PREFACE

Dear Students,

Welcome to CAN-RGX, Canada's only competition for post-secondary students to design, build and test a small payload to be flown on board the National Research Council of Canada (NRC)'s premier parabolic research aircraft, the Falcon 20. The CAN-RGX challenge was conceived to be a real-world opportunity for students to conduct meaningful microgravity research. As such, it will push your limits as you learn skills not taught in traditional classrooms. Resourcefulness and perseverance are among the many things you will develop throughout this experience, which are always in high demand in the space sector. We hope you will be inspired to apply what you've learned to even greater challenges being faced today to responsibly advance humankind's presence in space.

In this Handbook, you will find information about rules and regulations of the competition, deadlines for submissions, and guidelines on how to complete major project milestones. Although intended to be comprehensive, you are encouraged to contact the organizers, listed under 'Important Contacts', for further details. We look forward to your participation in this year's CAN-RGX challenge!

— The entire SEDS-Canada team

SEDS-Canada (Students for the Exploration and Development of Space) is a student-run non-profit, federally incorporated since October 2014. We are a member-based organization with hundreds of members all across Canada who partners with many established university student groups.

We are dedicated to promoting the development of the Canadian space sector and supporting our fellow students who wish to pursue careers in this industry. To achieve this mandate, we offer students opportunities for professional development. Our strategy includes national competitions such as CAN-RGX, an annual conference, and eventually, competitive grants.

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IMPORTANT CONTACTS

NOTE: For submission of Proposals, PDR, CDR, TEDP, etc. or general comments, questions e-mail canrgx@seds.ca

Louis Burelle | CAN-RGX Project Manager |

louis.burelle@seds.ca | (613) 876-4041

Louis is pursuing his M.A.Sc. in Mechanical Engineering at Queen's University and holds his B.A.Sc. in Applied Mathematics from the same university. He is enthusiastic about student-driven endeavours after seeing the amazing opportunities related to SAE Aero Design and CAN-RGX. He aims to bring all aspects of his experience to make this year's competition successful and memorable.

Patrick Chin | CAN-RGX Assistant Project Manager |

patrick.chin@seds.ca | (905) 818-4585

Patrick holds a Bachelor's of Applied Science in Applied Mathematics from Queen's University. He is currently pursuing a Master's of Applied Science in Mechanical Engineering at McMaster University, specializing in advanced manufacturing techniques for automotive and aerospace applications. His manufacturing experience has taken him through construction of a 3U CubeSat, high-precision measurement devices, and robotics systems. An alumnus of the CAN-RGX competition, Patrick will be providing support throughout the campaign.

Pundeep Hundal | CAN-RGX Assistant Project Manager |

pundeep.hundal@seds.ca | (780) 200-8791

Pundeep is a 3rd-year student at the University of Alberta and is studying mechanical engineering. Passionate about everything space, Pundeep has shown a keen interest in human space exploration from a young age and is enthusiastic about helping develop the Canadian space sector. His passion and interests have led him to join the University of Alberta's CubeSat team, AlbertaSat, where the team is developing three CubeSats as part of the Northern SPIRIT collaboration between the University of Alberta, Yukon University, and Aurora Research Institute. Pundeep hopes to bring his passion, experiences, and willingness to learn towards making CAN-RGX a success.

Alina Kunitskaya | SEDS-Canada Projects Chair |

alina.kunitskaya@seds.ca | (403) 400-1559

Alina Kunitskaya holds a bachelor's degree in chemical engineering from the University of Calgary and is currently a PhD student in biomedical engineering at the University of British Columbia. Her passion for solving space exploration challenges led to her involvement in developing a process to recycle astronauts' fecal waste into 3D-printable bioplastics, developing and flying a scientific payload in microgravity as part of SEDS-Canada CAN-RGX project, developing an oxygen production process on Mars, and completing a simulated sub-orbital spaceflight to help scientists examine the physiological and psychological impacts of g-forces associated with spaceflight.

Project Advisors/Subject Matter Experts

- **Shahrukh Alavi**, Instrumentation Engineer @ Flight Research Lab, National Research Council of Canada
- **Derek "Duff" Gowanlock,** Falcon Microgravity Facility Manager @ Flight Research Lab, National Research Council of Canada
- **Dr. Heather Wright-Beatty**, Human Factors Team Lead @ Flight Research Lab, National Research Council of Canada
- **Steeve Montminy**, Acting Director, Engineering and Capacity Development, Canadian Space Agency
- **Michel Wander,** Systems Engineer, Canadian Space Agency
- **Dr. Mark Dejmek,** Program Lead, Canadian Space Agency
- **Dr. Mouhannad Nassouri,** Safety and Mission Assurance Engineer, Canadian Space Agency
- **Dr. Yvan Soucy,** Senior Structural Dynamics Engineer, Canadian Space Agency
- **Nabil Hadjaz,** Systems Engineer, Canadian Space Agency
- **Francisco Ortega,** Systems Engineer, Canadian Space Agency
- **Dr. Roxy Fournier,** University of Toronto
- **Dr. Aaron Persad**, Massachusetts Institute of Technology & Project PoSSUM

ABBREVIATIONS

CBE — Current Best Estimate

CDR — Critical Design Review

COTS — Commercial-off-the-Shelf

CSA — Canadian Space Agency

EDT — Eastern Daylight Savings Time

EST — Eastern Standard Time

FRL — Flight Research Laboratory

MSDS — Material Safety Data Sheet

NRC — National Research Council of Canada

OAR — Outreach Activities Report

PDR — Preliminary Design Review

SEDS — Students for the Exploration and Development of Space

SME — Subject Matter Expert

STEM — Science, Technology, Engineering and Math

TBA — To Be Announced

TBC — To Be Confirmed

TEDP — Test Equipment Data Package

VAC — Volts of Alternating Current

WBS — Work Breakdown Structure

1. COMPETITION OVERVIEW

1.1. Project Scope

The Canadian Reduced Gravity Experiment Design Challenge (CAN-RGX) is a competition for Canadian post-secondary students to design, build and test a small scientific experiment to be flown on board the National Research Council's (NRC's) Falcon 20. This aircraft, which has been modified for reduced gravity experiments in association with the Canadian Space Agency (CSA), produces short periods of microgravity by performing parabolic maneuvers. Student teams will be challenged to design experiments for research in a range of fields in physical and life sciences. Any student team at a post-secondary academic institution can submit a proposal for their experiment, after which, 4 teams will be selected to fully design, build, and fly their experiments. Two members of each team will be selected as Mission Specialists to fly on board the aircraft to run their experiment. Additionally, Mission Specialists will be given the opportunity to contribute to our understanding of human physiological and psychological responses to parabolic flight by voluntarily participating in an ongoing study measuring vital signs with non-invasive monitoring devices.

SEDS-Canada and its collaborators developed this initiative to benefit students who are passionate about space exploration by providing them access to a platform to do ground-breaking research in microgravity. CAN-RGX trains students to complete a full engineering design cycle from conception to execution. This is a valuable opportunity to gain transferable professional skills applicable to careers in Canada's space industry. Student teams will gain exposure to project management and risk mitigation which are essential components of many projects in the space industry. In addition, they will have the opportunity to work with Subject Matter Experts (SMEs) who will coach and mentor them throughout the competition. At the end of the competition, two awards will be given: one for the team showing overall excellence in all aspects of the competition, and one for the team who demonstrated exceptional outreach efforts. For the fifth consecutive year, students in Canada will be able to lead the development of their own microgravity flight science experiments and fly with them onboard an aircraft equipped for parabolic flight.

Note about the 2022-23 competition: Due to the ongoing COVID-19 pandemic, certain aspects of the project such as timelines and the number of mission specialists and ground crew may change to comply with COVID-19 related regulations. Considering the uncertainties due to the pandemic, we're including a short checklist to ensure teams are set up for success and are able to complete their project; **you will be required to submit this checklist as part of your proposal**. Any questions or concerns regarding COVID-19 related safety precautions can be forwarded to canrgx@seds.ca.

The CAN-RGX Student Handbook is a resource detailing the full requirements and expectations of participating students, teams, faculty, and partners. Included is the competition timeline, key information about deliverables, statements on project restraints, and examples of tables and charts that must be submitted throughout development. The Handbook will guide teams through every step of the development cycle, but if any questions arise that are not answered here they should be addressed to canrgx@seds.ca.

1.2. Eligibility

All undergraduate and graduate students enrolled at recognized post-secondary institutions in Canada are eligible to enter this competition. We also encourage teams to include high school students in their project as part of their team's outreach efforts. **Students will be required to provide proof of enrolment at the time of submission of the proposal**. The percentage of graduate students and high school students per team must not exceed 34%. At least one member of your team must be/become a member of SEDS-Canada (see seds.ca/membership). Teams must obtain a Faculty Advisor and must submit a Faculty Letter of Endorsement at the Proposal stage (see Section 1.5.7 and Appendix 12.3).

1.3. Competition Timeline

1.3.1. Selection

Students must adhere to the following timeline and requirements to qualify for the selection process. All submissions should be made to canrgx@seds.ca (unless otherwise specified below).

- **Sunday October 30, 2022, 11:59 p.m. (EST)**: Submit your **Proposal**
- **Monday November 21, 2022**: Teams will be notified of their selection and feedback will be provided by SMEs

1.3.2. Project Milestones

NOTE: As milestones are scheduled, this timeline may be outdated; an updated timeline can be found on the CAN-RGX webpage (seds.ca/can-rgx).

Some of the following milestones include documents that must be submitted by selected teams. These documents will be evaluated by SMEs throughout the experiment design phases, and proper feedback will be provided. **A checklist of all expected deliverables (once selected for the CAN-RGX competition) can be found in Chapter 10.** Specific instructions for submitting these documents can be found in their respective guideline sections of this handbook. All submissions should be made to canrgx@seds.ca.

- **Week of November 28, 2022:** CAN-RGX Kickoff meeting with selected teams
- **Week of December 5, 2022:** CAN-RGX Kickoff meeting with Faculty Advisors (FA) of selected teams
- **Sunday January 8, 2023, 11:59 PM (ET):** Submit a short **Progress Presentation (PP1)**
- **Week of January 9, 2023:** Progress Meeting with SEDS-Canada
- **Week of February 6, 2023: Preliminary Design Review (PDR)** via teleconference (comments and feedback provided shortly after)
- **Sunday February 12, 2023, 11:59 PM (ET):** Submit your **PDR** report
- **Sunday March 12, 2023, 11:59 PM (ET):** Submit a short **Progress Presentation (PP2)**
- **Week of March 13, 2023:** Progress Meeting with SEDS-Canada
- **Sunday April 30, 2023, 11:59 PM (EDT):** Submit a short **Progress Presentation (PP3)**
- **Week of May 1, 2023:** Progress Meeting with SEDS-Canada
- **Sunday June 4, 2023:** Submit Critical Design Review (CDR) Presentation
- **Week of June 5, 2023: Critical Design Review (CDR)** via teleconference (comments and feedback provided shortly after)
- **Week of June 12, 2023:** Submit your **CDR** report. The CDR report is due a week after your scheduled CDR teleconference.
- **Sunday July 7, 2023, 11:59 PM (EDT)**: Submit your **Test Equipment Data Package (TEDP)**
- **Sunday July 14, 2023, 11:59 PM (EDT)**: Submit your **Outreach Activities Report**
- **July 31 to August, 2023:** Flight Campaign period (TENTATIVE)
- **August 30, 2023, 11:59 PM (EDT):** Deadline to submit your **Post-flight survey** (sent out as a Google Form)

1.4. Formatting Guidelines for Submission of Documents

The following guidelines should be followed for all report submissions, including the proposal.

- PDF file type
- Submit electronically to canrgx@seds.ca
- Submit all files using the following file name format: teamname_document_year.format (ie: UVic_PDR_2020.pdf)
- Standard 8 ½” x 11” pages
- 1” margins on the top, bottom and sides
- 12 point Times New Roman font

- Numbered pages on the bottom right corner
- Include a cover page (see Section 2.3)

1.5. Team Guidelines

1.5.1. Primary Institution

The Primary Institution is a recognized college or university in Canada where the team leader is enrolled as a student.

1.5.2. Collaborating Institutions

Collaborating institutions are colleges, universities and high schools who have contributed time and/or resources to the project.

1.5.3. Team Leader

The team leader is responsible for organizing and coordinating the efforts of the entire team for the duration of the project. Duties and tasks may vary depending on the size and composition of the team, however the one requirement for the team leader is that they be enrolled at the team's primary post-secondary institution. The Team Leader should also act as the primary point of contact with SEDS, the NRC, and the CSA. In most cases, the Team Leader is also the member of SEDS-Canada.

1.5.4. Team Size and Composition

Teams must be a minimum of 4 students and can be composed of students from the primary institution or collaborating institutions. There is no maximum size. A team can be composed of undergraduate and graduate students, as well as high school students, but the fraction of graduate students and high school students must not exceed 1/3 of the team. One member of the team must also be/become a member of SEDS-Canada (see seds.ca/membership).

1.5.5. Mission Specialists

Each team must choose two primary Mission Specialists and two backup Mission Specialists to fly onboard the Falcon 20 during the Flight Campaign. Mission Specialists should be directly involved with designing, building and testing the experiment and should be highly knowledgeable about all its parts and components as well as procedures that must be carried out during and between each parabola. Mission Specialists will also be given the opportunity to wear a non-invasive mobile monitoring device during the flight to record their biometrics which will contribute to an ongoing NRC study on the physiological effects of parabolic flight. Mission Specialists should be 18 years or older on the day of the flight. Otherwise, a parental consent waiver must be provided (contact competition organizers to request this form).

1.5.6. Ground Crew

The Ground Crew will consist of the two backup Mission Specialists and any other team members who are not primary Mission Specialists. This crew will be responsible for assisting with assembly/dismantling of the experiment at the Campaign site (if necessary) as well as performing any tune-ups to the experiment prior to loading onto the aircraft. The Ground Crew may also serve as a support team to the Mission Specialists, however, it should be noted that there is no communication between the ground crew and aircraft during the flights.

1.5.7. Faculty Advisor(s)

Teams must enlist one faculty member from their primary institution to act as their team's advisor. These faculty members **must complete a Faculty Letter of Endorsement** which is submitted with the Proposal (a template can be found in Appendix 12.3). Teams may have additional faculty advisors (from the primary or any collaborating institutions) as needed. The faculty advisor(s) are required to attend progress meetings via teleconference. It should be noted that faculty advisors cannot become SMEs or project reviewers/judges for the competition. Organizers from SEDS and the NRC will meet with Faculty Advisors in accordance with the schedule in Section 1.3.2 to discuss expectations and availability.

