Viking Mission Support

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This article discusses the capabilities of the Deep Space Network (DSN) as a factor in the design of the Viking telecommunications system. The problem of accommodating simultaneous downlinks from two orbiters and one lander with dual uplinks to one orbiter and one lander or two orbiters is discussed.

Because the Viking encounter and subsequent orbital and landed operations take place near maximum earth–Mars separation (approximately 400 $\times$ 10^6 km), the signal-to-noise ratios on both up and downlinks are minimal to support the extensive command and data retrieval requirements.

The tradeoffs between DSN capabilities and project requirements such as these are described in the context of the mission design.

I. Introduction

Continuing the series of articles on DSN support for the *Viking* Mission, this article discusses the capabilities of the DSN as a factor in the design of the *Viking* telecommunications system.

An earth-to-spacecraft telecommunications link must provide telemetry, command, and metric data for navigation and scientific purposes. It must be almost totally reliable and must have sufficient performance margin to permit the achievement of basic mission objectives in the event of anomalous conditions in spacecraft or ground data systems.

A multiple space vehicle mission of this kind poses significant problems for the DSIF in accommodating simultaneous downlinks from two orbiters and one lander with dual uplinks to one orbiter and one lander or two orbiters.

Unlike most of the orbital flyby missions we have supported in the past, the *Viking* encounter and subsequent orbital and landed operations take place near maximum earth-Mars separation (approximately 400 $\times$ 10^6 km).

As a consequence, signal-to-noise ratios on both up and downlinks are minimal to support the very extensive command and data retrieval requirements of the project.

The tradeoffs between DSN capabilities and Project requirements such as these are described in the context of the mission design as it stands at this time.

II. Telemetry

Each *Viking* orbiter has three telemetry channels as shown in Table 1. Each *Viking* lander has two telemetry data channels as shown in Table 2. Each *Viking* orbiter may transmit the following combinations of channels: B only, A and B, B and C. Each lander will transmit A and B simultaneously during most of the mission. The DSN must be capable of receiving telemetry data simultaneously from two orbiters and one lander at one DSS and providing that data (along with metric data streams from two of the vehicles) in real time for processing and display at the SFOF. Table 3 illustrates the combinations of telemetry data which must be handled.

The baseline functional configuration with which the DSIF expects to support these combinations of data streams is given in Fig. 1. This diagram covers representative 26- and 64-m deep space stations in the multiple-mission telemetry and command configuration.

All data streams pass through the subcarrier demodulator assemblies (SDA). The uncoded low-rate data goes directly to the telemetry and command processors (TCP) for formatting and transmission to the SFOF. The medium-rate block-coded data is symbol synchronized in the symbol synchronizer assembly (SSA) and decoded in the data decoding assemblies (DDA) before passing to the TCP for formatting and transmission to the SFOF via high-speed data lines (HSDL). The high-rate block-coded data is similarly processed except that the DDA outputs this data directly to a wideband buffer for driving the 50 kbps wideband data system (WBS).

The functional arrangement of the entire DSN telemetry system for *Viking* is given in Ref. 1, Fig. 6, p. 13.

The DSN telecommunications parameters with which the *Viking* Project must work in designing its telecommunications links are given in Ref. 2. Preliminary performance studies that result from an orbiter design including a 20-W TWT are shown in Figs. 2 and 3. Preliminary performance estimates for the lander are shown in Figs. 4 and 5. Many options exist to improve the margins shown in these figures and these are continually under evaluation as the design of the mission proceeds.

Both the orbiter and lander telecommunications links are significantly degraded by the noise and spectral spreading effects around the period of solar conjunction as is shown in Figs. 2, 3, and 4. Unfortunately, very little data exists on which to base theoretical estimates of the magnitude of these effects, and the DSN is attempting to collect as much data as possible on missions prior to *Viking* to permit a better analytical understanding of the problem.

III. Command

The DSN multiple-mission command system will be used to support *Viking*, using a single bit rate of 4 bps. Because of the multiple spacecraft nature of this mission, the Project requires a capability in the 64-m subnet for two simultaneous uplinks on different frequencies.

This allows the project to simultaneously command one orbiter and one lander, or two orbiters. Lander and orbiter telecommunication link designs are such that simultaneous carriers of 10 kW each are needed at DSSs 43 and 63 and carrier levels of 40 kW each at DSS 14. The DSN plans to meet these requirements with 100-kW transmitters at DSSs 43 and 63 and a 400-kW transmitter at DSS 14. At all three stations dual exciters and command modulation assemblies (CMA) permit dual carrier operation with separate carrier frequencies, separate subcarrier frequencies, and separate command modulation.

