LAUNCH CANADA CHALLENGE

2025 Rules & Requirements Guide

Revision History

REVISION	DESCRIPTION	DATE
R0	Initial Release for the 2024-2025 competition cycle.	11-Oct-24
R1	Revised submission deadlines for IDP, PDR and progress updates. Added information on progress updates. Increased parity with DTEG. Improved language.	13-Oct-24
R2	Specified time deadline for all deliverables. Revised format and submission for IDP. Clarification on submission of Payload Challenge documentation for FDR. Added information to scoring breakdown.	21-Oct-24
R3	Added report page limits and file naming convention. Added information regarding Payload Challenge documentation submissions. Added clarification and details for scoring breakdown.	24-Nov-24

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1.0 INTRODUCTION

The Launch Canada Challenge is Canada's premier national rocketry competition that supports the development of talent in the interdisciplinary field of rocket engineering, while fostering a strong culture of safety. It includes two launch challenges as well as a technology development challenge for component and subsystem-level technologies. The competition aims to be a flexible, adaptable framework to support innovation across the full range of rocket and launch-related technologies, and actively works with stakeholders to create challenges that solve real industry problems. Through national collaboration, this competition provides a local launch opportunity for Canadian students, encourages innovation across the multidisciplinary field of rocketry, and helps Canada's advanced rocketry community to take their activities to the next level.

1.1 BACKGROUND

In over 25 universities across Canada, teams of passionate and committed students are leading the world in developing sophisticated rocket technology and participating in innovative ways to develop amateur sounding rockets. The Launch Canada Challenge provides an opportunity for these students to present, test and demonstrate their best work in aerospace engineering and launch vehicle-related technology within Canada. This national competition rewards the initiative of these teams and their commitment to space technology and engineering excellence, and provides them with an unmatched, real-world learning experience that will help place them in the top tier of young engineering talent.

With backing from its visionary sponsors across diverse industries, Launch Canada helps channel the passion and develop the skills of young scientists and engineers in the cross-disciplinary field of rocket engineering.

1.2 PURPOSE & SCOPE

This document defines the rules and requirements governing participation in the Launch Canada Challenge, including information regarding each of its competition challenges, code of conduct, procedures, timeline, expected deliverables and general guidelines for teams to refer to.

This document is not a detailed guide for the technical requirements for the Launch Canada Challenge. A detailed overview of the technical requirements can be found in the ***Launch Canada Design, Test and Evaluation Guide (DTEG)***, provided by Launch Canada via its webpage.

This document is also not a detailed guide for how judging and scoring is conducted for the Launch Canada Challenge. A detailed overview of the judging process, including the scoring rubrics used to assess each team, titled the ***Launch Canada Judges Handbook***, has been prepared internally by Launch Canada.

Should there be any questions or concerns regarding the information provided in this document, teams are encouraged to reach out to the organizers for support.

1.3 REVISION

It is expected that this ***Launch Canada Rules & Requirements Guide (R&R)*** may require revision from one competition to the next, based on the experiences and lessons learned by both host organizations and the participants. Revisions will be accomplished by complete document reissue. The authority to issue revised versions of this document rests with Launch Canada.

2.0 LAUNCH CANADA COMPETITION OVERVIEW

With the goal of helping students develop their skills in rocketry and boosting the aerospace industry in Canada, Launch Canada has different challenge levels for teams to choose from. The aim is for students to safely demonstrate their ability to develop requirements and engineer real aerospace systems that meet them, whether that system is a component or an entire rocket vehicle. The competition is divided into three challenges as described below. A common goal of all three challenges is to cultivate an understanding of good systems engineering practices that can help a team to be successful in taking on complex aerospace problems. As a result, teams are expected to formally define the requirements for their project, such as target altitude, and they will be judged on their complete engineering design, development and testing process, and on how effectively the final product meets the requirements for which it was designed.

- **Launch Challenge**: The central rocket engineering, launch and recovery challenge. All vehicles must target an apogee of at least 914 m (3,000 ft). This challenge is broken down into two categories based on complexity of the project:
  - **Basic**: Restricted to single-stage vehicles with Commercial Off-The-Shelf (COTS) rocket motors. The motor total impulse must not exceed 40,960 N·s (9,208 lbf-s, i.e., “O” impulse motor; FAA Class 2). This category (also called “Basic Launch”) is geared towards both new teams just getting started in rocketry, as well as more experienced teams who may want to flight test new technologies for the first time using off-the-shelf propulsion systems.
  - **Advanced**: For rockets using Student Researched And Designed (SRAD) or multi-stage/clustered propulsion. This category (also called “Advanced Launch”) is geared towards teams with more experience that wish to create more complex rockets and undertake their own propulsion system development. A rocket is fundamentally a complex aerospace system, and this category focuses on rigorous systems engineering.

- **Technology Development Challenge**: Aimed at rocket component or subsystem design and development, this challenge (also called the “Tech Dev Challenge”) is for teams that wish to perform new research and take a “deep dive” into specific areas of rocket technology, develop specialized expertise, or take their ideas to market. This challenge is designed to provide the freedom for teams to pursue different areas of interest in rocketry and any relevant technology may be entered. Unlike the other challenges, the Tech Dev Challenge emphasizes how engineering requirements are driven by and beholden to business objectives. The business case for a project may comprise of, but is not limited to, novel products, services, training or establishing an institution. This challenge culminates in a demonstration at the competition to illustrate the key project progress in support of identified business objectives.

- **Payload Challenge**: A rocket’s ultimate purpose is to carry a payload that performs a useful function and Launch Canada teams are encouraged to develop and fly an innovative payload as part of their project. All payloads will be evaluated as a separate technology based on function and scientific value of the experiment, but this challenge is not “stand-alone”, and payloads must be entered with the intent of launching onboard a rocket that has also been entered into the Launch Challenge. Additionally, payloads must not perform a function that controls or influences the trajectory of the rocket itself; such entries are to be entered into the Tech Dev Challenge instead. There are no specific constraints on payload envelope or weight, but teams are strongly encouraged to follow good systems engineering practices to ensure the vehicle design properly accounts for the payload, and that the payload, in turn, respects the constraints provided by the vehicle.

3.0 COMPETITION RULES

SRAD propulsion systems are defined as those designed by students—regardless of whether fabrication is performed by students directly, or by a third party working to student-supplied specifications—and can include student designed modifications of COTS systems.

Multi-stage or clustered complex launch vehicles and all chemical propulsion types (solid, liquid and hybrid) are allowed. Note that all propellants used must be "non-toxic". Ammonium perchlorate composite propellant (APCP), potassium nitrate and sugar (aka "rocket candy"), nitrous oxide, liquid oxygen (LOX), hydrogen peroxide, kerosene, ethanol and propane are all considered non-toxic. Toxic propellants are defined as those requiring breathing apparatus, special storage and transport infrastructure, extensive personal protective equipment, etc. (e.g., Hydrazine and N_2O_4).

At the current time no vehicle can exceed 18,288 m (60,000 ft) AGL or drift further than 27 km from the launch site which, depending on the failure modes of the recovery system, might further limit approved altitude. This is to encourage teams to define their own target and engineer a system to meet that target through careful analysis, simulation, testing and potentially the use of control systems. Any teams that wish to target an altitude greater than 6,096 m (20,000 ft) above ground level (AGL) will require Launch Canada's prior approval. The approval process will require much more detailed trajectory modeling and analysis of the vehicle's flight.

There is considerable freedom for teams to create unique and impressive rockets, however for the sake of safety and logistics of recovery there are basic technical requirements and standards that must be complied with. These can be found in the DTEG. All participating teams are expected to be familiar with the DTEG. Additionally, all projects must comply with Canadian law. Launch Canada reserves the right to reject a proposed project if there are safety or legal concerns with any aspects of it.

Payloads shall not contain significant quantities of lead or any other hazardous materials. Similarly, any use of radioactive materials shall be permitted only if deemed operationally necessary and such operational necessity is concurred with by competition officials. If approved, any such materials shall be fully encapsulated and are limited to 1 μC or less of activity. Finally, payloads shall not contain any live, vertebrate animals.

3.1 TOTAL IMPULSE LIMIT

All rockets flown at Launch Canada must fall within the Transport Canada definition of Low Impulse Suborbital Rockets, i.e. having a total impulse of not more than 889,644 N·s (200 000 lbf-s). Within this, there is no specific restriction imposed on the thrust level or total impulse of the rockets entered into the Advanced category of the Launch Challenge. Teams are however strongly encouraged to keep their total impulse within the definition for FAA Class 2 (i.e., having a combined total impulse of 40,960 N·s (9,208 lbf-s) or less). Rockets having a total impulse greater than this are contingent on approval by Launch Canada. There may be other propulsion restrictions listed and it would be pertinent to refer to the DTEG.

