The
Canadian Satellite Design Challenge
CSDC-7

General Rules & Requirements

Canadian Satellite Design Challenge
Conception d'un satellite pour un défi canadien
CSDC
TM

Presented by:

The Canadian Satellite Design Challenge Management Society Inc.

Issue 7a

September, 2024

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Acronyms

CSDC	Canadian Satellite Design Challenge
CDR	Critical Design Review
DIETR	Design, Interface, Environmental, and Test Requirements
EOL	End-Of-Life
FEM	Finite Element Model
ITU	International Telecommunications Union
LEO	Low-Earth Orbit
PDR	Preliminary Design Review
PMP	Project Management Plan
TBC	To Be Confirmed
TBD	To Be Determined
TLA	Three-Letter Acronym
TMM	Thermal Mathematical Model
TRR	Test Readiness Review
UTC	Co-ordinated Universal Time

Change Record

Date	Version	Changes
Sept. 2021	6a	New version for the Selfie-Sat mission of CSDC-6. Re-numbering of requirements from Version 5.
Sept. 2024	7a	Added in de-orbiting requirement; Selfie-Sat mission is optional.

1 Introduction

This document presents the general rules and regulations governing the participation of university teams in the seventh offering of the Canadian Satellite Design Challenge, which runs from September, 2024 to June, 2026.

This document presents the Rules and Requirements for the Canadian Satellite Design Challenge (ñCSDCò or ñthe Challengeò) ñSelfie-Satòmission.

These rules and requirements are applicable to all teams which will be participating in the Challenge, as well as to any faculty or industry advisors who may provide expertise to one or more teams.

1.1 Overview

The Canadian Satellite Design Challenge is a Canada-wide competition for teams of university students (undergraduate and graduate) to design and build a small satellite. The satellites will undergo full launch and space environmental qualification testing, with the goal of launching the winning satellite into orbit in order to conduct scientific research.

The CSDC is an innovative and academically-challenging initiative which will advance space education in Canada, inspire students to pursue science and engineering educations and careers, and prepare tomorrowôs leaders with the interdisciplinary teamwork skills which are necessary for success.

For more information regarding the general structure and objectives of the CSDC, please see the ñCSDC Overviewòdocument, available on the CSDC web-site (www.csdcms.ca).

1.2 Management and Schedule

The CSDC is managed by The Canadian Satellite Design Challenge Management Society Inc. (CSDCMS), with the generous assistance of experts and advisors in the Canadian space community.

The CSDCMS is responsible for all issues regarding technical requirements, team participation, sponsorships and fund-raising, communications and media relations, and government relations (e.g., regulatory requirements).

The planned schedule for this offering of the CSDC is shown in Figure 1-1.

The programme is intended to run over two academic years, starting in September, 2024. Environmental qualification testing is expected to occur after the completion of the second academic year, in May or June of 2026.

Although it is our goal to secure a launch for the winning teamôs satellite, we cannot guarantee it.

