Students for the Exploration and Development of Space

SEDS-ÉEDS CANADA

Étudiants pour l'Èxploration et le Développment Spatial

CAN-SBX 2019

SEDS-CANADA CSA

CAN-SBX 2019 Student Handbook

www.seds.ca SEDS-Canada @sedscanada

SEDS-EEDS, 4925 Dufferin St, North York, ON M3H 5T6

INTRODUCTION

Dear Students,

Welcome to CAN-SBX, Canada's first nationwide competition for post-secondary students to design and build a small payload to be flown on board a stratospheric balloon gondola provided by the Canadian Space Agency. The CAN-SBX challenge was conceived to be a real-world opportunity for students to conduct meaningful stratospheric 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 in order 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 this document is 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 the first ever CAN-SBX 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 13 chapters across 4 provinces, and we partner 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 and CAN-SBX, an annual conference, and eventually, competitive grants.

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IMPORTANT CONTACTS

NOTE: For submission of project milestones (Proposal, PDR, CDR, TEDP), e-mail cansbx@seds.ca

Robert Nagle | CAN-SBX Project Manager **|**

robert.nagle@seds.ca | (613)315-7594

Robert holds a Bachelor's degree in Aerospace Engineering from Carleton University with a concentration in Space System Design. Robert is currently a Satellite Communication System Engineer at Honeywell Aerospace, as well as an Executive for the Canadian Space Society, Ottawa Chapter. Robert is also currently pursuing a specialization in RF Engineering through the University of California. As CAN-SBX project manager Robert overseas all activities pertaining CAN-SBX and is dedicated to ensuring a successful flight campaign for all proponents.

Kristen Cote | SEDS-Canada Projects Chair |

kristen.cote@seds.ca | (780) 233-9335

Kristen holds a B.Sc. (Hons) in Astrophysics from the University of Alberta, a M.Sc in Earth and Space Science from York University, and is starting her PhD in Physics at the University of Toronto. Having been involved with many life-changing student projects—like the Ex Alta-1 cube satellite—she is excited to further opportunities for student involvement in Canada's space exploration community as the Project Chair on the SEDS-Canada Board of Directors.

Project Advisors

- **Steeve Montminy**, Systems Engineer, Canadian Space Agency
- **Philippe Vincent**, Payload Integration Officer, Canadian Space Agency

ABBREVIATIONS

CBE — Current Best Estimate

CDR — Critical Design Review

COTS — Commercial-off-the-Shelf

CSA — Canadian Space Agency

EDT — Eastern Daylight Time

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 and Data Package

VAC — Volts of Alternating Current

WBS — Work Breakdown Structure

1. COMPETITION OVERVIEW

1.1. Project Scope

The Canadian Stratospheric Balloon Experiment Design Challenge (CAN-SBX) is a competition for Canadian post-secondary students to design, build and test a small scientific experiment to be flown on board, a stratospheric balloon gondola. The gondola is capable of lifting 250-600 kilograms 30-35 kilometers in the air. This year, the Canadian Space Agency (CSA) campaign will include the two selected CAN-SBX experiments. Undergraduate students from Canadian universities across Canada will be challenged to submit a proposal outlining a payload design in accordance with constraints determined by SEDS-Canada and the CSA. The two experiments selected by judges will be evaluated on several criteria including feasibility of the design, relevance to Canadian stratospheric science, the project's team management structure and the teams' outreach plan. Any student team from a post-secondary academic institution can submit a proposal for their experiment, however only two will have the opportunity to build and test their experiment. Students will be responsible for overseeing the execution of their experiment. The location and date of the flight campaign will be provided by the CSA in the near future. In 2017-2018 the flight campaign was held in Timmins Ontario.

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 the stratosphere. CAN-SBX 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 STEM. 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 who will coach and mentor them throughout the competition as well as the opportunity to participate in an international campaign involving several space agencies.

1.2. Eligibility

All undergraduate students enrolled at recognized post-secondary institutions in Canada are eligible to enter this competition. Students will be required to provide proof of enrolment at the time of submission of the Letter of Intent. Post-graduate students such as those enrolled in Masters, PhD and Post-Doc programs cannot form a team but may join undergraduate teams. The percentage of graduate 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/join).

