# TELECOMMUNICATION SUBSYSTEM FOR THE LEONIDAS MICROSATELLITE

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## ABSTRACT

An S-Band Telecommunication Subsystem of a microsatellite is researched, analyzed, and planned. The Low Earth Orbit Nanosatellite Integrated Distributed Alert System (LEONIDAS) project will need a Telecommunication Subsystem in order to have a communication link between the spacecraft and the ground station. Also, the spacecraft will have an Ultra High Frequency (UHF) secondary Telecommunication Subsystem that will serve as a redundancy and a back up. The University of Hawaii at Manoa (UHM) has an X-Band ground station that will be formatted into S-Band for communicating with the microsatellite in orbit.

## INTRODUCTION

The LEONIDAS project will assemble a Low Earth Orbiting (LEO) microsatellite. Currently the LEONIDAS team consists of nine mechanical and electrical engineering students. Each student is a lead in there own specified subsystem such as: systems, payloads, command and data handling (C&DH), telecommunications, attitude and control system (ACS), power, thermal, orbits, and structure. The satellite will be assembled with components off the shelf (COTS). The integration of the subsystems to coincide with one another will be very crucial to our success.

Hawaii has the capabilities and the facilities to manufacture, integrate and test space flight hardware. Also, the cost of a microsatellite is approximately 1% of manufacturing and launching large satellites, which is over $300 M. Since 2002, the LEONIDAS project has been working on building a microsatellite as an engineering demonstration for the University of Hawaii. It will give students a great learning experience on space technology and the process on how to build a spacecraft. Students will gain networking skills, communication skills, and the experience in working in an engineering team effort environment.

## BLOCK DIAGRAM

The Telecommunication Subsystem provides a communication link between the spacecraft and the ground station, using S-Band and UHF frequencies. Figure 1 illustrates a block diagram of the Telecommunication Subsystem. It includes an S-band transmitter, S-band receiver, S-band antenna, UHF antenna, UHF transceiver, and a Terminal Node Controller (TNC).

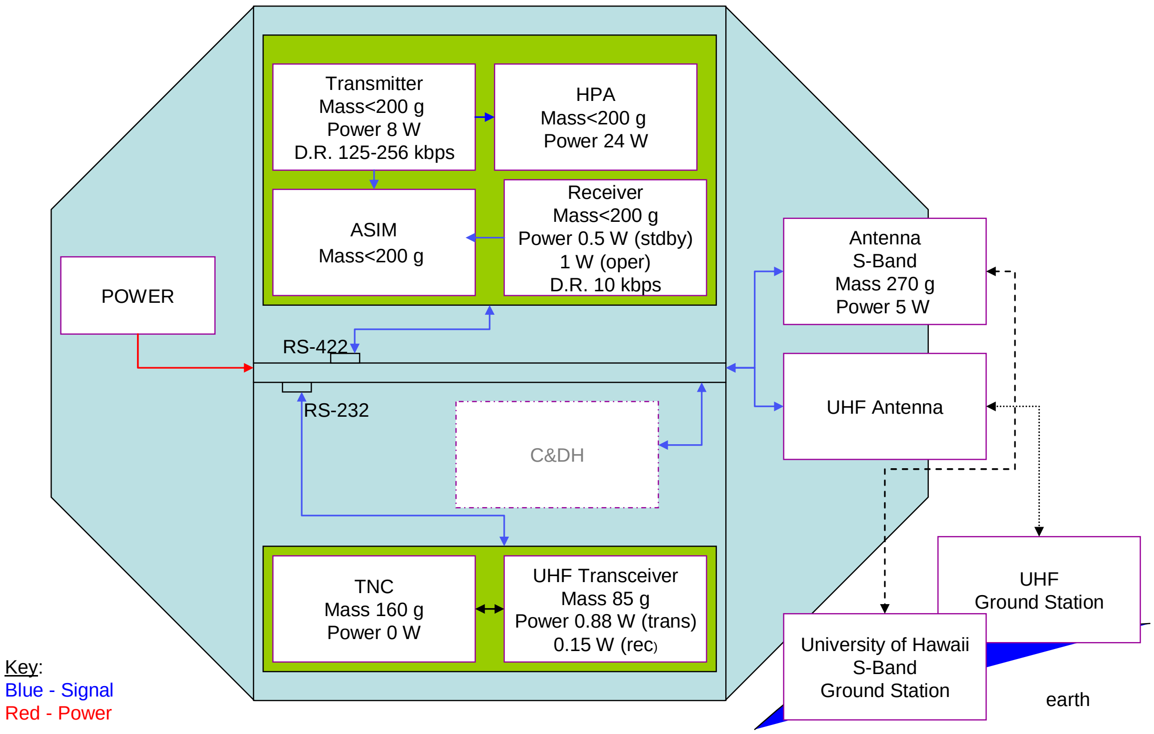


Figure 1: Telecommunication Subsystem Block Diagram

## S-BAND

There are four components that make up the S-Band subsystem. It includes an Appliqué Sensor Interface Module (ASIM), a High Power Amplifier (HPA), a transmitter, and a receiver developed by AeroAstro. It is connected with an RS-422 interface to the interface board which then routes to the Command and Data Handling (C&DH) Subsystem. Also, the components are then connected to the S-Band Antenna by Antcom that is placed on the outer surface of the spacecraft. The data that is compiled from the C&DH Subsystem is sent to the transmitter. This is where the data is then modulated onto a carrier. The transmitter has an output data rate of 125-256 kbps that will route the data to the antenna where it will radiate to the ground station. The ground station will be able to receive spacecraft telemetry and send command data to the spacecraft. This frequency signal will enter through the antenna and to the receiver that has an input data rate of 10 kbps. It will demodulate the frequency signal and route the data to the C&DH Subsystem. The reason in having an S-Band rather than an X-Band subsystem is to eliminate interference because there is a heavy exploit of X-Band in Hawaii due to military usage.