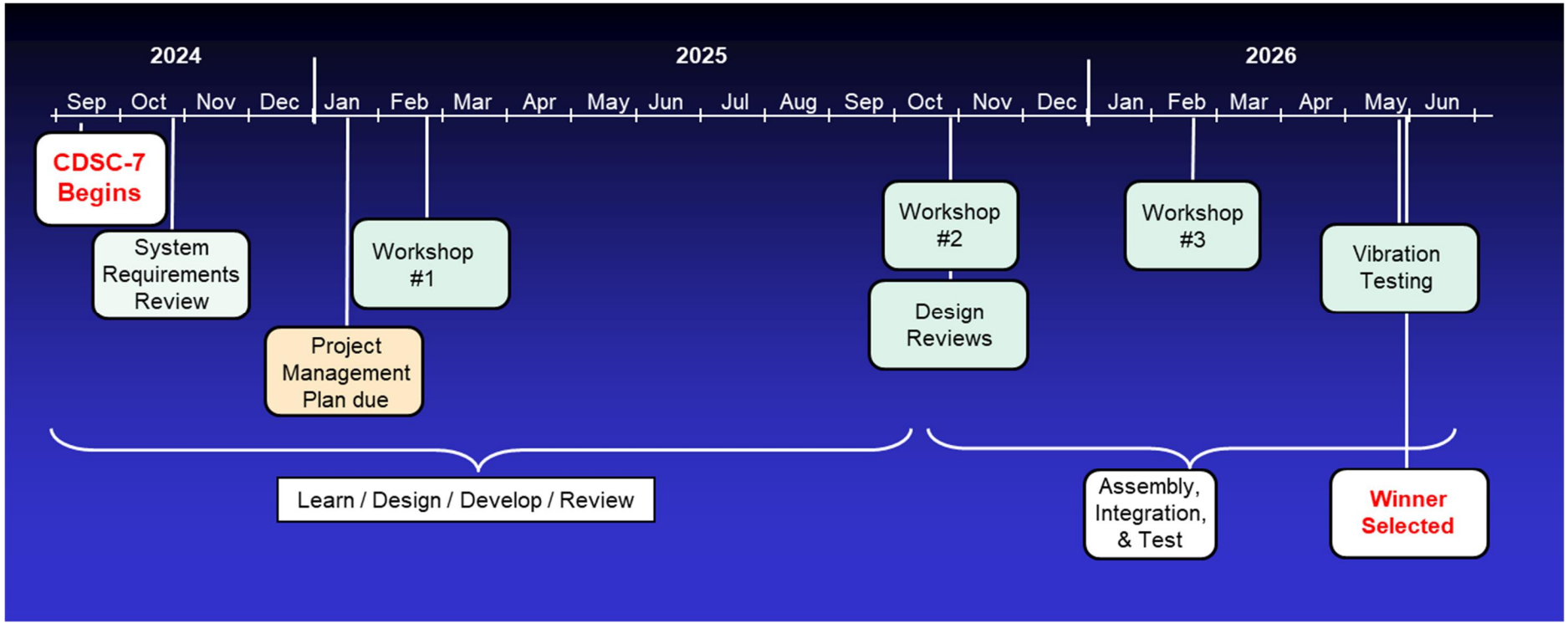

Figure 1-1. CSDC-7 Schedule.

1.3 Interpretation of Rules and Requirements

The CSDCMS will be the ultimate authority with regards to the interpretation of all rules and requirements of the Challenge. Official announcements from the CSDC Management shall be considered part of, and shall have the same validity as, the Rules and Requirements.

Any team may request interpretations of the rules and requirements of the CSDC; however, any questions, and their answers, may be copied to all teams (without revealing the source of the questions).

The wording of statements in this document determines their applicability:

- ñ**SHALL**ò or ñ**MUST**ò are used to indicate a mandatory requirement.
- ñ**MAY**ò indicates an option.
- ñ**WILL**ò indicates a statement of fact or intention.

The section and paragraph headings in this document are provided only to facilitate reading; they do not affect the paragraph contents.

These rules and requirements are subject to change if deemed necessary by the CSDC Management Team.

1.4 Point of Contact

The point-of-contact for the CSDC is:

Lawrence Reeves, CSDC Manager
5050 Elgin St. Vancouver, B.C. V5W 3J6
Phone: 778-988-6343
E-mail: LReeves@CSDCMS.ca

It is requested that only the Faculty Advisors and student team leaders contact the CSDC Manager regarding any issues or questions about the Challenge and their participation in it.

1.5 Reference Documents

The following documents may be applicable to this document, or just for reference. Any conflicts between this document and any of the reference documents, if not noted, should be brought to the attention of CSDC Management.

[RD-1] ñCSDC Design, Interface, Environmental, and Test Requirements (DIETR)ò, Issue 7a.

