INTRODUCTION

Dear Students,

Welcome to the Canadian Analog Research Expedition (CAN-ARX), Canada's only competition for post-secondary students to design an experiment for Canada's regions analogous to space. The CAN-ARX challenge was designed to be a real-world opportunity for students to conduct meaningful scientific research in Canada's remote areas.

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 intended to be comprehensive, you are encouraged to contact the organizers, listed under 'Important Contacts', for further details. We look forward to your participation in this year's CAN-ARX 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 students from all across Canada, 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, CAN-SBX, the Young Space Entrepreneurs (YSpacE) competition, an annual conference, and eventually, competitive grants.

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IMPORTANT CONTACTS

NOTE: For submission of proposals, questions about the competition, etc. e-mail:

canarx@seds.ca

Ricky Wang | CAN-ARX Project Manager | ricky.wang@seds.ca

Ricky is currently a recent Mechanical Engineering graduate from the University of Waterloo with an option in Management Sciences. He has strong passions involving the aerospace and energy sectors, with experience ranging from design, manufacturing, project management, and more. He also has his private and glider pilot's licence! Ricky is currently working as a thermal/fire engineer in Vancouver.

Amanda Spilkin | CAN-ARX Asst. Project Manager | amanda.spilkin@seds.ca

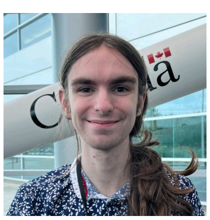
Amanda is currently pursuing her PhD in Mechanical Engineering at Concordia University. She founded the Space Health Division at ConcordiaU in 2019.

Ahmad Khan | CAN-ARX Asst. Project Manager | ahmad.khan@seds.ca

Ahmad is a BSc in Mathematics major with a minor in Criminology entering his second year at the Wilfrid Laurier University Waterloo Campus.

Connor McNeill | Projects Chair | connor.mcneill@seds.ca

Connor is currently a 3rd year Mechanical Engineering student at the University of Alberta. He is very interested in developing the aerospace industry in Canada and Alberta. His experience includes participating in CAN-RGX during the 2023 flight campaign, building a go kart and leading the mechanical design of an imager payload for AlbertaSat's third satellite!



Cici Hall | Projects Director at Large | cici.hall@seds.ca

Cici is currently studying Aerospace Engineering and Management Sciences at Toronto Metropolitan University. They have extensive experience with managing large space-based projects and teams, particularly as the former Events Chair of SEDS Canada and as the Principal Investigator for the European Space Agency's "Fly a Rocket!" programme.

Project Advisors & Subject Matter Experts

- **Roxy Fournier, Postdoctoral Fellow, Schlegel-UW Research Institute for Aging**

  Roxy studies astronaut physiology and develops countermeasures to improve crew health in space. Her background is in bone biology and her doctoral dissertation characterized the behaviour of bone cells in different environments, including simulated microgravity. She loves learning new languages, exploring new places, and long-distance running.

- **Justin Quan, Engineering Analyst, Environment & Climate Change Canada / Associate Director, Save The Water**

  Justin Quan is an Engineering Analyst at Environment & Climate Change Canada where he specialises in energy and emissions modelling, technology assessment, and engineering analysis of clean energy technologies for the decarbonisation of Canadian oil and gas. Justin is also the Associate Director of Research & Engineering at Save The Water, an American environmental non-profit organisation focused on addressing water pollution. He holds degrees in Chemical Engineering and Biochemistry from the University of Ottawa, as well as certificates from Cornell University, Google, the University System of Georgia, and Energy Safety Canada.

- **Alexandre Rivard, B.Eng., Medical Student at Université de Montréal, Delegate of Living Lab de Charlevoix**

  Alexandre started as a mechanical engineering student geeking about aeronautic and space technologies and ended up being the Team Leader of the Groupe Aérospatial de l'Université Laval that built and launched rockets in the context of the ESRA's Intercollegiate Rocket Engineering Competition. After Alexandre's Bachelor's, his interest shifted towards medical studies and rural challenges, studying medicine at UdeM. Alexandre has also been working with the Living Lab de Charlevoix for the past two years and is very excited to be a part of the CAN-ARX project.

ABBREVIATIONS

EDT — Eastern Daylight Time

EST — Eastern Standard Time

MSDS — Material Safety Data Sheet

OAR — Outreach Activities Report

PI — Principal Investigator

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

WBS — Work Breakdown Structure

1. COMPETITION OVERVIEW

1.1. Statement on Inclusivity & Accessibility

SEDS-Canada is committed to creating an environment that is inclusive and equitable of all persons and treats all members of the community in an equitable manner. As part of this commitment, SEDS-Canada strives to provide support for, and facilitate the accommodation of all students/applicants regardless of race, ethnic group, nationality, socioeconomic status, sex, gender identity, gender expression, sexual orientation, ability, language, religious affiliation, or age. On a case-by-case basis, and to the best of our ability, we will try to accommodate individuals with different abilities. If you believe there may be an accessibility issue, please contact canarx@seds.ca with your concerns.

In CAN-ARX, SEDS-Canada is committed to creating a safe, welcoming, and inclusive environment that supports learning, research activities, and community outreach/engagement with a broad nationwide reach, specifically within remote communities in Canada.

1.2. Project Scope

The Canadian Analog Research Expedition (CAN-ARX) is a competition for Canadian post-secondary students to test an experiment in an analog of the Canadian landscape in collaboration with LivingLab Charlevoix. For the first time in Canada, student teams will operate a full research project relating to remote conditions from design to execution, starting with a proposal outlining their scientific goals, project feasibility, and management plan. A major component of the CAN-ARX challenge will be to build connections with the scientific community and public living near the research and expedition sites, along with properly executing and conducting their project research. As such, SEDS-Canada will guide student teams towards the successful completion of several outreach initiatives throughout the competition timeline and during the expedition itself. Additionally, students will gain experience in planning and executing a research project requiring extra logistics inherent to remote analog area research. Subject Matter Experts (SMEs) in areas such as planetary science, instrumentation, and analogue testing will act as mentors throughout the competition and provide valuable feedback at major project milestones. These technical field skills and opportunities to network with industry professionals are often lacking in course-based educational institutions. Yet, they are critical for the future space industry workforce, as many space operations require expertise in handling extreme and remote environments. SEDS-Canada is pleased to contribute to the development of Canada's next generation of space industry leaders with the introduction of the CAN-ARX challenge.

There is a vast amount of science one can do in a remote analog environment, but CAN-ARX focuses on four key subject areas. These are:

planetary science (incl. astrobiology, remote sensing)
atmospheric science
resource utilization & food production
remote healthcare

Within each of these broad subjects, projects can be either **science-based** (i.e. utilizing an instrument, or doing fundamental science) or **engineering-based** (designing and testing an instrument, tool, or mechanism). Projects that involve an engineering component, e.g. designing and testing an instrument or system, will fall under the engineering category, while projects that involve fundamental research, e.g. geological studies, will fall under science. This distinction has to be made in order to effectively evaluate science and engineering project proposals against each other (since they typically involve *different* types of work and preparation). Most notably, engineering projects will include the development of a novel technology while a science project may use existing or commercial components (if needed). One project may fall into two or more categories; please choose the category that is most closely related to your project. If you need help categorizing your project, please email canarx@seds.ca.

