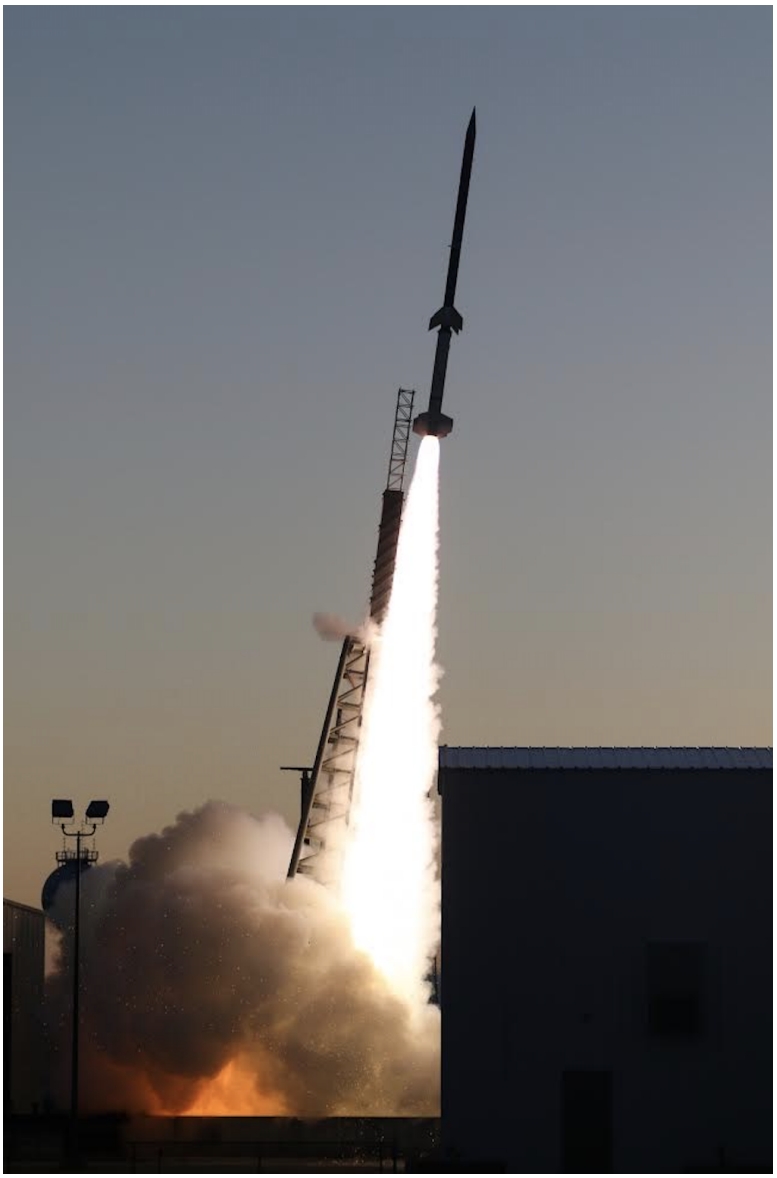
RockSat-C
User's Guide

The Next Step In Low Cost
Student Access To Space



Wallops Flight Facility
Wallop Island, Virginia

0.0 APPROVALS AND TRACKING

0.1. Signatures

Prepared & Approved by: _____
RockSat-X Program Manager

WFF Concurrence: _____
Sounding Rockets Program Office

0.2. Revisions

Revision	Description	Date	Approval
A	Initial release	08/31/2023	

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1.0 INTRODUCTION

1.1. RockSat Program

RockSat-C is a follow-up program to the RockOn Workshop where customers design their own sounding rocket experiment and compete for a spot on the launch vehicle. The RockOn Workshop teaches participants how to build a sounding rocket experiment in three days. The goal is that participants will take what they learn during the workshop and return the next year with an original experiment to fly with the RockSat-C or RockSat-X programs. Participation in the RockSat program starts with the submission and acceptance of the RockSat Intent to Fly Form (IFF) which is due in September.

The RockSat-C program is designed to provide students with access to low-cost flight opportunities and further develop their engineering skills. The RockSat-C flight is made possible through significant cost sharing provided by Wallops Flight Facility (WFF) and the RockSat Program Fee paid by RockSat-C teams.

The program uses a modular canister system to allow for simple integration to the WFF Sub-SEM ring assembly. This standardized approach simplifies final integration and allows for more focus on the design of the experiment. The organizers of the RockSat-C program guide the RockSat-C customers through the design process in the fall with multiple design reviews and test reviews in the spring. Since space on the rocket is limited, only the most developed and capable projects as well those who perform well during the design review are selected for flight in November following the Preliminary Design Review (PDR). Following selection and manifesting, the projects complete their Critical Design Review (CDR) in December and continue to have subsystem and system testing reviews with the RockSat-C organizers through May. Experiments are shipped to WFF in May. Teams travel to WFF in Virginia in June to support integration, testing and launch of their experiment. All experiments remain integrated to the rocket until launch. If an experiment develops a mechanical failure during WFF testing, de-integration and repair may be permitted if WFF and RockSat organizers allow.

1.2. Participant Eligibility and Responsibility

The intent of the RockSat-C program is to provide hands-on experiences to students and faculty advisors to better equip them for supporting the future technical workforce needs of the United States and/or helping those students and faculty advisors become principal investigators on future NASA science missions. Therefore, RockSat-C is limited to U.S. educational institutions; only experiments from U.S. educational institutions are eligible to participate in the RockSat-C program. For the purpose of the RockSat-C, '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 Wallops at rocksatprogram@gmail.com 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 encouraged. However the experiment shall be a student project with students doing the design, build, test, documentation, operation, and data analysis. Participation in the RockSat-C program includes teleconferences with WFF employees and contractors as well as all integration, testing, launch, and recovery operations that take place at WFF. Normal access to WFF facilities and personnel is limited to U.S. persons only. Therefore, individuals participating in the RockSat-C program must be a U.S. Person. U.S. federal law defines a U.S. Person as: a citizen of the United States, an alien lawfully admitted for permanent residence, or a corporation that is incorporated in the U.S. (22 CFR 120.14, 15 – and by 8 U.S.C. 1101(a)(20)). Persons in the U.S. on a work visa are not considered U.S. persons.

Additionally, participants in the RockSat-C program shall comply with export regulations in regard to disclosures of technical data. All participants warrant and represent that they will limit disclosure of any technical data contained in, made available, or generated in the performance of their participation in the RockSat-C program in accordance with export restrictions imposed by the U.S. Export Administration Regulations, 15 C.F.R. Parts 768 et seq. and the International Traffic in Arms Regulation, 22 C.F. R. Part 120 et seq. This applies to all parties involved (such as an industrial partner to an educational institution). As a baseline, the RockSat-C program does not permit ITAR and/or Export Controlled hardware/experiments on the program. Teams may ask WFF for exception to this baseline during the CoDR and PDR design reviews.

1.3. Purpose

The purpose of this document is to identify the interfaces, requirements and logistics pertaining to the WFF RockSat-C program. This document also establishes the guidelines and requirements for qualifying an experiment for selection to be flown, along with the review and integration schedule. Experiments shall be student based with faculty and/or industry involvement only. RockSat-C is not available to experiments that are profit related endeavors and/or solely industry research and development. Students shall be actively engaged and involved.

1.4. Getting Involved (Intent to Fly Forms)

Interested institutions/teams shall submit an Intent to Fly Form (IFF) in September by the due date listed on the IFF in order to be considered for participation in the RockSat-C program. IFF can be found here. https://tinyurl.com/rocksat-24-iff Although required, submission of the IFF does not mean that your team has been selected for flight on the RockSat 2024 program. Due to the limited experiment space on the RockSat launch vehicles, a

down-selection process will be utilized after the successful completion of the RockSat Conceptual (CoDR) and Preliminary (PDR) design reviews.

1.5. Experiment Space

There are five full experiment spaces on the RockSat-C launch vehicle. These spaces are enclosed in the RockSat Experiment Canister. Teams can elect to use half of a full experiment space, however the weight and volume limits are reduced to approximately half of the full space limits. Specific allocations will be discussed with teams after the flight manifest is finalized after PDR. In the event that a subset of customers would like to redistribute allotments, all customers of the subset must contact WFF, and changes will only be made with written approval of all parties involved and WFF. The five full experiment spaces cannot be split into any size smaller than half. For half experiment spaces, one customer will mount to the bottom plate of the canister and the other will mount to the top plate. The customer hardware will not interface with each other, only to the canister. However, customers sharing a canister should be in contact to make sure integration will go smoothly with both experiments meeting the structural and electrical requirements outlined in this document. A mid-mounting plate is available on request to provide separation between experiments or a mount for a camera utilizing an optical port. WFF provides access to a limited number of ports, which can be provided upon request. Ports provide experimenters with access to the space environment from within the sealed canister. The port types include: atmospheric, multipurpose, and optical.

1.6. Program Fee

The RockSat Program Fee pays for the RockSat Program. It covers the costs to administer, run, and manage the RockSat program which begins with reviewing the IFF and ends with the review of each team's final report. The Program Fees are used as teams progress through the program and are therefore non-refundable. See additional details below. The Program Fee associated with RockSat-C is contingent upon the amount of the experiment space being utilized. Teams will receive (1) RockSat-C experiment canister (shall be returned after flight) after their final of 3 payments has been made. Additionally, teams will receive 8 program t-shirts during the June launch trip. Travel costs to and from Wallops Flight Facility, lodging, meals, or other expenses incurred while supporting these trips are the responsibility of the teams.

The Program Fee for a full experiment space is $15,000. The Program Fee for a half experiment space is $9,000. The Program Fee is to be paid in 3 payments based on the schedule below. Payments shall be made by check, Purchase Order, or credit card. Details on where to send payment will be provided on the invoice. Payment is NET 30.

Invoice Date	Due Date	Payment Amount	Notes
09-20-2023	10-20-2023	Full = $5,000 Half = $3,000	
12-08-2023	01-08/2024	Full = $5,000 Half = $3,000	
02-27-2024	03-27-2024	Full = $5,000 Half = $3,000	Canisters and ports sent after this payment
	Totals	**Full = $15,000** **Half = $9,000**	

1.7. Refund Policy

The Program Fee is only refundable if a team is down-selected on November 28, 2023. Teams not selected for flight during this process will receive a full refund of program fees paid minus a small processing fee. Teams selected for flight will be responsible for completing their remaining two payments by the due dates. Additionally, launching rockets has inherent design issues, schedule risks, technical unknowns, and weather factors. While launch and recovery of the RockSat rockets is the intention of this program, it is not guaranteed. If in the event that the rocket is unable to launch due to any factor listed above or for some other reason beyond Wallops Flight Facility control (this has never happened), experiments will be returned to teams and there will not be a refund of the program fee. If the rocket is not recovered after launch (this has happened once) Wallops will not compensate teams for the lost experiment hardware, travel, etc and there will not be a refund of the program fee. If Wallops determines your team is non-compliant with the RockSat User Guide at any time (if possible, teams may be given time to become compliant) and/or if your experiment fails a pre-launch delivery and/or testing benchmark, you will be removed from the flight manifest. If integration to the rocket has already occurred, your experiment may still fly as an inactive experiment or it may be returned to you. In both cases, you will not receive a refund of the program fee.

1.8. Points of Contact

At this time, RockSat Points of Contact (POC) are still being determined. For now please direct all inquiries to rocksatprogram@gmail.com

1.9. Applicable Documents and Links

- Sounding Rocket Program Office - Student Flight: https://sites.wff.nasa.gov/code810/student.html
- NASA Wallops Flight Facility: http://www.nasa.gov/centers/wallops/home/index.html
- NASA Sounding Rockets User Handbook http://sites.wff.nasa.gov/code810/files/SRHB.pdf

2.0 ROCKSAT OVERVIEW

The RockSat Experiment canister is a modular system of canisters designed for suborbital flights with Wallops Flight Facility's (WFF) Sub-SEM ring assembly (Figures 4 and 5). Images and solid models are also given below in Figures 1-3, 6, and Appendix A. The objective of the RockSat-C experiment canister 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-C experiment canister has flown successfully since the first launch in June 2008.

RockSat-C is a fully pressurized rocket. It reaches an altitude of ~70 miles and is recovered. The rocket is spinning at 5-7 times a second to stabilize it during the flight. This spinning will persist throughout the flight and will not allow for a microgravity environment. No power or data storage/transmission is provided by the RockSat-C rocket and shall be provided by the experiment.

