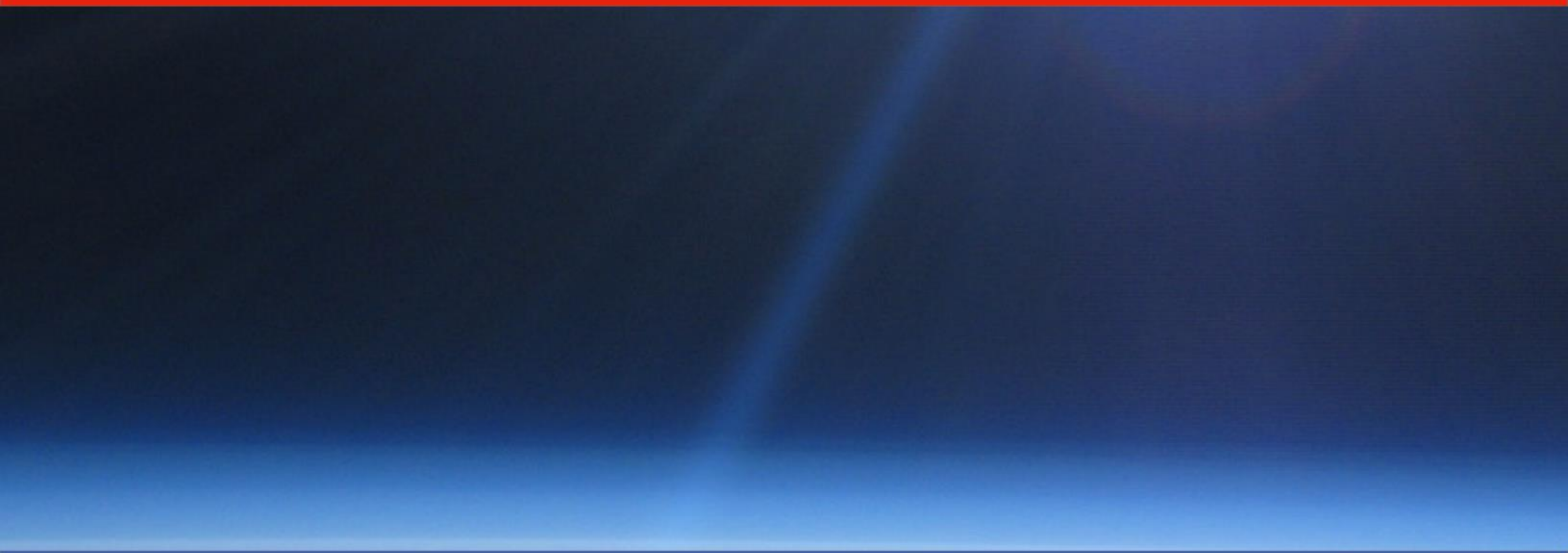
Students for the Exploration and Development of Space

SEDS-ÉEDS CANADA

Étudiants pour l'Èxploration et le Développment Spatial



Canadian Stratospheric Balloon Experiment (CAN-SBX)
Design Challenge Handbook

Visit **seds.ca/projects/can-sbx** for more information

www.seds.ca SEDS-Canada @sedscanada

INTRODUCTION

Dear Students,

Welcome to CAN-SBX, Canada's only national competition for post-secondary students to design and build a small payload to be flown onboard a stratospheric balloon 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 to responsibly advance humankind's presence in space.

In this handbook, you will find information about the 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, we encourage you to contact the organizers, listed under 'Important Contacts', for further details. We look forward to seeing you at the CAN-SBX campaign!

— 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 that 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 and CAN-SBX, an annual conference, and eventually, competitive grants.

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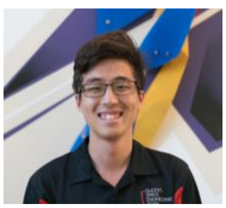
IMPORTANT CONTACTS

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

Ilija Hristovski | CAN-SBX Project Manager **|**

ilija.hristovski@seds.ca | (778) 821-1724

Ilija holds a Bachelor of Applied Science Degree majoring in Electrical Engineering from the University of British Columbia's Okanagan campus (UBC). He is currently enrolled in a Master's degree in electrical engineering and is on his way to fast-tracking to his PhD. His current and future research focuses on developing optical structures for efficient and secure free-space optical ground-to-satellite, satellite-to-satellite, and satellite-to-deep-space communication links. As project manager, Ilija oversees all activities pertaining to the CAN-SBX campaign.