1.3. Competition Timeline

1.3.1. Selection

Students must adhere to the following timeline and requirements to qualify for the selection process.

- **Friday December 7th 2018, 11:59 p.m. (EST)**: Submit your **Proposal** to cansbx@seds.ca.
- **Friday December 21st 2018**: Teams will be notified of their selection and feedback will be provided by SMEs

1.3.2. Project Milestones

The following documents are required milestones for selected teams. These documents will be evaluated by SMEs throughout the experiment design phases. Specific instructions for submitting these documents can be found in their respective guidelines sections of this handbook. All submissions should be made to cansbx@seds.ca.

- **January 4th 2019, 11:59 p.m. (EST):** Submit a short **Progress Report (PR1)**
- **January 11th 2019:** Progress Meeting
- **February 22nd 2019**: **Preliminary Design Review (PDR)** via teleconference (comments and feedback provided immediately)
- **March 4th 2019, 11:59 PM (EST):** Submit your **PDR** report
- **March 11th 2019:** Pelican cases delivered to teams
- **April 1st 2019, 11:59 PM (EDT):** Submit a short **Progress Report (PR2)**
- **April 8th 2019:** Progress Meeting
- **May 1st 2019, 11:59 PM (EDT):** Submit a short **Progress Report (PR3)**
- **May 8th 2019:** Progress Meeting
- **June 21st 2019**: **Critical Design Review (CDR)** via teleconference (comments and feedback provided immediately)
- **July 1st 2019, 11:59 PM (EDT):** Submit your **CDR** report
- **August 5th 2019:** Deliver experiment hardware
- **August 12th – 30th 2019:** Flight Campaign period
- **September 30th, 11:59 PM (EDT):** Submit your **Post-flight report**

1.4. Formatting Guidelines for Submission of Documents

- Only electronic copies will be accepted
- 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

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 institution. In most cases, the Team Leader also becomes the member of SEDS-Canada.

1.5.4. Team Size

There are no constraints for team size however it is recommended that a team be composed of at least 6 students.

1.5.5. 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 (Appendix 8.2) which is submitted with the Letter of Intent. Teams may have additional faculty advisors (from the primary or any collaborating institutions) as needed. The faculty advisor(s) is required to attend progress meetings via teleconference. It should be noted that faculty advisors cannot become SMEs or project reviewers/judges for the competition.

1.6. Funding Expectations

Selected teams will be encouraged to apply for the CSA FAST grant to cover the cost of travel from their primary institution to Timmins and food/accommodations for up to 6 students for the duration of the campaign. The grant will also cover the experiment's shipping expenses to and from Timmins. The maximum grant value is $30,000 CAD. For the grant to be disbursed, the team's faculty advisor must submit an application to the CSA outlining the expected expenses. **The fast grant is not a guaranteed source of funding. Selected teams will be encouraged to apply for alternative sources of funding. Funding will be discussed further with selected teams and the CSA.**

All other expenses incurred during the development of the experiment, such as building materials and access to tools and lab space, are expected to be covered by the team. Teams are encouraged to acquire funds for their project through fundraising campaigns, college/university grants, and government grants.

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
2. Weigh no more than 12 kg (not including the Pelican case)
3. Constrain its power consumption below 30Wh
4. Be suited for the provided gondola (see Section 1.7.2)
5. SEDS payloads, without transmitting TC/TM, may be plugged in the CSA telemetry system and get time-stamping, GPS location, Real-Time Clock and record data everything onboard. No telemetry transmission instrumentation will be provided, and telemetry bandwidth is limited.

1.7.1. Pelican case

All experiments must be designed to fit into a hard-shell case to ensure the safety of the experiment as well as the gondola. The case is a Pelican product (Pelican Storm iM2275) which will be supplied to the two selected teams by the CSA. The inner dimensions of the case are 35.9 x 33.5 x 25.1 cm. Further details can be found on the Pelican website.

Figure 1: Pelican case for the CAN-SBX experiment.