## UHF

Separately, the Alinco DJ-C5T UHF transceiver built by Yaesu Company is connected to the TNC by PacComm. It is connected with an RS-232 interface to the interface board which then routes to the C&DH Subsystem. Also, the components are then connected to a UHF antenna that is placed on the outer surface of the spacecraft. This is a second Telecommunication Subsystem that will act as a redundancy and a back up in the situation when or if the S-Band subsystem fails.

## REQUIREMENTS

The Telecommunication Subsystem has a set of requirements that has to be met in order to function well with the other subsystems in the spacecraft. Table 1 states the Telecommunication Subsystem requirements.

Table 1: Telecommunication Subsystem Requirements

| **REQUIREMENTS** | |
|---|---|
| Volume | 20 cm x 27 cm x 11 cm |
| Power Budget | 40 W + 2 W |
| Mass Budget | 2.5 kg + 0.5 kg |
| Frequency | S-Band (2.0-4.0 GHz) |
| Altitude | 300-400 km |
| Lifetime | 6 months |

## SPECIFICATIONS

The S-Band Telecommunication Subsystem has a volume, power consumption, mass, and frequency that accommodate the requirements. The power describes the power assumption during the transmitting operation and the receiving operation phases. Also, with the UHF transceiver, it shows its power assumption during its transmitting and receiving operation.

Table 2: Telecommunication Subsystem Specifications

| **SPECIFICATIONS** | |
|---|---|
| Volume | 8.9 cm x 5.1 cm x 2.5 cm (each module) x3 |
| Power | Transmitting Operation: 37.5 W<br>Receiving Operation: 6 W<br>Transmitting with UHF Transceiver Operation: 1.42 W<br>Receiving with UHF Transceiver Operation: 0.69 W |
| Mass | Less than 1.341 kg |
| Frequency | S-Band (2.0-4.0 GHz) |

## LINK BUDGET

A link budget of the Telecommunication Subsystem is calculated with a radio link budget calculator (Shown in figure 2). The white boxed values are the inputs that were given and researched. The green boxed values are the outputs that were calculated. This is in the case of working at S-Band, specifically at a frequency of 2.4 GHz.

| | |
|---|---|
| Frequency GHz | 2.4 |
| Transmit antenna diameter m | .663 |
| Transmit antenna aperture efficiency e.g. 0.65 | .85 |
| Transmit antenna transmit gain dBi | 23.72 |
| Transmit antenna, power at the feed W | 35 |
| Transmit EIRP dBW | 39.16 |
| Range km | 400 |
| Path (spreading) loss dB | 152.0 |
| Power flux density at receive end dBW/m^2 | -83.87 |
| Bandwidth Hz | 22000000 |
| Receive antenna diameter m | 5 |
| Receive antenna aperture efficiency e.g. 0.65 | .65 |
| Receive system noise temperature (antenna+LNA) K | 300 |
| Signal power at output of receive antenna dBm | -40.941309 |
| Receiver sensitivity (see manufacturer spec e.g -80 dBm) | -80 |
| Receive margin dB (0-5dB=marginal, 10-15dB=good) | 39.058690 |
| Receive antenna gain dBi | 40.113323 |
| Receive G/T dB/K | 15.342110 |
| Link C/N dB | 57.59 |

Figure 2: Link Budget Calculator

## COST ANALYSIS

A cost analysis on the Telecommunication Subsystem components is given in Table 3. This is to accommodate the cost budget that is given for the LEONIDAS project, specifically the Telecommunication Subsystem.

Table 3: Cost of Components

| COST ANALYSIS | |
|---|---|
| S-Band Transceiver | $150,000.00 |
| S-Band Antenna | $540.00 |
| UHF Transceiver | $150.00 |
| TNC | $179.00 |
| **Total** | **$150,869.00** |

## GROUND STATION

LEONIDAS has an S-Band (2.0-4.0 GHz) subsystem with an X-Band (7.0-12.5 GHz) ground station associated with Dr. Torben Nielsen. He said the ground station is a 5-m Cassegrain system with a G/T of 32 dB/K in X-Band and that it is also equipped with a parasitic S/L-Band feed. The 5-m Cassegrain system is fitted with an S-Band parasitic feed where the gain is more than enough for this mission.

## CONCLUSION

The S-Band Telecommunication Subsystem of the microsatellite is qualified for this mission. The Subsystems volume that occupies the spacecraft will be adequate. The mass and power allocated for the subsystem is accommodated. The cost analysis has a reasonable amount for funding and the link budget associated with the ground station is sufficed. The Telecommunication Subsystem will serve its purpose in having a communication link between the spacecraft and the ground station.

## ACKNOWLEDGMENTS

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