The standard DSN command system facilities for command verification, confirmation, enable/disable and abort are available on each individual command data stream. The functional configuration of the DSN command system for *Viking* is given in Ref. 1, Fig. 6, p. 14.

The command links to the orbiter and lander are affected by the solar degradation mentioned above in the same way as downlinks, and a much better understanding of the degradation process is needed to be able to adequately predict the effect on the mission.

IV. Tracking

The spacecraft tracking function performed by the DSN yields, among other things, the radiometric data (range, doppler, time) required by the project to carry out its navigation function. The telecommunication link performance constitutes a major constraint on amount and quality of the data that can be provided.

A. Doppler

To satisfy the requirements of a multiple-spacecraft mission it is planned to provide two doppler extractors at each 64-m antenna and one doppler extractor at each 26-m antenna. Together with the dual uplinks at the 64-m stations, this will provide two simultaneous coherent two-way doppler streams at these stations. The 26-m stations will support one two-way doppler stream. Adequate carrier margin appears to be available to support the two-way doppler requirements, although more attention is required on expected doppler tracking rates as the mission details become more clearly identified.

B. Planetary Ranging

There are two requirements for planetary ranging, one for lander science purposes and the other for improving the quality of the doppler data by means of the differenced range versus integrated doppler (DRVID) technique. In both cases, the maximum communications range presents difficulty in meeting the required acquisition time because of marginal signal-to-noise ratios. This is particularly acute in the case of the lander, where the daily lander *on* time is limited by thermal and power considerations to approximately 2 hr, and SNR conditions preclude simultaneous ranging and telemetry transmissions. The project's requirement for lander ranging acquisition time is 4 min, and this requirement is under evaluation to find an acceptable solution under the link conditions described above.

C. X-Band

In addition to its S-band transponder, the *Viking* orbiter will carry a small (100 mW) X-band transponder to be used for radio science dispersive measurements of electron content in the Mars and interplanetary environment. The X-band downlink carrier will be coherent with the S-band uplink carrier and will be modulated with the planetary ranging code only.

The performance margins in the X-band downlink are being developed at this time but do not appear to present a problem. Of much more concern is the multiplication of phase instability effects from the S-band uplink into the X-band downlink.

The DSN plans to support the X-band experiment with X-band ranging receivers at each 64-m station in addition to the standard S-band ranging receivers. These receivers will also provide the DSN with an alternative to DRVID techniques for calibration of charged particle effects in the doppler data. The configuration of the entire DSN tracking system for *Viking* is described in Ref. 1.

References

1. Mudgway, D. J., "Viking Mission Support," in *The Deep Space Network*, Space Programs Summary 37-62, Vol. II, pp. 12–22. Jet Propulsion Laboratory, Pasadena, Calif., Mar. 31, 1970.
2. Jet Propulsion Laboratory Document 810-5, Rev. A, DSN Standard Practice, Deep Space Network/Flight Project Interface Design Handbook, Pasadena, Calif., Dec. 15, 1970.

Table 1. Orbiter telemetry channels

Telemetry Channel	Description	Bit rate	Subcarrier frequency, kHz
A	Uncoded science data	1, 2, or 4 kbps	240
B	Engineering data	8⅓ or 33⅓ bps	24
C	Coded (32, 6) science data	1, 2, 4, 8, or 16 kbps	240

Table 2. Lander telemetry channels

Telemetry Channel	Description	Bit rate	Subcarrier frequency, kHz
A	Uncoded engineering data	8⅓ bps	23.3
B	Coded (32, 6) science data	250 or 500 bps	144.0

Table 3. Orbiter and lander telemetry combinations

Combination No.	Lander data	Orbiter A	Orbiter B
1	A and B	B	B
2	A and B	B	A and B
3	A and B	B	B and C
4	A and B	A and B	A and B
5	A and B	A and B	B and C
6	A and B	B and C	B and C