1.6. Funding Expectations

Teams will be expected to fully fund the development of their experiment and the logistics of team travel to the Campaign site. Each team is encouraged to procure funds through university and government grants, corporate sponsors, etc. SEDS-Canada will inform you of any unique funding opportunities.

Please contact canrgx@seds.ca with any funding concerns (especially if it is prohibitive to your team submitting an application). SEDS-Canada may be able to leverage industry partners for travel support.

1.7. Experiment Constraints

For reviewers to assess the project proposal, the design must:

1. Be contained within a Pelican case as specified in Section 1.7.1 (except for laptops or tablets required for data collection and observation which can be mounted on top of the case). There will also be a storage box available on board for storage of auxiliary equipment.
2. Weigh no more than 45 kg (not including the Pelican case).
3. Peak power consumption must be below 600 W.
4. If applicable, use only dry cells, zinc-air, alkaline, or Ni-Cad batteries. Electrolyte or lithium-type batteries should be avoided whenever possible. When unavoidable, such as in

commercial electronics, teams must be able to demonstrate batteries are in good health. It is best to purchase new brand name batteries; third party imitations should be avoided.

5. Be free of materials classified as physical, health or environmental hazards under Canada's Hazardous Products Act such as high-pressure, toxic, corrosive, explosive and flammable materials. See Section 12.1. Note that any non-hazardous substance requiring secondary containment (e.g. water or dust) will need to be structurally tested for maximum loads experienced during the flight.
6. Be free of hazardous radiation (e.g. Class 3 and 4 lasers).
7. Exclude the use of human and animal test subjects which would require Research Ethics Board approval. See note about biological specimens below.
8. Not rely exclusively on automation to be actioned (e.g. using accelerometer data to begin a sequence). There must be a manual trigger to start your experiment.

NOTE: As cabin temperature is not controlled until airborne, extreme seasonal temperatures may be experienced while on the ground. The use of perishable or temperature-sensitive materials should be avoided to ensure consistent results. If temperature is a key factor in your experiment, it must be precisely controlled within the system.

If biological specimens are used, please follow these specific design constraints. The specimen must:

1. Not present any risk to experimenters, the flight crew and the aircraft. Specifically, the specimen must fall under **Biosafety Level/Risk Group 1**. You should submit a safety data sheet, or point to a database (e.g. https://health.canada.ca/en/epathogen) or other resource which shows the Risk Group (RG) classification of your specimen.
2. Be contained within a sealed space capable of withstanding the physical parameters of parabolic flight (g-forces, pressure, temperature, vibration). See Section 1.8.
3. Not be handled directly by experimenters during flight.

1.7.1. Pelican Case

All experiments must be designed to fit into a hard-shell case to simplify the integration process into the aircraft. The case will also serve as a protective envelope which allows for containment of the experiment's potential hazards to reduce risk to the aircraft and its passengers. The case is a Pelican product 0350 Cube Case, modified for parabolic flight with external dimensions 57.2 x 57 x 54 cm (L x W x D) and inner dimensions 50.8 x 50.8 x 46.6 cm (L x W x D). The modifications include the addition of a 115VAC outlet, power switch, cable pass-through and an ethernet port (bottom-right corner in Figure 1b). Inside is a threaded mounting plate, whose dimensions are given in Figure 1a). A complete STP file of the modified case will be provided to the selected teams for exact dimensions.

Figure 1: (a) Pelican case interior mounting plate with dimensions 459.49 x 464.49 mm. (b) Pelican case exterior with modifications (bottom-right corner)

If the experiment requires the use of a laptop, a RAM Tough Tray Spring-Loaded Laptop Tray will be provided and attached at the top of the Pelican case. The tray accommodates laptops up to 15 inches in size.

1.8. Falcon 20 Specifications

1.8.1. Research Environment

The reduced gravity environment will be provided by the NRC's Falcon 20 aircraft, which has been modified to enable reduced gravity maneuvers in partnership with the Canadian Space Agency. The aircraft is operated the NRC's Flight Research Laboratory (FRL) in Ottawa.

1.8.2. Parabolic Flight

The total flight time for science flights will be approximately 1.5 hours and consist of typically 15 parabolas. The 1.5 hour time includes taxi time to and from the runway, flight from the airport to the research airspace, and the parabolic maneuvers. The typical parabola is shown in Figure 2; altitude is shown in blue and acceleration is shown in orange, with distinct periods of 2g and 0g acceleration. These parabolas can be stacked back-to-back in a sequence (Figure 3; bottom) or can be spaced out with level flight time in between (Figure 3; top) if required by the experiment. A nominal parabolic sequence consists of 6 back-to-back parabolas followed by a short break, however during the design review process, the specific needs of each team will be evaluated and the parabolic sequence will be adjusted accordingly. The number of parabolas may vary during the actual flight depending on the external factors and environmental conditions. However, each team will be given a minimum of 3 instances to collect experimental data. As each flight has two teams, SEDS-Canada and the NRC will endeavor to group teams with similar parabola sequence needs (as set by their scientific objectives). As a result, and for example, the specific parabolic profile may be 6 pairs of parabolas with 2 minutes in level flight in between each pair of parabolas to permit equipment adjustment. Whereas another flight might have 3 sets of 6 parabolas with 4 minutes in between each set. The ability to tailor the parabola sequence is limited in that the overall flight time cannot exceed 1.5 hours (i.e. 15 parabolas with 5 minutes in between parabola each would exceed the total flight time). Therefore, back-to-back parabolas are preferred wherever possible as to maximize microgravity time. Teams will have the chance to specify their optimal flight profile, however the experiment should be designed with flexibility as the other team you fly with may not have the same requirements. The exact sequence of procedures will be determined prior to the flight, in consultation with the flight crew, SEDS-Canada and both teams. It should be noted that during the 2g pull-up maneuvers equipment adjustment cannot be safely performed. These actions are not permitted during 2g pull-up and pull-out maneuvers.

Shakedown flights will be conducted prior to science flights to ensure teams will not experience faults with their experiments or in-flight procedures. Each team will have the opportunity to fly with their payload on a short flight of 1-4 parabolas to test both their equipment and their procedures. These flights will have the same structure as the science flights (e.g. same amount of level flight time, if required). The same Mission Specialists will fly on both the shakedown and science flights; switching team members introduces additional risk and will only be done if a previous Mission Specialist cannot fly again for a medical reason. In certain instances, the teams can use these flights to collect additional data for their experiment, but the primary purpose of these flights will be to test their experiment before data gathering and to acclimatize the mission specialists to parabolic flight.

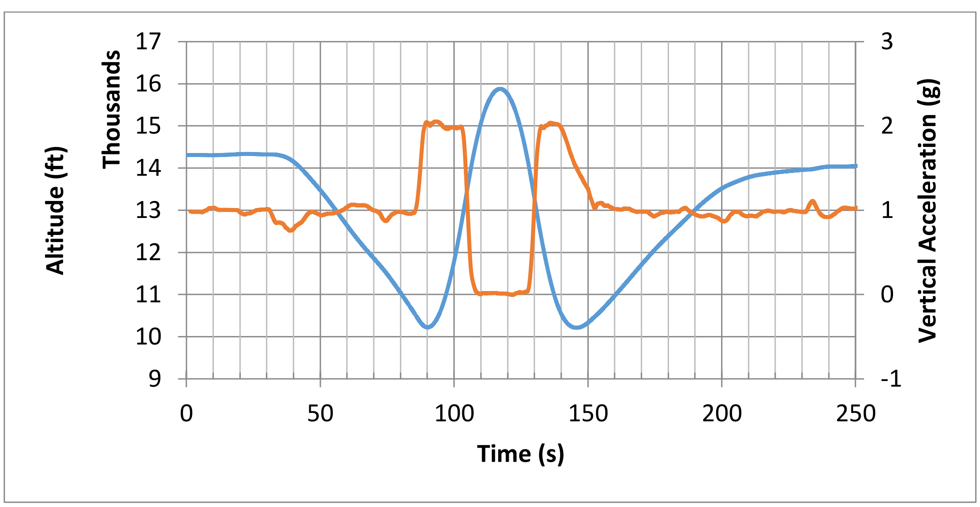


Figure 2: Typical microgravity parabolic profile; altitude is in blue and vertical acceleration is in orange.

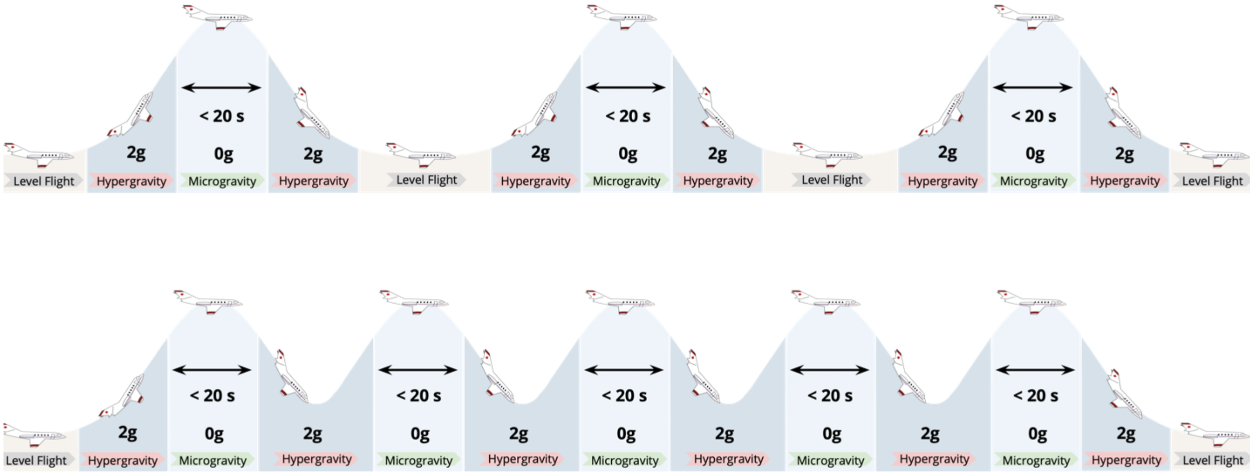


Figure 3: A visual representation of the difference between parabolas which have level flight time in between (top) versus back-to-back parabolas (bottom).

1.8.3. Cabin Layout

The aircraft cabin will be set up as shown in Figure 4. Two teams fly on each flight, one experiment on each side. The primary operator will be seated immediately behind the experiment, with the secondary operator seated across the aisle. Each experiment will have access to 5 Amps (A) of 115 Volts of Alternating Current (VAC). All teams must use the power from this aircraft outlet and batteries (not including laptop batteries) will only be allowed in the experimental setup in certain special cases. Every seat is equipped with an intercom headset with which communication with teammates, pilots, and other NRC crew is facilitated. Standard ¼" mounts placed around the cabin are available for small cameras.

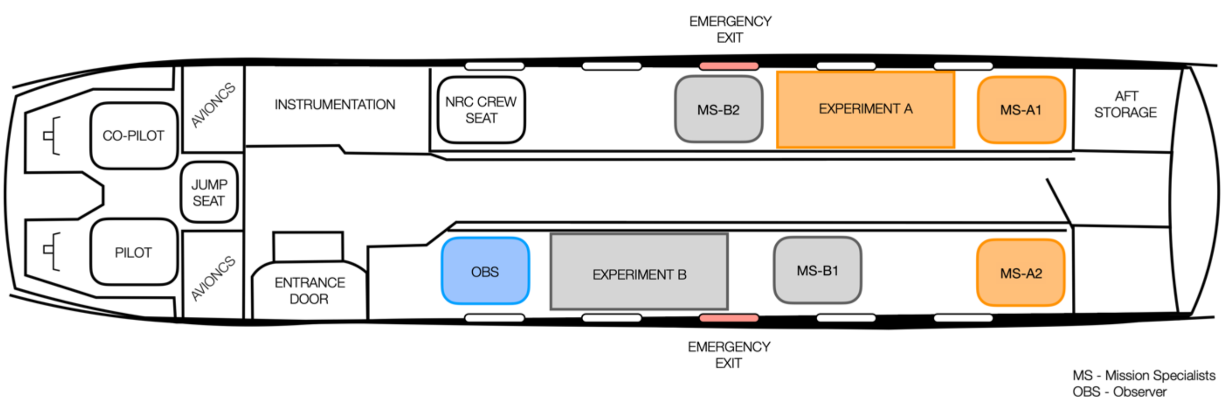


Figure 4: Cabin Layout; MS = Mission Specialist.

Cabin pressure is typically maintained between sea level (14.7 psi) and 1000 ft Mean Sea Level (MSL) during the parabolic maneuvers. However, loss of cabin pressure could result in a cabin pressure as low as 7 psi. This is to be considered in the design of the test equipment. In-flight cabin temperature is normally maintained within a comfortable level (nominally 22°C). On the ground, before and after flight, cabin temperatures can approach (and in summer exceed) outside air temperature. If the experiment is very sensitive to temperature or pressure variation, measures should be taken to minimize the effects.

Note: The number of teams and/or crew members on each flight may be modified due to COVID-19 restrictions. This information will be updated as the situation evolves.

1.9. Integration onto the Falcon 20

Pelican cases will be integrated onto the Falcon 20 on the day of your flight. This takes up to 1 hour. On flight day, your experiment may sit in the hangar or on the tarmac for up to 4 hours. If your experiment is sensitive to this period of inactivity (e.g. a plunger will get stiff or a seal might come loose) you should design to mitigate this. You should test your experiment for its ability to withstand sitting untouched for up to 4 hours.

1.10. Campaign Site

The CAN-RGX campaign will take place at NRC's Flight Research Lab (FRL) in Ottawa, ON. FRL operates from an aircraft hangar, which is fully equipped for the modification, maintenance, and operation of its fleet of experimental aircraft.

Assume that any special requirements such as biological lab space, clean rooms, etc. are not typically available. It is the team's responsibility to supply any specialty tools or equipment required for their experiments and to secure additional lab space, if required. For questions or assistance, please contact us at canrgx@seds.ca.

