Latin American Space Challenge
2023 LASC Edition

Design, Test and Evaluation Guide

The electronic version is the official, approved document.
Verify this is the correct version before use.

LIST OF REVISIONS

REVISION	DESCRIPTION	DATE
00	Baseline of the 2023 LASC Design, Test & Evaluation Guide.	16/01/2023

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1. INTRODUCTION

The Latin American Space Challenge (LASC), hosted at the Cape Canavial area in Brazil, is Latin America's largest experimental rocket and satellite engineering competition.

It is widely recognized that such STEM competitions foster innovation and motivate students to extend themselves beyond the classroom, while learning to work as a team, solving real world problems under the same pressures they will experience in their future careers.

The event seeks to stimulate students, startup entrepreneurs and enthusiasts to complete a simulated space mission, by designing and building the rockets and satellites themselves. is a combination of the Rocket Challenge and the Satellite Challenge.

Since LASC's first edition, in 2019, where more than 350 students were present to 2022, with 1,600 students participating, the growth of the competition is visible with an increasing number of interested teams applying to the competition.

The LASC Event and this document were built on the legacy of the joint ESRA – Experimental Sounding Rocket Association and Spaceport America since their first annual IREC – Intercollegiate Rocket Engineering Competition back in 2006, now known as the Spaceport America Cup.

The LASC Organization would like to take this moment and thank ESRA and the Spaceport America Cup for their ground-breaking work in the making of the Spaceport America Cup competition. Also, LASC Organization would like to thank EuRoc and the Portuguese Space Agency for their contribution to this technical guide.

This document defines the rules and requirements governing participation in LASC. Revisions of this document will be accomplished by document reissue, marked by the version number.

2. PURPOSE AND SCOPE

This document defines the minimum design, test, and evaluation criteria the event organizers expect LASC teams to meet before presenting or launching at the LASC event. The event organizers use these criteria to promote flight safety.

Departures from the guidance this document provides may negatively affect an offending team's score and flight status, depending on the degree of severity. The foundational, qualifying criteria for the LASC are contained in the LASC Rules & Requirement Document.

Teams should avoid feeling constrained before seeking clarification, and may contact LASC with questions or concerns regarding their project plans' alignment with the spirit and intent of the LASC Design, Test, & Evaluation Guide (DTEG).

3. CONVENTION AND NOTATION

The following definitions differentiate between requirements and other statements. The degree to which a team satisfies the spirit and intent of these statements will guide the competition officials' decisions on a project's overall score in the Latin American Space Challenge.

Shall

This is the only verb used to denote mandatory requirements.

Failure to satisfy the spirit and intent of a mandatory requirement will always affect a project's score and flight status negatively.

Should

This verb is used for stating non-mandatory goals.

Failure to satisfy the spirit and intent of a non-mandatory goal may affect a project's score and flight status, depending on design implementation and the team's ability to provide thorough documentary evidence of their due diligence on-demand.

Compliance to recommended goals and requirements may impact a team's score and flight status in a positive way, as demonstrating additional commitment and diligence to implement (often safety and reliability related guidelines) is commendable.

Will

States facts and declarations of purpose. These statements are used to clarify the spirit and intent of requirements and goals

Flight Status

Refers to the granting of permission to attempt flight, and the provisions under which that permission remains valid. A project's flight status may be either nominal, provisional, or denied.

- **Nominal:** A project assigned nominal flight status meets or exceeds the minimum expectations of this document and reveals no obvious flight safety concerns during flight safety review at the Latin American Space Challenge.

- **Provisional*:*** A project assigned provisional flight status generally meets the minimum expectations of this document, but reveals flight safety concerns during Flight Readiness Review (FRR) at the Latin American Space Challenge which may be mitigated by field modification or by adjusting launch environment constraints. Launch may occur only when the prescribed provisions are met.

- **Denied*:*** Competition officials reserve the right to deny flight status to any project that fails to meet the minimum expectations of this document, or reveals un-mitigatable flight safety concerns during the Flight Readiness Review (FRR) at the Latin American Space Challenge.

An effort is made throughout this document to differentiate between launch vehicle and payload associated systems. Unless otherwise stated, requirements referring only to the launch vehicle do not apply to payloads and vice versa.

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4. ROCKET CHALLENGE

This section contains guidelines, criteria, or required standards for the Rocket Challenge as stated in Section 7 of the 2023 LASC Rules & Requirements Document.

4.1. PROPULSION SYSTEM

4.1.1. NON-TOXIC PROPELLANTS

Launch vehicles entering LASC shall use non-toxic propellants. Ammonium perchlorate composite propellant (APCP), potassium nitrate and sugar (aka "rocket candy"), nitrous oxide, liquid oxygen (LOX), hydrogen peroxide, kerosene, propane, alcohol, and similar substances, are all considered non-toxic.

Toxic propellants are defined as those requiring breathing apparatus, unique storage and transport infrastructure, extensive personal protective equipment (PPE) and others. Gunpowder, also known as Black Powder (BP), is not permitted as a main part of the propellant.

4.1.2. IGNITION SYSTEMS FOR SOLID MOTORS

For all solid motors, the use of the electronic ignition system provided by the LASC Organization is **mandatory.**

4.1.3. PROPULSION SYSTEM SAFING AND ARMING

A propulsion system is considered armed if only one action (e.g. an ignition signal) must occur for the propellant(s) to ignite.

The LASC-provided **PION Remote Launch Control Unit** (PION RLCU) provides sufficient propulsion system arming functionality for all launch vehicles using single stage, solid rocket propulsion systems and some hybrid/liquid propulsion systems.

The "arming action" is usually something (i.e., a switch in series) that enables an ignition signal to ignite the propellant(s). For example, a software-based control circuit that automatically cycles through an "arm function" and an "ignition function" does not, in fact, implement arming.

In this case, the software's arm function does not prevent a single action (e.g., starting the launch software) from causing unauthorized ignition. This problem may be avoided by including a manual interrupt in the software program.