3.2 ROCKET TRACKING & TRANSMISSIONS

All parts of the rocket that are intended to be recovered separately (e.g., separate multistage parts, deployed payloads, etc.) need to have a COTS tracking device incorporated into them. This should allow teams to track and recover all components. The COTS system may be the primary or back up system, but its presence is required. Teams will be required to declare in their final report the frequencies of all radio devices on their vehicle and ground support equipment. Teams must be able to change the frequency of these systems within channel parameters to prevent interference upon discovery of shared frequencies after their reports are read. Teams may choose to transmit on a Canadian license-exempt frequency band (e.g., the 33 cm (902-928 MHz) band). Use of the 70 cm (430-450 MHz) or APRS is also permitted, but as these frequencies require an amateur radio (HAM) license, the team must have at least one member present at the event who is suitably licensed. Teams choosing to use radios on any frequency CB, UHF, VHF, HF, ELF, GMRS, FRS, or otherwise for communications, must declare all channels or frequencies intended for use including backup frequencies. Teams may be told to change frequencies based on Launch Canada communications or the communications of other teams, especially if any interference is found at any time during the competition event itself.

3.3 OFFICIAL ALTITUDE LOGGING

Teams are required to prove that their altitude matches that which the rocket was designed for and simulated to achieve. For this purpose, all rockets must carry a COTS barometric altimeter with on-board data storage, which will provide an official log of apogee for scoring. This may be a standalone COTS product, or a feature of a COTS flight computer, for example one used for recovery system deployment. If the project features a deployable payload, the official altitude logging device shall be mounted to the launch vehicle and not the payload.

At the launch site, there will be a designated area used for judges. Each team must report directly to their assigned judges at the competition once they return after recovering their rocket, bring any necessary equipment to show judges their recovery data (e.g., laptop and cable), and be prepared to also email this same information to Launch Canada at competition@launchcanada.org. Some altimeters are designed to report apogee through a series of beeps, but beeps shall NOT be accepted except as a last resort. Failure of a team to provide their recovery data to Launch Canada will result in them receiving no score for this aspect of the Launch Challenge.

3.4 ROCKET MARKINGS

The team's identification (ID) number (a number assigned by Launch Canada), project name, academic affiliation(s) and contact information shall be clearly identified on the launch vehicle airframe, nose cone, and other locations where possible. In case a rocket is lost, contact information for the team should be marked on the vehicle so that it can be returned if found. The Team ID especially, shall be prominently displayed (preferably visible on all four quadrants of the vehicle, as well as fore and aft), assisting competition officials to positively identify the project hardware with its respective team throughout the LC Challenge.

The centre of gravity (CG) and centre of pressure (CP) location of the fully loaded vehicle shall be clearly marked on the rocket. For liquid/hybrid rockets, the fully fueled CG can be a calculated value.

There are no further requirements for airframe coloration or markings; however, LC offers the following recommendations to student teams:

- Mostly white or lighter tinted color (e.g., yellow, red, orange, etc.) airframes are especially conducive to mitigating some of the solar heating experienced during a launch on a hot day in the summer.
- High-visibility schemes (e.g., high-contrast black, orange, red, etc.) and roll patterns (e.g., contrasting stripes, “V” or “Z” marks, etc.) may allow ground-based observers to more easily track and record the launch vehicle’s trajectory with high-power optics.
- Any form of green or brown colours, for example as associated with camouflage patterns, are strongly discouraged. Remember, you may need to find your rocket in a forest, so make sure it stands out!

For deployed payloads, all requirements for marking remains consistent with the rest of the launch vehicle.

4.0 TEAM COMPOSITION & ELIGIBILITY

4.1 STUDENT TEAM MEMBERS

Teams entering the competition may be high school, college, undergraduate or graduate run student teams. These teams may have any educational background and may consist of any number of students. However, due to constraints at the launch site, teams may be asked to limit the number of participants they bring to the site of the competition itself.

Teams are generally encouraged to assign student members to specific roles and may structure their teams how they see fit. However, specific names must be assigned for the following 4 roles and officially communicated to Launch Canada as part of the competition entry:

- **Faculty Advisor**: a high school/college/university faculty/staff member who provides official oversight of the team. *If the team is from a high school, then this role must be fulfilled by an individual who is over the age of 18 years old.*
- **Team Captain**: a team member who is responsible for leading the team and the main point of contact for logistical and technical questions by LC safety personnel.
- **Chief Engineer**: a team member responsible for overseeing and coordinating the engineering activities of the project. They are responsible for managing the project requirements, flowing them down to the sub teams doing the work, and ensuring the final design meets the requirements.
- **Chief Safety Officer**: a team member with overall safety responsibility. They are responsible for working with their team to identify the safety hazards associated with the team's project and activities and ensure those hazards are mitigated through design, training, operations, and the proper use of protective equipment. *If the team is from a high school, then this role must be fulfilled by an individual who is over the age of 18 years old.*

In support of active outreach and building the talent pipeline, teams from colleges and universities may also invite individuals from local high schools to join their team. However, for a team to be considered as still from a university or college, a maximum of 15% of the team composition is allowed to consist of members under the age of 18 years old who are still attending high school(s).

All individuals considered as team members must be listed on a team's roster and this complete roster list submitted to Launch Canada. For all individuals under the age of 18 years old, a signed parental consent form must also be submitted.

4.1.1 TEAM ORGANIZATION & SUBMISSION LIMITATIONS

Teams may participate in one or both launch categories, but they may not compete in both using the exact same rocket. Should a given team choose to enter different rockets into separate launch challenges they may do so. It is also permissible, however, for a team to simultaneously enter one of the launch categories and the Technology Development Challenge, if the launch itself is used to perform a flight demonstration of a new technology present on a rocket.

If a team joins the competition with the intent of competing in a given challenge or category but decides over the course of the year that they wish to change it, this change may be permitted until the Final Design Report is submitted. However, it is extremely important to note that if a team does make this change, that any deliverables submitted prior will no longer be included in the team's final score for the competition.

Teams must notify Launch Canada of any planned challenge or category changes as early as possible.

If a team is entering with more than one project, they must submit a separate entry form ***for each of their projects***. Separate deliverables will also be expected for each of the entries, including the presentations and reports. Teams are permitted to enter any number of projects, subject to overall limits imposed by Launch Canada personnel requirements. Teams with multiple entries must select a single project (excluding Payload Challenge projects on a competing rocket) for competition scoring purposes. For example, a team with entries in the Advanced Launch and Tech Dev Challenges must select one project for scoring.

4.2 OUTREACH, DIVERSITY & INCLUSION

Aerospace and rocketry have always had a powerful ability to inspire and motivate people to take on difficult problems and pursue excellence. We know that diversity is one of our greatest strengths and that Canadians from all backgrounds and in all places have limitless potential to accomplish amazing things. One of Launch Canada's goals is to ensure that Canadians from coast to coast can take part and harness that inspiration.

Student teams have been the "front line" for Canadian rocketry, and all teams are strongly encouraged to be ambassadors for Canadian rocketry and pursue an active and creative outreach program to build links in their own communities and beyond to:

- Build awareness of science, technology, engineering and mathematics (STEM), aerospace, and rocketry in particular;
- Showcase the work and accomplishments of the team, and the value of Canadian rocketry and space;
- Encourage the next generation of Canadians to pursue rocketry and STEM, including especially those from traditionally under-represented communities;
- Include all Canadian communities, from urban to remote, in the nation-wide effort to explore and develop space.

Teams will be evaluated in part based on the scope, creativity, and demonstrated effectiveness of their outreach programs in meeting the above goals. Many paths exist to accomplishing this effectively, but Launch Canada strongly encourages the following as a blueprint to build upon:

In general, teams should have a formal outreach program led by at least one team member overseeing outreach activities as part of their management team (as partial or full responsibility).

In terms of communication with the public, the teams are encouraged to have a social media platform (or more) on which they openly share updates regarding their development efforts and competition attendance. The teams can also leverage funding opportunities with their institution or governmental organizations to be able to share their progress on national and international platforms through conferences (e.g., IAC, SSC, etc.), webinars, tabling events (e.g., AstroFest, etc.) and more. It is also recommended that all team members understand holistically the technology their team is presenting to competition (with a focus on recent advances) so that they can explain and communicate their technology to other teams and audiences from school children to seniors.

To promote the education and awareness of the public in the STEM fields, teams are encouraged to prepare at least one educational activity linked to their technology for members of the public visiting the Launch Canada competition, that are accessible to audiences of all ages. If they develop innovative technology during the year, Launch Canada also encourages teams to share a short-form 15-minute presentation on the topic for the conference section of the competition to share their newly acquired knowledge openly with the local community.

Launch Canada teams are similarly advised to hold such presentations and similar events throughout the development year to educate and spread knowledge about rocketry and STEM to their local communities across Canada.

Inclusivity, education and training can also be embodied through sharing between teams! More experienced teams are encouraged to provide support and guidance for younger, less experienced teams attempting technical challenges (e.g., test site development and safety procedures). Not all teams have equal resources, thus sharing knowledge and helping each other can be a great way to bridge these uneven foundations and help grow a safer, more sustainable, equitable and, overall, exciting rocketry field in Canada.

Finally, to uphold the ***highest degree of inclusivity, respect and cultural awareness***, teams must remember that when they attend competition, they are guests in a community that is generously hosting us, and their actions and interactions with members of the community reflect on Launch Canada. All attendees should inform themselves of the local customs of the community in which the competition is taking place and conduct themselves in a respectful and culturally sensitive manner.

All of these are ways to contribute to a longer-term vision of the Canadian student rocketry field and thus are elements that can contribute to the Launch Canada competition.