2.1. RockSat experiment Canister Images

Figure 1: RockSat Experiment Canister

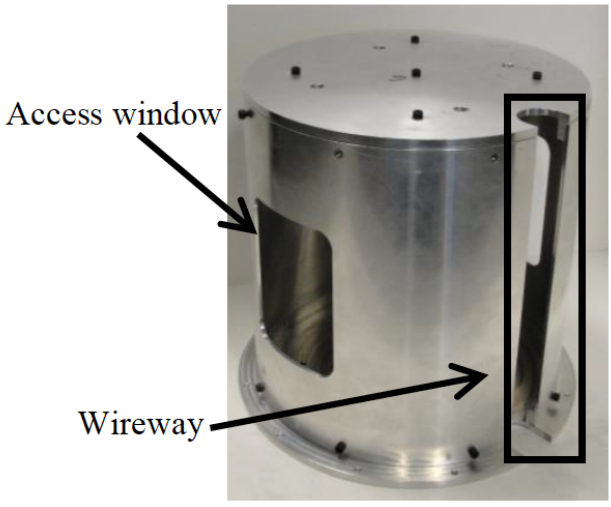


Figure 2: RockSat Experiment Canister

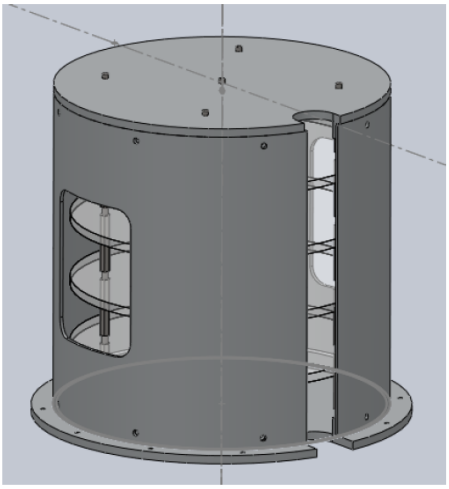


Figure 3: RockSat Experiment Canister

** Makrolon plates visible in the picture and SolidWorks model are part of the RockOn workshop and ** ** are not required or included. **

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 their experiment.

3.1. RockSat experiment Canister Interface General Description

Each RockSat experiment canister will be attached to the Sub-SEM ring assembly in a stacked configuration (Figure 4). The Sub-SEM rings are further attached to longerons that span the entire length of the experiment section (Figures 4 and 5). With 9 RockSat canisters flying (4 RockOn, 5 RockSat-C customers), the Terrier-Orion is estimated to reach an altitude of approximately 68-72 miles (110-120 km).

Full experiment space canisters shall use five (5) top bulkhead bolts and five (5) bottom bulkhead bolts to secure the experiment to both the canister lid and base. Half experiment space canisters shall use either the five (5) top bulkhead bolts or five (5) bottom bulkhead bolts to secure the experiment to both the canister. If a mid-mount plate is used, the experiment may be allowed to only be mounted to this plate and not the canister lid.

In addition to meeting the bolt interface requirements, each experiment shall conform to the activation requirements set forth in Section 5.3.2.1 A compliance test shall be performed before integration. Experiments that do not meet these requirements shall be removed from the flight. The experiment activation system shall be designed such that the wires pass through the designated wire-way.

Further details on the dimensions and location of the wire-way can be viewed in Section 5.2.5 and Appendix A.

The RockSat-C experiment canister is cylindrical in shape. The usable volume for a full experiment space has a diameter of approximately 9.3 inches and an approximate height of 9.5 inches; see Figure 6 and mechanical drawings in Appendix A for exact dimensions. Each experiment canister weighs approximately 6.7 pounds without top and bottom bolts. A mid-mount plate (1.5 lbs) is also available to provide separation for half experiment spaces if desired by the customers. The total weight of the integrated full experiment space canister, complete with customer hardware, shall be 20±0.2 lbf. This works out to be ~13.3 pounds for the experiment itself. The total weight of the integrated half experiment space canister, complete with customer hardware, shall be 6.6±0.2 for the experiment itself. Once integrated with the other half experiment and the canister, the overall weight shall be 20±0.2 lbf. No modifications shall be made to the RockSat experiment canister. Violation of this rule will result in the customer being removed from the flight.

3.1.1. Modular Structure, Sub-SEM, and experiment Space Images

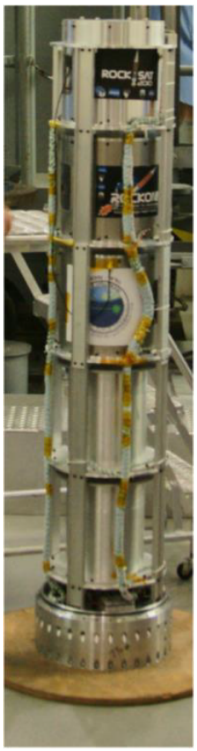


Figure 4: Modular Stacked Assembly

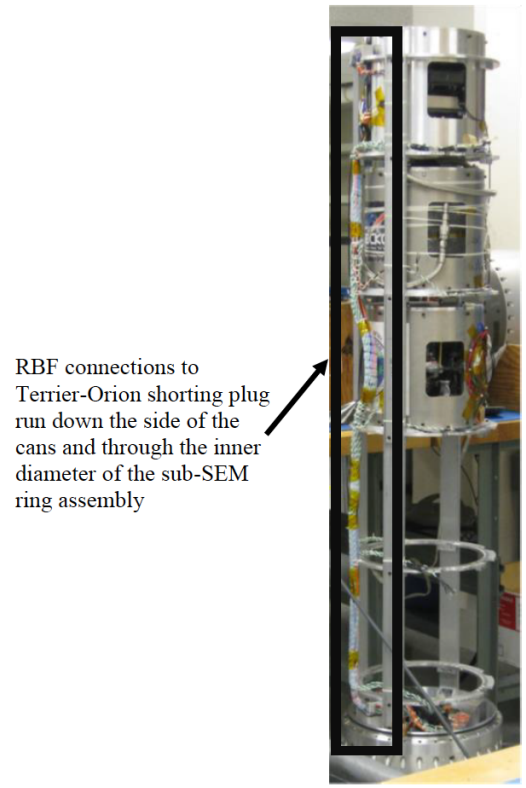


Figure 5: Longerons and Sub-SEM Ring

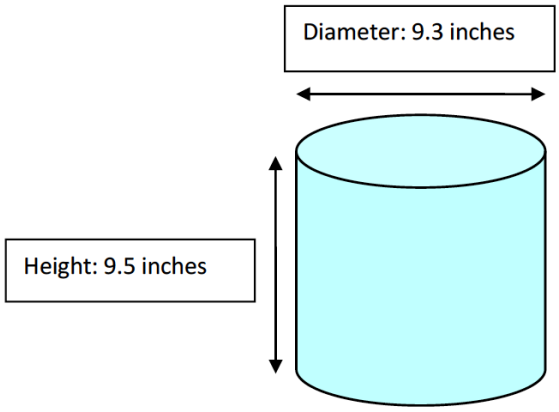


Figure 6: RockSat Experiment Canister Volume Constraints

3.2. Rocket Key Performance Parameters

Table 2: Key Performance Parameters

Key Performance Parameter	Value	Notes
Apogee (miles)	≈72 miles	1,2
Spin Rate (Hz)	≈1.3 Hz at Terrier burn out; ≈5.6 Hz at Orion burn out	1,2
Maximum Ascent G-Load	25 G	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

The biggest environmental factor to consider for WFF flights will be G-loading. During the 2008 RockOn workshop, participants recorded sustained G-loads of approximately 25 Gs during ascent on the improved Orion rocket. Experiments shall be designed to withstand 25 Gs of quasi-static loading in all three axes with possible impulses of approximately 50 Gs in the Z (longitudinal) axis. Three-axis

vibration testing will be conducted by WFF before flight. Experiments that do not pass the WFF vibration test will be removed from the flight at WFF's discretion. Temperatures in the experiment section typically begin at ambient (72° F) for and climb to a maximum of 120° F during the ascent of the improved Orion. The rocket is spin stabilized, which reduces the quality of the microgravity environment. Outgassing is not an important consideration for the RockSat-C program as the rocket is pressurized with oxygen-less air.

3.4. Disclaimer

Recovery of experiments is planned but 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 WFF cannot plan for. Selected experiments assume all risks, and WFF shall not be held responsible in the event of an anomaly and/or unrecoverable experiment. Program Fee will not be refunded in the event that the rocket is not recovered. Customers should also be aware that thermal and structural loading will be substantial upon re-entry. Pending a successful recovery of the experiment section, customers should expect severe and un-repairable damage to flight hardware.

4.0 ORGANIZATIONAL RESPONSIBILITIES

4.1. Customer and WFF Responsibilities

Component and functional design responsibilities are listed below.

RockSat-C Experiment Customer

- Experiment and support system
  Support system includes:
  - Power to operate experiment
  - On board data storage
  - Thermal system (if desired)
  - Internal structure and connection to RockSat experiment canister
  - All environmental sensors (if desired)
  - Activation system at launch (in accordance with Section 5.3.2.1)
- Mechanical interface and bolts to the ten (10) bulk head screws outlined in Section 3.1.
- Safety features for experiment-related hazards
- Teflon insulated activation wires of 22 - 24 AWG of at least 3 feet exiting the canister for each experiment
- All required ground side data analysis equipment (computers not provided)
- Required interfacing between sharing customers

WFF

- Terrier-Orion rocket, range safety, launch support, recovery and tracking
- One (1) RockSat experiment canister (shall be returned after flight)
- Sixteen (16) 8-32 Black Oxide Alloy Steel Socket Head Cap Screws (for canister side screws) (bulk heads not provided)
- Pressure and vibration testing and integration onto rocket
- Mission management support

4.2. Ground Control

After the RockSat-C experiment canisters have been integrated onto the sub-SEM ring assembly prior to launch, the customer will have very limited access to the experiment, if any. WFF will handle all activities pertaining to final experiment preparation, launch, and recovery. Customers will not have access to the experiment after integration until the rocket has been recovered and the experiment section is de-integrated.

5.0 EXPERIMENT DESIGN & INTERFACE REQUIREMENTS

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

The following subsections outline the physical requirements and constraints of the RockSat-C experiment.

5.1.1. Constraints on Experiment Types

The purpose or mission of an experiment is open to the customer. The customer shall design an experiment that by all standards (engineering and layperson) would be considered safe and practical. Experiments shall not put other experiments, WFF experiment as a whole, WFF employees, or the launch vehicle at risk. All experiments shall be formally selected before the customer can become a contender for flight. This formal selection will come after acceptance of the IFF by WFF in September. This formal selection does not mean the experiment has been selected for flight. That will come when the official manifest is made in November.

5.2. Mechanical

5.2.1. Physical Envelope

All experiments shall be contained within the RockSat-C experiment canister. The canister is cylindrical in shape with a diameter of 9.3 inches and a height of 9.5 inches for full experiment spaces. The diameter is the same for half experiment spaces but the height is ~4.0 inches. The experiment may occupy as much or as little of this space as desired as long as it meets the requirements outlined in the following section. Mechanical drawings of the RockSat experiment canister are contained in Appendix A.

5.2.2. Mass Properties

The entire RockSat experiment canister and experiment within shall weigh 20±0.2 lbf (9.07 kg). Experiments with hardware weighing less than this 20±0.2 lbf requirement shall incorporate well-secured ballast to meet this weight requirement. The RockSat-C experiment canister will be weighed prior to WFF integration to the rocket. This weight will not include the mass of the multipurpose port and contents nor NPT/tubing. Each experiment canister weighs approximately 6.7 pounds without top and bottom bolts. A mid-mount plate (1.5 lbs) is also available to provide separation for half experiment spaces if desired by the customers. The total weight of the integrated full experiment space canister, complete with customer hardware, shall be 20±0.2 lbf. This works out to be ~13.3 pounds for the experiment itself. The total weight of the integrated half experiment space canister, complete with customer hardware, shall be 6.6±0.2 for the experiment itself. Once integrated with the other half experiment and the canister, the overall weight shall be 20±0.2 lbf. Experiments not conforming to the weight constraints will be removed from the flight.