These requirements generally concern more complex propulsion systems (i.e., hybrid, liquid, and multistage systems) and all teams provided launch control systems.

4.1.4. GROUND-START IGNITION CIRCUIT ARMING

All ground-started propulsion system ignition circuits/sequences shall not be "armed" until all personnel are at least **15 meters** away from the launch vehicle.

The LASC provided **PION Remote Launch Control Unit** (PION RLCU) satisfies this requirement by implementing a removable "safety jumper" in series with the pad relay box power supply. The removal of this single jumper prevents firing current from being sent to any of the launch rails associated with that pad relay box.

Furthermore, access to the socket allowing insertion of the jumper is controlled via multiple physical locks to ensure that all parties have positive control of their own safety.

4.1.5. PROPELLANT OFFLOADING AFTER LAUNCH ABORT

Hybrid and liquid propulsion systems shall implement a means for remotely controlled venting or offloading of all liquid and gaseous propellants in the event of a launch abort.

4.1.6. PROPULSION SYSTEM TESTING

Teams shall comply with all rules, regulations, and best practices imposed by the authorities at their chosen test location(s). The following requirements concern verification testing of researched and developed propulsion systems.

LASC recommends teams complete these tests two months prior to the event. While <u>not</u> a requirement, this date is recommended to assure teams are prepared for the Latin American Space Challenge.

4.1.6.1. <u>COMBUSTION CHAMBER PRESSURE TESTING</u>

All propulsion system combustion chambers shall be designed and tested according to the pressure vessel requirements defined in Section 4.3.2 of this document. Note that combustion chambers are exempted from the requirement for a relief device.

4.1.6.2. <u>HYBRID/LIQUID PROPULSION SYSTEM TANKING TESTING</u>

All propulsion systems using liquid propellant(s) shall successfully (without significant anomalies) complete a propellant loading and off-loading test in "launch-configuration". This test may be conducted using either actual propellant(s) or suitable proxy fluids. This test may be conducted using either actual propellant(s) or suitable proxy fluids. Links to videos and testing data should be posted in your final report.

4.1.6.3. STATIC HOT-FIRE TESTING

While not a requirement, all propulsion systems should successfully (without significant anomalies) complete an instrumented (chamber pressure and/or thrust force), full scale (including system working time) static hot-fire test prior to the LASC.

In the case of solid rocket motors, this test does not need to be performed with the same motor casing and/or nozzle components intended for use at the LASC (e.g. teams must verify their casing design but are not forced to design reloadable/reusable motor cases).

4.1.6.4. MINIMUM THRUST-TO-WEIGHT RATIO

The minimum thrust-to-weight ratio for all competition launches shall be at least **5:1.** Thrust-to-weight ratio will be calculated based on either initial thrust of the motor or the average thrust of the motor (whichever is greater), divided by the takeoff weight (launch vehicle plus payload) of the rocket.

4.2. RECOVERY SYSTEMS AND AVIONICS

4.2.1. SINGLE OR DUAL-EVENT RECOVERY

Each independently recovered launch vehicle body anticipated to reach an apogee **above 1500 meters AGL** shall follow a **"dual-event"** recovery operations concept (CONOPS), including an initial deployment event (e.g. a drogue parachute deployment; reefed main parachute deployment) and a main deployment event (e.g. a main parachute deployment; main parachute un-reefing).

Independently recovered bodies whose apogee is **not anticipated to exceed 1500 meters AGL** are exempted, and may feature only a **single/main deployment event.**

Multistage vehicles and side boosters are **not** permitted in the Latin American Space Challenge and shall not be used on the rocket configuration.

4.2.1.1. INITIAL DEPLOYMENT EVENT

The initial deployment event for dual-event recovery shall occur at or near apogee, stabilize the vehicle's attitude (i.e. prevent tumbling), and reduce its descent rate enough to permit the main deployment event yet not so much as to exacerbate wind drift (e.g. between 20-45 m/s).

4.2.1.2. MAIN DEPLOYMENT EVENT

The main deployment event shall occur at an altitude **no higher than 500 meters AGL** and reduce the vehicle's descent rate sufficiently to prevent excessive damage upon impact with the ground (i.e. less than 10 m/s).

Teams with rockets being recovered on a point out of the Cape Canavial Hazard Area will be penalized if the main reason has been an earlier ejection of the main deployment event.

4.2.1.3. EJECTION GAS PROTECTION

The recovery system shall implement adequate protection (e.g. fire resistant material, pistons, baffles) to prevent hot ejection gasses (if implemented) from causing burn damage to retaining cords and other vital components as the specific design demands.

4.2.1.4. PARACHUTE SWIVEL LINKS

The recovery system rigging (e.g. parachute lines, risers, shock chords) should implement swivel links at connections to relieve torsion as the specific design demands. This will mitigate the risk of torque loads unthreading bolted connections during recovery.

4.2.1.5. PARACHUTE COLORATION AND MARKINGS

When separate parachutes are used for the initial and main deployment events, these parachutes shall be highly dissimilar from one another visually. This is typically achieved by using parachutes whose primary colors contrast those of the other chute. This will enable ground-based observers to more easily characterize deployment events with high-power optics.

4.2.1.6. NON-PARACHUTE/PARAFOIL RECOVERY SYSTEMS

Teams exploring other (i.e. non-parachute or parafoil based) recovery methods shall notify LASC of their intentions at the earliest possible opportunity, and keep LASC apprised of the situation as their work progresses. LASC may make additional requests for information and draft unique requirements depending on the team's specific design implementation.

4.2.2. SINGLE OR REDUNDANT ELECTRONICS

Launch vehicles anticipated to reach an **apogee above 1500 meters AGL** shall implement redundant recovery system electronics, including sensors/flight computers and "electric initiators" - assuring initiation by a backup system, with a separate power supply (i.e. battery), if the primary system fails.