[RD-2] ñCubesat Design Specificationò, Rev. 14.1, Cal Poly SLO.
http://www.cubesat.org

2 General Requirements

The requirements in this Section apply to all participating teams, students, faculty co-ordinators, and team advisors.

2.1 Team Eligibility

The Canadian Satellite Design Challenge is open to teams comprised of post-secondary students, from universities and/or colleges. A team may be comprised of students from more than one university or college. Teams may also include participants from a foreign university or college.

Participating universities may enter more than one team in the Challenge; however, each team and its members must be independent of the other, and each entry must be a unique design.

There is no minimum or maximum number of students which may comprise a team, although between approximately 10 and 25 is recommended.

2.2 Team Member Eligibility

Individual team members must be students enrolled full-time or part-time in a programme at a university or college, in any faculty or department.

Because the duration of the CSDC will be over two academic years, students who are eligible to be team members for the first academic year of the competition (e.g., final-year students in the September 2024 to April 2025 academic year), may continue as team members even if they graduate or otherwise cease to be considered a student.

A student may be a member of only one team.

Because liability waivers may be required for certain portions of the Challenge, all team members must be old enough to legally enter into a contractual obligation.

2.3 Team Registration

In order to register for the CSDC, a team representative (student or faculty) should notify the CSDC Manager, by October 31, 2024, of their intention to participate.

The notification to the CSDC Manager shall identify:

- the name and contact information (e-mail and phone number) of one or two primary student contacts for the team (if determined at that time); and,
- (optional) a Faculty member contact.

The CSDC Management Team will acknowledge the registration. Applications beyond this date will be considered on a case-by-case basis by the CSDC Manager.

2.4 Registration Fee

There is no fee to enter a team.

2.5 Team Advisors

Each team may use any number of Advisors, e.g., from space industry companies, university faculty, or elsewhere.

Team Advisors may advise their teams on general principles of space missions, engineering, and project management theory, but may not design, fabricate, or assemble any part of the spacecraft,

or prepare any documentation or design review presentation material (although participating in presentations to the public is permissible and encouraged).

In summary, the satellite must be designed and built by the student team members without direct involvement from any Advisors. There are two potential exceptions to this requirement:

- An advisor may intervene where a design decision which the team makes is certain or likely to lead to spacecraft failure or a safety hazard; and,
- An advisor may perform specialised analyses, instruction, software programming, or other assistance, on the strict condition that the assistance is authorised by the CSDC Manager in advance and does not require more than 10 hours of effort.

In order to remove any appearance of conflict of interest, an Advisor for one team must not become a team member of, or an Advisor or Faculty Co-ordinator for, another team during a single instantiation of the Challenge.

2.6 Design Originality

Any spacecraft designed and presented for the CSDC must be an original design, the configuration of which is conceived by the student team members alone. It can, however, be a refinement of previous team designs.

Team members may use any publicly available literature or knowledge related to spacecraft design and construction.

Teams are welcome to collaborate with one or more professors, companies, or research institutions, on ideas for payloads. A team can accept an entire payload instrument from any of the above, and incorporate it into the spacecraft. The payload provider can provide only operational and interface requirements for proper use of the instrument, and must not contribute to the design of the bus systems which mount or operate it.

2.7 Compliance to the Rules and Requirements

By entering a team into the Challenge, the team, individual members of the team, faculty and industry advisors, and any other associated personnel, shall comply with, and be bound by, the letter, spirit, and intent of the CSDC Rules and Requirements, and all interpretations or procedures issued or announced by the CSDC Manager. All student team members, advisors, and other university or college representatives shall co-operate with, and follow all instructions from, the CSDC Manager.

Teams are responsible for reading and understanding the Rules and Requirements for the Challenge. Failure to do so may result in a team being disqualified from participation in the Challenge.

2.8 Official Languages

The official languages of the CSDC are English and French.

Design reports, review presentations, correspondence with the CSDC Manager, or other documentation, shall be prepared in one of these official languages.