5.2.3. Center of Gravity

All experiments shall be designed to have a center of gravity (CG) that lies within a 1 x 1 x 1 inch envelope of the geometric centroid of the integrated RockSat-C experiment canister. To ensure stable flight, WFF may require a moment of inertia (MOI) test prior launch. This test will confirm that the CG of the experiment and RockSat experiment canister lie within the one inch cube envelope discussed above. Experiments that do not meet WFF's CG requirements may be removed from the flight. WFF understands that this test at the experimenter level may be difficult to perform and will accept analytical models showing compliance to this requirement.

5.2.4. Material Selection

When designing the structure for the experiment, materials with high resistance to stress corrosion cracking (SCC) are recommended. Materials that have worked well in the past have been aluminum (6061), steel, and Makrolon. Makrolon is used for all RockOn Workshop experiment decks and has worked well for other WFF rocket experiments. Aluminum is not permitted for components such as stand-offs and the use of steel or a suitable equivalent is recommended. Additionally, structural components shall not be 3D printed. Plastics or other petroleum based materials shall be used sparingly. In the event of a pressure loss, outgassing could fog optics or sensors on other RockSat-C experiments.

5.2.5. Experiment Access Openings and Wire-Way

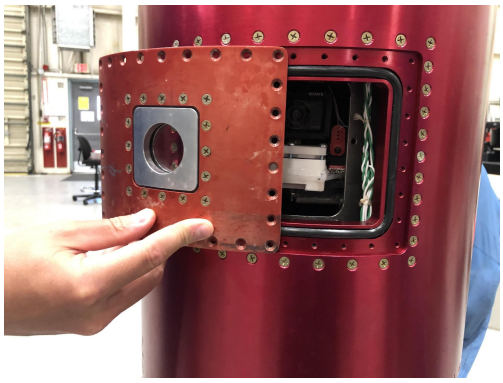
The RockSat-C experiment canister has two (2) experiment access openings that are separated by 180 degrees. These openings have approximate dimensions of 3.5 inches wide by 4.5 inches tall. The wire-way is offset 90 degrees from these windows. The wire-way consists of a notch on the bottom and top bulkheads that allow the Remove Before Flight (RBF) and other necessary wires to pass down

the experiment section. In addition to the notches, the RockSat-C experiment canister skin has a cut-away for running wires. Mechanical drawings of the locations and dimensions of the windows and wire-way can be found in Appendix A.

WFF requires that each RockSat-C experiment canister pass down one (1) set of two (2) wires that WFF personnel will connect to the launch vehicle shorting plug and/or relay (see Section 5.3.2 for more information on electrical interfaces). Each experiment shall have one (1) set of RBF wires of no shorter than 3 feet and either 22 or 24-gauge thickness wire. These wires shall use Teflon coated high temperature wire (PTFE). These wires will be trimmed and will have Winchester connectors added at WFF. If you need thicker wire, it must be approved by WFF Management no later than the CDR. Current passing through these wires must comply with the requirements outlined in Section 5.3.2.1, Experiment Activation. If other wires need to be passed to other experiments or to WFF, a formal variance request should be submitted to WFF Management.

5.2.6. Environmental Access Ports

Experiments are expected to be contained within the RockSat-C experiment canister and will not have access to an environmental access port (i.e. optical, multipurpose, or atmospheric ports). If a port is desired, this needs to be explicitly stated in the CoDR presentation. Not all experiments can be granted access to these ports due to limitations of the rocket skin.



For a typical RockSat-C flight, WFF can provide a total of two static pressure ports, two dynamic pressure ports, and seven total optical or multipurpose ports (with a maximum of 4 optical ports). As stated above, not all experiments can be granted access to these ports, and any desired ports shall be indicated in the CoDR presentation. Additionally, only full experiment space customers can be guaranteed access to more than one port (multipurpose or environmental). Half experiment space customers may request multiple ports, but it is not guaranteed that both requests will be accommodated. It should be noted that only one optical port can be provided per canister. The optical ports have a diameter of 1.5 inches and are made of quartz. Center of the optical port does not align with the center of the "window" cut out in the RockSat-C canister. Details on dimensions of center of optical port and "window" will be provided to optical port teams before PDR.

If a customer is granted access to an atmospheric port, they shall provide the drop down tubing to interface to WFF. The customer end shall terminate with a male ¼" NPT connector. Tube lengths shall be at least 3 feet long. All customers shall use PFA tubing and tube fittings from Swagelok for all connections between port and experiment. More details are included in Appendix C. In addition to providing the drop down tubing, customers using an atmospheric port shall also design a redundant valve to close prior to splash down to ensure that no water will enter the experiment section in the event of a WFF shut off valve failure. Experiments utilizing the atmospheric port shall also perform a pressure test to ensure that they are airtight. If an experiment is not well sealed and there is a risk of the rocket losing pressure, the atmospheric port will be sealed off before flight. WFF valves are designed to open at 5,000 feet on ascent and close at 5,000 feet during descent.

5.2.7. Multipurpose Ports

Beginning on the RockSat-C 2016 launch, a new type or port – known as a multipurpose port – was utilized in order to standardize access to the space environment. These ports were designed to accommodate numerous types of scientific hardware and include a simple method for integration with the experiment and the rocket.

The port pocket is the part of the multipurpose port that holds the customer's hardware. The hardware space is approximately a 2.5"x2.5" square with an approximate depth of 1.4" (depending on location in the pocket). The hardware within the pocket is secured using four screws attached to the lower level holes (the upper level holes are used to secure the cover). Two types of connections are available depending on the customer's needs: 9-pin or a dual SMA. The hardware within the port will connect internally to the connector and a separate wire (provided by the customer) will connect the port externally to the experiment. The pocket also has an optional, modifiable cover. Figures 10 and 11 show the completed multipurpose port including the cover.

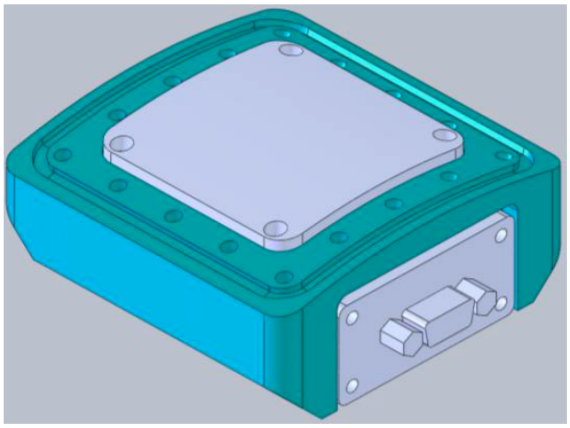


Figure 10: Assembled port pocket with cover and 9-pin connector

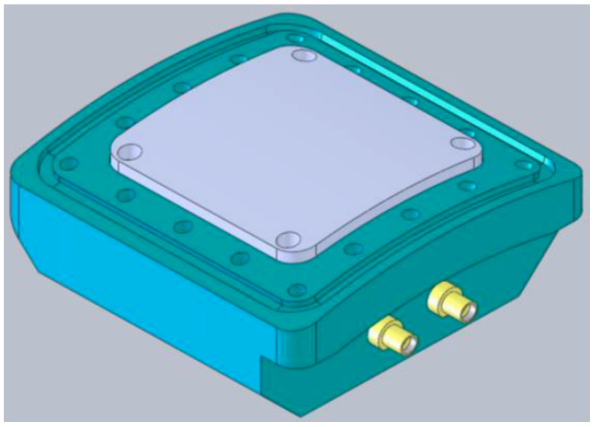


Figure 11: Assembled port pocket with cover and dual SMA connector

If a customer is granted access to a multipurpose port, they shall must provide the appropriate connection between the port and their experiment (ie. 9-pin or dual SMA). If using SMA connectors, please research how to properly attach experiment wires to the SMA connectors (i.e. proper crimping tools, method, etc). Although the cover may be modified, it shall not extend past the rocket skin, and no hardware shall extend past or wrap around the skin without prior consent from WFF. Nothing can be permanently attached to the port pocket although they can be attached to the cover. Additionally, the hardware must be isolated from the pocket (ie. there is no voltage on the pocket). More details on how the ports interface with the rocket skin and additional drawings are included in Appendix C.

5.2.8. Summary of Key Constraints

Table 3: Summary of Key Constraints

Type	Quantitative Constraint
Physical Envelope (full experiment space)	Cylindrical: Diameter: 9.3 inches Height: 9.5 inches (Full experiment spaces) Height: ~4.0 inches (Half experiment spaces)
Mass	Full Experiment = 13.3±0.2 lbf Half Experiment = 6.6±0.2 lbf Canister = 6.7 lbf Mid Mount Plate (optional) = 1.5 lbf
Center of Gravity	Lies within a 1x1x1 inch envelope of the RockSat experiment canister's geometric centroid.
Ports – optical, multipurpose, or atmospheric	Customer shall provide drop down tubing for atmospheric plumbing. Plumbing must terminate with a male ¼" NPT connector. Additionally, the customer shall design in a redundant valve to protect the experiment at splash down. Customer shall provide appropriate connection between port and experiment (dual SMA or 9-pin). Additionally, customer shall not permanently attach anything to the port pocket. The customer may modify the cover.

5.3. Experiment Interfaces

The main interfaces the customer must consider to integrate to the launch vehicle are mechanical and electrical. The following sections discuss the requirements for each interface type.

5.3.1. Mechanical Interfaces

The experiment shall be contained within the RockSat-C experiment canister. The restrictions on volume, mass, and CG can be found above in Section 5.2.3. In addition to the above restrictions, each full space experiment shall be designed such that its internal structure mounts to both the top and bottom bulkheads of the RockSat experiment canister. The top and bottom bulkheads each have holes for five (5) 8-32 black oxide alloy steel socket head cap screws. The customer's experiment shall mount to at least eight of the ten (10) said bolts. The bolt head shall be on the outside of the canister going into the experiment. This requirement will ensure that the top and bottom bulkheads are secured to the experiment. Half experiment space canisters shall use either the five (5) top bulkhead bolts or five (5) bottom bulkhead bolts to secure the experiment to both the canister. If a

mid-mount plate is used, the experiment may be allowed to only be mounted to this plate and not the canister lid.

No experiment may alter or modify the RockSat-C experiment canister in any way. The RockSat-C experiment canister shall remain in the same state that it was issued in, and no part of the internal experiment shall be mounted to any other part of the RockSat-C experiment canister except the bulkheads as described above. RockSat-C canisters remain the property of WFF and after flight and recovery, shall be returned to WFF.

Half experiment space customers have the option to use a mid-mounting plate to provide separation between customers. The mid-mounting plate, if requested, will be provided to the customer by WFF with the canister. Customers may also alter the mid-mounting plates for hardware mounting if desired, but all alteration requests must be approved by WFF prior to any alterations. Mid-mounting plate request must be submitted to RockSat Management prior to the Critical Design Review (CDR).

5.3.2. Electrical Interfaces

Each experiment shall be electrically self-contained. No power will be provided by WFF or the launch vehicle to the experiments. It is highly recommended that all experiments use rechargeable batteries. Customers may use rechargeable lithium batteries, but rechargeable lithium ion batteries may not be recharged while the experiment is at WFF. Other types of rechargeable batteries may be used and recharged at WFF, such as NiMH. Non-rechargeable lithium ions are allowed. It is recommended that all experiments have their batteries approved by WFF before purchasing them. All rechargeable batteries that will require recharging at WFF shall have a UL listing on both the charger and the batteries. There are no exceptions to this requirement. Button/coin cell batteries or other batteries that may allow continuous power to components of your experiment when activation lines are not connected are not allowed due to safety concerns for WFF employees. That being said, real-time clocks and other devices requiring button/coin cell batteries may be allowed but shall be presented no later than the PDR for WFF approval.

In addition to providing power, the customer shall ensure that the experiment is electrically isolated from the canister. Their experiment electronics shall not be shorted or connected to the canister in any way.

The customer must provide at least one (1) set of two (2) wires for experiment activation, conforming to the requirements outlined in Section 5.3.2.1 below. These wires shall be Teflon insulated to ease the RockSat-C/WFF interfacing. Customers must also provide one (1) wire connected to the experiment ground, for use in confirming isolation from the canister during the Check-In procedure prior to arriving at WFF. These wires must be 22-24 AWG to allow the wire to be successfully soldered to the Winchester Connectors at Wallops Flight Facility.

