

Pioneer 10 and 11 Mission Support

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The Deep Space Network has completed more than a full year of continuous telemetry data acquisition, command, and radio metric tracking support for Pioneer 10. Pioneer 11 was successfully launched on April 5, 1973. Detailed encounter support planning activity was initiated. Organizational changes in the JPL support to the Pioneer Project which have taken place since the last article was published are described.

I. Changes in the JPL Support Organization for the Pioneer Missions

There have been two major changes in the JPL organizations engaged in Pioneer support. The first involves the readjustment of the Ground Data System responsibilities in accordance with new Headquarters guidelines from the Office of Space Sciences and the Office of Tracking and Data Acquisition. The second involves the reorganization of the elements under tracking and data acquisition at the Laboratory. Reference 1 describes the JPL organization prior to these two changes.

The principal effect of the new OSS/OTDA guidelines was the separation of the computer processing necessary for the mission operations and mission analysis from the computer processing necessary for the operation of the DSN. As a consequence, the DSN is implementing a Network Control System (NCS) which will enable the DSN to phase out of the Mission Control and Computing Center (MCCC) computers by July of 1974. Prior to this separation, an off-lab project such as Pioneer was able to look to the DSN as the single interface point for JPL support. The Pioneer Project's concern for having to deal

with two interfaces, the DSN and MCCC, lead to the establishment of a Pioneer support coordination function under the auspices of the Assistant Laboratory Director for Flight Projects. The resulting JPL organizations involved in Pioneer support are shown in Fig. 1. Responsibilities of the respective organizations are briefly as follows:

- (1) Tracking and Data Acquisition (TDA): responsible for TDA planning, DSN Systems and Subsystem engineering, and operation of the DSN.
- (2) Office of Computing and Information Systems (OCIS): responsible for the Mission Control and Computing Center, associated supporting research, engineering, and operations.
- (3) Flight Projects: responsible for the Ground Data System coordination and interface with the projects. This involves assuring that the interface between TDA and OCIS will result in a Ground Data System that meets project requirements.
- (4) Telecommunications Division: responsible for DSN research and subsystem implementation.

- (5) Mission Analysis Division: responsible for the navigation support of the Pioneer project.

Figures 2 and 3 show the management structure in the Flight Projects Office and the Office of Computing and Information Systems, respectively. In mid 1972 TDA underwent a major reorganization. The most significant change was the move of DSN operations from the Telecommunications Division to TDA. The new organization is shown in Fig. 4.

II. Pioneer 10 Cruise Significant Events

Two major cruise events have occurred since the last DSN Progress Report article on Pioneer: The successful exit of the spacecraft from the asteroid belt and the solar occultation.

One of the primary objectives of the Pioneer 10 and 11 mission is to investigate the nature of the asteroid belt and, in particular, to ascertain what risk to future mission success spacecraft passage through the asteroid belt poses. Pioneer 10 entered the asteroid belt in the middle of July of 1972 and safely exited from the region of the asteroid belt in January of 1973. The spacecraft sustained no measurable damage during this time period.

The Pioneer 10 and 11 spacecraft carried two meteoroid related instruments. The first is an asteroid meteoroid detector constructed by General Electric. This instrument is designed to detect particles greater than 10^{-6} g in mass. Its detection method is by reflected solar light. The instrument consists of four independent telescopic subsystems providing four overlapping fields of view; the light signatures are detected by photomultiplier tubes. The telescope arrangement allows the determination of trajectories of detected particles. The second instrument is a meteoroid detector from Langley Research Center. This experiment detection method consists of pressurized cells mounted on the back side of the spacecraft high-gain antenna. When particles penetrate the cells, the rate at which pressure is lost from the cell indicates the size of the hole made, and thus the mass and energy of the particle responsible for the impact.

Significantly, there was no noticeable change in the number of events determined by the two meteoroid instruments upon entering or exiting the asteroid belt. Instead a nearly continuous decrease in the event rate has been observed since the spacecraft was launched on March 4, 1972.

The solar occultation period extended from essentially January 11 through January 21 of 1973. The two major spacecraft concerns during this time period were: (1) trying to avoid the automatic switching of elements in the spacecraft radio subsystem that would take place if there was no uplink for longer than 36 hours, and (2) the loss of roll reference that would occur if the spacecraft spin axis were oriented too close to the sun.

