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| Inter-Satellite Communication Link Budget Overview  Rascal Internal Document  Team: Communication (COM)  3/4/2014 -- Revision: - |  |

Revision History

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| - | 3/4/2014 | Initial Release | Nate Richard | Tom Moline | All |
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# Background:

This document will go over the inter-satellite communication link budget. A link budget is the sum of the gains and losses a radio signal will experience as it travels through the radio and propagates through space. Losses come from inefficiencies or noise in the hardware and interference between the transmitter and receiver. Gains come from the antennas and how loud or energetic the signal is. When calculating a link budget everything is on the logarithmic scale, so things such as transmit power need to be converted to dB. The sum of the gains and losses must zero or greater, this means the link has been closed. A closed link means communication can go back and forth between the two radios. The higher the number is the less chance there is for bit errors.

# Assumptions:

The primary spacecraft was assumed to have a patch antenna with 5 dB gain. Several antennas were looked for the dummy spacecraft. The antennas were monopole, dipole, and a canted turnstile. The gains for these antennas came from AMSAT-IARU link Budget. The propagation range was assumed to five kilometers. Loses on both spacecraft were assumed to be 2dB. Pointing losses change with the antennas used, which also can from the AMSAT-IARU link Budget. Loss due to antenna polarization was assumed to be 0.2 dB. The primary spacecraft was assumed to have a transmit power of 5W and the dummy to have a transmit power of 1W. The downlink data rate for the primary spacecraft was assumed to be 100 kbps and the uplink data rate was assumed to 4 kbps. The dummy spacecraft was assumed to be 4 kbps on both downlink and uplink. The uplink and downlink frequency for the primary spacecraft was assumed to be 440 MHz and 145 MHz, respectively. The uplink and downlink frequency for the dummy spacecraft was assumed to be 145 MHz and 440 MHz, respectively.

# Discussion/Results:

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| --- | --- | --- | --- | --- |
|  | Primary S/C | | Dummy S/C | |
| Antennas | Uplink | Downlink | Uplink | Downlink |
| Monopole | 72.491 | 51.263 | 65.243 | 72.491 |
| Dipole | 81.291 | 64.663 | 78.643 | 81.291 |
| Canted Turnstile | 81.291 | 64.363 | 78.343 | 81.291 |

For standard operations inter-satellite communication will not be a problem. These numbers show that there is plenty of margin in the link. The maximum distance before bit errors became a problem was from 2,000 kilometers to 59,000 kilometers depending on the antenna. The spacecraft finding each other with GPS should not be difficult if they travel far apart. There is not a noticeable difference between the dipole and the canted turnstile antenna this likely due to them sharing similar architecture.

For standard operations inter-satellite communication will not be a problem. These numbers show that there is plenty of margin in the link. Worst case scenarios were not looked, but there is plenty of margin for the two spacecraft to get far apart. There is not a noticeable difference between the dipole and the canted turnstile antenna this likely due to them sharing similar architecture.