Basic Hitchhiker Payload Requirements

by

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Introduction

This document lists the requirements for the NMSU Hitchhiker experiment payload that were developed as part of the EE 498/499 Capstone Design class during the 1999-2000 academic year. This document is used to describe the system needs as described in the mission document [1]. The requirements listed here are those primarily used to generate the basic electronic and data processing requirements developed in the class design document [2]. The needs of the experiment components are more fully described in the draft NASA hitchhiker customer requirements document [3]. Many of the details for the overall payload are given in full detail in the NASA hitchhiker documentation [4].

Figure 1 illustrates the way in which the requirements are allocated. The overall project is divided into the areas of

1. Mission Objectives to describe the purpose of the payload and the experiments
2. System to describe the necessary functions and management structure
3. Flight Segment to describe the on-orbit components
4. Ground Segment to describe the ground operations needs
5. Mission Operations to describe how the payload will actually operate.

The requirements listed here are intended to last through the design projects of EE 499. The full system requirements need a full development to include the areas not covered during EE 499. This would be done by any follow-up Capstone Design class.

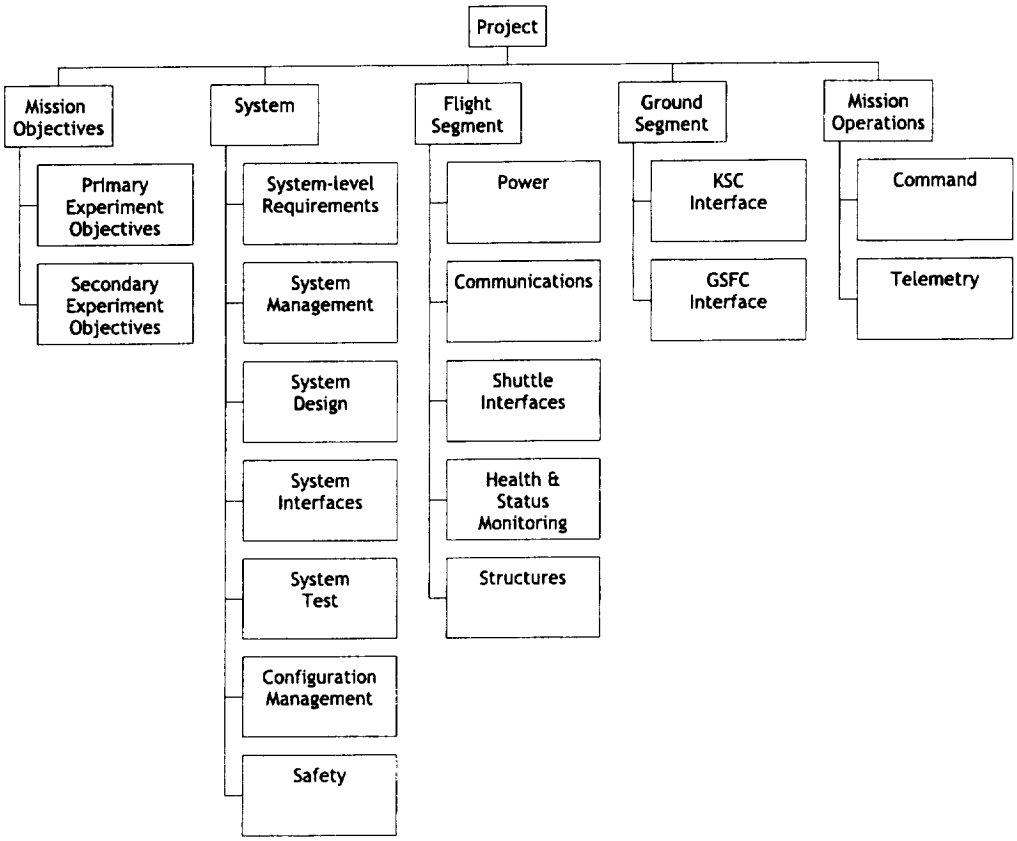

Figure 1 - Hitchhiker payload requirements tree.