In this context, an electric initiator is the device energized by the sensor electronics, which then initiates some other mechanical or chemical energy release to deploy its portion of the recovery system (i.e. electric matches, nichrome wire, and light bulbs).

Launch vehicles anticipated to reach an **apogee below 1500 meters AGL** should implement redundant recovery system electronics, but are permitted to implement a single recovery system electronics.

4.2.2.1. COTS RECOVERY ELECTRONICS

The recovery system electronics subsystem shall implement a COTS flight computer (e.g., StratoLogger, G-Wiz, Eggtimer, EasyMini, TeleMetrum, RRC3, etc.). This recovery system electronics subsystem will also serve as the official altitude logging system specified in Section 10.6.1 of the LASC Rules & Requirements Document.

To be considered COTS, the flight computer (including flight software) must have been developed and validated by a commercial third party. While commercially designed flight computer “kits” (e.g. the Eggtimer) are permitted and considered COTS, any student developed flight computer assembled from separate COTS components will not be considered a COTS system. Similarly, any COTS microcontroller running student developed flight software will not be considered a COTS system.

4.2.2.2. DISSIMILAR REDUNDANT RECOVERY ELECTRONICS

There is **no** requirement that the redundant/backup system be dissimilar to the primary; however, there are advantages to using dissimilar primary and backup systems. Such configurations are less vulnerable to any inherent environmental sensitivities, design, or production flaws affecting a particular component.

4.2.3. ON-BOARD POWER SYSTEMS AND RAIL STANDBY TIME

Loss of launch slots have been experienced on multiple occasions as onboard batteries are typically located in inaccessible positions. Despite the requirement of battery life on the launch rail, an unsuccessful launch attempt typically results in the teams deciding to:

- Disarm any energetic pyrotechnics;
- Take the flight vehicle off the launch rail;
- Haul the rocket back to the team’s preparation area;
- Use tools to perform medium to extensive disassembly of the flight vehicle to extract batteries;

- Spend one to several hours recharging the batteries, if charged spares are not readily available;
- Perform the whole operation in reverse and return to the launch rail many hours later, to perform an additional launch attempt, if the possibility is given.

This is a critically inefficient use of valuable and limited launch campaign time. Teams should adopt one of the following two strategies:

- Implement an on-board charging and charge level maintenance system using an umbilical connection and cable;
- Place all rechargeable or replaceable batteries conveniently under service panels accessible from ground level, without resorting to ladders or lowering the launch rail, having several spare sets of charged batteries ready at any time.

The implementation of an on-board charging and charge level maintenance system, based on a vehicle-wide charging bus and an umbilical cable (featuring friction-based pull-release), connected to a ground-based power supply, should be designed/implemented as follows:

- A “charging bus” should run along the entire length of the flight vehicle, interfacing to all batteries to facilitate charging and continuous charging and subsequent maintenance trickle charging;
    - ➔ Use mating connectors at every structural joint;
    - ➔ Largely all benefits of the system are lost if even a single battery is left out of the umbilical charging bus system.
- Each tap-off from the on-board charging bus to individual battery subsystems shall be reverse current flow protected by a suitably rated diode;
    - ➔ All on-board batteries should feature the same nominal voltage, as far as possible;
    - ➔ If bus voltage step-down is required for batteries with lower nominal voltage, adequately heat-dissipated linear regulators are strongly recommended and placed upstream of the mandatory cell balancing circuits;
    - ➔ Switch-mode regulation or onboard battery chargers are strongly discouraged due to generated EMI and electrical noise; o LiPo battery cell balancing circuits shall protect each individual battery pack;

- ➔ LiPo battery cell balancing circuits of up to 12S cell count are widely available as pre-assembled PCBs for a low price, complete with built-in under voltage-cut-off, overcurrent-protection and overcharging cut-off;
- ➔ Flight vehicle batteries could all be considered "permanently" installed, not requiring removal past initial installation during on-site preparation. The ground-based power supply should simply be outputting the battery trickle charge voltage, plus a diode drop, for easiest implementation.

The advantages of implementing such a system are in most cases worth the effort. Most significantly, the launch vehicle rail standby time changes to "infinite" and the launch vehicle is always launched with 100% peak charged batteries.

4.2.4. SAFETY CRITICAL WIRING

For the purposes of this document, safety critical wiring is defined as electrical wiring associated with recovery system deployment events.

4.2.4.1. CABLE MANAGEMENT

All safety critical wiring shall implement a cable management solution (e.g. wire ties, wiring, harnesses, cable raceways) which will prevent tangling and excessive free movement of significant wiring/cable lengths due to expected launch loads.

This requirement is not intended to negate the small amount of slack necessary at all connections/terminals to prevent unintentional de-mating due to expected launch loads transferred into wiring/cables at physical interfaces.

4.2.4.2. SECURE CONNECTIONS

All safety critical wiring/cable connections shall be sufficiently secure as to prevent demating due to expected launch loads. This will be evaluated by a "tug test", in which the connection is gently but firmly "tugged" by hand to verify it is unlikely to break free in flight.

4.2.4.3. CRYO-COMPATIBLE WIRE INSULATION

In case of propellants with a boiling point of less than -50°C any wiring or harness passing within the close proximity of a cryogenic device (e.g., valve, piping, etc.) or a cryogenic tank (e.g., a cable tunnel next to a LOX tank) shall utilize safety critical wiring with cryo-compatible insulation (i.e., Teflon, PTFE, etc.).

4.2.5. RECOVERY SYSTEM ENERGETIC DEVICES

All stored-energy devices (i.e. energetics) used in recovery systems shall comply with the energetic device requirements defined in Section 4.3 of this document.

4.2.6. RECOVERY SYSTEM TESTING

Teams shall comply with all rules, regulations, and best practices imposed by the authorities at their chosen test location. The following requirements concern verification testing of all recovery systems.

All recovery system mechanisms shall be successfully (without significant anomalies) tested prior to LASC, either by **one or more ground tests** of key subsystems. Flight test demonstration is not required.

