicts were furnished in the standard DSN format, and some minor conversions were necessary to obtain receiver tuning frequencies for DSS 13.

All equipment worked well during the preceding tests as well as during the encounter sequence.

II. In Support of Section 333

A. Source Observation

During the 61 hours devoted to observing weak radio sources, the sources tabulated in Table 3 were measured at 2295 kHz, with the 26-m antenna adjusted to receive right-circular polarization (RCP), with data processing being done by the noise adding radiometer (NAR).

B. Radio Star Calibration

With the receiver tuned to 2278.5 MHz, and the 26-m antenna adjusted to receive RCP, flux measurements were made of radio sources 3C123, 3C218, Cygnus A, and Virgo A during 91-1/4 hours of observation.

C. 26-m Antenna Sidelobe Measurements

In completion of this measurement of antenna sidelobes (Ref. 1), a short observation period was devoted to reaffirmation of the baseline data with the quadripod legs covered; the covering was then removed, and additional observation was done to obtain "after" baseline data. Total observation was 8-1/4 hours, at 2278.5 MHz, RCP, with data collection being performed by the NAR. This completed this program at DSS 13.

D. Sky Survey

With the 26-m antenna fixed in azimuth at 180 deg and progressively positioned in 0.1-deg increments between 86.5- and 88.2-deg elevation, 1210 hours of data were automatically collected during the night and weekend hours when the station was not manned. Additionally, 19-1/4 hours of data were collected by the NAR with the 26-m antenna positioned to point at the pole star, Polaris.

III. In Support of Section 335

A. X-Band Planetary Radar

The modification to the DSS 13 Transmitter Control System to enable simultaneous operation of the two klystrons to be used in this system has been completed. Satisfactory testing of the dual klystron configuration (installed into the feedcone to be used at DSS 14) at sustained powers of 300 kW (150 kW per klystron) has been achieved. These tests included the complete waveguide/feed system to be employed in the final configuration at DSS 14.

After testing, the feedcone and dual klystron, waveguide system, and feed were moved to DSS 14 and installed onto the 64-m antenna during the week ending September 29, 1974. Modification of the DSS 14 Transmitter Control System to operate this system has been completed and control function testing is underway. Radio frequency (RF) testing will commence as soon as water is available for cooling klystrons and waveguide/feed systems.

Due to late delivery of the buffer amplifier system, and failure of the traveling wave tube amplifiers that are to be used in that system, a temporary, substitute system is being locally fabricated so that normal testing, including phased operation under automatic phase lock control, can proceed at DSS 14, striving for a December 1, 1974, operational date.

B. DSS 63/43 100-kW Transmitter Testing

The DSS 63 100-kW transmitter system testing has been completed, and all components have been shipped to Spain for installation. The JPL/contractor team scheduled to go to Spain to effect installation on-site is now engaged in additional technical training and Spanish language classes, with an anticipated departure date of November 15–28, 1974.

The DSS 43 system testing has progressed to the crowbar cabinet, which has the new dual-ignitron (series arrangement of two ignitrons) setup. The local control cabinet has been checked out, an 8-hour heat run at 1 MW has been made on the power supply and filter configuration and modification of the control logic cards has been completed.

C. 26-m Antenna Maintenance

Some difficulty has been experienced with intermittent fuse blowing in the servo system. An analysis of the existing circuitry indicated that, probably as a result of several modifications in the past, the clutch and brake circuits were incorrectly wired. The wiring was revamped and the problem was solved.

Observation of the valve drive current required during track, as well as some "brake off" testing, indicated the antenna was out-of-balance in elevation. Measurements using a dynamometer in series with an anchor cable indicated that an additional 9072 kg (10 tons) of counterweight would be required to rebalance. Section 332 personnel fabricated this weight in two modules of lead weights mounted in steel supports. These modules were then positioned on the antenna and welded into place. Subsequent testing indicates significant reduction in valve drive current, and less tendency to "fall" when brakes are released.

D. 20-kW Transmitter Efficiency Measurement

In anticipation of installing 20-kW transmitters at all 26-m DSN stations, it was desirable to know, by actual measurement, whether or not a nominal 50 kW (62.5 kVA) 60- to 400-Hz frequency changer was capable of furnishing the required operating power. After retuning according to current DSN practices, the 20-kW transmitter at DSS 11 was measured to have an ac-to-RF efficiency of 38.9% at 20-kW RF output, and an HV dc to RF efficiency of 50.5% at 20-kW RF output power. The measured power factor was 0.9, which places operation at these power levels well within the capabilities of the standard 50-kW frequency changer.

E. Kapton Feedhorn Cover Testing

In anticipation of installing thicker (0.127 mm (0.005 inch)) feedhorn covers, made of Kapton,[1] onto DSN antennas, a determination of power handling capability was necessary. Testing was first accomplished on the 26-m antenna, at a power output of 400 kW at 2388 MHz, for a period of 2 hours. Testing was also accomplished on the 9-m antenna, at a power output of 100 kW at 7149.9 MHz. (The power density in the 9-m feedhorn is 2-1/4 times that of the 26-m antenna.) In both cases, subsequent visual examination did not reveal any damage. Both

[1] Trademark of Dupont Corp.

feedhorn covers remained in service and are used for routine operations. Testing is planned at 8495 MHz, 400 kW, when the X-band radar at DSS 14 goes into service. However, testing thus far has given ample indication that the new covers are safe for DSN use at S-band.

