Team Bravo Request for Proposal
Saint Louis University

<u>by</u>

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1. Mission Introduction

Team Bravo is requesting proposals for a mission consisting of a CubeSat-Class satellite system that is capable of demonstrating three key proximity operations relative to a resident space object: stationkeeping, "escape" maneuvers, and rendezvous. Table 1-1 lists the definition of each of these proximity operation terms, while the Appendix discusses in detail general terms associated with any CubeSat mission.

Table 1-1. Key Proximity Operations Definitions

Proximity Operation Terms	Definition
Stationkeeping	Maintaining a set relative displacement between two space objects for a period of several orbits
"Escape" Maneuver	Performing an orbital maneuver that increases the relative displacement between two space objects, as to avoid on-orbit collisions and potential orbital debris creation.
Rendezvous	Performing an orbital maneuver that decreases the relative displacement between two space objects within a set distance for a period of several orbits.
Resident Space Object	Any satellite or space debris residing in an orbit around the Earth.

Along with performing each of the above proximity operations, the proposed mission has several other limits on its successful implementation, as listed in Table 1-2 below. These constraints are associated with the launch capabilities of current launch providers (Such as Space X, Orbital Science, United Launch Alliance, etc.), past CubeSat launch history, a required 25 year mission deorbit time (As specified in the *NASA-STD-8719.14A* Document) and standard specifications laid out in Revision 12 of the *CubeSat Design Specification* (CDS) document issued by California Polytechnic State University's CubeSat Program, the current authority on CubeSat mission launch integration.

Table 1-2. Mission Constraint Definitions

Mission Constraint	Definition
Lifetime	The amount of time required to successfully execute each of the proposed mission goals.
Orbit Range	The orbit range over which the mission goals can be met while the mission is able to De-Orbit within a 25 year time period.
Launch Survival	The successful survival of the mission in a given launch environment.
Thermal Operational Range	The successful operation of the mission between maximum and minimum temperature values.
Mass	The maximum mass that the mission can have, as specified in the CDS document.

Based on these definitions, each particular constraint can be specified as follows:

▪ To accomplish all of the mission goals, it is reasonable to set a minimum mission lifetime of six months.

▪ A minimum orbit of 400 km can be set based on a 6 month mission lifetime. An upper orbit bound of 575 km can be set based on meeting the 25 year deorbit requirement.

▪ The standard method of verifying that a particular satellite can survive its launch environment is to subject it to random vibration testing. Since the final launch provider for the proposed mission is unknown, a standard vibration profiles must be used that accounts for any current launcher, such as the NASA GEVS (General Environmental Verification Standard) qualification profile, as defined in Revision A of the *GSFC-STD-7000* document.

▪ Based on previous spacecraft mission on-orbit temperature data, the operational temperature range over which the proposed mission can be set as -20 ⁰C to 70 ⁰C.

▪ Finally, a maximum mission mass of 8 kg can be set, as defined within the CDS document.

These mission constraints are summarized in Table 1-3 below:

Table 1-3. Proposed Mission Constraints

Mission Lifetime	Orbit Range	System Size	Launch Survival Verification	Operational Temperature Range	System Mass
6 Months	400-575 km	6U	NASA GEVS Qualification Random Vibration Profile	-20 ^{o}C to 70 ^{o}C	8 kg

2. Mission Overview

With the constraints discussed in the previous section in mind, the objective and success criteria of the proposed mission can be defined as follows:

2.1. Mission Objective

The proposed mission shall demonstrate proximity operations and rendezvous within a 6U spacecraft architecture.

2.2. Mission Success Criteria

The proposed mission shall demonstrate:

1. Stationkeeping within a 10-75 m sphere of a resident space object for at least 5 orbits.

2. An "Escape" Maneuver by performing an orbital maneuver that intentionally increases the final relative displacement between the mission spacecraft and a resident space object to at least 100 meters in a maximum time of 1 orbit.

3. Rendezvous by performing an orbital maneuver that intentionally decreases the final relative displacement between the mission spacecraft and a resident space object to within 50 m for a period of time of at least 5 orbits.