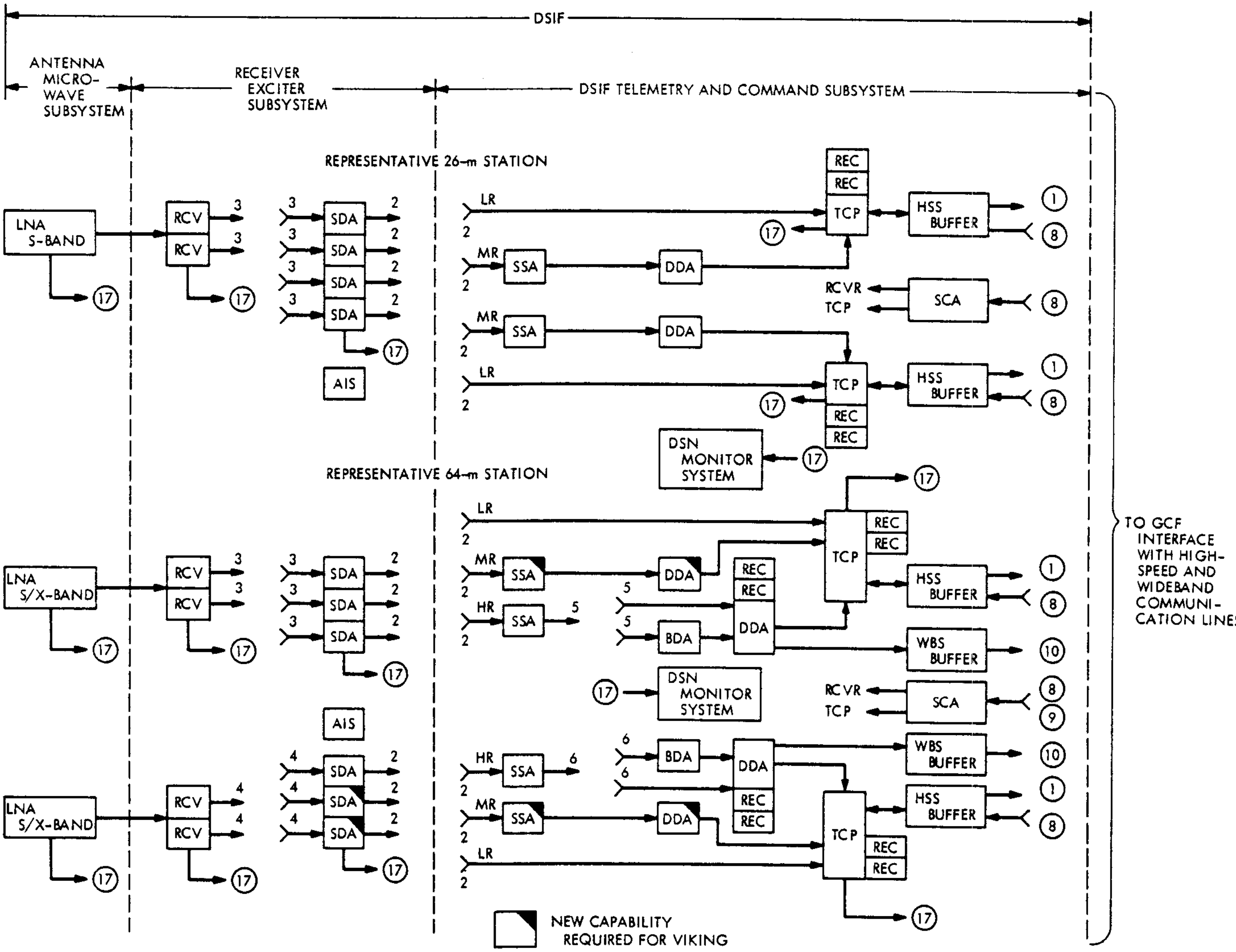

Fig. 1. DSIF telemetry configuration for *Viking*

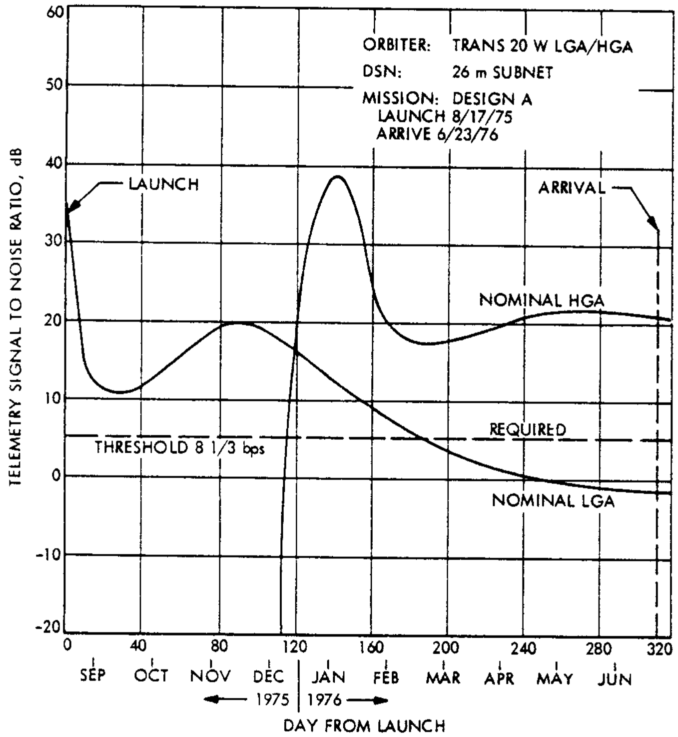

Fig. 2. Orbiter low-rate telemetry. Nominal performance