1.3. Example Projects

The following sections have brief examples of possible projects for each subject area. Note that some may overlap with more than one category. All proposed projects should have implications for future space exploration, i.e. must be motivated by an existing need in current space research. For example, if you want to field-test an instrument that detects atmospheric composition, it must have some application in space/planetary science. The following projects are color coded by science (in blue) and engineering (in green) subcategories.

1.3.1. Planetary Science

- Collection and testing of extremophiles from a lake or stream
- Collecting samples near the research station to explore the geological history of the area and how it relates to future space missions
- Field-testing a novel imaging spectroscopy technique using a commercial instrument
- Field-testing a novel, team-built instrument for future space exploration (e.g. something similar to current Mars rover/lander instruments; seismometer, chemical composition detector, specific rover parts, etc.)

- Perform remote sensing over the field site to detect e.g. mineral types, soil moisture content, water ice using a commercial sensor
- Perform remote sensing over the field site to detect e.g. mineral types, soil moisture content, water ice using a novel, team-built sensor

1.3.2. Atmospheric Science

- Field-testing a novel, team-built instrument that detects atmospheric composition
- Collecting atmospheric composition samples

1.3.3. Resource utilization & food production

- Testing a novel, team-built greenhouse component for Martian/Lunar environments
- Collecting soil samples near the station & analyzing them for greenhouse use

1.3.4. Remote Healthcare

Special attention will be paid to healthcare projects as LivingLab Charlevoix is mainly a health research facility.

- Testing commercial biomonitoring equipment in and around the field site (e.g. does it perform well in cold remote areas)
- Testing novel biomonitoring equipment in and around the field site (e.g. does it perform well in cold remote areas)
- Testing a device and/or software application related to remote healthcare
- Testing a device and/or software application related to remote healthcare
- Field-testing novel spacesuit hardware on a human subject
- Human exploration mission operations in healthcare and/or medicine (e.g. human physiology, communications, mission planning)
- Field-testing geological sample collection methods (including studies looking at future human space exploration, e.g. how do you effectively collect samples with big gloves)
- Expedition testing applications and/or experiments with rural medicine
- Data collection and analysis of emergency health technologies, such as monitors, or extractions

1.4. 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 enrollment at the time of submission of the proposal.** The percentage of graduate students (i.e. students enrolled in Masters, PhD programs) per team must not exceed 34%. At least one member of your team must be/become a member of SEDS-Canada (see seds.ca/membership/).

1.4.1. Health Awareness

Students will be expected to participate in activities requiring moderate physical fitness, such as hiking over uneven terrain while carrying gear. Although the expedition is set to take place during the summer and fall season, daily temperatures may be below freezing and all successful participants will be expected to participate in all excursions. Medical questionnaires will be requested closer to the expedition date. SEDS-Canada is committed to the accessibility and inclusivity of this project (see Section 1.1) and will make accommodations when necessary.

1.5. Competition Timeline

The competition timeline is **subject to change**. The exact deadlines will depend on the expedition dates, and will be adjusted when the expedition dates have been finalized. Please check the CAN-ARX website for latest details, or email canarx@seds.ca for any questions.

1.5.1. Selection

Students must adhere to the following timeline and requirements to qualify for the selection process. All submissions should be made to canarx@seds.ca.

- **Sunday, October 8, 2023 at 11:59 p.m. (EST)**: Submit your **Proposal**
- **Monday November 13, 2023**: Teams will be notified of their selection and feedback will be provided by SMEs

1.5.2. Project Milestones

The following are required milestones for selected teams. Note that all dates are approximate and may change without notice (check seds.ca/can-arx for the most up-to-date timeline). Requested documents will be evaluated by SMEs throughout project design phases. Specific instructions for submitting these documents can be found in their respective guideline sections of this handbook. All submissions should be made to canarx@seds.ca.

- **Thursday, November 16, 2023: CAN-ARX Kick-off Meeting**
- **Week of March 11, 2024:** Preliminary Project Review (PPR) presentation and report due
    - Presentation slides is to be a quick summary of the contents of the report
- Week of May 13, 2024: Informal progress check-in with teams
- **Week of June 10, 2024:** Submit Critical Project Review (CPR) report along with Pre-Expedition Plan and Outreach Activities Report
- **August 12th to 16th 2024:** Expedition period
- **September 2024 (TBD):** Submit Post-expedition Survey & Report

1.6. Formatting Guidelines for Submission of Documents

- PDF file type
- Submit electronically to canarx@seds.ca
- Standard 8 ½" x 11" pages
- 1" margins on the top, bottom and sides
- 12 point Times New Roman font
- Single-spaced
- Numbered pages on the bottom right corner
- Include a cover page
- Use APA style for citations

1.7. Team Guidelines

Teams must be a minimum of 4 students and can be composed of students from the primary institution or collaborating institutions (see definitions below). There is no maximum size. A team can be composed of undergraduate and graduate students, but the fraction of graduate students must not exceed 34%. Teams are encouraged to diversify their areas of expertise by enlisting students from other departments/faculties.

Primary Institution	A recognized college or university in Canada where the team leader is enrolled as a student.
Collaborating Institutions	Colleges, universities, and high schools that have contributed time and/or resources to the project.
Team Leader	The team leader is responsible for organizing and coordinating the efforts of the entire team for the duration of the project. 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.

1.7.1. Collaborating with students at LivingLab Charlevoix

If selected to participate in CAN-ARX, your team will be matched with students from LivingLab Charlevoix, composed of local-to-the-expedition site students who are interested in space and ready to share their knowledge. Students will work with the selected team remotely to achieve mission goals, and can provide critical input to the team in areas such as:

- aiding in the design of an instrument, payload, or other device via participation on a subsystem team,
- creation of any required software, as well as analysis of data post-expedition,
- performing in-depth background research for the experiment as it relates to the specific expedition site,
- providing insight into site-specific considerations,
- setting up a research paper, white paper, or other working group paper post-experiment,
- participation in the field expedition (incl. guiding the team to appropriate field locations, field portable instrument operation, documentarian, etc.),
- and others.

1.7.2. Expedition Crew

The Expedition Crew will consist of up to 5 students who will travel to the remote location to complete project goals, administer community outreach, and participate in local activities.

1.7.3. Faculty Advisor(s)

Teams must enlist one faculty member from their primary institution to act as their team's advisor. These faculty members must complete a Faculty Letter of Endorsement which is submitted with the Proposal (a template can be found in Appendix 9.2). Teams may have additional faculty advisors (from the primary or any collaborating institutions) as needed. **The faculty advisor(s) are required to attend one meeting via teleconference and are encouraged to attend all meetings.**

1.8. Funding Limitations

Conducting analog research in Canada is resource-intensive and logistically complex. Most researchers obtain grants to cover costs of flights, accommodations, licenses, field equipment, and more. Similarly, the 2023-24 CAN-ARX campaign is contingent upon SEDS-Canada's successful procurement of funding through grants and sponsorships. **For this reason, funding is not guaranteed for the project and may result in early termination of the campaign**. The outcome of funding status may not be known until early 2024. Student teams will be expected to develop their experiments under the assumption that the expedition will occur in August of 2024 and must assume the risks associated with early termination. SEDS-Canada and its partners will do their best to help ensure funding is secured.

1.9. Expedition Location

There are many relevant analog & remote environments across the Canada. For the CAN-ARX 2024 Expedition, SEDS-Canada has partnered with LivingLab Charlevoix, in Baie-Saint-Paul, QC to have access to an analog environment for student teams.