4.3 MENTORSHIP

Rocketry is a complex, multidisciplinary field with a steep learning curve, particularly for newer teams or those exploring advanced areas like experimental propulsion. Experience is essential for ensuring safety, success, and avoiding common mistakes. Inexperienced teams often face launch delays, last-minute rework, or competition failures. Therefore, it is strongly recommended that teams seek out one or more experienced mentors to provide guidance and help avoid common pitfalls.

Many Launch Canada rockets align with advanced high-power rocketry (HPR), and there is an active community of experienced individuals, both in Canada and internationally, who can assist with key areas such as airframe design, recovery systems, avionics, and telemetry. These mentors are often affiliated with organizations like the Canadian Association of Rocketry/Association Canadienne de Fuséonautique (CAR/ACF), Tripoli Rocketry Association (TRA), or the National Association of Rocketry (NAR). For teams working on advanced propulsion, such as hybrid or liquid engines, it is especially important to seek mentors with relevant experience—ideally former propulsion leads from other institutions—who can provide expert guidance and help avoid "groupthink" within the team.

First-time competitors, high school teams or teams that have faced repeated failures in the past two years must have a high-power certified mentor approved by Launch Canada.

Launch Canada requires all high school teams to have an onsite mentor attend the competition in person to ensure proper guidance and oversight. This mentor must be certified at the level of motor the team plans to fly. For example, if a team plans to fly with a Level 3 (TRA/NAR or L4 CAR/ACF) motor, the mentor must be certified to that level and have flown a Level 3 motor (M, N or O) with successful electronic deployment. Mentors are also required to participate in at least one virtual review (IDR, PDR or FDR) for both their team and another team. While additional sub-team mentors are welcome, they are not mandatory.

Although new college/university teams are not required to have an onsite mentor, it is strongly recommended that they do so for additional support during competitions. Having a local mentor who can work closely with the team is invaluable and Launch Canada staff are also available to provide feedback on official deliverables or design reviews throughout the year.

If a team lacks a mentor, Launch Canada can help identify a suitable individual. Teams should seek mentors from impartial third parties, ideally outside their immediate network. While former team leads from other programs can serve as effective mentors, former team members from the same program should not be considered for this role, although their input can still be useful.

5.0 PROJECT DELIVERABLES & DEADLINES

To participate in the competition and to allow for the evaluation of the project as it progresses, teams will have several deliverables to submit. This includes the following:

DELIVERABLE	DUE DATE	HOW TO SUBMIT	SCORED?
Entry Form and Participant Clearance	Friday, October 25, 2024	Online form	
Post-Mortem Report (for all participants in competition cycle from prior year)	Friday, October 25, 2024	competition@launchcanada.org	
Initial Design Proposal (slide deck)	Friday, November 1, 2024	competition@launchcanada.org	
Initial Design Review	Start: Friday, November 1, 2024	Online form	
Project Technical Reports and Forms			
Preliminary Design Report	Friday, January 31, 2025	competition@launchcanada.org	
Progress Update Forms	With each report and by: Saturday, December 28, 2024 Saturday, April 5, 2025 Saturday, June 21, 2025	competition@launchcanada.org	
Site Plan (for Advanced Launch or Tech Dev	Last Friday in May	safety@launchcanada.org	
Engine Static Test Firing Request	Prior to engine testing	safety@launchcanada.org	
Engine Static Fire with Flight Hardware	With Final Design Report	Include in Final Design Report	
Flight Hardware Abort Test	With Final Design Report	Include in Final Design Report	
Final Design Report	Monday, July 21, 2025	competition@launchcanada.org	✓
Virtual Inspections	Minimum 2 weeks prior to competition	Online form	
Ops Rehearsal (for Advanced Launch)	Final Design Report	Email safety@launchcanada.org to schedule	
Additional Documents			
School Participation Letter	Friday, July 11, 2025	events@launchcanada.org	
School Insurance	Friday, July 11, 2025	events@launchcanada.org	
Signed Waiver	Friday, July 11, 2025	Online form	
Competition Fees			
Competition Entry Fee ($250)	Friday, December 6, 2024	e-transfer to adam@launchcanada.org Cheque or bank transfer possible	
Deadline for Entry Fee Refund	Friday, May 16, 2025		
Rocket Fee ($500)	Friday, June 6, 2025		
Rocketeer Fee ($65 per attendee)	Friday, June 6, 2025		

<u>**Deadlines/Due Dates:**</u>

Unless specified otherwise, all deadlines are at 11:59 p.m. in your team's local time zone.

<u>**Report Formatting & Content:**</u>

Templates for technical reports may be found on Launch Canada's website. These templates are more guidelines to follow than a rigid structure, but they are intended to convey the basic content that is expected. Appendix B: Elements of A Technical Report lists some of the various required aspects of a technical report that must be included in a submission. The following subsections describe each of the deliverables in more detail and provide context to their purpose and function.

All design reports and presentations submitted to Launch Canada shall adhere to the following naming convention:

Team <u>#</u> - <u>Team Name</u> - <u>TLA</u>

where the underlines indicate values to be filled in by the team. The "#" should be replaced by the team ID number assigned for the competition by Launch Canada. "TLA" is a three-letter acronym for the deliverable name as follows: Post-Mortem Report = PMR, Initial Design Proposal = IDP, Preliminary Design Report = PDR, Final Design Report = FDR. For Payload Challenge submissions, append "Payload" to the file name.

<u>**Report Length Limits:**</u>

The design reports also serve to showcase the communication and technical writing skills of the team. Reports should be as concise as possible, without compromising on completeness or clarity. **As such, the design reports outlined in Sections 5.2, 5.4 and 5.7 must be no more than 275 pages, including their appendices.**

<u>**Document Revisions:**</u>

All teams are expected to submit any revisions to deliverables on or before the assigned due date. In cases when LC staff request additional information (especially regarding safety concerns), the team should submit a revision. In other cases, LC staff will only use the last revision provided before the submission deadline.

<u>**Recommended Supplemental Documents:**</u>

A major focus of Launch Canada is rigorous engineering design and development. As such, if a team has performed research, developed reliable testing or operating procedures and gathered well logged data, they may also submit that documentation to be reviewed. Creating a working system or procedure is valuable in industry and thus, effective procedures and well documented engineering drawings may also be submitted.

Teams shall include links to all test results (data, documentation and videos) in each report or progress update for Launch Canada staff to review.

<u>**Conference Day Presentations:**</u>

At the end of the Launch Canada Challenge competition cycle, specifically on days known as the "conference days", Launch Canada invites external presenters to give special talks on a variety of aerospace related topics (after these designated days teams proceed with attempting to launch their rocket, payload or operate their technology demonstration). The conference days are also an excellent opportunity for teams themselves to present topics to attendees related to their entries and further demonstrate their own communication and outreach skills to the general public. If a team so wishes to give a presentation, then, at the discretion of Launch Canada, they may be awarded bonus points for such presentations. However, the following guidelines apply:

- Duration between 15-30 minutes.
- Presentations that primarily cover overall system architectures and/or consist of technical information

readily obtainable by reading the team's final report alone, will not be awarded bonus points.

5.1 ENTRY FORM & PARTICIPANT CLEARANCE

All teams are required to complete and submit an entry form to participate in this challenge. The entry form will allow teams to state their intent to participate, declare the category (or categories) in which they wish to compete and the expected number of students that will attend the competition event. Note that final confirmation of participation will occur after the technical report has been submitted and the proposed project has met the safety requirements (more details below). Teams may be denied the ability to participate should their project not meet the safety and engineering standards outlined in the *DTEG*, and should those shortcomings not be rectified.

5.2 POST-MORTEM REPORTS

As the final deliverable of the competition cycle, Launch Canada teams are requested to provide a brief post-mortem report, regardless of whether the flight within the Launch Challenge or Technology Development Challenge, as applicable, was successful or not. The report should be submitted as soon after the competition as possible, and this report must be received before the team will be permitted to register for the following year's competition. This report is meant to serve as a record of the team's operations and flight or demonstration at the competition and a comparison to the team's predictions. It is also intended to summarize any problems or anomalies that arose during setup and operations, and to identify the lessons learned and changes that will be made. This information provides an important record for the teams to preserve for future years, while also helping Launch Canada identify problems that might be addressed through our own standards, training and event planning. It also helps us demonstrate to government bodies that we as a community are constantly learning and improving based on our collective experience. The post-mortem report must include:

- **Executive Summary:** Give a quick overview of the launch or demonstration, including setup, flight performance and/or key data obtained, and any problems, mishaps or failures that occurred. If the launch or demonstration failed to occur, summarize what happened to prevent it. Discuss the determined root causes of any such problems and summarize any changes you'll be making next time to address them.
- **Overview of Preflight Operations:** For projects in the Launch Challenge, summarize your setup and prelaunch activities. If any problems came up that caused delays or prevented your launch, discuss them, what you learned, and what you'll be doing differently next time. This can include technical/hardware issues but can also include operational issues relating to planning or preparedness shortcomings.
- **Test Setup:** For projects in the Technology Development Challenge, describe the final test setup used, including photographs and summarize all instrumentation used and their final locations and orientations.
- **Overview of Flight/Demonstration Results:** As applicable, summarize your flight performance, test data, actual apogee and a description of nominal and off-nominal events. Provide photos where appropriate. For advanced launch teams the estimation of impulse and thrust curve of motors or engines based off the acceleration curves from altimeters and the measured mass at launch will provide valuable insight as to the accuracy of thrust curves determined from static tests. If pressure data was recorded that should also be sent in with the thrust curve from flight.
- **Recovery Location:** Provide details of the recovery location (GPS coordinates), and comparison of the actual recovery point with your predictions from simulation.
- **Recovery Operations:** Description of the recovery operation, ideally including photos: how did you find the rocket, were there any challenges in locating it or reaching it, and did you learn any lessons to improve

location and recovery in the future? Provide photos of any damage sustained to the rocket.