during cruise operations

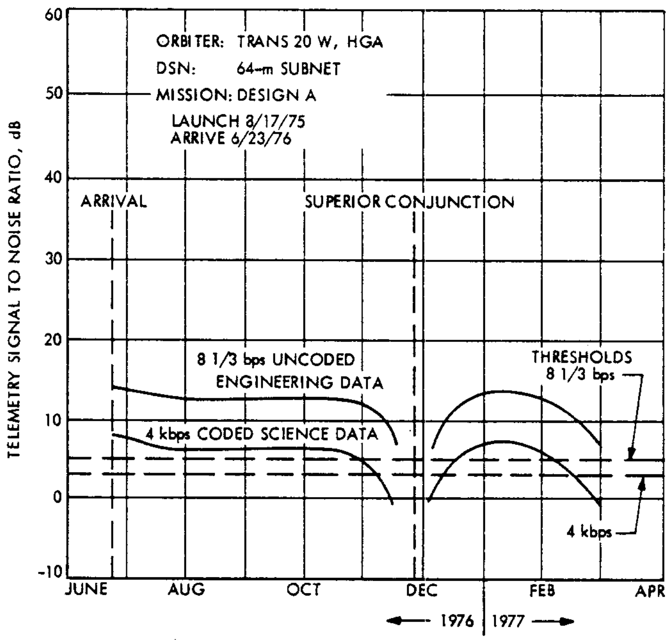

Fig. 3. Orbiter low-rate and high-rate telemetry. Nominal performance with sun effects during orbital operations