Requirements

I. Mission Objectives

MiObj.01

Description:	To demonstrate and to characterize optical and radio communications techniques for small satellites in a flight environment
Priority:	Critical
Status:	Final
Traceability:	DWN: MiObj.01.1
Verification:	Critical Design Review

MiObj.01.1

Description:	The communications techniques shall accommodate three experiment configurations - non-gimbaled antenna pointing - low-power optical communications - DSP Doppler Tracking
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01; DWN: MiObj.01.1.1, MiObj.01.1.2, MiObj.01.1.3
Verification:	Critical Design Review

MiObj.01.1.1

Description:	The non-gimabled antenna pointing experiment shall demonstrate return-link data transmission from LEO orbit through a TDRS to the WSC
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01.1; DWN Sys.01, Sys.02
Verification:	Critical Design Review

MiObj.01.1.2

Description:	The Low-Power Optical Communications experiment shall provide passive command and telemetry services between the shuttle and at least one ground-based laser system
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01.1; DWN: Sys.01, Sys.02
Verification:	Critical Design Review

MiObj.01.1.3

Description:	The DSP experiment shall provide real-time estimates of the doppler offset to a LEO telecommunications satellite signal and track that signal in real-time.
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01.1; DWN: Sys.01, Sys.02
Verification:	Critical Design Review

MiObj.02

Description:	To show the effectiveness of the technology via experimental results and comparisons with analytical or simulation results
Priority:	Goal
Status:	Final
Traceability:	
Verification:	Critical Design Review

MiObj.03

Description:	Provide for educational and program development of students and faculty
Priority:	Goal
Status:	Final
Traceability:	
Verification:	Critical Design Review

II. System

Sys.01

Description:	Provide accomodations and support for experiments via the payload flight segment
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01.1. DWN: Flt.01
Verification:	Critical Design Review

Sys.02

Description:	Provide accomodations and support for experiments via the payload ground segment
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01; DWN:Gnd.02
Verification:	Critical Design Review

Sys.03

Description:	Provide means to operate and control experiments during flight
Priority:	Critical
Status:	Preliminary
Traceability:	UP: MiObj.01; DWN: MiOps.01
Verification:	Critical Design Review

Sys.04

Description:	Provide necessary pre-launch accommodations and support for the payload
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01; DWN: Gnd.01
Verification:	Critical Design Review

Sys.05

Description:	Provide necessary Program Management support for payload, pre-launch support, and operations
Priority:	Critical
Status:	Final
Traceability:	UP: MiObj.01; DWN: Sys.05.1
Verification:	Critical Design Review

Sys.05.1

Description:	Maintain a controlled set of system documents
Priority:	Critical
Status:	Final
Traceability:	UP: Sys.05; DWN: Sys.05.1.1, Sys05.1.2, Sys05.1.3, Sys05.1.4, Sys05.1.5, Sys.05.1.6, Sys05.1.7, Sys05.1.8
Verification:	Critical Design Review

Sys.05.1.1

Description:	The project shall produce a Mission Design Document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.2

Description:	The system shall produce a systems requirement document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.3

Description:	The system shall produce a preliminary design document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.4

Description:	The system shall produce a critical design document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.5

Description:	The system shall produce an interface control document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.6

Description:	The system shall produce a test plan document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.7

Description:	The system shall produce a configuration control document to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

Sys.05.1.8

Description:	The system shall produce all necessary flight safety documentation as required by NASA to describe the hitchhiker mission
Priority:	Critical
Status:	Final
Traceability:	UP:Sys.05.1
Verification:	Critical Design Review

