ROCKSAT-X

User's Guide

Pushing The RockSat

Concept to New EXtremes

Colorado Space Grant Consortium
Discovery Learning Center Room 270
520 UCB
Boulder, Colorado 80309-0520

Wallops Flight Facility
Wallop Island, Virginia

0.0 APPROVALS AND TRACKING

0.1. Signatures

Prepared by: _____ _____
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RockSat-X Student Project Manager

Reviewed by: _____ _____
Chris Koehler, COSGC — Date
COSGC Boulder Director

Concurrence: _____ _____
Phil Eberspeaker, Wallops Flight Facility — Date
Chief, Sounding Rockets Program Office

0.2. Revisions

Revision	Description	Date	Approval
DRAFT	Initial release	8/6/2010	SMC
Revision 1	All updates are highlighted in yellow. Major updates include: mechanical interface definition, power interface definition, telemetry interface definition, preliminary environmental testing characteristics, mechanical drawings, power and telemetry connector pictures, parallel timing diagram (Appendix C)	10/22/2010	SMC

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1.0 INTRODUCTION

1.1. Eligibility

Due to International Traffic in Arms Regulations (ITAR) restrictions, RockSat-X is limited to U.S. educational institutions; only payloads from U.S. educational institutions are eligible to participate in the RockSat-X program. Additionally, participants in this program will be exposed to technical documents and participate in reviews with Wallops Flight Facility that will fall under ITAR restrictions. This means that ***all participants must be U.S. Citizens or be classified as a U.S. Person as defined by ITAR.***

For the purpose of the RockSat-X, 'educational institution' is defined broadly and includes, but is not limited to, the following: universities, colleges, technical schools, public and private high school, middle school and grade school, science museums, etc. Organizations which are not included in the above listing are encouraged to contact COSGC to clarify their eligibility in the program. In addition, U.S. entities (e.g. industry, research institutions, etc.) that fall outside of the eligibility conditions listed above, but who are interested in participating in the program, are encouraged to team with an eligible U.S. educational institution. Teaming between educational institutions and industry or other interests is allowed and in fact encouraged.

1.2. Purpose

The purpose of this document is to identify the interfaces, requirements and logistics pertaining to the University of Colorado at Boulder (CU-Boulder) Colorado Space Grant Consortium's (COSGC) RockSat-X program. This document also establishes the guidelines and requirements for qualifying a payload for selection to be flown, along with the review and integration schedule. Payloads shall be student based with faculty and/or industry involvement only. RockSat-X is not available to payloads that are profit related endeavors and/or industry research and development. Students must be actively engaged and involved.

1.3. Getting Involved (Notice of Intent—NOI)

Interested institutions will need to submit a Notice of Intent (NOI) no later than September 10, 2010 at 4:00 PM MDT. No later than October 08, 2010, ***each*** initially selected institution will make a $ 2,000 earnest deposit. This deposit is

fully refundable until the customer has been down selected as a finalist. Further details on the selection process can be found in Section 9.0.

1.4. Sharing

Customers that wish to share payload space and mass shall indicate this on the submitted Notice of Intent (NOI). Sharing customers must specify their respective fractions in the NOI. Adjustments to these fractions are not unexpected, but final fractions shall be assigned at final down select, and selected customers will be billed accordingly. Any changes in sharing fractions after final down select must be handled between customers, and financial adjustments are the responsibility of the involved institutions.

Customers are encouraged to collaborate and pair prior to the submittal of the Notice of Intent (NOI). Customers wanting to share payload space/mass can pair off with one other institution for a total of not more than two (2) universities per payload space. Greater than two (2) experiments per payload space will not be permitted. ***Sharing customers should be aware that the power and telemetry connections available are per payload space and those customers must share the standard resources described in the sections below.*** (i.e. additional power and telemetry connections will NOT be provided to spaces with customers sharing space.)

After final down select, all pairings, mass allotments, and volume allotments are final and cannot be changed without written consent of COSGC. In the event that a subset of customers would like to redistribute allotments, all customers of the subset must contact COSGC, and changes will only be made with written approval of all parties involved and COSGC. Cost sharing is covered in Section 1.5.

Customers that share a canister are responsible for interfacing to each other. It is required that all sharing customers assigned to a payload space collaborate and create specific interfacing slides for all design reviews. Interfacing across state lines can be extremely challenging but is a realistic challenge that many aerospace projects must overcome.

1.5. Cost

The cost of a flight is contingent upon the fraction of the canister being utilized. This cost covers the following expenses: launch costs, use of one (1) RockSat-X payload deck with power and telemetry interface, mission management support, environmental testing, and other amenities provided during the week of environmental testing and launch.

During the weeks of environmental testing and launch, the cost includes a TBD number of breakfasts and lunches for a TBD number of participants per team. Additionally, each of the TBD members will receive a RockSat-X t-shirt. Additional meal options and shirts will be available for additional team members beyond the primaries at a TBD cost. Please notify Shawn or Chris as soon as possible if this will be the case. The cost will NOT cover travel to and from Wallops Flight Facility, lodging, or other expenses incurred.

Comment [SMC1]: More Details To Come Later

1.5.1. Dedicated Customers

A dedicated customer is an institution whose payload will occupy an entire deck. If a dedicated customer's payload is chosen to fly at final down select, he/she will then make two (2) additional equal payments of $11,000 per the schedule in Section 10.0. ***After receipt of the first installment of $11,000, each customer will be sent one (1) RockSat-X payload deck with a power and telemetry interface contingent upon machining completion, and all deposits shall become non-refundable.*** All payments must be made in the form of a check made payable to: University of Colorado. Payments should be sent to:

Colorado Space Grant Consortium
Discovery Learning Center Room 270
520 UCB
Boulder, Colorado 80309-0520

1.5.2. Share Customers

A share customer is an institution whose payload will occupy only a fraction of a canister. Share customers are universities occupying half of a payload space; no other fractions will be allowed due to the added complexity of pairing. The assigned fraction sets the maximum volume and mass that the shared customer can occupy from the available mass and volume. How each shared customer occupies his/her territory is the business of the sharing customers in a specific payload area. Table 1-1 summarizes the total cost for shared customers. ***These costs include the earnest deposit of $2,000***.

