



**Aerospace
Systems Division**

ALSEP Link Performance VS
Antenna Pointing Error

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This analysis determines the command link received power margin in excess of that required for an error rate of 10^{-9} as a function of the antenna (ALSEP) pointing error. The results of the analysis and the parameters used are shown in Table 1 and Figure 1. The received power margin is used instead of probability of error because of the false sense of security that would result in observing such low error rate. The calculations include the measured effects of the command receiver threshold losses.

Tables 2 and 3 show the parameters and results for the telemetry link calculations. The results are plotted in Figure 2 for the nominal and worst cases. Probability of error versus pointing error is plotted. The measured prototype antenna pattern (Figure 3) was used in the calculation.

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TABLE 1
COMMAND LINK CALCULATIONS

<u>Parameter</u>	<u>Nominal Value</u>	<u>Worst Case</u>	<u>Source</u>
1. MSFN Trans. Power (dbm)	+70.0	+70.0	Ref. 1, p. 11
2. MSFN Trans. Circuit Loss (db)	included in ant. gain.		Ref. 1, p. 11
3. MSFN Ant. Gain (30'dish) (db)	+43.0	+43.0	Ref. 1, p. 11
4. MSFN Ant. Pointing Loss (db)	0	0	Ref. 1, p. 11
5. Space Loss (db)	-210.8	-211.4	Ref. 2, p. 11
6. Polarization Loss (db)	-0.1	-0.2	Ref. 2, p. 11
7. Multipath Loss (db)	0	-1.0	Ref. 2, p. 11
8. ALSEP Ant. Boresight Gain (db)	+15.0	+14.7	Ref. 1, p. 11
9. ALSEP Rec. Circuit Loss (db)	-2.5	-3.7	Ref. 1, p. 11
10. ALSEP Rec. Input Power (dbm)	-85.4	-88.4	Sum 1-9
11. Minimum Rec. Input Power for $P_e = 10^{-9}$ (dbm)	-97.0	-95.5*	Ref. 3, Fig. 2.8.3
12. Rec. Input Power Margin Vs. Ant. Angle (db)			
<u>0°</u>	<u>G(db)</u>		
0	0	+11.6	+7.1
5	-0.5	+11.1	+6.6
10	-1.5	+10.1	+5.6
15	-3.0	+8.6	+4.1
20	-6.0	+5.6	+1.1
			Sum 10 + 11

* - Noise Figure 1.5 db more than nominal case.