1.7.2. Gondola

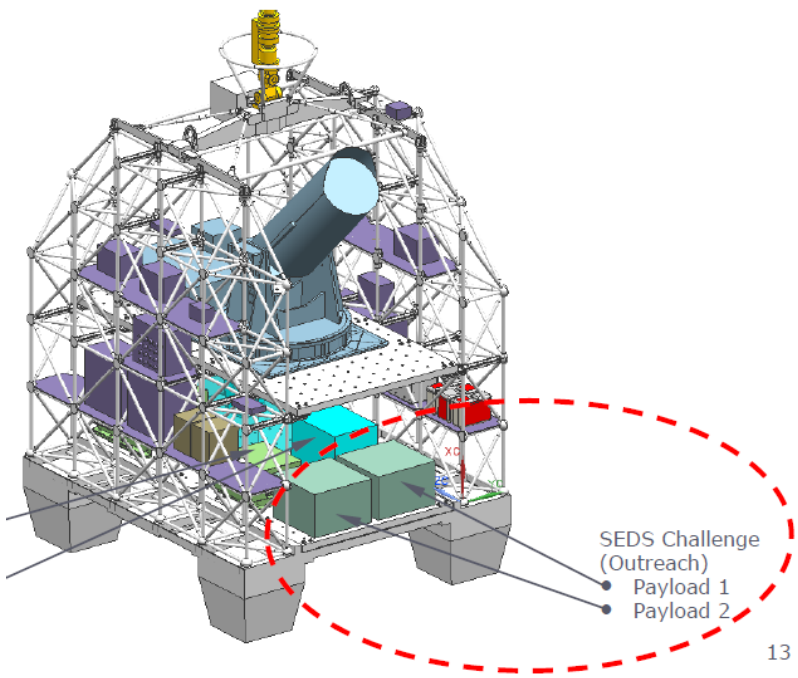


Figure 2: Flight gondola.

The experiments must be designed under the following gondola specifications:

- Non-pointing: orientation cannot be controlled
- Non-insulated: temperature cannot be controlled
- Day phase: flight will occur during daylight hours
- 9-12 hour flight from launch to retrieval
- Multi-altitude flight profile: balloon will reach a ceiling height followed by to-be-determined descents to specific altitudes
- Power: 30Wh of power distributed to each CAN-SBX experiment through circuit lines

- On-board radio communication: CAN-SBX experiments can be controlled through to-be-determined radio frequencies

Note that gondola specification may change depending on availability and other payload requirements. Students will be notified if the gondola specifications change.

1.8. STRATO Science 2019 Campaign Information

1.8.1. Agencies involved

The STRATO Science 2019 Campaign is a collaboration between CNES and the CSA. The flight campaign will take place in August 2019, **exact dates TBD.**

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 the STRATO Science 2018 Campaign. This document will be judged by a panel of SMEs with experience in the field of stratospheric research using balloons and should be written with this audience in mind. Your document must be limited to 20 pages, including appendices. Please read all the requirements to ensure your proposal is reviewed.

NOTE: Proposals which do not meet the experimental constraints outlined in Section 0 will not be reviewed.

2.2. Submission Deadline

Sunday September 30th 2018, 11:59 p.m. (EST)

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 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
   - Experimental design requirements met
   - Scientific value
   - Abbreviated budget and timeline
   - Outline of 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 7 to complete the Risk Assessment Tables for technical and managerial risks, the Work Breakdown Structure, and the Budget and Funding Table.

6) References

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

7) Appendix

   The appendix 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.)

2.4. Proposal Review Criteria

Each submitted proposal will be evaluated and scored according to a standardized rubric for the following criteria (weight in brackets):

Description of Criteria	Marking Scheme
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?).	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.	0 = an experiment with major similarities has been conducted in the past 1 = some literature research was conducted 2 = in-depth literature research is provided leading to the conclusion that the experiment is novel
Relevance of the high altitude	
Describe why the project requires stratospheric altitudes to achieve its scientific objectives. Show that the scientific objectives can be achieved within the flight profile of the balloon	0 = the experiment was not designed for a high altitude environment 1 = reasoning for conducting the experiment in a reduced gravity environment is described but details not elaborated on how experiment will survive a high altitude environment 2 = the experiment is appropriate for up to a high altitude environment
Bonus: Importance to Canada's space sector	
Referring to the Canadian Space Agency's 2018-19 Departmental Plan, 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)
Technical description and feasibility (35%)	
Experimental Design	

