FOREWORD

The Canadian Stratospheric Balloon Experiment Design Challenge (CAN-SBX) is a competition for Canadian post-secondary students run by SEDS-Canada in association with the Canadian Space Agency (CSA). CAN-SBX is 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 CSA. 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. Any student team at a Canadian post-secondary academic institution can submit a proposal for their experiment, after which, teams will be selected to fully design, build, and fly their experiments.

CAN-SBX trains students to complete a full engineering design cycle from conception to execution. This is a valuable opportunity to gain transferable professional skills applicable to careers in Canada's space industry. Student teams will gain exposure to project management and risk mitigation which are essential components of many projects in the space industry. In addition, students will have the opportunity to work with Subject Matter Experts (SMEs) who will coach and mentor them throughout the competition. At the end of the competition, two awards will be given: one for the team showing Overall Excellence in all aspects of the competition, and one for the team who demonstrated Exceptional Outreach Efforts.

This CAN-SBX Application Guide aims to provide a resource detailing the proposal writing process for the competition. The guide begins with a set of instructions for the proposal writing process, alongside grading rubrics that describe the proposal evaluation process. Next an overview of the competition is provided, including timeline information and an introduction to the CSA's stratospheric balloon platform available for student-led research. Teams must consult this section to guide their decision making with regards to the conceptual design of their proposed experiment. Finally, a series of templates and examples are provided to assist students with proposal writing. Please contact cansbx@seds.ca with any questions regarding the application process.

1. APPLICATION INSTRUCTIONS

1.1. Overview

A complete application to the CAN-SBX competition consists of two components:

- A completed CAN-SBX Application Form
- A completed research proposal document

These two documents must be submitted electronically to SEDS-Canada at cansbx@seds.ca prior to the application deadline **Sunday October 6, 2024, 11:59 p.m. Eastern Time (ET)**. The following section contains the instructions for completion of the research proposal document.

1.2. Proposal Guidelines

A required element of a complete application to the CAN-SBX competition is a proposal. The proposal is the first of a series technical documents that must be submitted for a team to advance through to the Flight Campaign. Proposals will be scored by a panel of SMEs with experience in the field of stratospheric balloon-based research and should be written with this audience in mind. Proposals must be limited to 20 pages, not including appendices.

The proposal must include the following four sections and its relevant subsections:

Section 1. Introduction
- 1.1 Motivation
- 1.2 Novelty of Experiment
- 1.3 Goals
- 1.4 Importance to Canada's Space Sector
- 1.5 Relevance to the High-Altitude Environment
- 1.6 Research Hypothesis

Section 2. Experiment Concept Design
- 2.1 Scientific Objectives
- 2.2 Science Traceability Matrix
- 2.3 System Architecture
- 2.4 Block Diagram

Section 3. Concept of Operation
- 3.1 Equipment Requirements
- 3.2 Environmental Requirements
- 3.3 In-flight Operations

Section 4. Project Plan
- 4.1 Funding Strategy
- 4.2 Outreach Strategy

The instructions for each section and its marking scheme is provided in section Proposal Review Criteria.

NOTE: Proposals which do not meet all experimental constraints outlined in the CAN-SBX Application Form will not be reviewed.

1.3. Proposal Review Criteria

Each submitted proposal will be evaluated and scored according to a standardized rubric by a panel of subject matter experts (SMEs) in the field of stratospheric balloon-based research. In addition to the criteria listed in the marking schema, a qualitative assessment may also be applied based on the experience of the SMEs. The scoring rubric is found in the table below. If one of the sections listed in the rubrics cannot be found in the submitted proposal, it will be scored as 0.

Description of criteria	Marking scheme
Section 1: Introduction	
1.1 Motivation	
Provide a high-level summary of the problem you are trying to solve. Provide general context for the problem by addressing the following questions: What is the problem? Who does this problem impact? Why is this problem important to solve? How is the high-altitude environment related to this problem? Include references to recent and relevant peer reviewed publications to support this section.	0 = The introduction is not well-aligned with the proposal or the main focus is not clearly presented. 1 = Introduction identifies the major topics and stakeholders. 2 = All necessary background context is succinctly summarized. The scope of the problem, key stakeholders, and motivation for the experiment is completely described.
1.2 Novelty of Experiment	
Describe the current state of academic research in this topic. Highlight the limitations of past research and questions that remain to be answered. Indicate how your experiment fills these gaps in knowledge. Include references to recent and relevant peer reviewed publications to support this section.	0 = Marginal evidence is provided from literature to justify the experiment. 1 = Some literature review was conducted that supports the need for the experiment. Knowledge gap is identified but evidence is lacking. 2 = A comprehensive review of current and relevant literature is presented. Knowledge gaps are clearly identified. All claims are well supported by a variety of current and relevant peer reviewed publications, books, or other credible sources.
1.3 Goals	