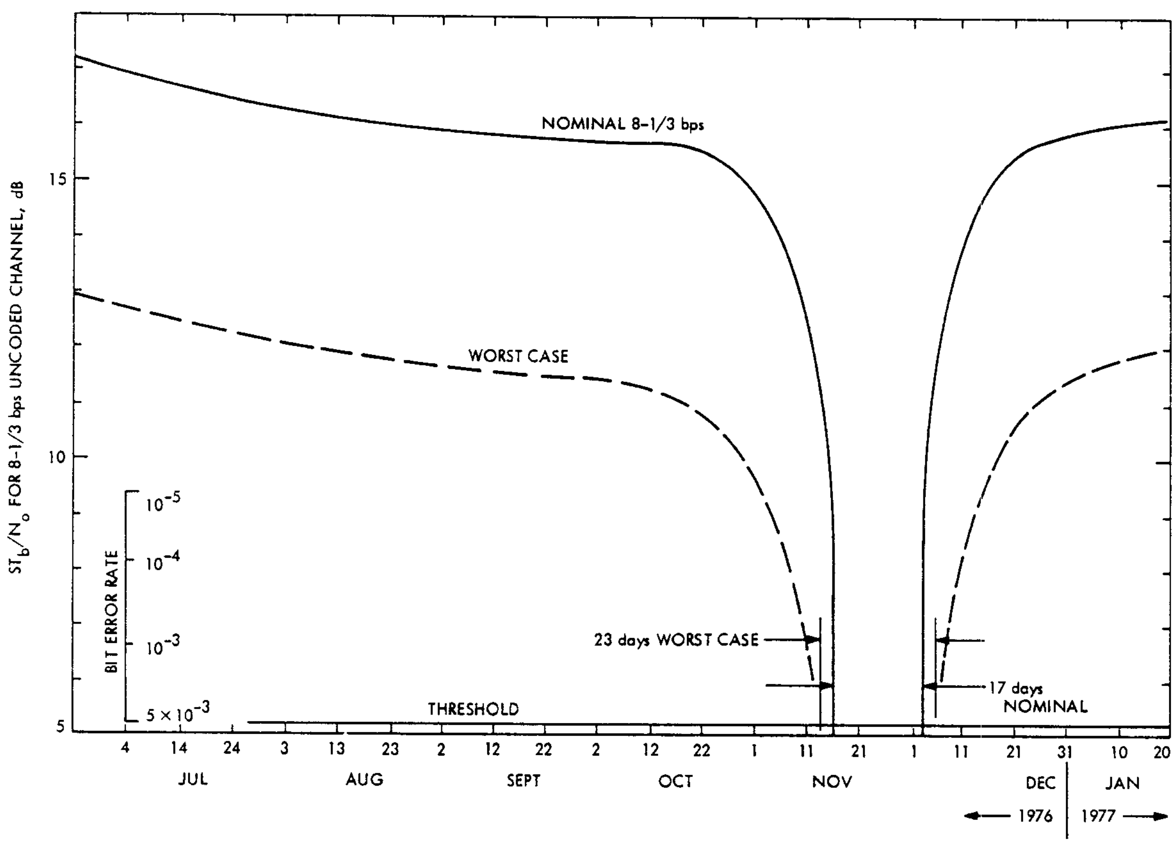

Fig. 4. Lander engineering data channel performance with sun effects

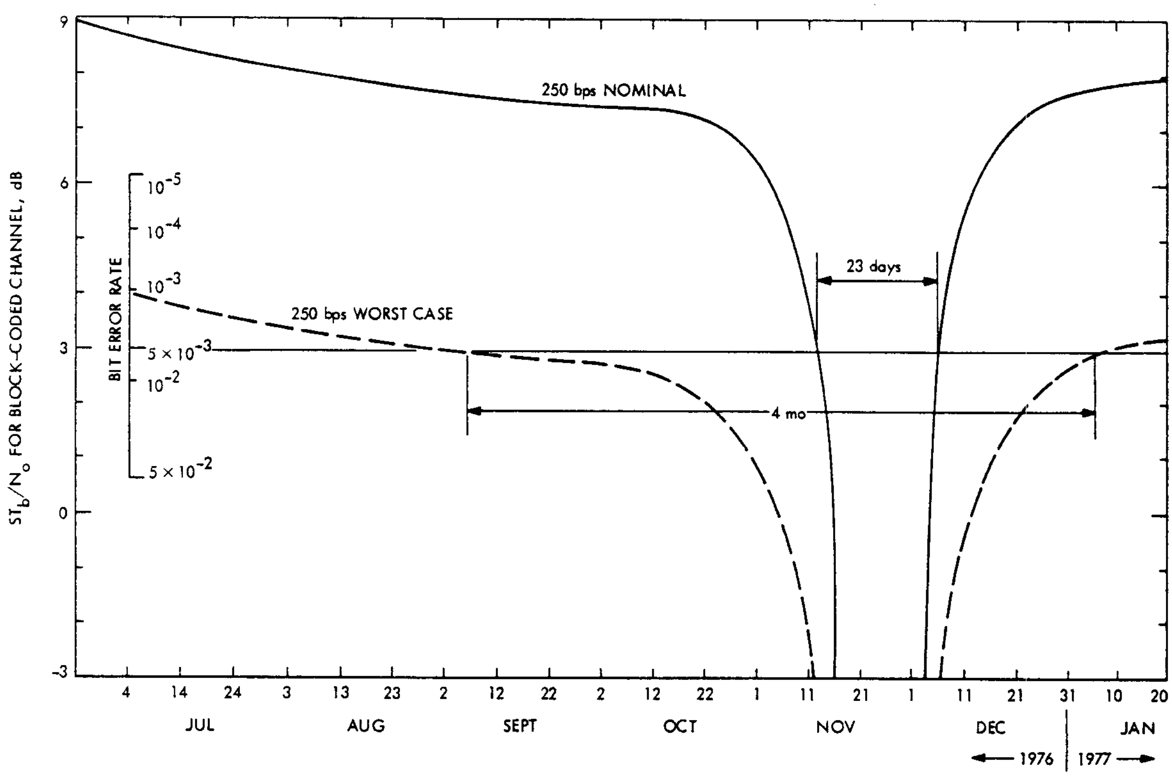

Fig. 5. Lander science data channel performance with sun effects