Sharing Range Capability at the Conjoint Stations

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Enhancement of 26-m subnet ranging coverage by sharing 64-m ranging capability has been proposed in order to improve tracking capability. An analysis of the error sources contributing to the ranging system accuracy indicates that high-frequency noise and range-modulation group-delay instability are of primary concern but that the overall result is that the range error is virtually unaffected by the additional cabling.

I. Introduction

Currently, three sets of planetary ranging equipment are available to be located at one of the 26-m stations as well as at the 64-m stations. Considering the Viking Operations Mission A recommended prime landing site (A-1), the requirements for tracking and commanding of the Mission A orbiter and lander and the approaching Mission B spacecraft during the critical period in which spacecraft B is 10–3 days from Mars orbit insertion can be met if the planetary ranging equipment is located at the Madrid 26-m station. If, for some reason, the Mission A prime site is unacceptable and landing occurs at the backup site (A-2), then it would be necessary to locate the planetary ranging equipment at the Goldstone 26-m station. Since changing the Mission A site from A-1 to A-2 is a real-time decision, there would not be time to move the planetary ranging equipment from the Madrid station to the Goldstone station; therefore, tracking and commanding requirements would not be met (Ref. 1).

One possible solution to this problem is that since the overseas 26-m stations are located conjointly with the 64-m stations, it may be possible to share the ranging capability of the 64-m stations with the 26-m stations. Then by locating one set of planetary ranging equipment at the Goldstone 26-m station, it would be possible to give planetary ranging capability to all three 26-m stations and provide full flexibility in mission planning. The purpose of this report is to provide information on the feasibility of the proposed solution.

II. System Performance

Table 1, derived from Ref. 2, is a list of the system error sources contributing to the planetary ranging system accuracy for both the 64-m and 26-m stations at the conjoint sites. The effect of low input signal margin or signal-to-noise ratio is to introduce a variance (high-frequency noise) in the measured value of range, which is a function of the integration time. A system analysis (Ref. 3) has shown that the integration time required to achieve an acceptable variance σ_T^2 is given by

$$t_i = \frac{T^2 No}{32\sigma_T^2 S}$$

where

T = period of the highest frequency component, 2×10^{-6} s

No = system noise spectral density

S = power in the ranging signal

Assuming that an uncertainty of ± 5 m would be acceptable, and employing the highest frequency component C_1, the equation simplifies to

$$t_i = 112.5 \frac{No}{S}$$

Figure 1, which is derived from data in Ref. 4, shows a plot of ranging signal performance margin vs time (GMT) for the Viking Orbiter with the S-Band discrete ranging system. Integration time for a 1σ instability of 5 m is shown along the right-hand margin.

The other ranging system error source in Table 1 affected by sharing range capability is instability in range modulation group delay. Figure 2 is a sketch of cabling affected by the change, with switching and dimensions indicated. The portion of the cabling that is delay sensitive is, for the 64-m station, an additional 15 m between the exciter and the planetary ranging assembly and, for the 26-m station, an additional 76 m between the exciter and the planetary ranging equipment. If polyethelene-insulated coaxial cable is used, there is a delay of 0.001 ns/100 m/10°C. The additional range error for group delay instability in Table 1 is 0.0045 m for the 64-m station and 0.0225 m for the 26-m station.

III. Results

The DSS planetary ranging system error is primarily dependent on the high-frequency noise. When switched from the 64-m station to the 26-m station, the planetary ranging system suffers a loss in signal-to-noise ratio but may be compensated to a certain extent by allowing a longer integration time.

The additional cabling affects primarily range-modulation group-delay instability. Some of the signals are compensated for by the fact that the reference for these signals also shifts by the same amount of range delay, the overall result being that the error is virtually unaffected by the additional cabling.

References

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Table 1. Planetary ranging performance

Ranging system accuracy due to error sources, 1σ	10^3-s round-trip light time			
	1973		1975	
	64-m	26-m	64-m	26-m
High frequency noise, m rms[a]	5.0	5.0	5.0	5.0
Instability in range modulation group delay, m/12 h	2.0	2.0	1.0[b]	2.0
Uncertainty in knowledge of frequency, m	1.5	1.5	1.5	1.5
Station calibration error, m	2.5	2.5	1.0[b]	2.5
Time of measurement error, m (35 km/s)	0.7	0.7	0.7	0.7
RSS total (m, 1σ)	7.0	7.0	6.0	7.0

[a]Can be reduced below 5 m rms by selection of integration time.
[b]Operation with Block IV receiver/exciter.