LivingLab Charlevoix is an organization based in Baie-Saint-Paul, QC, aimed to improve and research better healthcare for rural communities. LivingLab Charlevoix is comprised of various experts ranging from doctors, to engineers, to researchers all working towards the same goal of improving health science in underdeveloped and more isolated towns and communities. LivingLab Charlevoix is also providing limited resources on site for expedition use, dependent on project scope, needs, and availability.

More information on LivingLab Charlevoix can be found at
https://www.livinglabcharlevoix.ca/accueil

1.10. Experiment Constraints

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

1. Fall under one of the major CAN-ARX research topics (planetary science, atmospheric science, resource utilization & food production, or remote healthcare)
2. The research topic is not restricted by permitting requirements at LivingLab Charlevoix, and the Province of Quebec; some examples may include, but are not limited to:
    a. living beings
    b. dangerous goods
    c. ethical requirements relating to environmentally invasive projects
3. Have an experiment duration no longer than scheduled field duration (2 weeks; see Expedition Schedule). For example, an atmospheric monitor cannot be placed and retrieved at a date passed the expedition time frame.
4. If project includes sample collection,
    a. The total amount of material collected must not weigh more than 23 kg, and
    b. You must demonstrate that you have the proper authority to collect and transport. Please check the permitting sites above to ensure that you are allowed to collect samples at the selected site.

       If you plan on collecting samples, a detailed transport plan (back to your university or institution) must be provided.
5. If the project includes the use of specific instruments or a major part of the project includes the design of new equipment, these must:
    a. Have a total volume no more than 27" x 21" x 14" (the size of a typical checked bag). Large items must be deconstructed and reassembled in the field, unless special arrangements are made.
    b. Weigh no more than 23 kg total.
    c. Must be fully transportable by foot and battery-operated in the field. Battery charging may be available. See Facilities for tools and equipment that is already available at the field location.

       Teams are allowed to bring up to 6 items/packages fitting these design constraints (size, weight, and transportability). Special arrangements may be permitted for larger items. Contact canarx@seds.ca if you have concerns about the size, weight, and transportability of your devices.
6. If biological specimens are used, specimens must:

    a. Not present any risk to other expeditioners
    b. Be contained within a sealed space
    c. Have a specific plan to be utilized/stored safely in the field and at the research labs near the field site
7. Be free of materials classified as physical, health or environmental hazards under Canada's Hazardous Products Act such as high-pressure, toxic, corrosive, explosive and flammable materials. See Physical and Health Hazards.

1.11. Facilities

You can find more information about the specific facilities (incl. the types of laboratory facilities available, tools and equipment, and housing & accommodations) at each location by following the relevant links below.

https://www.livinglabcharlevoix.ca/accueil

LivingLab Charlevoix may be able to provide wilderness training if necessary, as well as experiment equipment relating to the expedition itself. More information to be determined closer to the expedition date.

1.12. Engagement Plan

Part of this competition involves inspiring the next generation of STEM leaders, educating youth and the public on space exploration and development at large, and communicating your work & providing knowledge transfer to your peers. Even as students, we are the 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 selected team is expected to participate in three parts of our engagement plan.

- During the entirely of the challenge:
    - Collaborating with students from LivingLab Charlevoix
    - Peer-to-peer seminars between the primary and delegate teams will be conducted to foster information sharing and exchange. SEDS-Canada will schedule regular seminars between the primary and delegate teams.
- During the expedition:
    - Through partnerships with the local communities, we may administer hands-on activities designed to fit within the curriculum of a selected age or grade group.The final activities

will be selected in concert with local teachers based on their teaching curriculum. Expeditioners will be expected to participate if necessary.

Teams will also participate in a CAN-ARX Closing Ceremony. This Closing Ceremony will be a commemoration of the entire project as well as a celebration of the achievements of all students involved in the expedition. This will be a 1-day in-person event held near the expedition research site, which will consist of:

- Posters presentations or short presentations from students,
- a short presentation from SEDS-Canada, and
- short presentation(s) from local community member(s)

2. PROJECT PROPOSAL

2.1. Overview

The project proposal is the first of four technical documents that must be submitted for a team to advance through to the analog expedition. This document will be judged by a panel of SMEs with experience in the applicable fields of research for this expedition and should be written with this audience in mind. Your document must be limited to 20 pages (not including References and Appendices). Only the first 20 pages of the proposal will be reviewed.

A Google Doc version of this document can be found here. It may be useful to utilize editable tables.

NOTE: Proposals which do not meet the Experiment Constraints will not be reviewed.

2.2. Proposal Guidelines

In the order listed below, your project proposal should include the following sections, **and should directly address all scoring criteria listed in the Proposal Review Criteria**:

1) Cover page

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

   - Project title
   - Project subject area & type

     Identify the relevant subject area out of those listed in the Project Scope (e.g. out of planetary science, atmospheric science, resource utilization & food production, and remote healthcare).

     Also identify the relevant type of project. Is this an engineering-based project or a science-based project?

     One project may fall into multiple areas; please choose the area that is most closely related to your project. If you need help categorizing your project, please email canarx@seds.ca.

   - Team member names, academic affiliation, specialization, and level of study
     e.g. "Jane Doe, University of Toronto, Biology, 3rd year undergraduate"
   - 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.

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 and project type, including **Clearly indicate the need for your experiment to be tested in an analog site(s)**
   - Summary of experimental design requirements met (see Experiment Constraints)
   - Overview of the project's budget, timeline, and location (choose one or more from those listed in Expedition Locations)
   - Overview of expected outcomes

5) Proposal Plan

   Following the scoring criteria provided in the Proposal Review Criteria, address all proposal criteria in full sentences, using primary research literature and diagrams when necessary. References should be cited in APA style and a bibliography should be provided before the appendix. Diagrams or tables 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 captions. Follow the templates provided to complete the scoring criteria which require filling of specific tables (e.g. objectives & success criteria, risk assessments, requirements, etc.).

   If your project is identified as an engineering project (as declared for your project type) you also must include a mass and power budget.

6) References

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

7) Appendices

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

   You must also include the following appendices:

   a) Team/Project Checklist
   b) Faculty Letter of Endorsement

c) Proof of Enrollment

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

2.3. Proposal Review Criteria

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

Description of Criteria	Marking Scheme
Scientific Merit (45%)	
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?). Use the Expedition Objectives & Success Criteria table provided**.**	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 expedition environment	
Describe why the project requires an analog remote environment to achieve its scientific objectives.	0 = the experiment was not designed for the site environment 1 = reasoning for conducting research in the site environment is described, but lacks detail 2 = the research is appropriate for the site and reasoning is well-described and the research is well-suited to an identified field site(s).