While the wires can be either solid or stranded, WFF recommends stranded for a better connection during soldering as well as vibration loads.

5.3.2.1. Experiment Activation

Experiment activation can occur in multiple ways. There are a total of approximately twenty-seven activation connections on the rocket for the five RockSat-C experiment canisters. The rocket electrical system contains nine (9) relays capable of providing connections for up to three (3) pairs of shorting wires. Each full experiment space shall strive to minimize the number of required activation lines and shall not exceed three (3). Experiments can choose how to activate, but for safety reasons all experiments shall conform to either Requirement 1.SYS.1 or 1.SYS.2, whose parent is 0.SYS.1:

> 0.SYS.1 All experiments shall be designed such that Wallops will always know its power status as active or inactive (current flowing/not flowing).
>
> 1.SYS.1 Experiments wishing to activate early shall be designed such that Wallops can activate and deactivate the experiment via a single set of shorting wires.
>
> 1.SYS.2 Experiments wishing to activate at launch shall be designed with two opens in the system such that activation occurs if and only if Wallops has shorted the connection and the experiment g-switch has been triggered by launch of the rocket.

Typically, RockSat-C experiments activate using the 1.SYS.2 configuration, with an experiment provided g-switch. An example schematic is provided in the 1.SYS.2 section to demonstrate this activation scheme.

Requirement 1.SYS.1 – Early Activation

Requirement 0.SYS.1 is the parent requirement mandated by Wallops Flight Facility. Because each experiment provides its own power, Wallops must be able to verify that current cannot flow anywhere in the experiment during the arming procedure of the rocket, which could result in prematurely igniting the rocket motor. An experiment designed to conform to 1.SYS.1 will activate/deactivate at Wallops' command. This system is likened to a light switch, where Wallops can inhibit the flow of current via a relay. This type of activation shall not latch on the experiment side, meaning that when power is turned on, it can still be turned off. WFF must have full control of activating and deactivating the experiment. A pictorial representation of this activation scheme is given in Figure 12. This activation is the simpler of the two options, but is reserved for teams that require an early activation. The diagram shows that the wires presented as the open can be the wires directly connected to the power on the experiment. Be advised that the experiment activation system will be checked by WFF to ensure compliance. This means that the experiment will be powered on and off during inspection. Be

sure to design the experiment activation system so that any data collection occurring will be able to either be reset or that there is enough memory space to account for the power-on during inspections. Any sensors that activate or deploy upon experiment power on will also need to be retracted/de-activated upon experiment power-down. Each set of wires conforming to 1.SYS.1 shall not exceed a peak current of 1000 mA

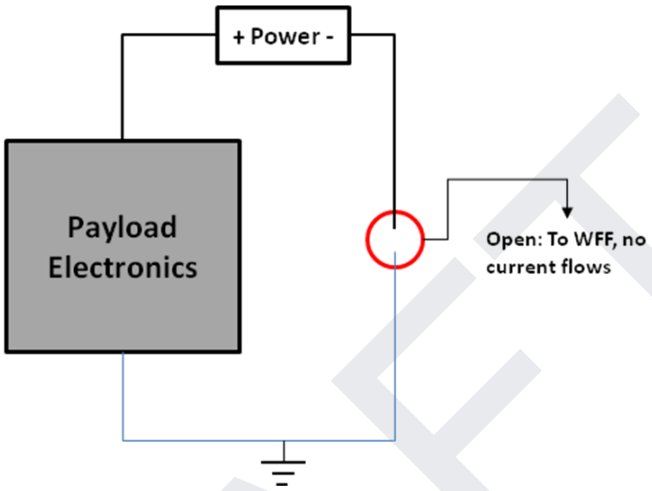


Figure 12: 1.SYS.1 Activation Diagram

The advantage of 1.SYS.1 is that Wallops can activate these experiments up to 10 minutes prior to launch. Customers may request an early activation time between T-10 minutes before launch to T-30 seconds before launch. However, if WFF chooses to hold the launch countdown for any reason, it may be after the T-10 minute mark, but typically not past by the T-3 minute mark. For this reason, it is strongly recommended that customers choose to activate at T-3 minutes or less. Requests must be clearly communicated to WFF by the Critical Design Review (CDR). Of the activation lines available, some of the lines will be designated to activate with a 1.SYS.1 activation type. This means that there are a limited number of early activation times that must be agreed upon by RockSat-C customers utilizing 1.SYS.1. The circuit provided by the relays will remain closed during the duration of the flight and well after landing.

Requirement 1.SYS.2 – G-switch Activation

Requirement 1.SYS.2 is based off of the RockOn activation system. The system shall be constructed such that there are two "opens" in the experiment activation system before the shorting wires are closed: a WFF ARM connection and a G-switch. Once WFF closes the ARM connection via a relay, this will leave only one open in the system; the mechanically activated experiment G-switch. No current shall flow through any portion of the experiment until both opens have been closed at launch. The G-switch is internal to each experiment and is not activated by WFF but by the physical launch of the rocket.

It is HIGHLY recommended that 1.SYS.2 experiments latch in a manner similar to the RockOn SHIELD board with something like solid state relay. Diagrams of an acceptable 1.SYS.2 activation system and the three key states are shown below.

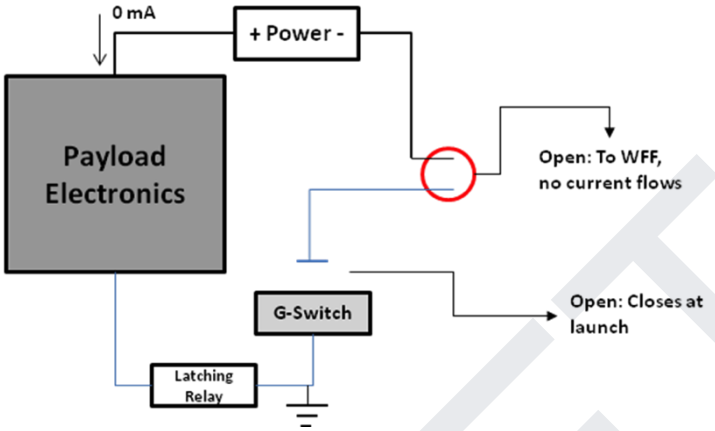


Figure 13: Initial State of RBF System (Safe)

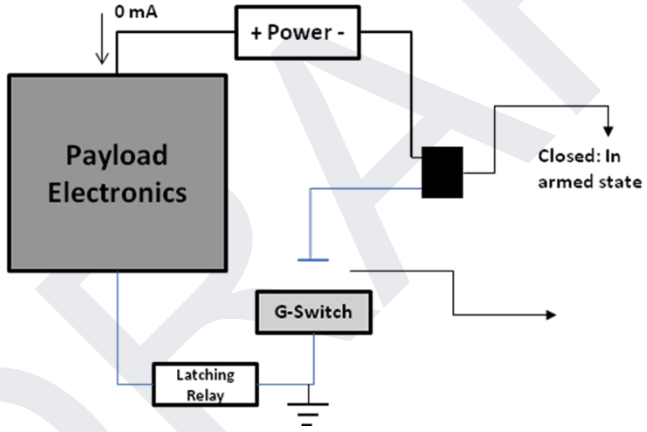


Figure 14: RBF System After WFF Shorting Plug Added (Armed)

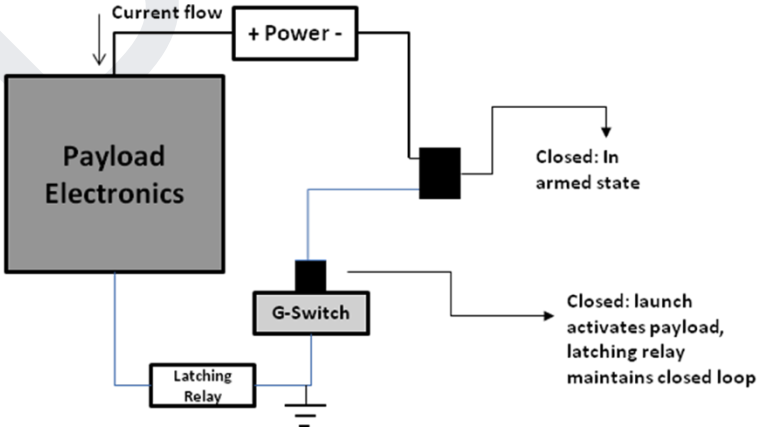


Figure 15: RBF System After Launch (Activated)

Experiments utilizing an activation system conforming to 1.SYS.2 are proven and have worked well in previous missions. Unless the experiment must activate early for calibration or other purposes, it is recommended that all experiments design to 1.SYS.2. Activation systems conforming to 1.SYS.2 will also be connected to one of the available relays. Experiments correctly designed to meet 1.SYS.2 shall have the ability to connect to an early activating relay in the event that there are not enough designated RBF lines. This will not change the operation of the activation, since the system shall not activate until the mechanical g-switch is activated. The following figure (figure 16) is the RockOn g-switch activation, and can be used as an example when designing the 1.SYS.2 activation.

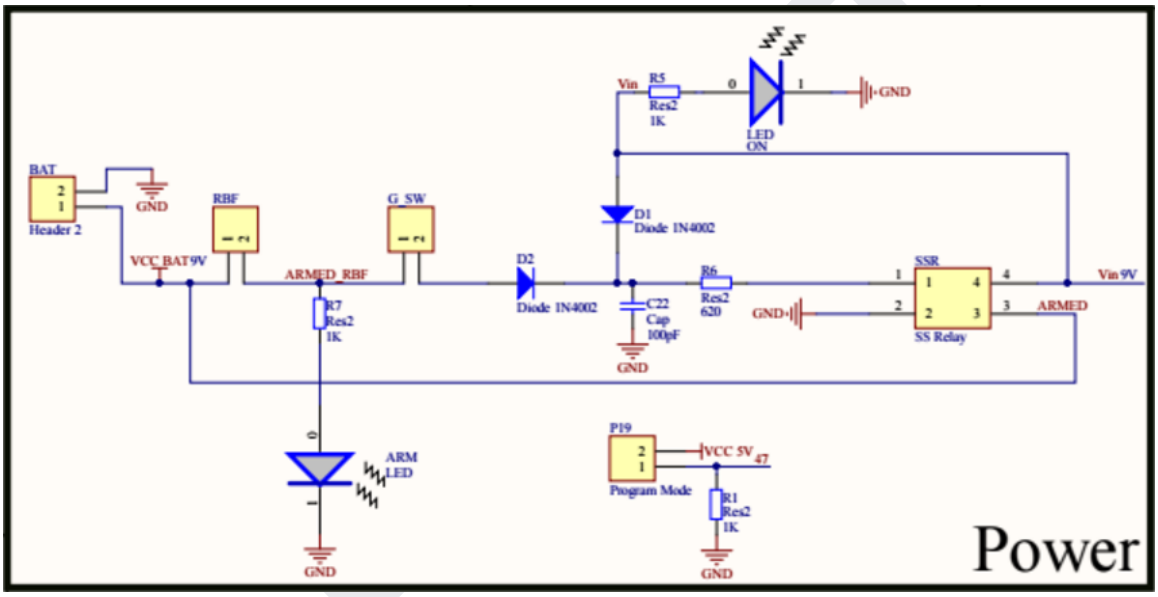


Figure 16: Activation Schematic with G-Switch Implementation (RockOn Workshop Design)

Note that the ARM LED must be excluded in the final design, as this is solely an indicator, and will cause an unpermitted current draw when the experiment is off. It can simply be removed from the circuit, leaving the wire open.

5.4. Can Shorts and Voltage Checks

To ensure the safety of Wallops personnel, the potential of experiment ground and all shorting wires will be measured relative to the RockSat-C experiment canister. The potential between the canister and all shorting/ground wires shall be 0 V and source no current. Otherwise, the customer will be removed from the flight at Wallops' discretion. This DOES NOT mean the experiment ground should be shorted to the canister to ensure 0V potential between them. The canister must be fully isolated from the experiment. The customer must ensure that no power sources are shorted to the canister in any way (through heat-sinks, accidental battery shorts, mounting holes on circuit boards etc.). The procedure used to

check this requirement is fully explained in the Visual Inspection Procedure, which will be distributed at a later date, and must be checked prior to arriving at Wallops to ensure compliance.