Table 1-1: Shared Customer Costs

Shared Customer Costs	
Fraction	*Cost*
1/2	$14,000.00

At the time that earnest deposits are due, all share customers shall still pay the earnest deposit of $2,000 made payable in the same method as described in

Section 1.5.1. ***After receipt of the first installment all deposits shall become non-refundable.*** In the event that a subset of sharing customers is chosen at final down select, the remaining cost to each customer will be broken into two equal payments. These payments will be made on the dates indicated in the schedule (see Section 10.0). The RockSat-X payload deck with power and telemetry interface will be shipped to one of the customers prior to environmental testing contingent upon completion of machining. It is the customer's responsibility to coordinate sharing the deck for fit checks and integration.

1.6. Points of Contact

Program points of contact (POC's) are as follows:

Colorado Space Grant Director	Chris Koehler 303-492-4750 koehler@colorado.edu
Colorado Space Grant RockSat-X Student Program Manager	Shawn Carroll 720-234-4902 rocksatx@gmail.com

1.7. Applicable Documents and Links

- Colorado Space Grant Consortium RockSat website: www.rocksatx.com
- NASA Wallops Flight Facility: http://www.nasa.gov/centers/wallops/home/index.html

2.0 ROCKSAT-X OVERVIEW

The RockSat-X payload deck is a modular system based around decks designed for suborbital flights with Wallops Flight Facility's (WFF) Sub-SEM ring assembly. Figure 2-1 and Figure 2-2 (below) show the deck/longeron structure and plate layout, respectively.

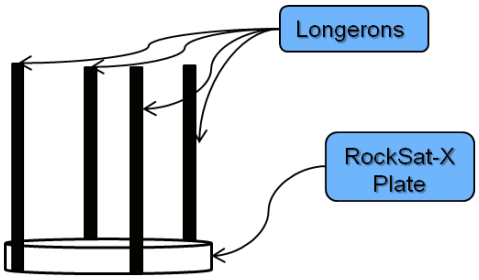


Figure 2-1: RockSat-X Deck in Longeron Structure (Conceptual)

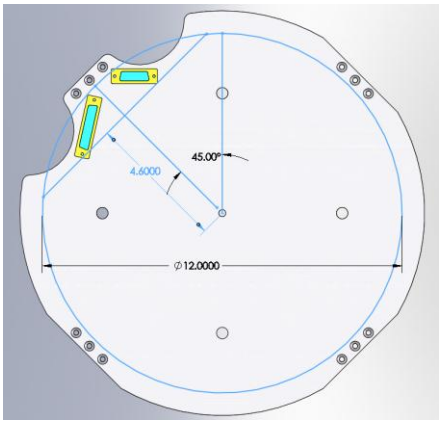


Figure 2-2: RockSat-X Deck Layout

The objective of the RockSat-X payload deck is to give customers a design envelope to build around that will allow easy integration to any WFF rocket using the Sub-SEM ring assembly. This standardized approach provides customers low cost access to space. The RockSat-X payload deck is a new concept that is being tested for the first time this year. COSGC and Wallops are confident this system will work well, but this is a learning process for both institutions, and your patience is much appreciated.

The RockSat-X deck is the next phase in a partnership with Wallops Flight Facility designed to give students access to space. The predecessor, RockSat-C, will continue to run concurrently, and it is COSGC's and WFF's goal to pipeline students, faculty mentors, and industry partners from the RockSat-C program into the RockSat-X program, which is designed to be more capable and more technically challenging.

RockSat-C provides a standard canister for customers to build, design, test, and fly experiments in. RockSat-C provides optical and atmospheric ports for various experiments, but it is full access to the space environment that opens the door to endless possibilities on sounding rockets. RockSat-X will have an ejectable skin and nose cone

that will fully expose experiments to the space environment at apogee. Additionally, the rocket will be de-spun to a reduced rate of ~ 0.5 Hz to allow for a greater range of experiments.

Wallops will also provide power and telemetry. By providing these amenities, experimenters can spend more time on payload design and less on power and data storage systems. The current design also allows for future expansion of an Attitude Control System (ACS) to align the rocket parallel or anti-parallel to the magnetic field. This capability will be added once the program had matured.

3.0 ROCKET DESCRIPTION AND CAPABILITIES

This section covers key interfacing and launch vehicle capabilities that customers should be aware of for the design of his/her payload.

3.1. RockSat-X Deck Interface General Description

Each RockSat-X deck will be attached to the Sub-SEM ring assembly in a stacked configuration. The Sub-SEM rings are further attached to longerons that span the entire length of the experiment section (Figure 2-1 and Figure 3-1). With 4 RockSat decks and a camera/data payload flying, the launch vehicle (Terrier-Improved Orion or Terrier-Improved Malamute) is estimated to reach an altitude of approximately 150 – 170 km, or approximately 100 miles.

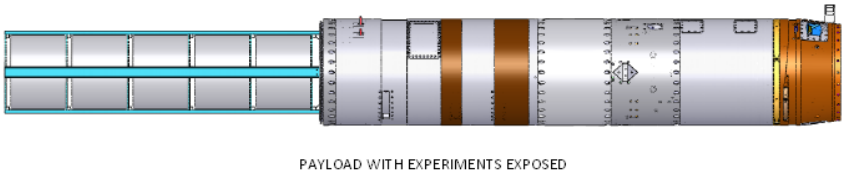


Figure 3-1: Payload Stack (Conceptual)

There will be a total of four (4) RockSat-X decks/spaces available for purchase. There will be a fifth "payload" that will capture video and flight characterization data. A simplified diagram of the payload layout is given as Figure 3-2.