The technique that was used to avoid these problems was to step the spacecraft around the sun prior to solar occultation and leave the spacecraft in an orientation ahead of the sun so that the Earth-spacecraft angle would slowly converge on realigning the spacecraft high-gain antenna. This reorientation was accomplished on the 11th of January. The result was that the spacecraft high-gain antenna was not directed at Earth and, therefore, the effective gain of the spacecraft antenna was decreased. However, the result was actually an increase in the effective uplink margin during the solar occultation because the off-pointing decreased the noise input from the solar corona into the spacecraft antenna. The off-pointing with respect to the sun enabled the sun sensor roll pulse to be operative during the solar occultation. Use of DSS 14 400-kW transmitter during the solar occultation enabled the daily establishment of an uplink to prevent the automatic switching within the spacecraft receiver subsystem. To aid in the determination that an uplink had been established during the height of the solar blackout, an experimental open-loop receiver was used to detect the change from the non-coherent to the coherent frequency on the downlink. Telemetry blackout extended from January 13 to January 17 at DSS 14. Although there were extensive problems with the DSS 14 R&D high-power transmitter, excellent support by station and DSN operations personnel enabled the uplink requirement to be met each day of the blackout.

A report on the tracking and telemetry system performance during the solar occultation will appear in a later DSN Progress Report written by Network Operations Analysis personnel.

III. Pioneer 10 Encounter Planning

An encounter planning working group was held at Ames Research Center on Feb. 20, 1973. The implementation plan of the DSN in support of Pioneer 10 encounter was described and the resource allocation conflict was identified between Pioneer 10 encounter and Mariner Venus Mercury '73 launch requirements.

In a splinter meeting an encounter test and training schedule was developed in sufficient detail to enable the DSN to negotiate the detailed requirements with Mariner Venus Mercury.

Subsequent to the working group meeting, an additional requirement on DSN resources was identified for the Viking Project: 64-m-antenna Goldstone tracks were required for Mars radar observations with the goal of determining the surface characteristics of selected landing sites. In March of this year two meetings were held at JPL, between the representatives of the Viking, Pioneer, and Mariner Venus Mercury '73 Projects, and radio science users, and the DSN managers for these activities. At these meetings agreements were reached and guidelines established that should be sufficient to solve all resource allocation conflicts through the end of calendar 1973.

The following implementations are identified as required for Pioneer 10 encounter support:

- (1) The completion of DSS 63 and its transfer to operations.
- (2) The completion at DSSs 14 and 43 of wideband modifications to the open-loop receivers. These

modifications are necessary in order to handle the doppler offsets that would be experienced during Jupiter encounter.

- (3) The implementation at DSSs 14 and 43 of manually programmable precision oscillators. These units will be used to control both the exciter and the receiver in order to maintain receiver lock both at the spacecraft and on the ground during the high doppler rates of the Jupiter encounter.
- (4) Installation at DSS 14 of a breadboard manually programmable precision oscillator. This implementation is necessary because of the late delivery of the operational units at DSSs 14 and 43. A breadboard unit will be used for testing and training starting in June of this year.
- (5) Modification of the command system at the DSS to allow commanding while doing linear tuning using the manually programmable precision oscillators.

Details of the encounter test and training plan, the implementations in the DSN necessary for encounter support, and the actual encounter sequence will be described in later issues.

Reference

1. Siegmeth, A. J., "Pioneer Mission Support," *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VIII, pp. 8-19, Jet Propulsion Laboratory, Pasadena, Calif., April 15, 1972.