Summarize the overall goal(s) of the experiment into a series of singular, high-level statements. Goals should be directly motivated by the content of the previous sections. If applicable, rank the goals based on the relative importance.	0 = Goals are too vague, too complex to reasonably address, or otherwise not well-described. 1 = Project goals are aligned with the overall proposal. The primary project goal is achievable but some elements of secondary goals may be infeasible. 2 = Project goals are well presented and in alignment with the previous evidence of the research proposal. Strong evidence is provided to demonstrate that all goals are achievable within the competition scope.
1.4 Importance to Canada's space sector	
Describe the value of this research project to Canada's space sector. Make specific reference to how the proposed research aligns with the Canadian Space Agency's Departmental Plan and/or other relevant market evaluation.	0 = Motivations for the research are lacking in justification. Limited connections are made with the goals of Canada's space sector. 1 = The proposal is aligned with some goals of Canada's space sector. The motivations are logical, but not directly applicable. 2 = Direct and measurable impacts to key strategic initiatives within Canada's space sector are clearly demonstrated.
1.5 Relevance to high-altitude environment	
Describe the reasons why a stratospheric balloon flight is required to conduct your experiment. Provide evidence to support that a flight of under 3 hours will be sufficient to conduct your experiment.	0 = The experiment is not suited to stratospheric balloon flight. The experiment could reasonably be conducted on ground, or is unachievable in the under 3 hour flight window. 1 = The necessity of stratospheric balloon flight is argued. Some evidence is provided to indicate the experiment is feasible in stratospheric balloon flight. Less than hours will be sufficient time to observe the phenomena under investigation. 2 = A comprehensive argument describing the necessity of stratospheric balloon flight to perform this experiment is clearly presented. Strong evidence is presented indicating that less than 3 hours will be sufficient time to observe the phenomena under investigation.

<table>
<tr><th colspan="2">1.6 Research hypothesis</th></tr>
<tr><td>Present a scientific hypothesis statement that addresses your project goal. This statement must provide a proposed explanation for an observed natural phenomena under investigation. The statement must be presented such that the explanation is testable via experimentation.</td><td>0 = Hypothesis is not testable, or not aligned with the project goals.

1 = Hypothesis is testable and is somewhat aligned with the primary project goal. More development is required.

2 = Hypothesis statement is well-crafted and is indicative of a testable experiment that directly addresses all project goals.</td></tr>
<tr><th colspan="2">Section 2: Experiment Concept Design</th></tr>
<tr><th colspan="2">2.1 Scientific Objectives</th></tr>
<tr><td>Present a list of specific objectives for the experiment design. Indicate the measurement techniques that will be used to investigate these objectives. Make a clear connection to demonstrate how each Scientific Objective serves overall goals defined in the proposal.</td><td>0 = Objectives do not logically follow from the project goal.

1 = Objectives support the project goal. The core objective is feasible with minor modification. Too many Objectives might be presented.

2 = Clear and concise objectives are present that directly serve the project goal. Objectives are written to follow specific lines of scientific inquiry that can be investigated with quantifiable experimental techniques.</td></tr>
<tr><th colspan="2">2.2 Science Traceability Matrix</th></tr>
<tr><td>Present a Science Traceability Matrix (STM) for the experiment. Accompany the STM with text that explains how the low-level performance requirements logically follow from the high-level goals and objectives.

Note: the STM is an industry standard tool used to translate overall mission goals and objectives into quantifiable experiment performance requirements. Consult Section 3.1 for best practices on developing a STM.</td><td>0 = Significant logical inconsistencies are evident in the STM. Measurement and instrument requirements are not well-described, missing units, or are unrealistic to achieve.

1 = The STM is logically consistent. The core experiment is feasible, but the STM requires more development. Elements of the measurements or instruments are unclear or under defined.