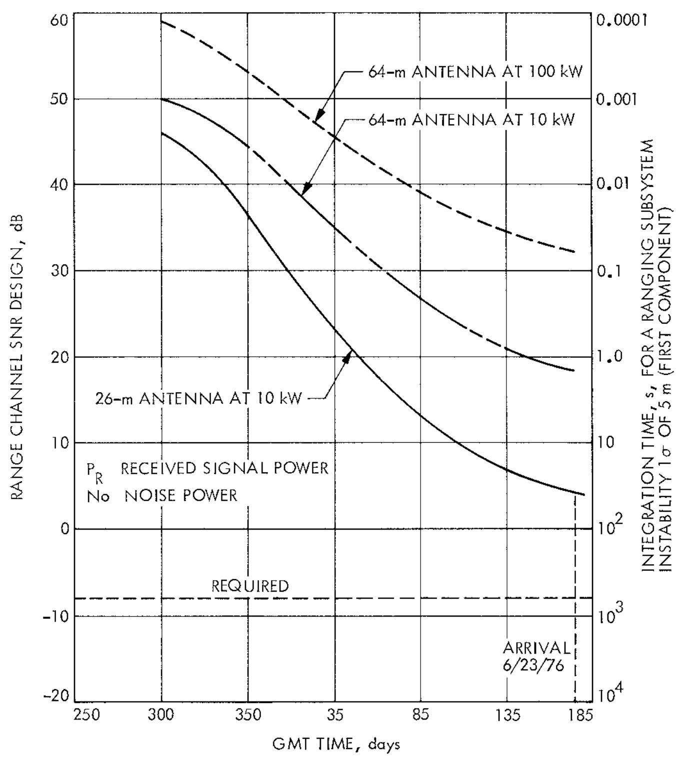

Fig. 1. Ranging P_R/No vs time for Viking Orbiter S-band ranging, discrete spectrum, command on, high-gain antenna, in cruise mode.

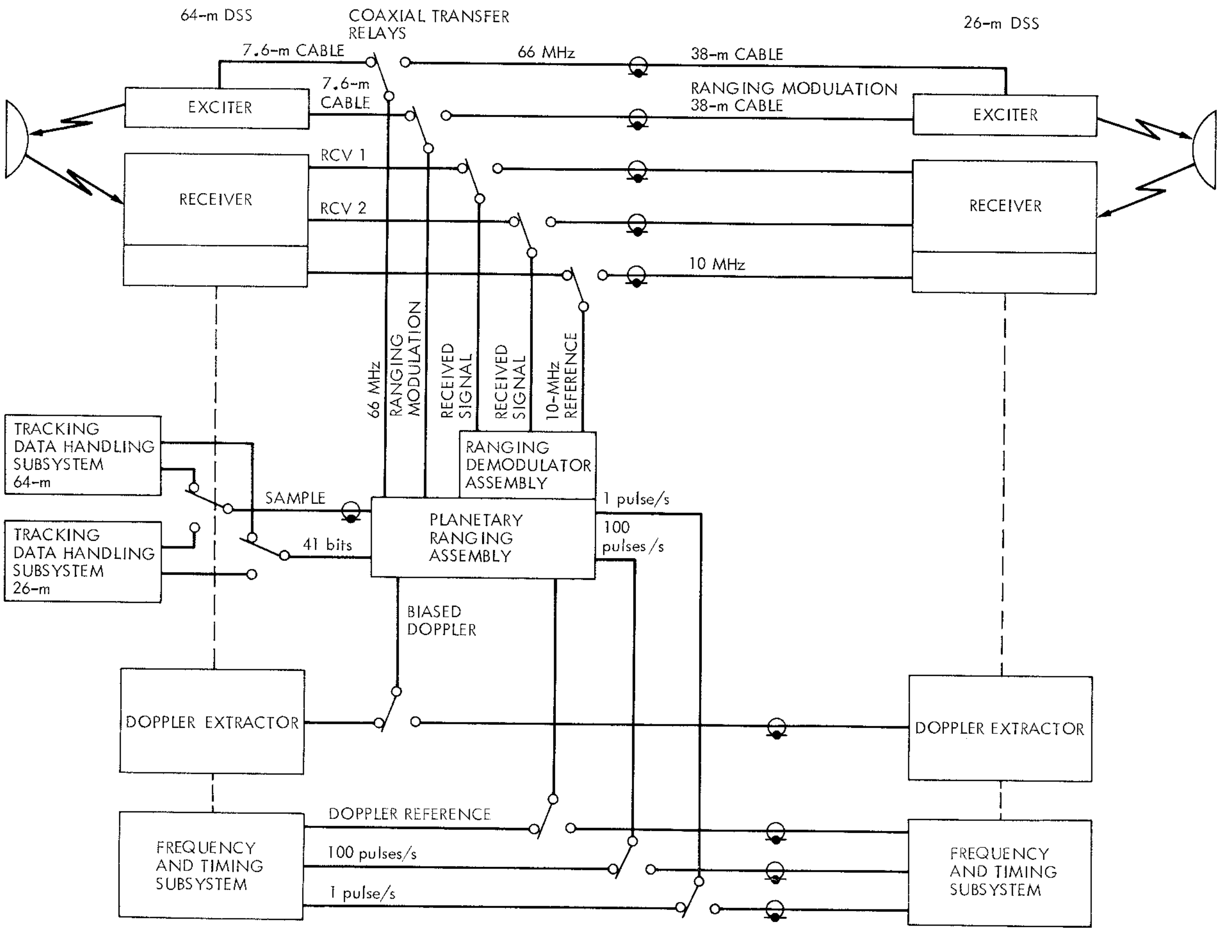

Fig. 2. Switching and cabling modifications required.