Importance to Canada & the space sector	
Referring to the Canadian Space Agency's 2022-2023 Departmental Plan (https://www.asc-csa.gc.ca/pdf/eng/publications/dp-2022-2023-v2.pdf), describe how the proposed project fits within the CSA's planned results (referred to as "Departmental Results" in the document, starting on page 5)	0 = no relevance to the CSA's Departmental Plan was detailed 1 = some relevance to the CSA's Departmental Plan was listed, but the areas of relevance are not appropriate 2 = appropriate and well-described evaluation of the proposal's relevance to the CSA's Departmental Plan
Technical Description and Feasibility (25%)	
Experimental Design	
Describe how the experiment satisfies each of the Experiment Constraints. Use diagrams and/or sketches to illustrate how the experiment satisfies these constraints.	Pass/Fail* *Only projects satisfying all experimental constraints will be reviewed, unless special accommodations have been made.
Describe the design of your experiment and how it meets your mission objectives.	0 = proposed design is inappropriate/inadequate 1 = proposed design could reasonably meet success criteria & therefore mission objectives, but it is lacking in detail 2 = proposed design can meet success criteria & therefore mission objectives, and is well-described
Describe what you intend to measure (e.g. your variables) and the data collection methods involved.	0 = proposed variables or data collection methods are inappropriate/inadequate 1 = proposed variables and data collection methods are reasonable but lacking in detail 2 = proposed variables and data collection methods are achievable and well-described
Using the mass budget template, complete a table listing component names, descriptions, quantities, and estimated mass budget (in kg) of all components of the design (e.g., mechanical and electrical parts) or experiment (e.g. critical instruments or equipment you would need to bring to the expedition site).	0 = table is not provided or is inappropriate 1 = table is lacking detail in its description of components, and some components seem inappropriate 2 = thorough descriptions of all components are provided and components are appropriate
★ This row is only required for engineering projects ★ Using the power budget template, complete a table listing component names, descriptions, quantities, and estimated power draw (in W) of all power-drawing components of the	0 = table is not provided or is inappropriate 1 = table is lacking detail in its description of components, and some components seem inappropriate 2 = thorough descriptions of all components are provided and components are appropriate

design.	
List all components of your experiment classified as hazards under [Canada's Hazardous Products Act]() and specify each hazard, if applicable. Provide a Material Data Safety Sheet (MSDS) in your appendix for each identified hazard.	0 = the hazards of the experiment were not listed or assessed 1 = incomplete assessment of hazards, or MSDS for each hazard not provided 2 = all hazards were identified and specified. MSDS provided for each
Bonus points will be given for teams who demonstrate the use of (or a plan to use) existing open source data to support their project (e.g. Earth observation, census data). Motivation for use of the data must be given (e.g. does it help you meet one of your Expedition Objectives).	2 bonus points will be given for appropriate and well-motivated use (or plan to use) open source data.
Experimental Procedures	
Describe procedures for proper execution of the experiment in the field. Include diagrams and/or sketches as needed.	0 = descriptions not provided 1 = descriptions are incomplete or lacking detail 2 = procedures are well-described and are appropriate for field work
Equipment, tools, and facilities	
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 pre-expedition (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; or, the experiment does not require specialized facilities or tools/equipment
For instruments or other equipment brought into the field, describe their portability in terms of power (i.e. ipad: will be charged at the base, handheld x-ray spectrometer: 6W battery charged at the base, rover: will be supplied with self-built battery pack/generator). Indicate, especially, those components which cannot be recharged at the base.	0 = no measure of portability was given 1 = some measure of portability was given, but details are missing 2 = all equipment required for the field was listed with measures of portability
Risk Assessment	
(a) Human	
Using the [template provided](), describe risks involved to team members during the building and assembly of the experiment and how these risks will be handled (will the team need to be trained to use tools/equipment, etc.). Special attention should be given to risks involving	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

hazardous products.	
Using the [template provided](), describe the risks to the Expedition Crew when executing any specific tasks during the expedition, such as setting up the experiment or implementing procedures. Provide mitigation strategies to eliminate (or minimize) risks. Be sure to include all human risks in the risk summary table. Only one risk summary table should be included in your proposal (covering all types of risks).	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
(b) Technical	
Describe any points of failure for the experiment, such as mechanical malfunctions, samples are not accessible, etc. that would block you from meeting your Expedition Objectives. Be sure to include all technical risks in the risk summary table. Only one risk summary table should be included in your proposal (covering all types of risks)	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
(c) Procedures	
Describe the procedures *specific to your experiment* to be performed during an emergency in the field to prevent risks and hazards to the Expedition Crew. For example, if there is a reason we have to evacuate the field site quickly, are there any kill switches that should be flipped?	0 = no procedures provided 1 = inadequate procedures provided 2 = well-defined, adequate procedures provided
Project Plan (20%)	
Team Structure & Management	
To encourage diversity and participation from Northern communities, bonus points will be given to applicants from the Territories.	0 = application does not originate from the Territories 2 = application originates from the Territories
Following the [template provided](), create a Work Breakdown Structure with assigned roles and tasks for each team member, including Delegate Team members, 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
Describe the strategy taken to mitigate the impact if a team member chooses not to continue with the project and 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
Describe a plan for the involvement/engagement of Delegate team members in the project, making sure to consider that they are participating remotely. You may refer back to your Work Breakdown structure.	0 = no specific plan or roles for Delegate Team members was provided 1 = roles were given to Delegate Team members, but strategies for engagement were not 2 = clear roles and responsibilities are carved out for Delegate Team members and a plan is in place for engagement of Delegate Team members
Project Timeline	
In a table, diagram or Gantt chart, present an expected timeline of the project's development. Include details such as prototype building and testing, final product manufacturing and testing, and completion dates of deliverables such as the PPR, and CPR, etc. Estimate the length of time required to complete each task. A Gantt chart template is provided, if needed.	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 = the team has not planned to stay on schedule or the plan is insufficient 1 = the team has listed some mitigation strategies but no detailed plan provided 2 = the team has provided details about which team members will lead the scheduling efforts and how each key team member will contribute to staying on schedule
Budget & Funding	
Following the template provided, include all foreseeable expenses for the design and development of the project, purchase and fabrication of equipment/parts, etc. Describe current and future sources of funding including the duration and amount of this funding (academic/student grants, industry partnerships/sponsorships, etc.).	0 = budget and funding plan not provided or inappropriate 1 = budget and funding plan not elaborated in detail 2 = budget and funding plan is achievable and well-described
Describe the measures the team will take to ensure the project stays within budget and how the team intends to acquire the necessary funds. Identify key team members involved in controlling project expenses and how other members are involved in the process.	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

Outreach (10%)	
Outreach in Local Community	
Each selected team is encouraged to administer outreach activities online or in their local community. Describe the way your team could facilitate engagement with the public (not including the expedition).	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 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.
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

The following sections apply once the team successfully passes the proposal stage and is selected to participate in CAN-ARX 2024.

3. PRELIMINARY PROJECT REVIEW

3.1. Overview

If selected, your team will be required to give a Preliminary Project Review (PPR) presentation containing a thorough technical review of your scientific experiment.

The PPR must provide evidence that you are making progress and that your experiment will satisfy the Experiment Constraints. During the PPR presentation SMEs will review your work and provide comments and feedback. You will be expected to make any necessary revisions. Some items to consider, you must address any issues raised from the feedback received and present your updated design specifications. In most cases, teams will only make minor changes to the project outlook after the presentation, unless major concerns are flagged.

The requirements for the PPR presentation are detailed in the next section (PPR Presentation).

3.2. PPR Presentation (Details herein TBC)

Teams will be required to provide a 15-minute presentation (followed by a 15-minute discussion period) to our panel of SMEs and judges. The purpose of the PPR presentation is to obtain comments and feedback from SMEs and judges in order to improve and expose any critical design flaws early on in the project. You must convince the SMEs that your experiment is feasible given the constraints of the selected research location, so be prepared to answer technical questions. You must also demonstrate that your design can safely meet all the requirements of your scientific experiment. Please structure the presentation as follows. Make reasonable assumptions if items are unknown at the time.

