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SYSTEM PERFORMANCE AND LINK BUDGETS

This document provides an overview of the LRIT system performance.

SYSTEM PERFORMANCE AND LINK BUDGETS

1.0 Introduction

The LRIT initial operational phase will transmit at 64 kbps. The current user receiver and 1-meter antenna are assumed to be part of the user terminal. The final operational phase will operate at 128 kbps. It is assumed in the analysis that user terminals will be 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 in Section D.4 as a basis for more optimistic assessments.

2.0 Conservative Analysis Results

Tables 1 and 2 present conservative link budgets for the LRIT downlink for the IOC and FOC data rates (64 kbps and 128 kbps). The performance goal of 10^{-8} BER is achieved almost to the edge of coverage (i.e., out to an incident angle of 5°). The IOC downlink margin varies from OdB near the edge of coverage to 3 dB at the zenith (90°). The FOC downlink margin varies from 1.9 db near the edge of coverage to 4.9 dB at the zenith. Either increasing the size of the antenna or improving the noise temperature of the receiver can increase both downlink margins.

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 GOES-N is operational.

Table 1. Link Performance during the Initial Operational Phase

Elevation Angle	5	10	15	20	30	40	60	90	Units
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	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	kbps
EIRP	48.2	48.4	48.5	48.5	48.7	48.9	49.2	49.7	dBm
Propagation Parameters									
RCVR Pointing Loss	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Range	41108020	40664900	40139600	39633300	38690300	37858800	36597900	35786000	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
Received Power	-141.68	-141.23	-141.03	-140.73	-140.35	-139.98	-139.33	-138.62	dBm
Receiver Parameters									
Gain	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	dBi
System Temp	190.55	190.55	190.55	190.55	190.55	190.55	190.55	190.55	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	55.62	56.07	56.28	56.57	56.95	57.32	57.97	58.68	dB-Hz
C/No as Ratio	364581	404459	424132	453796	495956	539486	626232	738280	W/(W/Hz)
Turnaround C/No	55.45	55.90	56.11	56.40	56.78	57.15	57.80	58.51	dB-Hz
Modulation Loss	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	dB
Eb/No Theoretical (for BER of 10^{-8})	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	5.09	5.54	5.74	6.04	6.42	6.79	7.44	8.15	dB
Eb/No Required	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	dB
Margin	-0.11	0.34	0.54	0.84	1.22	1.59	2.24	2.95	dB

Table 2. Link Performance during the Final Operational Phase

Elevation Angle	5	10	15	20	30	40	60	90	Units
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									
RCVR Pointing Loss	0.0	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
Received Power	-141.68	-141.23	-141.03	-140.73	-140.35	-139.98	-139.33	-138.62	dBm
Receiver Parameters									
Gain	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	190.55	190.55	190.55	190.55	190.55	190.55	190.55	190.55	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	60.62	61.07	61.28	61.57	61.95	62.32	62.97	63.68	dB-Hz
C/No as Ratio	1152907	1279012	1341224	1435028	1568351	1706006	1980319	2334647	W/(W/Hz)
Turnaround C/No	60.45	60.90	61.11	61.40	61.78	62.15	62.80	63.51	dB-Hz
Modulation Loss	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	dB
Eb/No Theoretical (for BER of 10^{-8})	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	7.08	7.53	7.73	8.03	8.41	8.78	9.43	10.14	dB
Eb/No Required	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	dB
Margin	1.88	2.33	2.53	2.83	3.21	3.58	4.23	4.94	dB

4.0 User Receiver Parameters

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

4.1 G/T

The G/T can be further 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. This is sufficient to raise the performance in the initial operational phase to a 3-dB margin over the 10^{-8} BER performance.

If the low-noise receiver were used in combination the larger antenna, the final operational phase could achieve the performance level with over a 3 dB margin at 128 kbps.

4.2 Insertion Loss

In the link budget, an insertion loss of -1 dB is used to account for a front-end filter to reduce interference. User stations with about a 5-degree elevation angle may not be in an environment that would require the filter. This extra 1 dB with the 1-meter antenna and low noise receiver (system noise temperature of about 85K) could increase the performance margin of the final operational phase to +1.4 dB.

4.3 Coding Gain

In this analysis we have conservatively reduced the ideal coding gain from 9.4 dB to 7 dB. The ability of the concatenated coding to produce the full gain will be tested. If it were feasible to achieve the full coding gain, the link performance would increase by 2.4 dB. This is enough by itself to achieve a full 3-dB margin at 5° elevation during the initial operational phase and increase the margin to +2.3 dB at that range in the final operational phase.