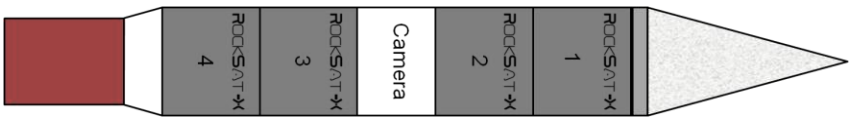


Figure 3-2: RockSat-X Payload Layout (Conceptual)

Each payload deck shall be provided with four timer controlled (4) power lines and associated ground wires that can be activated at TBD times prior to and during flight. One (1) of these power connections will be redundant. Each payload will also be provided with one (1) set of redundant activation wires that can be activated prior to launch through the Ground Support Equipment (GSE). It is highly recommended that main payload activation occur through the GSE line. Each deck will have 1 Amp Hour (Ah) available for the mission. Customers will connect to power via the power and telemetry interface described further in Section 5.2.1. ***Please note that sharing customers will need to share these four power lines.***

Each payload deck shall be provided with telemetry. Each deck has access to ten (10) 0 – 5 Volt, 16-bit Analog to Digital (A/D) lines. Analog signals from 0 – 5 Volts will be digitized and streamed back to the ground station in real-time, which eliminates the need for on-board data storage. Additionally, each deck will receive one (1) asynchronous line at a customer TBD baud rate and a 16 bit parallel line. Customers will output data via the power and telemetry interface described further in Section 5.2.1. More details on telemetry can be found in Section 5.2.1.4.

The RockSat-X deck is cylindrical in shape with a useable payload space (design envelope) having a diameter of approximately 12 inches with a keep out area that is defined in detail in Section 6.1.1. Each payload deck will have approximately 12 inches of height. Figure 3-3 gives a pictorial representation of the design envelope. Each RockSat-X deck is allotted 30 ± 1 lbs for payload. All payloads must be designed to this mass. ***Violation of this rule will result in the customer being removed from the flight***.

Comment [SMC2]: Under Review

Comment [SMC3]: Under Review

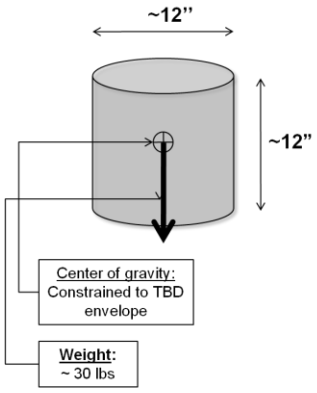


Figure 3-3: Payload Design Envelope (Conceptual)

3.2. Rocket Key Performance Parameters

Table 3-1: Key Performance Parameters

Key Performance Parameter	Value	Note
Altitude (km)	≈ 160 km	1
Spin Rate (Hz) at Burn-Out	≈ 1.3 Hz at Terrier burn out; ≈ 4.8 at Orion burn out	1,2
Maximum Ascent G-Load	25 G (Sustained) (50+ G Impulses Possible)	1,2
Rocket Sequence (Burn Timing)	5.2 s Terrier burn—9.8 s coast—25.4 s Orion burn	1,2
Chute Deploy (seconds)	489.2 s	1,2
Splash Down (seconds)	933 s	1,2

Notes:

1. All parameters are subject to change, but all customers will be notified of any changes.
2. Data from 2009 Terrier Improved Orion launch.

3.3. Flight Environment Conditions

3.3.1. G Loading

During ascent and descent payloads will experience both sustained and vibrational accelerations. Typical G loads can reach 25 Gs. Payloads shall be designed to withstand at least 25 Gs of quasi-static loading in all three axes with possible impulses of approximately 50 Gs in the Z (longitudinal) axis. Three axes vibration testing will be conducted by WFF before flight. Vibration/environmental testing will be completed approximately 1 month prior to launch. The specifics of this test can be found in Appendix B.

3.3.2. Space Environment

At apogee the skin and nose cone will be ejected exposing all payloads to the vacuum of space. Payloads will be exposed to hard vacuum and varying

temperature extremes. The primary mode of heat transfer at apogee will be radiation as convection becomes non-existent in the vacuum of space. The vacuum environment will also lead to outgassing. Requirements for design to account for thermal extremes and vacuum conditions are not being imposed, but these factors should be considered in design. Outgassing becomes particularly important for optical payloads located near high outgassing materials.

Outgassing properties for most materials can be found at: http://outgassing.nasa.gov/.

3.4. Disclaimer

Recovery of payloads is not guaranteed. As with any flight, there are possible anomalies that can occur during the flight or recovery that can severely damage or destroy flight hardware. All selected teams should consider this and understand that space flight involves risks that neither COSGC nor WFF can plan for. Selected payloads assume all risks, and neither of the said institutions shall be held responsible in the event of an anomaly and/or unrecoverable payload. Customers should also be aware that thermal and structural loading will be substantial upon re-entry. Pending a successful recovery of the payload section, customers should expect severe an un-repairable damage to flight hardware.

4.0 ORGANIZATIONAL RESPONSIBILITIES

4.1. Hardware and Interface Responsibilities

Component and functional design responsibilities are listed below.

RockSat Payload Customer

- Payload experiment and support system.
    - Support system includes:
        - Thermal system (if desired)
        - On-site tools and hardware for environmental testing and final integration
        - All environmental sensors (if desired)
        - Power regulation from nominal 28V to any required payload voltages
- Mechanical interface to RockSat-X deck.
- Safety features for experiment-related hazards
- Power harness from payload to power and telemetry interface interface (minus connectors)
- Telemetry harness from payload to power and telemetry interface interface
- All required ground side data analysis equipment (computers not provided)
- Required interfacing between sharing customers

COSGC and WFF

- Terrier-Improved Orion or Terrier-Improved Malamute rocket, range safety, launch support, recovery and tracking
- One (1) RockSat-X deck with power and telemetry interface for loan with associated power and telemetry harness connectors and stand-offs
- Environmental testing and integration onto full rocket

4.2. Ground Control

After the RockSat-X decks have been integrated onto the sub-SEM ring assembly prior to launch, the customer will have very limited access to the payload. WFF will handle all activities pertaining to payload preparation, launch, and recovery until the Rocket has been recovered and the payload is deintegrated.