1.11. Publicity Guidelines

The CAN-RGX competition has given many students the opportunity to experience the design process of an experiment and the thrill of microgravity flight since 2016. SEDS-Canada is committed to continue organizing and supporting this amazing learning opportunity for future participants. One of the main ways SEDS-Canada is able to continue running this project is through the support of sponsorship and publicity. Therefore, all participants who are selected to take part in the project will be asked:

- for consent in being featured in photo/video content for the purposes of SEDS-Canada publicity material (can opt-out),

- for consent to use submitted materials in advertisement campaigns (can opt-out), and
- **to acknowledge the work of SEDS-Canada in the organization of this campaign or include SEDS-Canada as a contributor in any external publicity, social media materials, outreach activities, or the like. We can supply teams with appropriate logos.**

These steps will help us advertise our organization and the CAN-RGX program to future participants and potential sponsors, allowing us to continue hosting these amazing experiences.

2. PROJECT PROPOSAL

2.1. Overview

The project proposal is the first of four technical documents that must be submitted for a team to advance through to the Flight Campaign. This document will be judged by a panel of SMEs with experience in the field of reduced gravity research using parabolic aircraft and should be written with this audience in mind. Your document must be limited to 20 pages, not including appendices. Remember to follow the formatting guidelines laid out in Section 1.4.

NOTE: Proposals which do not meet the experimental constraints outlined in Section 1.7 will not be reviewed.

Along with the proposal, a Faculty Letter of Endorsement (see Appendix 12.3) and proof of student enrollment for the team **must be submitted** (see Proposal Guidelines).

Although not required, a proposal template is available (Google Docs/Word). The instructions found in these proposal templates are NOT exhaustive, and teams should be sure to read the accompanying Proposal Review Criteria table in the CAN-RGX Student Handbook to ensure they are fulfilling all proposal criteria.

2.2. Submission Deadline

Sunday October 30, 2022, 11:59 p.m. (EDT)

2.3. Proposal Guidelines

In the order listed below, your project proposal should include the following sections:

1) **Cover page**

The cover page should include all the necessary information about your team and project:

- Project title
- Team name
- Team member names, emails, and academic affiliation
- Date of submission
- Team logo (optional)

2) **Table of contents**

3) **List of tables and figures**

This will serve as a directory for figures and tables included in the document. Provide page numbers or refer to the appendix for each item.

4) Executive summary

The executive summary should provide an overview of all the sections in the proposal in **one** page or less. It should only include information that can otherwise be found in the body of the proposal:

- Brief introduction of the project
  Clearly explain why a microgravity environment is needed to perform your experiment!
- Summary of experimental design requirements met (See Section 1.7)
- Summary of the project's budget and timeline
- Outreach activities planned
- Conclusion and expected outcomes

5) Proposal Plan

Following the marking scheme provided in Section 2.4, address all proposal criteria in full sentences, using primary research literature and diagrams when necessary. References should be cited in IEEE style and a bibliography should be provided before the appendix. Diagrams may be included in the body of the text if they are small or in the appendix section if they are full-page. All diagrams must include a descriptive legend or caption. Follow the templates provided in Section 11.2 to complete the Risk Assessment Tables for technical, human, and managerial risks, the Work Breakdown Structure (Section 11.3), and the Budget and Funding Table (Section 11.7).

6) References

Following IEEE style, provide a list of references cited in your proposal.

7) Appendices

Appendices should be used for full-page diagrams, engineering drawings, and any other documents which are referenced in your proposal. List appendices using capital letters (i.e., Appendix A, B, C, etc.)

You must also include the following appendices:

a) Team/Project Checklist (see Section 12.2)
b) Faculty Letter of Endorsement (see Section 12.3)
c) Proof of Enrollment

   Include proof of enrollment documentation confirming that your team members are enrolled at a recognized Canadian post-secondary institution. Proof of enrollment can be unofficial, as long as it clearly shows name/student ID (examples include: a picture of a student ID card showing the student ID, name, and expiry date; a screenshot of a timetable showing the student ID and name; a financial statement showing the student ID and name).

2.4. Proposal Review Criteria

Each submitted proposal will be evaluated and scored according to a standardized rubric for the following criteria (weighting in brackets). In addition to the criteria listed in the marking scheme a qualitative assessment may also be applied based on the experience of the SMEs:

Description of Criteria	Marking Scheme
2.4.1. Scientific merit (35%)	
Scientific Objectives	
Describe the scientific objectives and the expected outcomes of the proposed experiment (e.g., what are your hypotheses and how will you test them?). Please use the Mission Objectives & Success Criteria table provided in Section 11.1.	0 = no objectives provided, or, objectives are inadequately defined, or not aligned with purpose of competition 1 = objectives are aligned with purpose of competition 2 = the objectives are well aligned with the purpose of the competition and have a high likelihood of delivering on the stated outcomes
Novelty	
Have similar experiments been conducted in the past? If so, describe how the proposed experiment is different/original. Experiments that have flown with CAN-RGX before will be considered, but teams need to be very clear about how the previous flight objectives were different.	0 = an experiment with major similarities has been conducted in the past 1 = some literature review was presented, but it’s not clear if the experiment is novel 2 = in-depth literature research is provided leading to the conclusion that the experiment is novel
Relevance of the reduced gravity environment	
Describe why the project requires the reduced gravity environment to achieve its scientific objectives. Show that the scientific objectives can be achieved within 20 seconds of being in reduced gravity.	0 = the experiment was not designed for a reduced gravity environment or requires more than 20 seconds of reduced gravity 1 = reasoning for conducting the experiment in a reduced gravity environment is described but details not elaborated to indicate if 20 seconds will be enough time 2 = the experiment is appropriate for up to 20 seconds of reduced gravity and reasoning is well-described
Bonus: Importance to Canada’s space sector	
Referring to the Canadian Space Agency’s 2020-21 Departmental Plan (https://www.asc-csa.gc.ca/eng/publications/dp-2020-2021.asp), describe how the proposed project fits within Canada’s current planned results (referred as 'Departmental Results' in the document)	2 bonus marks will be given for an appropriate and well-described evaluation of the proposal’s relevance to at least one key strategy area (referred to as ‘sub-sub programs’ in the document)

2.4.2. Technical description and feasibility (35%)	
Experimental Design	
Describe how the experiment satisfies each of the experimental constraints of the Falcon 20 aircraft (refer to Section 1.7). Use diagrams and/or sketches to illustrate how the experiment satisfies these constraints.	Pass/Fail* *Only projects satisfying all experimental constraints will be reviewed.
Describe the design of your experiment and how it meets your mission objectives.	0 = proposed design is inappropriate/inadequate 1 = proposed design could reasonably meet success criteria & therefore mission objectives, but it is lacking in detail 2 = proposed design can meet success criteria & therefore mission objectives, and is well-described
Describe what you intend to measure (e.g. your variables) and the data collection methods involved.	0 = proposed variables or data collection methods are inappropriate/inadequate 1 = proposed variables and data collection methods are reasonable but lacking in detail 2 = proposed variables and data collection methods are achievable and well-described
Using the templates in Section 11.6, complete a table listing component (a) names (b) descriptions, (c) quantities, (d) estimated power budget (in Watts) and estimated mass budget (in Kgs) of all components of the design (e.g., mechanical and electrical parts). Specify if a component has moving parts. Include estimated total power consumption and mass (with and without a 15% margin).	0 = a table not provided or inappropriate/ incompatible for parabolic flight 1 = table is lacking detail in its description of components or power and mass budgets 2 = thorough descriptions of all components are provided and components are appropriate
Explain how pressure, g forces, vibration and temperature in the aircraft will affect the proposed experiment (Refer to Section 1.8). Do these unique conditions pose additional hazards?	0 = assessment of each variable is incomplete, or the effects of at least one variable is hazardous 1 = assessment of each variable is provided but lacking details 2 = assessment of each variable is provided and no additional hazards are expected
List all components of your experiment classified as hazards under Canada's Hazardous Products Act (Refer to Section 12.1) and specify each hazard. Provide a Material Data Safety Sheet (MSDS) in your appendix for each identified hazard.	0 = the hazards of the experiment were not listed or assessed 1 = incomplete assessment of hazards, or MSDS for each hazard not provided 2 = all hazards were identified and specified. MSDS provided for each.
Experimental Requirements & Procedures	
List all of the required equipment (except basic tools which will be provided by the NRC, see Section 6.2, item 13) and any special accommodations needed on-site (at the Flight Campaign location) in the day(s) before and after flight. For example, if your experiment uses biological	0 = it is unclear what equipment or accommodations the experiment requires (if any) 1 = some equipment or accommodations were listed, but it's unclear why they are needed or how they support the experiment

samples, do you require certain equipment to keep those samples alive? Do you require your payload to be powered constantly? Do you require a lab space? After the flight do you need to rush your samples to the lab?	2 = it is very clear what equipment and accommodations the experiment requires (if any) in both the days before and after the flight
Using the Flight Test Procedures flowchart in Section 11.8, describe procedures for: • pre-parabola level flight • proper execution of the experiment in flight (including the 2g portions of the parabola, during microgravity, and between each parabola) • landing prep & post-landing (including any specific accommodations needed related to the analysis of your experiment, e.g. if cells have to be transported quickly to a lab for analysis) Specify if there are any moving parts, and if there are, how they function throughout these parabolas (e.g. "plunger is actuated").	0 = Flight Test Procedures not provided or inappropriate 1 = Flight Test Procedures are incomplete or lacking detail 2 = Flight Test Procedures are well-described for each stage of flight and are appropriate for parabolic flight
Resources	
Describe the specialized facilities or tools/equipment needed and how the team intends to gain access to these to design, build and test the experiment (e.g., CAD software, laboratory facilities, custom-machined parts).	0 = the resources needed are inappropriate/inadequate 1 = the resources are listed but details not provided 2 = the resources are well-defined and achievable
Risk Assessment	
a. Human	
Describe risks involved to team members during the building/assembly of the experiment and how these risks will be handled (will team need to be trained to use tools/equipment, etc.). Use the template provided in Section 11.2. Special attention should be given to risks involving hazardous materials that were previously identified.	0 = the risks are not described or inappropriate/avoidable and/or the team failed to provide a risk assessment for hazardous material present (if applicable) 1 = the risks are defined but mitigation strategies are not 2 = the risks and mitigation strategies are well-defined and unavoidable
Describe the risks to the Mission Specialists when executing any tasks during flight, such as setting up the experiment or implementing procedures. Provide mitigation strategies to eliminate (or minimize) risks. Use the template provided in Section 11.2. Special attention should be given to risks involving hazardous materials that were previously identified.	0 = the risks are not described or inappropriate/avoidable and/or the team failed to provide a risk assessment for hazardous material present (if applicable) 1 = the risks are defined but mitigation strategies are not 2 = the risks are minimal; mitigation strategies are well-defined and unavoidable
b. Technical & Environmental	

Describe any points of failure for the experiment, such as mechanical malfunctions, leaks, etc.	0 = points of failure were not described or are inappropriate for the experimental design 1 = points of failure inadequately described 2 = all possible points of failure have been described in sufficient detail
Describe the safety mechanisms (ex: kill switches) that will be integrated into the experiment (providing technical drawings/diagrams is encouraged).	0 = no safety mechanisms included 1 = inadequate safety mechanisms or description is lacking detail 2 = well-defined, adequate safety mechanisms
Describe the procedures specific to your experiment to be performed during an emergency to prevent risks and hazards to the crew and aircraft. This may include (but not limited to) a power outage, fire, cabin depressurization or medical emergency.	0 = no procedures provided 1 = inadequate procedures provided 2 = well-defined, adequate procedures provided
2.4.3. Project Plan (15%)	
Team Structure and Management	
Following the template provided (see Section 11.3 Work Breakdown Structure), assign roles and tasks for each team member, including high school students and faculty advisors. You may rearrange or add components to the template to suit your project and team size.	0 = the roles of each member are unclear/poorly defined 1 = the roles of each member are defined but lacking detail 2 = the roles of each member are defined in detail for each stage of the project
If a team member chooses not to continue with the project, describe the protocol for re-organizing the division of labour.	0 = no strategies provided 1 = a strategy is provided but lacking details 2 = a well-defined strategy is described
CAN-RGX is a scientific experiment but also a training experience for Canada's future space workforce. Therefore, points will be awarded to those teams which have members that have not previously participated in CAN-RGX. Teams which are new to CAN-RGX will be given a default score of 1.	0 = all members have previously participated in CAN-RGX 1 = one or more team members have never participated in CAN-RGX
Project Timeline	
In a table, diagram or Gantt chart, present an expected timeline of the project's development. A Gantt chart template is provided in Section 11.4, if needed. Include details such as prototype building and testing, final product manufacturing and testing, and completion dates of deliverables such as the PDR,	0 = a timeline is not provided 1 = the timeline is inappropriate or lacking details 2 = the timeline is complete and well-defined

CDR and TEDP. Estimate the length of time required to complete each task.	
Describe how the team intends to stay on schedule and provide strategies that would be implemented when the project is behind schedule including the role of each key team member.	0 = the team has not planned to stay on schedule or the plan is insufficient 1 = the team has listed some mitigation strategies but no detailed plan provided 2 = the team has provided details about which team members will lead the scheduling efforts and how each key team member will contribute to staying on schedule
Budget and Funding	
Following the template provided (see Section 11.7) include all foreseeable expenses for the entire duration of the project including travel and food for the flight campaign, purchase and fabrication of equipment/parts, etc. Describe current and future sources of funding including the duration and amount of this funding (includes academic/student grants, industry partnerships/sponsorships, etc.).	0 = budget and funding plan not provided or inappropriate 1 = budget and funding plan not elaborated in detail 2 = budget and funding plan is achievable and well-described
Describe the measures the team will take to ensure the project stays within budget and how the team intends to acquire the necessary funds. Explain the role of each key team member.	0 = the team has not planned to stay within budget or the plan is insufficient 1 = the team has listed some measures for staying within budget but no detailed plan provided 2 = the team has provided details about which team members will lead the budgeting efforts and how each key member will contribute to staying within budget
2.4.4. Outreach (15%)	
Public	
Describe how the team intends to engage with the public and K-12 students for each stage of the project, including after the flight campaign.	0 = the team has not made an engagement plan or the plan is inappropriate for this project 1 = the team has listed some methods for engagement but has not elaborated on details or some aspects of the plan are missing 2 = a detailed plan for engagement throughout the duration of the project is provided
Describe a plan for the involvement of high school students in the project.	0 = the team has either chosen not to pursue the inclusion of high school students or a plan for recruiting from high schools was not provided 1 = the team intends to recruit high school students but a plan to achieve this has not been elaborated in enough detail 2 = the team intends to involve high school students in the project and they have a descriptive plan for the contributions these students will provide
Academic	

Describe how this project will benefit the scientific community (publications, seminars, etc.).	0 = the team has not provided any information on the project's impact on the scientific community 1 = Benefits are listed but details are not provided 2 = the team has elaborated on the project's impact on the scientific community and given specific examples of how the scientific community will benefit

3. PROGRESS PRESENTATIONS

3.1. Overview

Progress presentations are a chance to check-in with teams before major milestones and provide a more informal opportunity for feedback, asking questions, raising concerns, and practicing presentation skills. Teams are expected to be professional in their presentations. This is a great chance to receive help and engage with SEDS-Canada and SMEs (whom are optional attendees); we are all here to help you towards a successful design! Presentation slides should be submitted to canrgx@seds.ca prior to your presentation for review.