In the case of such ground tests, sensor electronics will be functionally included in the demonstration by simulating the environmental conditions under which their deployment function is triggered.

The test results and a statement of a successful test, complete with dates and signatures are considered a mandatory deliverable and annex to the Technical Report.

Correct, reliable and repeatable recovery system performance is absolute top priority from a safety point of view. Statistical data also concludes that recovery system failures are the major cause of abnormal “landings”.

4.3. STORED-ENERGY DEVICES

4.3.1. ENERGETIC DEVICE SAFING AND ARMING

All energetics shall be in the safe position/safed (i.e. “remove before flight connected”) until the rocket is in the launch position, at which point they may be "armed". An energetic device is considered on the safe position/safed when two separate events are necessary to release the energy.

An energetic device is considered armed when only one event is necessary to release the energy. For the purpose of this document, energetics are defined as all stored-energy devices - other than propulsion systems - that have reasonable potential to cause bodily injury upon energy release.

The following table lists some common types of stored-energy devices and overviews in what configuration they are considered non-energetic, safed, or armed.

Table 1. Energetic Devices and Configurations.

DEVICE CLASS	NON-ENERGETIC	SAFED	ARMED
Igniters/Squibs	Small igniters/squibs,	Large igniters with	Large igniters with

	nichrome, wire or similar	leads shunted	noshunted leads
Pyrogens (e.g. black powder)	Very small quantities contained in non shrapnel producing devices (eg pyro-cutters or pyro-valves)	Large quantities with no igniter, shunted igniter leads, or igniter(s) connected to unpowered avionics	Large quantities with non-shunted igniter or igniter(s) connected to powered avionics
Mechanical Devices (e.g. powerful springs)	De-energized/relaxed state, small devices, or captured devices (ie no jettisoned parts)	Mechanically locked and not releasable by a single event	Unlocked and releasable by a single event
Pressure Vessels	Non-charged pressure vessels	Charged vessels with two events required to open main valve	Charged vessels with one event required to open main valve

Although these definitions are consistent with the propulsion system arming definition provided in Section 4.1 of this document, this requirement is directed mainly at the energetics used by recovery systems and extends to all other energetics used in experiments, control systems and others.

Note that while Section 4.1.4 requires propulsion systems be armed only after the launch rail area is evacuated to a specified distance, this requirement permits personnel to arm other stored-energy devices at the launch rail.

4.3.1.1. ARMING DEVICE ACCESS

All energetic device arming features shall be externally accessible/controllable. This does not preclude the limited use of access panels which may be secured for flight while the vehicle is in the launch position.

4.3.1.2. ARMING DEVICE LOCATION

All energetic device arming features shall be located on the airframe such that any inadvertent energy release by these devices will **not** impact personnel arming them.

For example, the arming key switch for an energetic device used to deploy a hatch panel shall not be located at the same airframe clocking position as the hatch panel deployed by that charge.

Furthermore, it is highly recommended that the arming mechanism is accessible from ground level, without the use of ladders or other elevation devices, when the rocket is at a vertical orientation on the launch rail.

4.3.2. PRESSURE VESSELS

The following requirements concern design and verification testing of SRAD and modified COTS pressure vessels. Unmodified COTS pressure vessels utilized for other than their advertised specifications will be considered modified, and subject to these requirements. SRAD (including modified COTS) rocket motor propulsion system combustion chambers are included as well but are exempted from the relief device requirement.

4.3.2.1. RELIEF DEVICE

SRAD pressure vessels shall implement a relief device, set to open at no greater than the proof pressure specified in the following requirements. Rocket motor propulsion system combustion chambers are **exempted** from this requirement.

4.3.2.2. BURST PRESSURE FOR METALLIC PRESSURE VESSELS

SRAD and modified COTS pressure vessels constructed entirely from isotropic materials (e.g., metals) shall be designed to a burst pressure no less than 2 times the maximum expected operating pressure, where the maximum operating pressure is the maximum pressure expected during pre-launch, flight, and recovery operations.

4.3.2.3. BURST PRESSURE FOR COMPOSITE PRESSURE VESSELS

All SRAD and modified COTS pressure vessels either constructed entirely from non-isotropic materials (e.g., fiber reinforced plastics; FRP; composites) or implementing composite overwrap of a metallic vessel (i.e., composite overwrapped pressure vessels; COPV), shall be designed to a burst pressure no less than 3 times the maximum expected operating pressure, where the maximum operating pressure is the maximum pressure expected during pre-launch, flight, and recovery operations.

4.3.2.4. PRESSURE VESSEL TESTING

Teams shall comply with all rules, regulations, and best practices imposed by the authorities at their chosen test location. The following requirements concern design and verification testing of SRAD and modified COTS pressure vessels. Rocket motor propulsion system combustion chambers are included as well.

LASC Organization recommends teams complete these tests two months prior to the event. **While pressure vessel testing is not a requirement**, this date is recommended to assure teams are prepared for the LASC.

SRAD and modified COTS pressure vessels should be proof pressure tested successfully (without significant anomalies) to 1.5 times the maximum expected operating pressure for no less than twice the maximum expected system working time, using the intended flight article(s) (e.g., the pressure vessel(s) used in proof testing must be the same one(s) flown at LASC). The maximum system working time is defined as the maximum uninterrupted time duration the vessel will remain pressurized during pre-launch, flight, and recovery operations.

4.4. ACTIVE FLIGHT CONTROL SYSTEMS

4.4.1. RESTRICTED CONTROL FUNCTIONALITY

Launch vehicle active flight control systems shall be optionally implemented strictly for pitch and/or roll stability augmentation, or for aerodynamic "braking".

Under no circumstances will a launch vehicle entered in the LASC be actively guided towards a designated spatial target.

LASC Organization may make additional requests for information and draft unique requirements depending on the team's specific design implementation.