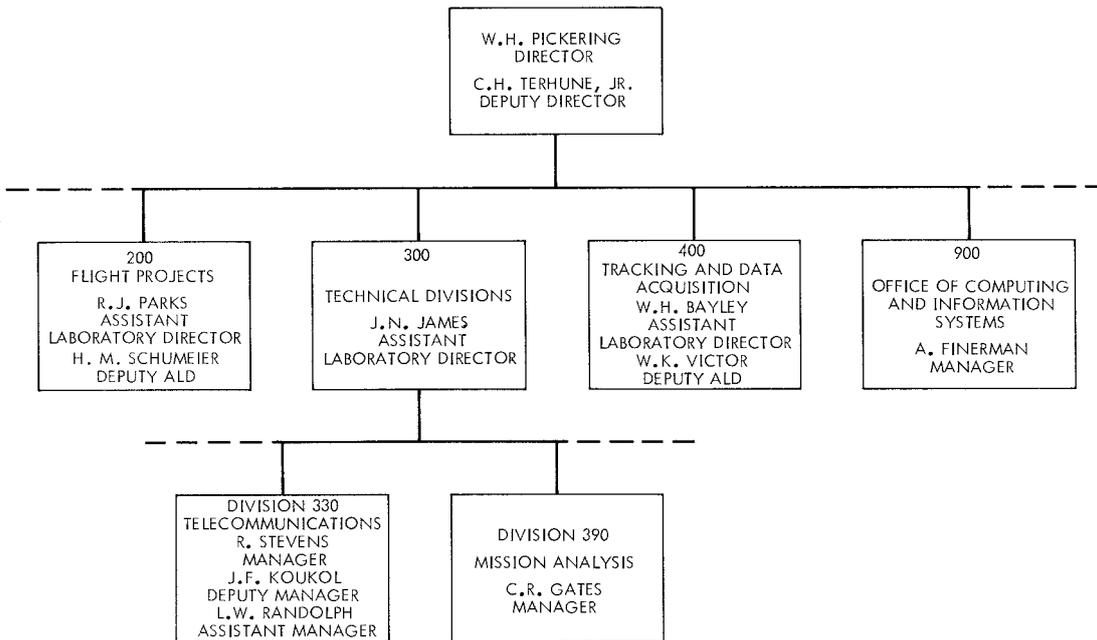


Fig. 1. Organizations supporting Pioneers 10 and 11