3.2. Format

Progress presentations must meet the formatting requirements set out in Section 1.4 (though the size should follow that of a regular presentation).

3.3. Expectations

Except for the first progress presentation, teams will nominally be provided with Progress Presentation Guidelines that are unique to each individual team. The content we will ask you to review or update will be content that has been flagged in previous meetings (e.g. via comments or concerns voiced, or questions that have been left unanswered or that need more context). The presentation, however, should reflect any work that has been completed since the last deliverable, including design changes, assembly, testing, analysis, outreach, and any other work done by the team. Further, it should identify the immediate next steps that the team is to take during the development cycle. The use of the formatted tables required on the PDR and CDR is not necessary for progress presentations, however the key information should be succinctly summarized in the contents. Teams should be sure to bring **questions, concerns, and roadblocks.**

Note that not all team members need to be present at Progress Presentations, but this is encouraged for PDR and CDR.

4. PRELIMINARY DESIGN REVIEW

4.1. Overview

Your team will be required to give a Preliminary Design Review (PDR) presentation and subsequently submit a report containing a thorough technical review of your scientific reduced-gravity payload.

The PDR must provide evidence that you are making progress and that your experiment will satisfy your design requirements based on preliminary quantitative analyses and hardware specifications. During the PDR presentation SMEs will review your work and provide comments and feedback. You will have 7 days from the date of your PDR presentation to make any necessary revisions to your work and will then submit your PDR Report. In your report you must address any issues raised from the feedback received and present your updated design specifications. In most cases, teams will complete both the report and the presentation by the deadline, and then only make minor changes to the report after the presentation. An unsuccessful or incomplete PDR can lead to project cancellation at the discretion of SMEs. Your report must be limited to 35 pages, not including appendices. Remember to follow the formatting guidelines laid out in Section 1.4.

The requirements for the PDR presentation are detailed in the next section, and requirements for the PDR report are given in Section 4.3.

4.2. PDR Presentation

Teams will be required to provide a **20-minute** PowerPoint/Keynote presentation (followed by a 40-minute discussion period) to our panel of SMEs and judges via teleconference. The purpose of the PDR presentation is to obtain comments and feedback from SMEs and judges before submission of your PDR report. You must convince the SMEs that your experiment will work in microgravity, so be prepared to answer technical questions. You must also demonstrate that your design can safely meet all the requirements of your scientific experiment. Please structure the presentation as follows:

- Title slide
    - Include all team information, responsibilities of each member and the chosen Mission Specialists and backup Mission Specialists.
- Introduction
    - 1-2 slides on the topic of research and the proposed experiment
    - Mission Objectives & Success Criteria table (see Section 11.1)
- Experiment design and procedures
    - Full system specifications, including mass and power
    - Procedural flowcharts, including team responsibilities:
        - Pre-flight procedures

        - Flight Test Procedures
        - Post-flight procedures
    - Risk Mitigation
- Preliminary testing
    - Describe your prototype and previous testing done to date, and lessons learned
    - Describe your plan to execute a full cycle of ground tests prior to submission of the CDR.
- Present a requirement compliance table (see Section 11.5)
    - Identify if analysis/simulations, testing, or inspection are necessary to satisfy each requirement.
- Project management
    - Updated timeline
        - Highlight the most important milestones completed to date and the remaining tasks to accomplish prior to the CDR.
    - Budget
        - Include all the incurred and estimated costs for all the phases of the project.

Your presentation should follow from the content of your report.

4.3. Sections for PDR Report

In the order listed below, your PDR document should include the following sections:

1) **Cover Page**
   Include all team information (including updated list of team members) and graphics

2) **Table of contents**
3) **List of figures and tables**
4) **Executive summary**
   The executive summary should provide an overview of all the sections in the PDR in **one** page or less. It should only include information that can otherwise be found in the body of the document:
    - Brief introduction of the project
    - Outline of experimental procedures, risk mitigation plan, prototype testing plan, preliminary test results (if applicable) and data analysis plan
    - Overview of progress and updates to the management plan and outreach plan

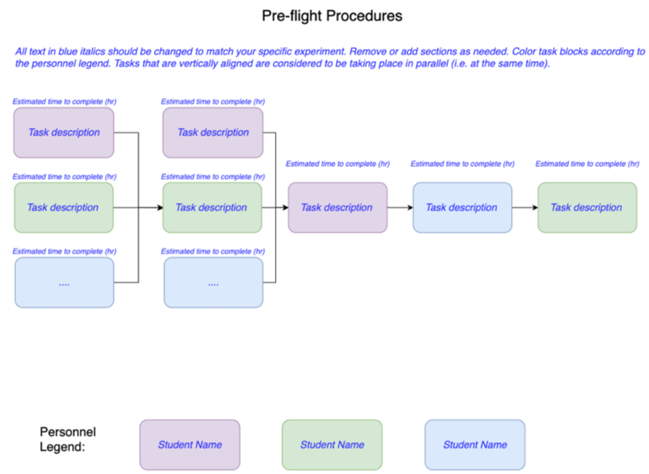
5) **Introduction**
   This section may build upon the Scientific Merit section of your proposal. Make changes or add details as necessary. Cite primary research literature whenever possible and use IEEE style. Include the following:

- An introduction to your research topic
- Your hypothesis or hypotheses for your experiment
- Describe the mission objectives (what questions do you want to answer?) and the success criteria for meeting these objectives **in a table like the one provided in Section 11.1.**
    - If you need help crafting your success criteria, SEDS-Canada would love to help.
- Novelty
- Importance to the advancement of space exploration, science and technology

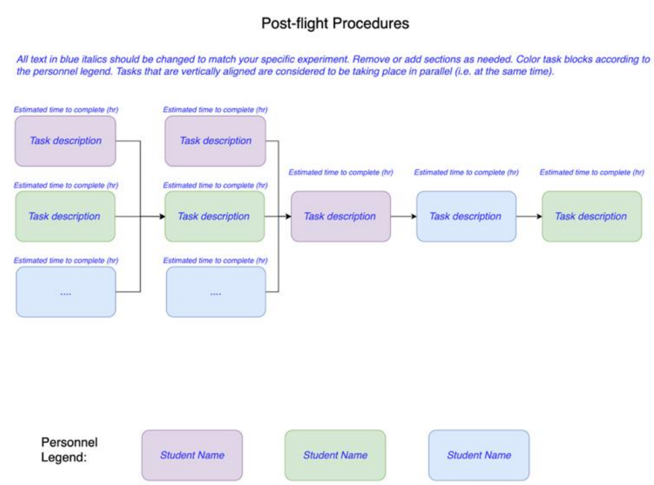
6) Technical Specifications and Procedures

This section should provide the technical details of your experiment, how it meets the experimental constraints of Section 1.7, and full system specifications. You may use flowcharts and reference the following in your appendix: mechanical drawings, electrical schematics, software flowcharts, CAD models, Bill of Materials (BOM)

- Describe how the experiment satisfies each of the experimental constraints.
    - **NOTE: Teams that fail this step will be given 1 week to re-submit their PDR. Failure to do so with the appropriate corrections will result in immediate disqualification.**
- Updated Flight Test Procedures flowchart (from the proposal stage) and a draft of pre-flight and post-flight procedures for proper execution of the experiment, using the templates provided in Sections 11.8. and 11.9. These procedures should be structured as follows:
    - Pre-flight procedures
        - List the ground facilities/equipment required to operate your equipment.
        - Identify the procedures proposed to set-up and operate your equipment on the ground; for example, assembly of components that are shipped unassembled (if shipping is required).
        - Identify every step that must be completed between arrival at the Campaign site and loading of the experiment aboard the Falcon 20, including estimated time, and responsible personnel using the templates provided in Section 11.9.



- Flight Test Procedures (see Section 11.8)
  - Updated from your proposal submission, or added, if not included in previous documentation.
- Post-flight procedures
  - Using the template provided in Section 11.9, identify any special procedures required, including estimated time, after disembarking from the flight, before the case can safely be removed from the aircraft by NRC personnel.
  - Identify the procedures proposed to teardown your equipment on the ground (including any requirements regarding biological sample handling).



Note that you may not have all the details at this point, but we want to see a draft for each stage (pre-flight, flight, post-flight) of the campaign.

- Updated safety plan of steps to be followed by the Mission Specialists and Ground Crew in case of problems with the experiment (electrical or mechanical failure, etc.).

7) Technical Risk Assessment

- From the risks identified in your proposal, have any been encountered? If so, describe how the mitigation and/or contingency plans were initiated, and whether they were effective. Describe any consequences and lessons learned.
- Include risk assessment tables from the proposal with updated estimates of likelihood and impact, as well as more technical details in the mitigation and contingency plans. Include new risk assessment tables, as needed.

8) Experiment Testing

- Describe your prototype built to test the experiment, lessons learned, and how those tests have impacted the preliminary design.
- Prior to submitting your CDR, your team will be required to test one full cycle of the experiment on the ground, as you would in flight. Provide a complete plan for this test, including operations procedures and responsibilities, a list of variables to be measured, and outcomes expected. Describe how the environment differs from that onboard the Falcon 20 and how that will impact the ground test. This should align with the overall project timeline included in this document.

9) Plan for data analysis / results interpretation

Building and flying your experiments is a lot of fun, but it doesn't end there. Briefly describe steps to be taken to analyze data and interpret results. Ideally, your team can write scripts to automate some basic analysis and generation of results that can be included in your final presentation at the closing ceremony.

10) Project management update/review

- Create a verification matrix for the requirements associated with your design and the constraints outlined in this handbook. It is recommended to follow the template provided in Section 11.5. Identify whether analysis/simulations, testing, or inspection are necessary to satisfy each requirement. Briefly describe (if applicable) the procedure implemented to verify each requirement and the results obtained. Mark the requirement as compliant (C), partially compliant (PC) or noncompliant (NC) based on the expected compliance (see the template for more details). If you are not currently compliant but expect to be compliant, detail why in the remarks section. Any sections for which you are not compliant need to be flagged as early as possible.
- Provide an updated timeline, including all the activities associated with your experiment from conception to manufacturing and testing, and the duration of each

activity throughout each phase of the project. A Gantt chart or other project management tool is recommended.

- Provide an updated budget and funding plan, including the status of any outstanding grant applications or sponsorships. Describe if the budget from your proposal is on track or was overestimated or underestimated, supported with justifications. Identify any obstacles encountered which have affected the budget from your proposal. See Section 11.7.
- Provide any necessary updates to the Work Breakdown Structure, including the identification of 2 primary and 2 backup Mission Specialists.

11) Project outreach update

Describe any outreach activities performed which were planned in your proposal **by completing an Outreach Activity Record (OAR; see Section 7.3 for template) for each activity** that has been completed. Provide details such as purpose, location, audience and outcomes. If any changes were made to the outreach plan, provide justifications. If no outreach activities were completed, please indicate it in your PDR.

12) References

Cite all your references using IEEE format.

13) Appendices (if needed)

5. CRITICAL DESIGN REVIEW

5.1. Overview

The Critical Design Review (CDR) must demonstrate that your experiment design has achieved sufficient level of maturity to proceed with full-scale manufacturing, integration with NRC's Falcon 20 aircraft, and testing in reduced gravity conditions. An assembled experiment (including the Pelican case) is expected at this stage. Like the PDR, the CDR will be presented to SMEs for feedback, and then a final CDR report will be submitted 7 days later. Comments from experts must be addressed in this document. In most cases, teams will complete both the report and the presentation by the deadline, and then only make minor changes to the report after the presentation.

The guidelines for the presentation are found in the next section, followed by the report guidelines in Section 5.3.

An unsuccessful or incomplete CDR can lead to project cancellation at the discretion of SMEs. Your CDR report must be limited to 50 pages, not including appendices. Remember to follow the formatting guidelines laid out in Section 1.4.

5.2. CDR Presentation

Teams will be required to provide a **20-minute** PowerPoint/Keynote presentation (followed by a 40-minute discussion period) to our panel of SMEs and judges via teleconference. The purpose of the CDR presentation is to obtain comments and feedback from SMEs before submission of your CDR report. You must demonstrate that your design satisfies all the requirements with compelling evidence, and that your experiment is either ready for flight or you have a clear path to flight. Please structure the presentation as follows:

- Title slide
    - Include all team information, responsibilities of each member and the chosen Mission Specialists and backup Mission Specialists.
- Introduction
    - 1 slide on research topic and experiment
    - Mission Objectives & Success Criteria table (see Section 11.1)
- Technical Experiment and Procedures
    - Final system specifications and diagrams
    - Final procedural flowcharts, including team responsibilities and time required:
        - Pre-flight procedures
        - Flight Test Procedures
        - Post-flight procedures
    - Final technical risk assessment

- Completed Ground Testing
    - Demonstrate functionality of your experiment in the final set-up inside the Pelican case
        - Briefly describe the setup of the final ground test(s) conducted prior to integration with the Falcon 20.
        - **Include a video of completed ground testing with a fully integrated payload (as well as any intermediate testing completed)**
        - Describe the results of the test and how they have impacted the final design specified in the CDR report.
- Present a requirement compliance table
    - Identify if analysis/simulations, testing, or inspection was required to satisfy the requirements of your design.
- Project management
    - Updated timeline
        - Highlight the most important milestones completed to date and the remaining tasks to accomplish prior to the integration of your experiment with NRC's Falcon 20 parabolic flight aircraft.
    - Budget
        - Include the final incurred costs for all the phases of the project and amount of funds remaining.

Your presentation should follow from the content of your report.