5.5. High Voltage Requirements

WFF pressurizes the experiment sections on the rocket, but in the event that the seal is broken, the experiments will experience near vacuum conditions at apogee. To mitigate risk, no high voltage experiments (high voltage is defined as anything greater than 34V) will be allowed without a formal variance request. If a team would like to fly a Geiger Counter, WFF may require the device to be conformal coated to reduce the risk of stray voltage. High voltage requests must also include a plan to prevent injury to personnel handling the experiment. This variance must be in written form and approved by WFF.

5.6. Telemetry Tracking and Control

Wallops Flight Facility will not provide real-time telemetry. Communication systems are prohibited; no experiment shall transmit data of any kind, unless approval is sought through WFF and shall be presented in the CoDR presentation. All data should be stored on on-board memory. Using on-board memory alleviates the complexity of a communication system, and has been proven to be extremely effective for the RockOn workshop and other WFF rocket experiments. Post flight radar tracking of the rocket will be made available. In the event that radar skin tracking data is provided from Wallops Flight Facility, data will be provided to teams upon their request.

5.7. Lasers and Liquids

Lasers will require training and completion of WFF safety forms. Liquids will require accompanying MSDS sheets and a secondary containment designed into the experiment. Volume of liquid will be limited to 50 ml. Flammable liquids will not be permitted under any circumstances. All use of these items will be contingent upon Wallops approval. Any requests to have these items shall be presented in the CoDR.

5.8. Thermal Design Requirements

The customer is responsible for thermal control of their experiment. Due to the short duration of the flight and the closed experiment section, thermal systems may not be required. The RockOn workshop of 2008 saw an increase in temperature of 18 degrees Fahrenheit during the flight. RockOn workshop experiments do not use thermal control, but the choice to use a thermal control system will be left to the customer.

5.9. Electrical Design Requirements

Experiment electronics shall be designed to be safe and practical. Each experiment is required to have a 1.SYS.1 or 1.SYS.2 activation system described in Section 5.3.2.1. It is highly recommended that a latching relay system be used

with 1.SYS.2 where the shorting connection allows a mechanical G-switch to complete the circuit and activate the experiment upon launch. Any experiment that uses alternating current or circuitry with substantial switching (relays) shall notify WFF by the PDR presentation. Fast switching can induce magnetic interference that must be approved by WFF.

5.10. Electrical Harnessing and Staking

All experiments shall harness wires with a nylon lacing tape or the equivalent (electrical tape, zip ties, etc.). Wire harnesses that are excessively long shall 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/or staked in place using aerospace grade Room Temperature Vulcanizing (RTV) sealant, or at minimum, hot glue. An example of a well-harnessed and staked experiment can be seen below in Figure 17.

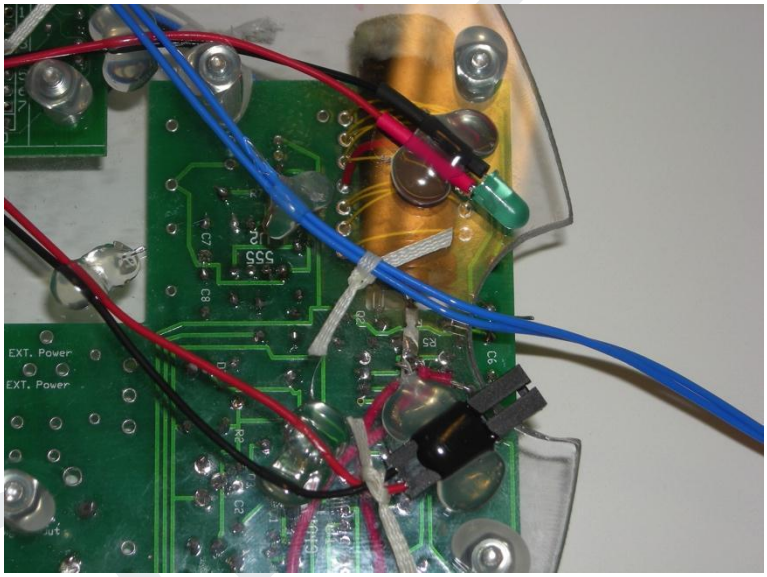


Figure 17: Staking and Harnessing

6.0 EXPERIMENT HARDWARE INTEGRATION

The customer shall deliver (via shipment to WFF) a complete, functional, and fully integrated experiment to WFF in June. Prior to this delivery, a Visual Verification Check-in (VVC) shall be presented by the RockSat-C customer to WFF Management. The review shall demonstrate that the experiment meets all of the requirements of this document and is flight ready. If the experiment does not meet the specifications of this document or the expectations of WFF management, the customer will not be permitted to ship their experiment for integration and testing. All RockSat-C experiments will then be re-tested at WFF after shipment. If re-test is successful, the experiment will be integrated and undergo environmental testing. After environmental testing, experiments shall remain

integrated at Wallops until launch. Teams will not receive experiments back prior to launch. The only exception to this will be if there is a structural failure during vibration testing and in that case, WFF may choose not to re-integrate the experiment.

7.0 EXPERIMENT TEST REQUIREMENTS

Testing of the experiment shall be performed by the customer to ensure experiment functionality and survivability. All tests shall be documented and/or recorded for the testing reviews, whose dates are established in Section 9.

7.1. Structural Testing

The customer shall perform any testing that they see fit to ensure that their experiment 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 but not required that customers perform vibration testing prior to arriving at Wallops Flight Facility. Details on the vibration testing levels can be found in Appendix B.

7.2. Vacuum Testing

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

7.3. Day in the Life Testing (DITL)

The customer is required to run and document at least two (2) full mission simulations to demonstrate functionality of the experiment. This test should consist of the experiment being operated on the bench as an integrated experiment 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.

7.4. Visual Inspection Testing

The customer is required to fully integrate the experiment and perform a visual inspection using the same procedure as that being followed when the experiment is checked after shipment at WFF in June. This test ensures that experiments interface with the canister correctly and that there are no shorts between the canister and the experiment (requirement discussed in Section 5.4). The procedure will be provided at a later date, and a completed and initial copy must be sent to WFF before shipment to WFF. This copy will be used by WFF for the official inspection at WFF in June. All experiments will be held by WFF after the check-in.

7.5. Wallops Flight Facility Testing

The testing performed before launch at WFF in June will be the closest to a true mission simulation that will be available. The experiments are installed onto the WFF experiment section and testing is conducted to ensure systems behave in a way that is safe and acceptable for flight. It is required that experiments be fully

mechanically and electrically functional and active during the June testing. WFF will not allow or accept significant mechanical or electrical changes after the June testing has occurred. During all WFF environmental testing, experiments will not be activated. The following tests will be conducted in June:

- Full electrical sequence
  - All experiment activation systems will be turned at the experiment level
- Vibration
  - Full experiment stack will be tested on the vibration tables as described in Appendix B.
- Moment of inertia (possible)
- Spin balance

The June launch date is dependent on many factors that can cause a launch to slip beyond the intended launch window. All launches have a launch window of 3-4 days. While the first day of the window is ideal, weather, boats in the recovery area, issues with the launch vehicle, or other circumstances may cause a delay in the launch. For this reason, the RockSat-C program makes no promise of a launch on a specific date. Many launches do occur on time and without issue.

8.0 SELECTION PROCESS

Any educational institution wanting to participate in RockSat-X shall submit the IFF in September. The completion IFF is required to participate in RockSat 2024 and is due no later than SEP 21, 2023 at 11:59 PM EDT. The IFF can be found here. https://tinyurl.com/rocksat-24-iff It is expected to take ~20 minutes to complete this form. Although required, submission of the IFF does not mean that your team has been selected for flight on the RockSat 2024 program. The IFF will be reviewed, and initial selections will be made by the end of September. Initially selected candidates will be chosen based on responses to the questions on the IFF. Due to the limited experiment space on the RockSat launch vehicles, a down-selection process will be utilized after the successful completion of the RockSat Conceptual (CoDR) and Preliminary (PDR) design reviews. Each of these presentations will be reviewed and used to determine the flight worthiness of all initially selected candidates. If a team is down-selected, a full refund for their first payment will be issued minus a small processing fee. No later than November, WFF will award flight opportunities (the flight manifest) to the RockSat-X experiments that are the most mature and ready to continue in the engineering process. Once a project has been selected, 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 experiment before launch or being removed from flight by either Wallops Flight Facility.

9.0 SCHEDULE

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

Date	Milestone/Event
SEP 21, 2023	IFF DUE
OCT 09-13, 2023	CoDR (Review)
OCT 20, 2023	1st Payment DUE
NOV 13-17, 2023	PDR (Review)
NOV 28, 2023	Down-Select Complete and Flight Manifest
DEC 04-15, 2023	CDR (Review)
JAN 08, 2024	2nd Payment DUE
FEB 19-23, 2024	STR (Review)
MAR 18-22, 2024	ISTR (Review)
MAR 27, 2024	3rd Payment DUE
APR 22-26, 2024	FMSR (Review)
MAY 28-JUN 4, 2024	VVC (Review)
JUN 07, 2024	Ship Experiments
JUN 13-20, 2024	RockSat-C I&T + Launch Trip
JUL 31, 2024	RockSat-C Reports DUE