5.0 PAYLOAD DESIGN AND DESIGN REQUIREMENTS

5.1. Payload Physical Envelope, Mass, and Center of Gravity Requirements

The following subsections outline the physical requirements and constraints of the RockSat-X deck.

5.1.1. Constraints On Payload Types

The purpose or mission of a payload is open to the customer. The customer shall design a payload that by all standards (engineering and laymen) would be considered safe and practical. Experiments shall not put other payloads, WFF employees, COSGC employees, or the launch vehicle at risk. All payloads shall be formally selected before the customer can become a contender for flight (NOI). This approval will come with signatures on the Notice of Intent (NOI) that will be submitted no later than September 10, 2010 at 4:00 PM MDT. The RockSat-X payload deck can be sub-divided between other customers to share space and cost. If payload space is to be shared, this should be documented on the NOI.

5.1.2. Physical Envelope

All payloads must be securely mounted to the RockSat-X payload deck. The deck will be approximately 12 inches in diameter, excluding keep out area. Customers will also have approximately 12 inches of height to work with. A pictorial representation of the design envelope can be viewed as Figure 3-3 (above). The payload may occupy as much or as little of this space is required. Mechanical drawings of the RockSat-X payload deck are contained in Appendix A.

Comment [SMC4]: Under Review

5.1.3. Mass Properties

Each RockSat-X payload (not including deck and PT interface) shall be 30±1 lbf (13.61 kg). Integrated payloads will be weighed prior to integration. ***Payloads not conforming to the weight constraints will be removed from the flight***.

Comment [SMC5]: Under Review

5.1.4. Center of Gravity

All payloads shall be designed to have a center of gravity (CG) that lies within a 1 inch square in the plane of the RockSat-X deck. The center of mass in the longitudinal direction is less important but shall be accounted for in design reviews. To ensure stable flight, WFF may require a moment of inertia (MOI) test prior launch. This test will confirm that the CG of the payload falls within the said requirement. ***Payloads that do not meet WFF's CG requirements will be removed from the flight.***

5.2. Power and Telemetry

5.2.1. Power and Telemetry Interface

The RockSat-X program utilizes a standard interface to deliver power from Wallops Flight Facility to the customer. Additionally, the said interface provides a standard for passing telemetry from the customer to WFF. This standard interface has been referred to as the Power and Telemetry interface to this point, but from herein may be referred to as the PT interface.

To keep this program low cost and low impact to both Wallops Flight Facility and COSGC, a standard interface and number of power and telemetry lines has been established for all payload decks. The PT interface will mount to the RockSat-X deck and will provide customer side and Wallops side connections. Using this standard will allow COSGC to develop a Ground Support Equipment (GSE) suitcase. This suitcase will provide 28 V to power lines and allow monitoring of the telemetry lines to verify functionality prior to final integration to the rocket.

5.2.1.1. PT Interface Design

The customer side Power and Telemetry Interface consists of two (2) d-sub connectors that are provided by Wallops Flight Facility. Each payload deck will receive one (1) thirty-seven (37) pin d-sub connector for telemetry and one (1) fifteen (15) pin d-sub for power. These connectors and associated mounting hardware (stand-offs) will be mailed to final down selected customers in late January or early February. Figure 5-1 shows both the thirty-seven (37) and fifteen (15) pin connectors that will be mailed.

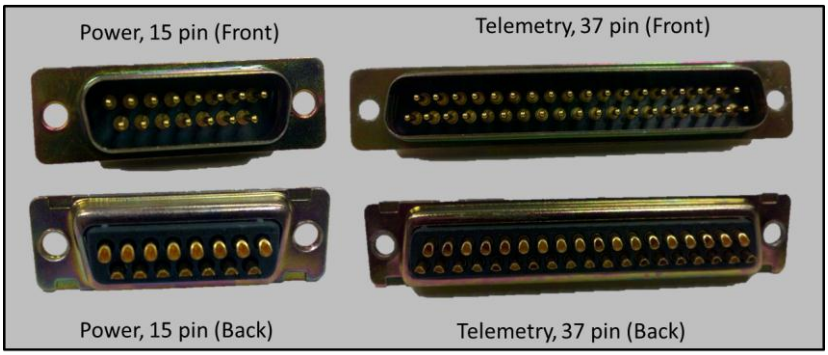


Figure 5-1: Power and Telemetry Connectors

Both connectors have solder cups on the back side (pictured above) that customers must solder their power, ground, and telemetry lines to directly. Once the appropriate connections have been made, it is the customer's responsibility to mount the d-sub connectors to the plate with the associated mounting hardware. The exact location of these connectors is described in Section 6.1.1. The pin-outs for both connectors are located in Sections 6.1.2 and 6.1.3.

5.2.1.2. Power Provided and Activation

Each payload deck will be provided with five (5) power lines from WFF. Four (4) of the events can be activated at any time after the launch (T+X minutes) of the vehicle.

The on-board timer controls the timing of these lines. These lines are characterized by three (3) states: on, dwell, and off. At a customer specified time (t_{on}) after launch, the line will switch from off (no power) to on for a customer specified dwell time, t_{dwell}. After t_{dwell}, the line will switch from on to off and will remain in this state for the remainder of the mission until t_{splash}. Figure 5-2 shows the timing diagram for the four (4) timer controlled power lines. The green times indicate those specified by the customer.

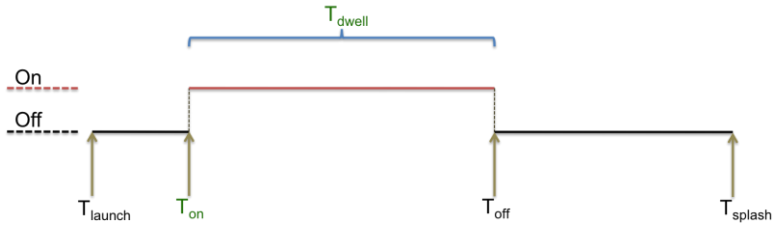


Figure 5-2: Timer Timing Diagram

Of the four power lines controlled by the timer, one (1) will be redundant. This line will have two dedicated timer events (occurring at the same time) and two independent solenoids for two levels of redundancy.