5.3. Sections for CDR Document

In the order listed below, your CDR document should include the following sections:

1) **Cover Page**
   Include all team information (including updated list of team members) and graphics

2) **Table of contents**
3) **Summary of major changes** made to the design since submitting the PDR. Include the location (page number, section number, etc.) of these changes.
4) **Updated list of figures and tables**
5) **Updated executive summary**
   The executive summary should provide an overview of all the sections in the PDR in **one** page or less.

6) **Introduction**

The introduction section of the CDR should build upon the PDR introduction and the comments provided by the SMEs. Make changes or add details as needed. Cite primary research literature whenever possible and use IEEE style.

Your introduction should include a Mission Objectives & Success Criteria table (see Section 11.1).

7) Experiment details and procedures

- This section should provide a complete technical review of your experiment and full system specifications. Include updated flowcharts and reference the following as appendices (as needed):
  - Final mechanical drawings
  - Final electrical schematics
  - Final software flowcharts
  - Final CAD model
  - Final Bill of materials (BOM)
- Updated (or new, if not included in previous documentation) pre-flight procedures, the Flight Test Procedures, and post-flight procedures using the templates provided in Section 11.8 and 11.9, based on feedback from SMEs.
- Updated safety plan based on feedback from SMEs.

8) Technical Risk Assessment

- From the risks described in the PDR, have any been encountered? If so, describe how the mitigation and/or contingency plans were initiated, whether they were effective. Describe any consequences and lessons learned.
- Include risk assessment tables from the PDR with updated estimates of likelihood and impact, and any updates to the mitigation and contingency plans. Include any new risk assessment tables with the same level of detail.

9) Experiment Testing

- Provide a thorough description of experimental tests conducted since submission of the PDR, lessons learned, and how those tests have impacted your final design.
- Each team is expected to complete at least one full cycle of ground tests with the fully assembled experiment at this stage (including the Pelican case), running through all the steps that will be performed during the actual flight (based on the finalized flight itinerary TBC).
- Provide a description of the completed ground tests, including operations procedures and responsibilities, a list of variables measured, and outcomes. Describe how the environment differs from that onboard the Falcon 20 and how that will impact the results during the actual flight.

10) Plan for data analysis / results interpretation

State if there are no updates on how you plan to analyze data and interpret results since the PDR. Otherwise, provide an updated plan in this section.

11) Project management update/review

- Provide an updated requirement verification matrix. Identify whether analysis/simulations, testing, or inspection are necessary to satisfy each requirement. Briefly describe (if applicable) the procedure implemented to verify each requirement and the results obtained. Mark the requirement as compliant (C), partially compliant (PC) or noncompliant (NC). Full compliance is expected at the CDR level.
- Provide an updated timeline, including all the activities associated with your experiment from conception to full-scale manufacturing and testing, and the duration of each activity throughout each phase of the project.
- Provide an updated budget and funding plan, including the status of any outstanding grant applications or sponsorships. Describe if the budget from the PDR is on track or was overestimated or underestimated, supported with justifications. Identify any obstacles encountered which have affected the budget since the PDR.
- Provide any necessary updates to the Work Breakdown Structure.

12) Project outreach update

Describe any outreach activities performed **since** submitting the PDR by **completing an OAR (See Section 7.3 for template) for each activity**. Don't list activities that have already been listed in the PDR. Provide details such as purpose, location, audience and outcomes. If any changes were made to the outreach plan since the PDR, provide justifications.

13) References (cite all your references in IEEE format)

14) Appendices (if needed)

6. TEST EQUIPMENT DATA PACKAGE

This documentation, based on the NRC Falcon 20 User Guide, must be prepared to determine flight readiness of the experiment. Most of the TEDP can be adapted from previous reports. Remember to follow the formatting guidelines laid out in Section 1.4.

6.1. Outline

Please submit your TEDP in the order listed below. Detailed descriptions of each section's requirements can be found following this outline.

- Cover Page
- Table of Contents
- Flight Manifest
- Experiment Background
- Experiment Description
- Equipment Description
- Structural Verification
- Electrical Analysis/Verification
- Laser Certification (if applicable)
- Crew Assistance Required
- Hazard Analysis
- Tool Requirements
- Ground Support Requirements
- Hazardous Material
- Material Safety Data Sheet(s) (MSDS)
- Procedures
- References
- Appendices

6.2. Sections for TEDP

In the order listed below, your CDR document should include the following sections:

1) **Cover Page**

Should contain the experiment name, team name, an updated list of all team members, the team leader's contact information (e-mail and phone number), name and address of the primary institution and the date of TEDP submission.

2) **Table of contents**

3) **Flight Manifest**

The flight manifest section lists the names of the two primary Mission Specialists, the two backup Mission Specialists and any additional team members that may support on site (Ground Crew). Ensure that all Mission Specialists (primary and backup) are physically able to withstand the rigours of microgravity flight. This list should include the nationalities of everyone who will be attending the flight campaign.

4) **Experiment Background**

Briefly describe, at a high level, why the experiment is being flown.

5) **Experiment Description**

In this section, briefly explain your experiment. You may use diagrams which can be included in the text or as appendices. A photograph of the fully assembled experiment (inside the Pelican case) should be included (or a full CAD model).

6) **Equipment Description**

Thoroughly describe the equipment required for performing the experiment, as follows:

- Final weight of the experiment (including and excluding the Pelican case)
- Table listing individual weight of each subassembly (you can use the mass table provided in Section 11.6)
- A list of systems or components that will be assembled during the flight campaign
- If necessary, a description of experiment layout or component changes that must be accomplished by the Mission Specialists during the flight (e.g. after each parabola), if any. Use the templates provided in Section **Error! Reference source not found.**. I nclude annotated diagrams or photographs of the pre-flight layout and in-flight layout.
- Describe, in detail, any component with special handling requirements or special hazards.
- List all items to be taken onboard the aircraft during flight, including cameras (specify brand and model), outreach experiments, any specialty tools (prior approval by NRC required), personal items, mementos, etc. Note that these items must be included in the final weight of the experiment.
    - Standard camera (¼-20 thread) mounts will be available for teams who wish to document their flight. Adapters for GoPros are also available. The weight limit for each camera is 5 lbs.

- No free-floating items are allowed during the parabolas. **Everything should be tethered or contained.**

7) Structural Verification

During the parabolic flight phase, the research package will experience loads up to 2g's. The research package must be designed to withstand **2g downward loading with a factor of safety of 1.5**. Compliance to this requirement can be shown via software simulation, or a simple physical test (e.g. loading the structure with double its weight).

8) Electrical Analysis/Verification

All experiments that use any type of electrical power (including battery power) must provide an electrical analysis structured in four parts: 1) Schematic, 2) Load Table, 3) Stored Energy and 4) Emergency Shutdown Procedures. Manufacturer-supplied batteries used to power mobile devices should be included in this analysis.

1) Schematic

The analysis should provide a graphical schematic drawing that clearly details the top-level electrical design of the experiment. The schematic should include the following:

- All wiring and electrical devices [including Commercial-off-the-Shelf (COTS)].
- The gauge number and current carried on each wire (Nominal and Peak current values).
- A current limiting device (fuse, circuit breaker) and its limiting value for each sub-system.
- The grounding method used to bond exposed metal surfaces.

2) Load Table

The purpose of a load table is to describe the electrical power drawn from each power source and ensure that the source is not overloaded.

Battery powered COTS devices that are being used as designed, without any modifications, do not need to be included in the load table. The same device should be included in the load table when it is powered using an AC adapter.

The table shall provide a detailed list of each load device and the maximum current draw of each device. The sum of the maximum device currents cannot exceed the rated current of the power source (5A).

Ideally, a circuit should be designed so that the total nominal current of all devices does not exceed 80 percent of the rated supply current.

A single 115VAC, 5A outlet is provided inside each Pelican case. If the team requires additional outlets, they must incorporate an appropriate power bar inside the case.

Follow the example from Table 11.6 – Power Budget.

3) Stored Energy
The analysis describes any devices used to build a large electrical charge (e.g., large capacitors, wire coils). The description should provide the maximum voltage of the charge and explain how this energy will be dissipated in the experiment.

4) Emergency Shutdown Procedures
Finally, each experiment is to have emergency shutdown capabilities. A detailed description of the electrical shutdown procedures is to be provided in the electrical analysis. The procedures shall describe the experiment's reaction to a power loss.

9) Loss of Electrical Power

In the event of electrical power loss (expected or unexpected), all experiments must fail to a safe configuration. Teams should be prepared to demonstrate their experiment's emergency shutdown capability prior to the flight campaign.

10) Laser Certification (if applicable)

This section should include a detailed description of any lasers to be used during the experiment. It should include the following:

- Identify the class, type and manufacturer of the laser being used with the experiment. **NOTE: Class 3 and 4 lasers are prohibited as described in Section 1.7, Experiment Constraints.**
- Brief description of the laser's purpose
- When the laser will be used during the flight, and for what duration
- Description of the containment controls (i.e., describe the protective housing, interlock switches, emergency kill switch, temperature/fire control, protective eyewear)

11) Crew Assistance

Identify any ground crew assistance that may be required, both on the ground and during flight.

12) Hazard Analysis Report

List all potential hazards in the test equipment and procedures of your experiment. The list should distinctly include all the hazards to safety and hazards to successful science. Hazards to safety include the hazards that can affect the safety of personnel in the Falcon 20 during flight as well as the aircraft itself. Hazards to successful science include all the hazards that can affect the successful outcome of the proposed experiment. For each of these hazards, identify the appropriate controls that have been implemented to eliminate the hazard. The report should be of sufficient depth and detail so that NRC personnel can determine if adequate hazard elimination or control has been accomplished or if additional hazard resolution analysis is required. In addition to these, the conditions as well as hazards that will require termination of flight or will stop the current set of parabolas for a level flight must also be included in the discussion.

13) **Specialty Tool Requirements**
All tools at the FRL are controlled. No outside tools are allowed inside the FRL hangar. Upon arrival, the teams will be assigned a tool box, which contains all of the basic hand tools that they might require for their final integration and testing. The toolbox is inventoried before a flight and the aircraft cannot be released until all tools have been returned. Experiments should be designed as much as possible such that no tools are required in flight. In the rare case that a specialty tool is required (onsite or in flight), this section should describe the tool and why it is required.

14) **Material Safety Data Sheets (MSDS)**
In this section of the TEDP, include information that applies to any chemical, fluid, etc. that the experiment utilizes (hazardous and non-hazardous). MSDSs are to be provided for all chemicals brought onto the Campaign site. Copies of MSDSs are to be kept with the chemicals at their ground-based storage areas.

15) **Experiment Procedures Documentation**
The information presented in this section of the TEDP will describe all the procedures involved with operating the experiment. This section should include procedures from your previous documents, including pre-flight, Flight Test Procedures, and post-flight flowcharts (following templates provided in Sections **Error! Reference source not found.** and 11.9). T his section should also include the Flight Test Matrix (see Section 11.10). This section should be comprehensive, and include as many details as possible

This is one of the most important sections in the TEDP document, as it helps NRC plan for payload verification and integration into the Falcon 20. If you have any concerns about the requirements of this section email canrgx@seds.ca.

16) **Emergency/Contingency**
Provide off nominal, contingency, and emergency procedures. Include actions by team members as well as FRL aircrew.

17) **References** (Cite all your references in IEEE format)

7. OUTREACH ACTIVITIES REPORT

7.1. Overview

Part of this competition involves inspiring the next generation of STEM leaders, educating youth and the public on microgravity research and space exploration and development at large, and communicating your work to peers in your field. Even as students, we are custodians of the scientific world and have a responsibility to nurture the curiosity and fascination with the universe that is innate among all of us. Also (particularly for the general public) it is important that people know why science is important, that way when they go to the polls they vote for a representative with a focus on science and education.

The Outreach Activities Report (OAR) must demonstrate that throughout the course of your project, your team has made an impact on students, the public and your peers through various activities and presentations. We encourage you to pursue a variety of outreach pathways such as interactive demos, school visits, festival exhibits, and academic presentations/posters. Topics may vary but at least one activity must relate to your project's research and experiment.

Remember to follow the formatting guidelines laid out in Section 1.4.

7.2. Structure

The OAR should include a title page that clearly lists all team members involved in the planning and delivering of outreach activities and their specific roles. The document should read as a consecutive list of events or activities, and for each activity a record should be completed. At the end of the document, an overview should be constructed that details your team's overall impact on each level of audience listed in the record template below.

If you included high school students during the planning, design, build, or characterization of your payload an extra section is required. This section should detail the specific roles these students held during the project and work they have completed. It would be advantageous to interview the high school students about their involvement in the project to see how you could improve a similar activity in the future; details like this, if included in the report, will strengthen SEDS-Canada's ability to apply for STEM education related grants (that would go towards things like student travel) and expand the reach of the CAN-RGX project to high school students.

The format of the document should follow the requirements listed in Section 1.4.

7.3. Outreach Activities Report

Every outreach activity you perform, fill out an outreach activity record using the formatted table below.

Table 7-1: Outreach activities record

Activities		
Location(s) of activity		
Dates(s) of activity		
Names and roles of team members involved in this activity.		
Were these activities part of a larger event? If so, please provide a name and brief description.		
Was this activity related to your project? (Y/N)		
Was this activity included in your Outreach Plan in the Proposal? (Y/N)		
Audience		
Educational level	**Number of Participants**	**Was this the primary audience? (Y/N)**
K-4		
5-8		
9-12		
Post-secondary		
Educator		
Other		
Summary		
Describe the activities conducted at the event.		
Describe any feedback you received from the audience or organizers.		

Describe any challenges faced while planning or executing the activities.
Would you repeat these activities? Justify why or why not. Suggest any improvements.

8. FLIGHT CAMPAIGN

8.1. Schedule Outline

We have the flight campaign currently slotted for **July/August 2023**, but this is subject to change due to uncertainties associated with the COVID-19 restrictions and deployment site. Below is a brief overview of the schedule. Students should plan to be on-site for the duration of the campaign to allow for flexibility around aircraft maintenance and technical issues, experimental issues, weather, etc. For reference ONLY, a previous year's detailed agenda is given in Appendix 12.4.

Sunday	Student teams arrive at Campaign site
Monday	Registration at the center of operations Pre-flight briefings/ground-school Final experiment assembly and preparation
Tuesday	Flight #1 (teams 1 and 2) - shakedown flight (morning) Flight #2 (teams 3 and 4) - shakedown flight (afternoon)
Wednesday	Flight #3 (teams 1 and 2) - data flight (morning) Flight #4 (teams 3 and 4) - data flight (afternoon)
Thursday	Contingency day
Friday	Contingency day Closing Ceremony

Note: teams are responsible for arrangements for their own transportation, lodging and food for the duration of the Flight Campaign. **We highly recommend booking refundable transportation & accommodation options, as flight campaign dates can change due to circumstances beyond our control**. Organizers of CAN-RGX are not responsible for any financial losses if teams book non-refundable options and the dates change.