James Xie | CAN-SBX Asst. Project Manager **|**

james.xie@seds.ca | (613) 217-8064

James has a Bachelor of Applied Science in Engineering Chemistry from Queen's University. He is now working as a consultant for Stroud International in Calgary, specializing in process optimization. James is interested in astrobiology and space advocacy, and has worked on payloads on-board nano-satellites and rovers for the Canadian Satellite Design Challenge and University Rover Challenges. As assistant CAN-SBX project manager, James will be involved with all activities associated with the campaign.

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

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 advisor Robert aids planning of CAN-SBX.

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, an M.Sc in Earth and Space Science from York University, and is currently studying towards 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 Projects Chair on the SEDS-Canada Board of Directors. As Projects Chair, Kristen oversees all SEDS-Canada projects.

Project Advisors

- **Steeve Montminy**, Manager, Suborbital Demonstration, Canadian Space Agency
- **Philippe Vincent**, Payload Integration Officer, Canadian Space Agency
- **Sebastien Lafrance**, Systems Engineer, Canadian Space Agency
- **Martin LaFlamme**, Engineer, Power Electronics, 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

EST — Eastern Standard 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

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 onboard a high-altitude balloon at up to 30 km in altitude. Post-secondary students from Canadian universities are challenged to submit a proposal of their payload design in accordance with constraints set by the Canadian Space Agency (CSA) and SEDS-Canada. Experiments will be evaluated by the CSA on several criteria including the feasibility of the design, relevance to Canadian stratospheric science, the team's management structure and the team's outreach plan. Any student team from a post-secondary academic institution can submit a proposal for their experiment, and the top teams will have the opportunity to build and launch their experiment. Students will be responsible for overseeing the execution of their experiment. The location and date of the flight campaign will be confirmed by the CSA in the near future, but will most likely occur at the CSA headquarters in Longueuil, Quebec. The 2018-2019 flight campaign was held in August in Timmins, Ontario as part of the CSA/CNES STRATOS project.

SEDS-Canada and its collaborators developed this initiative to benefit students who are passionate about space exploration by providing access to a platform to perform ground-breaking research in the stratosphere. CAN-SBX trains students to complete a full engineering design cycle from conception to execution and is a valuable opportunity to gain transferable professional skills applicable to careers in the Canadian space industry. Student teams will gain project management and risk mitigation skills which are critical for 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, and gain unique experience through operating a mission with the CSA.

New for 2019-2020: For the previous two iterations of the CAN-SBX Design Challenges, student teams designed and tested experiments for a CNES gondola, as part of the STRATOS partnership between the CSA and CNES. This year, student teams will help the CSA demonstrate the agency's individual high-altitude balloon launch capabilities. These launches will be on a smaller scale, so students will have to design payloads that are both compact and lightweight, which may be challenging for certain applications. The launch campaign will involve students in launch operations and payload recovery, so that students will be experienced enough to <u>tangibly lead balloon launches from their home institutions!</u>

Note: This document is currently missing detailed information about the PDR, CDR, and Flight Report document requirements. The handbook will be updated as soon as possible.

1.2. Eligibility

Any undergraduate student enrolled at recognized post-secondary institutions in Canada is eligible to enter this competition. **Students are required to provide proof of enrolment at the time of submission of the proposal.** Graduate students such as those enrolled in Masters, PhD, and Postdoc 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). Teams must obtain a Faculty Advisor, and must submit a Letter of Endorsement at either the Notice of Intent or Proposal stages (see Section 1.5.5).

1.3. Competition Timeline

1.3.1. Selection Process

Students must adhere to the following timeline and requirements to qualify for the selection process. All submissions should be emailed to cansbx@seds.ca (unless otherwise noted).

- **Monday October 14th 2019, 11:59 p.m. (EST)**: Submit your **Notice of Intent** online

  (see the SEDS-Canada webpage for the link to the Notice of Intent submission form, or access it directly here)

- **Monday December 2nd 2019, 11:59 p.m. (EST)**: Submit your **Proposal**
- **Monday December 18thth 2019**: Teams will be notified of their selection and feedback will be provided by SMEs

1.3.2. Project Milestones

Some of the following milestones include documents that must be submitted by the selected teams. These documents will be evaluated by subject matter experts (SMEs) from the CSA throughout the experiment design phases. Specific instructions for submitting these documents can be found in their respective guidelines sections of this handbook. **A checklist of all expected deliverables (once selected for the CAN-SBX competition) can be found in Section 8.** All submissions should be emailed to cansbx@seds.ca.