- **Failure Investigation**: When something does not go according to procedure or identifies shortcomings in procedures regardless of severity (but prioritizing more severe issues), describe what happened. Include photos and other details to clearly document it. Present the analysis of the root cause of the failure using the available data, as far as possible, and explain any changes you'll be making in the future to your design, manufacturing, testing and/or operations to prevent the failure next time.

- **Summary of Deviations**: Although a Final Design Report should fully reflect the final product that will be brought to competition, Launch Canada recognizes that sometimes design changes might still occur for various reasons even after project deadlines and deliverables have been met. Though this is not ideal from a project management and systems engineering point of view, it is important that any late modifications or changes made to the rocket, project, test plans or operations be thoroughly documented, substantiated and reported. If changes in a design were made prior to arriving at the competition (in the last cycle), the team will also be expected to describe what all those deviations were.

5.3 INITIAL DESIGN PROPOSAL & REVIEW (IDP)

The first deliverable is intended to provide a technical mission- and concept-level overview of the team's project so that Launch Canada understands the planned project and the team's strategy. This is an opportunity for the team to receive feedback from Launch Canada's volunteers, to ensure the team has a sound project and a feasible approach for achieving it, and to identify any potential problems early on. The IDP should aim to provide Launch Canada (and the team) with a clear overview of the project and relevant technologies. The IDP is a critical time to highlight low TRL/high risk components and how the team intends to make them succeed. The clearer the proposal, the easier it will be for Launch Canada volunteers to provide actionable and useful feedback, which can be translated into requirements to guide development efforts.

<u>Content Outline:</u>

This shall be a presentation slide deck that should include (listed below in no particular order):

- An overview of the team: its history and past accomplishments, structure, current members and leads.
- An overview of the team's past and planned outreach activities.
- A summary of the planned project, highlighting the key design goals, performance targets and design features.
- In the case of technology development projects, the report should present some background on the context behind the technology. Why is it important? What industry need does it address? Who are the most critical internal and external stakeholders of this technology? Does the team intend to attempt to bring their project to market or not, and why or why not? And it must identify what the final hardware deliverable will be and what sort of demonstration is proposed.
- In the case of Advanced Launch projects utilizing a non-flight proven technology for the team, whether that be a SRAD avionics system, recovery system, or propulsion system (such as but not limited to a cluster, staged vehicle or the first hybrid or liquid engine) identify the long term goals that these flight untested systems seek to fill in the future development of the team and why they need to be tested on a vehicle of this scale.
- An overview of the mission and concept of operations (ConOps). In the case of a launch project, this should identify the major phases of flight and events, target apogee, and a trajectory simulation.
- A mass budget, showing a breakdown of vehicle masses as used in the trajectory simulation, and an overview of any assumptions made.
- A look at each subsystem, summarizing the key design features.
  - For launch projects, this should include details of the planned airframe structure (materials,

construction and key dimensions), fins (dimensions, thickness and attachment), recovery system (design parameters, parachutes, cords, attachments and deployment approach), avionics (description, identification of COTS and SRAD avionics, power sources, telemetry and an overview of their planned installation and wiring) and propulsion (motor selection, mounting and thrust structure).

  - For SRAD propulsion, it should also include the key details of the propulsion system, including the key performance parameters (propellants, thrust, chamber pressures, burn duration, estimated specific impulse, ignition method), thrust chamber design (injector, chamber & nozzle sizing, seals, materials and construction details), propellant tank design (operating pressures and safety factors, sizing and key dimensions, materials and an overview of construction/fabrication details), fluid controls (valves and actuators, regulators, instrumentation, overpressure protection, primary and backup abort draining systems) and any ground support equipment for propellant loading, offloading, ignition and engine operation.

- A summary of the planned payload, if any.
- An overview of planned component and subsystem tests, including when the tests will be performed, what type of testing will be conducted for each (i.e., design/development, qualification or acceptance) and how the resulting data will be used.
- A project timeline.
- A summary of project risks, in other words, technical or non-technical factors that could affect the ability of the team to complete the project, and what is being done to mitigate those risks.
- Note that it is reasonable at this stage for the team to still be considering multiple candidate designs (i.e., trade studies) for a given component or subsystem. In such cases, the candidate options should be summarized, and the team should identify how and when they will be choosing between them.

Initial Design Review:

The reviews will consist of a 30-minute walkthrough of the submitted IDP slides and an open discussion of the team's proposed project. All teams will be invited to select their review time slot via an online sign-up sheet. It is crucial that key members involved in the design be available for the review since there will be questions regarding specific details and the design choices made by the teams. The submitted IDP slides and any other relevant materials will serve as reference to explain the project and goals. The reviews will go over the high-level mission/concept design choices to ensure projects adhere to Launch Canada rules and are feasible for the team. This review format enables Launch Canada staff/volunteers to directly address areas of concern or higher risk subsystems and components and provide actionable feedback.

The reviews will be recorded, and the video will be provided to the team for reference. Launch Canada staff/volunteers will also provide the team with written feedback to help them as they progress with their projects and will flag any concerns that the team will be expected to address.

5.4 PRELIMINARY DESIGN REPORT (PDR)

The intent of technical reports submitted for the Launch Canada Challenge is to ensure that the rocket design and build process are properly documented. Additionally, they help evaluate the design and manufacturing decisions and allow corrections to be made throughout the engineering process. Feedback will be provided on all the submitted reports, and calls between the team and Launch Canada will be set up to discuss any areas of concern.

The preliminary design report (PDR) will be due early in the new year. As the first design milestone, the PDR should comprehensively cover the design and project progress up to the end of the preliminary design phase. By this stage, the team's design should be largely finalized [or mature], with all major subsystems and components designed and/or selected and few if any unresolved design choices to be made. As such, this report should represent a thorough description of the project. Note that this does not require the system to be manufactured by this point. As necessary, teams should provide indications for specifications yet undetermined (i.e., To Be Confirmed (TBC), To Be Determined (TBD)). This allows for highlighting work in progress and for relating plans to verification and validation (V&V) efforts.

Other elements that should be included are an up-to-date and fully fleshed out timeline, and an up-to-date testing plan and identification of project risks. In addition, the report should include a thorough quantitative hazard analysis for the project. This should clearly identify any hazards associated with the project and operations, as well as potential hazards resulting from component or system failures. It should attempt to identify the likelihood and consequences of each, and identify how they will be mitigated, through design, operations, and/or safety measures. This section should clearly demonstrate to the reviewers that the team understands the hazards associated with their project and has a sound approach for mitigating them. For all SRAD propulsion systems used in either the Launch Challenge or Technology Development Challenge, teams must calculate safety clear zones; refer to the *DTEG* for further details. For all SRAD propulsion systems in the Launch Challenge, teams must define flight criteria and calculate maximum impact range and flight impact hazard areas; refer to the *DTEG* for further details.

For each subsystem, the team should be able to identify what the key information is that a reader would need to understand and assess the design. This should be presented as concisely as possible, making extensive use of clearly labeled and dimensioned figures. Supporting data and additional details, such as detailed drawings of main components, calculations or detailed descriptions of analyses and/or tests may be included in appendices, with only the important highlights summarized in the main body of the report. **For Launch projects with accompanying Payload projects, the information on the payload is to be submitted within the document as a single appendix. This Payload Appendix does not count towards the overall report page limit.**

For all Launch Challenge projects, teams should provide references that include links to videos and test data. Though not an exhaustive list, this information should pertain to testing of recovery systems and their mechanisms, and any additional flight test demonstrations used in place ground testing. Please refer to the *DTEG* for further details regarding technical and operational requirements for such tests.

For projects in the Launch Challenge or Technology Development Challenge that employ SRAD or modified COTS propulsion systems, teams should provide references that include links to videos and test data. Though not an exhaustive list, this information should pertain to propellant fill and drain tests, instrumented full burn duration static hot-fire tests (i.e., minimum of propellant tank pressure, chamber pressure and thrust measurement testing), and ground testing of composite and metallic tubes. Please refer to the *DTEG* for further details regarding any further technical and operational requirements for such tests. For all technology demonstrations it is critical that, either directly within the body of the preliminary design report or attached as appendices, test plan(s) the team intend to use in their demonstration for Launch Canada are included, and that it is made clear what type of test the plan(s) will cover (i.e., design/development, qualification and/or acceptance). Any deviations from those originally stated as envisioned in the team's initial design proposal should also be indicated.

