DSN Research and Technology Support

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Major activities in support of the Deep Space Network research and technology program performed at both the Venus Deep Space Station and the Microwave Test Facility during the last two months are presented. Progress and performance summaries are given in the following areas: pulsar reception, mu ranging from DSS 14, tricone assembly and testing, precision antenna gain measurements on the 26-m antenna weak-source observations of various radio sources, very long baseline interferometry in cooperation with National Radio Astronomy Observatory, dual carrier measurements, noise and intermodulation experiments, clock synchronization transmissions, and various maintenance activities.

During the two months ending February 15, 1972 the Development Support Group (Section 335) was engaged in the following activities.

I. DSS 13 Activities

A. In Support of Section 331

1. Pulsars. The Venus DSS continues to devote approximately 23 h/wk to the observation of pulsars. Information obtained includes pulse-to-pulse spacing, pulse time of arrival, and pulse shape. The program observes twenty-two of the approximately fifty known pulsars. The pulsars observed during the two-month period ending February 15, 1972 are tabulated in Table 1 with their coordinates.

2. SDS 930 installation at DSS 14. In preparation for performing mu-ranging at DSS 14, the Development Support Group installed at DSS 14, in Room 201 on the second floor of the 64-m antenna pedestal, the SDS 930 which was used at the Echo DSS for off-line program support. With the additional installation of the communications buffer from the DSS 13 SDS 930, and the other specialized hardware required, successful mu-ranging of the *Mariner 9* spacecraft has been performed. We will continue to provide maintenance support on this machine in order to assure success of the celestial mechanics experiment with *Mariner 9*.

B. In Support of Section 332

1. Tricone support structure (TCSS). With the installation of interior waveguide plumbing and installation of the S-band polarization diversity feed cone atop the TCSS, high-power testing could commence. Extensive testing was done with the standard DSN 20-kW transmitter and, after some waveguide cleaning, smoothing, and removal of manufacturing debris, 400 kW was successfully attained and held for an 8-h period. Extensive measurements were made of the total system temperature during these tests in order to measure the expected weak signal performance of the cone in 400-kW diplexed operation. After full testing was completed, the harmonic filter was replaced with one of a slightly different design. It was also successful in handling the power, and the total system temperature showed a decrease, possibly due to different manufacturing techniques, which result in a physically cleaner filter in the radio-frequency path in the new filter.

After completion of the high-power testing, the SPD cone was removed and shipped overseas to DSS 42A, the TCSS was disassembled and shipped to DSS 42A, and the TCSS destined for DSS 61A was assembled on the DSS 13 test pad. Interior components, waveguide, and a feed cone have been installed atop this unit, with testing proceeding on schedule.

C. In Support of Section 333

1. Precision antenna gain measurements. In continuing the project to perform an accurate measurement of the gain of the 26-m antenna at DSS 13, the comparison standard gain horn was relocated to the periphery of the antenna and extensive measurements were made by Section 333 personnel of the impedance match between the antenna feedhorn, the subreflector, and the maser. Measurements continue to be made of Cygnus A and *Apollo* lunar surface experiments package (ALSEP) to obtain comparison data between the gain of the antenna and the gain of the standard gain horn.

2. Weak-source observations. Extensive time has been devoted to this activity by both Section 333 and Development Support Group personnel. A semiautomated data taking technique has been developed, with long periods of stability measurements and technique validation being accomplished with the maser terminated in the antenna feedhorn and the antenna at various fixed positions. Substantial amounts of data have also been taken on various radio sources, in particular 3C48, 3C123, 3C218, 3C270, 3C353, Cygnus A, and the Moon.

3. Very long baseline interferometer (pulsars). In cooperation with the National Radio Astronomy Observatory (Green Bank, Maryland), a very long baseline interferometer experiment was performed involving observation of 38 pulsars and reference sources at 2295 MHz. The data was taken from the receiver as wideband noise and recorded with a digital tape recorder at a bandwidth of 325 kHz. Table 2 tabulates, with their position coordinates, the pulsars and reference sources which were jointly observed in this experiment. Fringes have been observed on the reference sources and source diameters are now being computed.