- **Monday January 13th 2019:** Meeting with Faculty Advisor
- **Monday February 10th 2020, 12 noon (EST):** Submit a short Progress Presentation (PP1)
- **Thursday February 13th 2020:** Progress Meeting with Experiment Requirement Review via teleconference (comments and feedback provided immediately)
- **Monday March 16th 2020**: **Preliminary Design Review (PDR)** via teleconference (comments and feedback provided immediately)

- **Wednesday March 25th 2020, 11:59 PM (EST):** Submit **PDR** report
- **Monday May 11th 2020, 12 noon (EDT):** Submit a short Progress Presentation (PP2)
- **Thursday May 14th 2020:** Progress Meeting
- **Monday June 29th 2020**: **Critical Design Review (CDR)** via teleconference (comments and feedback provided immediately)
- **Wednesday July 8th 2020, 11:59 PM (EDT):** Submit **CDR** report & draft Flight Report
- **July 29th, 2020, 23:59 (EDT):** Submit **Flight Report** & **Outreach Activities Report**
- **August 3rd – 14th 2020:** Flight Campaign period
- **September 30th, 11:59 PM (EDT):** Submit **Post-flight Report & Survey**

1.4. Formatting Guidelines for Submission of Documents

- Only electronic copies will be accepted
- Standard 8 ½" x 11" pages
- Submitted to cansbx@seds.ca
- 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 that 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. The team leader must be enrolled at the team's primary institution. In most cases, the Team Leader also becomes a 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 at least one faculty member from their primary institution to act as their team's advisor. The faculty advisor(s) must complete a Faculty Letter of Endorsement (Appendix A.2) to be submitted with the Notice of Intent or Proposal. Teams may have additional faculty advisors (from the primary or any collaborating institutions) as needed. The faculty advisor(s) is/are required to attend progress meetings via teleconference. Faculty advisors cannot become SMEs or project reviewers/judges for the competition.

1.6. Funding Expectations

Funding for the CAN-SBX project is not guaranteed. Student teams should not expect funding or support and should exhaust all existing routes to fund their experiments (e.g. Student Union grants, University-based travel grants, partnerships with industry specific to their project, crowd-funding campaigns, etc.) All 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.

Please contact cansbx@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 self-contained (i.e. an enclosure must be designed)
2. Weigh no more than 3 kg (including enclosure, power, & thermal protection)
3. Be self-powered (using batteries)

There will be no telemetry capabilities provided by the CSA. Teams who wish to communicate with their experiment must have a communication system within their own payload, meeting the above experiment constraints (i.e. the payload must still weigh under 3 kg).

1.7.1. Experiment Enclosure

Enclosures for small-scale high-altitude balloon missions are typically made out of high-density styrofoam. Not only is styrofoam easy to manipulate (e.g. you can cut out windows for sensors, among other things), it is also lightweight, inexpensive, and buoyant. Figure 1 shows example experiment enclosures, including one from a NASA high-altitude balloon mission (middle).

Figure 1: Example experiment enclosures.

1.7.2. Flight Constraints

The experiments must be designed under the following flight constraints:

- Non-pointing: orientation cannot be controlled
- Non-insulated: temperature cannot be controlled
- Flight can occur during daylight or nighttime (can be specified as a requirement in the proposal)
- ~3 hour flight
- Up to 30 km altitude
- Flight profile: balloon will reach ceiling height and burst
- No power is supplied to payloads
- Communication is not facilitated by the CSA

Flight train, launch and related services, and recovery will be provided by the CSA.

1.7.3. Flight Campaign

Although the launch of these high-altitude balloons will be facilitated by the CSA, the goal of this year's CAN-SBX project is to train students as Highly Qualified Personnel (HQP), such that student teams will be able to launch their own high-altitude balloons in the future. As such, students will have the opportunity to participate in the launch and recovery efforts during this year's flight campaign. More information on the tasks required for these roles will be specified at a later date.

2. PROJECT PROPOSAL

2.1. Overview

The project proposal is the first of three technical documents that must be submitted. 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 1.7 will not be reviewed.

2.2. Submission Deadline

Monday December 2nd 2019, 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

     Clearly indicate the need for your experiment to fly to the stratosphere!

   - 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 10 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 the 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 2019-20 Departmental Plan, describe how the proposed project fits within Canada's current planned results (referred to 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 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 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 10, 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 A.1 .	0 = no hazards were specified 1 = some hazards are missing or were not specified according to Canada's Hazardous Products Act and Section A.1

	2 = all hazards were identified and specified according to Canada's Hazardous Products Act and Section A.1
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 10.1.	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 when 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 10.1.	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 10.2, 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
A team member has been identified as an Outreach Lead in the Work Breakdown Structure.	0 = no Outreach Lead is identified 1 = an Outreach Lead is identified
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 and CDR.	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 10.5 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.	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 10.1). 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. PROGRESS PRESENTATIONS

3.1. Overview

The progress presentations are a chance to check-in with teams before major milestones and provide an opportunity for feedback, asking questions, raising concerns, and practicing presentation skills. While this is not a formal milestone, teams are expected to be professional in their presentations. This is a great chance to receive help and engage with SMEs; we are all here to help you towards a successful design!