The fifth power line (28V) is controlled by Wallops Ground Support Equipment (GSE), and can be activated up to ten (10) minutes prior launch. It is recommended that primary electronics be controlled through the GSE line with peripheral sensors and subsystem being activated through the above described timer lines. Wallops will activate the GSE lines during environmental, which will provide a sufficient test of an active payload under load. The provided power lines and timing and summarized in Table 5-1.

Table 5-1: Power Lines Provided

Type	*Number*	*Timing*
Redundant (28V)	1	Customer specified, post launch (T+)
Non-redundant (28V)	3	Customer specified, post launch (T+)
Redundant GSE (28V)	1	Customer specified, pre-launch (T-)

Each payload will be allotted 1 Ah of capacity and can draw no more than 1 A on any line at a given instant. Wallops will include limiters to ensure current draw isn't exceeded to ensure the safety and functionality of the electrical system.

5.2.1.3. Independent Power Sources

Wallops Flight Facility shall provide the power for all instruments. In the event that a payload needs a voltage greater than the provided 28V, the customer will be responsible for providing power. This power source must be cleared by both WFF and COSGC, and a written, formal approval must be issues from both institutions before the payload can fly. Payloads utilizing high voltage must also conform to the requirements provided in Section 5.5.

5.2.1.4. Telemetry Provided

Customers will not be responsible for storing data internally. Each RockSat-X deck will be provided with ten (10) 16 bit 0 – 5V A/D lines. ***This implies that customers must condition all sensor signals to 0-5V.*** These signals will be converted by Wallops to a 16 bit digital representation that will be sent down on the telemetry stream. These lines are high impedance into the A/D deck, so buffering the signals is not necessary. The A/D decks **do not** filter the data in any way; however, so it is strongly recommend that each input be filtered appropriately to minimize undesired noise. ***The sample rate is fixed at 1 kHz***.

In addition to the A/D lines, customers will be provided with one (1) parallel line and one (1) asynchronous line. The parallel line will accept a 16 bit digital signal that will also be sampled at 1 kHz. Most customers use a parallel line to monitor status (on/off) of certain aspects of the mission. The asynchronous line will have a baud rate TBD by the customer.

Table 5-2: Telemetry Lines Provided

Type	*Number*
16 Bit 0-5V A/D	10
Parallel (16 bit)	1
Asynchronous	1

5.3. Mechanical

5.3.1. RockSat-X Deck Description

The RockSat-X deck is standard developed to simplify integration of the customer to the launch vehicle. The concept of a standard mechanical interface was derived from RockSat-C, which has greatly simplified integration and makes the program possible.

5.3.2. Mechanical Requirements

RockSat-X is based around a deck rather than a canister. A deck gives customer more freedom. The customer is also responsible for mounting his/her payload to the plate in a manner that will ensure its survival during flight. Finite Element Analysis (FEA) is highly recommended but not required. All payloads will be environmentally tested prior to flight, which is the ultimate test of structural integrity. Customers then have approximately one month to make necessary adjustments and get the payload prepared for final integration.

Customer experiments must be designed for integration to fit within the 12 inch diameter by 12 inch high envelope (minus keep out area) already defined. Payloads ***can*** deploy booms and other mechanical devices once the skin has been ejected. Deployable or ejectable payloads introduce a new level of complexity and are subject the more stringent scrutiny from COSGC and Wallops.

Comment [SMC6]: Under Review

5.3.3. G Loading

Each payload will experience extreme and varying G-loads during the course of flight. It is not atypical to see up to 25 Gs in the positive Z (longitudinal) direction during ascent and experience about +/- 10 Gs in the X and Y (lateral) axes. In the event of a parachute failure, there will be more extreme loading in all three axes.

5.3.4. Material Selection

When designing the structure for the payload, materials with high resistance to stress corrosion cracking (SCC) are recommended. Materials that have worked well in the past have been aluminum (6061) and steel. Plastics or other petroleum based materials shall be used sparingly.

5.4. Space Environment

Payloads will be exposed to a large variety of environments; the most extreme of these environments will occur at apogee. All payloads will be exposed to the vacuum and thermal extremes of space. Time spent in this environment will be minimal due to the suborbital nature of the flight, but payloads shall be designed to survive vacuum conditions. ***Pressure vessels are prohibited unless explicit, written permission has been issued from COSGC and Wallops Flight facility.***

The vacuum of space will also lead to outgassing. Customers should strive to design with low outgassing components. Customers should also design payloads to survive thermally considering the absence of convection. On board computers may need additional heat sinking to prevent thermal failures that otherwise wouldn't be a concern in the presence of a convective medium.

5.5. High Voltage

All payloads using the provided 28 V from WFF are strongly encouraged to conformal coat all electronics to protect against coronal discharge. ***All payloads utilizing voltages higher than 28 V shall conformal coat all boards.*** Payloads

utilizing higher voltages must obtain the written permission of both Wallops Flight Facility and COSGC.

5.6. Electrical Harnessing and Staking

All payloads shall harness wires with a nylon lacing tape or the equivalent. Wire harnesses that are excessively long should be staked to the structure to mitigate the risk of disconnects during flight. It is also highly recommended that all connectors and IC sockets be tied and staked in place using aerospace grade RTV. Wallops Flight Facility and COSGC payloads use Dow Corning products (734 and 736) for potting and electrical connection. These products can be purchased from McMaster Carr at:

www.mcmaster.com

5.7. Summary of Key Constraints

Table 5-3: Summary of Key Constraints

Type	Quantitative Constraint
Physical Envelope	Cylindrical**: Diameter: ~12 inches (minus keep out) Height: ~12 inches ** Deployables and booms are permitted once skin has been ejected
Weight	Payload shall be: 30±1 lbf
Center of Gravity	Lies within a 1 inch square in the plane of the RockSat-X plate.
Power and Telemetry	Telemetry Ten (10) 0 – 5V 16 bit A/D Lines One (1) parallel line One (1) asynchronous line Power One (1) redundant power line (28V) Three (3) non-redundant power lines (28V) One (1) GSE power line (28V) 1 Ah capacity
High Voltage	All payloads utilizing higher voltage (>28V) shall conformal coat all electronics.