FIG. 1 - COMMAND LINK

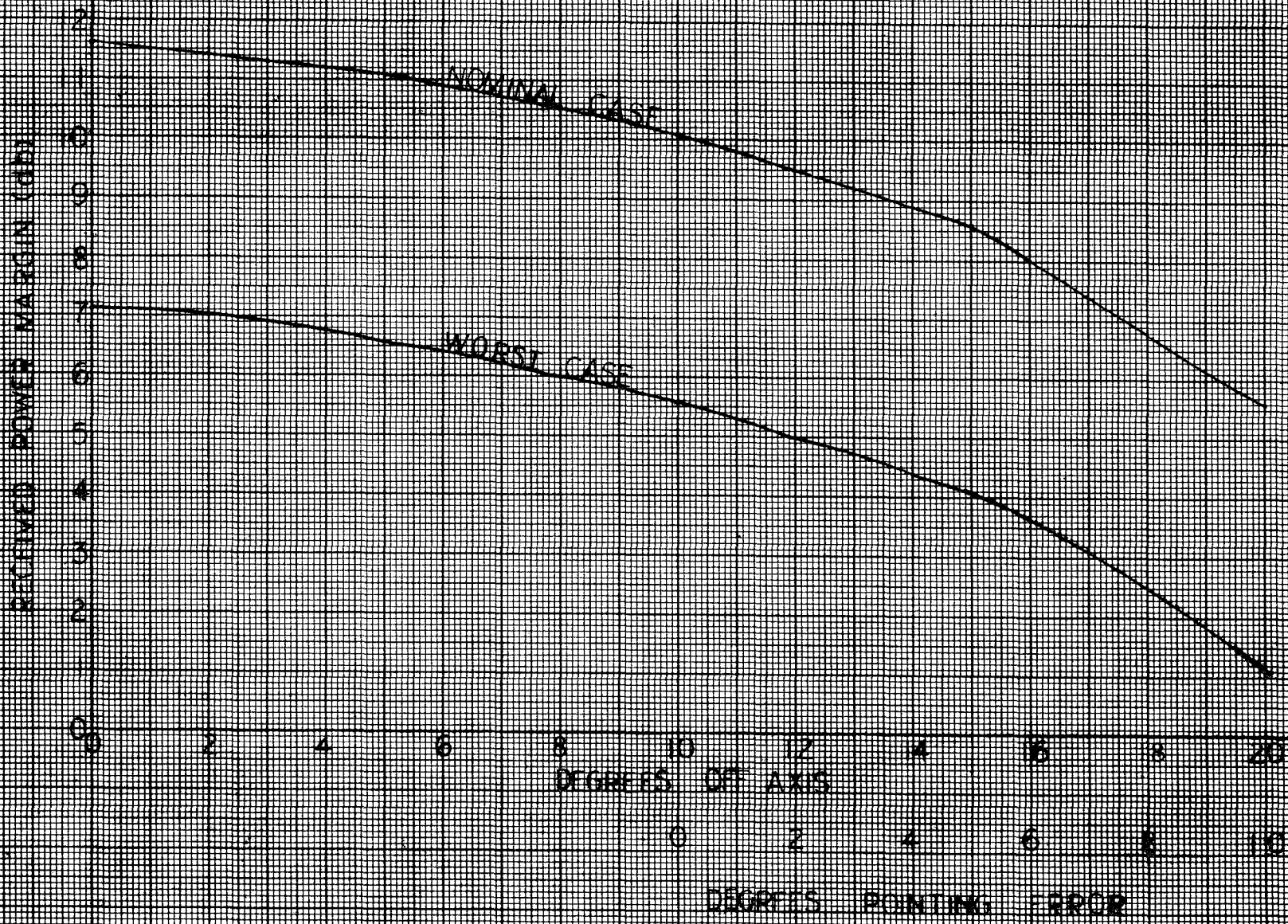


TABLE 2

TELEMETRY LINK CALCULATIONS
R = 1.06 Kbps

<u>Parameter</u>	<u>Nominal Value</u>	<u>Worst Case</u>	<u>Source</u>
1. ALSEP Trans. Power (dbm)	+30.1	+30.0	Ref. 1, p. 8
2. ALSEP Trans. Circuit Loss (db)	-2.4	-2.7	Ref. 1, p. 9
3. ALSEP Ant. Boresight Gain (db)	+15.8	+15.2	Ref. 1, p. 8
4. Space Loss (db)	-211.6	-211.8	Ref. 2, p. 12
5. Polarization Loss (db)	-0.1	0.2	Ref. 2, p. 12
6. Multipath Loss (db)	0	-1.0	Ref. 2, p. 12
7. MSFN Ant. Gain (30'dish) (db)	+44.0	+44.0	Ref. 1, p. 8
8. MSFN Ant. Pointing Loss (db)	0	0	Ref. 1, p. 9
9. MSFN Rec. Circuit Loss (db)	included in Ant. Gain		Ref. 1, p. 9
10. MSFN Rec. Input Power (dbm)	-124.2	-126.5	Sum 1 - 9
11. MSFN Rec. Noise Spectral Density	-174.5*	-173.4**	Ref. 2, p. 14
12. Modulation Loss (db)	-0.5	-0.7	Ref. 2, p. 21
13. PCM Decom. Loss (db)	-1.0	-2.0	Ref. 1, p. 10
14. S/N in 1060 bandwidth (db)	+18.5	+13.9	Sum 10+12+13 -11 +30.3 db

*Moon at Zenith, uncooled paramp.

**Moon at horizon, uncooled paramp.



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TABLE 2 (CONT.)

<u>Parameter</u>		<u>Nominal Value</u>	<u>Worst Case</u>	<u>Source</u>
15. S/N vs. Ant. Angle (db)				
<u>0°</u>	<u>G (db)</u>			
0	0	+18.5	+13.9	Sum 14 + 15
5	-0.5	+18.0	+13.4	
10	-2.0	+16.5	+11.4	
15	-4.5	+14.0	+9.4	
20	-9.0	+9.5	+4.9***	
16. Data Prob. of Error vs. Ant. Angle				
<u>0°</u>				
0		< 1 x 10 ⁻²⁰	2 x 10 ⁻¹⁴	
5		< 1 x 10 ⁻²⁰	1 x 10 ⁻¹²	
10		< 1 x 10 ⁻²⁰	1 x 10 ⁻⁸	
15		< 2 x 10 ⁻¹⁴	2 x 10 ⁻⁵	
20		< 1 x 10 ⁻⁵	5 x 10 ⁻³	