Describe how the experiment satisfies each of the CAN-SBX experimental constraints (refer to Section 0). 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 what you intend to measure (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 7.4, 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 high altitude 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 the stratospheric environment (pressure, vibration, temperature, radiation, etc.) will affect the proposed experiment.	0 = no detailed description for any of the variables provided, or the effects of at least one variable is inappropriate/hazardous 1 = a description for each variable is provided but lacking details or appropriate assessment 2 = a detailed description for each variable is provided and no risks are expected
List all components of your experiment classified as hazards under Canada's Hazardous Products Act and specify each hazard. Refer to Section 8	0 = no hazards were specified 1 = some hazards are missing or were not specified according to Canada's Hazardous Products Act and Section 8 2 = all hazards were identified and specified according to Canada's Hazardous Products Act and Section 8
Experimental Procedures	
Describe pre-flight, in-flight and post-flight procedures for proper execution of the experiment. Specify how any moving parts will function throughout these procedures. Include diagrams and/or sketches as needed.	0 = descriptions not provided or inappropriate 1 = descriptions are incomplete or lacking detail 2 = descriptions are well-described for each stage and are appropriate for the balloon's flight profile
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
Technical 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.). Special attention should be given to risks involving hazardous products. Refer to Template in Section 7.1.	0 = the risks are not described or inappropriate/avoidable 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 team members whe executing any tasks during pre-launch and post-flight procedures such as experiment setup and retrieval. Provide mitigation strategies to eliminate (or minimize) risks. Refer to Template in Section 7.1.	0 = the risks are not described or inappropriate/avoidable 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) and how they will be initiated.	0 = no safety mechanisms included 1 = inadequate safety mechanisms or description is lacking detail 2 = well-defined, adequate safety mechanisms which are easily initiated
Project Plan (15%)	
Team Structure and Management	
Following the template provided (see Section 7.2, 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
Demonstrate that team members have a variety of backgrounds. Teams should strive to have discipline diversification throughout their teams (i.e. both scientists and engineers)	0 = no discipline diversity presented 1 = team has some discipline diversity 2 = team has a diverse range of disciplines
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
Project Timeline	
In a table, diagram or Gantt chart, present an expected timeline of the project's development. Include details such as length of time required for building and testing of each sub-system of the experiment, and completion dates of deliverables such as the PDR, CDR and TEDP.	0 = a timeline is not provided 1 = the timeline is inappropriate or lacking details 2 = the timeline is complete and well-defined

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 = no plan provided or the plan is insufficient 1 = some mitigation strategies but no detailed plan provided 2 = details about which team members will lead the scheduling efforts and how each key team member will contribute to staying on schedule were provided
Budget and Funding	
Following the template provided (see Section 7.5 Budget and Funding) include all foreseeable expenses for the entire duration of the project including travel and food, purchase and fabrication of equipment/parts, etc. Describe current and future sources of funding including the duration and amount of this funding (includes potential CSA grant provided to the two selected teams)	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
Managerial Risk Assessment	
Create preliminary risk tables based on the template provided (see Section 7.1). Evaluate each risk based on its probability and its consequences. Provide brief justifications for your assessments.	0 = tables not provided or inappropriate 1 = tables are incomplete or lacking detail 2 = tables are well-elaborated and the level of detail is sufficient. Risks have been justified based on sound reasoning
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 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
Describe how this project will increase interest and retention of talent in space exploration and development in Canada and how it will inspire and encourage youth to pursue studies in STEM fields.	0 = the project will not increase interest and retention of talent or no adequate description was provided 1 = the description is lacking detail 2 = the project's rationale for increasing interest and retention of talent is appropriate and well-described.

3. PRELIMINARY DESIGN REVIEW

3.1 Overview

After your proposal has been reviewed by our panel of judges, and if you score amongst the top two teams, you will be notified to continue with the design process. 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 payload. The PDR presentation will be on or around **February 22nd 2019**, and the PDR Report will be due 10 days later.