Comment [SMC7]: Height Under Revision

Comment [SMC8]: Final Weight Under Revision

6.0 PAYLOAD INTERFACES

6.1.1. Mechanical Interface

All payloads shall be designed to mount to the RockSat-X deck. The deck design envelope is 12 inches.

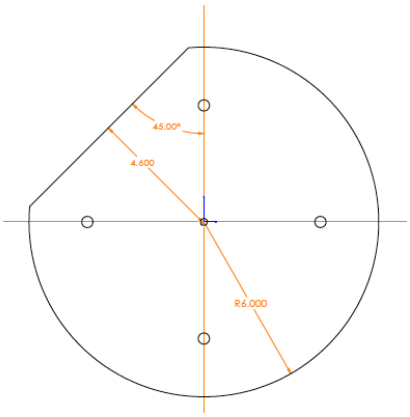


Figure 6-1: RockSat-X Payload Design Space

Figure 6-1 shows the footprint of the space that customers can utilize for the payload. The diameter is 12", and the excluded portion of the disk is a keep out area for the power and telemetry connectors and wire-ways. A more detailed drawing showing the connectors and wire-way is given in Figure 2-2.

The power and telemetry connectors have been previously described in Section 5.2.1.1 and will be provided by WFF and COSGC. In addition to providing the connectors, each payload space will be provided with a set of stand-offs to mount the connectors to the deck. For design purposes, relevant dimensions on the location of the holes for connector mounting are summarized in Figure 6-2.

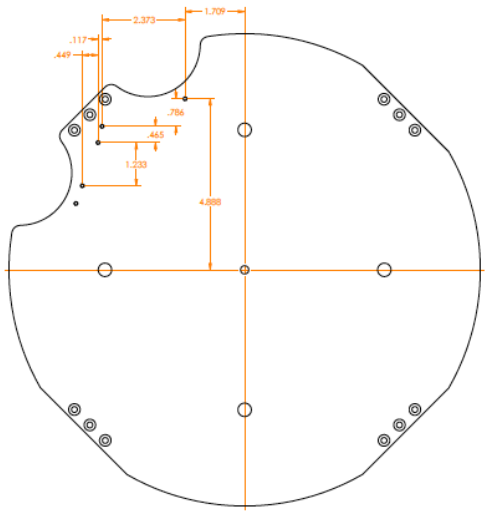


Figure 6-2: PT Connector Hole Dimensions

6.1.2. Electrical Interface

The power interface for each payload deck shall consist of a single fifteen (15) pin Cannon connector (Figure 5-1). Customers will solder all power and ground lines to the solder cups on the back side, and Wallops will mate directly with an opposite gender connector on the front side. This connector and associated mounting hardware will be provided by WFF and COSGC after final down selections.

Each payload deck shall receive the above said four (4) timer controlled power lines. Additionally, each payload deck gets one (1) redundant GSE activated power line. The pin-out convention is given below in Table 6-1.

Table 6-1: Power Interface Definition

Pin	Function
1	+ 28 Volts
2	Timer Event 1
3	Timer Event 2
4	Timer Event 3
5	GND
6	GND
7	GND
8	GND
9	+ 28 Volts
10	Timer Event 4
11	Timer Event 5
12	GND
13	GND
14	GND
15	GND

Pins 1 and 9 should be tied together on the customer side to create a 28 V redundant GSE power line. This line will become active at the customer specified T-X minutes prior to launch. X should be less than 10 minutes to prevent complications with the hot count. Pins 5-8 and 12-15 are payload and Wallops ground. Customers can tie their payload ground to all or any combination of these pins.

Pins 2 and 3 should be tied together on the customer side to create a 28 V redundant timer activated power line. These lines will become active at the customer specified T+X minutes into launch. Pins 4, 10, and 11 are the non-redundant timer controlled power lines that will activate at independent times specified by the customer. These times must occur after launch, as they are controlled by the launch timer.

Note that the pin numbers are engraved on the back side of the provided Cannon connector.

6.1.3. Telemetry Interface

The telemetry interface for each payload deck shall consist of a thirty seven (37) pin Cannon connector (Figure 5-1). Customers will solder all telemetry lines to the solder cups on the back side, and Wallops will mate directly with an opposite gender connector on the front side. This connector and associated mounting hardware will be provided by WFF and COSGC after final down selections.

The ten (10) A/D lines shall be conditioned to 0 – 5 volts and shall connect to pins 1 – 10 on the Cannon connector. Pins 11 – 16 will contain bits 1 – 6 of the parallel line with pin 11 being the Most Significant Bit (MSB). The final 10 bits shall be placed on pins 20 – 29, with 29 being the Least Significant Bit (LSB). Pin 30 is reserved for the parallel read strobe. The asynchronous connections shall be made on pins 32 and 33 for data to be transmitted and ground, respectively. Pins 18, 19, 36, and 37 shall be payload ground, which will be tied into Wallops ground via the connector. Pins 17, 31, 34, and 35 will not be utilized (NC). This convention is summarized below in Table 6-2.

Table 6-2: Telemetry Interface Definition

Pin	Function		
1	Analog 1	20	Parallel Bit 7
2	Analog 2	21	Parallel Bit 8
3	Analog 3	22	Parallel Bit 9
4	Analog 4	23	Parallel Bit 10
5	Analog 5	24	Parallel Bit 11
6	Analog 6	25	Parallel Bit 12
7	Analog 7	26	Parallel Bit 13
8	Analog 8	27	Parallel Bit 14
9	Analog 9	28	Parallel Bit 15
10	Analog 10	29	Parallel Bit 16 (LSB)
11	Parallel Bit 1 (MSB)	30	Parallel Read Strobe
12	Parallel Bit 2	31	N/C
13	Parallel Bit 3	32	RS-232 Data (TP1)
14	Parallel Bit 4	33	RS-232 GND (TP2)
15	Parallel Bit 5	34	N/C
16	Parallel Bit 6	35	N/C
17	N/C	36	Ground
18	Ground	37	Ground
19	Ground		

Note that the pin numbers are engraved on the back side of the provided Cannon connector.