4.4.2. UNNECESSARY FOR STABLE FLIGHT

Launch vehicles implementing active flight controls shall be naturally stable without these controls being implemented (e.g., the launch vehicle may be flown with the Control Actuator System (CAS) – including any control surfaces – either removed or rendered inert and mechanically locked, without becoming unstable during ascent).

Attitude control systems (ACS) will serve only to mitigate the small perturbations which affect the trajectory of a stable rocket that implements only fixed aerodynamic surfaces for stability.

Stability is defined in Section 4.7.2. of this document. LASC may make additional requests for information and draft unique requirements depending on the team's specific design implementation.

4.4.3. DESIGNED TO FAIL SAFE

Control Actuator Systems (CAS) shall **mechanically lock in a neutral state** whenever either an abort signal is received for any reason, primary system power is lost, or the launch vehicle's attitude exceeds 30° from its launch elevation. Any one of these conditions being met will trigger the fail safe, neutral system state. A neutral state is defined as one which does not apply any moments to the launch vehicle (e.g., aerodynamic surfaces trimmed or retracted, gas jets off, etc.).

4.4.4. BOOST PHASE DORMANCY

CAS shall **mechanically lock in a neutral state** until either the mission's boost phase has ended (i.e., all propulsive stages have ceased producing thrust), the launch vehicle has crossed the point of maximum aerodynamic pressure (i.e., max Q) in its trajectory, or the launch vehicle has reached an altitude greater than 1500 meters AGL.

Any one of these conditions being met will permit the active system state. A neutral state is defined as one which does not apply any moments to the launch vehicle (e.g., aerodynamic surfaces trimmed or retracted, gas jets off, etc.).

Since all flight vehicles with CAS are to be designed inherently passively stable at lift-off, CAS are not needed until somewhat into the flight, performing minor course corrections thereafter. In enforcing a boost dormancy phase, any unexpected, erratic, or faulty CAS system behavior will take place far from the launch rail, minimizing the chances of putting LASC participants at risk near the launch rail.

4.4.5. ACTIVE FLIGHT CONTROL SYSTEM ELECTRONICS

Wherever possible, all active control systems should comply with requirements and goals for "redundant electronics" and "safety critical wiring" as recovery systems — understanding that in this case "initiation" refers to CAS commanding rather than a recovery event.

These requirements and goals are defined in Section 4.2.2. respectively of this document. Flight Control Systems are exempt from the requirement for COTS redundancy, given that such components are generally unavailable as COTS.

As for all electronics, it is highly recommended to ensure easy and quick access to switches/connectors via an access panel on the airframe. Access panels should be positioned so they are reachable from ground level, ideally without ladders. Access panels shall be secured for flight.

4.4.6. ACTIVE FLIGHT CONTROL SYSTEM ENERGETICS

All stored-energy devices used in an active flight control system (e.g. energetics) shall comply with the energetic device requirements defined in Section 4.3 of this document.

4.5. AIRFRAME STRUCTURES

4.5.1. ADEQUATE VENTING

Launch vehicles shall be adequately vented to prevent unintended internal pressures developed during flight from causing either damage to the airframe or any other unplanned configuration changes.

Typically, a 3 to 5 mm hole is drilled in the booster section just behind the nosecone or payload shoulder area, and through the hull or bulkhead of any similarly isolated compartment/bay.

4.5.2. OVERALL STRUCTURAL INTEGRITY

Launch vehicles will be constructed to withstand the operating stresses and retain structural integrity under the conditions encountered during handling as well as rocket flight.

The following requirements address some key points applicable to almost all amateur high power rockets, but are not exhaustive of the conditions affecting each unique design. Student teams are ultimately responsible for thoroughly understanding, analyzing, and mitigating their design's unique load set.

4.5.2.1. MATERIAL SELECTION

PVC (and similar low-temperature polymers) shall not be used in any structural (i.e. load bearing) capacity, most notably as load bearing eye bolts, launch vehicle airframes, or propulsion system combustion chambers for the 3,000 meters apogee categories.

For 500 meters and 1,000 km categories, PVC (and similar low-temperature polymers) may be used in any structural (i.e. load bearing) capacity, most notably as launch vehicle airframes, or propulsion system combustion chambers.

4.5.3. LOAD BEARING EYE BOLTS AND U-BOLTS

All load bearing eye bolts shall be of the closed-eye, forged type - not of the open eye, bent wire type. Furthermore, all load bearing eye bolts and U-Bolts shall be steel. This requirement extends to any bolt and eye-nut assembly used in place of an eye bolt.

4.5.4. IMPLEMENTING COUPLING TUBES

Airframe joints which implement "coupling tubes" should be designed such that the coupling tube extends no less than one body caliber (1D) on either side of the joint — measured from the separation plane.

This rule applies both for "half" couplings (e.g., nosecone – body tube/coupling tube) as well as for "full" couplings (e.g., body tube – coupling tube – body tube).

See example in Figure 1 for clarity. Regardless of implementation (e.g., RADAX or other join types) airframe joints need to be "stiff" (i.e., prevent bending).