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 approximately 10 days to make any necessarily 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 presentation 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 document must be limited to 30 pages, excluding appendices.

3.2 Sections for PDR Document

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

1) Cover page — Include all team information and graphics
2) Table of contents
3) List of figures and tables — 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) Summary of major changes made since submitting the proposal. Include the location (page number, section number, etc.) of these changes (maximum 1 page)
5) 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 team management and outreach plan

6) Introduction

The introduction section of the PDR should be an abbreviated version of the Proposal introduction. Make changes or add details as needed. 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
- A description of your research objectives (what questions do you want to answer?) and how your experiment will address them
- Why your proposed experiment is important to the advancement of space exploration, science and technology

7) Technical Experiment and Procedures

This section should provide the technical details of your experiment, a list of design requirements, and full system specifications. You may use flowcharts and reference the following as appendices: mechanical drawings, electrical schematics, software flowcharts, CAD models, Bill of Materials (BOM)

- Describe how the experiment satisfies each of the experimental constraints (refer to Section 0, Experiment Constraints)
- 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 7.3. 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 results of verification at the PDR level. If one or more of your requirements can only be verified via experimentation, but the test setup was not ready at the time of your PDR submission, then the requirement should be marked as NC until proper testing is conducted at a later time.
- Write complete pre-flight, in-flight and post-flight procedures for proper execution of the experiment with annotated diagrams, and responsibilities assigned to team members
- Include steps to be followed by the team in case of problems with the experiment (electrical or mechanical failure, etc.).

8) Technical Risk Assessment

- From the risks identified in the Proposal, have any been encountered? If so, describe how the mitigation and/or contingency plans were activated, 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 any new risk assessment tables with the same level of detail.

9) Experiment Testing

- Describe any prototypes built to test the experiment, lessons learned, and how those tests have impacted the preliminary design.
- Each team should complete one full cycle of ground test experiments, as you would in the flight, prior to the CDR. 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 Gondola and how that will impact the ground test. This should align with the overall project timeline included in this document.

10) 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 report.

11) Project management update/review

- 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.
- Provide an updated budget and funding plan, including the status of any outstanding grant applications or sponsorships. Describe if the budget from the Proposal is on track or was overestimated or underestimated, supported with justifications. Identify any obstacles encountered which have affected the budget from the Proposal.
- Provide any necessary updates to the Work Breakdown Structure, including new teammates or high school students recruited since the Proposal.

12) References

- Cite all your references using IEEE format.

13) Appendices

3.3 Presentation

Teams will be required to provide a 20-minute presentation (followed by a 40-minute discussion period) to our panel of SMEs and judges via teleconference. You must convince the SMEs that your experiment is compliant with gondola requirements and will not interfere with other experiments on board, so be prepared to answer technical questions. Some of these questions may be related to sections of your PDR report. Please structure the presentation as follows:

- Title slide — Include all team information, and responsibilities of each member
- Introduction
    - 1-2 slides on the topic of research and the proposed experiment
- Experiment design and procedures
    - Full system specifications and diagrams
    - Procedures on pre-flight, flight and post-flight operations, along with team responsibilities.
- Preliminary testing
    - Describe any prototyping 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 7.3)
    - Explain if and why any requirements are not yet fully compliant
- Project management
    - Updated timeline. Highlight the most important milestones completed to date and the remaining tasks to accomplish prior to the CDR.

4. CRITICAL DESIGN REVIEW

4.1 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 the pelican case and the gondola, and testing on a stratospheric balloon. A cycle of ground tests with the assembled experiment (including the Pelican case) is expected at this stage. Comments from judges provided during the PDR stage should also be addressed at this stage.

Like the PDR, the CDR will be presented to SMEs for feedback, and then a final CDR report will be submitted about 10 days later. Comments from judges 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 PDR presentation will be on or around **June 21st 2019**, and the PDR Report will be due 10 days later.