10.0 Appendix A: Structural Drawings

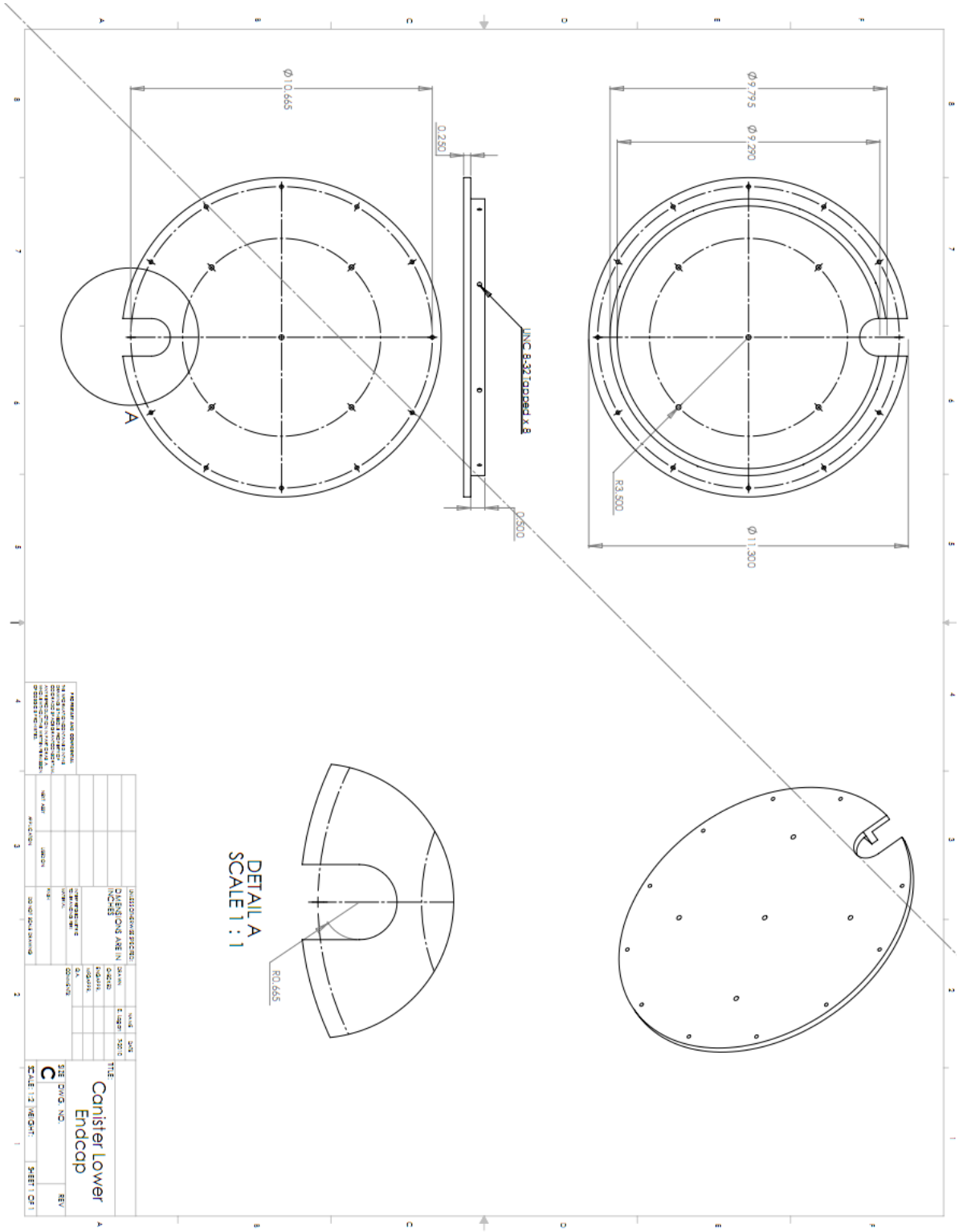


Figure 18: Lower End Cap Mechanical Drawing

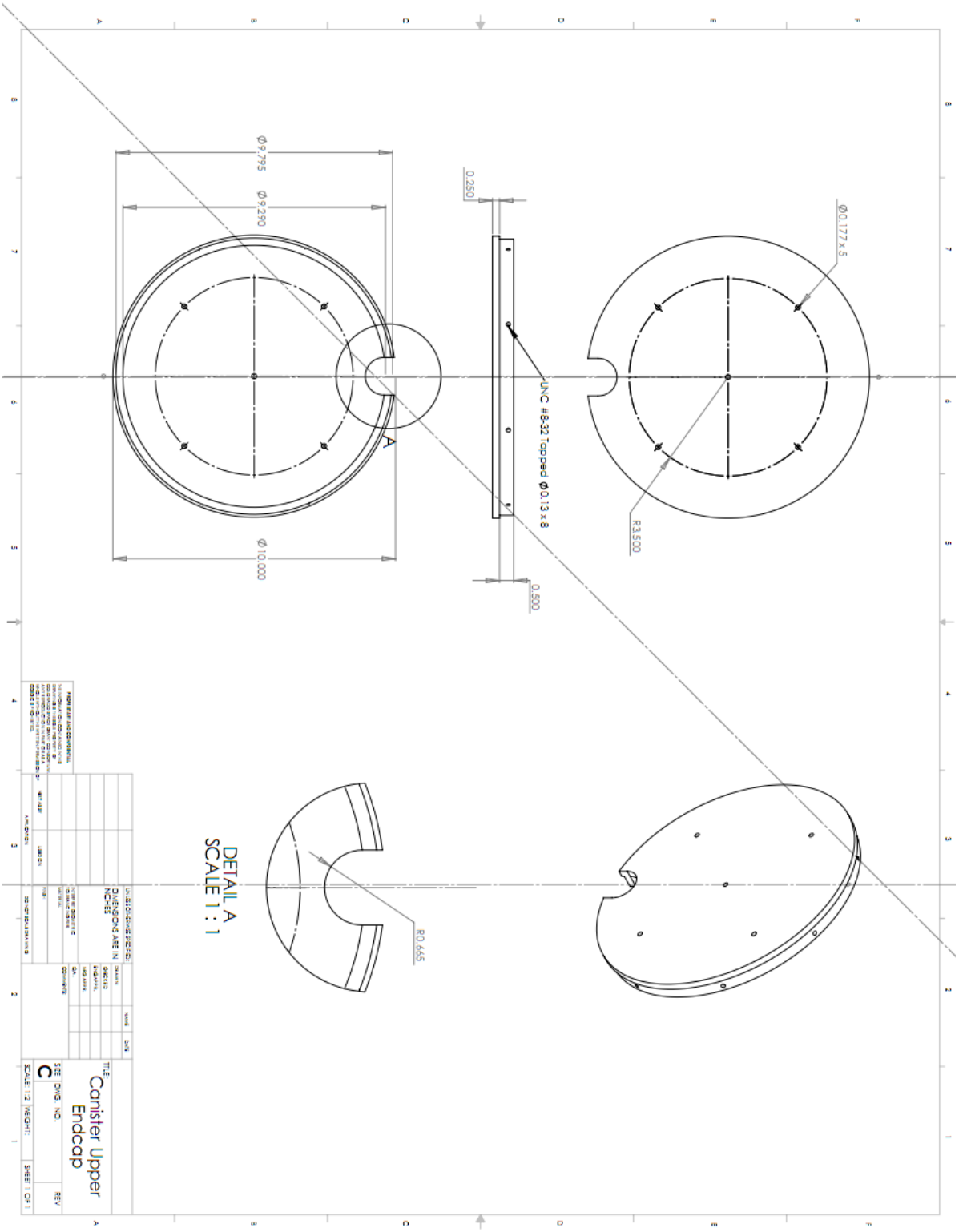


Figure 19: Upper End Cap Mechanical Drawing

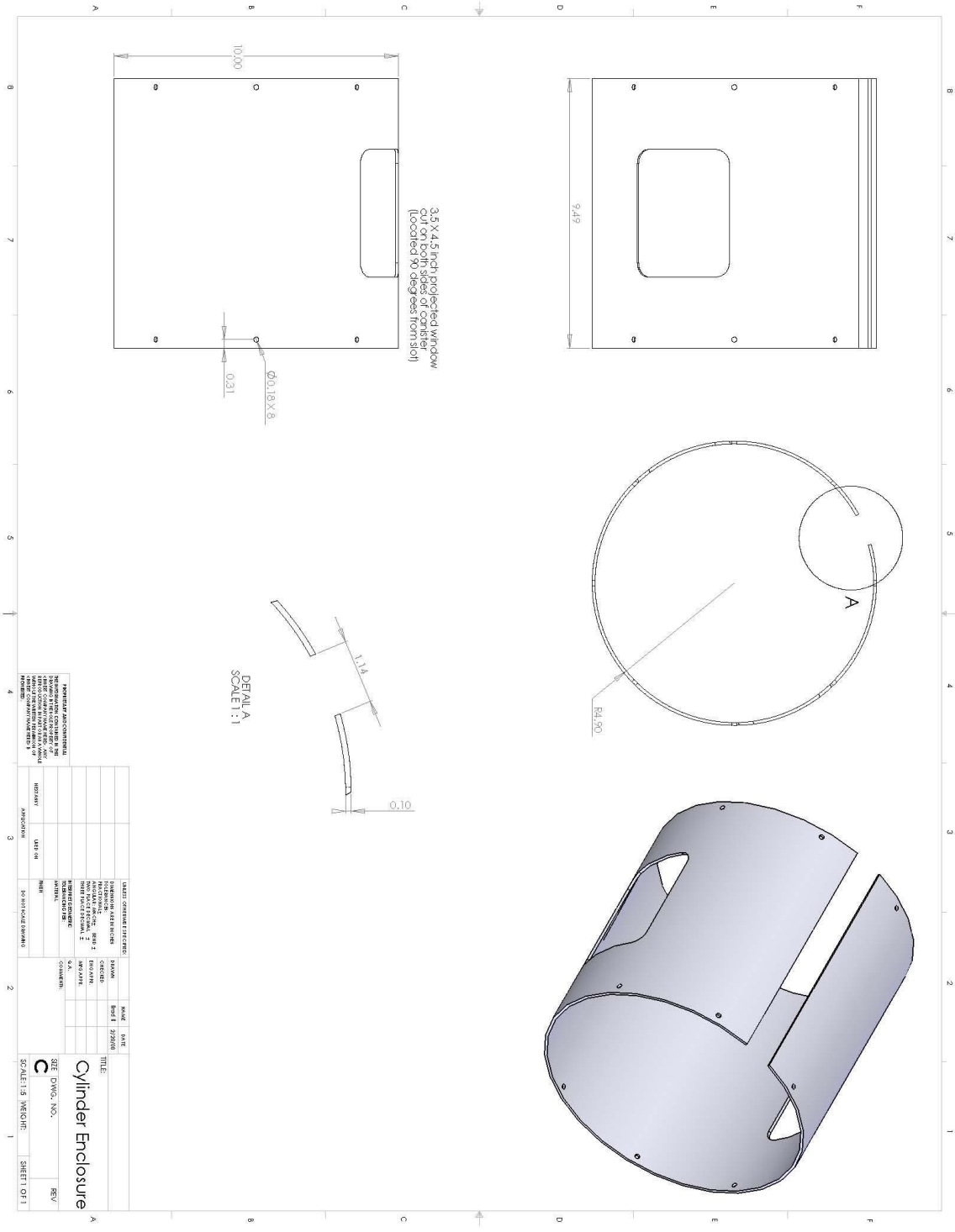


Figure 20: RockSat Canister Skin Mechanical Drawing

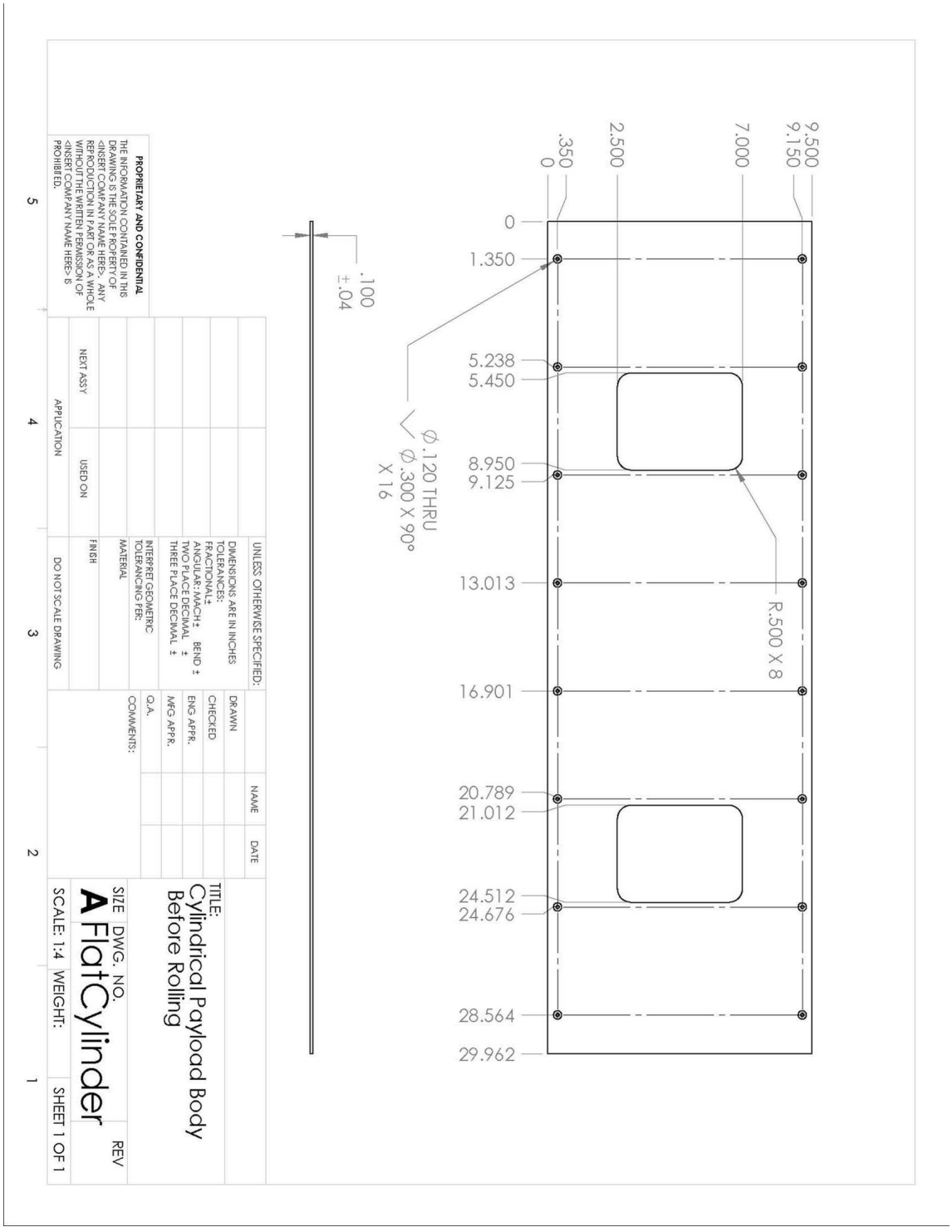


Figure 21: RockSat Skin Mechanical Drawing – 0.125" thick

11.0 APPENDIX B: Environmental Testing Characteristics

** NOTE: The following specifications are based on the levels 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 experiment 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 20-2000 Hz

12.0 Appendix C: PFA Tubing and Tube Connections

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PFA Tube Fittings

- Temperatures from 70 to 400°F (20 to 204°C)
- Working pressures up to 275 psig (18.9 bar)
- Sizes from 1/8 to 1/2 in.