2 = The STM presents a clear, logical flow from each of the high-level Scientific Objectives down through the low level measurement and instrument requirements. All requirements are fully-defined and achievable.</td></tr>
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<tr><th colspan="2">2.3 System Architecture</th></tr>
<tr><td>Propose an engineering solution that will achieve the Scientific Objectives of the STM. Identify all subsystems of the design at a high level. Describe the important mechanical, electrical power, and data transmission interfaces between these subsystems.</td><td>0 = System architecture is incomplete or does not address the design requirements.

1 = A complete list of subsystems and interfaces is presented. Some technical specifications are missing or unknown. Minor modifications are needed to meet the design requirements.

2 = A complete list of subsystems is presented with appropriate specifications. All interfaces between subsystems are identified with appropriate specifications. The proposed design meets all requirements.</td></tr>
<tr><th colspan="2">2.4 Block Diagram</th></tr>
<tr><td>Include a schematic to accompany the design of the system architecture. The block diagram must include all subsystems listed in the System Architecture. Draw the mechanical, electrical power, and data transmission interfaces between these subsystems in the diagram. Consult Section 3.2 for best practices on developing this block diagram.</td><td>0 = Diagram is unclear or incomplete.

1 = Diagram identifies all subsystems and interfaces. Some specifications for components or interfaces require additional development.

2 = Diagram clearly outlines all subsystems with appropriate specifications. All interfaces are completely described with specifications.</td></tr>
<tr><th colspan="2">Section 3: Concept of Operations</th></tr>
<tr><th colspan="2">3.1 Equipment Requirements</th></tr>
<tr><td>Identify any specialized equipment, if any, that is required to meet the Scientific Objectives identified in the STM. For example, a biological experiment may require an autoclave for sterilization procedures. List any specialized equipment that is required for the project.</td><td>0 = Obvious specialized equipment requirements are not accounted for.

1 = Specialized equipment is identified. Procurement plan is reasonable but underdeveloped.

2 = Specialized equipment is identified and a clear plan for procurement is presented.</td></tr>
<tr><th colspan="2">3.2 Environmental Requirements</th></tr>
<tr><td>Identify the environmental conditions at the integration site and during the balloon flight that pose a risk to the Scientific Objectives</td><td>0 = Considerations for the integration-site and/or stratospheric environment are not accounted for.</td></tr>
</table>

identified in the STM. For each identified risk indicate the mitigation strategies and engineering controls that will be used to reduce the severity and/or probability of occurrence.	1 = Some risks due to the integration site or stratospheric environment have not been addressed. Further development of risk mitigation strategies is required. 2 = Risks to the Scientific Objectives due to the stratospheric environment are clearly identified. Appropriate mitigation strategies are presented to address each risk.
3.3 In-flight Operations	
Describe at the high-level the sequence that must be performed before the stratospheric balloon flight as well as upon recovery. Include a note on what the outcome of your experiment would be if recovery is not possible.	0 = Procedures are incomplete or not feasible. 1 = Procedures are achievable with minor modification. 2 = Procedures are clearly presented and achievable.
Section 4: Project Plan	
4.1 Funding Strategy	
Describe the funding sources your team will pursue over the course of the competition. Indicate the status of these funding sources, the amount, the eligibility requirements, the deadline to apply if funding is not already obtained, and any conditions this funding is contingent on.	0 = Few funding sources are identified. No clear plan is presented for project funding. 1 = Some funding sources are identified. Project finances are concentrated on one key source. 2 = A robust funding strategy is presented which targets a diverse set of sources throughout the entire course of the project. Specific team members have been assigned to specific sponsorship and funding tasks.
4.2 Outreach Strategy	
Describe the outreach events your team will host over the course of the competition and beyond the flight campaign. Indicate the specific names, dates, and persons responsible for each event. Include a series of events that target audiences from the general public, K-12 students, and the academic community. Describe the measurable outcomes your team will record to quantity the success of your outreach activities.	0 = Outreach plan is nondescript or does not indicate any measurable outreach impacts. 1 = Outreach plan contains some events that involve the general public, K-12 students, and the academic community. Dates and key stakeholders are not presented for all outreach events. Some outreach goals are defined 2 = A series of diverse outreach events are

	presented to involve the general public, K-12 students, and the academic community with outcomes of the project. Specific events are planned with dates and stakeholders. Clear, measurable outreach goals are defined for the entire course of the project.