An unsuccessful or incomplete CDR can lead to project cancellation at the discretion of SMEs. Your document must be limited to 50 pages, excluding the appendix

4.2 Sections for CDR Document

1) Cover page - Include all team information and graphics
2) Table of contents
3) Updated list of figures and tables
4) Summary of major changes made since submitting the PDR. Include the location (page number, section number, etc.) of these changes (maximum 1 page)
5) Updated executive summary
    - The executive summary should provide a complete overview of all the sections in the CDR 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.
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)
  - 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.
  - Write complete pre-flight, in-flight and post-flight procedures for proper execution of the experiment with annotated diagrams, and responsibilities assigned to team members. Include steps to be followed by the team in case of problems with the experiment (electrical or mechanical failure, etc.).

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 activated, 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 the experimental tests conducted since submission of the PDR, lessons learned, and how those tests have impacted your final design.
   - Each team should complete at least one full cycle of ground tests with the fully assembled experiment (including the Pelican case), running through all the steps that will be performed during the actual flight, prior to the integration of the experiment assembly with the Gondola.
   - Provide a complete plan for this ground 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 Gondola and how that will impact the results during the actual flight.

10) Plan for data analysis / results interpretation
    - Provide an updated data analysis and interpretation plan. If no changes were made since the PDR, state that the plan has remained the same.

11) Project management update/review

- 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 from the PDR.
- Provide any necessary updates to the Work Breakdown Structure.

12) References

- Cite all your references using IEEE format.

13) Appendices

4.3 Presentation

Teams will be required to provide a 20-minute presentation (followed by a 40-minute discussion period) to our panel of SMEs and judges via teleconference. Some of these questions may be related to sections of your CDR report. You must demonstrate that your design satisfies all the requirements with compelling evidence. Please structure the presentation as follows:

- Title slide — Include all team information and responsibilities of each member
- Introduction
  - 1 slide on research topic and experiment
- Technical Experiment and Procedures
  - Final system specifications and diagrams
  - Procedures on pre-flight, flight and post-flight operations, along with team responsibilities.
- Experiment Testing
  - Briefly describe the setup of the final ground test(s) conducted prior to integration with the Gondola.
  - Describe the results of the test and how they have impacted the final design specified in the CDR report.
- Present a requirement compliance table
  - All requirements are expected to be fully compliant at the CDR stage.
- 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 the Gondola

5. OUTREACH ACTIVITES REPORT

Part of this competition involves inspiring the next generation of STEM leaders, educating youth and the public on stratospheric 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.

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.

The deadline to submit the OAR is **TBD**.

The OAR should include the following:

- Cover page - Include all team information and graphics
- Using the template provided in Section 7.6 for the OAR, complete 1 table per outreach activity conducted.

6. POST-FLIGHT REPORT

The Post-flight report 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.

The Post-flight report will be distributed to the teams after Closing Ceremonies and must be submitted by **September 30th, 11:59 PM (EDT).**

7. TEMPLATES

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

7.1 Risk Assessment Tables

Create a risk table for each technical risk (TR#) and management risk (MR#), describing what the risk is, its probability and consequence with associated rankings (Low, Medium or High), and a mitigation and contingency plan.

List all risks (TR1, MR1, etc.) in the Risk Assessment Matrix (Table 2).

Table 1: Risk table.

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	
Contingency Plan	Describe plan in case risk occurs	