Title slide

- Include all team information, responsibilities of each member and the chosen expedition crew (team members who will be travelling to the experiment site).

Introduction

- 1-2 slides on the topic of research and the proposed experiment

Traverse Plans

- Provide maps of the locations from which you wish to collect samples/conduct tests/etc.

- Provide background information on these field sites
- Describe why these locations are relevant to your experiment

Experiment design and procedures

- If applicable:
    - Describe your prototype in full detail
        - Include any testing done to date, and lessons learned
    - Describe your plan to execute a full cycle of tests prior to submission of the CPR.
- Provide a list of required field equipment, the purpose of these items, and their specifications
- Present a requirements compliance table
    - Identify if analysis/simulations, testing, or inspection are necessary to satisfy each requirement.
- If applicable, please provide the following additional information:
    - Detailed sampling/measurement strategies and methods
    - Field data sheets
- Experimental and/or data analysis protocols (during and after fieldwork)
- Annotated diagrams and flow charts for operational procedures, along with team responsibilities.
- Technological and human risks, along with their mitigation plans

Project management

- Include an updated timeline

  Highlight the most important milestones completed to date and the remaining tasks to accomplish prior to the CPR.

- Budget

  Include all the incurred and estimated costs for all the phases of the project.

3.3. Sections for PPR Report

In the order listed below, your PPR 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
4) Executive summary

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

- Brief introduction of the project
- Outline of experimental procedures, risk mitigation plan, prototype testing plan, preliminary test results (if applicable) and data analysis plan
- Overview of progress and updates to the management plan and outreach plan

5) Introduction

This section may build upon the Scientific Merit section of your proposal. Make changes or add details as necessary. Cite primary research literature whenever possible and use APA 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
- Novelty
- Importance to the advancement of space exploration, science and technology

6) Experiment Specifications and Procedures (if applicable)

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

- Describe how the experiment satisfies each of the experimental constraints.
- Illustrate your procedures using annotated technical diagrams and flow charts of the experiment and/or its subsystems.
- Updated safety plan of steps to be followed by group members and Expedition Crew in case of problems with the experiment (electrical or mechanical failure, weather etc.).

7) Technical Risk Assessment

- From the risks identified in your proposal, have any been encountered? If so, describe how the mitigation and/or contingency plans were initiated, and whether they were effective. Describe any consequences and lessons learned.

- Include risk assessment tables from the proposal with updated estimates of likelihood and impact, as well as more technical details in the mitigation and contingency plans. Include any new risk assessment tables with the same level of detail.

8) Experiment Testing
    - Describe your prototype built to test the experiment or how you will implement your scientific experiment or sample collection, lessons learned, and how those tests have impacted the preliminary design.

9) Plan for data collection (if applicable)
    - Considerations to address before going into the field
    - Detailed sampling/measurement strategies and methods
    - Field data sheets/field notebooks/tablets

10) Plan for data analysis / results interpretation
    - Deploying experiments in the field is fun, but it doesn't end there. Briefly describe the steps to be taken to analyze data and interpret results. Ideally, your team can write scripts to automate some basic analysis and generation of results that can be included in your final presentation at the closing ceremony.

11) Project management update/review
    - Create a verification matrix for the requirements associated with your design and the constraints outlined in this handbook following the Requirements Verification Compliance Matrix (RVCM) template. Identify whether analysis/simulations, testing, or inspection are necessary to satisfy each requirement.
    - Provide an updated timeline, including all the activities associated with your experiment from conception to design/manufacturing (if applicable) and testing, and the duration of each activity throughout each phase of the project. A Gantt chart or other project management tool is recommended.
    - Provide an updated budget and funding plan, including the status of any outstanding grant applications or sponsorships. Describe if the budget from your proposal is on track or was overestimated or underestimated, supported with justifications. Identify any obstacles encountered which have affected the budget from your proposal. See Budget and Funding.
    - Provide any necessary updates to the Work Breakdown Structure.

12) Project outreach update

- Describe any outreach activities performed which were planned in your proposal by completing an OAR. Provide details such as purpose, location, audience and outcomes. If any changes were made to the outreach plan, provide justifications. If no outreach activities were completed, please indicate it in your PDR.

13) References

- Cite all your references using APA format.

Appendices

4. PROGRESS PRESENTATIONS

4.1. Overview

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. Teams are expected to be professional in their presentations. This is a great chance to receive help and engage with SMEs and SEDS-Canada; we are all here to help you towards a successful design!

These are informal check-ins, which can be done through email at canarx@seds.ca , or through a virtual call coordinated with the team.

4.2. Expectations

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

5. CRITICAL PROJECT REVIEW

5.1. Overview

The Critical Project Review (CPR) must demonstrate that your experiment design has achieved a sufficient level of maturity to proceed with full-scale testing. A thoroughly completed experiment design is expected at this time, and all necessary experimental equipment must be determined at this point. Like the PPR, the CPR will be presented to SMEs for feedback, and then a final CPR report will be submitted about 10 days later. Comments made from earlier reviews should be addressed in this document.

The guidelines for the report can be found in Sections for CPR Document.

5.2. CPR Report (Details herein TBC)

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

1) Cover page - Include all team information and graphics
2) Table of contents
3) Summary of major changes made to the design since submitting the PPR. Include the location (page number, section number, etc.) of these changes.
4) Updated list of figures and tables
5) Updated executive summary
    - The executive summary should provide a complete overview of all the sections in the CPR in **one** page or less.
6) Introduction
    - The introduction section of the CPR should build upon the PPR introduction and the comments provided by the SMEs. Make changes or add details as needed. Cite primary research literature whenever possible and use APA 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):

        - Geological maps/cross sections
        - Sample collection container specifications
        - Final mechanical drawings
        - Final electrical schematics
        - Final software flowcharts
        - Final CAD model
        - Final Bill of materials (BOM)
    - Updated pre-expedition, expedition, and post-expedition procedures based on feedback from SMEs.
    - Updated safety plan based on feedback from SMEs.

8) Technical Risk Assessment
    - From the risks described in the PPR, have any been encountered? If so, describe how the mitigation and/or contingency plans were initiated, whether they were effective. Describe any consequences and lessons learned.
    - Include risk assessment tables from the PPR with updated estimates of likelihood and impact, and any updates to the mitigation and contingency plans. Include any new risk assessment tables with the same level of detail.
9) Experiment Testing
    - Provide a thorough description of experimental tests conducted since submission of the PPR, lessons learned, and how those tests have impacted your final design.
    - If applicable, each team should complete at least one full cycle of ground tests with the fully assembled experiment, running through all the steps that will be performed during the field days.
    - 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 in Cambridge Bay and how that will impact the results during the actual campaign.
10) Plan for data analysis / results interpretation
    - State if there are no updates on how you plan to analyze data and interpret results since the PPR. Otherwise, provide an updated plan in this section.
11) Project management update/review

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

12) Project outreach update

- Describe any outreach activities performed since submitting the PPR by completing an OAR. Provide details such as purpose, location, audience and outcomes. If any changes were made to the outreach plan since the PPR, provide justifications.