III. Flight Segment

Flt.01

Description:	Provide flight segment experiment accomodations in a Hitchhiker-compatible configuration that includes - power - communications - shuttle interfaces - experiment interfaces - control and health and status monitoring - structure - materials as part of the overall payload structure.
Priority:	Critical
Status:	Final
Traceability:	UP: Sys.01; DWN: Flt.01.1, Flt.01.2, Flt.01.3, Flt.01.4, Flt.01.5, Flt.01.6, Flt.01.7
Verification:	Critical Design Review

Flt.01.1

Description:	Provide accommodation to supply power for the payload infrastructure and the experiments
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01; DWN Flt.01.1.1, Flt.01.1.2, Flt.01.1.3, Flt.01.1.4, Flt.01.1.5, Flt.01.1.6, Flt.01.1.7
Verification:	Critical Design Review

Flt.01.1.1

Description:	Provide for power to allow monitoring of the inhibit state whenever the payload is active.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.2

Description:	Provide for power to allow monitoring of temperature and pressure sensors whenever the payload is active.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.3

Description:	Provide the means to enable and disable power to each experiment individually by operator command.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.4

Description:	Provide the means to monitor voltage levels for the power supplied to each experiment.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.5

Description:	Provide voltages at + 12V, + 5V, and -12 V for use in each experiment.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.6

Description:	Operate from the power supply provided voltage specified in HH CARS.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.1.7

Description:	Current draw and total power not exceed limits provided in HH CARS.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.1
Verification:	Critical Design Review

Flt.01.2

Description:	Provide accommodation to provide bi-directional communications for the payload infrastructure and the experiments
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01; DWN: Flt.01.2.1, Flt.01.2.2, Flt.01.2.3, Flt.01.2.4, Flt.01.2.5
Verification:	Critical Design Review

Flt.01.2.1

Description:	Provide for command input using the HH forward asynchronous link at 1200 bps, 8 bits, no parity, 1 stop bit
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.2
Verification:	Critical Design Review

Flt.01.2.2

Description:	Provide for telemetry output using the HH return asynchronous link at 1200 bps, 8 bits, no parity, 1 stop bit
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.2
Verification:	Critical Design Review

Flt.01.2.3

Description:	All operator commands shall be formatted as described in the Valid Command Table prior to transmission to the payload. Each command shall begin with a synchronization word (146F hex) and formatted in a standard format
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.2
Verification:	Critical Design Review

Flt.01.2.4

Description:	All telemetry values shall be formatted into data frames as described in the Telemetry Table prior to transmission to the ground. Each telemetry frame shall begin with a synchronization word (EB90 hex) and formatted in a standard format.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.2
Verification:	Critical Design Review

Flt.01.2.5

Description:	All command and telemetry data are to be sent as ASCII representations of numbers or as text.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.2
Verification:	Critical Design Review

Flt.01.3

Description:	Provide accommodation for shuttle interfaces for the payload infrastructure and the experiments
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01; DWN: Flt.01.3.1, Flt.01.3.2, Flt.01.3.3, Flt.01.3.4
Verification:	Critical Design Review

Flt.01.3.1

Description:	Provide for three inhibits to prevent power from being applied to the experiments until and unless permitted by payload operations
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.3
Verification:	Critical Design Review

Flt.01.3.2

Description:	Provide for the associated state monitoring of the inhibits and the telemetering of the state information to the payload operator
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.3
Verification:	Critical Design Review

Flt.01.3.3

Description:	Command interface to utilize cabling compatible with standard HH interface as in HH CARS.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.3
Verification:	Critical Design Review

Flt.01.3.4

Description:	Telemetry interface to utilize cabling compatible with standard HH interface as in HH CARS.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.3
Verification:	Critical Design Review

Flt.01.4

Description:	Provide accommodation for experiments to the payload infrastructure
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01
Verification:	Critical Design Review

Flt.01.5

Description:	Provide accommodation for control, and the health and status monitoring of the payload infrastructure and experiments.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01; DWN: Flt.01.5.1, Flt.01.5.2, Flt.01.5.3, Flt.01.5.4, Flt.01.5.5, Flt.01.5.6, Flt.01.5.7, Flt.01.5.8
Verification:	Critical Design Review