This report does not form part of the team’s final score; rather, Launch Canada’s reviewers use it to help ensure the team is on the right track to a project that will have a high likelihood of success, and most importantly, that will be deemed safe to compete.

5.5 PROGRESS UPDATE FORM

With the submission of each report deliverable and at intervals between each major report, teams will be required to fill out a progress update form. This form will be sent out to the teams prior to the submission deadlines with more information. This will be in the form of an initial declaration of some flight details and then function as a change log. The format of this form will be very short answer and multiple choice. There will be a comment section but this is not the place for prose. Questions that can help other teams should be asked in the Discord. Very specific questions should be sent to reviewers. Teams shall include links to all test results (data, documentation and videos) in this form for Launch Canada staff to review. Like the PDR, the Progress Update is not part of the team's final score but serves as a means for Launch Canada to ensure the team is progressing towards a safe and acceptable final product.

5.6 ENGINE STATIC TEST FIRING REQUEST

Static test firing of engines is a critical part of any SRAD rocket propulsion development and is also one of the most hazardous steps in the process of developing a rocket. Prior to performing any static test firing of engines, teams must submit their engine test stand design and static test firing procedure for review. Launch Canada will review test stand design and test firing procedure to ensure that they are acceptable and well thought out. This review is a straight-forward go/no go decision. Teams must receive approval before conducting any test firing attempts. Review of a team's test stand design and test firing procedure can occur whenever the team is ready, with the caveat that they should allow several weeks for the review. Additional information can be found the document *Requirements for Static Test Firing Approval*.

Any static tests to be performed at the Launch Canada event itself MUST have completed their static test firing approval. Additionally, any rockets to be flown at the competition that will be powered by a SRAD motor MUST have successfully completed full thrust, full duration static testing of the engine. Any test that did not meet the full expected delivered impulse or thrust of the theoretical design must be modeled in a trajectory analysis program such as OpenRocket, RocketPy or RockSim to determine whether the rocket would be safe to fly with the measured performance. In the event of low thrust, longer burn duration, lower specific impulse, long startup transient, pressure excursion, or other off-nominal cases, data must be sent to LC advanced safety personnel to investigate implications to the rocket's flight. The team should do this same analysis to determine whether changes need to be made and retested or if the reduced performance is acceptable for operation.

Upon completion of any approved tests, teams shall make the data available to Launch Canada for review. A link to videos of all testing regardless of success shall be included in submitted documentation. All testing documents and files should be dated in the "YYYY-MM-DD-DescriptionOfContent" format to indicate the most recent and representative test.

5.7 FINAL DESIGN REPORT (FDR)

This report will be due approximately one month before the competition. It represents a significant component of the team's final score in the competition. The FDR should build upon the PDR and should reflect the final configuration of the project, thoroughly supported by analyses and test data. It should be comprehensive, containing all details of design, manufacturing and testing. This should include the research performed and appropriate tables and charts. This report should convince judges of thoroughness, quality, reliability and safety of the project. The more flight ready the team is at the "30 days to launch point", the more impressive this report will be. It would also be expected that teams include their assembly and pre-flight checklists in this document. **For Launch projects with accompanying Payload projects, the information on the payload is to be submitted as a separate document.**

All teams are expected to submit their final report and any revisions to it, on or before the assigned due date. In cases when LC staff request additional information (especially regarding safety concerns), the team should submit a revised version of the FDR. This revised version will not be scored, however, if it is submitted after the initial FDR deadline. Instead, the scoring will be based on the last version submitted on or prior to the deadline. The team may also be offered the option to submit a summary that outlines the key critical differences between the original and revised FDRs to ease with their reviews.

5.8 STAKEHOLDERS MEETING

In industry it is commonplace to present project progress updates during meetings with stakeholders. For example, a group of engineers may be working on a research and development project but be requested to meet with their company directors (i.e., internal stakeholders) and present directly to them metrics, such as key performance indicators (KPIs), to convince them that their project should continue. Or, with the aid of the marketing department, this same group of engineers may be requested on another day to do a pitch presentation to a room full of investors (i.e., external stakeholders) and make arguments as to why their project is worth investing in.

To help provide students exposure to these similar scenarios, teams within the Technology Development Challenge must create and give a 15-minute presentation during the conference days, followed by a 15-minute question period. This presentation, for purposes of the Technology Development Challenge, is herein called the "Stakeholders Meeting" and it is important for teams to be aware that all presentations will be streamed live through the online video sharing and/or various social media platforms used by Launch Canada (e.g., YouTube, etc.). Aside from spectators, the public or even potentially investors in attendance, judges attend each Stakeholders Meeting, ask questions to the team during the question period, and use these sessions as another means to aid in general evaluation and scoring. Presentations for each Stakeholders Meeting must, at minimum, include slides that discuss the following:

1. Brief introduction of the team.
2. High level information about the team's technology project and setup.
3. Explanation of why the technology being developed is important (to the team and/or industry).
4. What results the team hopes to obtain from their demonstration.
5. Metrics that were used by the team to help keep development on track throughout the competition cycle, such as key performance indicators (KPIs).
6. A cost breakdown of all components and hardware used to build and assemble the team's technology demonstration.

Teams who wish to use the Stakeholders Meeting as an opportunity to attempt to pitch to the general audience their project are certainly encouraged also to do so. As a result, to help argue the business case side of their project, teams are free to expand their presentation to include discussions on their strategies to bring their technology to market, strengths/weaknesses/opportunities/threats (SWOT) analyses, and even include figures that have cashflow diagrams. Note that the 15-minute time limit, however, still applies to all Stakeholder Meeting presentations, regardless of any additional content added.

5.9 SITE PLAN (ADVANCED LAUNCH / TECH DEV)

Teams in the Advanced Launch or Technology Development categories tend to have unique projects, with unique ground support equipment, propellants/energetics and quantities. These can all differ greatly from project to project. To enable safe and efficient site setup, all teams in the Advanced Launch and Technology Development categories must submit a site plan to Launch Canada.

The Site Plan must include:

- A clear, labeled and dimensioned schematic of the launch or test area, showing at minimum:
    - The launch pad, launch trailer(s), and/or test stand.
    - Any blast deflection devices, clearly indicating the direction they will be oriented, or the permissible range of directions.
    - Location of any anchor points for guy wires, cables, and any other launch pad or test stand anchoring features, including a description of the type of anchor.
    - Location and layout of all major pieces of ground support equipment, plumbing lines, control transmission wires, electrical wiring, and generators
    - Location of all propellant vessels, compressed gases and pyrotechnics. This must include their location during the test itself, as well as the location of any storage or marshalling areas where they may be kept.
    - Location and inventory of all safety gear.
    - Location and description of any required terrain features:
        - Berms or embankments
        - Ditches
        - Trenches
        - Walls
        - Buried cable runs
        - Etc.
        - And how you intend to create them without the use of heavy equipment
    - Location of any required vehicle access routes. Remember that the site is a mixture of rocks and sand and/or consist of other natural impediments to vehicles. If it is critical for you to be able to get a vehicle into certain areas, those areas should be clearly indicated and the team should acquire appropriate vehicles for their operations. If areas need to be further flattened than observed in previous years, the team should make plans to tamp down the sandy rocky soil to meet the needs for their setup.
    - Dimensioned safety clear zones around the launch pad, test stand, and any other areas that may require it (e.g., propellant storage areas). All calculations of clear zones must account for both overpressure and shrapnel.
    - Dimensioned zones that must be kept clear of shrubs, trees and any other flammable objects.
    - Indication of where personnel need to be during a launch or test, including:
        - Minimum required distance.
        - Maximum allowable distance.
        - Any directionality constraints: can personnel be located anywhere outside a certain radius, or do they need to be in a specific direction from the site? How much flexibility is there on where personnel are stationed?
        - Any sight line constraints.
        - Any required structures or gear at the personnel area: tents, canopies, tables, bunkers, trailers etc.
        - All dimensions provided relative to the launch pad/test stand.
        - An itemized list of all energetics that will be present, including both the number and the mass or volume, referenced to the site schematic.
    - Compressed gas cylinders
    - Fuels
    - Oxidizers
    - Pyrotechnics
    - Generators

- An itemized list of any anchoring features that are needed, including the type, number and size. This can include concrete blocks, sandbags, ground anchors, etc. A description of plans to install those features.
- An itemized list of any safety gear, beyond normal PPE, that the team will be bringing or requiring. This could include fire extinguishers, water tanks / pumps, fire blankets, shovels, first aid kits, etc.

5.10 VIRTUAL INSPECTIONS

A major goal of all safety inspections conducted by Launch Canada staff is to verify the overall build quality of the rocket or technology demonstration. This cannot easily be assessed by a design report, but discovering major problems during safety inspections at the event itself leaves insufficient time to address them. As a result, teams must schedule a virtual inspection at least 2 weeks prior to the launch event. This can be done over Zoom or a similar video-capable platform. The team will be expected to show their completed rocket or propulsion technology demonstration project to Launch Canada's safety inspectors or show and discuss their technology demonstration and should be prepared to disassemble and interact with components at the request of the inspectors, provide closeup views of features of the rocket or project, and answer any questions the inspectors may have. The goal is to catch significant problems in enough time for the team to address them prior to the competition, reducing the amount of emergency rework teams need to perform at the event without access to their workshops, and streamlining the in-person inspections.