2.9 Insurance

In order to participate in some CSDC events (e.g., environmental testing at the David Florida Laboratory), teams may be required to demonstrate that they have third-party liability or Commercial General Liability coverage from their respective universities. A minimum of CAD $2,000,000.00 is required in order to conduct environmental testing in the David Florida Laboratory, and likely is the same for testing at any other facility.

3 Selfie-Sat Concept of Operations

Selfie-Sat is a 3U cubesat mission. Its primary payload is the ñSelfie-Camò optical imager. The Selfie-Sat Concept of Operations is illustrated in Figure 3-1, and described here:

1. Once Selfie-Sat has been commissioned and is ready for nominal operations, Amateur Radio Operators (ñAROsò) from around the world may contact the Mission Control Centre (MCC) in order to request a ñSelfie-Sat Passò. The AROs will send the MCC the location (latitude, longitude) of the centre-point of the desired space selfie image.
2. The Mission Control Centre will reply to the amateur radio operator with information about the Selfie-Sat Pass start and end times, and a password that the Amateur Radio Operator will use for the pass.
3. The MCC will uplink the required roll angle (≤ 25 deg) for Selfie-Sat to be able to point the camera boresight (middle of the image) at the AROôs specified location during the pass.
4. During the pass, the ARO will contact Selfie-Sat, and will uplink the command to acquire an image when Selfie-Sat is over the desired imaging area. Only one image will be acquired during a Space-Selfie Pass.
5. As soon as the command is uplinked, Selfie-Sat will immediately take the ñspace-selfieò photo with the Selfie-Cam payload imager.
6. Selfie-Sat will then immediately begin to downlink the Space-Selfie photo to the ARO.

During a pass, Selfie-Sat may also downlink other information, such as a list of recent downlinks, or other material determined by the CSDCMS (TBD).

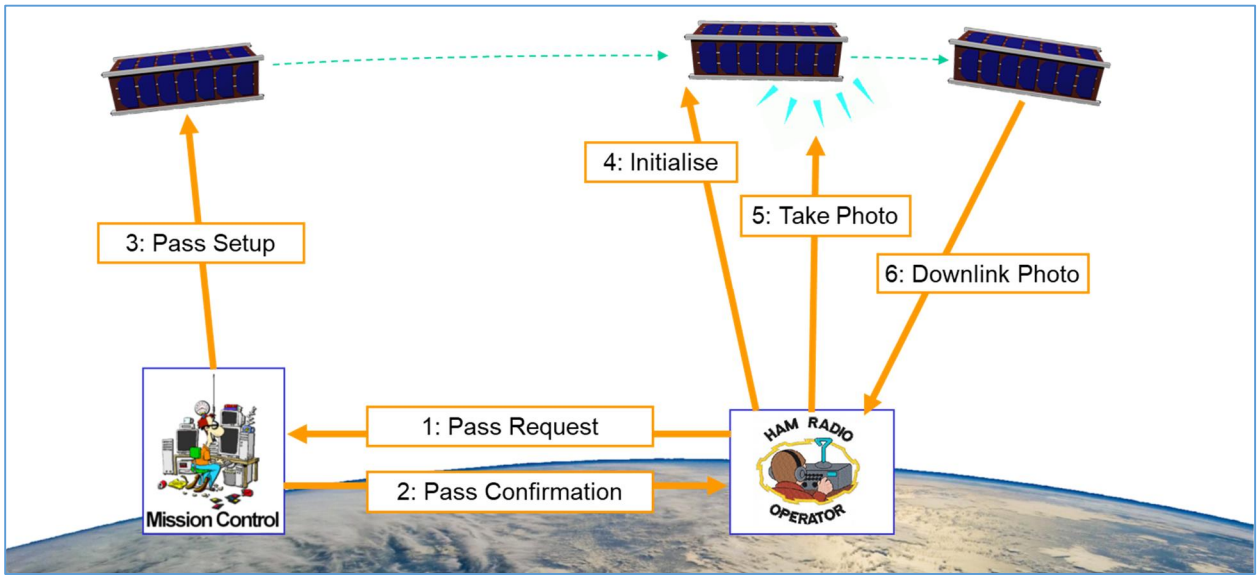

Figure 3-1. Selfie-Sat Concept of Operations.

