Rascal Requirements Verification Document

Saint Louis University

Rascal



Last Updated: 11/9/13

Document No: RCL-O-CMQA1

Copper Operational

Test Plan

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**Revisions Summary**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Revision** | **Description** | **Date** | **Prepared by** | **Approved by** |
| **-** | Description | 9/12/2013 | Insert Name Here | Insert Name Here |
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# INTRODUCTION

The Rascal Requirements Verification Document serves to define and elaborate on each of the requirements laid out in the RCL-RVM-CMQA1 Rascal Requirements Verification Matrix (RVM), as well as the ways in which each of said requirements will be validated prior to and during the Rascal mission.

The Rascal Mission, as defined by the RVM, can be broken down into Six Stages, with each stage having a set of requirements directly associated with it. Within the requirements associated with each of these stages are sub-requirements associated with a particular subsystem of the Rascal CubeSat system. The manner in which each of these requirements is associated with a particular stage or subsystem is with a simple notation scheme, as shown in Table 1-1.

**Table 1-1. RVM Requirement Notation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Mission Identifier** | **Stage Identifier** | **Sub-System Identifier** | **Requirement Number** |
| RCL | Pre Launch (PL) | Structures (STR) | Number Order |
| Post Launch Ejection (PLE) | Thermal (THM) |
| Separation and Stabilization (SS) | Propulsion (PRP) |
| Stationkeeping (SK) | Testing (TST) |
| “Escape” (ESC) | Mission Operations (MOP) |
| Rendezvous (RDZ) | Payload (PLD) |
| **Example** | **RCL.PL.STR1 (1st Pre-Launch Structures Requirement)** | | |

Ultimately, the goal of this document is to provide a specific rubric from which to develop the Rascal mission such that it meets all of the design constraints and mission success criteria laid out in the RCL-P-CMQA2 Rascal Request for Proposal document. Thus, if the designed mission meets all of the requirements laid out in this document, it can be considered to have successfully executed the Rascal mission as a whole.

# NOMENCLATURE

*RVM* Requirements Verification Matrix

*RFP* Request for Proposal

*SSRL* Space Systems Research Lab

*PL* Pre-Launch

*PLE* Post-Launch Ejection

*SS* Separation and Stabilization

*SK* Stationkeeping

*ESC* “Escape”

*RDZ* Rendezvous

*STR* Structures Subsystem

*THM* Thermal Subsystem

*PLD* Payload Subsystem

*PRP* Propulsion Subsystem

*TST* Testing Subsystem

*MOP* Mission Operations Subsystem

*CMQA* Configuration, Management, and Quality Assurance Subsystem

*U* Standard Unit (10 cm x 10 cm x 10 cm)

*Jade* Sub-Satellite of Rascal System #1

*Ruby* Sub-Satellite of Rascal System #2

*GEVS* General Environmental Verification Specification

*NASA* National Aeronautics and Space Administration

*RF* Radio Frequency Communication

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# REQUIREMENT STAGES

# Pre-Launch Requirements

1. **The Total CubeSat System Volume Shall Not Exceed 6U**

This requirement comes from the Team Bravo RFP (RCL-P-CMQA2) section 2.1 Mission Objective. The spacecraft will demonstrate proximity operations and rendezvous within a 6U spacecraft architecture. This requirement will be satisfied by complying with the CubeSat Design Specifications document, Rev 12, section 2.2 Mechanical Requirements.

1. **The Total CubeSat System Mass Shall Not Exceed 8.0 kg**

This requirement comes from the CubeSat Design Specification document, Rev 12, section 2.2.16 mass definition for 3U CubeSats. This requirement will be satisfied by weighing the completed spacecraft prior to integration with the deployer to ensure that it masses less than 8.0 kg.

1. **All Materials Used in the CubeSat System shall have a Total Mass Loss of Less Than 1.0%**

This requirement comes from the CubeSat Design Specification document, Rev 12, section 2.1.7.1. The spacecraft must satisfy all low-outgassing criteria to prevent contamination of other spacecraft and the launch vehicle during testing, integration, and launch. This requirement will be satisfied by using only materials found on the NASA approved list at http://outgassing.nasa.gov.

1. **All Materials Used in the CubeSat System Shall Have a Collected Volatile Condensable Material of less than 0.1%**

This requirement comes from the CubeSat Design Specifications document, Rev 12, section 2.1.7.2. The spacecraft must satisfy all low-outgassing criteria to prevent contamination of other spacecraft and the launch vehicle during testing, integration, and launch. This requirement will be satisfied by using only materials found on the NASA approved list at http://outgassing.nasa.gov.

1. **The CubeSat System Must be in Orbit for at Least 6 Months**

This requirement comes from the Team Bravo RFP (RCL-P-CMQA2) Table 1-2 Proposed Mission Constraints. This requirement will be satisfied by constructing an accurate power budget, performing a battery cycle test to ensure that the batteries can charge and discharge correctly, performing a day-in-the-life test to verify the accuracy of the power budget, performing a solar panel charge test to verify that the solar panels are performing as designed and can charge the batteries, and performing a solar cell degradation analysis to determine how quickly the solar cells will degrade due to radiation damage and determine how much power margin remains after six months of operation.