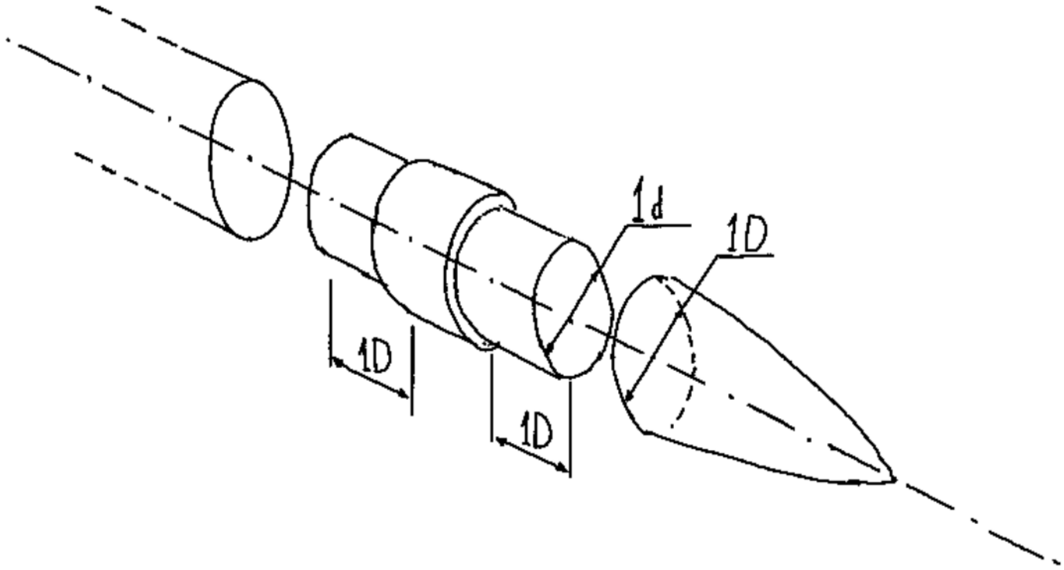


Figure 1. Examples for coupling tubes (Source: EuRoC DTEG).

4.5.5. LAUNCH LUG MECHANICAL ATTACHMENT

Launch lugs (i.e., rail guides) should implement "hard points" for mechanical attachment to the launch vehicle airframe. These hardened/reinforced areas on the vehicle airframe, such as a block of wood installed on the airframe interior surface where each launch lug attaches, will assist in mitigating lug "tear outs" during operations.

The aft most launch lug shall support the launch vehicle's fully loaded launch weight while vertical.

At LASC, competition officials will require teams to lift their launch vehicles by the rail guides and/or demonstrate that the bottom guide can hold the vehicle's weight when vertical. This test needs to be completed successfully before the admittance of the team to Launch Readiness Review (LRR).

4.5.6. RF TRANSPARENCY

Any internally mounted RF transmitter, receiver or transceiver, not having the applicable antenna or antennas mounted externally on the airframe, shall employ “RF windows" in the airframe shell plating (typically glass fiber panels), enabling RF devices with antennas mounted inside the airframe, to transmit the signal though the airframe shell.

RF windows in the flight vehicle shell shall be a 360° circumference and be at least two body diameters in length. The internally mounted RF antenna(s) shall be placed at the midpoint of the RF window section, facilitating maximizing the azimuth radiation pattern.

Note that even a single downward facing antenna mounted on a stabilization fin near the engine seems like a good way to provide nearly a 360° radiation pattern from a single antenna without significant dead-zones. This is true at any point in time, except when the rocket engine is active. The ionized exhaust gas from the engine is highly disruptive to RF signals, so degradation or loss of link is to be expected.
As popular as carbon fiber is for the construction of strong and lightweight airframes, it is also conductive and will significantly shield and/or degrade RF signals, which is unacceptable. Externally mounted antennas often provide a more powerful and uniform radiation pattern but finds the flight vehicle body providing RF dead zones, meaning that at least two antennas on opposite sides of the airframe are advisable.

RF antennas shall be kept as far away as possible from wiring and metallic structural elements. Numerous examples of poor installation practice have to a great extent ruined telemetry and link performances. Teams are highly advised to follow best RF-practices.

4.5.7. IDENTIFYING MARKINGS

The team's Team ID (a number assigned by LASC Organization) shall be clearly identified on the launch vehicle airframe. The Team ID will be prominently displayed, assisting competition officials to positively identify the project hardware with its respective team throughout the LASC.

4.5.8. OTHER MARKINGS

There are no requirements for airframe coloration or markings beyond those specified in this document; however, LASC Organization offers the following recommendations to the teams. High-visibility schemes (e.g. high-contrast black, orange, red) and reference marks for the center of gravity and pressure of the launch vehicle.

4.6. PAYLOAD

4.6.1. PAYLOAD RECOVERY

Payloads may be deployable or remain attached to the launch vehicle throughout the flight. Deployable payloads shall incorporate an independent recovery system, reducing the payload descent velocity to less than 10 m/s before it descends through an altitude of 500 meters AGL.

Note that deployable payloads implementing a parachute or parafoil based recovery system are not required to comply with the dual-event requirements described in

Section 4.2.1. of this document, being allowed to utilize a single-stage of 10 m/s descent rate from apogee recovery system.

Teams are advised that any hardware drifting off the launch area limits must be either abandoned or recovered at the team's own expense. The launch area will be briefed during the LASC Conference.

Payloads implementing independent recovery systems shall comply with the same requirements and goals as the launch vehicle for "redundant electronics" and "safety critical wiring". These requirements and goals are defined in Section 4.2.2 of this document.

4.6.2. PAYLOAD RECOVERY SYSTEM TESTING

Payloads implementing independent recovery systems shall comply with the same requirements and goals as the launch vehicle for "recovery system testing". These requirements and goals are defined in Section 4.2.5. of this document.

4.6.3. PAYLOAD ENERGETIC DEVICES

All stored-energy devices (e.g. energetics) used in payload systems shall comply with the energetic device requirements defined in Section 4.3. of this document.

4.7. LAUNCH AND ASCENT TRAJECTORY REQUIREMENTS

4.7.1. LAUNCH AZIMUTH AND ELEVATION

Launch vehicles shall be nominally launched at an elevation angle of 85°±2° and a launch azimuth defined by competition officials at the LASC. Competition officials reserve the right to require certain vehicles' launch elevation be as low as 70° if possible flight safety issues are identified during pre-launch activities.

The tolerance expressed within the nominal launch azimuth is intended as nothing more than an expression of acceptable human error by the operator setting the launch rail elevation prior to launch.

4.7.2. LAUNCH STABILITY

Launch vehicles shall have sufficient velocity upon "departing the launch rail" to assure they will follow predictable flight paths. In lieu of detailed analysis, a rail departure velocity of at least 30 m/s is generally acceptable. Alternatively, the team may use detailed analysis to prove stability is achieved at a lower rail departure velocity greater than 15 m/s either theoretically (e.g. computer simulation) or empirically (e.g. flight testing).

