BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

69 08011

SUBJECT: Performance at Lunar Range of a Unified S-Band PM Communication Link Between an MSFN Station With an 85 ft. Antenna and a LM Using an Omni Antenna - Case 900, 320

DATE: August 6, 1969

FROM: N. W. Schroeder

ABSTRACT

Circuit margins have been calculated for the communications link between a Manned Spaceflight Network Station equipped with an 85 foot diameter antenna (MSFN-85') and a LM, at lunar range, transmitting from an omni antenna (LM-omni). This link is under consideration as a possible contingency link in the event of failure of the LM steerable antenna.

The results of the calculations indicate that up voice, up data, low bit rate telemetry, downback up voice, and ranging can be transmitted over this link with positive margins. This link cannot be used to transmit normal voice or high bit rate telemetry because the margins are too negative.

(NASA-CR-106417) PERFORMANCE AT LUNAR RANGE OF A UNIFIED S-BAND PM COMMUNICATION LINK BETWEEN AN MSFN STATION WITH AN 85 FT ANTENNA AND A LM USING AN OMNI ANTENNA (Bellcomm, Inc.) 10 p

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MEMORANDUM FOR FILE

INTRODUCTION

A LM transmitting from an omni directional antenna to an MSFN (85') antenna is a possible contingency communication link in the event that the LM steerable antenna fails and a 210 diameter antenna is not available on Earth. Circuit margins have been calculated to determine the communications capability that can be expected from this link.

The calculations were made using the equations presented in Reference 1 - modified to include (1) downlink backup voice, (2) the parameters listed in Table II, and (3) a lunar range of 215,000 N. Mi. The results of the calculations are presented in Table I.

RESULTS

Table I contains the circuit margins for six combinations of communications services or transmission modes. The table shows that up voice, up data, low bit rate telemetry, ranging, and downlink backup voice can be transmitted over this link with positive margins; however, the margin for high bit rate telemetry is highly negative, even if transmitted alone.

CONCLUSIONS

For an 85 ft. MSFN station and a LM using an omni antenna in a PM mode, the analysis shows that:

1. The circuit margins for the uplink services are all positive.

2. Low bit rate telemetry, ranging, and backup voice can be transmitted with positive margins over the downlink.

3. The circuit margins for normal downlink voice with word intelligibility of 90% and high bit rate telemetry with a bit error of 10^{-6} are negative. No useful data is expected when either of these services is transmitted over this link.

N. W. Schroeder

2034-NWS-drc

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Attachment
Tables I and II

TABLE I

CIRCUIT MARGINS CALCULATED FOR
APOLLO USB COMMUNICATIONS
BETWEEN AN
LM(OMNI) AND AN MSFN(85')

LM Downlink Mode	Service	Circuit Margin Nominal Case	Circuit Margin Worst Case
2 with uplink mode 6	up voice	3.3	2.1
	up data	3.3	2.1
	down voice w/BIOMED	-13.1	-14.4
	telemetry-51.2KBPS	-15.5	-16.1
	ranging	-6.2	-7.5
* with uplink mode 6	up voice	3.3	2.1
	up data	3.3	2.1
	down voice w/BIOMED	-13.1	-14.4
	telemetry-1.6KBPS	1.0	.4
	ranging	-6.2	-7.5
1	down voice w/BIOMED	-12.4	-13.7
	telemetry-51.2 KBPS	-14.7	-15.4

TABLE I (Continued)

LM Downlink Mode	Service	Circuit Margin Nominal Case	Circuit Margin Worst Case
*	telemetry-51.2 KBPS (only)	-12.9	-13.6
3	telemetry-1.6 KBPS (only)	3.7	3.0
4	telemetry - 1.6 KBPS	.3	.3
	Backup Voice	2.2	1.8

These calculations apply to a lunar range of 215.000. N.Mi.

*Non standard modes which are not currently specified. The modulation indexes used for these modes are those indicated in Table II for downlink mode 2.

TABLE II

USB SYSTEM PARAMETERS USED IN
COMMUNICATIONS MARGINS
CALCULATIONS FOR THE LM

Parameter	MSFN (85') Nominal	MSFN (85') Worst	LM Nominal	LM Worst	Units
Receive Carrier (PM)	2282.5	2282.5	2101.802	2101.802	MHz.
NSD Constant A	210.	210.	3600.	3600.	Degrees Kelvin
NSD Constant B	3.05	3.05	.126	.126	X10.EXP15 Degrees/Watt
IF Bandwidth	4.8	5.3	4.8	5.1	MHz.
Video Bandwidth	-	-	1.8	1.8	MHz.
Ranging Channel Constant (R_0)	-	-	.630	.630	None
Carrier Loop Bandwidth	50.	50.	1100.	1500.	Hz.
Pointing Loss	0.	0.	0.	0.	dB.
Polarization Loss	0.	0.	0.	0.	dB.
Transmit Power	10.	9.5	.020	.017	K watts
Antenna Gains					
- MSFN (85') Transmit	52.5	52.5	-	-	dB.
- MSFN (85') Receive	52.5	52.5	-	-	
- LM (Omni)	-	-	-3.	-3.	dB.