1. **The CubeSat System Must Deorbit within 25 Years of being Launched**

This requirement comes from the CubeSat Design Specifications document, Rev 12, section 2.4.5. All spacecraft components must deorbit within 25 years of being launched. This requirement will be satisfied by performing an orbital analysis using orbital parameters provided by the launch provider to calculate the orbital lifetime of the spacecraft.

1. **Jade and Ruby Shall be Conjoined Prior to Launch Vehicle Integration**

This requirement comes from RCL.STR.RVM1, which constrains the system to a 6U volume. This constraint effectively rules out conducting the mission with a previously space-borne object as the rendezvous target. Because the target vehicle must be incorporated into the 6U volume, it is necessary that the two spacecraft be securely conjoined prior to launch vehicle integration. This requirement will be satisfied by conducting an integrated vibration test as noted in requirement RCL-TST-RVM1 and separation test as noted in requirement RCL-STR-RVM16.

1. **The CubeSat System Shall Incorporate a Deployment Switch**

This requirement comes from the CubeSat Design Specifications document, Rev 12, section 2.3.4. The Remove Before Flight (RBF) pin cuts off all power when inserted by physically separating the batteries from the rest of the spacecraft and must be accessible from the deployer’s access points as shown in Figure 3-1 of the Team Bravo RFP (RCL-P-CMQA2). This is done so that the spacecraft is not active during testing and integration.

1. **No Protrusion Shall Extend beyond 6.5 mm Normal to Any External Surface of Jade or Ruby**
2. **No External Components Other than the CubeSat Rails of Jade and Ruby may make Contact with the Deployer**
3. **The Deployer Shall not be Used to Secure Any CubeSat Deployables**
4. **The Center of Gravity of the total CubeSat System Shall be Located within a Sphere of 2 cm of the Geometric Center of the System**
5. **The Center of Gravity of Jade and Ruby Shall be Located within a Sphere of 2 cm of their Geometric Center**
6. **The CubeSat System Coordinate System Shall be Defined As Specified in Figure 1-1**
7. **The Local Coordinate System of Jade and Ruby Shall be Defined as Specified in Figure 1-1**
8. **The Ends of the Rails on the +Z/-Z Faces of the CubeSat System Shall have a Minimum Surface Area of 6.5 mm x 6.5 mm**
9. **The +Y/-Y Faces of Ruby and Jade Shall have a Length of 100 mm**
10. **Jade and Ruby Shall be Capable of Determining Relative Displacement between Each Other**
11. **The CubeSat System Shall be Capable of Recording Relative Displacement Data between Jade and Ruby**
12. **Low Friction, 2D Testing of the CubeSat System Release Mechanism Shall be Conducted**
13. **All Pressure Vessels Shall have a Factor of Safety of No Less Than 4**
14. **All CubeSat Components Shall be Rated to Operate within Temperature Range of at least -20⁰C to 70 ⁰C**
15. **Static Thrust Testing Shall be Performed with the Flight Version of All Pressure Vessels at a Pressure No Greater than 1x10-4 Torr Prior to CubeSat Integration**
16. **All Pressure Vessels Must Pass Thermal Cycle Testing between Temperatures of -30 ⁰C and 70 ⁰C for at Least Two Cycles or for 10 Hours**
17. **Low Friction, 2-D Dynamic Thrust Testing Shall be Conducted with All Pressure Vessels**
18. **The CubeSat System Must Survive Random Vibration Testing Relative to the NASA GEVS Qualification Profile**
19. **The CubeSat System Shall be Subjected to a Temperature of 60 ⁰C at a Pressure No Greater than 1x10-4 Torr for a Minimum of 6 Hours**
20. **The CubeSat System Shall be Able to Execute All Commands Associated with its Operation over RF**
21. **The CubeSat System Shall be Able to Close a Link with the SSRL Ground Station from a Distance of at least 200 meters**
22. **The CubeSat System Shall be able to Document the Functionality of Each of its Subsystems through the Running of a Full-Functional Test**

# Post-Launch Ejection Requirements

1. **The CubeSat System Shall not Broadcast in RF Until Ejection +45 Minutes**
2. **The CubeSat System Shall not Release Deployables Until Ejection +45 Minutes**
3. **The CubeSat System Shall Establish Communication Between Itself and the SSRL Ground Station**
4. **The CubeSat System Shall Pass a Health Check Administered from the SSRL Ground Station**

# Separation and Stabilization Requirements

1. **Jade and Ruby Shall be Capable of Separating from One Another with a Relative Velocity of No Greater than 5 cm/s**
2. **Jade and Ruby Shall Achieve a Local Slew Rate of Less than 1 deg/s**
3. **Jade and Ruby Shall Continuously Record Relative Displacement Data Between Each Other**

# Stationkeeping Requirements

1. **Jade and Ruby Shall be Able to Stationkeep within a 10-75 meter Sphere of Each Other for at Least 5 Orbits**

# “Escape” Requirements

1. **Jade and Ruby Shall be Able to Perform an “Escape” Maneuver that Increases the Relative Displacement Between Each Other to at Least 100 Meters within 1 Orbit**

# Rendezvous Requirements

1. **Jade and Ruby Shall be Able to Perform a Rendezvous by Decreasing the Relative Displacement Between Each Other to Within 50 meters for at Least 5 Orbits**