Note that teams must submit their final report to be eligible to book a virtual inspection. Teams that do not complete a virtual inspection within the allocated time will be disqualified based on Launch Canada review.

5.11 OPERATIONS (OPS) REHEARSAL (ADVANCED LAUNCH)

Teams in the Advanced Launch category, particularly those flying hybrid or liquid propellant vehicles, typically require significant ground support equipment that adds a large amount of operational complexity compared to COTS solid rockets. Designing a safe and efficient operation is frequently as complex as designing the rocket itself, if not more. Experience has shown that a majority of hybrid or liquid teams fail due to problems with their ground support equipment, and due to excessively time-consuming setup and tear-down that leaves the team with little margin to address problems when they do arise. Complications in integration remain constant problems of staged and clustered vehicles such that inert integration rehearsals are required for these teams as well.

Moreover, your team will be working in relatively close proximity to other teams. Your operations affect them, and their operations affect you. If the launch area must be closed for an excessive period of time because a team's hazardous operations, propellant fill, and/or abort are overly slow, this impacts all the other teams.

As a result, Launch Canada requires all Advanced Launch teams to complete an Ops Rehearsal prior to the competition. This will be a “wet dress rehearsal” of the actual launch, and it must include:

- The complete setup of the launch rail, ground support equipment, and the rocket.
- Installation of the rocket onto the launch rail
- Anchoring the rocket to prevent it from accidentally departing the rail
- Performing a complete propellant fill, preferably using simulated propellant if appropriate
- After fully filling the rocket, executing a full abort procedure to return the rocket to a safe state
- Lowering the rail, removing the rocket, and tearing down the launch rail and ground support equipment

The team must submit proof of this rehearsal in the form of a video (timelapse is acceptable with a clock visible in frame) and a short accompanying summary report. The report must include:

- A summary of the test, including the actual time taken for the major setup and teardown steps, as well as for the complete fill and abort.

- A timeline showing:
  - All major events in the setup and teardown
  - The start and completion of propellant loading
  - The start and completion of the abort procedure
- A summary of any problems or unexpected issues encountered during the test
- A summary of any lessons learned

Among other things, Launch Canada will be looking to verify that the fill and abort times do not exceed 30 minutes. Refer to the DTEG for specific requirements on fill and abort times.

Teams must notify Launch Canada at least 2 weeks in advance of this rehearsal and Launch Canada will additionally aim to have a representative attend to witness the test.

Teams should also create multiple problem components perhaps drawn from a hat at random to practice taking down the rocket and quickly replacing components such as a battery or a burst disk and reloading the rocket. Adding this rapid reset and reintegration test allows teams to discover potential pitfalls that they may experience in competition. Such a drill provides a team with some experience that is necessary when everything does not go according to plan. A team's ability to quickly replace failed components maximizes the probability that a team fly early or at all if weather in the launch week is poor. This is not required but as long as the team is conducting a drill it shouldn't be assumed all launch preps are equal.

5.12 ADMINISTRATIVE DOCUMENTS

5.12.1 SCHOOL PARTICIPATION LETTER

To ensure that each student team is participating with consent and support from their academic institution, a participation letter is required. This will also be required to verify that a team is allowed onto the launch site premises. The key information required on this document is the name, date and purpose of this event. It should show confirmation of attendance and the names of the participants who will be on the launch site.

5.12.2 SCHOOL PROOF OF INSURANCE

Launch Canada's insurance policy provides liability coverage for Launch Canada and its staff. To ensure that students and their schools are covered in the case of accidents or damages that may be caused due to their actions and rocket, each team must provide proof of insurance coverage from their school. This should include comprehensive general liability coverage in the amount of at least $2 million, covering injury or property damage.

5.12.3 WAIVER & RELEASE OF LIABILITY FORM

A signed waiver from every person attending the event is required. Entry to the launch site will be denied without a filled form. This form can be found on the Launch Canada website.

5.12.4 COMPETITION FEES

Launch Canada works hard to support and create opportunities for Canada's student rocketry community and does everything in its power to minimize the costs that have to be passed on to the student teams, but unfortunately some fees remain necessary to help cover the expenses associated with putting on an event such as this. There are three components that make up the competition fees. These are as follows:

- **Competition Entry Fee: $250 per team**
  This fee is due as part of competition registration and helps cover rental, equipment and other costs ahead of the event. It is refundable if a team withdraws in the month of May, by the date issued by Launch Canada. After this point, it becomes non-refundable.

- **Rocket Fee: $500 per team**
  The rocket fee helps cover fixed costs of the event (i.e., those that are not directly related to the number of students in attendance).

- **Rocketeer Fee: $65 per student**
  The rocketeer fee helps cover the costs that are a function of the number of students in attendance.

5.13 SCORING & AWARDS

5.13.1 SCORING BREAKDOWN

Scoring in the Launch Canada Challenge is broadly based on the following two core elements with the weighting provided for each competition category:

	Launch	Tech Dev
1. Documented engineering process, analyses and design	50% of total	60% of total
2. Performance, build quality and team conduct (at competition)	50% of total	40% of total

Engineering work is evaluated based primarily on the final report, initial presentation and other design documentation or reports submitted by the team. Such documentation should not only clearly detail the design of each project and safety aspects but should also demonstrate the engineering decision-making process of the team, including the various analyses and tests conducted and how those results informed the final design. Furthermore, the presentation of the engineering work (either oral or written) should demonstrate the communication and organizational abilities of the team. This includes evaluating the team's project management such as via the confirmed, on-time submission of all competition deliverables and via project progress evidenced by comparison of design reports throughout the year.

The evaluation of project performance, build quality and team conduct occurs at the final event hosted for the Launch Canada Challenge (herein referred to as the "final event"). In simple terms, this score component is based on how well the team and project work, how well it was built (manufacturing) and how well it was put together (integration and assembly). The achieved altitude and safe recovery of the rocket are the basis for the performance score of Launch projects. Altitude scoring is based solely on accuracy compared to simulations. The team will specify their target altitude immediately prior to launch and that will be used for comparison with apogee recorded by flight computers (after recovery). Note that the scoring curve for SRAD propulsion projects is more forgiving than for COTS propulsion, rewarding more points for the same absolute altitude deviation. This difference is built in to acknowledge the difficulties in fully characterizing SRAD propulsion systems. For Tech Dev projects, performance is evaluated based on how well the demonstration achieves the defined goals and requirements. For all projects, Launch Canada judges team performance based on safety, operations (including organization and error handling/problem-solving) and general attitude and conduct at the competition. Finally, the assessment of build quality (manufacturing and integration/assembly) includes how well the team justifies deviations between the projects as built and the design in their final report.

Launch Canada will provide teams with the scoring rubrics for any evaluated deliverables after the competition. All rubrics and evaluations will include feedback from the judges involved explaining how items were scored.

5.13.2 PENALTIES

Final Report:

Final reports submitted after the deadline listed in Section 5.0 will be penalized 12.5% per day late. Reports submitted one week or more after the deadline will receive no points. If a team does not submit their final report prior to the end of the virtual inspection time window, they may be disqualified from the competition.

Safety Infractions:

Teams will be heavily penalized for unsafe or unsportsmanlike conduct during the competition. Unsafe conduct includes, but is not limited to, violating the range operating procedures enforce by LC, failure to use any checklists during operations, violating motor vehicle traffic safety rules, and failure to use appropriate personal protective equipment. Unsportsmanlike conduct includes, but is not limited to, hostility shown towards any other participants, intentional misrepresentation of facts to any LC staff (including judges), and intentional failure to comply with any reasonable instruction given by any of the LC safety team (e.g., RSO, etc.).

Safety infractions follow a three-strike system. A team is permitted a maximum of two infractions to be applied against their score. If a third infraction occurs, the team will be required to cease all operations at the event and will be immediately disqualified.

5.13.3 CATEGORY "PLACE" AWARDS

Teams will be competing for 1st, 2nd and 3rd places in each of the challenge categories. This placement will be evaluated based on a combination of all the project deliverables, including presentations and launches/demonstrations.

Basic Launch Challenge prizes will feature motor hardware donated by Cesaroni Technology. Both the Advanced category in the Launch Challenge and the Technology Development Challenge will feature prize money for the top three teams:

1st place: $3,000

2nd place: $1,500

3rd place: $500

Teams that partake in the Launch Challenge (i.e., Advanced and Basic) may also be awarded the Launch Challenge Grand Trophy. For an entry to be eligible, the team must have a nominal flight (i.e., successful up, successful drogue and main recovery events and retrieval of rocket). In addition, any teams with safety/major infractions are disqualified from receiving the Launch Challenge Grand Trophy. Finally, teams that reuse the exact same rocket from previous competition cycles will not be eligible for the Grand Trophy. This trophy shall be awarded to the project that not only has achieved a high score at the end of the competition but is also one that the judges believe consists of a team of individuals who have acted with the highest level of professionalism and positive conduct throughout the final event. The entire judging team will meet to deliberate which project will be awarded this prestigious award, and once this decision has been made, the winning project will receive this trophy during the closing ceremonies.

