

**Rascal**

Mission Overview Document

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# Executive Summary

Rascal’s mission is to demonstrate proximity operations within a small satellite architecture, including stationkeeping, “Escape”, and rendezvous.

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# Program Introduction

Rascal is a spacecraft mission that seeks to demonstrate the performance of in-orbit proximity operations within a small spacecraft architecture. Proximity operations are defined as the performance of orbital maneuvers, such as Stationkeeping, Rendezvous, and Collision Avoidance, relative to a resident space object (As Defined in Table 1-1).

**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 |
| Collision Avoidance | 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 object residing in space |

Proximity operations have been designated by the NASA Innovative Advanced Concepts (NSPIRES) program as one of many transformative ideas that will help enable new aeronautics and space systems capabilities[[1]](#footnote-1). If successful in demonstrating the performance of such operations, Rascal would act as a stepping stone to future development and refinement of the technologies and processes involved with the performance of proximity operations, potentially leading to the creation of small satellites that are capable of inspecting, or even repairing, damaged satellites or crew capsules, saving millions of dollars and man hours associated with the replacement of said systems that would normally have no cost-effective means of being repaired in-orbit.

This document serves to elaborate on the relevance and feasibility of proximity operations demonstrations for small spacecraft from historical, analytical, and operational perspectives, as well as outline the mission requirements, success criteria, and design flow-downs for the Rascal mission itself.

# Mission Relevance and Justification

## Relation to NASA Objectives

## Proximity Operation Mission History

## Related Activity in Proximity Operations

# Mission Objectives

## Baseline Mission

## Success Criteria

# Requirements Verification

## Rationale and Taxonomy

Requirements Verification is the method of verifying that mission success has been fully met by a given mission. This mission success is determined by the ability of a mission developer’s design to meet a checklist of primary requirements that have been issued by a potential customer (Such as NASA, Boeing, the DoD, Etc). If these top-level mission requirements are not met, it is within the customer’s judgment to determine whether or not their requirements were too strict, their desired mission is too impractical, or if their selection of mission developer is at fault. If it is the latter case, it is within the potential customer’s power to part ways with the mission developer, thus making any effort that went into the development of the mission a waste of time, money, and resources.

Hence, one of the most important portions of the preliminary stages of spacecraft mission design is properly defining mission requirements. In the case of the Rascal mission, the main source of these requirements is the Team Bravo Request for Proposal (RFP). This document describes both the type of mission that is to be attempted, as well as the success criteria associated with said mission, and thus is the main driver of mission design going forward. Implicit in these requirements is the need to remotely verify their successful completion when it comes time for the actual mission; otherwise the relevance of the Rascal mission would be moot and the rationale for its launch would be non-existent. Finally, even if the Rascal mission is designed to meet all of these requirements, and can demonstrate as much, it would be completely unreasonable for said mission to take an extended amount of time to be completed. The longer a mission takes to run out, the more resources have to be utilized in its operation and the more likely that it will experience a failure before mission success can be met. Thus, mission lifetime is a key factor in defining the mission success as a whole.

