Software Subsystem Test Design For RockSat-X Payload - Hephaestus

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Abstract

The Oregon State University (OSU) RockSat-X payload Hephaestus is a proof of concept for the construction of physical structures in space using a robotic arm. This document shall describe the experiments that will be used to test three of the functional requirements of the Hephaestus payload described in previous documents and reviewed briefly in this document.

The purpose of these experiements is to discover bugs in the software prior to system integration into the RockSat-X rocket. The experiments shall be performed throughout the implementation and integration phases of the payload development. The experiments shall constitute one third of the module tests and shall cover the requirements for target generation, arm movement, and arm position tracking.

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1 Introduction

This document is an initial design of the experiments that will be conducted in order the test the modules of the Hephaestus payload. The purpose of performing these tests is to discover bugs in the Software Subsystem prior to integration of the software with the hardware and electrical subsystems in the Hephaestus payload and to the integration of the payload with the 2017 RockSat-X rocket.

These experiments will constitute the module tests to be performed throughout the implementation and integration phases of the Hephaestus project. Data shall be collected from these experiements, which will provide a guide for fixing bugs and insuring that the payload operates within our desired parameters.

System and integration tests shall be performed to supplement these unit tests. In addition to these unit tests, unit tests shall be developed and performed for the six other functional requirements defined in the Technical Review Document.

1.1 Document Overview

This document includes an overview of the three functional requirements that will be tested. These requirements include target generation, arm movements, and arm position tracking. The requirements were defined in the Technical Review and Requirements Overview documents. They will be covered again in this document. Additionally, this document will describe the experiments that will be performed as tests. These descriptions will include the experiment's purpose, pre-conditions, post-conditions, tools required, method, and data. Finally, this document will include the inputs that will be used as test cases for the experiments.

2 Requirements Review

2.1 Target Generation

2.1.1 Description

Target points shall be generated in 3D Polar form. These points shall include an angle, radius, and height. The angle shall be measured from the normal vector, defined as the direction of payload deployment from the rocket body. The radius shall be measured in centimeters from the center of the mount point of the Hephaestus arm to the arm assembly body. The height shall be measured in centimeters above the arm assembly body platform.

The target points shall be the points that the Hephaestus arm attempts to touch during the experiment. These points will constitute the total on-orbit test of the Hephaestus arm and shall therefore be representative of the range of motion of the Hephaestus arm.

2.1.2 Requirements to be Tested

1. The targets generated are within the range of motion of the arm.
2. The targets are generated in 3D polar form.
3. The set of target generated is representative of the arm's abilities.

2.2 Arm Position Tracking

2.2.1 Description

The position of the arm shall be tracked and stored in 3D Polar Coordinates, as described above. The position of the arm following a motion will be calculated using the initial position of the arm and reverse kinematics. This means that the position will be calculated using the motion of the motors.

The position of the arm shall be reset periodically in order to limity the propagation of error over the course of the flight. This will be accomplished by returning to the initial position and resetting the position values to zero. The frequency with which the position is reset shall be determined by experiment. The position of the arm shall be denoted p and shall represent the location of the tip of the arm.

2.2.2 Requirements to be Tested

1. Determine the rate of deterioration of position accuracy as a function of time, number of operations performed, and distance traveled.
2. Determine the accuracy of the arm's location at a point.
3. Determine the accuracy of the calculation of the arm's current location by reverse kinematics.

2.3 Arm Movement

2.3.1 Description

The motions performed by the arm shall constitute the arm's functionality. The movement of the arm shall be determined by finding the most efficient path from $p_{current}$ and p_{target}. The efficiency of the path shall be determined by minimizing the rotation of the motors. The position of the arm shall be tracked as described in the previous subsection.

2.3.2 Requirements to be Tested

1. The path generated is the most efficient (as defined above) path.
2. The arm follows the path defined in (1).
3. The arm accurately moves to the target point.

3 Tests

3.1 Experiment 1: Accuracy of Stored Position at a Point

3.1.1 Purpose

3.1.2 Pre-Conditions

3.1.3 Post-Conditions

3.1.4 Tools

3.1.5 Method

3.1.6 Data

3.2 Experiment 2: Deterioration of Position Accuracy Over Course of Flight

3.2.1 Purpose

3.2.2 Pre-Conditions

3.2.3 Post-Conditions

3.2.4 Tools

3.2.5 Method

3.2.6 Data

3.3 Experiment 3: Validation of Path Efficiency

3.3.1 Purpose

3.3.2 Pre-Conditions

3.3.3 Post-Conditions

3.3.4 Tools

3.3.5 Method

3.3.6 Data

3.4 Experiment 4:

3.4.1 Purpose

3.4.2 Pre-Conditions

3.4.3 Post-Conditions

3.4.4 Tools