4 Mission and Spacecraft Requirements

4.1 Mission Requirements

Note: The implementation of the Selfie-Sat mission is optional. Thus, any Requirements referring to SelfieSat are only applicable if implemented.

4.1.1 Optional Primary Mission: Selfie Sat

[CSDC-0100] **Selfie-Sat Mission**

The spacecraft shall fulfill the ñSelfie-Satòmission as outlined in the Concept of Operations (Section 3), to acquire a ñSpace-Selfieòoptical image when commanded by an Amateur Radio Operator, and to downlink it immediately to that Operator.

[CSDC-0110] **Only One Space-Selfie Per Pass**

The spacecraft shall acquire at most one image per Space-Selfie Pass.

[CSDC-0120] **Space-Selfie Image Geographic Dimensions**

The Space-Selfie image shall encompass an area of at least 40km x 40km, and not more than 120km x 120km, on the ground at nadir, assuming a 400km altitude.

4.1.2 De-Orbit Mission

[CSDC-0130] **De-orbit Mission**

The spacecraft shall include the capability to decrease the spacecraftôs semi-major axis quicker than otherwise would occur through natural atmospheric drag decay.

4.1.3 Additional Missions & Payloads

[CSDC-0140] **Additional Payloads**

The spacecraft may contain additional payloads at the Teamôs discretion and choice.

4.1.4 Orbit

[CSDC-0150] **Orbit**

Teams shall design their missions to be able to operate in a Low-Earth Orbit (LEO), between 300 km and 600 km.

At the time of the release of this document a launch has not been procured, and more specific orbit parameters cannot be given; thus, it is advantageous to have a mission and satellite design which can operate in both a sun-synchronous orbit, and in the orbit of the International Space Station (inclination = 51.66°).

[CSDC-0160] **Orbit Knowledge**

It shall be possible to determine the spacecraftôs orbit parameters throughout the mission, to an accuracy as required by the mission.

4.2 Spacecraft Requirements

4.2.1 General Design Requirements

[CSDC-0170] **Spacecraft General Design**

The spacecraft shall be designed to accomplish its mission purpose and to maintain spacecraft health during the design lifetime of the mission.

The spacecraft shall be passive and self-contained (i.e., electrically OFF, no charging of batteries, no telemetry, and no other support) from the time it is loaded into the launch dispenser until after its deployment on-orbit. This may encompass a duration of several months.

[CSDC-0180] **Spacecraft Design Life**

The spacecraft shall be designed for a nominal mission lifetime of one year.

[CSDC-0190] **Design for End-of-Life**

The spacecraft shall be designed such that all requirements are met at nominal End-of-Life (EOL).

[CSDC-0200] **Comply with DIETR**

The spacecraft shall comply with all requirements of the ñCSDC Design, Interface, Environmental, and Test Requirementsò(DIETR) [RD-1].

4.2.2 Power Subsystem

[CSDC-0210] **Power Subsystem General Requirements**

The spacecraft shall incorporate sufficient power generation and power storage capability to support all operational states and modes during the design lifetime of the mission. More specific requirements for the Power system are given in the ñCSDC Design, Interface, Environmental, and Test Requirementsò(DIETR) [RD-1].

4.2.3 Communications Subsystem

[CSDC-0220] **Comply with ITU Regulations**

The spacecraft shall comply with the International Telecommunications Union (ITU) applicable radio licensing regulations for the required Radio Frequency operations.