Although the presentation can be created in your favourite presentation software (PowerPoint, Keynote, Beamer, etc.) slides should be submitted to cansbx@seds.ca as a PDF. Presentations will be kept to a strict 20 minutes, with 30 minutes at the end for questions. The presentations will be held via teleconference with CSA advisors and the SEDS team using the Cisco Webex platform. Please arrive in the teleconference at least 5 minutes before your scheduled time and have your slides ready to begin.

3.2. Presentation Content

As progress over the development cycle will be unique to each team, there is no strict requirement for content. The report, however, should reflect any work that has been completed since the last milestone, 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 (including an updated timeline) and an update on the budget and funding plan. Questions and concerns (both logistical and technical) are encouraged and should be brought up here before the major milestones. If for your team, a topic is not relevant to the progress meeting, it should be explicitly stated with a rationale.

4. PRELIMINARY DESIGN REVIEW

We are reducing the amount of paperwork needed from student teams by working with the Canadian Space Agency to synergize our PDR, CDR, and Flight Report with their documentation requirements. **The requirements for PDR will be updated once this process is completed.**

5. CRITICAL DESIGN REVIEW

We are reducing the amount of paperwork needed from student teams by working with the Canadian Space Agency to synergize our PDR, CDR, and Flight Report with their documentation requirements. **The requirements for CDR will be updated once this process is completed.**

6. FLIGHT REPORT

We are reducing the amount of paperwork needed from student teams by working with the Canadian Space Agency to synergize our PDR, CDR, and Flight Report with their documentation requirements. **The requirements for the Flight Report will be updated once this process is completed.**

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.

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 Record

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

Table 1: Outreach activities record.

<table>
<tr><th colspan="3">Activities</th></tr>
<tr><td>Location(s) of activity</td><td colspan="2"></td></tr>
<tr><td>Dates(s) of activity</td><td colspan="2"></td></tr>
<tr><td>Names and roles of team members involved in this activity.</td><td colspan="2"></td></tr>
<tr><td>Were these activities part of a larger event? If so, please provide a name and brief description.</td><td colspan="2"></td></tr>
<tr><td>Was this activity related to your project? (Y/N)</td><td colspan="2"></td></tr>
<tr><td>Was this activity included in your Outreach Plan in the Proposal? (Y/N)</td><td colspan="2"></td></tr>
<tr><th colspan="3">Audience</th></tr>
<tr><td>Educational level</td><td></td><td></td></tr>
<tr><td>K-4</td><td></td><td></td></tr>
<tr><td>5-8</td><td></td><td></td></tr>
<tr><td>9-12</td><td></td><td></td></tr>
<tr><td>Post-secondary</td><td></td><td></td></tr>
<tr><td>Educator</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
<tr><th colspan="3">Summary</th></tr>
<tr><td colspan="3">Describe the activities conducted at the event.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Describe any feedback you received from the audience or organizers.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Describe any challenges faced while planning or executing the activities.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Would you repeat these activities? Justify why or why not. Suggest any improvements.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

8. DELIVERABLE CHECKLIST

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

- ❑ Progress Report 1
- ❑ Preliminary Design Review (PDR) Presentation
- ❑ PDR Report
- ❑ Progress Report 2
- ❑ Progress Report 3
- ❑ Critical Design Review (CDR) Presentation
- ❑ CDR Report
- ❑ Outreach Activities Report
    - ❑ Pictures/video for social media
- ❑ Flight Report
- ❑ Post-flight Report & Survey

9. POST-FLIGHT REPORT & SURVEY

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

- Were your experiment objectives met? Explain why or why not?
- What results were obtained from the data collected? Was the data expected or unexpected? Explain.
- What changes would you make to the CAN-SBX competition?

The Post-flight report & survey must be submitted by **September 30th, 11:59 PM (EDT).**

10. TEMPLATES

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

10.1. 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 3).