F. Microwave Power Transmission Testing

To demonstrate feasibility and to develop RF-to-dc power conversion devices of appropriate efficiency, a contract has been awarded to the Raytheon Corporation to demonstrate microwave power transmission from the DSS 13 26-m antenna to the DSS 13 near-field collimation tower, a slant range of 1546 m. Contract requirements specify a minimum recovered power of 12,500 W, at an efficiency (incident RF power-to-recovered dc) of at least 75%.

After field probing at low level (10 W radiated) to determine field distribution, high-power testing of a prototype device was performed with the device mounted on the collimation tower. Testing was accomplished at various incident power levels, up to 150 mW/cm^2 calculated (total radiated power of 275 kW at 2388 MHz, vertical polarization). The prototype demonstrated dc recovery at efficiencies greater than 75%.

IV. In Support of Section 421

A. VLBI

Paired with DSS 43, DSS 13 participated in interferometric measurements of 69 radio sources, including Pioneer 11. Source switching was accomplished on an average of every 13 minutes, and actual observation consumed 15 hours, with an additional 2-1/2 hours for data testing and calibrations. Data were recorded on a special video tape recorder temporarily installed for this purpose.

B. Scintillation Experiment

In an experiment proposed and conducted by Drs. W. A. Coles and E. A. Ricketts of the University of California at San Diego, and approved by the Radio Astronomy Experiment Selection (RAES) Panel as RA-157, 33-1/2 tracking hours and 7 non-tracking hours of support have been provided. These measurements of radio sources 3C273, 3C279, and PKS 1148-00 were made in the interferometric mode; the paired station was another DSN station. Measurements were made at 2290 MHz, with the antenna adjusted to receive RCP. The output data, converted to a frequency of 2.5 MHz, were microwaved to DSS 14 for realtime data reduction during some of the experiments. During others, the other station(s) microwaved their data to DSS 13 for realtime data reduction.

V. In Support of Section 422

Clock Synchronization Transmissions

Continuing with transmissions as scheduled by DSN scheduling, clock synchronization signals were provided to other DSN stations as tabulated in Table 4. Total transmission time was 12-1/4 hours.

VI. In Support of Section 825

A. Pioneer 10 and 11 Science Support

DSS 13 continued to provide an average of 8-1/4 hours per week of routine observation. Measurements of the radiation from Jupiter and the radio source calibrators tabulated in Table 5 were made at 2295 MHz with the 26-m antenna adjusted to receive RCP. Observations were made for a total of 140-3/4 hours, with the data being collected by the NAR.

B. Interstellar Molecular Line Search

In a continuing experiment (Ref. 2), observations designed to detect recombination lines of carbon were made at DSS 13 for total observing time of 32 hours. Observations, using the 26-m antenna, were made at 2273 MHz, directed at an area in the vicinity of NGC 2023, in an effort to detect emission lines from $C_{142}\alpha$. In addition to the tracking support, an additional 8-1/4 hours of non-tracking support was provided for data analysis and program checkout. This experiment was performed by Drs. G. R. Knapp, Owens Valley Radio Observatory, and T. B. H. Kuiper, Jet Propulsion Laboratory.

References

1. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report 42-20*, p. 125, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1974.

2. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report 42-22*, p. 111, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1974.

Table 1. Current computer capabilities

Computer	PIN available	POT available	Interrupt available	Memory size (24-bit)
SDS-910A	6	8	22	8,192
SDS-910B	6	7	32	8,192
SDS-930	9	11	10	16,384

Table 2. Pulsars selected for test observation at DSS 13 (6/16–10/15)

0031−07	0833−45	1818−04
0329+54	1133+16	1911−04
0355+54	1237+25	1929+10
0525+21	1604−00	1933+16
0628−28	1642−03	2021+51
0736−40	1706−16	2045−16
0823+26	1749−28	2111+46
		2218+47

Table 3. Weak radio sources observed at DSS 13 (6/16–10/15)

3C218	3C286	NCC 7027
3C273	3C309.1	Virgo A
3C274	3C348	W33
3C279	3C353	

Table 4. Clock synchronization broadcasts from DSS 13

DSS 42	DSS 43	DSS 51	DSS 62	DSS 63
3	4	1	3	1

Table 5. Radio source calibrators used for Pioneer science support (6/16–10/15)

3C17	3C123	3C348
3C48	3C274	3C353
3C66	3C309.1	PKS 0237-23
		Virgo A

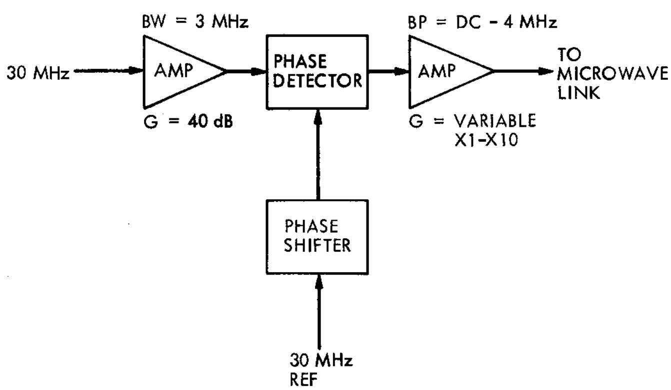

Fig. 1. DSS 13 receiver connection for phased array experiment