Mariner 10 Mission Support

E. K. Davis
DSN Systems Engineering Office

This report covers the period from October 15, 1974 through February 15, 1975. The primary objectives during this portion of the extended mission were to assure survival of the spacecraft for a third Mercury encounter through conservation of attitude control gas and to conduct trajectory correction maneuvers (TCMs) as necessary to target the spacecraft for a solar occultation zone pass. Special support activities included TCMs 6 and 7 conducted on October 30, 1974 and on February 12–13, 1975, respectively. This period also saw the DSN interface organization involved in (1) the allocation of sufficient coverage to assure accurate orbit determination solutions, (2) monitoring of DSN implementation for Viking to assure maintenance of compatible interfaces and capabilities required for Mariner 10, and (3) the development of encounter coverage, sequences, and readiness test plans.

I. Planning and Operations

During October 1974, the DSN participated with the Project in planning and preparing for TCM 6. A major effort went into obtaining sufficient tracking coverage for Mariner 10 in the face of higher priority tasks: Pioneers 10 and 11, Helios A pre-launch tests, Viking implementation, and Deep Space Station (DSS) upgrades. This period saw DSS 44 down for conversion from the Spaceflight Tracking and Data Network (STDN) to DSN configuration; DSS 14 down for Viking implementation; and DSS 63 down for gear box repairs. Limited but adequate coverage was provided for Mariner 10. TCM 6 was accurately performed on October 30, 1974, and there were no DSN support problems.

Due to spacecraft attitude control problems and high usage of attitude control gas in October, Project placed the spacecraft in a roll-drift mode with the high-gain antenna and solar panels positioned to produce torques in the pitch, yaw, and roll axes that would minimize gas consumption. This required communications to be conducted over the spacecraft low-gain antenna and lowering of the data rate to 8-1/3 bps. Furthermore, the spacecraft roll mode seriously impacted the navigation accuracy achievable with the previously negotiated DSN tracking time. Project requested additional radio metric data, particularly three-way doppler data to understand roll signatures in the doppler data and additional ranging points. Special efforts were required to resolve the tracking coverage conflicts among the various users.

Planning for TCM 7 continued through November and early December 1974. In order to allow for a single maneuver strategy and to avoid coverage conflicts during the Helios A launch and Pioneer 11 encounter periods, TCM 7 was rescheduled from early January 1975 to February 12, 1975. This permitted allocation of adequate coverage for Mariner 10 pre- and post-maneuver orbit determination activities. During this time the spacecraft continued its flight in the solar torque, roll-control mode. Following resolution of the December 1974–February 1975 tracking allocations, full attention was given to development of a compromise plan for the March 1975 period.

On December 16, 1974, the DSN met with the Mariner 10 Project to develop an understanding of essential encounter requirements, as well as the requirements of other flight projects during the March 1975 period. This meeting resulted in a significant reduction of Mariner 10's initial requirement for 8 days of continuous 64-meter subnet coverage at encounter. This reduction was a key factor in permitting the DSN to draft a recommended solution to the problem. In summary, the problem was as follows:

(1) Helios and Mariner view periods are almost entirely overlapping during March 1975.

(2) Helios A perihelion, an event of prime interest, would occur March 15, 1975, requiring 64-meter subnet coverage during the period March 5–25, 1975.

(3) Mariner 10's Mercury encounter would occur on March 16, 1975, requiring 64-meter subnet coverage during the period March 12–20, 1975.

(4) Pioneer 11 and 10 solar conjunction would occur on March 24, 1975 and April 4, 1975, respectively, requiring 64-meter subnet coverage during the period March 19–April 4, 1975.

The problem was significantly reduced by the following:

(1) Helios A would not use DSS 63 since coverage in this longitude is provided by the German tracking station.

(2) Mariner 10 agreed to schedule pre-encounter critical events to occur over DSS 63. These included: (a) central computer and sequencer load for encounter (March 11, 1975), (b) Canopus reacquisition (March 13, 1975), and (c) far encounter TV calibrations and tests (March 14–15, 1975), thus leaving DSSs 14 and 43 free to support other projects.

(3) Mariner 10 reduced the encounter 64-meter subnet coverage requirements to the minimum essential to recover near-encounter imaging and non-imaging data, three consecutive passes on March 16–17 (GMT).