***Carrier SNR margin negative by 0.7 db.

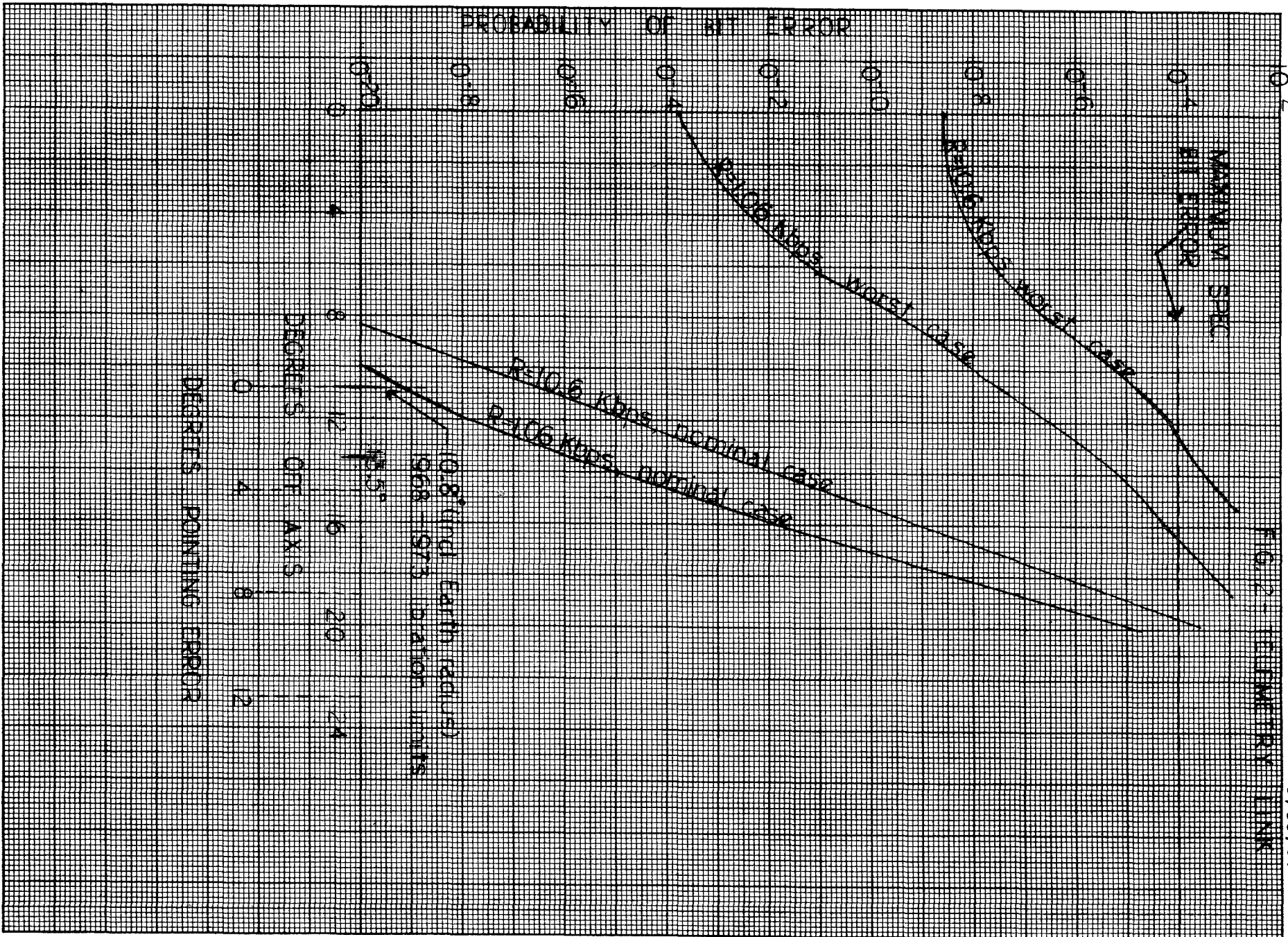


TABLE 3
TELEMETRY LINK CALCULATIONS
R = 10.6 Kbps

<u>Parameter</u>	<u>Nominal Value</u>	<u>Worst Case</u>	<u>Source</u>
1. ALSEP Trans. Power (dbm)	+30.1	+30.0	Ref. 1, p. 8
2. ALSEP Trans. Circuit Loss (db)	-2.4	-2.7	Ref. 1, p. 9
3. ALSEP Ant. Boresight Gain (db)	+15.8	+15.2	Ref. 1, p. 8
4. Space Loss (db)	-211.6	-211.8	Ref. 2, p. 12
5. Polarization Loss (db)	-0.1	-0.2	Ref. 2, p. 12
6. Multipath Loss (db)	0	-1.0	Ref. 2, p. 12
7. MSFN Ant. Gain (85' dish) (db)	+53.0	+50.5	Ref. 1, p. 8
8. MSFN Ant. Pointing Loss (db)	0	0	Ref. 1, p. 9
9. MSFN Rec. Circuit Loss (db)	included in Ant. gain		Ref. 1, p. 9
10. MSFN Rec. Input Power (dbm)	-115.2	-120.0	Sum 1-9
11. MSFN Rec. Noise Spectral Density (dbm/Hz)	-174.8*	-174.8*	Ref. 2, p. 14
12. Modulation Loss (db)	-0.5	-0.7	Ref. 2, p. 21
13. PCM Decom. Loss (db)	-1.0	-2.0	Ref. 1, p. 10
14. S/N in 10600 bandwidth (db)	+17.8	+11.8	Sum 10+ 12+ 13 -11 +40.3 db

*Moon at zenith, cooled paramp.