5.13.4 ADDITIONAL AWARDS

In addition to the category awards, targeted awards may be offered by partner organizations to incentivize particular technologies or missions. These will be announced on an ongoing basis.

5.13.5 DISQUALIFICATION FROM CONSIDERATION FOR ANY AWARD

In extreme cases where teams deviate from rules regarding safety standards while handling rockets and safe range operations they will be disqualified from the competition. Teams that disregard the DTEG and develop an unsafe or unregulated technology will also not be considered for any awards. In special circumstances where teams display extremely disrespectful behavior and disregard the wellbeing of others, they may be disqualified from the competition. Judges and event staff reserve the right to log, report and evaluate these circumstances.

5.14 WITHDRAWAL FROM COMPETITION

Teams may encounter issues that prevent them from attending the competition. In such situations, the event organizers must be informed of a decision to withdraw from the competition. This shall be done via a formal email to competition@launchcanada.org, and cc'd to adam@launchcanada.org.

- If the team withdraws on or before the Deadline for Refund of Entry Fee (see Sections 5.0 and 5.12.4), the entry fee will be refunded. After this date, the entry fee becomes non-refundable.
- If the team withdraws after the payment of the Rocket Fee and Rocketeer Fee for the event, those fees may not be refunded but may be carried over to the following year, at Launch Canada's discretion.

APPENDIX A: ACRONYMS, ABBREVIATIONS &TERMS

ACRONYMS & ABBREVIATIONS	
AGL	Above Ground Level
APCP	Ammonium Perchlorate Composite Propellant
CFR	Code of Federal Regulations
COTS	Commercial Off-the-Shelf
FAA	Federal Aviation Administration
IREC	Intercollegiate Rocket Engineering Competition
LOX	Liquid Oxygen
SRAD	Student Researched & Developed
STEM	Science, Technology, Engineering and Mathematics

TERMS	
Amateur Rocket	14 CFR, Part 1, 1.1 defines an amateur rocket as an unmanned rocket that is "propelled by a motor, or motors having a combined total impulse of 889,600 Newton-seconds (200,000 pound-seconds) or less and cannot reach an altitude greater than 150 kilometers (93.2 statute miles) above the earth's surface".
Excessive Damage	Excessive damage is defined as any damage to the point that, if the systems intended consumables were replenished, it could not be launched again safely. Intended Consumables refers to those items which are - within reason - expected to be serviced/replaced following a nominal mission (e.g. propellants, pressurizing gasses, energetic devices), and may be extended to include replacement of damaged fins specifically designed for easy, rapid replacement.
FAA Class 2 Amateur Rocket	14 CFR, Part 101, Subpart C, 101.22 defines a Class 2 Amateur Rocket (aka High Power Rocket) as "an amateur rocket other than a model rocket that is propelled by a motor or motors having a combined total impulse of 40,960 Newton-seconds (9,208 pound-seconds) or less."
Non-toxic Propellants	For the purposes of the Launch Canada: Launch Canada, the event organizers consider ammonium perchlorate composite propellant (APCP), potassium nitrate and sugar (aka "rocket candy"), nitrous oxide, liquid oxygen (LOX), hydrogen peroxide, kerosene, propane and similar, as non-toxic propellants. Toxic propellants are defined as requiring breathing apparatus, special storage and transport infrastructure, extensive personal protective equipment, etc.

APPENDIX B: ELEMENTS OF A TECHNICAL REPORT
COMMUNITY & ORGANIZATION

- Team history
- Team breakdown structure
- Team composition
- Outreach conducted since the previous LC competition
- Project timelines/scheduling

RANGE SAFETY

- Report Executive Summary
  - For each submitted report for the entire competition, create a one-page executive summary to be submitted as the second page of your report, only for range safety. This summary shall regard only topics that impact the flight characteristics of the launch vehicle, engine or operations. Half of the page but no more than 75% percent of the page and no less than 25% of the page, should cover updates or progress made to subsystems from the last report or in the case of the entry form since the last competition. Half of the page but no more than 75% percent of the page and no less than 25% of the page should address issues and shortfalls with subsystems from the last report or in the case of the entry form since the last competition. No more than 1-2 sentences or 10% of the page shall be dedicated to team growth metrics and financing if applicable. No questions should be included in the executive summary as those should have been emailed to Launch Canada as they arose. The page need not be filled with text. If no updates have been made between reports state that simply and succinctly.
- Stability plots
  - For ground wind speeds of 5-20 mph in at least four even increments
  - Angle of attack during boost from the time of rail exit to the point where engine thrust drops below 5% of peak thrust
  - CP/CG margin during boost
- Mass budget
- Total impulse
  - In the form of a number and thrust curve for every test conducted, partial fill, full fill, failed ignition, etc.
- Trajectory simulation including drift
  - Simulations should consider dispersion analysis of the following conditions (Nominal, Ballistic, Main at Apogee, and Drogue only)
  - Simulations shall consider at least single simulations of the following conditions (Nominal, Ballistic, Main at Apogee, and Drogue only) for 10 mph, 15 mph and 20 mph ground level wind conditions.
- Recovery Working Load and Dimensions Diagram
  - Working load limits on all hardware including but not limited to eyebolts, eye-nut, U-bolts, shanks for eye-nuts, recovery harness, swivels, bulkheads, quick links
  - Coefficient of drag (C_d), Diameters, maximum opening forces for Parachutes, Ballutes, Streamers
    - For reefed parachutes C_d, and effective diameters for reefed and disreefed states and maximum opening forces in the reefing transient, duration of reefing transient
  - Lengths of all sections of recovery harness
  - Drogue descent rate
  - Main descent rate
- Parts and Instrumentation Diagram (P&ID) for all plumbing
  - Minimum orifice in each component and known discharge coefficients
  - Pressure Ratings of all valves and lines

  - Initial and final loading masses
  - Must include a legend
- Other systems-level parameters (e.g. - max speed, target altitude, minimum safety factor, location of corresponding max loads, etc.)
- SRAD Electronic Testing
  - Test barometric sensor functionality. Vacuum Pot test. Plot of chamber pressure versus measured pressure.
  - Test acceleration sensor functionality. Flight test, Stomp rocket, low power rocket flight, highway on ramp. Comparing accelerometer data over time to a COTS altimeter rigidly mounted to the same avionics sled
  - Test voltage and current in deployment channels throughout simulated flight and boot
    - Chart of voltage and current in deployment with time with time stamps of simulated events for simulated flight operations. Should have charts of voltage and current from switch activation through startup, launch, Mach, apogee, main deployment, and touch down. If historical barometric data from cots altimeters is available to the team then that archival pressure data should be used to benchmark the SRAD system.
  - Battery drain test – pad hold duration test – time until the SRAD avionics do not function as intended
- Table of safe operating parameters or a Go-No-Go Flight Envelope for hybrids and liquids based on tank pressure and fill level, detailing rail exit velocity and apogee for each state, built on simulated engine performance and benchmarked with the static tests conducted by the team. The resolution of this table is for the team's benefit at launch. At a minimum the outline of safe pressure versus safe fill level is required.
- Safety distances/zones
  - Blast fragmentation distances
    - For determining expected yield take the sum of the relevant contributions listed below.
    - Energy in the preheater grain and bp ejection charges.
    - Assume in the case of exothermic decomposition of an oxidizer such as nitrous oxide, a tank with 0% ullage, at maximum density to determine decomposition energy of the oxidizer. This is to mirror the conditions that have been observed with a jammed open fill and vent valve which has occurred luckily without resulting in a full abort in the end without losing the vehicle.
    - In the case of a liquid engine assume the worst case for yield magnification wherein the assumption is maximum liquid fuel loading and instantaneous stoichiometric combustion of the fuel in air not the onboard oxidizer. This is to simulate the overpressure of a vessel rapidly dispersing and mixing the fuel into the air.
    - For hybrid engines, do not include energy stored in solid fuel that is not doped with a solid oxidizer. If the grain is doped include the energy of the complete stoichiometric combustion of the fuel and air not the onboard oxidizer
    - This will likely overestimate effects but that is what we want to plan for to provide margins on those safety distances.
  - Maximum lateral displacement in 20 mph wind, where the tower is angled down wind, of a cold gas ignition failure with full actuation of the run valve takeoff.
  - If flying over 20,000 ft: Ballistic Zone with no recovery system deployed and landing energy.
    - 1σ and 2σ outlined on a map using the road in the middle of the advanced launch area as the takeoff point. Assuming a dispersion of velocities from 16-32 km/h (10-20 mph) winds. 360° variation in wind direction.
  - If flying over 20,000 ft: Dispersion Analysis with no main parachute deployed and landing energy
    - 1σ and 2σ outlined on a map using the road in the middle of the advanced launch area as the takeoff point. Assuming a dispersion of velocities from 16-32 km/h (10-20 mph) winds. 360° variation in wind direction.
    - Material Testing
- Hydrotesting