## Mission Constraints

### Launch Vehicle Integration (Volume)

### Cost

### Mission Lifetime

### Mission Success Verification

### Mission Development Experience

## Requirements Verification Matrix

| **Requirement** | **Verification Method(s)** | | | | **Rationale** | **Requirement Designation** |
| --- | --- | --- | --- | --- | --- | --- |
| **Test** | **Analysis** | **Demo** | **Examine** |
| Primary Requirements |  |  |  |  |  |  |
| The mission will be executed by a spacecraft |  |  |  |  | RFP Requirement | RCL-RFP1 |
| The mission must be capable of demonstrating station keeping within a 50 meter sphere of a resident space object for at least 5 orbits | x | x | x |  | RFP Requirement | RCL-RFP2 |
| The mission must be capable of demonstrating a Collision Avoidance maneuver by intentionally increasing the relative distance between it and a relative space object to at least 100 meters within one orbit | x | x | x |  | RFP Requirement | RCL-RFP3 |
| The mission shall be capable of demonstrating rendezvous with by intentionally reducing the distance between it and a resident space object to at most 50 meters for at least 5 orbits | x | x | x |  | RFP Requirement | RCL-RFP4 |
| A method of verifying the successful completion of each mission requirement shall be incorporated into the spacecraft design and mission operations procedures | x | x | x |  | Mission Operations Requirement | RCL-MOP1 |
| The spacecraft mission shall be executed within 6 months of spacecraft launch | x | x | x |  | Mission Operations Requirement | RCL-MOP2 |
| Primary Sub-Requirements |  |  |  |  |  |  |
| The spacecraft must be capable of determining relative distance between it and a resident space object | x | x | x |  | RCL-MOP1 | RCL-MOP1-1 |
| The spacecraft must be capable of recording relative distance between it and a resident space object | x | x | x |  | RCL-MOP1 | RCL-MOP1-2 |
| The spacecraft must be capable of relaying relative distance between it and a resident space object to the ground | x | x | x |  | RCL-MOP1 | RCL-MOP1-3 |
| The spacecraft will utilize a Structures Subsystem | x | x | x | x | RCL-RFP1 | RCL-RFP1-STR |
| The spacecraft will utilize a Propulsion Subsystem | x | x | x | x | RCL-RFP(2-4) | RCL-RFP-PRP |
| The spacecraft will utilize a Power Subsystem | x | x | x | x | RCL-MOP2 | RCL-MOP2-PWR |
| The spacecraft will utilize an Attitude Determination and Control Subsystem | x | x | x | x | RCL-MOP1 | RCL-MOP1-ADC |
| The spacecraft will utilize a Command and Data Handling Subsystem | x | x | x | x | RCL-MOP1 | RCL-MOP1-CDH |
| The spacecraft will utilize a Communications Subsystem | x | x | x | x | RCL-MOP1 | RCL-MOP1-COM |
| Structures Requirements |  |  |  |  |  |  |
| The spacecraft will utilize the CubeSat standard architecture |  |  |  | x | Cost Constraint | RCL-STR-1 |
| The mission will consist of two 3U spacecraft |  |  |  | x | Launch Vehicle Integration Constraint | RCL-STR-2 |
| The two spacecraft must be able to integrate into the same dispenser |  |  | x |  | Risk Reduction | RCL-STR-3 |
| The two spacecraft will be conjoined for integration into dispenser | x |  | x | x | Risk Reduction | RCL-STR-4 |
| The two spacecraft will be capable of separating in orbit | x |  | x |  | RCL-RFP(2-4) | RCL-STR-5 |
| Power Requirements |  |  |  |  |  |  |
| The power subsystem will utilize an Electrical Power System to manager power distribution to each subsystem of the spacecraft |  |  |  | x | RCL-MOP2 | RCL-MOP2-PWR1 |
| The power subsystem will utilize a battery capable of powering each subsystem for the duration of the mission | x | x | x |  |  | RCL-MOP2-PWR2 |
| The power subsystem will utilize solar panels to generate a sufficient amount of power to compensate for the energy consumption of each subsystem of the spacecraft |  |  |  |  |  | RCL-MOP2-PWR3 |
| The ADC subsystem will be capable of autonomously commanding the propulsion system to perform the orbital maneuvers associated with the RFP requirements |  |  |  |  |  | RCL-MOP1-ADC1 |
| Propulsion Requirements |  |  |  |  |  |  |
| The propulsion subsystem will be capable of executing orbital maneuvers issued to it from the ADC subsystem |  |  |  |  |  | RCL-RFP-PRP1 |
| The communication subsystem will utilize a radio for transmitting data to the ground |  |  |  |  |  | RCL-MOP1-COM1 |
| A link budget will be created that ensures that the power level, frequency, and altitudes over which the spacecraft transmits data are sufficient to produce a signal to noise ratio on the ground that is greater than one |  |  |  |  |  | RCL-MOP1-COM2 |
| The Command and Data Handling subsystem will be capable of managing the operation of each subsystem of the spacecraft, as well as the communication of data between said subsystems |  |  |  |  |  | RCL-MOP1-CDH |

## Top Level Requirements

## Structures Requirements

## Power Requirements

## Attitude Determination and Control Requirements

## Propulsion Requirements

## Communication Requirements

## Command and Data Handling Requirements

# System Overview

# Subsystem Overview

## Structure

## Power

## Attitude Determination and Control

## Propulsion

## Communications

## Command and Data Handling

## Ground Operation

1. Weaver, David. "ASA Continues Implementation Of 2010 Authorization Act Program Offices, New Technology Solicitations Announced." *NASA*. NASA, 01 Mar. 2011. Web. 06 Dec. 2013. <http://www.nasa.gov/home/hqnews/2011/mar/HQ\_11-057\_Program\_Offices.html>. [↑](#footnote-ref-1)