GEORGIA INSTITUTE OF TECHNOLOGY

Excerpts from Telecommunications System Design Document

Team RECONSO

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Georgia Institute of Technology

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NOMENCLATURE

Astrodev – Astronautical Development, LLC

COM – Telecommunications subsystem

E_b/N_0 – Ratio of received energy-per-bit to noise density

FCC – Federal Communications Commission

LEO – Low Earth orbit

NUG – Nanosat user guide

RF – Radio frequency

SNR – Signal to noise ratio

Tyvak – Tyvak Nano-Satellite Systems, LLC

UHF – Ultra high frequency

VHF – Very high frequency

1. PROJECT OVERVIEW

1.1. INTRODUCTION

RECONnaissance of Space Objects (RECONSO) is a student-led cubesat participant in the current University Nanosatellite Program (UNP-8) competition supported by the Air Force Office of Scientific Research (AFOSR). RECONSO will place an optical payload in Low Earth Orbit (LEO) to enable low-cost unqueued space object detection and tracking. Inertial bearing and apparent magnitude measurement will be processed on-board and downlinked to Georgia Tech for further processing and distribution. This data will directly support efforts to mitigate the threat of space debris to national and international space assets by supplementing existing Space Surveillance Network (SSN) sensors.

1.2. SUBSYSTEM INTRODUCTION

The primary goal of the telecommunications (COM) subsystem is to downlink the information gathered by the spacecraft and uplink all necessary commands and other information to the spacecraft from the ground station. The link must have a strong enough signal to noise ratio and a high enough data rate to transmit the data recorded by the spacecraft. In its current configuration, the COM subsystem consists of an Astronautical Development, LLC (Astrodev) Beryllium 1 S-Band Transmitter, S-Band Patch Antenna, and S-Band Bi-Directional Amplifier for the downlink and a Tyvak Nano-Satellite Systems, LLC (Tyvak) UHF Radio Flight Unit with a to be determined deployable UHF antenna system for the uplink. This living document will be continuously updated to reflect to reflect the current status of the COM subsystem.

1.3. APPLICABLE REQUIREMENTS

The telecommunications subsystem requirements are described below in Table 1. This document will be continuously updated throughout the design process to reflect the manner in which these requirements are satisfied.

TABLE 1: TELECOM SUBSYSTEM REQUIREMENTS

COM	Telecommunications Subsystem	
COM-1	The telecom subsystem shall provide bi-directional communication between RECONSO and the Georgia Tech Ground Station, or other authorized ground stations.	MO-4
COM-2	The telecom subsystem shall downlink object bearings, engineering data, telemetry data, and health information to the Georgia Tech Ground Station	MO-4
COM-2.1	The telecom subsystem shall be capable of downlink speeds of at least 9600 baud	COM-2
COM-2.2	The telecom subsystem shall use any extra bandwidth to downlink images from the visible imager payload to the Georgia Tech Ground Station	COM-2
COM-2.3	The telecom subsystem shall maintain a link margin of at least 6dB.	COM-2
COM-3	The telecom subsystem shall receive commands only from the Georgia Tech Ground Station	MO-4
COM-4	All communication shall abide by ITU and FCC regulations. The RECONSO team shall obtain the necessary spectrum licenses for operating its space segment radio communication equipment prior to FCR	NUG-6.7

1.4. SYSTEM DESIGN

The COM system consists of two additional subsystems: the uplink and downlink. In its current form, the uplink consists of a UHF transceiver and a yet to be determined deployable antenna system on the spacecraft and the downlink consists of an S-band transmitter, power amplifier, and patch antenna.

Transmitters/Transceivers

To accomplish the requirements outlined in Table 1, different combinations of transmitters and transceivers have been considered. The current design was motivated by two driving characteristics: 1. The Georgia Tech ground station solely receives on S-band and transmits on UHF frequencies, and 2. An S-band transmitter is necessary to achieve a high enough data rate to transfer large quantities of data, including pictures, from the spacecraft to the Georgia Tech ground station. Moreover, due to commercial availability of transmitters/transceivers, we have specified that the downlink will comprise an S-band transmitter while the uplink will comprise a UHF transceiver operating in a receive-only mode.

A patch antenna will be coupled to the S-band transmitter/amplifier in order to maximize the signal strength and data rate between the spacecraft and the ground station. In its current configuration, the aforementioned S-Band transmitter and power amplifier will be coupled to an Astrodev S-Band Patch Antenna. This antenna was selected due to its high gain, low cost, and its ease of integration with the chosen S-Band transmitter. Furthermore, certain aspects of this antenna, including the polarization and mounting substrate, will be customized to meet our mission's needs. Moreover, this antenna was selected primarily due to its high antenna gain, low cost, and more importantly, its ease of integration with the chosen S-band transmitter. The current iteration of the RECONSO link budgets validates the usability of these selections to meet the COM requirements.

1.4.1. TRADE STUDY 1: RADIO FREQUENCY (RF) BAND

The first trade study for the COM subsystem analyzes different commercially available RF bands. The most common RF bands for small satellites are S-band and VHF/UHF, both of which have an assortment of available commercial components. Table 4 is a brief comparison of these two RF bands.

TABLE 4: RF BAND TRADE STUDY

	VHF/UHF	**S-band**
Frequency Range (MHz)	0.3-300	2000-4000
Power Required	Low power for antennas and transceivers	Transmitters have high power requirements
Link Data Transmission Rate	Up to 200 kbps	Up to 2000 kbps
Modulation schemes available	Transceiver dependent	Transceiver dependent
Losses	Lower frequency results in rain/weather losses	Very small losses due to weather
Cost	Transceivers generally less expensive than S-band transmitters	Components more expensive than VHF/UHF equipment; transmitters and receivers are usually separate so two components must be purchased
Licensing	Depends upon chosen frequency	Requires mandatory FCC license to test and operate

The single most important parameter driving the selection of the RF band was compatibility with the Georgia Tech ground station, which only transmits in UHF and receives in S-Band frequencies. This has the added side effect of resulting in higher available link data transmission rates. As a byproduct of selecting an S-Band frequency, the RECONSO mission will need to acquire an experimental FCC license in order to operate our selected radio equipment

for both testing and during the actual mission.