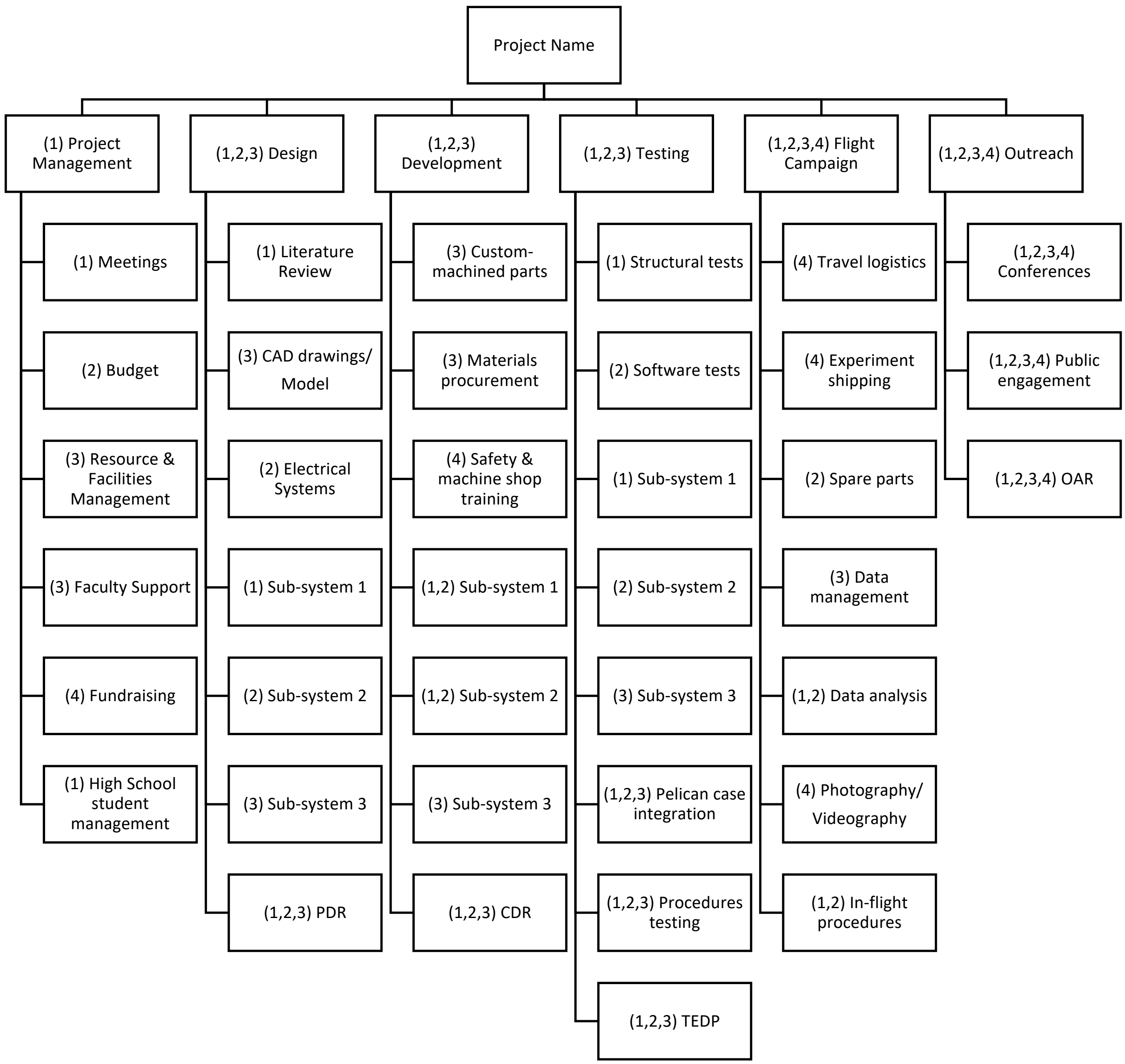
Table 2: Risk assessment matrix.

		Probability		
		Low	Medium	High
Consequence	Low			
	Medium			
	High			

7.2 Work Breakdown Structure

The work breakdown should follow (but should not be limited to) the general scheme outlined below and should comprise your entire project from start to finish. 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.

Example:



Legend: (1)=Student 1 name, (2)=Student 2 name, (3)=Student 3 name, (4)=Student 4 name

7.3 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.

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 3: 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	Experiment was measured on a scale prior to integration.	X			
	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 (See Section 1.7.1)	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	T/I	-	X			Some internal parts have their own

		below 600W.						regulated power supply.
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 12 parabolas per cycle) were conducted on the ground to verify proper functionality.	X			

7.4 Mass and Power Budgets

The following is 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 (SolidEdge, Pro-Engineer, etc.)