6.1.3.1. Asynchronous Framing and Baud Rates

Customers utilizing the asynchronous line are responsible for correctly framing data before sending it to the telemetry connector. Framing is easily accomplished through a Universal Asynchronous Receive Transmit (UART). Most COTS microcontrollers have this ability.

All customers shall use the 8-N-1 convention. 8 indicates that each frame consists of 8 data bits, N indicates that no parity bits are being used, and 1 indicates a single stop bit. The typical 8-N-1 frame is summarized in Figure 6-3.

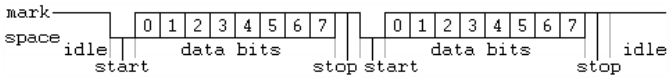


Figure 6-3: 8-N-1 Asynchronous Serial Framing

Source: www.wikipedia.com

The start bit is always a signal low followed by eight bits (0-7) of data, with a final stop bit at logic level high. A UART will complete all framing if implemented correctly. Customers can communicate over this serial connection at the following baud rates: 19200; 9600; 1200; or 300.

Baud rate is NOT equal to data rate. 9600 Baud implies that 9600 characters per second can be communicated, where "characters" includes the required start and stop bits. For an 8-N-1 frame, 2 start/stop bits or characters are required per frame, which implies a 20% overhead (2 [start-stop bits]/10 total bits). Extrapolating this concept, a 9600 Baud connection is capable of streaming 7680 [0.8*9600] bits of actual data per second.

7.0 PAYLOAD HARDWARE INTEGRATION

The customer shall furnish a complete, functional, and fully integrated payload to COSGC and WFF on the day of the Launch Readiness Review (LRR), tentatively June 10th, that meets all of the requirements of this document. Customers shall present LLRs to COSGC and WFF personnel to ensure compliance with the requirements of this document and to give an update on the flight readiness level of the payload. All RockSat-X payloads will then be integrated and undergo environmental testing June 14th – 16th. After environmental testing, experiments will be returned and customers will have approximately one month to resolve issues associated with environmental testing. Customers will then return July 30th for the final LRR. Payloads deemed flight ready will then be integrated for flight August 1st – 2nd with a tentative launch scheduled for August 4th.

8.0 PAYLOAD TEST REQUIREMENTS

Testing of the payload shall be performed by the customer to ensure payload functionality and survivability. All tests shall be documented and/or recorded for the testing reviews whose dates have been established in Section 10.0.

8.1. Structural Testing

The customer shall perform any testing that he/she sees fit to ensure that his/her payload will survive the launch environment. In addition to the testing completed by the customer, WFF will perform a three axes vibration test in June. ***It is highly recommended that customers perform vibration testing prior to arriving at Wallops Flight Facility.*** Details on the vibration testing levels can be found in Appendix B.

8.2. Vacuum Testing

It is not required but highly recommended that the customer run a full mission simulation in a vacuum chamber.

8.3. Day in the Life Testing (DITL)

The customer is required to run two (2) full mission simulations to demonstrate functionality of the payload. This test should consist of the payload being operated on the bench as an integrated payload for the entire mission life (less than 30 minutes). The results of these tests will be presented at the weekly teleconferences as indicated on the schedule.

9.0 SELECTION PROCESS

Any educational institution wanting to fly shall submit the NOI either via email or by fax no later than September 10, 2010 at 4:00 PM MDT. The NOI will be emailed along with this document upon its release.

The Notice of Intent will be reviewed, and initial selections will be made by September 15, 2010. Initially selected candidates will be chosen based on responses to the questions on the NOI. Institutions that submit an NOI will be expected to pay a refundable earnest deposit of $2,000 no later than October 08, 2010. All payments must be in the form of a check made payable to the University of Colorado (Section 1.5.1). At this point in the selection process, there will be more candidates than available positions. Over the next three months, candidates will refine their mission and complete three (3) design reviews. The first review is the Conceptual Design Review (CoDR), which will mature to a Preliminary Design Review (PDR), which will ultimately end with a Critical Design Review (CDR). In addition to these reviews, candidates will submit monthly, online progress reports. Each of these presentations and online progress reports will be reviewed and used to determine the flight worthiness of all initially selected candidates.

No later than January 14, 2011, COSGC and WFF will award flight opportunities to the four RockSat-X experiments that are the most mature and ready to continue in the engineering process. Up to two decks of customers may be kept as reserve payloads, and will continue in the design process.

If an institution is NOT selected at final down select, their earnest deposit will be refunded in full. Those institutions that are awarded flights will continue to the next step of the engineering process. The four selected decks and the reserve customer(s) will make the first non-refundable installment on February 4, 2011. ***Once the initial payment is received, the customer's space has been reserved and no refunds will be issued for any reason; this includes but is not limited to failing to complete the payload before launch or being removed from flight by either Wallops Flight Facility or COSGC.*** The final non-refundable installment will be due April 1, 2011. For further details concerning the engineering/design process after final down select, please see the schedule in Section 10.0.

In the event that a customer cannot complete his/her payload or does not follow requirements set forth in this document, a reserve customer will become a primary customer, and the primary customer will ***not*** be refunded or compensated in any way. In the event that the four finalists all launch, the reserve customer(s) will be refunded the cost of flight, but will NOT be compensated for any hardware, travel, or miscellaneous expenses incurred in the engineering process.