Swagelok

2 PFA Tube Fittings

Features

- Audible click ensures tubing is inserted properly.
- Visual indication of proper pull-up:
  - no gap between body hex and hex nut
  - hex flat alignment.
- Smooth, molded internal wetted surfaces reduce potential for system contamination.
- Grooved tubing allows for higher working pressure.
- Wrench assembly avoids the potentially unsafe practices of hand assembly and disassembly.

Materials

- Fittings—Molded PFA/ASTM D3307 Type I

Pressure-Temperature Ratings

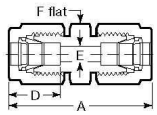
Pressure ratings are for Swagelok® PFA tube fittings used with properly grooved Swagelok PFA tubing.

Tube Wall, in.	0.030	0.047	0.062		
Tube Size, in.	1/8	1/4	1/4	3/8	1/2
Temperature, °F (°C)	Working Pressure, psig (bar)				
70 (20)	275 (18.9)	200 (13.7)	275 (18.9)	180 (12.4)	125 (8.6)
100 (37)	245 (16.8)	180 (12.4)	245 (16.8)	155 (10.6)	115 (7.9)
200 (93)	145 (9.9)	110 (7.5)	145 (9.9)	93 (6.4)	68 (4.6)
300 (148)	87 (5.9)	64 (4.4)	87 (5.9)	48 (3.3)	32 (2.2)
400 (204)	47 (3.2)	34 (2.3)	47 (3.2)	11 (0.75)	11 (0.75)

Ordering Information and Dimensions

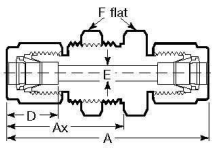
Dimensions, in inches (millimeters), are for reference only and are subject to change. Dimensions shown with Swagelok nuts finger-tight. E dimensions refer to the minimum opening.

Unions



Tube Size in.	Ordering Number	Dimensions, in. (mm)			
		A	D	E	F
1/8	PFA-220-6	1.45 (36.8)	0.50 (12.7)	0.09 (2.3)	1/2
1/4	PFA-420-6	1.70 (43.2)	0.60 (15.2)	0.19 (4.8)	5/8
3/8	PFA-620-6	1.80 (45.7)	0.67 (17.0)	0.28 (7.1)	13/16
1/2	PFA-820-6	2.05 (52.1)	0.90 (22.9)	0.41 (10.4)	1

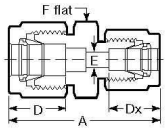
Bulkhead Unions



Tube Size in.	Ordering Number	Dimensions, in. (mm)				
		A	Ax	D	E	F
1/4	PFA-420-61	2.42 (61.5)	1.41 (35.8)	0.60 (15.2)	0.19 (4.8)	7/8

Panel hole size is 0.70 in. (17.8 mm); maximum panel thickness is 0.44 in. (11.2 mm).

Reducing Unions



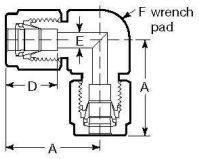
Tube Size in.	Ordering Number	Dimensions, in. (mm)				
		A	D	Dx	E	F
3/8 to 1/4	PFA-620-6-4	1.77 (45.0)	0.67 (17.0)	0.60 (15.2)	0.19 (4.8)	13/16
1/2 to 1/4	PFA-820-6-4	1.91 (48.5)	0.90 (22.9)	0.60 (15.2)	0.19 (4.8)	1
1/2 to 3/8	PFA-820-6-6	1.94 (49.3)	0.90 (22.9)	0.67 (17.0)	0.28 (7.1)	1

Swagelok

Ordering Information and Dimensions

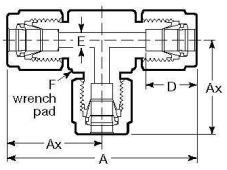
Dimensions, in inches (millimeters), are for reference only and are subject to change. Dimensions shown with Swagelok nuts finger-tight. E dimensions refer to the minimum opening.

Union Elbows



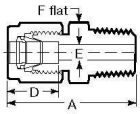
Tube Size in.	Ordering Number	Dimensions, in. (mm)			
		A	D	E	F
1/8	PFA-220-9	0.91 (23.1)	0.50 (12.7)	0.09 (2.3)	1/2
1/4	PFA-420-9	1.13 (28.7)	0.60 (15.2)	0.19 (4.8)	5/8
3/8	PFA-620-9	1.23 (31.2)	0.67 (17.0)	0.28 (7.1)	13/16
1/2	PFA-820-9	1.45 (36.8)	0.90 (22.9)	0.41 (10.4)	1

Union Tees



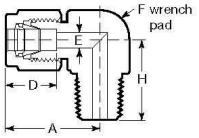
Tube Size in.	Ordering Number	Dimensions, in. (mm)				
		A	Ax	D	E	F
1/8	PFA-220-3	1.82 (46.2)	0.91 (23.1)	0.50 (12.7)	0.09 (2.3)	1/2
1/4	PFA-420-3	2.26 (57.4)	1.13 (28.7)	0.60 (15.2)	0.19 (4.8)	5/8
3/8	PFA-620-3	2.46 (62.5)	1.23 (31.2)	0.67 (17.0)	0.28 (7.1)	13/16
1/2	PFA-820-3	2.90 (73.7)	1.45 (36.8)	0.90 (22.9)	0.41 (10.4)	1

Male Connectors



Tube Size in.	Pipe Size in.	Ordering Number	Dimensions, in. (mm)			
			A	D	E	F
1/8	1/8	PFA-220-1-2	1.21 (30.7)	0.50 (12.7)	0.09 (2.3)	1/2
1/4	1/8	PFA-420-1-2	1.36 (34.5)	0.60 (15.2)	0.19 (4.8)	5/8
	1/4	PFA-420-1-4	1.54 (39.1)			
3/8	1/4	PFA-620-1-4	1.60 (40.6)	0.67 (17.0)	0.28 (7.1)	13/16
	3/8	PFA-620-1-6				
1/2	3/8	PFA-820-1-6	1.74 (44.2)	0.90 (22.9)	0.41 (10.4)	1
	1/2	PFA-820-1-8	1.93 (49.0)			

Male Elbows



Tube Size in.	Pipe Size in.	Ordering Number	Dimensions, in. (mm)				
			A	D	E	F	H
1/8	1/8	PFA-220-2-2	0.91 (23.1)	0.50 (12.7)	0.09 (2.3)	1/2	0.67 (17.0)
1/4	1/8	PFA-420-2-2	1.13 (28.7)	0.60 (15.2)	0.19 (4.8)	5/8	0.78 (19.8)
	1/4	PFA-420-2-4					0.96 (24.4)
3/8	1/4	PFA-620-2-4	1.23 (31.2)	0.67 (17.0)	0.28 (7.1)	13/16	1.03 (26.2)
	3/8	PFA-620-2-6					
1/2	3/8	PFA-820-2-6	1.45 (36.8)	0.90 (22.9)	0.41 (10.4)	1	1.14 (29.0)
	1/2	PFA-820-2-8					1.33 (33.8)

Ordering Information and Dimensions

Dimensions, in inches (millimeters), are for reference only and are subject to change. Dimensions shown with Swagelok nuts finger-tight. E dimensions refer to the minimum opening.

Back Ferrules

Tube Size in.	Ordering Number①
1/4	PFA-424-1
3/8	PFA-624-1
1/2	PFA-824-1

① 1/8 in. back ferrule integral with nut.

Front Ferrules

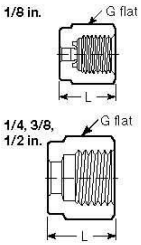
Tube Size in.	Ordering Number
1/8	T-203-1①
1/4	PFA-423-1
3/8	PFA-623-1
1/2	PFA-823-1

① PTFE material.

Plugs

Tube Size in.	Ordering Number
1/8	PFA-220-P
1/4	PFA-420-P
3/8	PFA-620-P
1/2	PFA-820-P

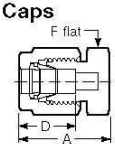
Nuts



Tube Size in.	Ordering Number	Dimensions in. (mm) G	L
1/8	PFA-222-1①	1/2	0.57 (14.5)
1/4	PFA-422-1	5/8	0.65 (16.5)
3/8	PFA-622-1	13/16	0.68 (17.3)
1/2	PFA-822-1	1	0.79 (20.1)

① 1/8 in. back ferrule integral with nut.

Caps



Tube Size in.	Ordering Number	Dimensions, in. (mm) A	D	F
1/8	PFA-220-C	0.83 (21.1)	0.50 (12.7)	1/2
1/4	PFA-420-C	0.98 (24.9)	0.60 (15.2)	5/8
3/8	PFA-620-C	1.04 (26.4)	0.67 (17.0)	13/16
1/2	PFA-820-C	1.18 (30.0)	0.90 (22.9)	1

Installation

⚠ **PFA tubing MUST be grooved for use with PFA tube fittings. Use the Swagelok groove cutter tool.**

1. Insert grooved PFA tubing into the Swagelok PFA tube fitting until a clicking sound is heard.

2. While holding fitting body steady, tighten the blue nut until there is no gap between the nut and body hexes.

3. Continue tightening until the nut and body hexes are aligned.

PFA Tubing and Tools

For PFA tubing in accordance with ASTM D3307, Type II, in 1/8 to 1 in. and 6 to 12 mm sizes, see the Swagelok *Hose and Flexible Tubing* catalog, MS-01-180. The catalog also contains ordering information for the Swagelok groove cutter tool.

Safe Product Selection
When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange parts with those of other manufacturers.

Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit swagelok.com or contact your authorized Swagelok representative.

13.0 Appendix D: Multipurpose Port Explanation

All the experiments are contained within canisters, which are mounted inside of the rocket skin. The canisters have a window cut into both sides, 180 degrees opposite and 90 degrees offset from the wire-way. See the RockSat-C User's Guide Appendix A for detailed mechanical drawings of the canister with dimensions. Figure 21 below shows a typical canister.

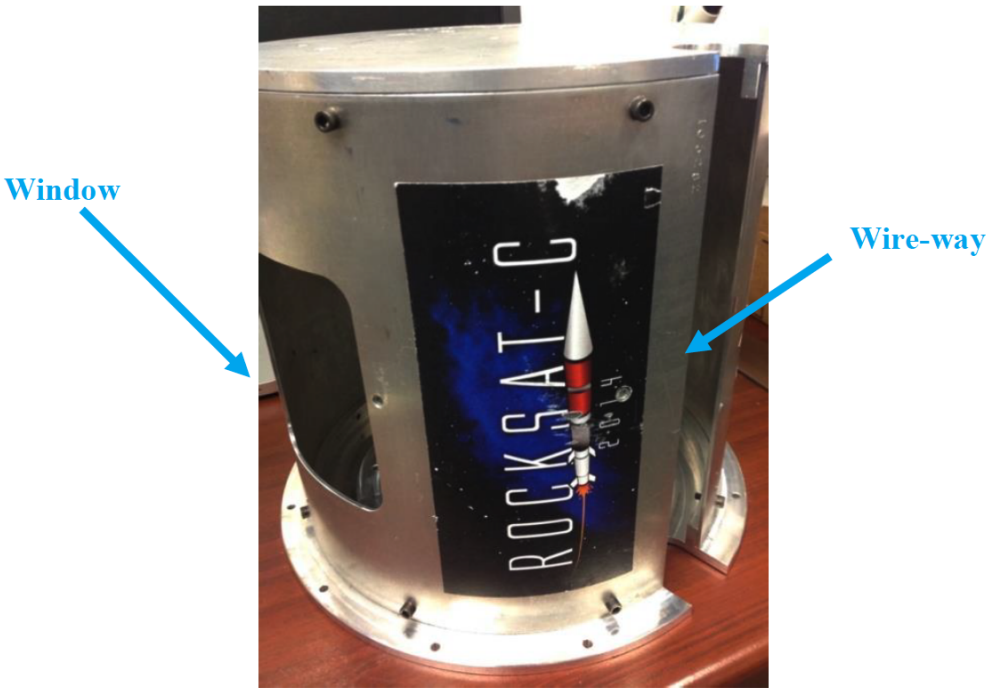


Figure 21. Experiment Canister

The **ports** are holes in the rocket skin shown in Figure 22.

