DSN Research and Technology Support

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The activities of the Development Support Group, including the Microwave Test Facility, during the two-month period ending April 15, 1972 are summarized. Activities include operational clock synchronization, precision antenna gain measurement, weak source observation, pulsar observation, tricone support structure testing, and planetary radar preparation and execution. Activities at the Microwave Test Facility include special klystron testing and tuning for the Manned Spaceflight Tracking and Data Network, special part fabrication for the tricone support structure, and design and fabrication of the flow panel and crowbar subassemblies for the clock synchronization transmitting system. Significant maintenance items include replacement of the azimuth drive gear reducer on the 26-m-diameter antenna and modification of the power distribution system associated with the 100-kW clock synchronization transmitter.

During the two months ending April 15, 1972, the Development Support Group was engaged in the following activities.

I. DSS 13 Activities

A. In Support of Section 331

1. Pulsars. The Venus Deep Space Station (DSS 13) continues to devote approximately twenty-four hours per week (a total of 182 hours during this period) to the observation of pulsars. Information obtained includes pulse-to-pulse spacing, pulse time of arrival, and pulse shape. Pulsars regularly observed (about 22 of the 50 known pulsars) were tabulated in Ref. 1.

2. Planetary radar. In preparation for the Mercury–Venus planetary radar observations, the 400-kW development transmitter (2388 MHz), which had been removed from DSS 14 in late 1971, was completely tested at the Venus station and reinstalled at DSS 14. The development receiver at DSS 14 was modified by adding a new wide band "front end" converter, which operates from 2290 to 2390 MHz, with intermediate frequencies of 30 and 2.5 MHz (double conversion). Phase-lock capability is not provided and first local oscillator frequency control is accomplished with a programmed oscillator.

Manual gain control is provided in the 30-MHz portion of the receiver with a local control at the DSS 14 64-m-diameter antenna pedestal control room, while a remote control is provided at DSS 13 via telephone lines. The 2.5-MHz intermediate frequency output is typically connected to the Venus station via the microwave link for signal processing.

To facilitate generation and control of ranging modulation for the transmitter in these observations, the Station Control and Monitor (SCAM) at the Venus station was modified and reprogrammed to provide real-time evaluation of the range polynomial. Previously the range polynomial had been evaluated "off line" with a large computer, and the range as a function of time had been punched onto paper tape at 60-second intervals. The generation and handling of this tape was not only burdensome, but the tape reader represented a significant portion of the computer failures. Real-time polynomial evaluation not only saves time and effort, but also provides a measurable increase in reliability.

These changes were tested on April 7, 1972 when the planet Mercury was successfully ranged on the first attempt using a pseudonoise (PN) code having a digit period of 10 microseconds, resulting in a range resolution of 750 m, two-way, without interpolation.

3. Hydrogen maser installation. In preparation for planned interferometer experiments in cooperation with DSS 14, a hydrogen maser, installed in a special trailer, has been placed just south of the Operations Building (G-51) and provisions made for hooking into the station's Central Frequency Synthesizer. (The trailer blocks the operator's view of the 9-m antenna so a closed-circuit television system was installed to allow the operator to see the 9-m antenna and the surrounding area to ensure safety during operation of the 100-kW X-band transmitter.)

B. In Support of Section 332

1. Tricone support structure (TCSS). The TCSS destined for DSS 61A has been completely tested, including testing at 400-kW radio frequency of all components which are designed to handle that power level. The feed cone used for testing has been dismounted, packed, and shipped to DSS 61A. The remainder of the TCSS will be dismantled and shipped, in conjunction with the subreflector for the 64-m antenna, in late June of 1972.

2. 26-m antenna azimuth drive maintenance. The 26-m antenna is normally driven in azimuth by four hydraulic motors individually driving the azimuth drive gear through gear reducers having a reduction ratio of 239.96. The hydraulic pressure on these motors, arranged in pairs, is controlled so that two drives "lead" and two "lag," thus providing reduced backlash operation and reversal. In August 1970 one of the gear reducers failed and was removed, and operation continued on an unbalanced arrangement of two and one. In September 1971 the system was balanced by the removal of a second gearbox, and operational limitations were imposed which required cessation of tracking at wind velocities of 72 km/h (45 mi/h) and "stowing" the antenna in the zenith look position. With all four gearboxes connected, tracking had been permitted at wind speeds up to 80 km/h (50 mi/h).

In March 1972 one of the two remaining gearboxes developed failure symptoms and was replaced to avoid possible catastrophic failure. Removal and replacement of this gearbox was accomplished in 3½ days of sustained effort by personnel of the Development Support Group. The removed gearboxes have been returned to the manufacturer for repair as necessary.

C. In Support of Section 333

1. Precision antenna gain measurements. Continuing this important development project, extensive data taking continues with Cygnus A and the *Apollo* Lunar Surface Experiments Package (ALSEP) as sources. While phase-lock-tracking the ALSEP transmitter, received signal strength ratios are established between the 26-m antenna and the gain standard horn. After correction for differential path losses in the interconnecting waveguide, waveguide switches, and coaxial cables, a measurement of the absolute gain of the 26-m antenna is obtained in comparison to the gain of the gain standard horn whose gain has been carefully measured by the National Bureau of Standards (NBS). The observed system temperature of the radio source Cygnus A is then measured. After correction to an equivalent 100% efficient antenna temperature, Cygnus A can then be used by other DSIF stations to measure their antenna gain at the same frequency. During this period 98 hours were devoted to tracking Cygnus A and 124 hours to tracking ALSEP.