4. Maser instability. Most of the measurements made by DSS 13 require that the maser have very good stability. In the early part of December, the S-band maser developed a periodic gain instability. It steadily worsened until, on January 9, 1972, the instability had a peak-to-peak variation of 0.88 dB, with a repetition rate of once per 26 min, in a very periodic fashion. These changes are depicted in Fig. 1, which is a chart recording of the noise power output from the maser instrumentation system. Extensive troubleshooting did not uncover the cause of this regular instability, and a new developmental maser with a superconducting magnet was installed on January 24, 1972. Although some minor instability problems manifested themselves with this new maser, they have been corrected and the system is now operating. System performance with this new maser is given in Table 3 at the three frequencies at which most work is done at DSS 13.

D. In Support of Section 335

1. 100-kW dual-carrier experiments. In preparation for the *Viking* Project, which will require communicating with two spacecraft, measurements were made on a 100-kW transmitter excited with two simultaneous carriers. Measurements were made with balanced carriers (10 to 20 kW per carrier) and unbalanced carriers (50 and 10 kW) and in the frequency domain of the resulting intermodulation products and their relative amplitudes.

2. Effects of snow on 26-meter antenna. Several inches of snow fell during the holiday season and, since the antenna had been left in the zenith position, the surface was partially covered with snow. Measurements were made of total system temperature and then a radio star was tracked and data recorded on apparent source temperature and boresight error for later study to see what effect partial snow cover had on beam direction. These measurements continued until the snow was basically all gone from the antenna surface.

3. Servo performance measurements with PN codes. Maintaining an antenna/servo system in optimum adjustment requires some knowledge of the system's transfer function, so a simple technique for measurement of the antenna's response is desirable. By impressing a small ($\pm$0.050 deg) error signal generated by a 255 state PN code onto the normal smooth rate tracking input, the antenna's response to an impulse function input can be determined without the stresses that would be associated with actually inputting an impulse. The only requirement is that the individual PN states be short with respect to the antenna response time. The changes in the antenna position readouts are then correlated with the input PN for all possible delays, and the resulting correlation function as a function of delay allows observation of the antenna response to an impulse function. Figure 2 is the result of one such measurement, made on the elevation axis, in high-speed mode. Note the classical underdamped appearance, basically what one would expect from the high-speed mode which is not ordinarily used for tracking. The horizontal axis is 0.5 s per division, while the vertical axis is in arbitrary units, depending upon correlation time. These measurements are discussed at greater length elsewhere in this issue.

E. In Support of Section 337

1. Clock synchronization transmissions. Routine transmission of clock synchronization signals continued, using the Moon as a reflector. These transmissions were made to DSSs 14, 41, 42, 51, 62, and United States Naval Observatory at a power of 100 kW on a five-day week schedule. During a particularly cold period the water-cooling system fractured, and since it could not be drained, the heat exchanger core was damaged by freezing. A new core, with a design change to allow gravity draining of the coolant, has been installed and no further damage from freezing is expected.

The interface between the SDS-910 computer used for clock synchronization control and the programmed oscillator used for frequency generation failed when power was turned off during the weekend shutdown period. This has been repaired and modified so that power-off conditions will not cause any future troubles. Additionally, when an attempt was made to use a new 50-MHz reference generator, the receiving stations were unable to obtain correlation. This difficulty was traced to excessive noise on the 50-MHz reference caused by high power supply ripple from the central frequency synthesizer. Repairs are under way.

The 400-Hz motor generator, located in the transmitter control area in Building G-58, has been removed and power is now being furnished by an externally installed generator which was removed from Building G-51. Cross connections were made so that one generator now furnishes power to G-51, G-58, and G-53, thus freeing the previously used generator to be relocated to the 26-m area to aid in tricone testing.

To aid in smooth tracking of the Moon, the 9-m antenna has been rebalanced by the removal of approximately 498 kg of lead from various parts of the structure. The removal of this lead is counterbalanced by the weight of the various electronic components installed in the electronics room.

II. Microwave Test Facility Activities

A. In Support of Section 332

1. Tricone. Extensive machine shop support continues to be furnished to the tricone project. Fabrication of bracketry, waveguide spacers, etc., has been quite heavy. Additionally, major modifications were performed on the transmitter mounting drill jig as well as doing major precision redrilling three times as requirements changed. The angle requirements on this rework were quite stringent.

B. In Support of Section 335

1. Transmitter development. The continued modification and development of the 100- and 20-kW transmitters at DSS 13 require special high-voltage connector work, bracketry, waveguide adapters, etc. Extensive machine shop support has been given in this area. Additionally, construction of a flow monitor panel and design and fabrication of a voltage crowbar for the clock synchronization transmitter is under way.