2. COMPETITION OVERVIEW

2.1. Competition Timeline

2.1.1. Selection

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

- **Sunday October 6, 2024, 11:59 p.m. (ET)**: Submit your Application.
- **Monday October 30, 2024**: Teams will be notified of their selection and feedback will be provided by SMEs.

2.1.2. Project Milestones

NOTE: An updated timeline can be found on the CAN-SBX website (seds.ca/can-sbx). It is each team's responsibility to monitor the website and communications from SEDS-Canada for timeline updates.

Date	Milestone
Week of **Oct. 28, 2024**	**Kickoff meeting** with SMEs, selected teams and Faculty Advisor.
Sun., **Dec. 1, 2024**	Submit **Technical Questionnaire** (QT).
Week of **Dec. 2, 2024**	**Progress Presentation 1**.
Week of **Jan. 27, 2025**	Present **Preliminary Design Review** (PDR) to SMEs via teleconference.
Week of **Feb. 3, 2025**	Submit version 1 of **Experiment Safety Data Package** (ESDP).
Week of **Feb. 24, 2025**	**Progress Presentation 2**.
Week of **Mar. 31, 2025**	Present **Critical Design Review** (CDR) to SMEs via teleconference.
Week of **Apr. 7, 2025**	Submit version 2 of **Equipment Safety Data Package** (ESDP) and updated feedback sheet.
Week of **May 5, 2025**	**Progress Presentation 3** (if necessary).
Week of **June 2, 2025**	Submit **final ESDP** and updated Feedback Sheet for flight approval.
August 2025	Launch Campaign period (TENTATIVE).
Mid-August, 2025	Submit your Post-flight Survey (sent out as a Google Form) and Outreach Activities Report

	(OAR).

NOTE: Milestones requiring document submission should be made to cansbx@seds.ca. Specific instructions for submitting these documents will be provided to selected teams. Additionally, all presentations are given over teleconference and scheduled such that SEDS-Canada staff, the CSA, and the team are able to be present.

2.2. Funding Expectations

The costs of the stratospheric balloon flight are covered through participation in the competition. However, teams will be expected to fully fund the development of their experiment and the logistics of team travel to the Campaign site. Each team is encouraged to procure funds through university and government grants, corporate sponsors, etc. SEDS-Canada will inform you of any unique funding opportunities.
NOTE: Please contact cansbx@seds.ca with any funding concerns (especially if it is prohibitive to your team submitting an application).

2.3. Stratospheric Research

2.3.1. CSA's STRATOS Research Program

The CSA operates a stratospheric balloon program called STRATOS which provides Canadian academia and industry with an opportunity to test and validate new technologies and perform scientific experiments in a near-space environment, while inspiring and training the next generation of experts. Launches typically occur at the end of the summer in Timmins, Ontario.

Figure 2.1: Stratospheric Balloon Launched by the CSA in Timmins

2.3.2. Payload Constraints

The stratospheric balloons available for student-led experiments in CAN-SBX have to fit within a cylindrical volume of up to 600 mm in height and 300 mm in diameter, shown in Figure 2.2. It is possible for the payload to have a Nadir view through the bottom of the gondola as long as the payload respects the available volume. You may propose a payload that has small components which protrude from the allowed volume (e.g. antennas). However, you must acknowledge in your proposal that you would need to complete a Request for Deviation for this requirement and be aware that a **request may not be approved**. Other requirements are laid out in the Eligibility Requirements section of the application form.

2.3.3. Flight Campaign

The flight campaign occurs over a period of several days to allow for optimal weather and coordination with other flights. Teams must ensure they are able to deploy to the campaign location during the entire campaign. Payloads will be integrated onto the gondola before the flight. It is expected that teams will arrive at minimum the night before Day 1. Day 1 includes a series of orientation activities, training, and final integration checks. Teams should be prepared for their experiment to fly on the first day.

A typical flight begins with 1-2 hours of ascent until the balloon bursts at approximately 30 km and descends to the ground in approximately 30 mins. The location of the payload is tracked so that it can be recovered once it has hit the ground.