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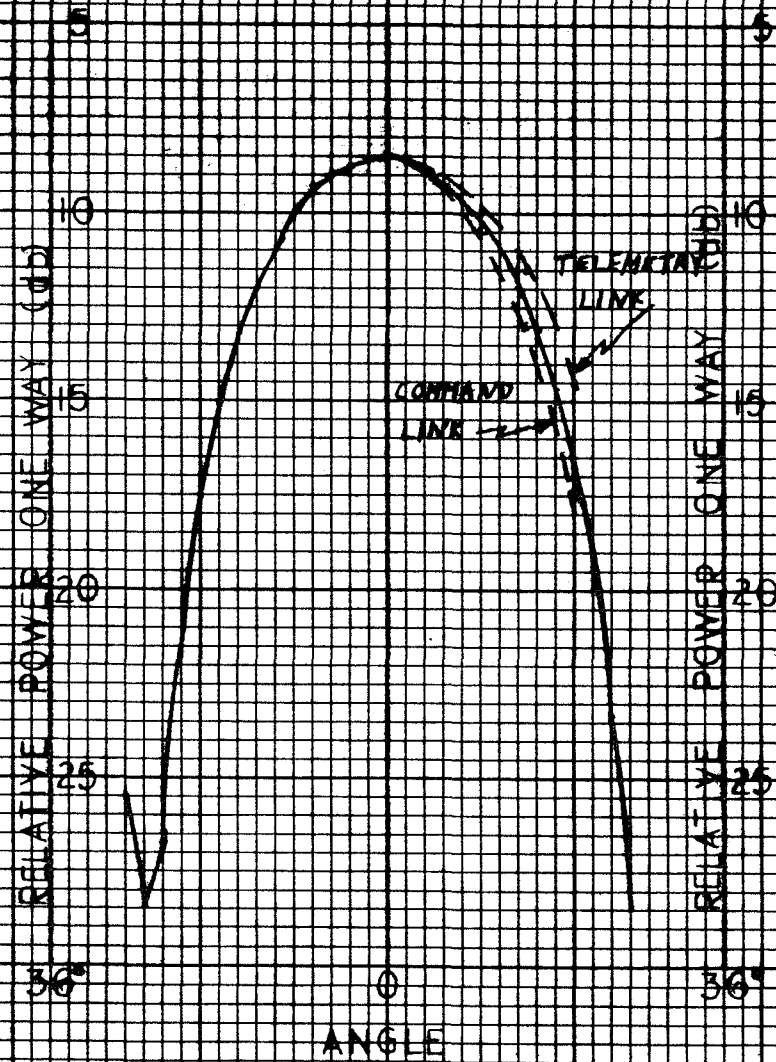
TABLE 3 (CONT.)

<u>Parameter</u>			<u>Nominal Value</u>	<u>Worst Case</u>	<u>Source</u>
15. S/N vs Ant. Angle (db)					
<u>0°</u>	<u>G (db)</u>	<u> Limiter Loss (db)**</u>			
0	0	0	+17.8	+11.8	Sum 14 + 15
5	-0.5	0	+17.3	+11.3	
10	-2.0	-0.3	+15.2	+9.5	
15	-4.5	-0.7	+12.6	+6.6	
20	-9.0	-1.0	+7.8	+1.8	
16. Data Prob. of Error vs. Ant. Angle					
<u>0°</u>					
0			< 1 x 10 ⁻²⁰	3 x 10 ⁻⁹	
5			< 1 x 10 ⁻²⁰	1 x 10 ⁻⁸	
10			< 1 x 10 ⁻¹⁸	1 x 10 ⁻³	
15			< 1 x 10 ⁻¹⁰	1 x 10 ⁻³	
20			< 2 x 10 ⁻⁴	4 x 10 ⁻²	

** Ref. 1, p. 9

MEASURED ANTENNA PATTERN (PROTOTYPE MODEL)
E AND H PLANE AVERAGE FREQUENCY = 2275 MHz

FIG. 3





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