13) References

- Cite all your references using APA format

14) Appendices

6. PRE-EXPEDITION PLAN

6.1. Overview

The Pre-Expedition Plan (PEP) milestone will ensure you are prepared and well-planned for the experiment site. Here we expect the experiment to be fully researched, designed, and tested, and a work plan to be finalized, following the preliminary schedule of the expedition. We also expect teams to have a handle on their hands-on outreach activity and the public-level presentation to be completed. This will mostly contain information about your project from CPR (with appropriate updates), with a few key additional components. The following sections cover the PEP document.

6.2. PEP Report (Details herein TBC)

The PEP document will include:

- Final experiment “check” & checklist for experimental procedures
- Results from fully integrated hardware tests (if not done at CPR stage)
- Specific breakdown of plans for the expedition (e.g. how many prep days do you think you’ll need)
- What tools, materials do you need for experiment & describe shipping procedures to the field site
- List of spare parts, anticipating potential repairs on-site
- Finalized expedition crew

Post-expedition plan breakdown (e.g. analysis, papers/presentations, when will you expect results be ready)

- Outline of planned post-flight activities. Include details for planned analysis of samples, including expected dates for obtaining results
- Highlight any conferences or papers you hope to use this data for.

Final packing list and final approximate weight of luggage

- Participants must include a list of packed materials for the flights to the field site, including approximate weight of all materials. This is to ensure they meet the airline requirements for baggage.
- Participants must also include a list of packed materials for the return flights, being sure to include the weight of any samples gathered.

Final Authorization forms

- Students must fill out a [Health Statement and General Medical Information Form] ensuring participants are in good health, and outlining any accommodations that may need to be provided
- Participants must include proof of valid travel insurance for the duration of the expedition

7. EXPEDITION SCHEDULE

7.1. Schedule Outline

Table 1 gives an example of a 1-week expedition schedule. Note that the expedition may be longer than 1-weeks. Activities include:

- **Orientation:** Orientation will include an introduction to the field site, the other teams, and the community.
- **Prep days:** Data collection instrumentation preparation, collection location determination, etc.
- **Field days:** Data collection in the field under desired conditions.
- **Activity Day:** students participating in the campaign will learn about the campaign location & local residents through activities with local organizations, or learn from local scientists studying at the station.
- **Outreach:** Student teams will work with SEDS-Canada to deliver an outreach activity in a local school(s).
- **Safety Training**: Facility staff will be on-site to provide specific training for the expedition's fieldwork environment. This includes learning about first-aid, personal protective equipment (PPE), wildlife safety, operating equipment such as ATVs and snowmobiles.
- **Data analysis:** Students will analyze some preliminary data and present it to the local community. The presentation should include the motivation behind the projects, the goals, implications and future work.

Table 1: Preliminary 1-week expedition schedule.

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Arrival	Orientation Safety Training Prep Day	Field Day	Activity Day	Field or Prep Day	Field or Analysis Day	CAN-ARX Closing Ceremony Departure

This expedition may also include a study of the psychological and/or physiological effects of working in isolated and remote environments. Participation in this study is optional but highly encouraged, in order to supplement the scientific potential of the expedition.

7.1.1. Required Equipment & Suggested Packing Items

On top of the Expedition Team's proposed experimental equipment, some suggested things to bring for the 1-week expedition include:

- Day pack (suggested volume of 35L+)
- Water bottle
- Sleeping bag
- Shower towel
- Shower soap and shampoo
- Shower shoes or sandals
- Headlamp
- USB phone charger cable
- Personal medications

7.1.2. Safety Training

As part of the expedition, the SEDS-Canada CAN-ARX team will co-lead a safety briefing prior to the expedition. Due to the remote and rigorous field nature of this expedition, it is mandatory for all participants to complete a certification for the *Wilderness & Remote First Aid Program*. The logistics for this training will be facilitated by SEDS-Canada with expenses covered, depending on the secured funding.

7.1.3. Closing Ceremony/Final Presentation

The CAN-ARX Closing Ceremony will be a commemoration of the entire project as well as a celebration of the achievements of both primary and delegate students involved in the expedition. This will be a 1-day (ideally, in-person) event held near the expedition research site, which will potentially consist of:

- Posters presentations or short presentations from the team
- A short presentation from SEDS-Canada
- A short presentation from local community member(s)

8. OUTREACH ACTIVITIES REPORT

8.1. 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.

8.2. 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 be 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.

The format of the document should follow the requirements listed in the next section.

8.3. Outreach Activities Record

Every outreach activity you perform, fill out an outreach activity record using the formatted table below. For the purpose of our overall CAN-ARX engagement plan, we encourage the team(s) to focus on ***online*** and/or ***their local community*** *(i.e. local institutions, K-12 schools, etc.)* outreach activities in order to complete this section. SEDS-Canada will be facilitating outreach activities in the north.

Table 2: Outreach activities record.

Activities	
Location(s) of activity	
Dates(s) of activity	
Names and roles of team members involved in this activity.	

Were these activities part of a larger event? If so, please provide a name and brief description.		
Was this activity related to your project? (Y/N)		
Was this activity included in your Outreach Plan in the Proposal? (Y/N)		
Audience		
Educational Level	Number of Participants	Was this the primary audience? (Y/N)
K-4		
5-8		
9-12		
Post-secondary		
Educator		
Other		
Summary		
Describe the activities conducted at the event.		
Describe any feedback you received from the audience or organizers.		
Describe any challenges faced while planning or executing the activities.		
Would you repeat these activities? Justify why or why not. Suggest any improvements.		

9. POST-EXPEDITION SURVEY & REPORT

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

- *Were your experiment objectives met? Explain why or why not?*
- *Did the expedition meet the data collection requirements for your experiment?*
- *What results were obtained from the data collected? Was the data expected or unexpected? Explain.*
- *What were the biggest difficulties you encountered during experiment planning and execution?*
- *How did participating in CAN-ARX affect your interest in working in the space industry?*
- and other general questions related to the objectives of CAN-ARX, logistics, project management, student resources, and other.

The Post-expedition survey Google Form will be distributed to all participating individuals after the expedition and must be submitted by the appropriate date as listed on the Competition Timeline.

10.DELIVERABLE CHECKLIST

In an effort to be utterly clear about the deliverables expected throughout the CAN-ARX competition, the following can be used as a checklist - the following items apply if the team passes the proposal stage and is selected to participate in the CAN-ARX project.

- ❑ Preliminary Project Review (PPR) Presentation
- ❑ Critical Project Review (CPR) Report
- ❑ Pre-Expedition Plan (PEP) Report
- ❑ Outreach Activities Report
    - ❑ Pictures/video for social media
- ❑ Post-Expedition Survey & Report

11. TEMPLATES

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

11.1. Expedition Objectives & Success Criteria Table

Describe the mission objectives (e.g. what questions do you want to answer?) and the success criteria for meeting these objectives (e.g. what are you actually going to measure or observe to verify your objective is met) in a table like the following. A couple of examples are given, but be sure to make these specific to your experiment.

Table 3: Mission objectives & success criteria template.

Expedition Objective	Success Criteria
Example: Demonstrate operation of weather station in Mars-like conditions.	*Example: The weather station is able to collect X atmospheric data, while uplinking to an online database and the weather station configuration is able to withstand harsh polar desert conditions.*

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

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

11.2. Risk Assessment Tables

Create a risk table (see Table 4 below) for each technical risk (TR#) or human risk (HR#), describing what the risk is, its probability and consequence with associated rankings (Low, Medium or High), and a mitigation and contingency plan. Replace the instructions (in italics) with your inputs.