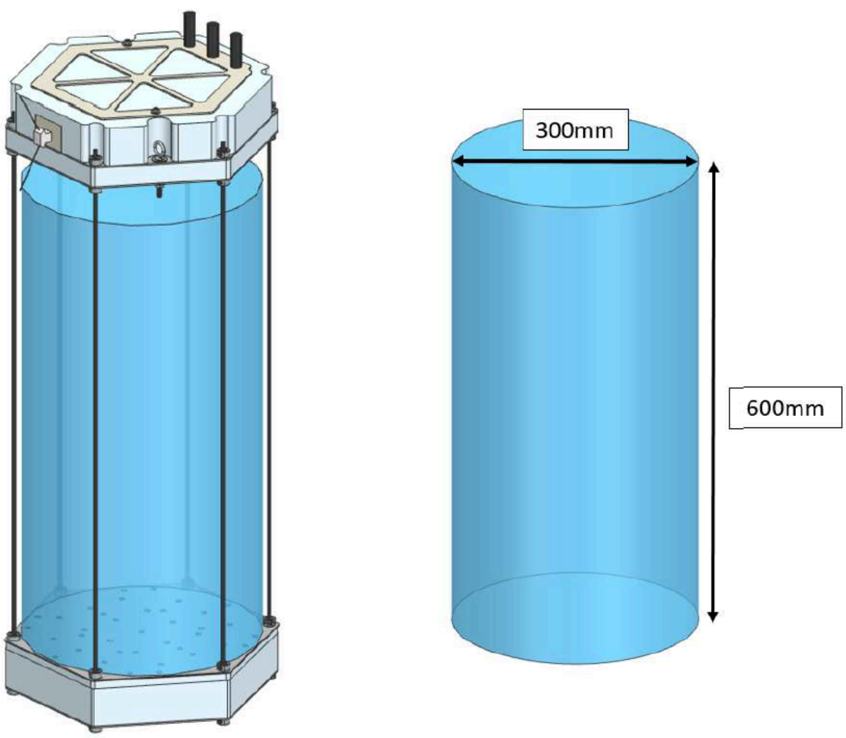

Figure 2.2: Payload volume constraint in blue. Note that the payload must be clear of the 6 rods on the perimeter.

3. TEMPLATES

This section contains templates to assist students in writing the research proposal. For questions regarding use of these templates please contact cansbx@seds.ca.

3.1. Science Traceability Matrix

A Science Traceability Matrix (STM) is a communication tool that is used to simply explain the importance of a scientific investigation and clearly outline how that investigation will be carried out. A good STM provides a high-level view of what an experiment sets out to accomplish and provides a continuous flow of logic to translate how the high-level objectives translate into quantifiable measurement requirements, and instrument performance metrics.

There are six columns that must be included in the Science Traceability matrix (STM):

Table 3.1: Required content for a Science Traceability Matrix (STM)

Scientific Objective	A specific line of investigation that supports the overall mission goal. The Scientific Objective should indicate the core question that is under investigation, and the type of physical phenomena that can be measured.
Measurement Objective	A description of one observable physical phenomena that is key to understanding the question posed by the Scientific Objective. Multiple Measurement Objectives may be required to meet the Scientific Objective.
Measurement Requirement	Quantify the specific characteristics of the measurement that are needed to meet the Scientific Objective. Description the range and type of measurement data that is needed to achieve the Scientific Objective.
Instrument	A description of the tool that is needed to conduct the measurement. In this section, name the tool that is needed to collect the experimental data.
Instrument Requirement	Quantify the minimum performance metrics for the instrument that will satisfy the corresponding measurement requirement. Units of measurement are needed for all instrument requirements. Common instrument requirements include the range, accuracy, precision, and repeatability of the instrument.
Mission Requirement	Describe the sequence of events that must occur which would result in a successful measurement. The experiment design must facilitate this sequence of events from occurring and provide the opportunity for the instruments to collect data at the appropriate events.

Table 3.2: Example Science Traceability Matrix for CAN-RGX

Scientific Objective	Scientific Measurement		Scientific Instrument	
	Measurement Objective	**Measurement Requirement**	**Instrument**	**Instrument Requirement**
A specific line of investigation that supports the overall Mission Goal	*Description of a observable physical phenomena that is key to understanding the Scientific Objective*	*Definition of the minimum measurement characteristics required to meet the Scientific Objective*	*Name of the tool that is required to conduct the measurement.*	*Definition of the minimum instrument performance metrics to meet the measurement requirement.*
Quantify the "sloshing" phenomena during fluid transfer in micro-g	Force transferred to the fluid chamber during filling in micro-g	Average force (N) in the direction of fluid transfer	Parallel beam type load cell	0-500 N range 0.1 N resolution 1 kHz sampling rate
Quantify the impact of flowrate on "sloshing" forces	Amount of fluid flowing through the test chamber during filling in micro-g	Average fluid flow rate (L/min) through the test chamber	Flowmeter	0-20 L/min range 0.5 L/min resolution 1 kHz sampling rate
Explore the impact of slat design on "sloshing" forces	Compare forces from fluid cells with different slat geometries	Use 2 different slat designs, plus a control design.	N/A	Experimental design must include 2+1 slat geometries

