Viking Mission Support

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Since the redirection of the Viking Project in January 1970, the DSN interface organization has been heavily involved with project organizational elements in advanced planning, exchanges of technical information, identification of requirements, capabilities, problems, and their resolution. This article is a general summary of the accomplishments in these areas of long-range planning including pertinent open questions to be resolved in the detailed planning phase.

I. Introduction

In Ref. 1, the author states that subsequent articles would describe significant *Viking*-related achievements in certain specific areas as the DSN interface organization progresses through the planning, implementation, testing, and operational stages of the mission. This shift in reporting emphasis is in keeping with the current activities of the DSN interface organization. The long-range, functional planning phase nears completion, while detailed planning will constitute the major activity during the next year.

This article summarizes the achievements during the long-range planning phase which have established a readiness for accomplishing detailed plans. As a general progress report, it will serve as a baseline for future detailed reports. Items discussed are primarily those which are prerequisite to the detailed definition of interfaces and plans, such as: (1) Project Tracking and Data System management agreements regarding organizational interfaces and procedures for planning, coordination, control, and documentation; (2) approved Project-/System-level schedules; (3) validated tracking and data acquisition requirements which are based on an approved mission design; (4) Tracking and Data System Functional Specifications for *Viking* 1975; (5) DSN System Requirements and Plans which consider *Viking* 1975 requirements; (6) exchange of preliminary technical design and interface information to avoid subsequent incompatibilities at the interfaces between the Project and Deep Space Network; (7) general correlation of Deep Space Network planned capabilities and Project requirements identifying areas requiring detailed attention; (8) Deep Space Network commitments; and (9) budget guidelines and approved financial plans which provide resources required to support *Viking*-related activities.

The information herein generally covers the period subsequent to the redirection of the *Viking* Project from the

1973 to the 1975 opportunity—January 1970 to August 30, 1971.

II. Management Agreements

Following is a brief summary of Project, Tracking and Data System, and Deep Space Network management agreements which are pertinent to on-going activities.

A. Organizational Interfaces for Planning

To facilitate planning and coordination, the Project has organized a number of Working Groups, Sub-Working Groups, and Teams. Personnel of the DSN interface organization are assigned as members of the appropriate groups and teams. Those of primary importance are: Telecommunications Working Group, Mission Analysis and Design Team, Integrated Test Working Group, Flight Operations Working Group, and its Test/Training and Software Sub-Working Groups. As the titles imply, these groups represent the major areas wherein interfaces exist between the DSN and Project.

Likewise, the DSN has planning teams in which Project personnel participate. Prior to the redirection of the *Viking* Project, the DSN Capabilities Planning Team for *Viking* was well into its task of developing baseline configurations for each of the DSN systems for *Viking* support. After the redirection, the DSN Capability Planning Team was terminated until the effect on requirements was evaluated. The telemetry, command, and tracking systems diagrams which were completed will serve as a starting point when Capability Planning Team activities resume in September 1971. DSN-detailed planning will be accomplished by the DSN Interface Team.

B. Project Control

The Project has implemented a number of techniques to exercise control over schedules and configurations. The DSN has agreed to participate in the employment of these techniques to the extent outlined below.

1. Schedules. Various levels of schedules are the essential elements in the control function. The *Viking*-Tracking and Data System Schedule, level 3, supports the Project Master Schedule and includes a relatively small number of DSN major milestones. This schedule, along with a narrative analysis, is submitted monthly for inclusion in the Project Management Report.

DSN Milestone Schedule, level 5, has been published and is the controlling schedule for DSN activities. Detailed activities in this schedule have been set to meet TDS Schedule commitments. On a trial basis in October 1970, the DSN agreed to participate in the *Viking* Integrated Program Evaluation and Review Technique (PERT). The level 5 schedule served as the basis for inputs to PERT. This has been a useful tool for accomplishing detailed schedule coordination between the DSN and elements of the Project. Therefore, DSN participation shall continue.

2. Configuration management. The *Viking* Project Configuration Management Plan sets forth detailed requirements and procedures to be used by Project systems. However, the multiple-mission nature of the DSN precludes internal application of Project control procedures. Commitments to the *Viking* Project are generally based upon or take the form of interface agreements. Therefore, the DSN position regarding Project configuration management is that Project procedures shall be applicable to but not beyond the established interfaces. DSN procedures will be employed to guarantee the continued compatibility of the interfaces until the end of the *Viking* mission. DSN changes which alter the interfaces will be subjected to Project approval through the *Viking* Integrated Change procedure. The Project has concurred with this approach as documented in Appendix B to the *Viking* Project Configuration Management Plan.

C. Documentation

The *Viking* Project Data Management Plan sets forth policies and procedures for standardizing and controlling documentation in the Project systems. The plan establishes that the existing documentation system may be employed. However, the TDS and DSN have agreed to alter certain standard documentation practices where desirable to meet joint Project/DSN documentation objectives.