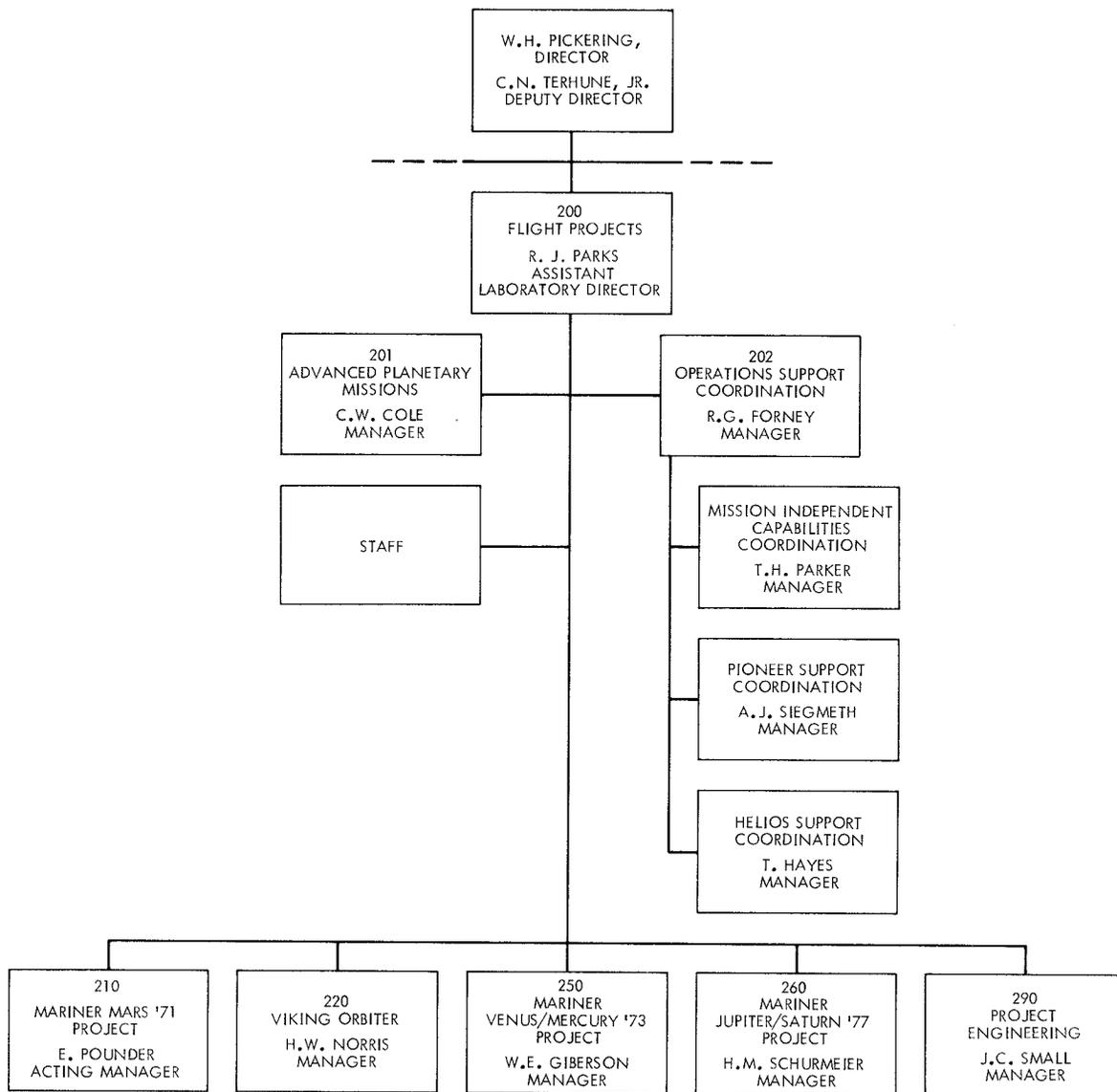


Fig. 2. Flight Projects organization

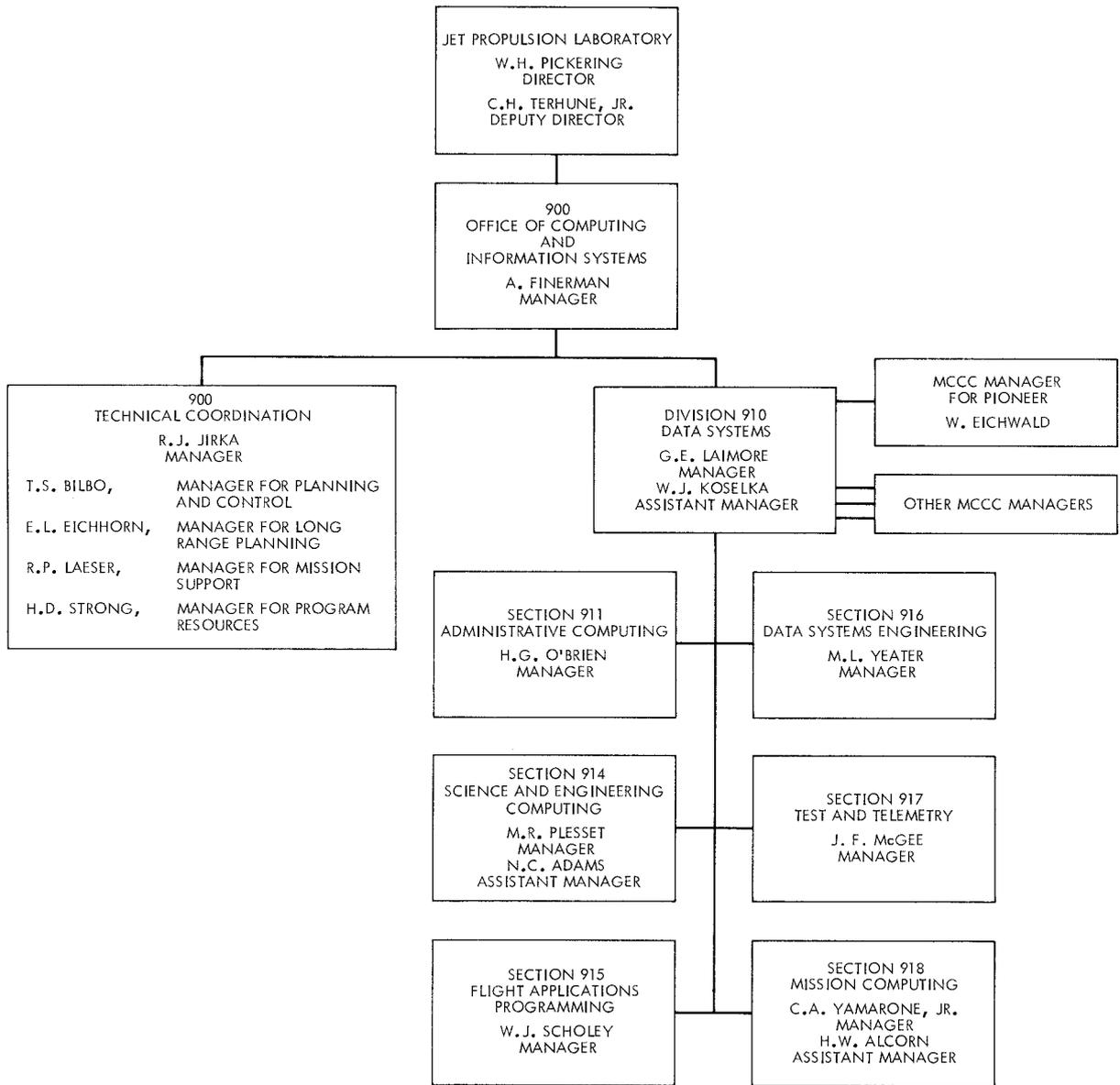