Mission Requirements *Describe the scenario that must occur to result in a successful measurement for the mission.*
The Mission Specialists must initiate the experiment after entering micro-g. Fluid must be forced through the test chamber during the period of micro-g. Load cell and flowmeter data must be sampled during this period and saved for post-processing. Three replicates for each of the experimental conditions must be captured for analysis. Fluid transfer must be completed within 20 sec, and should be completed in less than 15 sec.

Note: Additional resources to generating STMs may be beneficial to consult to further your understanding [1], [2], [3]

3.2. Block Diagram

A block diagram is a communication tool that is used to identify the design intent of the experiment. The diagram contains a series of blocks which indicate different components of the design. Each component is connected with a series of interfaces represented by lines. At minimum, the diagram must indicate the various mechanical, electrical, and data transmission interfaces between the different components. For the CAN-SBX competition, the block diagram is necessary to quickly identify the following information:

- What components are part of the payload
- How each component is mechanically connected together
- How does electrical power flow through the system, and where are the electrical inhibit systems
- How are command and data signals sent through each component

If any of the previous information is not clearly evident from the block diagram, that is a sign that the design requires more development. An example block diagram is provided for reference.

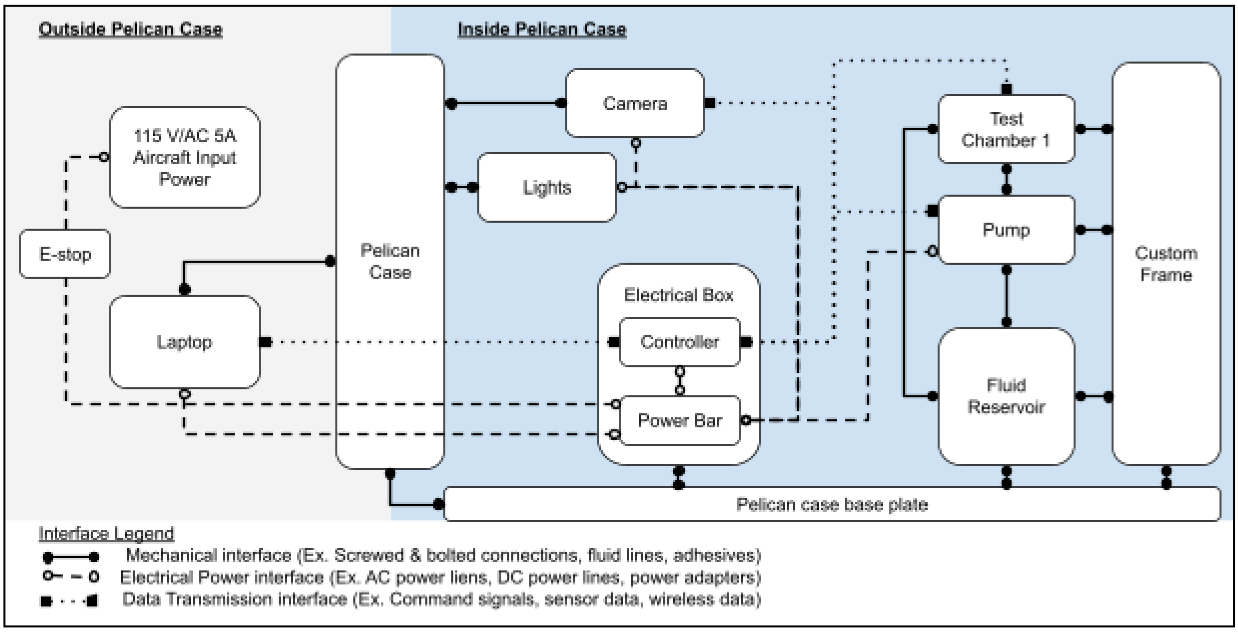

Figure 3.1: Example Block Diagram for CAN-RGX