  - Any SRAD pressure vessel must be hydrotested with a figure showing the apparatus.
  - Change in dimensions of tanks after a hold at 1.2 MEOP for twice sum of expected fill, hold and abort times.
  - A team needs to proof test closure systems. If their full tank assembly has a significantly high safety factor allowing the 1.2 MEOP test above to be conducted at 1.5 MEOP than that should be done. Alternatively, after the 1.2 MEOP test for the complete system, a representative test with a shorter tube can be proof tested to 1.5 MEOP with an identical closure system. This is a proof test of bolts or closure systems at 1.5 MEOP to determine change in dimensions and must include photos of any stretching or deformation.
- SRAD Igniter or Preheater Testing
  - Test the flammability of the igniter
  - Video with a fuel material present to check ability to light the fuel.
    - In the testing of a preheater or igniter for a pyro-operated burst disk / hose in the case of burst disk or UC valve hybrid, submit pictures of the burst disk or nylon fill line after fire. Additional hydrotesting of a burst disk or fill line to determine decreased burst pressure after a non burn through would be appreciated if added to your report.
- SRAD Injector Testing
  - Use of an oxidizer simulant such as water, CO_2, or N_2 can be used to determine discharge coefficients, mixing, atomization, and mass flow rate of an injector for characterization prior to feeding into engine internal ballistics simulation. These simulations should be further benchmarked to static test performance from the hot fires to work back to actual discharge coefficients for the chosen oxidizers and fuels. This testing is critical in troubleshooting underperforming engines.
- Full Successful Static Test(s)
  - This is a test to full desired state for the operation of the rocket engine in this competition year. IF a larger vessel is used for an oxidizer or fuel tank such that overfilling beyond this state is not restricted by plumbing then a full fill test shall be conducted to determine the maximum impulse and minimum thrust under the liquid phase of the burn. If plumbing for an ullage adequately restricts the liquid fill level of a tank only to that fill state is required for a “full” static test. If subscale testing reveals later in the project an issue with regression rate of fuel such that a filled tank would be problematic, a minimum of 1.5 Maximum Design Fill will be excepted as a full tank but no fill state above 1.2 Maximum Design Fill will be accepted at launch. Otherwise cutting down the length of a tank would be appropriate in most cases. Thrust and pressure curves for tanks and if instrumented
- Use of Unsuccessful or Partially Successful Tests for Defining operating Parameters
  - In the event of off nominal testing where a partial fill, cold start, low pressure fire or high pressure fire were to occur, these tests should still be submitted to Launch Canada reviewers along with “.rse” or other engine files should be made to determine how your rocket would behave under a similar issue at competition. This data should be used in conjunction with simulated data to flush out Fire Envelope with real benchmarking data to determine Go-No–Go conditions for launch which are a deliverable.
- Engine Cold Flow Test
  - In addition to cold flow testing, we would like a CO_2 or N_2 dump to determine expected thrust under a non-ignited operation of the engine. This can be combined with igniter tests in some cases if the pressurized working fluid is non energetic. A thrust curve for the cold flow must be submitted along with apogee prediction under this cold flow thrust curve.
- Hold to Abort Testing
  - The hold to abort testing can be completed after a failed ignition during a static test with live oxidizer, or during the operational rehearsal with an inert propellant simulant. The abort test should be at the full fill state condition outlined in the static fire. After filling the tank, the tank should be held at pressure for the quoted hold time and then detanked with the primary purge valve. In the event that an abort of a static test has already been conducted where the primary abort through the purge has been tested, and a backup remote

purge system is in place to be tested, teams should attempt to abort through a remotely operated secondary system to test secondary systems. If multiple aborts of static fires occur such that all abort systems are tested repeat tests but reach out to advanced launch staff to help the team troubleshoot the engine.

- Operational Rehearsals
  - A running clock must be present in all video components. Operations should be parallelized. Operations should be conducted at your test stand due to the abort test integrated into this rehearsal.
  - Starting from the packaged or crated state of the rocket and all relevant equipment being brought to LC
  - Assemble the tower and GSE
  - Integrate the subsystems of the rocket with inert ejection charge and e-match simulants such as a burnt-out e-match in a plastic ejection charge.
  - Mount the Rocket on the rail/tower and then erect the rail/tower with the rocket as per your procedure with any umbilical connected at the time dictated by the procedure
  - Conduct ignition plugs out fill, hold and abort test. This must be simulated fully as a launch attempt that is aborted due to igniter failure.
    - If umbilical removal is done prior to ignition and not a result of takeoff. This operation should be done with the umbilical retracted.
    - If plumbing or electrical to the ground side is connected until the rocket starts accelerating upwards it can be assumed this is still connected.
  - Practice disarming operations of altimeters
  - Lowering of the tower and taking off the rocket
  - Disassembly of the rocket back to transportation state.
- Optional Extended Reintegration Rehearsal
  - It would benefit the team to rehearse common issues at competition. Once a rocket fails to launch there are typically several problems with different subjections that are pseudo random. A similarly random selection of pitfalls can be simulated in order to drill your team. Each subteam should put a few potential problems to be randomly drawn. For avionics this might be replacing a switch, changing a battery, changing an altimeter. For propulsion it might be replacing the igniter, burst disk, or fill line. For recovery it might be checking attachment of a tether because a checklist was missed. To drill your entire team each team should draw a problem at random. So, when the team brings down the rocket, they each have a component to replace or practice unfouling, to determine the time to rerail a rocket and to improve the parallelization of tasks within a team to increase the probability of having more than one launch attempt within a day. This is a highly suggested additional optional rehearsal.
- SRAD Recovery Testing
  - In the event the team has fabricated their own parachute.
    - Drag and effective wet area should be determined in a wind tunnel or during a vehicle pull test or in a flight test at expected descent velocities.
  - In the event the team has fabricated a dual deploy out of a single bay mechanism.
    - These systems must undergo several levels of testing
    - Unloaded actuator static testing
    - Statically loaded actuator static testing
    - Low velocity drop test or vehicle pull test
    - This is the approved for flight minimum
    - Flight tests are preferable, as are high velocity vehicle pull tests over distance. Speeds of deployment should be gradually increased.
- Optional Flight Testing
  - If a rocket is flight tested at another competition or at a regional launch, please create a postmortem of systems that did work and did not work and what improvements are being made. If only certain subsystems are being tested in a test flight, make sure to indicated which systems were being tested.

BUSINESS ANALYSIS (TECH DEV ONLY)

- Cash flow analysis
- SWOT/market research
- Balance sheet

ENGINEERING

- Requirements
- Concept of Operations (ConOps)
  - MLBD (mission-level block diagram).
  - FMEA/risk and hazard analysis (quantitative)
    - Based on ConOps/procedure tree and known failure rates
- Systems Architecture (SysArch)
  - Labelled diagram of rocket/system
  - Dimensioned drawings showing components or assemblies (often in an appendix)
- V&V/testing (tests/analyses planned and outcomes/results and data)
  - Start with table/list of tests and why you are doing them (including outcomes for completed tests).
  - Follow with subsections describing each test (and results if completed).
  - This only needs to be provided for high risk/low TRL (for the team) items.
    - Risk ID based on risk assessment in report.
  - If test hardware is different than flight hardware, explain differences (specifically) and how they affect performance.
- Power and energy budgets
- Telemetry ranges
- Ops timelines and estimations of duration
- Procedures
- Simulation inputs and model/calculation assumptions
- Multi-stage and air-starting
  - Schematic diagram air-start motor ignition and recovery electronics.
  - A graph illustrating flight simulation profile, to include altitude, velocity and acceleration as a function of time, up to the expected time of apogee.
  - An explanation of the strategy for the flight based on the above flight profile (i.e., what is the rationale behind the selection of staging times, coast times, etc.)
  - A description of specific procedures that will be used to prevent air-start motor ignition on the ground.
  - A description of specific procedures that will be used to inhibit air-start motor ignition in the event of a non-nominal flight.
  - Drawing & description of the interstage coupler.
- Analyses
  - Structural analysis (e.g. - free-body diagrams, FEA, etc.)
  - Identification of critical load cases and free-body diagrams drawn out for each, which, at minimum, have been deduced using quasi-static loads. Critical load cases for a rocket, for example, may include but are not limited to transportation, installation on the launch rail, release off the rail, at maximum dynamic pressure and for parachute events.
  - Table summarizing margins of safety for all components and joints used in the construction of the rocket, demonstration or payload, that, if they were to fail, would result in its structural failure. Some common aerospace components of a rocket, for example, include but are not limited to bulkheads, couplers, fins, longerons, nose cones and stringers. Some common methods for joining different aerospace components

together include, but are not limited to adhesives (i.e., structural bonding), fasteners (e.g., bolts, rivets, shear pins) and welds.

- Calculations presented for margins of safety equal to less than one (MS < 1) for all primary structural components (e.g., those used to assemble the rocket's external and internal structure, demonstration or payload).
- Aeroelastic analysis results
  - Determination of shear modulus
  - Divergence speed
  - Flutter speed
  - Max speed/dynamic pressure
  - Plot of divergence and flutter speeds and rocket speed VS altitude to show aeroelastic margin visually

- Airframe Testing
  - SRAD composite tubes must be sample tested. A sliced off tube end can be used to determine compressive strength and should be compressed to failure if equipment is available. A picture of the loading setup is acceptable. A proof test of 1.5 times the maximum thrust of the motor must be conducted on a representative tube, with a picture of the setup. This representative tube does not have to be full length and should be a slice of a tube as to not create and excess of stored energy.