Meetings and negotiations continued between the flight projects throughout January 1975 to reach agreements on detailed tracking schedules based on the proposed compromises.

By early February 1975, plans for TCM 7 were completed, and the required DSS coverage was allocated. Since the spacecraft continued in the roll-drift mode, timing of the roll by monitoring Canopus and other star crossings was critical to proper execution of the maneuver. Coverage from 64-meter stations was required to acquire these data at 33-1/3 bps since link conditions were inadequate for communications via the 26-meter stations. However, shortly before start of the maneuver sequence on February 12, 1975, a change in time of the Canopus crossing was noted and the TCM was postponed until February 13.

Excellent support was provided by DSS 63. Recovery of data was continuous throughout the TCM even though a dropout had been expected due to the planned adverse pitch angle. DSS 63 accomplished two post-TCM replays of telemetry data acquired during the burn to fill gaps caused by difficulties at the data processing facility. As evidenced by greater than planned changes in the doppler data, TCM 7 was other than planned. Early indications indicated a 20 percent error as a result of either engine overburn, roll error, pitch error, or a combination of all of these error sources. Effect on the required Mercury aim point is uncertain at this time. It will be necessary for the Project to negotiate for additional DSS tracking passes to obtain sufficient doppler and ranging data to rapidly redefine the orbit.

Planning for support at Mercury's third encounter is in the final stages. Requirements have been defined, and the DSN has developed a minimum, but adequate, test plan to revalidate DSS 64-meter subnet data systems and verify readiness to support special data rates and sequences at encounter. In many respects, third encounter will be similar to the first encounter. The primary objective is to obtain non-imaging science data at 2450 bps, particularly from the solar occultation zone. A secondary objective is to recover imaging data during near encounter, except when passing the dark portion of the planet in the solar occultation zone. Unlike the first encounter, the spacecraft will not pass through the Earth occultation zone during

this third pass. This targeting provides an opportunity to acquire data for support of celestial mechanics experiments which was not available on the previous encounters: first encounter had a tracking gap due to Earth occultation giving a break in continuous two-way doppler near the planet; the second encounter was targeted to optimize television on a bright-side pass, but was too far from the planet to provide precise results.

A number of engineering tests with the spacecraft have been planned for the immediate post-encounter period including propulsion subsystem burn to depletion. The spacecraft will be programmed to command its transmitter off on April 1, 1975. DSS coverage will be scheduled to confirm this event, which will mark the end of a very dynamic and productive mission.

II. Program Control

The DSN continued to provide monthly inputs to the Project Management Report throughout this period. The interface organization kept the Project informed of changes in the network status due to Viking implementation activities and negotiated changes to capabilities that occurred during this period. The DSN will conduct an encounter readiness review in early March 1975 following completion of planned tests.

III. Implementation Activities

Very little implementation was planned or required for Mariner 10 during this period. Primary attention was given to maintaining required capabilities and interface compatibility in the face of extensive network implementation for the Viking mission.

As planned, the Project was committed to transfer operations to the redesigned command system by mid-January 1975. After resolution of initial minor difficulties on January 16, 1975, the change-over took place smoothly and commanding has continued in this mode.

The low-noise ultra cone has been maintained at DSS 43 for third encounter support. This required negotiation of the DSS 43 RF cone reconfiguration work scheduled in preparation for Viking 75. However, maintaining the low-noise S-Band Megawatt Transmit (SMT) cone in place at DSS 14 could not be accommodated through a delay of cone reconfiguration work. During January 1975, the SMT cone was replaced with the S-Band Polarization Diversity (SPD) cone. The DSN will, however, install the SMT maser in the SPD cone to improve system performance.

With Project agreement, it was necessary to terminate the Block III planetary ranging capability at DSS 14 in order to meet the Viking schedule for completing the Block IV configuration. Connection of the ranging assembly to the Block IV receiver–exciter is in process. If this configuration is not verified and operational by early March 1975, the Block III configuration will be restored for Mariner 10 encounter support.

The 230-kbps super group communications service between DSS 14 and JPL is in the process of reactivation. The circuit had been deactivated during cruise to avoid lease costs.