2. Noise and intermodulation testing. In cooperation with personnel from the Goddard Space Flight Center, experiments have been ongoing to determine the causes of noise generation and what effects various waveguide pressurizing gases have on this noise. Special test jigs with needle points to produce arcing, carefully lapped flanges for flatness, and other special fixtures have been fabricated and used in this investigation. Sulphur hexafluoride (SF_6) has proven to suppress minor arcing and noise production and more experiments are planned. Both 20-kW transmitters, operating into a combiner, have been utilized in these experiments to investigate noise and intermodulation production.

Table 1. Pulsars currently being observed at DSS 13

Pulsar	Sidereal hour-angle	Declination
0031	351.834	352.497
0301	314.563	19.367
0329	307.314	54.482
0525	278.253	21.986
0628	262.577	331.438
0736	245.599	319.375
0823	233.728	26.722
0833	231.415	314.929
1133	186.368	16.011
1237	170.423	25.045
1604	118.550	359.555
1642	109.164	356.750
1706	103.039	343.350
1749	92.221	331.891
1818	85.169	355.591
1911	71.915	355.250
1929	67.291	10.926
1933	66.384	16.210
2021	54.606	51.765
2045	48.267	343.618
2111	41.882	46.684
2218	25.209	47.769

Table 2. Pulsars and reference sources, with positions, jointly observed with NRAO

Source	Right ascension, deg	Declination, deg
3C279	193.688	−05.640
3C273	186.925	02.204
3C274	187.358	12.536
0Q208	211.471	28.656
DA406	243.158	34.271
3C345	250.504	39.857
3C371	271.758	69.816
VR422201	330.383	42.145
3C418	309.438	51.222
PSR1929	292.725	10.930
0U080	297.179	8.042
3C409	303.313	23.488
1821 + 10	275.658	10.721
3C424	311.704	6.971
NRAO 530	262.867	−13.064
1741 − 03	258.904	−3.838
2128 − 12	322.513	−12.239
2134 + 00	323.792	0.566
2127 + 04	322.288	4.914
3C84	49.496	41.416
CP0329	52.725	54.483
NRAO 150	59.371	50.895
3C91	53.929	50.664
0607 − 15	92.113	−15.710
0704 − 23	106.367	−23.166
0J297	134.863	−28.020
0814 − 35	123.783	−35.506
PSR0833	128.608	−45.077
0807 − 38	122.158	−39.005
0843 − 33	131.021	−33.718
1055 + 01	164.271	1.714
CP0950	147.929	8.060
0K290	148.821	25.387
CP1133	173.658	15.999
1116 + 12	169.371	12.718
1148 − 00	177.329	−0.245

Table 3. Performance of DSS 13 development S-band maser with superconducting magnet

Frequency, MHz	Gain, dB	Total zenith system Temperature, K
2278	44.8	17.8
2295	43.6	16.3
2388	32.4	17.8

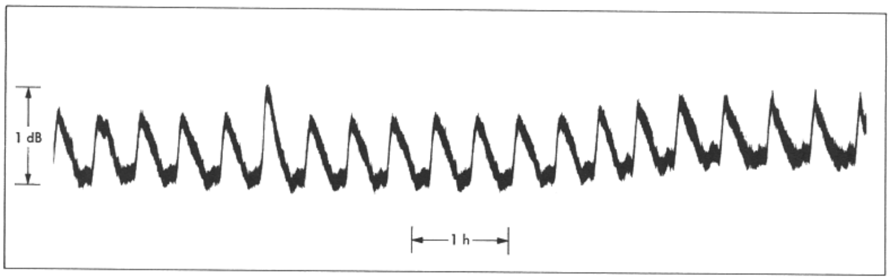

Fig. 1. Periodic gain instability in DSS 13 S-band maser

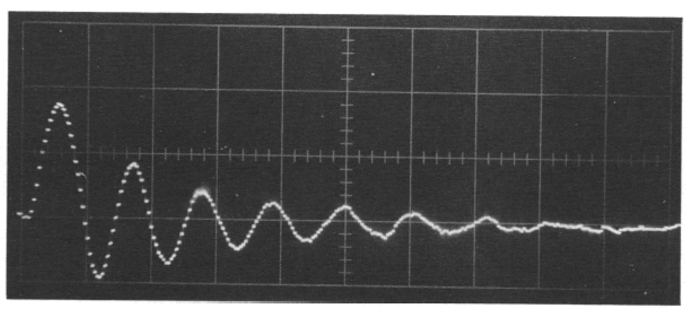

Fig. 2. Elevation response (high-speed), 26-m antenna