TABLE II (Continued)

Parameter	MSFN (85') Nominal	MSFN (85') Worst	LM Nominal	LM Worst	Units
Transmit Circuit Loss					
- MSFN (85')	0.	0.	-		dB.
- LM (Omni)	-	-	-4.4	-4.4	dB.
Receive Circuit Loss					
- MSFN (85')	0.	0.	-	-	dB.
- LM (Omni)	-	-	-5.7	-5.7	dB.
Required Signal/Noise Ratios					
(PM)					
- Carrier	12.0	12.0	12.0	12.0	dB.
- Up Voice (For 90% word intelligibility)	-	-	10.0	10.0	dB.
- Up Data (For a maximum message rejection rate of one per 1000)	-	-	10.0	10.0	dB.
- Down Voice (For 90% word intelligibility)	8.0	8.0	-	-	dB.

TABLE II (Continued)

Parameter	MSFN (85') Nominal	MSFN (85') Worst	LM Nominal	LM Worst	Units
- TLM (51.2 KBPS)					
(For a BER=10^{-6})	8.5	8.5	-	-	dB.
- TLM (1.6 KBPS)					
(For a BER=10^{-6} with normal voice)	5.9	5.9	-	-	dB.
(For a BER=10^{-6} with Back Up Voice)	8.0	8.0	-	-	dB.*
- Ranging (For a maximum acquisition time of 60 sec.)	32.0	32.0	-	-	dB.
Predetection Bandwidths					
- Up Voice	-	-	22.0	24.2	KHz.
- Up Data	-	-	22.0	24.2	KHz.
- Down Voice	42.0	48.0	-	-	KHz.
- TLM (51.2 KBPS)	180.	180.	-	-	KHz.
- TLM (1.6 KBPS)	7250.	7250.	-	-	Hz.
- Ranging	1.	1.	-	-	Hz.

Except for the items indicated by (*), the system parameters listed above were taken from the MSC ISD Master Parameter list dated November 21, 1968.

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*This parameter was taken from a plot of test data contained in "Apollo Block II Command Module Unified S-Band Manned Space Flight Network Systems Test Program's Data and Performance Summary," EB68-3224(U), November 8, 1968, MSC Houston, Texas.

TABLE II (Continued)

UPLINK MODES - CSM: 2106.4 MHZ LM/SLV - 2101.8 MHZ

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	SUBCARRIER FREQUENCY (MHZ)	PEAK CARRIER DEVIATION
1	Ranging	PM on Carrier	---	1.34 ± 0.13 Rad
2	Voice	FM/PM	30	1.85 ± 0.18 Rad
3	Command	PSK/FM/PM	70	1.85 ± 0.18 Rad
4	Ranging	PM on Carrier	---	0.38 ± 0.04 Rad
	Voice	FM/PM	30	1.2 ± .12 Rad
5	Ranging	PM on Carrier	---	0.38 ± 0.04 Rad
	Command	PSK/FM/PM	70	1.2 ± .12 Rad
6	Ranging	PM on Carrier	---	0.44 ± 0.04 Rad
	Voice	FM/PM	30	1.0 ± 0.1 Rad
	Command	PSK/FM/PM	70	1.0 ± 0.1 Rad
7	Voice	FM/PM	30	1.1 ± 0.1 Rad
	Command	PSK/FM/PM	70	1.1 ± 0.1 Rad
8	Ranging	PM on Carrier	---	0.38 ± 0.04 Rad
	Backup Voice	FM/PM	70	1.2 ± 0.12 Rad

TABLE II (Continued)

LM PM DOWNLINK MODES (2282.5 MHZ)

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	SUBCARRIER FREQUENCY (MHZ)	PEAK CARRIER DEVIATION
00	No Carrier	---	---	---
01	HBR TLM	PCM/PM/PM	1.024	1.3 + 21%, -15% Rad
	Voice w/BIOMED	FM/PM	1.25	0.9 + 22%, -14% Rad
02	Ranging	PM on Carrier	---	Varies with Received uplink
	HBR TLM	PCM/PM/PM	1.024	1.3 + 21%, -15% Rad
	Voice w/BIOMED	FM/PM	1.25	0.9 + 22%, -14% Rad
03	LBR TLM	PCM/PM/PM	1.024	1.3 + 21%, -15% Rad
04	Backup Voice	PM on Carrier	---	0.8 + 25%, -15% Rad
	LBR TLM	PCM/PM/PM	1.024	1.3 + 21%, -15% Rad
05	Backup Voice	PM on Carrier	---	0.8 + 25%, -25% Rad
06	Key	AM/PM	512 KHZ	1.4 + 20%, -16% Rad
07	LBR TLM	PCM/PM/PM	1.024	0.7 + 21%, -15% Rad
	Voice	FM/PM	1.25	1.3 + 22%, -14% Rad
08	Backup Voice	PM on Carrier	---	0.73 + 65%, -39% Rad
	LBR TLM	PCM/PM/PM	1.024	1.3 + 21%, -15% Rad

The modulation indexes for both the uplink and the downlink modes are taken from "AS-506 MCC/MSFN Mission Configuration/System Description, June 1969, Manned Spacecraft Center, Houston, Texas."

REFERENCES

1. N. W. Schroeder, "Communications Margins for Apollo Unified S-Band Links with Phase Modulation," Bellcomm TM 68-2034-17, December 31, 1968.

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