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LRIT SYSTEM PERFORMANCE AND LINK BUDGETS

This document provides an overview of the LRIT system performance.

LRIT SYSTEM PERFORMANCE AND LINK BUDGETS

1.0 Introduction

The LRIT will transmit at 128 kbps. A 1-meter antenna is assumed to be part of the user terminal. Users in locations where the antenna elevation angle is low should consider using a 1.8-meter antenna.

The performance of the LRIT communications link is dependent upon many assumptions concerning the spacecraft, user receiver, and atmospheric losses. In this presentation the conservative assumptions have been chosen in order to determine the worst-case performance of the communications link. Variations in these assumptions will be discussed.

Two specific issues affect the performance and will be addressed in detail. The first is that certain propagation parameters are statistically variable and dependent on location and time. They will not always degrade the link performance.

Secondly, because low cost is an objective of the LRIT program, modest equipment parameters have been assumed.

2.0 Conservative Analysis Results

Tables 1 and 2 present the link budget for the LRIT downlink for a data rate of 128 kbps. Table 1 shows the performance for a 1-meter dish and Table 2 for a 1.8-meter dish. The minimum performance goal is a 10^{-8} ber with a 3-dB margin. This is not achieved near the edge of coverage (i.e. low antenna elevation angles) using the smaller antenna. For both antennas the link margin of 3 dB is achieved at elevation angles above 15°. However for the smaller antenna the performance of 10^{-8} ber is not achieved at 5° because of high scintillation loss.

3.0 Propagation Parameters

3.1 Polarization Loss

A nominal polarization loss of 0.2 dB was used in the link calculations. Such phenomenon as Faraday rotation and scintillation can cause much larger losses depending on the user station location and time. The losses can be large enough to prevent the link from working; however, these large losses are short in duration. The largest losses are associated with sun spot activity, which was at its peak in the year 2000 and will be lower at the time the GOES-N is operational.

3.2 Scintillation Loss

A loss of 5 dB is shown for the elevation angle of 5 degrees only. This parameter is highly dependent upon time and location. The high value of scintillation loss is presented here to conservatively represent losses that could occur for small percentages of time.

Table 1. Link Performance 1-meter dish

Elevation Angle	5	10	15	20	30	40	60	90	
Transponder Parameters									
Frequency	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	MHz
Wavelength	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	meters
Data Rate	128.0	128.0	128.0	128.0	128.0	128.0	128.0	128.0	kbps
EIRP	48.2	48.4	48.5	48.5	48.7	48.9	49.2	49.7	dBm
Propagation Parameters									
Scintillation Loss	-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Range	41108020.0	40664900.0	40139600.0	39633300.0	38690300.0	37858800.0	36597900.0	35786000.0	meters
Atmospheric Absorption	-0.400	-0.210	-0.200	-0.100	-0.090	-0.080	-0.060	-0.040	dB
Free Space Loss	-189.28	-189.19	-189.08	-188.97	-188.76	-188.57	-188.27	-188.08	dB
Polarization Loss	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	dB
Pointing Loss	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	dB
Rain Attenuation	-0.10	-0.07	-0.05	-0.04	-0.02	-0.02	-0.01	-0.01	dB
Received Power	-151.88	-144.96	-142.79	-142.00	-414.31	-140.86	-140.14	-139.41	dBm
Receiver Parameters									
Gain (1 meter dish)	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	dBi
Line loss (in temp)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
System Temp	190.50	190.50	190.50	190.50	190.50	190.50	190.50	190.50	K
G/T	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	dB/K
Filter Insertion loss	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	dB
C/No	52.62	59.54	61.72	62.50	63.20	63.64	64.36	65.09	dB-Hz
C/No as Ratio	182816	899692	1484979	1778604	2087672	2313127	2728690	3231768	W/(W/Hz)
Turnaround C/No	52.45	59.37	61.55	62.33	63.03	63.47	64.19	64.92	dB-Hz
Modulation Loss	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	dB
Eb/No Theoretical	12.20	12.20	12.20	12.20	12.20	12.20	12.20	12.20	dB
Coding Gain	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	dB
Eb/No Available	-0.92	6.00	8.18	8.96	9.65	10.10	10.82	11.55	dB
Eb/No Required	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	dB
Margin	-6.12	0.80	2.98	3.76	4.45	4.90	5.62	6.35	dB