3. Appendix

It is important to establish the meanings of various terms that are associated with any given CubeSat mission, such as the one proposed in this document. Firstly, 1U, or one standard unit, is defined as a cube of a uniform edge length of 10 cm. A CubeSat-Class satellite (aka a "nanosatellite") is a satellite whose dimensions derive from 1 or more of these standard units. An example of a 3U sized spacecraft is shown in Figure 1-1 below. The reason for creating such satellites is twofold: it greatly reduces the time and monetary investment associated with developing custom satellite shapes and structures, while also allowing the development of standard satellite deployers for integration into any rocket configuration, thus allowing greater access to launch opportunities for university missions. Currently, the largest volume CubeSat deployer is the NLAS (Nanosatellite Launch Adapter System) deployer, which has space for a 6U satellite configuration.
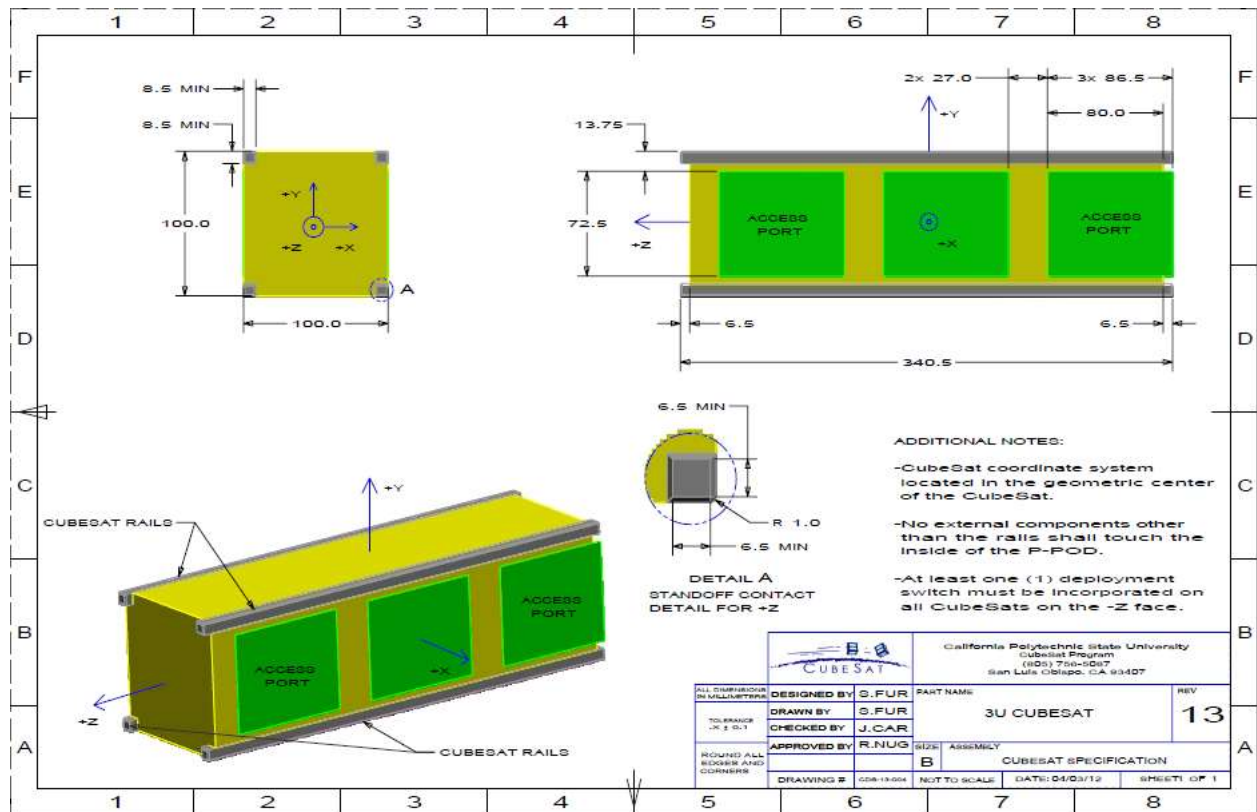

Figure 3-1. Example 3U CubeSat Architecture