8.1.1. Registration

NRC and SEDS-Canada Informed Consent Forms

Upon arrival at the Campaign site, students will be required to complete standard informed consent forms. Specific concerns regarding these forms should be addressed with the FRL Flight Director or the CAN-RGX project manager.

Checking into the Flight Research Lab

Students must check-in to FRL by signing and dating their entry. Students will receive a visitor badge and must wear this badge at all times while within FRL. Before leaving the building, students must return the visitor badge.

8.1.2. Pre-Flight Briefing

Medical Concerns

Due to the nature of the flights, it is expected that some people will experience a certain level of discomfort, including dizziness and nausea. This is a normal part of microgravity and can be experienced by both novice and experienced personnel. FRL staff will coach the Mission Specialists, before and during flights, with advice on minimizing any ill-effects. Anxiety plays an important role, typically the more relaxed a person is, the less likely that they will be sick. Everyone onboard has the right to abort the mission and return to base at any point during the flight.

All team members will participate in the pre-flight briefing where they will be given the opportunity to ask questions and address any concerns.

Note: Those on the aircraft are required to abide by the rules and regulations concerning the consumption of alcohol and cannabis. You will only be able to fly on the Falcon 20 if you are 12-hours free of any alcohol consumption, along with 28-days free of any cannabis consumption.

Ground test in the Falcon 20 cabin

It will be necessary to complete a simulated flight with all payloads and crew onboard (two experiments, Mission Specialists and FRL crew) for teams to make final adjustments to their in-flight procedures. This simulation will also allow teams to familiarize themselves with the cabin and account for any spatial restrictions.

Your experiment may be left (within the Falcon 20) in the hangar or on the tarmac for up to 4 hours.

Opportunity to participate in human physiology study

In addition to running the experiments, the Mission Specialists will be invited to participate in a physiological monitoring study. Upon review of the study information and consent documents, and if participants agree to participate, they will be asked to provide written informed consent. This study has been approved by NRC’s Research Ethics Board. Participants would be asked to wear a non-invasive mobile monitoring device, such as the EquivitalTM device (EQ02-SEM, Hidalgo Ltd., Swavesey, Cambridge, UK) to obtain an output of electrocardiogram (ECG), heart rate, R-R interval (R, the peak of the QRS complex of the ECG wave), respiration rate, skin temperature, accelerometer (X, Y, Z), body position, and motion status. In addition, an external sensor for oxygen saturation (Nonin® 7000A, Plymouth, MN, USA) or galvanic skin response will be connected to the EQ02-SEM and recorded in conjunction with the EQ02-SEM variables. All variables will be measured continuously and downloaded using Equivital Manager (Hidalgo Ltd., Swavesey, Cambridge, UK). According to manufacturer specifications, the participant's chest will be measured to ensure a proper fit of the Equivital^{TM} belt and electrodes will be wet with water prior to EQ02-SEM initialization. Participants will also be asked to complete a series of short subjective questionnaires or ratings that will give researchers an indication of their current mental and physical state (e.g., Dundee Stress State Questionnaire, and sleepiness, motion sickness, and thermal comfort ratings) to be correlated with the physiological data. Video and audio recordings will also be included as part of the flight tests, where participants will be asked to sign a consent. These combined measures will inform researchers of the physiological and psychological responses to stress and microgravity. The physiological monitoring aspect of the flight is part of an ongoing research project to elucidate the human physiological responses to parabolic flight. All of the information obtained from the participants will remain **strictly confidential**, unless we are required by law to disclose it. All data will be coded using random codes noted on the consent form, where a participants' name will not be associated with any individual data. All data will be stored in an area separate of the consent forms, and in a locked cabinet only accessible to project team members who are named on the consent form. You will be able to get your data after it is processed!

8.1.3. Closing Ceremony

To bring the competition to an end and to celebrate your accomplishments, a Closing Ceremony will be hosted by SEDS-Canada and their sponsors. All team members including faculty advisors and high school student volunteers are invited and teams will be asked to present a brief synopsis of their project. This is also an opportunity for students to share what they learned during the competition. Selected guest speakers from the space industry will be invited to give short talks followed by networking opportunities.

Two awards are given at the Closing Ceremonies. The Overall Excellence Prize is awarded to the team who demonstrates a consistent ability to plan, design, and develop a microgravity experiment, meets or exceeds all requirements stated in the CAN-RGX guidelines, and shows a positive attitude toward working with teammates, partners, and other stakeholders. Similarly the Outreach Prize is awarded to the team that puts forth a sustained effort to communicating science literacy, particularly as it pertains to space, microgravity, and CAN-RGX, in creative and compelling ways to a variety of groups.

NOTE: the Closing Ceremony may be hosted online, depending on the COVID-19 restrictions.

9. POST-FLIGHT SURVEY

The Post-flight survey will help SEDS-Canada improve the CAN-RGX competition. It includes questions such as:

- Were your experiment objectives met? Explain why or why not?
- How many parabolas were completed? Did the flight meet the data collection requirements for your experiment?
- What results were obtained from the data collected? Was the data expected or unexpected? Explain.
- How did participating in CAN-RGX affect your interest in working in the space industry?

The Post-flight survey Google Form will be distributed to all participating individuals after Closing Ceremonies and must be submitted by **August 30, 2023, 11:59 PM (EDT).**

10. DELIVERABLE CHECKLIST

In an effort to be utterly clear about the deliverables expected throughout the CAN-RGX competition, the following can be used as a checklist:

- ❑ Progress Presentation 1
- ❑ Preliminary Design Review (PDR) Presentation
- ❑ PDR Report
- ❑ Progress Presentation 2
- ❑ Progress Presentation 3
- ❑ Critical Design Review (CDR) Presentation
- ❑ CDR Report
- ❑ Outreach Activities Report
    - ❑ Pictures/video for social media
- ❑ Test Equipment Data Package (TEDP)
    - ❑ Pre-flight, flight, and post-flight procedures
- ❑ Post-flight Survey

11. TEMPLATES

This section contains templates that each team should use for various parts of the project.

11.1. Mission Objectives & Success Criteria

Describe the mission objectives (what questions do you want to answer?) and the success criteria for meeting these objectives in a table like the following (a couple of examples are given, but be sure to make these specific to your experiment):

Table 11-1: Mission objectives & success criteria template.

Mission Objective	Success Criteria
Example: Demonstrate operation of solar panels in space-like conditions.	*Example: The solar cells produce at minimum X amount of power and the panel wiring is able to distribute that power to all required components.*
Example: Demonstrate communication subsystem in space-like conditions.	*Example (of multiple criteria):* *1. (Minimum criteria) The ground station receives a beacon from the satellite.* *2. The satellite acknowledges reception of a ground station transmission (handshake between ground station and the satellite).* *3. The ground station receives a telemetry packet with X percentage of packet loss.*

Note that the success criteria should be constructed from variables you measure during your experiment, and should be as measurable and specific as possible.

If you do not know the specific success criteria, e.g. you know you will be measuring a variable, but don't know what amount you'd need to see to in order to consider the objective successful, you can write in "X" as a placeholder in that criteria. You'll be expected to finalize that criteria before or at the CDR.

11.2. Risk Assessment Tables

Create a risk table (like Table 11-2) for each technical risk (TR#), human risk (HR#), or managerial risk (MR#), describing what the risk is, its probability and consequence with associated rankings (Low, Medium or High), and a mitigation and contingency plan.

The definitions of Low, Medium, and High are:

- Low: unlikely to occur or requires multiple control elements to fail
- Medium: may occur if a control element fails
- High: likely to occur due to frequency of activity or lack of control elements

List all risks (TR1, MR1, etc.) in the Risk Assessment Matrix (Table 11-3**Error! Reference source not found.**).

Table 11-2: Risk table template.

Risk Event – TR1	**What is the risk?**	
Probability	L / M / H	*Describe probability*
Consequence	L / M / H	*Describe consequence*
Mitigation Plan	*Describe plan to mitigate risk* *This may include active methods (ex. detection, feedback, controls), passive methods (ex. deterrence, avoidance, initial planning), or no mitigation.* *You should include the mitigated probability (i.e. the probability given the mitigation strategies your team will employ) and the mitigated consequence (i.e. the consequence given the mitigation strategies your team will employ) in this section.*	
Contingency Plan	*Describe the response plan in case risk occurs.*	

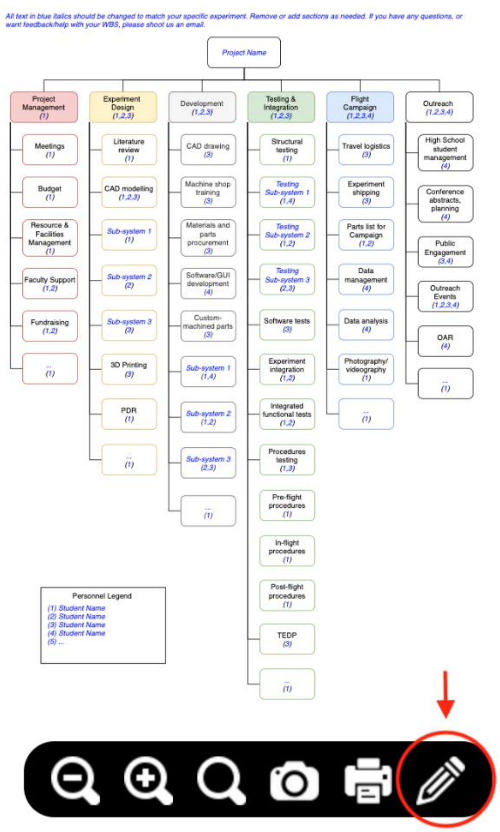
Table 11-3: Risk assessment matrix.

		Probability		
		Low	Medium	High
Consequence	Low	*E.g. MR1, TRI*		
	Medium		*E.g. MR2*	*E.g. TR2*
	High			

11.3. Work Breakdown Structure

A work breakdown structure (WBS) separates your project into distinct **scopes** and assigns a person responsible for managing that scope to ensure accountability and identify gaps in personnel. Scopes should be broken into sub-scopes which may have their own managers. Specific *activities* should be defined in the project timeline within each scope and may have linkages across different groups. In small spacecraft design, scopes are typically defined by *timeline* (ex. design, manufacturing, testing), *discipline* (ex. engineering, finances, management), or *system* (ex. comms, power, payload), with sub-scopes encompassing the other aspects. A WBS may contain multiple layers as needed to organize your project.

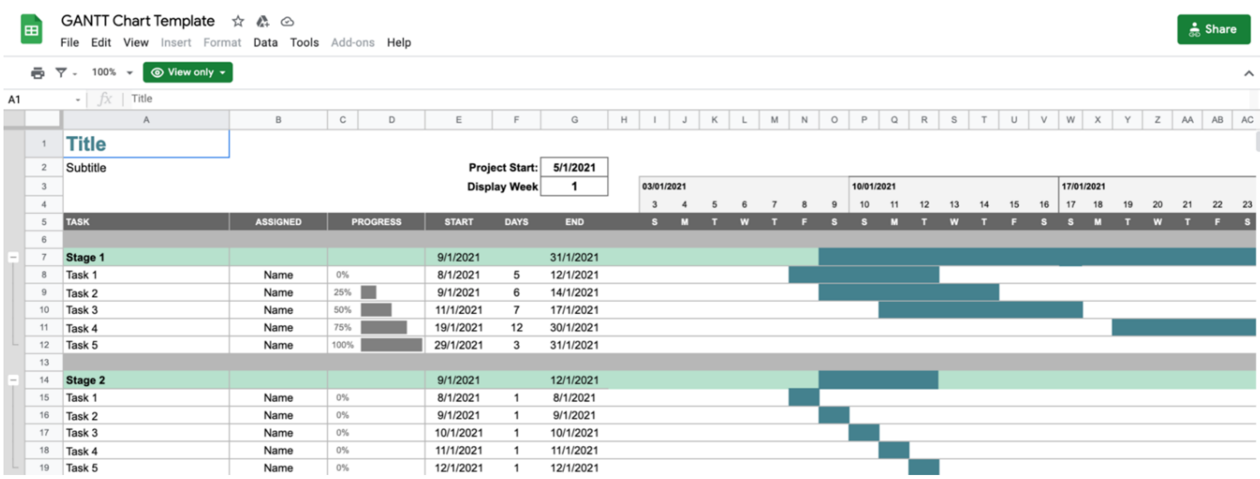
Modify the template tree outlined below (currently organized by discipline, with engineering split by timeline) to structure your project from start to finish. **You can access the template at seds.ca/templates**. Add or remove tasks as needed based on your project and management plan. Assign a number to each member of your team and list their names in the legend. Each task in the WBS should be given a number(s) corresponding to the team members responsible for that task. When accessing the template at **seds.ca/templates**, you can edit the WBS using the edit buttons shown in the screenshot below. It will open a new page in diagrams.net, where you can edit the WBS without modifying the template.



11.4. Gantt Chart Template

A Gantt chart is a type of bar chart that illustrates a project schedule. You can use it as a project management tool, as a way to ensure your project stays on schedule, and to foresee any timeline issues that may come up.

To create your own Gantt Chart using our Google Sheets template, head to **seds.ca/templates** and scroll to the bottom of the page. You should see a red button which will direct you to a View Only copy of the template. To create your own chart, click File > Create a Copy. It will save an editable version of the Gantt chart in your Google Drive.



Some instructions for using the chart:

- When adding a task, specify the start date and the number of days you expect to complete it in. The end date and task bar will then auto-populate.
- If you adjust the number next to *Display Week*, the calendar will shift left or right as it changes the week from which to start displaying information. This functionality is also useful near the beginning of the project, where you have only rough, longer-term estimates for task completion.
- To the left of the row numbers there are buttons to expand and collapse stages of the project. For example, if you press '-' next to row 7 or row 21 you can hide tasks related to stages 1 or 3, respectively.
- If you add a number in the left side of the *Progress* column the progress bar will auto-update

This template was created by Sam Aberdein (CAN-RGX 4.5 alum).