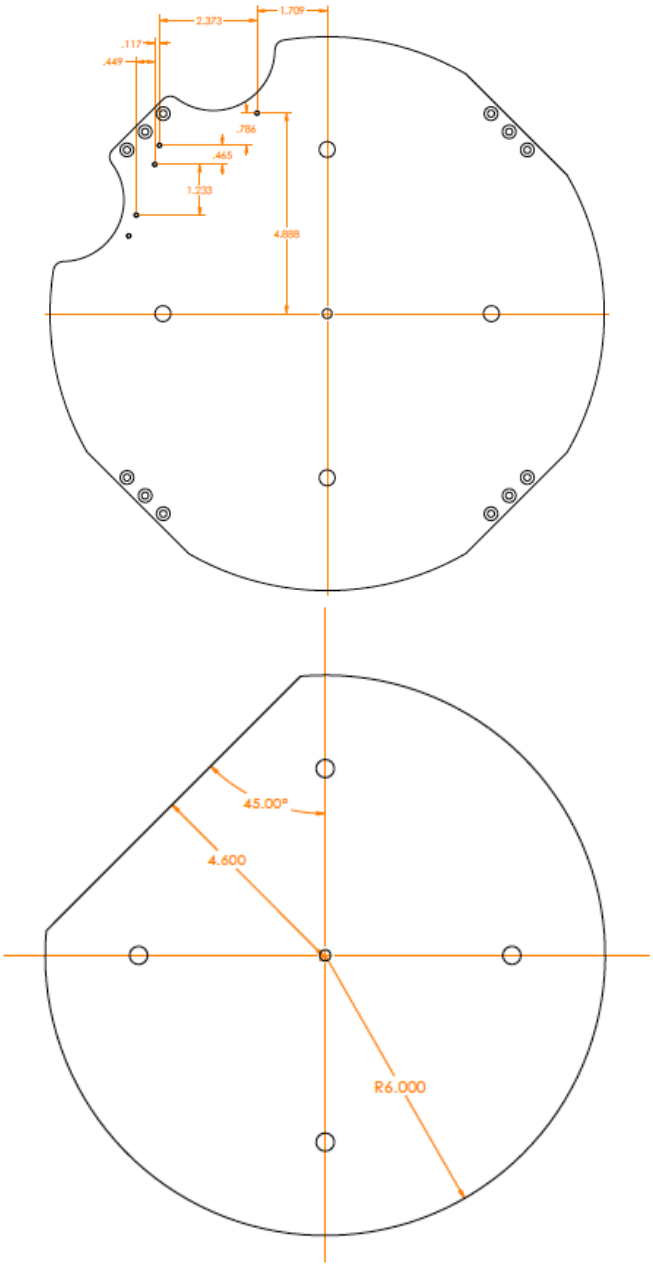
10.0 SCHEDULE

The following are key deadlines and reviews that the customer should be aware of.

8/06/2010	RockSat Payload User's Guide Released
9/10/2010	Submit Notice of Intent (NOI)
9/15/2010	Initial Down Selections Made
10/06/2010	Conceptual Design Review (CoDR) Due
10/08/2010	Conceptual Design Review (CoDR) Teleconference
10/08/2010	Earnest Deposit of $2,000 Due
10/22/2010	Online Progress Report 1 Due
10/27/2010	Preliminary Design Review (PDR) Due
10/29/2010	Preliminary Design Review (PDR) Teleconference
11/17/2010	Critical Design Review (CDR) Due
11/12/2010	Online Progress Report 2 Due
11/19/2010	Critical Design Review (CDR) Teleconference
12/03/2010	Post CDR Action Item Generation
1/14/2011	Final Down Select—Flights Awarded
1/28/2011	Post CDR Action Item Review
2/04/2011	First Installment Due
2/18/2011	Online Progress Report 3 Due
April 2011	RockSat Payload Decks Sent To Customers (Pending Completion)
2/23/2011	Individual Subsystem Testing Reports Due
2/25/2011	Individual Subsystem Testing Reports Teleconference
3/18/2011	Online Progress Report 4 Due
3/23/2011	Payload Subsystem Integration and Testing Report Due
3/25/2011	Payload Subsystem Integration and Testing Report Teleconference
4/01/2011	Final Installment Due
5/06/2011	Weekly Teleconference 1
4/20/2011	First DITL Test Report Due
4/15/2011	Online Progress Report 5 Due
4/22/2011	DITL 1 Teleconferences
5/13/2011	Weekly Teleconference 2
5/18/2011	Second DITL Test Report Due
5/20/2011	Weekly Teleconference 3 (2nd DITL Presentations)
5/27/2011	Weekly Teleconference 4
6/03/2011	Weekly Teleconference 5 (Travel Logistics)
6/10/2011	Launch Readiness Review 1 (LRR) Due

6/13/2011	Launch Readiness Review 1 (LRR) at Wallops
6/14-16/2011	Environmental Testing/Integration at Wallops
6/17/2011	Action Item Meeting with Wallops
7/08/2011	Post Environmental Tag-Up 1
7/29/2011	Post Environmental Tag-Up 2
7/30/2011	Final LRR Due
7/30/2011	Final Payload Inspections
7/30-31/2011	Final LRR and Inspections
08/1-2/2011	Final Payload Integration
8/04/2011	Launch!
8/5-7/2011	Contingency Launch

11.0 APPENDIX A: Mechanical Drawings/Interfaces



12.0 APPENDIX B: Environmental Testing Characteristics

** NOTE: The following specifications are the level used on RockSat-C/RockOn. If other levels are to be used, this section will be revised as necessary.

***Environmental Testing Characteristics*:**
Wallops Flight Facility's Environmental Test for the RockSat Program has two components: The Sine Test and the Random Test.

***Sine Test*:**
The Sine Test will vibrate the payload along the thrust axis at no more than 3 in/s. These rates will occur between the frequencies of 10 and 144 Hz. The thrust axis will also see 7G from 144 to 2000 Hz. The sweep rate is 4 octaves per minute.

***Random Test*:**
The random test will be completed in all three axes: thrust, lateral, and 90 degrees from lateral. The test will begin at lower levels and gradually increase to full level. Each axis will see 20 seconds at full level.

Thrust Full Level: 10 G_{rms} at 0.051 G^2/Hz from 20-2000 Hz
Lateral and Lateral 90 Full Level: 7.6 G_{rms} at 0.029 G^2/Hz from 20-2000Hz

13.0 APPENDIX C: Supplemental Telemetry Specifics