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Table 2. Link Performance 1.8-meter dish

Elevation Angle	5	10	15	20	30	40	60	90	
Transponder Parameters									
Frequency	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	1691.0	MHz
Wavelength	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	meters
Data Rate	128.0	128.0	128.0	128.0	128.0	128.0	128.0	128.0	kbps
EIRP	48.2	48.4	48.5	48.5	48.7	48.9	49.2	49.7	dBm
Propagation Parameters									
Scintillation Loss	-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Range	41108020.0	40664900.0	40139600.0	39633300.0	38690300.0	37858800.0	36597900.0	35786000.0	meters
Atmospheric Absorption	-0.400	-0.210	-0.200	-0.100	-0.090	-0.080	-0.060	-0.040	dB
Free Space Loss	-189.28	-189.19	-189.08	-188.97	-188.76	-188.57	-188.27	-188.08	dB
Polarization Loss	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	dB
Pointing Loss	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	dB
Rain Attenuation	-0.10	-0.07	-0.05	-0.04	-0.02	-0.02	-0.01	-0.01	dB
Received Power	-151.88	-144.96	-142.79	-142.00	-414.31	-140.86	-140.14	-139.41	dBm
Receiver Parameters									
Gain (1.8-meter dish)	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	dBi
Line loss (in temp)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
System Temp	190.50	190.50	190.50	190.50	190.50	190.50	190.50	190.50	K
G/T	4.70	4.70	4.70	4.70	4.70	4.70	4.70	4.70	dB/K
Filter Insertion loss	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	dB
C/No	57.62	64.54	66.72	67.50	68.20	68.64	69.36	70.09	dB-Hz
C/No as Ratio	578114	2845075	4695917	5624441	6601799	7314750	8628875	10219748	W/(W/Hz)
Turnaround C/No	57.45	64.37	66.55	67.33	68.03	68.47	69.19	69.92	dB-Hz
Modulation Loss	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	dB
Eb/No Theoretical	12.20	12.20	12.20	12.20	12.20	12.20	12.20	12.20	dB
Coding Gain	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	dB
Eb/No Available	4.08	11.00	13.18	13.96	14.65	15.10	15.82	16.55	dB
Eb/No Required	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	dB
Margin	-1.12	5.80	7.98	8.76	9.45	9.90	10.62	11.35	dB

4.0 User Receiver Parameters

This section discusses gain/temperature, insertion loss, as well as coding gain.

4.1 G/T

The current receiver systems are assumed to have a 1-meter dish with a G/T = -0.3 dB/K. The G/T can be improved by using either a larger antenna or a front-end amplifier with a lower noise figure. A 1.8-meter dish will provide 5 dB extra gain over the 1-meter dish.

If the low-noise amplifier were used in combination the larger antenna providing a system noise temperature of 80° or less, the system could achieve the performance level with about a 2-dB margin at an elevation angle of 5°.

4.2 Insertion Loss

In the link budget, an insertion loss of –1.0 dB is used to account for a front-end filter to reduce interference. This filter may be needed in areas where cell phone interference is being experienced.

4.3 Coding Gain

It is reported in the reference[1] that a coding gain of 2.5 dB over the Viterbi decoded convolutional-only coding system is the achievable result at 10^{-6} ber. At a performance level of 10^{-8} ber translates to an Eb/No of about 5.2 dB so the effective coding gain of the concatenated code is assumed to be 7 dB.

Theoretically the coding gain could be 9.4 dB. This level of coding gain would indicate an Eb/No of 2.8 dB. However, it would be difficult to acquire and hold lock on the carrier at this low level.

4.4 Modulation Loss

This loss accounts for the ability of the bandpass filters to match to the incoming signal filtering out the noise and preventing intersymbol interference. A value of less than 1 dB can be achieved with high quality equipment but less expensive equipment could have losses as high as 2.3 dB.

[1] Liu, Kuang Y. and Lee, Jun-Ji, "Recent Results on the Use of Concatenated Reed-Solomon/Viterbi Channel Coding and Data Compression for Space Communications," IEEE Transactions on Communications, Vol.,COM-32, No. 5, May 1984.