[CSDC-0230] **Timing of Radio Communications**

The spacecraft shall not generate or transmit any radio signal from the time of integration into the launch dispenser until at least five minutes after on-orbit deployment; however, the spacecraft can be powered ON immediately following deployment.

[CSDC-0240] **Space-Selfie Communications Characteristics**

The spacecraft shall use the AX.25 protocol for communications with the Amateur Radio Operators during a Space-Selfie pass. The uplink communications rate shall be at least 1200 bps; the downlink communications rate shall be 9600 bps. Communications shall be duplex.

[CSDC-0250] **Space-Selfie Link Budget**

Communications with Amateur Radio Operators for Space-Selfie passes shall be possible above an elevation angle of 10 degrees, with a link budget margin of at least 6dB.

[CSDC-0260] **Space-Selfie Data Downlink Duration**

Under nominal operational conditions, the spacecraft shall have the ability to downlink the entire Space-Selfie image within 90 seconds.

[CSDC-0270] **Command and Telemetry Communications Characteristics**

The team may choose the communications characteristics for the command uplink and telemetry downlink.

4.2.4 Telemetry, Command, and Control

[CSDC-0280] **Spacecraft Commanding**

The spacecraft shall have the ability to receive and execute immediate or time-tagged commands from the Mission Control Centre.

[CSDC-0290] **Space-Selfie Command Subset**

The spacecraft shall have a subset of commands for Amateur Radio Operators (AROs) to establish a connection with the spacecraft during a Space-Selfie Pass, and to command the spacecraft to immediately acquire an image with its Selfie-Cam. The spacecraft shall not accept any other immediate or time-tagged commands from AROs.

[CSDC-0300] **Command Uplink Encrypted**

All uplinked commands from the Mission Control Centre shall be encrypted, using as a minimum 56-bit-key Data Encryption Standard (DES). Commands uplinked by Amateur Radio Operators during a Space-Selfie pass are not required to be encrypted.

[CSDC-0310] **Command Uplink Encryption Time-Out**

If the spacecraft has not received a valid encrypted command for 48 hours, it may accept un-encrypted commands.

[CSDC-0320] **Command Storage**

The spacecraft shall have the ability to store time-tagged commands for up to three days prior to executing them.

[CSDC-0330] **Safety-critical Commands**

Any safety-critical or deployment commands shall be implemented as a two-step process.

Comment: This means that at least two separate commands must be sent in order to activate a deployment. Ideally at least one of the commands will be sent from the Control station during a pass, but this is not always possible (e.g., for initial antenna deployment).

[CSDC-0340] **Spacecraft Telemetry Collection**

The spacecraft shall record at least four different points of spacecraft health telemetry, each at a frequency of at least one sample every minute.

[CSDC-0350] **Spacecraft Telemetry to be Time-tagged**

The spacecraft shall time-tag all telemetry data.

[CSDC-0360] **Telemetry Downlink Latency**

Under nominal operational conditions, the spacecraft shall have the ability to downlink telemetry data with a latency of less than 12 hours from when it was recorded.

4.2.5 Attitude Determination and Control

[CSDC-0370] **Co-ordinate System for Selfie-Cam Operations**

The co-ordinate system for the Selfie-Cam operations shall have the Z+ axis towards geodetic nadir, the X+ axis in the orbital velocity direction, and the Y+ axis completing the right-hand axis system.

[CSDC-0380] **Attitude Extent for Selfie-Cam Operations**

The Space-Selfie camera shall be able to be pointed up to 25 degrees off-nadir in the roll axis; the nominal pitch and yaw for Selfie-Cam operations shall be zero degrees.

[CSDC-0390] **Attitude Control**

The spacecraft attitude shall be controlled (3σ) to an angle no greater than one-quarter of the Space-Selfie camera's along-track and across-track Field-of-View angles.

Comment: For example, at 400km altitude an across-track Field-of-View of 6.0° (full angle) would require across-track attitude control of ≤ 1.5°, in order to ensure that, in the worst case attitude control situation, the targeted image centre point will still be in the image.