Flt.01.5.1

Description:	Provide for monitoring of the internal pressure of the payload.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.2

Description:	Provide for the monitoring of payload temperatures at the four points as follows: - optical experiment - RF experiment - CPU - power supply.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.3

Description:	All commands received in the payload shall be compared against the Valid Command Table prior to processing.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.4

Description:	Only valid commands shall be processed. In valid command shall be rejected.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.5

Description:	All commands received shall be echoed in telemetry regardless of validity.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.6

Description:	A running count of all valid commands received while the payload is active shall be maintained and sent as part of the telemetry data.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.7

Description:	Telemetry frames shall be constructed and sent to the ground with all values for the Telemetry Table at most once per second.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.5.8

Description:	Telemetry frames shall be numbered with a consecutive counter and the count be part of the telemetry frame.
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01.5
Verification:	Critical Design Review

Flt.01.6

Description:	The payload structure shall meet requirements specified in the HH CARS document
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01; DWN: Flt.01.6.1, Flt.01.6.2
Verification:	Critical Design Review

Flt.01.6.1

Description:	The hitchhiker experiment cannot exceed the following dimensions: - 28.25 inches height - 19.75 inches diameter with the experiment inserted in the canister and the major axis vertical and perpendicular to the shuttle
Priority:	Critical
Status:	Final
Traceability:	UP: Flt 01.6
Verification:	Critical Design Review

Flt.01.6.2

Description:	The experiment center of gravity shall meet CARS specification
Priority:	Critical
Status:	Final
Traceability:	UP: Flt 01.6
Verification:	Critical Design Review

Flt.01.7

Description:	The payload materials shall meet requirements specified in the HH CARS document
Priority:	Critical
Status:	Final
Traceability:	UP: Flt.01
Verification:	Critical Design Review

IV. Ground Segment

Gnd.01

Description:	Provide KSC ground segment experiment accommodations
Priority:	Critical
Status:	Final
Traceability:	UP: Sys.02
Verification:	Critical Design Review

Gnd.02

Description:	Provide GSFC ground segment experiment accommodations
Priority:	Critical
Status:	Final
Traceability:	UP: Sys.04
Verification:	Critical Design Review

V. Mission Operations

MiOps.01

Description:	Provide a user interface for real-time command and telemetry interface
Priority:	Critical
Status:	Final
Traceability:	UP: Sys.01; DWN: MiOps.01.1, MiOps.01.2, MiOps.01.3, MiOps.01.4, MiOps.01.5, MiOps.01.6, MiOps.01.7, MiOps.01.8
Verification:	Critical Design Review

MiOps.01.1

Description:	Each command is to be prefaced with the synchronization word "146F" prior to transmission to the payload.
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.2

Description:	Command interface to prevent more than one experiment from being activated at a time.
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.3

Description:	Command interface shall show the user the last command transmitted
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.4

Description:	Command interface shall show the user the last command received in telemetry
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.5

Description:	Command interface shall require explicit user input to send a command to the payload
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.6

Description:	Telemetry interface shall provide the user with the capability to see raw telemetry from payload
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.7

Description:	Telemetry interface shall provide user with sensor inputs converted to measurement values with appropriate units as described in the Telemetry Table
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

MiOps.01.8

Description:	Data latency shall not exceed two seconds from the time of reception at the user interface until the data is displayed.
Priority:	Critical
Status:	Final
Traceability:	UP: MiOps.01
Verification:	Critical Design Review

References

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[2] S. Horan, "Basic Electronic Design for Proposed NMSU Hitchhiker Payload," NMSU-ECE-00-010, September 2000.
[3] S. Horan, "NASA Hitchhiker Program Customer Payload Requirements", NMSU-ECE-98-006, September 1998.
[4] National Aeronautics and Space Administration, "Hitchhiker Customer Accommodations & Requirements Specifications," 740-SPEC-008, 1999.