Table 2: 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	

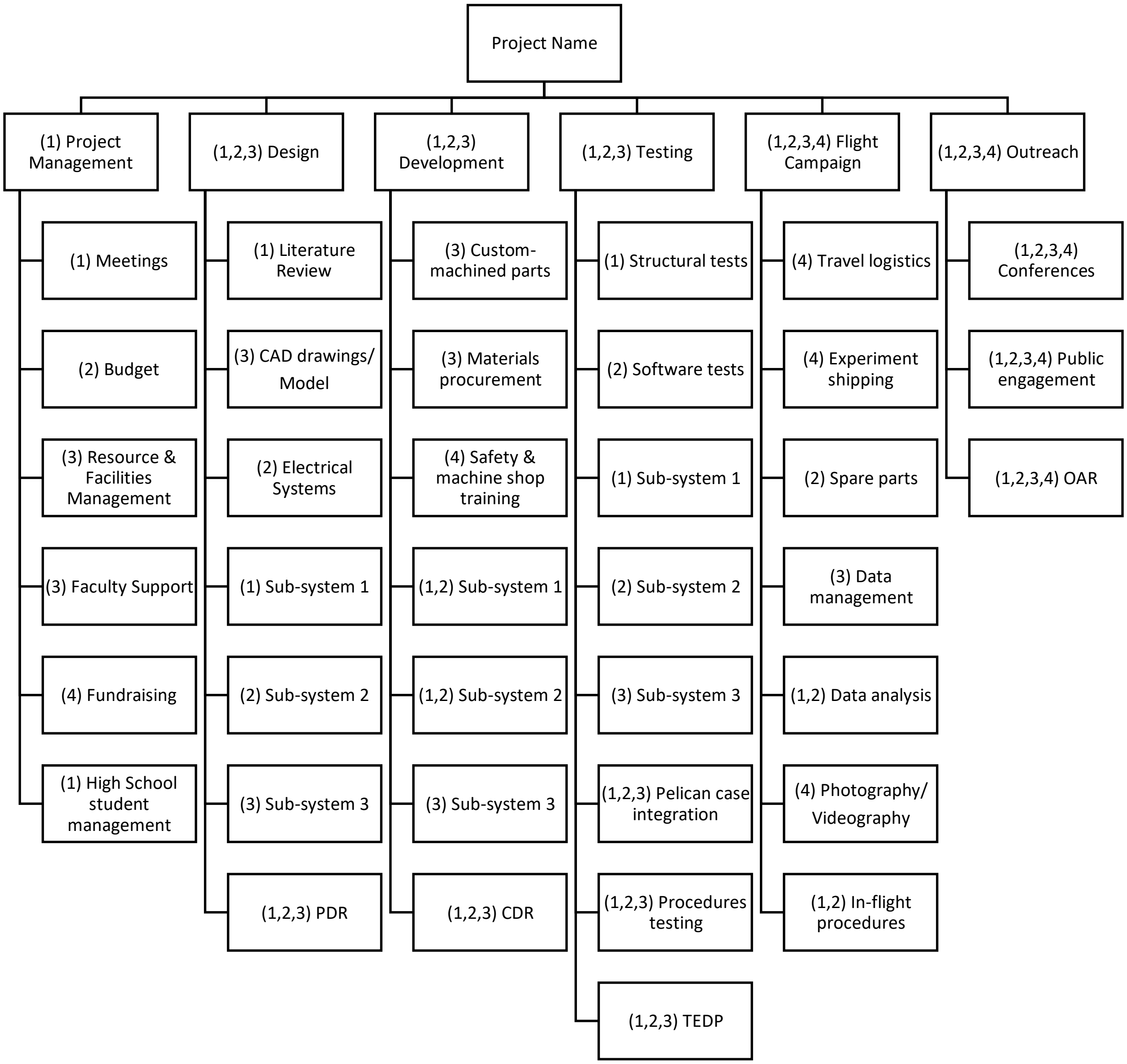
Table 3: Risk assessment matrix.

		Probability		
		Low	Medium	High
Consequence	Low			
	Medium			
	High			

10.2. 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

10.3. 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 4: Example requirement verification & compliance matrix.

Category	N	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 below 600W.	T/I	-	X			Some internal parts have their own 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			

10.4. 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

You may use Table 6 as a template for your power budget.

Table 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		
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%**	**-**

Table 6: 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%**	**-**

10.5. 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 7: Budget and funding plan.

Estimated Expenses					
Project Management	**Project Tasks**	**Labour Cost ($)**	**Material Cost ($)**	**Travel Cost ($)**	**Other Costs ($)**
	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 Quebec				
	Meals				
	Experiment shipping				
	Spare parts				
	Data collection and management				
	Data analysis				
	Photography/video				
	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)		

APPENDICIES

A.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, 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 the 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 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 onto 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.

A.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, ________________________________, w ill serve as Faculty Advisor to Team ________________________________, a nd 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: ____

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