11.5. Requirement Verification & Compliance Matrix (RVCM)

The following template should be used to verify your experiment design requirements. It is expected that your RVCM will be populated with far more requirements than what is shown in the example below, e.g. the experiment constraints should be applicable to your experiment (the one listed is here has example descriptions, verification methods, and remarks, etc.). In the compliance column you should list the ***expected*** level of compliance, not the ***current*** level of compliance; if a compliance listed is expected, but not yet met, a remark should be made about that.

The following nomenclature is used herein:

Verification Method

A = Analysis, S = Simulation, T = Testing, I = Inspection

Compliance Legend

C = Compliant, P = Partially Compliant, NC = Non-Compliant

Table 11-4: Example requirement verification & compliance matrix.

Category	No.	Requirement	Verification Method	Description	Compliance			Remarks
					C	P	NC	
Experiment Structure	1.1	Experiment mass shall be constrained below 45 kg.	A/S/T/I	Example: Experiment was measured on a scale prior to integration.	X			Example: A heavy part currently puts us over 45 kg, but this component will be have a reduced mass in ~3 weeks, and so our final payload will be compliant
	1.2	Design must tolerate vertical axial loads of up to 2g's.	A/S/T/I	Analyses and simulation work demonstrated tolerance to high positive and negative G's.		X		
	1.3	Experiment must be structurally compatible with the Pelican Case	A/S/T/I	Preliminary design was developed based on spec sheet. Verified via integration and inspection.	X			
Electrical Compatibility	2.1	Electrical components must be compatible with standard 115V/5A outlets.	T/I	-	X			
Power Consumption	3.1	The total power consumption should be constrained below	T/I	-	X			Some internal parts have their own regulated power supply.

		600W.						
Experiment Operations	4.1	Footage of water slosh in microgravity should be monitored at 50 fps using a high-speed camera.	T/I	Two full cycles of experiments (assuming 10 parabolas/cycle) were conducted on the ground to verify proper functionality.	X			

11.6. Mass and Power Budgets

Table 11-5 shows a mass budget template which can be used for your design documents (Proposal, PDR and CDR). Your experiment is expected to have more components than the sample budget below. Please use the following nomenclature:

E = Estimated Mass

M0 = Calculated using a 3D solid model (SolidWorks, Fusion360, Pro-Engineer, etc.)

M1 = Taken from a manufacturer spec sheet

M2 = Measured using a scale

Do not forget to include masses for your fasteners, wiring, and mounting interface to the pelican case itself. At the proposal stage, you should have over 15% margin or a plan to reduce mass in case your system exceeds the budget at later stages.

Table 11-5: Example mass budget.

Component	Status	Qty	CBE Unit [kg]	CBE Total [kg]	Mass Fraction	Remarks
Structure and Mechanisms			**Subtotal**	**9.00**	**52%**	
Aluminum Structure	M2	1	6.00	6.00		
Support Brackets	M2	5	0.20	1.00		
Experiment Components			**Subtotal**	**5.00**	**29%**	
High-Speed Camera	M1	1	0.50	1.00		
Power System			**Subtotal**	**0.85**	**5%**	
Batteries	M2	4	0.10	0.40		
9V Power Adapters	M2	3	0.05	0.15		
Data Handling			**Subtotal**	**1.10**	**6%**	
Data Logger	M2	1	0.50	0.50		
Electronics			**Subtotal**	**0.50**	**3%**	
Arduino UNO	M0	1	0.10	0.10		
Miscellaneous			**Subtotal**	**0.80**	**5%**	
Cabling	E	1	0.50	0.50		
Fasteners	M0	1	0.30	0.30		
TOTAL				**17.25**	**100%**	
Target Mass				**20.00**	**-**	
Margin				**2.75**	**14%**	

You should use the Table 11-6 as a template for your power budget.

Table 11-6: Example power budget.

Component	Status	Voltage	Power [W]	Qty	Experiment Operational Mode			
					Idle		Science	
					Average [W]	Duty Cycle	Average [W]	Duty Cycle
RF Module	E	5 VDC	0.17	4	0.00	0%	0.68	100%
Tablet	M1	115 VAC	10.00	1	10.00	100%	10.00	100%
Robotic Manipulator	M2	12 VDC	20.00	1	0.00	0%	20.00	100%
Microcontroller	M1	3.3 V	5.00	2	5.00	50%	10.00	100%
	Power Used [W]				**15.00**	**-**	**40.68**	**-**
	Power Available or Allocated [W]				**50**	**-**	**50**	**-**
	Margin [%]				**70%**	**-**	**19%**	**-**

11.7. Budget and Funding

Using your Work Breakdown Structure as a guide, complete a table listing the costs of each major task of the project. Include all current and future sources of funding to estimate total available funds and determine the overall project budget. Include as many details as possible.

Table 11-7: Budget and funding plan.

		Estimated Expenses ($CAD)				Actual Expenses ($CAD)
Project Management	**Project Tasks**	**Labour**	**Material**	**Travel**	**Other**	
	Meetings					
	Subtotal					
Design	CAD Model					
	Prototype					
	Sub-system 1					
	Subtotal					
Development	Custom-machined parts					
	Materials and Tools					
	Machine shop training					
	Sub-system 1					
	Subtotal					
Testing	Structural tests					
	Software tests					
	Sub-system 1					
	Procedures tests					
	Subtotal					
Flight Campaign	Travel to/from flight campaign					
	Meals					
	Experiment shipping (if required)					
	Spare parts					
	Data collection and management					
	Data analysis					
	Subtotal					
Outreach	Conferences					
	Public engagement					
	Subtotal					
Other Costs	Other costs					
	Subtotal					
Subtotals						
Subtotal With +15% Margin						
Total (Estimated)						
		Estimated Funding ($CAD)				**Actual Funding ($CAD)**
Funding **Sources**	University/College Grants					
	Government Grants					
Subtotal						
Subtotal with -15% Margin						

Total (Estimated)		
Deficit/Overture (Funding – Costs)		

11.8. Flight Test Procedures

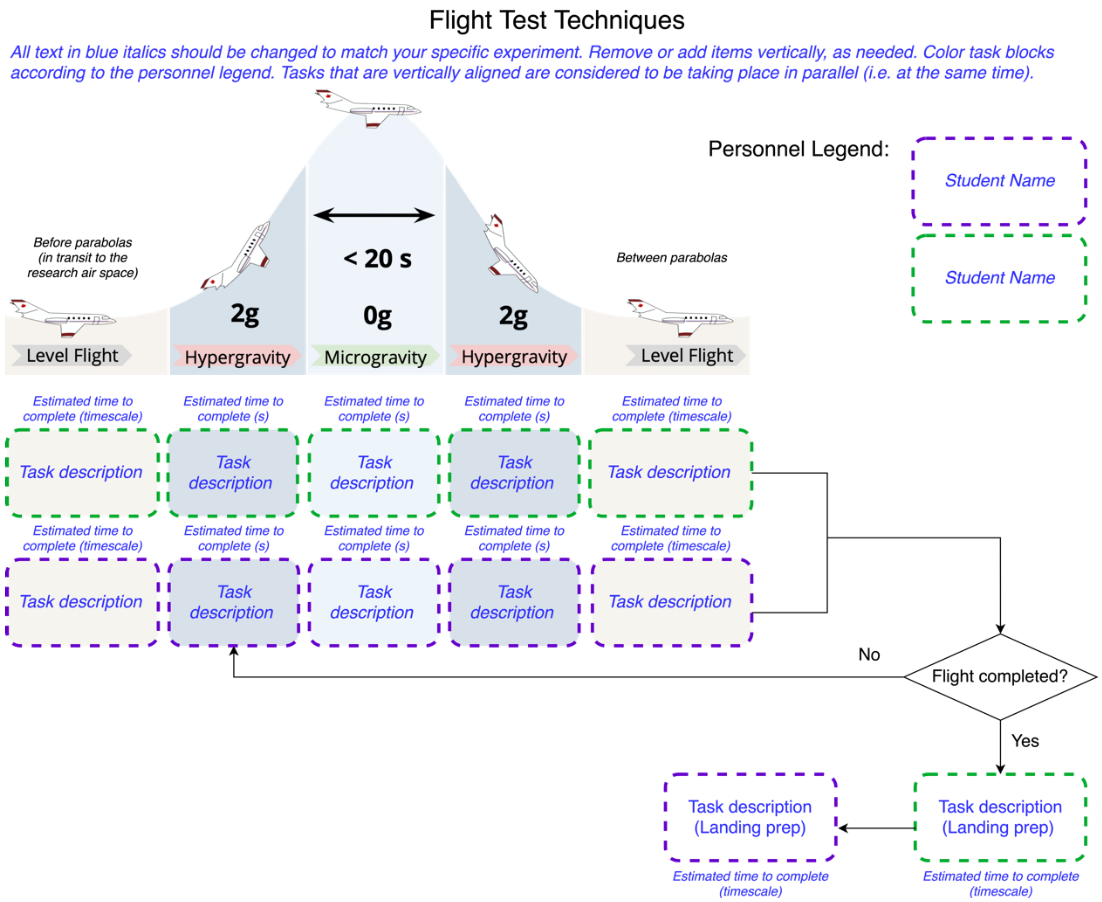
The following flowchart is used to visualize procedures that take place during a typical science parabola. **You can access the template at seds.ca/templates**. Note that you should specify tasks during six separate portions of the flight:

1. **Level Flight (before parabolas):** there will be some transit time to the research air space. Tasks required to be performed before the first parabola is flown should be listed here. This may include loading a time-sensitive material in the system, ensuring experiment status via laptop, verifying for foreign objects, etc.
2. **Hypergravity (2g):** for this and the following two sections, include all experimental procedures required (e.g. "start experiment routine on laptop", "observe [data parameter]", etc.)
3. **Microgravity (0g)**
4. **Hypergravity (2g)**
5. **Level Flight (between parabolas):** for some experiments level flight time is required to perform tasks critical to scientific results. Although not necessarily present after each parabola, if level flight time is required, the tasks expected to occur during level flight time should be listed here.
6. **Landing prep:** specify any tasks needed to complete right after the microgravity parabolas, during transit back to the airport and after landing. Include any steps required to power down the equipment by the time the aircraft parks and engines are shutdown (such as data transfer or computer shutdown protocols). Students may remove any time sensitive samples as they leave the aircraft. Pelican cases will be removed from the Falcon 20 as soon as possible – tasks performed after the experiments are removed from the plane can be detailed in post-flight procedures.

Add or remove tasks (vertical items) as needed based on your procedures. Write the estimated amount of time each part of the procedure will take. For example, if you need to press a button to start the experiment at the beginning of the microgravity portion you would specify "Estimated time: instant" if the experiment instantly starts, or "Estimated time: 2 s" if there is a short delay (for whatever reason). If level flight time between parabolas is not required, those tasks can be removed.

When accessing the template at **seds.ca/templates**, you can edit the flowchart using the edit buttons shown in the screenshot below. It will open a new page in diagrams.net, where you can edit the flowchart without modifying the template.

Wherever possible, you should also comment on any emergency procedures for returning the system to a safe state that are planned in case of emergency in text accompanying the flowchart.

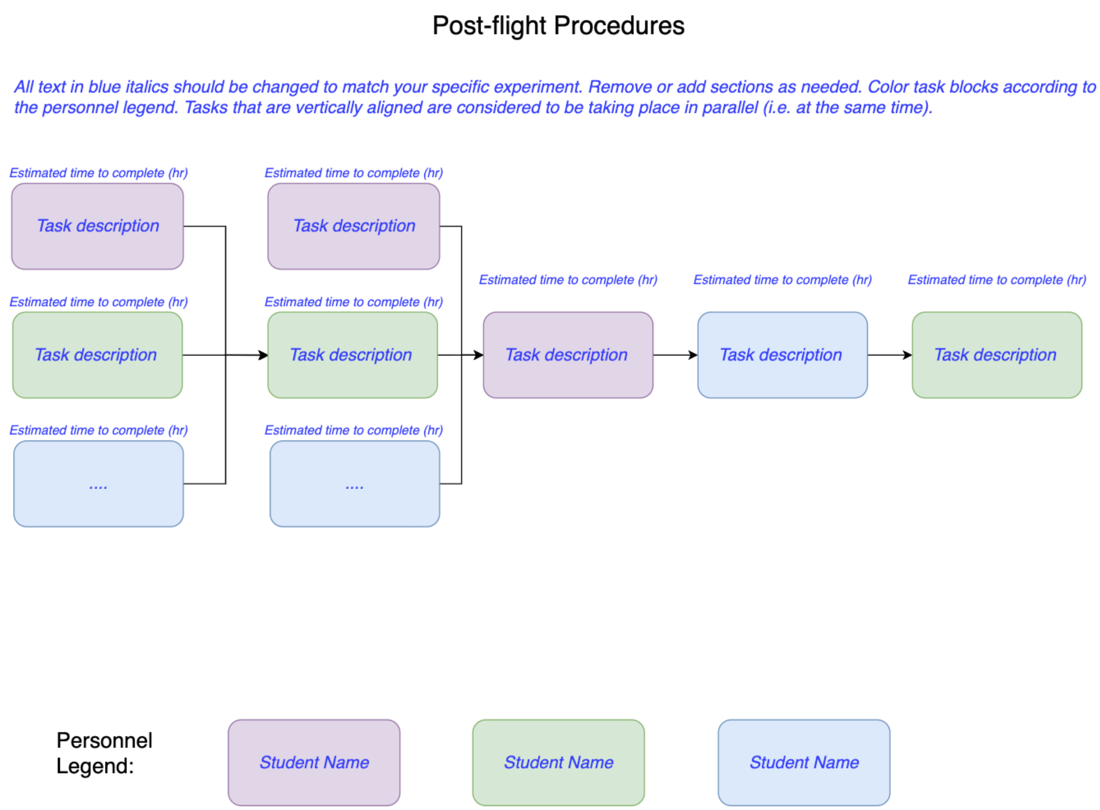


If you have any questions about how to properly complete these in-flight procedures, please send canrgx@seds.ca an email.

11.9. Pre-Flight and Post-Flight Procedures

Using a similar flowchart template as for the Flight Test Procedures (available at seds.ca/templates), complete your pre-flight and post-flight procedures. Your pre-flight procedures should include everything you'd need to do once arriving at the Flight Research Lab with your payload. For example, this would include things like having to prepare a biological sample, doing a ground flight test, or assembling a component. Your post-flight procedures should include everything you need to do with the payload or with the data or samples from the payload post-flight.

When accessing the template at **seds.ca/templates**, you can edit the flowchart using the edit buttons shown in the screenshot below. It will open a new page in diagrams.net, where you can edit the flowchart without modifying the template.