Fig. 3. OCIS organization

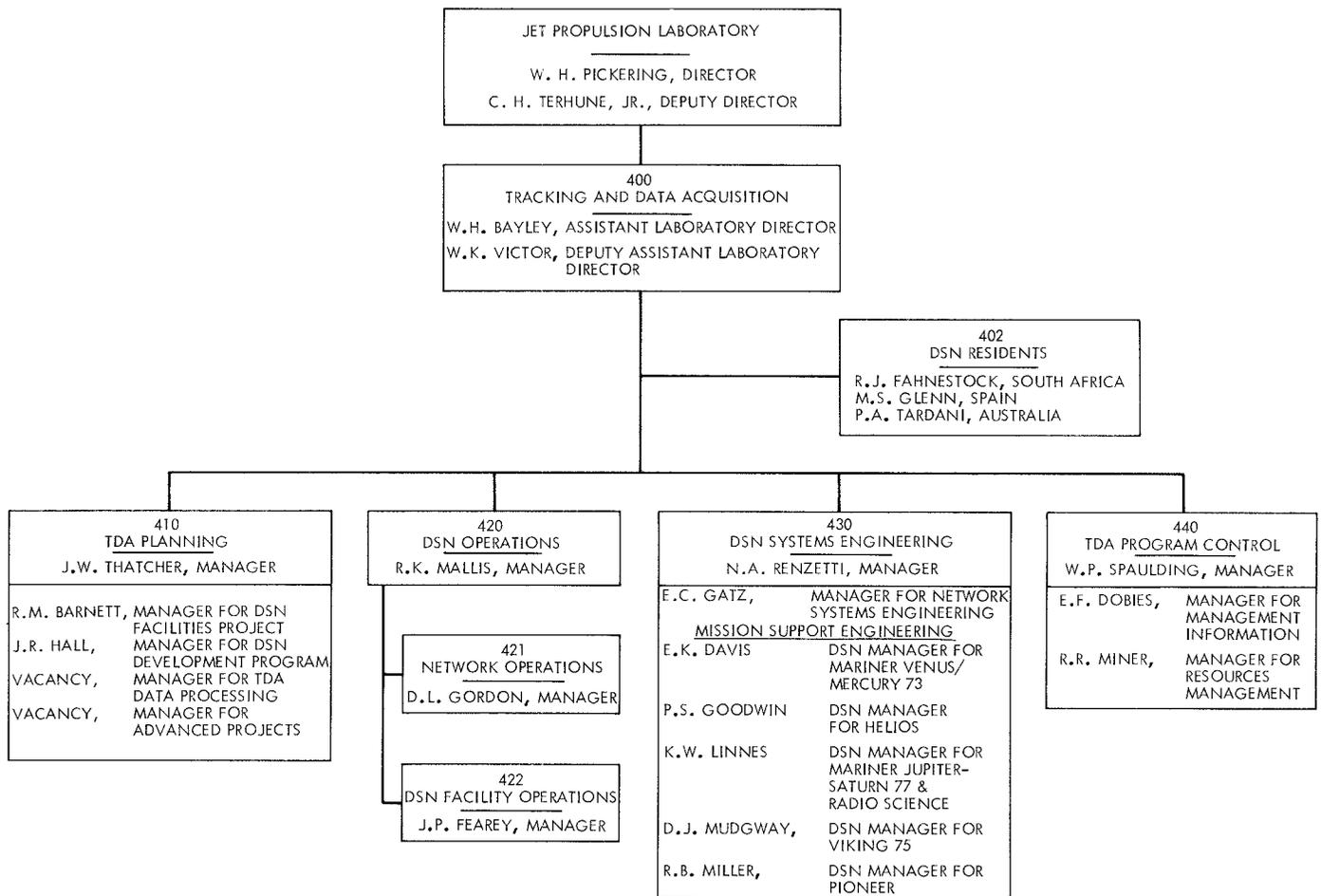


Fig. 4. TDA organization