Departing the launch rail is defined as the first instant in which the launch vehicle becomes free to move about the pitch, yaw, or roll axis. This generally occurs at the instant the last rail guide forward of the vehicle's center of gravity (CG) separates from the launch rail. LASC Organization will provide teams with launch rails measuring 4 meters in length (500 meters and 1,000 meters apogee categories) and 6 meters (any category).

4.7.3. ASCENT STABILITY

Launch vehicles shall remain "stable" for the entire ascent. Stable is defined as maintaining a static stability margin of at least 1.5 calibers throughout the whole flight phase (upon leaving the launch rail), regardless of CG movement due to depleting consumables and shifting center of pressure (CP) location due to wave drag effects (which may become significant as low as 0.5 Mach).

4.7.4. OVER-STABILITY

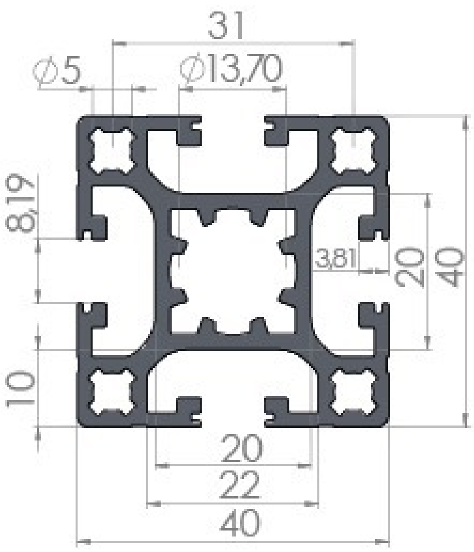
All launch vehicles should avoid becoming "over-stable" during their ascent. A launch vehicle may be considered over-stable with a static margin significantly greater than 2 body calibers (e.g. greater than 6 body calibers).

4.8. LASC LAUNCH SUPPORT EQUIPMENT

4.8.1. LASC-PROVIDED LAUNCH BASE SYSTEM

For all rockets, the use of the **LASC Launch Base System (LLBS)** provided by the LASC Organization is **mandatory.** LASC Organization will provide launch rails that feature at least 6 meters long, 40 mm x 40 mm cross-section aluminum rails.

Figure 2. LLBS Rail Cross Section (dimensions in millimeters).



These rails will accommodate any rocket body diameter and fin length. On these rails, the rocket is loaded horizontally on top of the guide rail and then the rail is erected to the required launch elevation.

All launch vehicles shall attach to these launch rails via at least two rail guides (e.g. lugs, buttons) which, together, support the vehicle's fully loaded launch weight if suspended horizontally. Once erected, the launch vehicle will be supported vertically by a submerged mechanical stop in the rail - whose position may be adjusted.

Note that hybrid and liquid propulsion systems may require team-customized devices or equipment. LASC Organization will not be responsible for any additional required devices for hybrid and liquid-propulsion rocket projects.

4.8.2. LAUNCH RAIL FIT CHECK

All teams shall perform a “launch rail fit check” as a part of the flight preparations, before going to the launch range. The launch rail fit check will ensure that such surprises are not encountered on the launch rails, causing delays and loss of launch opportunities.

The launch rail fit check can only be done in the presence of LASC officials. Teams cannot use the LASC launch rails without permission, any launch rail related activity shall be duly authorized by LASC officials.

4.8.3. LASC-PROVIDED REMOTE LAUNCH CONTROL UNIT

LASC Organization will provide a Launch Control System. The system will be a PION Remote Launch Control Unit (PION RLCU). More details will be provided during the Latin American Space Challenge.

Note that hybrid and liquid propulsion systems may require team-customized devices. LASC Organization will not be responsible for any additional required devices for hybrid and liquid-propulsion rocket projects.

4.9. TEAM-PROVIDED LAUNCH SUPPORT EQUIPMENT

4.9.1. EQUIPMENT PORTABILITY

If possible/practicable, teams should make their launch support equipment man-portable over a short distance (a few hundred meters). Environmental considerations at the launch site permit only limited vehicle use beyond designated roadways, campgrounds, and basecamp areas.

4.9.2. OPERATIONAL RANGE

All team provided launch control systems shall be electronically operated and have a maximum operational range of no less than 150 meters from the launch rail. The maximum operational range is defined as the range at which launch may be commanded reliably.

4.9.3. FAULT TOLERANCE AND ARMING

All team provided launch control systems shall be at least single fault tolerant by implementing a removable safety interlock (i.e., a jumper or key to be kept in possession of the arming crew during arming) in series with the launch switch.

4.9.4. SAFETY CRITICAL SWITCHES

All team provided launch control systems shall implement ignition switches of the momentary, normally open (also known as "dead man") type so that they will remove the signal when released. Mercury or "pressure roller" switches are not permitted anywhere in team-provided launch control systems.

5. SATELLITE CHALLENGE

This section contains guidelines, criteria, or required standards for the Satellite Challenge as stated in Section 9 of the 2023 LASC Online Rules & Requirements Document.

5.1. GENERAL REQUIREMENTS

5.1.1. POCKETQUBE-STYLE PROJECT

PocketQubes are picosatellite platforms based on a cubic-shaped form factor (approximately 50x50x50 mm per unit) with each side one half smaller than a CubeSat (100x100x100 mm per unit).

a) The satellite shall ensure no deliberate detachment of any components throughout the lifetime of the entire mission: launch, ejection and in orbit operation.

b) Explosives, detonators, pyrotechnics, and inflammable or dangerous materials are strictly forbidden. All materials used must be safe for the personnel, the equipment, and the environment.

c) Materials that can be toxic, flammable or potentially hazardous shall not be used. The use of Li-Ion batteries is exempted from this constraint, provided that there is adequate prevention against thermal runaway.