[CSDC-0400] **Attitude Determination Fault-tolerance**

The Attitude Determination subsystem shall be designed so that it is tolerant to at least one attitude sensor failure, and will maintain at least a degraded state of performance.

[CSDC-0410] **Attitude Control Fault-tolerance**

The Attitude Control subsystem shall be designed so that it is tolerant to at least one attitude actuator failure, and will maintain at least a degraded state of performance.

4.3 Ground Segment and Operations Requirements

[CSDC-0420] **Ground Segment Hardware**

The winning team shall provide a computer which will be used for spacecraft operations (i.e., to contain any mission planning, monitoring, and analysis software). The CSDC Management will provide the necessary Ground Segment hardware, consisting of the transmit/receive antennas, and any required antenna controller hardware, in order to communicate with the spacecraft during passes. The Ground Segment hardware provided by the CSDC Management will remain the property of the CSDC Management.

[CSDC-0430] **Spacecraft Operations Facility**

The winning team shall be responsible for providing a suitable location for the Ground Segment hardware (i.e., the transmit/receive antenna(s), any required antenna controller hardware, and the spacecraft operations computer hardware).

[CSDC-0440] **Spacecraft Operations Costs**

The winning team shall be responsible for any costs associated with maintaining and operating their operations facility.

[CSDC-0450] **Spacecraft Operational Lifetime**

The winning team shall be responsible for the operation of the spacecraft (consisting of mission and operations planning, command uplink transmission, data and telemetry downlink reception, and data storage and distribution) for a period of at least one year following launch.

The winning team may continue spacecraft operations past the one-year period, at their discretion and cost. Extended use of the ground segment hardware provided by CSDC Management will not be unreasonably withheld.

[CSDC-0460] **Network Operations Facilities**

The winning team may permit any other participating university to establish an operations facility for the purpose of performing any aspect of spacecraft operations. The CSDC Management will provide any requested information about the Ground Segment; however, the CSDC Management will not provide any hardware, and will not be responsible for any associated costs, for any additional operations facilities.

5 Programmatic Requirements

5.1 Documentation and Analyses

5.1.1 Exportable Technology

[CSDC-0470] **Exportable Technology**

The spacecraft shall only contain components which can be exported from Canada to any of the following countries without restrictions: India, Russia, United States, French Guyana, New Zealand.

Comment: The CSDCMS will manage any export permit paperwork and/or any required interfacing with the Canadian Government regarding the export of the satellite for launch.

5.1.2 Project Management Plan

[CSDC-0480] **Project Management Plan**

Each team shall prepare and submit a Programme Management Plan (PMP) to the CSDC Manager for review. The CSDC Manager will distribute specific details regarding the format and content of the PMP.

5.1.3 Mechanical Modelling and Analyses

[CSDC-0490] **Finite Element Modelling and Analysis**

Each team shall create a Finite Element Model (FEM) of their spacecraft. This model will be used to perform structural analyses to show compliance to the mechanical loading requirements, and as a prediction for environmental testing. The specific requirements for the FEM and analyses are currently TBD, and will be released separately.

5.1.4 Thermal Modelling and Analyses

[CSDC-0500] **Thermal Mathematical Modelling and Analysis**

Each team shall create a Thermal Mathematical Model (TMM) of their spacecraft. This model will be used to perform thermal analyses to show compliance of the design to the mission thermal environment, and as a prediction for environmental testing. The specific requirements for the TMM and analyses are currently TBD, and will be released separately.

5.2 Design Reviews

5.2.1 Preliminary Design Review

[CSDC-0510] **Preliminary Design Review**

Each team may be required to give a short presentation (~10 to 15 minutes), about their planned mission, at a CSDC Workshop which is expected be held in early 2019. The presentation should focus on the mission payloads, and the scientific or research importance of the resulting data.