Figure 22. Rocket skin before integration of canisters or ports

Each of the port holes will be covered by what WFF calls a "door" - a cover with an o-ring to seal the door and port hole. It also has another hole for the actual port pocket. Figure 23 shows a detailed view of the door and pocket. Figure 24 provides another view of the door and port integrated onto the rocket (the screws are not shown in the figure, but are fully screwed and torqued before flight).

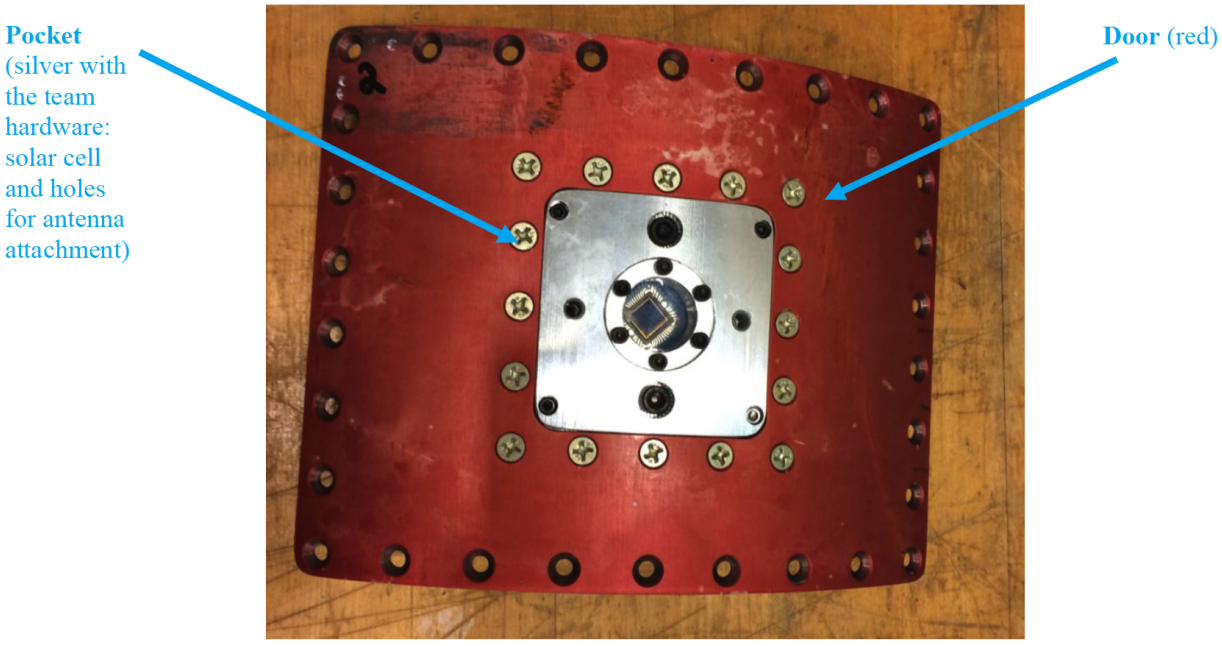


Figure 23. Port door with integrated pocket (2014 design)

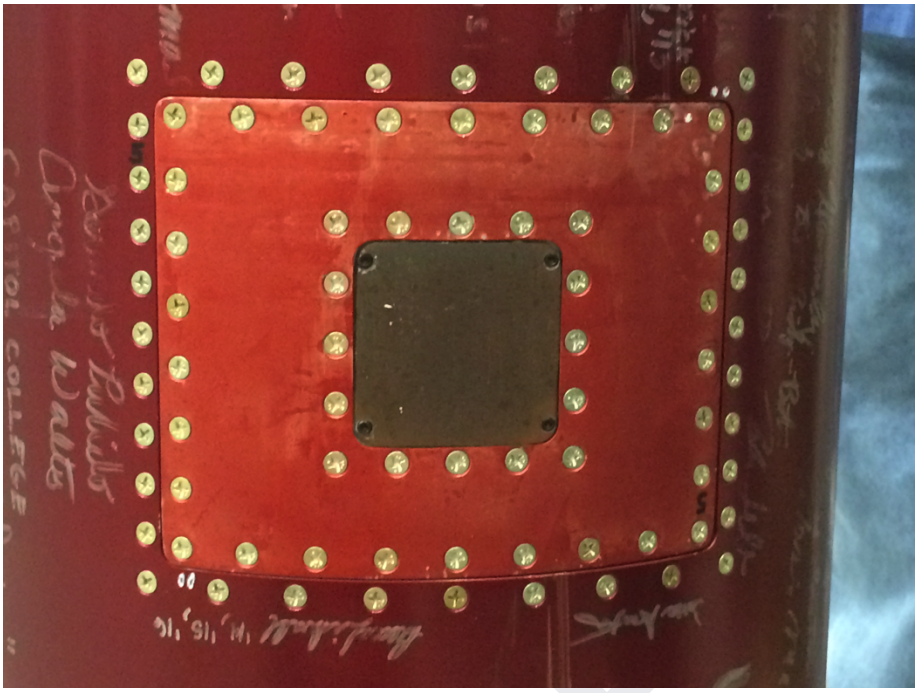


Figure 24. Port door with pocket (2016 design) integrated into rocket skin

The port pocket integrates into the door and holds the hardware. It is a smaller, approximately 2.5" x 2.5", square with a depth of approximately 1.4" (depending on location in the pocket) that each team will mount its components into. The pocket also includes the wire connector: a hermetically sealed connector. The pocket includes a grove for an o-ring on the outside face that mounts to the door for integration onto the rocket skin. See Figures 25 and 26 for images of the two pocket options. Note that the ports are made of aluminum, and the blue color is an artifact of the modeling software not an accurate indication of the pocket color.

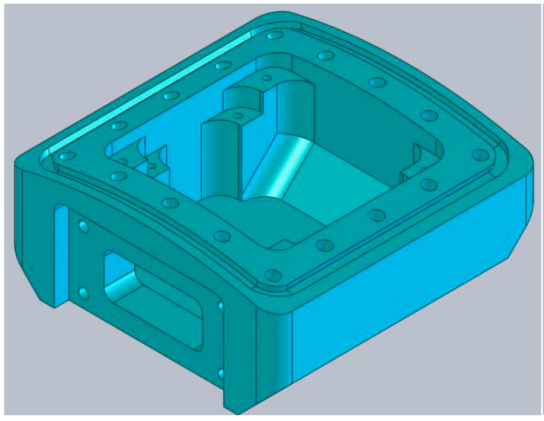


Figure *5*. Port pocket, 9-Pin Connector

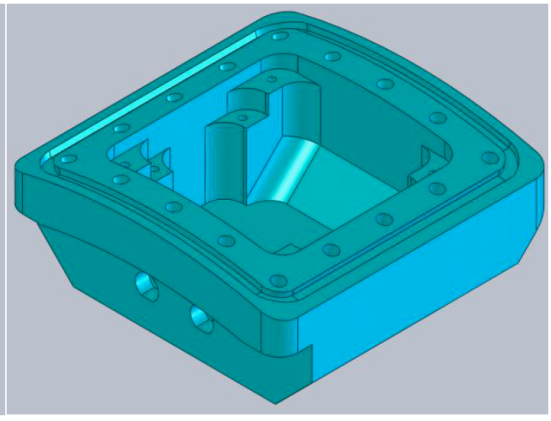
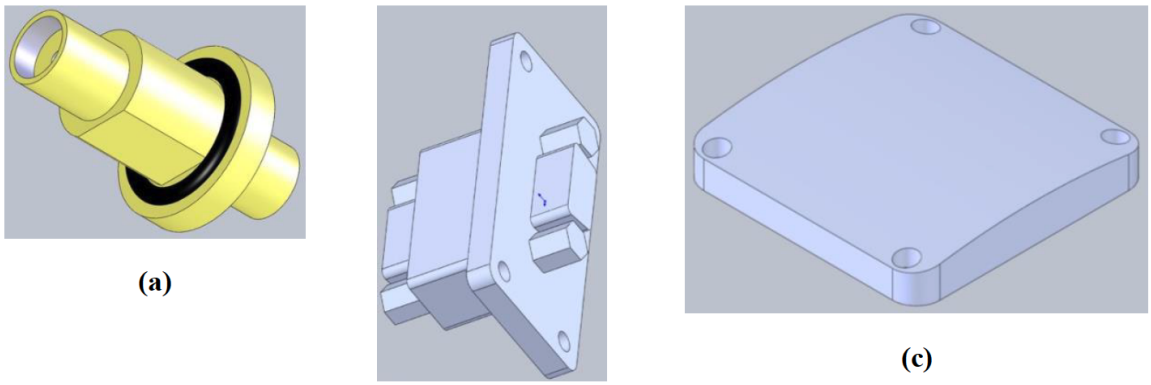


Figure 6. Port Pocket, Dual SMA Connectors

Notice Figure 25 utilizes a 9-pin connector while Figure 6 includes two SMA connectors. These connectors are also shown in Figure 27a and 27b. The pocket also has an optional, modifiable **cover** (Figure 27c). This cover is also included in the design files and is optional. The pocket and cover are the items that Wallops will provide to integrate each team's hardware; the pocket CANNOT be modified (the sealed part) but the cover can be modified if a team chooses to use it.



(a) **(b)** **(c)**

Figure 7. (a) SMA connector; (b) 9-pin connector; (c) Optional pocket cover

Pictures of the assembled port pockets with the connectors and the cover are shown in Figures 8 and 9. Again, the colors are not meant to reflect the appearance of the actual part.

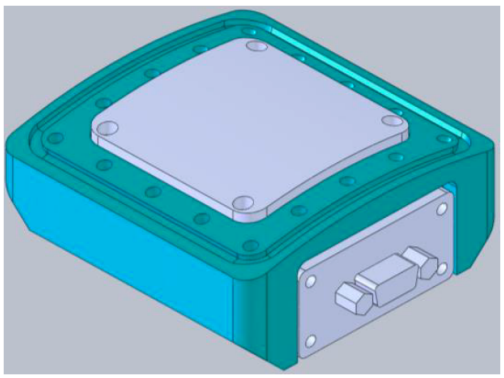


Figure 8. Assembled port pocket with cover and 9-pin

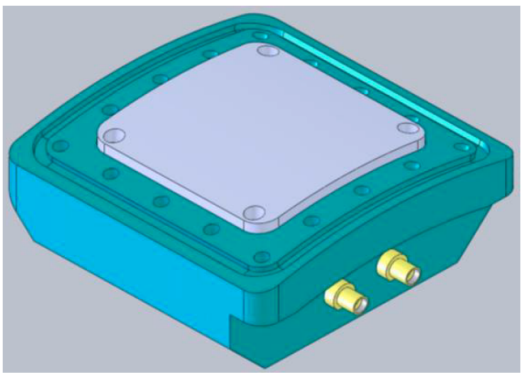


Figure 9. Assembled port pocket with cover and SMA

The components in each pocket should be contained within the pocket. If a team would like to extend anything outside of this, contact rocksatprogram@gmail.com.

Wallops Flight Facility machines the port pockets and covers. They will create two exact copies: one to send to teams in approximately April for testing and fit checks, and one for use in pre-integration testing, (i.e. pressure testing). Before shipment, ALL components for the port should be completely ready for integration (include the cables to interface with the port). At WFF, the shipped port hardware will be integrated into the Wallops flight version of the port that has been tested with the rocket prior to arrival. Teams are NOT allowed to permanently attach (i.e. epoxy) components to the port pocket, but teams

may permanently attach components to the cover if it is being used. The cover that is sent in approximately April will be the one that is flown if the team has chosen to use and/or modify it.

NOTES:

1. The pictures in Figure 22-23 both show modified port covers. Figure 22 shows the original port cover with additional holes and interfaces to accommodate the team's mission. Figure 23 shows a new cover that was machined by the team.
2. Contact rocksatprogram@gmail.com if you would like models of the port pocket, cover, and canister in SolidWorks, STL, and STP formats.
3. Failure to arrive to ship with all port hardware ready for integration could result in loss of the use of the port for flight.
4. If something is not clear, ask the WFF program manager (rocksatprogram@gmail.com)