The definitions of Low, Medium, and High Probability are:

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

The definitions of Low, Medium, and High Consequence are:

- Low Consequence: minor inconveniences
- Medium Consequence: injury to a person that is non-serious / non-negligible increase to payload cost/time
- High Consequence: Serious injury to a person or de-scoping of payload

List all risks (TR1, HR1, etc.) in the Risk Assessment Matrix (Table 5).

Table 4: Risk table.

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

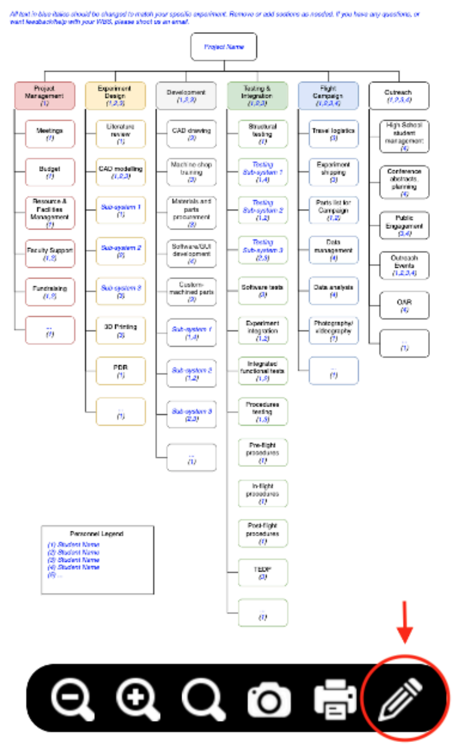
Table 5: Risk assessment matrix.

		Probability		
		Low	Medium	High
Consequence	Low	*e.g. TR1*		
	Medium		*e.g. HR1*	
	High			

11.3. Work Breakdown Structure

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

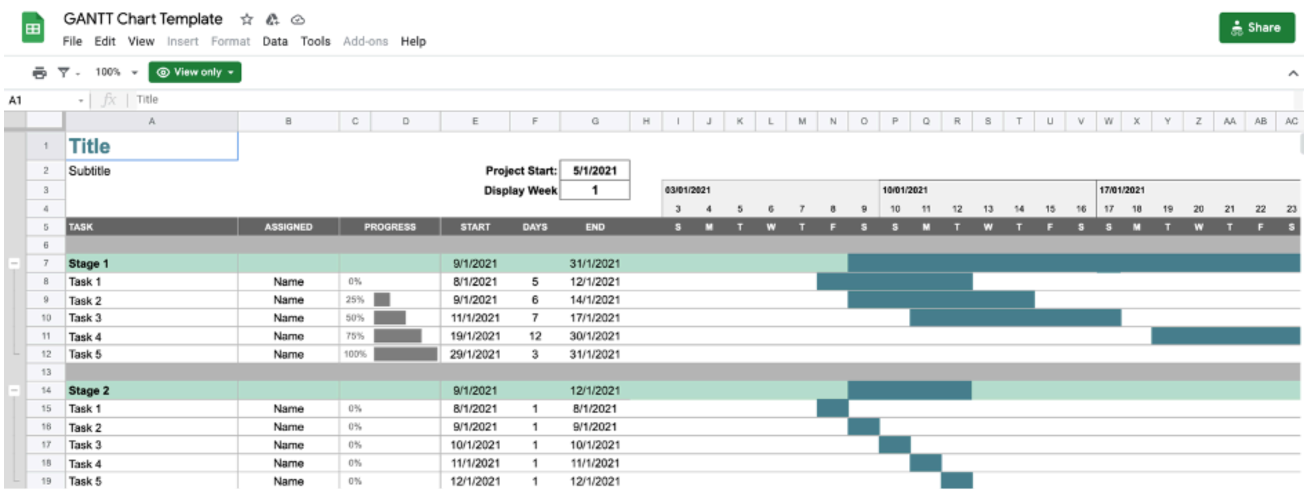
Modify the template tree outlined below (currently organized by discipline, with engineering split by timeline) to structure your project from start to finish. **You can access the template at seds.ca/templates**. Add or remove categories and tasks as needed based on your specific project and management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



11.4. Gantt Chart Template

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

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



Some instructions for using the chart:

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

This template was created by Sam Aberdein and Nicole Richardson.

11.5. Requirements Verification Compliance Matrix (RVCM)

The following template should be used to verify your experiment design requirements. It is expected that your RVCM will be populated with far more requirements than what is shown in the example below, e.g. the experiment constraints should be applicable to your experiment (the one listed here has example descriptions, verification methods, and remarks, etc. in italics). Requirements are set at the beginning of the project and should remain fixed.

Use the following guide to fill out the requirements table:

<u>Compliance</u>

Mark both current compliance (i.e. do you meet this requirement with your design) and planned compliance (i.e. do you plan to comply with the requirement).

Populate these columns with either C, P, or NC (C = Compliant, P = Partially Compliant, NC = Non-Compliant)

<u>Verification Method</u>

Mark how you've ensured you meet the requirement; A = Analysis, S = Simulation, T = Testing, I = Inspection.

<u>Remarks</u>

This column should include: remarks regarding plans to comply (e.g. plan of action for reducing mass), links to evidence showing compliance (e.g. a link to a section elsewhere in your documentation containing the analysis, simulation, test results, or inspection results that show you meet your requirement), or general notes.

Table 7: Example requirement verification & compliance matrix.

<table>
<tr><th rowspan="2">Category</th><th rowspan="2">No.</th><th rowspan="2">Requirement</th><th colspan="2">Compliance</th><th rowspan="2">Verification Method</th><th rowspan="2">Remarks</th></tr>
<tr><th>Current</th><th>Planned</th></tr>
<tr><td rowspan="2">Experiment Structure</td><td>1.1</td><td>Experiment mass shall be constrained below 23 kg.</td><td>C</td><td>C</td><td>A/S/T/I</td><td>Example: A heavy part currently puts us over 23 kg, but this component will be have a reduced mass in ~3 weeks, and so our final payload will be compliant</td></tr>
<tr><td>1.2</td><td>Experiment volume, in its shipping configuration, shall be constrained below 27" x 21" x 14"</td><td>P</td><td>C</td><td>A/S/T/I</td><td></td></tr>
</table>

		(the size of a typical checked bag)				
	1.3	The experiment shall be fully portable by foot and battery-operated	P	C	A/S/T/I	
Electrical Compatibility	2.1	Electrical components and rechargeable batteries must be compatible with standard 115V/5A outlets.	P	C	T/I	
Hazardous Materials	3.1	Experiment shall not contain hazardous material.	C	C	A	
Experiment Operations	4.1	Specimens collected from the field site shall be contained for transit.	P	C	T/I	

11.6. Mass and Power Budgets

Table 8 and 9 show mass and power budget templates which can be used for your design documents. Each table contains example values (in italics) to guide you in filling in your own. Your experiment is expected to have more components than the sample budget below. Do not forget to include masses for your fasteners, wiring, and mounting interface to the gondola itself. At the proposal stage, you should have over 15% margin or a plan to reduce mass in case your system exceeds the budget at later stages.