1. TDS Data Management Plan. The Project Data Management Plan required each system to produce a corresponding implementing plan. Although the existing TDS and DSN Standard Practices met many of the Project Plan requests, it was necessary to produce a TDS Data Management Plan for *Viking* to cover Project-peculiar requests and to obtain approval for exceptions to the Project Plan. The TDS Data Management Plan for *Viking* 1975 Project (614-4) was approved by the Project in April 1971 and published in May 1971.

2. Interface documents. Interfaces between the DSN and Project are normally documented in DSN Operations Plan, Volume II, requiring DSN and Project approval. Also, plans indicated that Project documents would be

produced which accomplished essentially the same purpose. In November 1970, agreements which eliminated this duplication were reached between the Flight Operations, Orbiter, Lander Systems and the Tracking and Data System. An Orbiter System, Lander System, and Launch and Flight Operations System to Tracking and Data System Interface Requirements Document will be produced. This is considered a Project-level document and will consist of four volumes: (1) General Requirements, (2) Orbiter System to DSN, (3) Lander System to DSN, and (4) Launch and Flight Operations to DSN. Consequently, DSN Operations Plan for *Viking* 1975, Volume II, will not be produced.

3. Compatibility Test Plans. Negotiations between the DSN and Project have established that the scope and objectives of DSN/Spacecraft RF compatibility tests will be included in the *Viking* 1975 Project Master Integrated Test Plan, Summary Volume. The Project published this document, with TDS Manager concurrence, in September 1970. It has further been agreed that the *Viking* TDS Compatibility Test Plan will be a Project document published as a sub-tier volume of the Master Integrated Test Plan and replacing DSN Test Plan for *Viking*, Volume I, Part A, DSN/Spacecraft Telecommunications Compatibility Test Plan. Test procedures required to execute this plan will be developed and published by the DSN as a part of the DSN Test Plan for *Viking*, Volume II, DSN Test Procedures. The *Viking* TDS Compatibility Test Plan has been published in Coordination Copy form and is now under review.

4. TDS Functional Specifications. The Project documentation plan and tree established the requirement for system specifications in response to the Project specification. Initially the TDS was excluded since this requirement was foreign to standard documentation practices. It was later determined that a TDS Functional Specification for *Viking* would be produced. This specification defines the DSN functional performance requirements and provides a basis for developing the formal commitments to the *Viking* 1975 Project. As such, this document supersedes JPL document 611-1, Rev. A, Change 1, "TDS Estimated Capabilities for *Viking* 75 Project," dated December 1, 1970. The TDS Functional Specification, 614-3, was released on August 19, 1971 in review copy form for comments prior to publication of the final copy.

III. Tracking and Data Acquisition Requirements

Work done prior to the redirection of the *Viking* Project and the subsequent redirection provided the basis for Project publication of the SIRD much earlier than normally experienced on prior projects. Coordination copies of the SIRD were distributed in April 1971, and a review copy in June 1971. The approval copy is scheduled for distribution in September 1971. The receipt of tracking and data acquisition requirements at these dates fits well with the DSN capability planning, design, and budget cycles. The DSN interface organization worked closely with the Project in developing the SIRD and the proper statement of requirements. This interaction in conjunction with the exchange of technical information (*Section V*) has given a first-level evaluation of requirements and capabilities.

IV. DSN System Requirements and Plans

Knowledge of *Viking* requirements permitted the DSN System Engineering Group to give detailed consideration to *Viking* needs in CY 71 updates of the DSN System Requirements Documents covering the 1972–1975 time period. Consequently, support for *Viking* has received early attention in on-going System Design Reviews. This has resulted in early determination of additional DSN resources required to provide *Viking* support. In turn, these have been factored into the current budget guidelines and FY 72–74 Financial Plan.

At the present time, the DSN interface organization is giving priority attention to the development of a preliminary version of the NASA Support Plan (NSP), in response to the SIRD. Open areas and requirements which cannot be met are being identified and will be subjected to resolution in the detailed planning phase.

V. Technical Exchanges

Working groups discussed in *Section II-A* provide the forum for technical exchanges between the DSN, orbiter, lander, and flight operations organizations. Technical exchanges have led to the identification of problems and recommendations for their resolution. These activities have required a high level of support by the DSN interface organization since January 1970. The primary areas wherein technical exchanges have occurred naturally identify with the DSN–Project interfaces: telecommunications and data processing. Following is a summary of the major accomplishments.

A. Interface Documentation

To facilitate the communication of technical information from the DSN to Project, the DSN/Flight Project Interface Design Handbook (DSN document 810-5) was developed and distributed in January 1970. Revisions pro-

duced in March 1970, October 1970, May 1971, and August 1971 have increased the level of detail and kept interface design data current with DSN plans. The handbook deals with DSN interface parameters and performance for telecommunication, data processing, and simulation. Reference 2 describes the purpose and content of the handbook in more detail.

Tracking and Data System documents 815-2, "Flight Project Standard Technical Interfaces"; 815-4, "TDS/Project Standard Compatibility Management Plan"; and Deep Space Network document 810-8, "DSN/Flight Project Interface Compatibility Test Design Handbook," were published in 1970 to facilitate Project understanding of DSN interface identification and compatibility verification requirements and plans.