M1 = Taken from a manufacturer spec sheet

M2 = Measured using a scale

Table 4: 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		
Three-Axis Manipulator	M0	1	2.00	2.00		
Support Brackets	M2	5	0.20	1.00		
Experiment Components			**Subtotal**	**5.00**	**29%**	
Sealed Liquid Water Tank	M2	2	2.00	4.00		
High-Speed Camera	M1	1	0.50	1.00		
Power Systems			**Subtotal**	**0.85**	**5%**	
Batteries	M2	4	0.10	0.40		
9V Power Adapters	M2	3	0.05	0.15		
Power Bar	M2	1	0.30	0.30		
Data Handling			**Subtotal**	**1.10**	**6%**	
Data Logger	M2	1	0.50	0.50		
Tablet	M2	1	0.60	0.60		
Electronics			**Subtotal**	**0.50**	**3%**	
Arduino UNO	M0	1	0.10	0.10		
Inertial Measurement Unit	M0	1	0.40	0.40		
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 may use the table below as a template for your power budget.

Table 5: Example power budget.

Component	Power Consumption [W]	Qty.	Experiment Operational Mode			
			Idle		Science	
			Average [W]	Duty Cycle	Average [W]	Duty Cycle
RF Module	0.17	4	0.00	0%	0.68	100%
Tablet	10.00	1	10.00	100%	10.00	100%
Robotic Manipulator	20.00	1	0.00	0%	20.00	100%
Microcontroller	5.00	2	5.00	50%	10.00	100%
Power Used [W]			**15.00**	**-**	**40.68**	**-**
Power Available [W]			**50**	**-**	**50**	**-**
Margin [%]			**70%**	**-**	**19%**	**-**

7.5 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 in order to estimate total available funds and determine the overall project budget. Include as many details as possible.

Table 6: Budget and funding plan.

Estimated Expenses					
	Project Tasks	**Labour Cost ($)**	**Material Cost ($)**	**Travel Cost ($)**	**Other Costs ($)**
Project Management	Meetings				
	Resource & Facilities Management				
	High school student management				
	Fundraising				
	Subtotal				
Design	CAD drawings/Model				
	Prototype				
	Electrical systems				
	Sub-system 1				
	Sub-system 2				
	Sub-system 3				
	Subtotal				
Development	Custom-machined parts				
	Materials and Tools				
	Machine shop training				
	Sub-system 1				
	Sub-system 2				
	Sub-system 3				
	Subtotal				
Testing	Structural tests				
	Software tests				
	Sub-system 1				
	Sub-system 2				
	Sub-system 3				
	Pelican case integration				

	Procedures testing				
	Subtotal				
Flight Campaign	Travel to/from FRL				
	Meals				
	Experiment shipping				
	Spare parts				
	Data collection and management				
	Data analysis				
	Photography/videography				
	In-flight procedures				
	Subtotal				
Outreach	Conferences				
	Public engagement				
	Subtotal				
Other Costs	Other costs				
	Other costs				
	Other costs				
	Subtotal				
Subtotals					
Subtotal With 15% Margin					
Total (Estimated)					
Estimated Funding					
		Value ($)			
Funding **Sources**	University/College Grants				
	Government Grants				
	Corporate Sponsorships				
	Fundraising Campaigns				
	Other				
Subtotal					
Subtotal with 15% Margin					
Total (Estimated)					
Deficit/Overture (Funding – Costs)					

7.6 Outreach Activities Report

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.

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.

Table 7: Outreach activities report.

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. Appendices

8.1 Physical 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 probably 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.

8.2 Faculty Endorsement Letter

Students for the Exploration and Development of Space

SEDS-ÉEDS CANADA

Étudiants pour l'Exploration et le Développement Spatial

Canadian Stratospheric Balloon Experiment Design Challenge (CAN-SBX)

Letter of Endorsement

To SEDS-Canada,

This letter is to certify that I, ______________________________, will serve as Faculty Advisor to Team ______________________________, and 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. I understand that I may also be asked to participate in progress meetings with the team and SEDS-Canada.

Faculty Advisor Signature: ______________________________ Date: __________

Faculty Advisor Information

Name: ______________________________

E-mail: ______________________________

Affiliation/Department: ______________________________

Is this the primary Faculty Advisor? □ Yes □ No

Team Information

Team Name: ______________________________

Leader Name: ______________________________

Leader E-mail: ______________________________

Affiliation/Department: ______________________________