Please use the following nomenclature for status:

E = Estimated mass/power

M0 = Calculated using a 3D solid model (SolidWorks, Eagle, etc.) or other software

M1 = Taken from a manufacturer spec sheet

M2 = Measured (using a scale, voltmeter, ammeter, etc.)

Table 8: Mass budget template

Component	Status	Qty	CBE Unit [kg]	CBE Total [kg]	Mass Fraction	Remarks
Structure and Mechanisms			**Subtotal**	***7.00***	***70%***	
Aluminum Structure	*M2*	*1*	*6.00*	*6.00*		*Aluminum 6061-T4*
Support Brackets	*M2*	*5*	*0.20*	*1.00*		
Experiment Components			**Subtotal**	***1.00***	***10%***	
High-Speed Camera	*M1*	*1*	*0.50*	*1.00*		*High-speed, #PN*
Power System			**Subtotal**	***0.55***	***6%***	
Batteries	*M2*	*4*	*0.10*	*0.40*		
9V Power Adapters	*M2*	*3*	*0.05*	*0.15*		
Data Handling			**Subtotal**	***0.50***	***5%***	
Data Logger	*M2*	*1*	*0.50*	*0.50*		
Electronics			**Subtotal**	***0.10***	***1%***	
Arduino UNO	*M0*	*1*	*0.10*	*0.10*		
Miscellaneous			**Subtotal**	***0.80***	***8%***	
Cabling	*E*	*1*	*0.50*	*0.50*		
Fasteners	*M0*	*1*	*0.30*	*0.30*		
			TOTAL	***9.95***	***100%***	
			Target Mass	***20.00***	***-***	
			Margin	***10.05***	***50%***	

Table 9: Power budget template.

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

11.7. Budget and Funding

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

Table 10: Budget and Funding table template.

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

Subtotal with 15% Margin	
Total (Estimated)	
Deficit/Overture (Funding – Costs)	

12. APPENDICES

12.1. Physical and Health Hazards

Physical Hazards

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

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

Health Hazards

Hazard Class	General Description
Acute toxicity	These products are fatal, toxic or harmful if inhaled, following skin contact, or if swallowed. Acute toxicity refers to effects occurring following skin contact or ingestion exposure to a single dose, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. Acute toxicity could result from exposure to the product itself, or to a product that, upon contact with water, releases a gaseous substance that is able to cause acute toxicity.
Skin corrosion/irritation	This class covers products that cause severe skin burns (i.e., corrosion) and products that cause skin irritation.
Serious eye damage/eye irritation	This class covers products that cause serious eye damage (i.e., corrosion) and products that eye irritation.
Respiratory or skin sensitization	A respiratory sensitizer is a product that may cause allergy or asthma symptoms or breathing difficulties if inhaled. Skin sensitizer is a product that may cause an allergic skin reaction.
Germ cell mutagenicity	This hazard class includes products that may cause or are suspected of causing genetic defects (permanent changes (mutations) to body cells that can be passed on to future generations).
Carcinogenicity	This hazard class includes products that may cause or are suspected of causing cancer.
Reproductive toxicity	This hazard class includes products that may damage or are suspected of damaging fertility or the unborn child (baby). Note: There is an additional category which includes products that may cause harm to breast-fed children.
Specific target organ toxicity – single exposure	This hazard class covers products that cause or may cause damage to organs (e.g., liver, kidneys, or blood) following a single exposure. This class also includes a category for products that cause respiratory irritation or drowsiness or dizziness.

Specific target organ toxicity – repeated exposure	This hazard class covers products that cause or may cause damage to organs (e.g., liver, kidneys, or blood) following prolonged or repeated exposure.
Aspiration hazard	This hazard class is for products that may be fatal if they are swallowed and enter the airways.
Biohazardous infectious materials	These materials are microorganisms, nucleic acids or proteins that cause or is a 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.

12.2. Faculty Endorsement Letter

You can also download a copy of this letter on the CAN-ARX website (seds.ca/can-arx).

SEDS-ÉEDS CANADA | Students for the Exploration and Development of Space
Étudiants pour l'Exploration et le Développement Spatial

SEDS-Canada Student Team Design Challenge

Letter of Endorsement

To SEDS-Canada,

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

Faculty Advisor Signature: ______________________________________ Date: _______________

Faculty Advisor Information

Name: ____

Email: ____

Affiliation/Department: ____

Is this the primary Faculty Advisor? ☐ Yes ☐ No

Team Information

Team Name: ____

Team Lead Name: ____

Team Lead Email: ____

Affiliation/Department:____

SEDS Canada · 663 Avenue Orly, Dorval QC, H9P 1G1 Canada
www.seds.ca

12.3. Team/Project Checklist

You can also download a copy of this letter on the CAN-ARX website (seds.ca/can-arx).

SEDS-ÉEDS CANADA | Students for the Exploration and Development of Space
Étudiants pour l'Exploration et le Développement Spatial

SEDS-Canada CAN-ARX Challenge: Team Checklist

This letter is to certify that our team, ____ has read and understood the following checklist requirements pertaining to our possible participation in the CAN-ARX Challenge. By submission of this proposal document we certify that our team meets all the following checklist requirements:

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

  If the workspace is at your university:

  - ☐ Our team is committed to creating a contingency plan for making progress on our experiment if our workspace access is revoked (e.g. because of COVID-19)
- ☐ Our team has access to the equipment/software we will need (although access may be limited) or are committed to securing access
- ☐ We acknowledge that, if selected, we will be paired with Delegate students from Canada's Arctic, and we are committed to including them in our project plan
- ☐ We acknowledge that **funding is not currently guaranteed for the CAN-ARX challenge and that may result in early termination of the campaign**
- ☐ All team members have been made aware of the above items

Team Lead Signature: ____________________________________ Date: __________________

Team Lead Name: ____

Team Lead Email: ____

Affiliation/Department:____

SEDS Canada · 663 Avenue Orly, Dorval QC, H9P 1G1 Canada
www.seds.ca

12.4. Health Statement and General Medical Information Form

You can also download a copy of this letter on the CAN-ARX website (seds.ca/can-arx).

SEDS-ÉEDS CANADA | Students for the Exploration and Development of Space
Étudiants pour l'Exploration et le Développement Spatial

Canadian Arctic Expedition (CAN-ARX) Challenge

Health Statement

Students must be capable of moderate physical activity, such as hiking over uneven terrain. Although we are visiting during the summer season, daily temperatures may be below freezing and all participants will be expected to participate in all excursions.

I, ___________________________, attest that I am in good health and capable of performing normal activities on this expedition. I further attest that I am capable of caring for myself during the expedition, and that I will not impede the progress of the expedition or the enjoyment of others aboard. I understand that this expedition will take me far from the nearest medical facility and that all expedition members must be self-sufficient. With that understanding, I certify that I have not been recently treated for, nor am I aware of any physical condition or disability that would create a hazard to myself or other members of the expedition.

Signature: ______________________________________ Date: ____________

General Medical Information

We are travelling to a remote place and we must be aware of any and all medical concerns and needs in order to be prepared for medical emergencies. Please outline any medical conditions, illnesses, and/or disabilities that require or have required the regular care of a doctor in the section below. It is VERY important that you provide as much information as possible. This information will only be shared with our expedition physicians and will otherwise be kept confidential.

Do you have any medical conditions, illnesses, disabilities and/or mental health issues (such as ADHD, depression, allergies, heart disease, emphysema, injuries, diabetes, recent surgery, etc.)? Please be thorough:

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