B. Telecommunications

DSN multi-mission command performance information pertinent to the decision on the single-channel versus dual-channel design for the spacecraft was provided through the Telecommunications Working Group. Subsequent adoption of the single-channel design was in keeping with the DSN Command System development plans. Frequency selection studies resulted in the assignment of channels 10, 13, 16, and 19. Dual-uplink power requirements/capability represented a major area of study in 1970. The resulting requirements for dual 40-kW uplink at DSS 14 and dual 10-kW uplink at DSS 43 and DSS 63 appear consistent with planned capabilities. Close coordination with the Mission Design and Navigation Groups verified that planned capabilities would meet mission navigation accuracy requirements.

C. Data Processing

In addition to the information provided by the DSN/Flight Project Interface Design Handbook, an extensive effort has been made to provide the Project with detailed data regarding design and operational interfaces with the DSN Central Processing System. User manuals and procedures were distributed. After analysis of the Project's planned software programs, it was decided in April 1971 that all nonreal-time programs would be developed to run on the 1108 computers. Therefore, in May 1971, efforts were directed toward determining the feasibility of converting Project contractor-developed programs to run on the 1108. As a part of this activity, a presentation was made to Project personnel on the 1108 organization and capabilities. The presentation included an actual demonstration wherein a contractor-developed converted lander entry program was run on the 1108 without difficulty. Additional tests of this nature were run in May–June 1971. A final report stated the following conclusions:

(1) Development of Flight Operations software on the contractor's baseline computer (CDC 6500) is a feasible concept. The technical problems in conversion are considered minimal.

(2) Conversion of programs written in minimal language (Fortran IV using no CDC-, IBM-, or Univac-peculiar features) is a relatively easy task, with clerical errors being the most frequent problem.

(3) In some programs having very sensitive numerical techniques, differences in results due to machine accuracies are the most difficult to resolve.

(4) Magnetic tapes can be interchanged between the CDC 6500 and Univac 1108.

Presentations and data exchanges were accomplished through the Flight Operations Working Group regarding spacecraft and DSN command and telemetry characteristics. Lander telemetry formats were found to be incompatible with DSN decommutation capabilities. Subsequent revisions to the lander telemetry design have significantly reduced the problem. Still, not all data processing requirements can be met by planned central processor capabilities. Additional recommendations are under consideration at this time. Therefore, resolution of telemetry processing interface problems will be a subject for future reports.

Similarly, it was found that command idle sequence characteristics of the orbiter and lander were different from each other and that neither was compatible with the DSN Command System. A series of technical exchanges resolved the problem by agreement to include the Project-unique portions of both idle sequences as a part of the Project-generated command message.

D. Test Support

Progress in compatibility test planning has been significant as indicated by the earlier discussion on Compatibility Test Plans. The essential elements of radio-frequency (RF) interface tests have been resolved. The DSN Milestone Schedule has been revised to provide support for Flight Operations/Spacecraft Compatibility Tests which will be conducted during the RF compatibility test period.

However, a serious incompatibility continues unresolved at this time between Project requirements for verification/demonstration tests and DSN test requirements for achieving operational readiness. The current schedule establishes May 1, 1975 as the DSN operational readiness date. The Project has levied a new requirement for a flight opera-

tions demonstration test in March 1975. In preparation for the demonstration, the Flight Operations System requires four months for system verification and crew training. Although partial DSN readiness could be achieved for the March 1975 demonstration test, it is not feasible to reach this state in November 1974 prior to Flight Operations verification tests. Solutions which would have advanced the Project software delivery date were unacceptable to the Project. Solutions which involved concurrent Flight Operations and DSN test activities were unacceptable due to the high risk of interference and of not achieving objectives. Resolution of this problem is being given high-level attention at this time.

E. Station Coverage

Using detailed tracking, telemetry, and command requirements in the SIRD and telecommunications performance information, the DSN Scheduling Group has analyzed DSN capabilities to provide the required coverage. The results show that the three-station, 64-meter subnet cannot meet requirements. The problem arises from extensive coverage requirements for both spacecraft and the tracking geometry. Both spacecraft have essentially the same Deep Space Station view period but both are not in the beamwidth of the antenna until approximately Mars-orbit insertion minus three days on the second spacecraft. Using the baseline design performance tables, the 26-meter subnet would experience threshold conditions in January 1976, about six months prior to orbit insertion. However, recent approval of orbiter design changes (two-degree freedom antenna and receive capability on the high-gain antenna) establishes the possibility of using the 26-meter subnet to solve the coverage problem. The Project is in the process of revising the 26-meter link performance analysis based on the new spacecraft parameters.

References

1. Mudgway, D. J., "*Viking* Mission Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. IV, pp. 40–46. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1971.
2. Mudgway, D. J., "DSN Support for *Viking*," in *The Deep Space Network*, Space Programs Summary 37-63, Vol. II, p. 14. Jet Propulsion Laboratory, Pasadena, Calif., May 31, 1970.