2. Weak source observation. Using almost completely automated data-taking procedures, measurements continue to be made of a number of radio sources and radio emissions from planets. The sources observed during this period are tabulated in Table 1, with 251 hours being devoted to tracking and 298 hours to equipment stability and "sky survey" measurements.

3. Faraday rotation. A long-term program (see Ref. 2) for collection of Faraday rotation data from geostationary satellite ATS-1 continues. Although other techniques for obtaining ionospheric correction information have been proposed and tested, Faraday rotation data represent a developed technique whose accuracy has been ascertained and confidence established. These data can be used to provide corrections to observed doppler and range measurements made on spacecraft. Data collection at DSS 13 is automated and continues 24 hours per day, 7 days per week.

D. In Support of Section 335

1. Automated subsystem and system operational technique development. In a continuing development of automated subsystem and system operational techniques, a PDP-11 digital computer has been interfaced with the control circuitry of the 400-kW development transmitter in such a way that full start-up, operation, and status monitoring can be accomplished by the computer at the command of the operator. Extensive support has been given this effort under the direction of personnel from Section 335 at Pasadena. The effort during the past two months was focused on initial hook-up, development of suitable programming, and initial testing. At the present time the computer has approximately 100 combined input and output connections and monitors the values of all meters and makes comparisons with stored limits to ensure that ratings are not exceeded. Error messages are typed out as necessary when a command input by the operator brings any parameter to a stored limit. Development in this area will continue with the number of outputs and inputs to be expanded to include monitoring of the status of the various interlocks as well as provision of greater control capability.

E. In Support of Section 337

1. Clock synchronization transmissions. Under the scheduled control of DSN scheduling, and as constrained by the availability of a mutual Moon view period, regular clock synchronization transmissions are made to each of the overseas DSN stations with calibration transmissions being made to DSS 14 and the United States Naval Observatory (USNO). The number of transmissions for the two-month period ending April 9 is tabulated in Table 2. (Each transmission is 30 minutes in duration.)

II. Microwave Test Facility Activities

A. In Support of Section 332

1. Tricone support structure (TCSS). Fabrication of various brackets, waveguide spacers, and special machine shop support continues at a steady pace. However, this effort is now finished with the completion of the final testing of the DSS 61A system.

2. Perimeter surveillance. A low key program, pursued on a noninterference basis, to provide perimeter surveillance at the Goldstone Space Communication Complex has been underway for some time. Basically, the concept calls for detecting the passage of a vehicle along approximately 24 of the desert roads leading into the Complex. The passage of a vehicle would initiate telemetering, via an inexpensive battery-powered transmitter, of the code assigned to that location which would then display at both the central security post and the mobile "roving patrol." By reference to an assignment sheet, the displayed two-digit number will be converted to a location, and the roving patrol will then investigate.

Suitable transmitters are available as "off the shelf" items, and control of power drain, design of rugged, inconspicuous vehicle detectors, and suitable telemetry encoding has drawn the most attention to date. Design of the detection/transmission/encoding unit is well along, and work on the receiver/decoder/display will start soon.

B. In Support of Section 333

1. Antenna panel noise burst generation. To reduce noise burst generation to a minimum, the joints between antenna surface panels are taped with metallic tape. To ensure that optimum results are obtained from this taping, a section of antenna with several surface panels has been set up at an approximate angle of 45 deg with the ground. These surface panels are irradiated from a standard Cassegrain feedcone which has been installed a few feet away in a horizontal position in a shipping cradle. The cone is fed by a 20-kW transmitter at 2110 MHz and receives with a maser at 2295 MHz via the usual diplexed arrangement. Total noise power output is recorded while various techniques of taping are tried and irradiated. Results of these tests will be used to choose a taping technique for the joints on the 64-m antennas.

C. In Support of Section 335

1. Clock synchronization transmitter. Design and construction of a water flow monitor panel and low (1 kV) voltage crowbar continues.

2. Transmitter development. The continuing testing of the 400- and 20-kW transmitters at DSS 13 requires fabrication of various support bracketry, special chassis, connectors, etc. Additionally, the machine shop has supported the interfacing of the PDP-11 computer with the development 400-kW transmitter.

D. In Support of Section 337

1. Acceptance klystron testing. In preparation for the *Apollo 16* flight, a 20-kW transmitter klystron was carefully tested and tuned to specific frequencies. All operational parameters were documented and the data and test results were included with the tube when it was turned over to Section 337.

References

1. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VIII, pp. 68–73. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1972.
2. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VII, pp. 124–125. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1972.

Table 1. Sources and source positions used in weak source observation program

Source	Position at time of observation	
	Right ascension, deg	Declination, deg
3C33	16.850	13.179
3C218	139.178	−11.981
3C270	184.502	5.975
3C348	252.452	5.000
3C353	259.772	−0.957
Cygnus X1	299.326	35.266
Beta Persei	46.500	40.850
Beta Lyrae	282.267	33.324
Jupiter	278.658	−22.895
Venus	63.419	24.706

Table 2. Clock synchronization activity from DSS 13

Station	Number of transmissions
DSS 14	44
DSS 41	33
DSS 42	32
DSS 51	29
DSS 62	26
USNO	30