11.10. Flight Test Matrix

Use this table to list *detailed* descriptions of all procedures to be performed by Mission Specialists during the *entire* flight. Unlike the Flight Test Procedures flowchart, which lists general items (e.g. "start experiment software", this chart should contain all procedures in explicit detail (e.g. instead of "start experiment software", you'd break that down into "Open experiment.py, Type START, Hit ENTER"). The chart should contain every step required, in case someone less experienced with experimental procedures needs to operate the experiment (e.g. a backup mission specialist), or the experimenter is disoriented during flight.

You should add to this chart the amount of parabolas needed to meet your Mission Objectives. Early cancellation due to motion sickness or longer than expected time requirements between parabolas could lead to the completion of as few as 6 or 7 parabolas. Please organize your experiment accordingly to ensure maximal data collection in the first 6 parabolas. If your experiment does not require level flight time between parabolas, remove these rows. If level flight time is required between certain parabolas, be sure to modify the length of time at level flight required. **Include as many details as possible in the "Procedure" column.** An example is shown in italics.

Table 11-8: In-flight procedures.

Stage		**Location**	**Length (mm:ss)**	**Procedure**
Boarding (Pelican case is already secured within Falcon 20)		Campaign site Tarmac	5:00	
Taxi		Airport	5:00	
Takeoff		Airport	5:00	
Transit to Research Airspace			15:00	
Acclimatization Parabola	2g	Research Airspace	0:20	*No tasks*
	µg		0:20	*- Press START button upon visual confirmation of 0g status* *- Monitor experiment functions via Dashboard* *- Once timer has reached 15 s, push FILL button to stop reaction*
	2g		0:20	*No tasks*
	Level flight		3:00	*- Record FILL STATUS to confirm successful trial*
Data Parabola 1	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	

Data Parabola 2	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 3	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 4	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 5	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 6	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 7	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 8	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 9	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
	Level flight		3:00	
Data Parabola 10	2g	Research Airspace	0:20	
	µg		0:20	
	2g		0:20	
Transit to YOW			15:00	
Landing		Ottawa Int’l Airport (YOW)	5:00	
Taxi		Ottawa Int’l Airport (YOW)	5:00	
Disembark (Pelican case stays mounted in Falcon 20)		Campaign site Tarmac	5:00	

12. APPENDIX

12.1. Physical and Health Hazards

Physical Hazards

Hazard Class	General Description
Flammable gases Flammable aerosols Flammable liquids Flammable solids	These four classes cover products that have the ability to ignite (catch fire) easily and the main hazards are fire or explosion.
Oxidizing gases Oxidizing liquids Oxidizing solids	These three classes cover oxidizers, which may cause or intensify a fire or cause a fire or explosion.
Gases under pressure	This class includes compressed gases, liquefied gases, dissolved gases and refrigerated liquefied gases. Compressed gases, liquefied gases and dissolved gases are hazardous because of the high pressure inside the cylinder or container. The cylinder or container may explode if heated. Refrigerated liquefied gases are very cold and can cause severe cold (cryogenic) burns or injury.
Self-reactive substances and mixtures	These products may react on their own to cause a fire or explosion, or may cause a fire or explosion if heated.
Pyrophoric liquids Pyrophoric solids Pyrophoric gases	These products can catch fire very quickly (spontaneously) if exposed to air.
Self-heating substances and mixtures	These products may catch fire if exposed to air. These products differ from pyrophoric liquids or solids in that they will ignite only after a longer period of time or when in large amounts.
Substances and mixtures which, in contact with water, emit flammable gases	As the class name suggests, these products react with water to release flammable gases. In some cases, the flammable gases may ignite very quickly (spontaneously).
Organic peroxides	These products may cause a fire or explosion if heated.
Corrosive to metals	These products may be corrosive (chemically damage or destroy) to metals.

Combustible dust	This class is used to warn of products that are finely divided solid particles. If dispersed in air, the particles may catch fire or explode if ignited.
Simple asphyxiants	These products are gases that may displace oxygen in air and cause rapid suffocation.
Physical hazards not otherwise classified	This class is meant to cover any physical hazards that are not covered in any other physical hazard class. These hazards must have the characteristic of occurring by chemical reaction and result in the serious injury or death of a person at the time the reaction occurs. If a product is classified in this class, the hazard statement on the label and SDS will describe the nature of the hazard.

Health Hazards

Hazard Class	General Description
Acute toxicity	These products are fatal, toxic or harmful if inhaled, following skin contact, or if swallowed. Acute toxicity refers to effects occurring following skin contact or ingestion exposure to a single dose, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. Acute toxicity could result from exposure to the product itself, or to a product that, upon contact with water, releases a gaseous substance that is able to cause acute toxicity.
Skin corrosion/irritation	This class covers products that cause severe skin burns (i.e., corrosion) and products that cause skin irritation.
Serious eye damage/eye irritation	This class covers products that cause serious eye damage (i.e., corrosion) and products that eye irritation.
Respiratory or skin sensitization	A respiratory sensitizer is a product that may cause allergy or asthma symptoms or breathing difficulties if inhaled. Skin sensitizer is a product that may cause an allergic skin reaction.
Germ cell mutagenicity	This hazard class includes products that may cause or are suspected of causing genetic defects (permanent changes (mutations) to body cells that can be passed on to future generations).
Carcinogenicity	This hazard class includes products that may cause or are suspected of causing cancer.

Reproductive toxicity	This hazard class includes products that may damage or are suspected of damaging fertility or the unborn child (baby). Note: There is an additional category which includes products that may cause harm to breast-fed children.
Specific target organ toxicity – single exposure	This hazard class covers products that cause or may cause damage to organs (e.g., liver, kidneys, or blood) following a single exposure. This class also includes a category for products that cause respiratory irritation or drowsiness or dizziness.
Specific target organ toxicity – repeated exposure	This hazard class covers products that cause or may cause damage to organs (e.g., liver, kidneys, or blood) following prolonged or repeated exposure.
Aspiration hazard	This hazard class is for products that may be fatal if they are swallowed and enter the airways.
Biohazardous infectious materials	These materials are microorganisms, nucleic acids or proteins that cause or is a probable cause of infection, with or without toxicity, in humans or animals.
Health hazards not otherwise classified	This class covers products that are not included in any other health hazard class. These hazards have the characteristic of occurring following acute or repeated exposure and have an adverse effect on the health of a person exposed to it - including an injury or resulting in the death of that person. If a product is classified in this class, the hazard statement will describe the nature of the hazard.

Refer to Canada’s Hazardous Products Act for more details.

12.2. Team/Project Checklist

SEDS-ÉEDS CANADA

Students for the Exploration and Development of Space
Étudiants pour l'Exploration et le Développement Spatial

SEDS-Canada Student Design Challenge: Team Checklist

This letter is to certify that our team, ____ has read and understood the following checklist requirements pertaining to restrictions put in place by the COVID-19 pandemic. By submission of this proposal document we certify that our team meets all the following checklist requirements:

- ☐ Our team is committed to working on the project during the pandemic following the timeline provided
- ☐ Our team is committed to balancing academic work and this extracurricular activity
- ☐ Our team has a platform (e.g. Slack, Discord) that we can easily communicate on
- ☐ Our team is committed to scheduling frequent & recurring team work sessions/meetings
- ☐ Our team has some access to a workspace (although access may be limited) or are committed to securing access

  If the workspace is at your university:

  - ☐ Our team is committed to creating a contingency plan for making progress on our experiment if our workspace access is revoked
- ☐ Our team has access to the equipment/software we will need (although access may be limited) or are committed to securing access
- ☐ We acknowledge that the Flight Campaign dates may have to be postponed due to the uncertainties of the pandemic

Team Lead Signature: ____________________________________ Date: __________________

Team Lead Name: ____

Team Lead Email: ____

Affiliation/Department:____

12.3. Faculty Endorsement Letter

Students for the Exploration and Development of Space
Étudiants pour l'Exploration et le Développement Spatial

Canadian Reduced Gravity Experiment Design Challenge (CAN-RGX)

Letter of Endorsement

To SEDS-Canada,

This letter is to certify that I, ____ will serve as Faculty Advisor to Team ____________________________________, and I understand that I will be asked to provide guidance and support through some or all of the phases of the challenge, including submission of the project Proposal, Preliminary Design Review, Critical Design Review, and Test Equipment Data Package.

Faculty Advisor Signature: ______________________________________ Date: ________________

Faculty Advisor Information

Name: ____

E-mail: ____

Affiliation/Department: ____

Is this the primary Faculty Advisor? ☐ Yes ☐ No

Team Information

Team Name: ____

Team Lead Name: ____

Team Lead E-mail: ____

Affiliation/Department:____

12.4. Example Flight Campaign Schedule

CAN-RGX
Flight Campaign Itinerary

Monday 22 July 2019

Location
NRC Flight Research Laboratory
1920 Research Private
Ottawa, ON, K1V 1J8

Ground School

Points of Contact

SEDS-Canada	NRC-CNRC
Alex Wlodarczyk	Duff Gowanlock
(613) 799-8790	(613) 716-5310

Time	Activity	Offices of Interest
0830	Team Arrival at FRL	CAN-RGX PM
0900	Welcome to FRL, Introductions, Sequence of Events, Admin	Dir R&D FRL NRC Research Crew
0920	Campaign Objectives	CAN-RGX PM NRC Research Crew CSA Sponsor
0945	Experiment Finalization & Assembly	NRC Research Crew Team Leads
1130	Break for Lunch	
1300	Biometric Measurement of Motion Sickness Indicators Research	NRC Human Factors
1320	Aircraft & Microgravity Briefing	NRC Research Crew
1400	On-Aircraft Familiarization	NRC Research Crew
1430	Procedures Review	NRC Research Crew
1600	Final points, wrap-up	NRC Research Crew CSA Sponsor CAN-RGX PM

CAN-RGX
Flight Campaign Itinerary

SEDS-ÉEDS
CANADA

Tuesday 23 July 2019

Location **NRC Flight Research Laboratory**
1920 Research Private
Ottawa, ON, K1V 1J8

Shakedown Flights

Team A: **QDMT & UWR**
Team B: **UVR & MERGE**

Time	Activity	Offices of Interest
0700	Weather Check	NRC Research Crew NRC Research Pilots
0730	Team A Load & Rehearsal	NRC Research Crew Team A Leads
0830	Team A Biometric Instrumentation	NRC Human Factors
0900	Team A Pre-flight Brief	NRC Research Crew NRC Research Pilots NRC Flight Ops
	Team B Dry Rehearsal & Instrumentation	NRC Research Crew NRC Human Factors
0945	Team A "Step" 2 – 3 Parabolas	NRC Research Crew NRC Research Pilots Team A Leads
1045	Team A Return, Debrief	NRC Research Crew NRC Research Pilots
1100	Team B Experiment Load & Lunch	NRC Research Crew
1200	Team A Lunch	
	Team B Rehearsals	NRC Research Crew Team B Leads

1300	Team B Pre-flight Brief	NRC Research Crew NRC Research Pilots NRC Flight Ops
	Team A De-Instrumentation	NRC Human Factors
	Team A Experiment Work	Team A Leads
1345	Team B "Step" 2 – 3 Parabolas	NRC Research Crew NRC Research Pilots
1445	Team B Return & Debrief	NRC Research Crew NRC Research Pilots
1500	Team A Experiment Load	NRC Research Crew
1600	Wednesday Weather Check	NRC Research Crew NRC Research Pilots NRC Flight Ops

CAN-RGX
Flight Campaign Itinerary

Wednesday 24 July 2019

Location — **NRC Flight Research Laboratory**
1920 Research Private
Ottawa, ON, K1V 1J8

Data Flights

Team A: **QDMT & UWR**
Team B: **UVR & MERGE**

Time	Activity	Offices of Interest
0700	Weather Check	NRC Research Crew NRC Research Pilots
0730	Team A Setup & Rehearsal	NRC Research Crew Team A Leads
0800	Team A Biometric Instrumentation	NRC Human Factors
	Team B Experiment Work	Team B Leads
0830	Team A Pre-flight Brief	NRC Research Crew NRC Research Pilots NRC Flight Ops
	Team B Instrumentation	NRC Human Factors
0930	Team A "Step" Data Flight	NRC Research Crew NRC Research Pilots
1100	Team A Return & Debrief	NRC Research Crew NRC Research Pilots
	Team B Lunch	
1130	Team B Experiment Load	NRC Research Crew
1200	Team A Lunch	
	Team B Rehearsals	NRC Research Crew Team B Leads

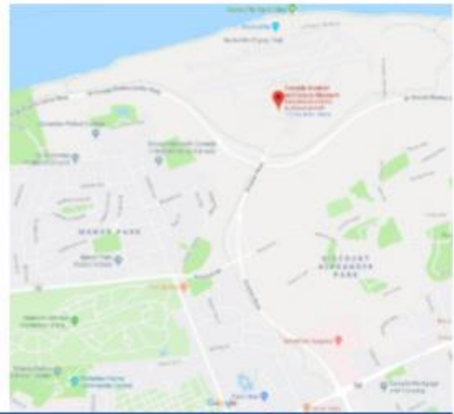
1300	Team B Pre-flight Brief	NRC Research Crew NRC Research Pilots NRC Flight Ops
	Team A De-Instrumentation	NRC Human Factors
	Team A Experiment Work	Team A Leads
1345	Team B "Step" Data Flight	NRC Research Crew NRC Research Pilots
1530	Team B Return & Debrief	NRC Research Crew NRC Research Pilots
1600	Team B Experiment Unload	NRC Research Crew

CAN-RGX
Flight Campaign Itinerary

SEDS-ÉEDS CANADA

Friday 26 July 2019

Location — **Canada Aviation and Space Museum**
11 Aviation Parkway
Ottawa, ON, K1K 2X5



Closing Ceremony

Dress Code — **Business Casual**

Parking — **$4 flat fee after 5 pm**

Time	Program	Speaker
1730	Cocktail Reception	
1800	Welcome	Chris Kitzan (TBC) Director General, CASM
1805	Opening Remarks	Alex Wlodarczyk CAN-RGX PM
	Video message	HE The Rt. Hon. Julie Payette Governor General of Canada
1810	Team Presentations	QDMT
1815		UWR
1820		UVR
1825		MERGE
1830	Dinner Served	
2100	Presentation of Awards and Recognitions	Kristen Côté (TBC) Projects Chair, SEDS
2130	Networking	