5.1.1.1. <u>EXTERIOR DIMENSIONS</u>

PocketQubes external dimensions are slightly different depending on the number of units, as outlined in the following for the 1P, 2P and 3P cases:

Table 2. PocketQube external dimensions and sliding backplate dimension.

Number of Units (P)	External dimensions without backplate (mm)	Sliding backplate dimension (mm)
1P	50x50x50	58x64x1.6
2P	50x50x114	58x128x1.6
3P	50x50x178	58x192x1.6

The envelope around the PocketQube shall be no more than 7 mm for components.

For appendages and deployables, maximum 10 mm is allowed. All deployable components shall be constrained by the PocketQube and not by the deployer.

5.1.1.2. MASS

Each PocketQube unit (1P) shall not exceed 250 g mass. Each 2P PocketQube shall not exceed 500 g mass. Each 3P PocketQube shall not exceed 750 g mass.

The center of mass of the PocketQube shall not exceed 1 cm from its geometric center in a stowed position.

5.1.1.3. MATERIALS

Recommended materials for the baseplate are: FR4, Aluminum (7075, 6061, 6065, 6082). Potential metallic materials used for the PocketQube that are in contact with the deployer and standoffs shall be hard anodized.

5.1.2. CANSAT-STYLE PROJECT

CanSats are picosatellite platforms based on a cylinder-shaped form factor. The challenge is to fit all the major subsystems, such as power, sensors and a communication system, into this minimal volume.

a) The satellite shall ensure no deliberate detachment of any components throughout the lifetime of the entire mission: launch, ejection and in orbit operation.

b) Explosives, detonators, pyrotechnics, and inflammable or dangerous materials are strictly forbidden. All materials used must be safe for the personnel, the equipment, and the environment.

c) Materials that can be toxic, flammable or potentially hazardous shall not be used. The use of Li-Ion batteries is exempted from this constraint, provided that there is adequate prevention against thermal runaway.

d) All the components of the CanSat must fit inside a standard soft drinks can with the following dimensions: 105±5mm height; and 66±1mm diameter.

e) Radio antennas and GPS antennas can be mounted externally on the top or bottom of the can, depending on the design, but not on the sides.

f) Any antennas, transducers and other elements of the CanSat cannot extend beyond the can’s diameter until it has left the launch vehicle.

g) The mass of the CanSat must be between a minimum of 200g and a maximum of 350g. CanSats that are lighter must take additional ballast with them to reach the 200g minimum mass limit required.

h) The CanSat must be powered by a battery and/or solar panels. It must be possible for the systems to remain switched on for four continuous hours.

i) The battery must be easily accessible in case it has to be replaced/recharged.

j) The CanSat must have an easily accessible master power switch.

k) Recommended materials for the structure are: PLA, ABS, PP e PETG. Potential metallic materials such as aluminum alloy may also be used.

5.1.3. CUBESAT-STYLE PROJECT

CubeSats are nanosatellite platforms based on a cubic-shaped form factor (approximately 100x100x100 mm per unit).

a) The satellite shall ensure no deliberate detachment of any components throughout the lifetime of the entire mission: launch, ejection and in orbit operation.

b) Explosives, detonators, pyrotechnics, and inflammable or dangerous materials are strictly forbidden. All materials used must be safe for the personnel, the equipment, and the environment.

c) Materials that can be toxic, flammable or potentially hazardous shall not be used. The use of Li-Ion batteries is exempted from this constraint, provided that there is adequate prevention against thermal runaway.

5.1.3.1. EXTERIOR DIMENSIONS AND MASS

CubeSats external dimensions and typical maximum mass are slightly different depending on the number of units, as outlined in the following for the 1U, 1.5U, 2U and 3U cases. The CubeSats shall be no larger than a 3U (three-units) for the Latin American Space Challenge.

Table 3. CubeSats external dimensions and maximum mass.

Number of Units (P)	External dimensions (mm)	Maximum mass (Kg)
1U	100x100x100	2.00
1.5U	150x100x100	3.00
2U	200x100x100	4.00
3U	300x100x100	6.00

5.1.3.2. MAIN SPECIFICATIONS

Deployables shall be constrained by the CubeSat, not the dispenser.

Rails shall have a minimum width of 8.5 mm measured from the edge of the rail to the first protrusion on each face. Rails should have a surface roughness less than 1.6 μm. The edges of the rails should be rounded to a radius of at least 1 mm. The ends of the rails on the +/- Z face shall have a minimum surface area of 6.5 mm x 6.5 mm contact area with neighboring CubeSat rails.

The CubeSat center of gravity shall fall within the ranges specified in the following table:

Table 4: Ranges of acceptable CG locations as measured from the geometric center on each axis.

Number of Units (P)	X axis	Y axis	Z axis
1U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 2 cm / -2 cm
1.5U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 3 cm / -3 cm
2U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 4.5 cm / -4.5 cm
3U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 7 cm / -7 cm

The CubeSat structure should be made from aluminum alloy. Typically, Aluminum 7075, 6061, 6082, 5005, and/or 5052 are used for both the main CubeSat structure and the rails.

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APPENDIX A: ACRONYMS, ABBREVIATIONS, AND TERMS

ACRONYMS & ABBREVIATIONS	
ACS	**Attitude Control System**
AGL	**Above Ground Level**
APCP	**Ammonium Perchlorate Composite Propellant**
CAS	**Control Actuator System**
CG	**Center of Gravity**
CP	**Center of Pressure**
CONOPS	**Concept of Operations**
COPV	**Composite Overwrapped Pressure Vessel**
COTS	**Commercial Off-the-Shelf**
DTEG	**Design, Test and Evaluation Guide**
GPS	**Global Positioning System**
LASC	**Latin American Space Challenge**
LLBS	**LASC Launch Base System**
LOX	**Liquid Oxygen**

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".
Body Caliber	A unit of measure equivalent to the diameter of the launch vehicle airframe in question.
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.