Spacecraft Control Center Training and Testing Environment

Product Description:

Capstone Project

Fall 2022

Draft

October 10, 2022

Customer: Prof Laskey (Applied Aviation – Space Flight Ops)

Product Owner: Prof Garfield (EECS – Comp Science)

Scrum Team:

# Overview:

Many people are familiar with the iconic photographs of NAS and NASA-contracted engineers sitting at consoles during the launch of space flight vehicles, or interacting with the International Space Station (ISS) from the control center in Houston, TX. This project will create a small-scale simulated version of a control center for use in testing and training of students in the Space Flight Operations degree program at Embry-Riddle Aeronautical University, Daytona Beach (ERAU-DB) campus. The simulated Spacecraft Control Center (SCC) Testing and Training Environment (TTE) will allow students to monitor and control individual systems within a simulated spacecraft in order to learn through hands-on experience the techniques and challenges of console operations. The simulated system will allow a test conductor to present the console team with off-nominal spacecraft behavior to give students practice in trouble-shooting and recovering from vehicle component deviations and failures.

Members of the control team will rehearse specific scenarios representing typical spacecraft housekeeping or mission functions. The control team will be provided with procedures through which spacecraft functions may be exercised. In some testing/training scenarios the test conductor may present off-nominal behaviors or conditions to the control team so they may rehearse troubleshooting and recovery procedures.

# SCC TTE Overview

The major components of the system are the simulated spacecraft, simulated control consoles (4 – 5 unique consoles anticipated), control team communication system, simulation command and control infrastructure, and test conductor system. These are explained in more detail below.

Ideally these systems are to be as modular as possible.

As a minimum, the overall system will support any scripted scenario for a specific, fixed SimCraft and associated console design.

Ideally, the system would allow for the creation of alternate SimCraft and appropriate console capabilities. That is, the system is more a simulation creation engine than a static simulation. This is clearly a stretch goal.

# Simulated spacecraft (SimCraft):

The SCC contains a simulated spacecraft (SimCraft) to be monitored and controlled via the mission control stations. The SimCraft has three subsystems as detailed below.

The SimCraft is presumed to be in a Low Earth Orbit (LEO), with a period of 90 minutes. The SimCraft is assumed to be in sunlight for 45 minutes and in the Earth’s shadow for 45 minutes.

## Attitude and Control Subsystem (ACS)

The Attitude and Control System (ACS) maintains the SimCraft is a proper orbit, with solar arrays aligned properly to produce electrical power to the spacecraft. Sensors related to the ACS, with nominal and off-nominal values, are shown in Table 1.

**Table 1: ACS Sensors and Values**

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Nominal Indicator  (green) | Off Nominal Warning  (yellow) | Off-Nominal Error  (red) |
| Angle of Incidence  (absolute values) | 0 – 5 deg | 5 – 30 deg | 30 – 90 deg |
| Rotational Drift | 0.0 – 0.1 deg/hr | 0.1 – 2 deg / hr | Greater than 2 deg/hr |
| Fuel Level Sensor #1 | 30% - 100% | 10% - 30% | 0% - 10% |
| Fuel Level Sensor #2 | 30% - 100% | 10% - 30% | 0% - 10% |
| Fuel Pressure Sensor #1 | 10 – 30 psi | 5 – 10 psi | 0 – 5 psi |
| Fuel Pressure Sensor #2 | 10 – 30 psi | 5 – 10 psi | 0 – 5 psi |
|  |  |  |  |
|  |  |  |  |

## Power Distribution Subsystem (PDS)

The power distribution system provides power to the SimCraft via solar panel, stores power in batteries, and distributes power as needed to the payload. While in sunlight, the SimCraft produces power via the solar panel. This power is distributed to the payload as needed, with excess power stored in the batteries. Power is supplied by the batteries when the SimCraft is in the Earth’s shadow.

Solar panel power production is related to angle of incidence with the sun, where the angle of incidence is defined as the angle between a line normal to the surface of the solar panel and the line pointing from the SimCraft to the sun, as shown in Figure 1. To simplify the simulation, only one degree of rotational freedom is considered when determining the angle of incidence. The ACS is presumed to maintain an incidence angle of +/- 5 degrees when operating normally, allowing for maximal energy capture during the daylight portion of the SimCraft orbit.

|  |
| --- |
|  |

**Figure 1: SimCraft Solar Panel Angle of Incidence**

Power generation as a function of angle of incidence is provided in Table bb. Battery specifications are shown in Table cc. Other indicators related to the PDS to be used in the SCC TTE are given in Table dd.

## Payload

The SimCraft is assumed have three scientific payloads, each operating independently. The payloads are represented abstractly as payload A, B, and C. The purpose of each payload, detailed operations, and data transmission are not represented in this simulation. Power requirements and general status indicators are of use in the SCC TTE and therefore represented. Specific power requirements are shown in Table xx, and status indicators are listed in Table yy.

# Simulated Control Consoles (consoles):

The simulated control consoles each provide monitoring, command, and control capabilities of a specific system aboard the SimCraft. The console simulations approximate how a real world control team performs space flight operations procedures. Each console interfaces with the appropriate simulated systems in the SimCraft to allow for monitoring and control of those systems.

## ACS Console

The ACS console presents the indicators shown in Table 1, and allows for the commands in Table yy.

## PDS Console

## Payload Console

The payload console provides monitoring and command capabilities for the payloads per Table iii.

## Flight Control Console

## Mobile Device Compatibility

The SSC TTE includes limited capability to monitor and command SimCraft operations via mobile devices.

# Control Team Communication System (Comms):

The Comms system provides voice communication capability across the control team. The Comms system may potentially be composed of several channels so that sub-sets of the control team may address a specific operation or issue without interfering (or being interfered from) communications with team members not involved in the immediate action. All voice communications are to be recorded for potential after action review.

# Simulation Command and Control Infrastructure (SCCI):

The simulation command and control infrastructure provides the capabilities for the test conductor in charge of the training activity to monitor the actions of the SimCraft controllers at their consoles. For example, the test conductor is able to verify that console operators are correctly following procedures, or responding appropriately to off-nominal situations injected by the test conductor. This infrastructure should maintain a log of all actions performed by the test conductor, SimCraft, and all console operators for after action review.

## Test Conductor (TC):

The test conductor system provides complete command and control of the entire simulation to the TC to allow for creation of scripted scenarios, injection of unplanned events in a scenario, observation of console operator activities, participation in the Comms system as needed by the scenario, and annotation of significant events in a simulation log file(s).