5.2.2 Critical Design Review

[CSDC-0520] **Critical Design Review**

Each team shall prepare a Critical Design Review (CDR) presentation.

The teams shall present the final spacecraft design, documentation or analyses which were requested arising from PDR, and the facilities and process to build and test the satellite and prepare for Space Qualification Testing.

The possible outcomes of the CDR are either pass or fail. In the event of a pass, the CSDC Management Team reviewers may still request additional documentation or make recommendations to the team, to assist them in the manufacturing stage. In the event of a fail, it may be recommended that the team withdraw from the Challenge and not proceed with the manufacturing stage.

In advance of the CDR, the CSDC Management Team will prepare and distribute specific details regarding the format and content of the material to be presented.

Teams are responsible for their own travel and accommodation costs to attend CDR; however, the CSDCMS has, in past, arranged a workshop to coincide with the CDR, and has offered travel and accommodation subsidies for each team to attend.

5.3 Spacecraft Environmental Test Campaign

The Spacecraft Environmental Testing Campaign will proceed as described in the ñCSDC Design, Interface, Environmental, and Test Requirementsò(DIETR) [RD-1].

5.3.1 Test Readiness Review

[CSDC-0530] **Test Readiness Review**

A Test Readiness Review (TRR) will be held prior to the Environmental Qualification Test campaign, at which each team shall demonstrate that their spacecraft has been fully constructed per their design presented at the Critical Design Review (including any permitted post-CDR changes), and is ready to proceed to environmental qualification testing.

In advance of the TRR, the CSDC Management Team will prepare and distribute specific details regarding the format and content of the material which is to be presented.

5.3.2 Environmental Qualification Testing

Details of the environmental qualification test campaign are given in the ñCSDC Design, Interface, Environmental, and Test Requirementsò(DIETR) [RD-1].

5.4 Spacecraft Final Selection

The CSDC Managing Body will review all relevant documentation and test results to select one or more winning satellites, based on the CSDC judging criteria.

6 Other Requirements and Issues

6.1 Intellectual Property

[CSDC-0540] **Ownership of Science Data and/or Intellectual Property**

Ownership of any Science Data or Intellectual Property arising from a teamôs participation in the CSDC shall be consistent with the policies in place at their university.

No claim on any resulting Intellectual Property will be made by the CSDCMS or any other entity affiliated with the CSDC (e.g., sponsors or advisorsôcompanies), unless covered by a separate pre-existing agreement.

[CSDC-0550] **Provision of Science Data**

Notwithstanding any policies and/or agreements which may affect any participating university team, the winning team agrees that it shall provide the science data to any participating team which requests it, after a period of at most one year following the date of downlink.

6.2 Educational Outreach

[CSDC-0560] **Educational Outreach Requirements**

Among the many objectives of the CSDC are the following:

- to motivate and inspire pre-university students to pursue science and engineering educations, which can lead to one of a multitude of challenging and rewarding space-related careers or research positions.
- to highlight the benefits and importance of satellites and space for Canadians.
- to increase public awareness and interest in the applications of satellite missions, and the importance of satellites and space for Canadians.

To that end, at least once per academic year each team shall be required to give presentations to a variety of audiences:

- at least one presentation to an elementary school; and,
- at least one presentation to a secondary school; and,
- at least one presentation open to their university campus; and,
- at least one presentation to the general public in the universityôs town/city (off-campus); and,
- at least one presentation to a sponsoring/participating company or professional organisation (e.g., professional engineering association).

The presentation can combine topics of:

- general satellite applications
- Canadian space mission history
- satellite design, particularly their teamôs satellite design and purpose
- applications/importance/benefits of satellites for Canadians

- science and engineering education disciplines involved in space missions

Teams are encouraged to distribute the responsibility of giving the presentations among as many team members as possible, rather than having the same few members give all presentations.

Each teamôs Faculty Advisor shall verify that the team has met this requirement. This requirement shall be met by the start of the Environmental Test Campaign.