LATIN AMERICAN SPACE CHALLENGE

2020 Design, Test, & Evaluation Guide

English Version
02/02/2020 – Revision 00 | PIØN

Revision History

REVISION	DESCRIPTION	DATE
00	Baseline of the document.	02/02/2020

1. INTRODUCTION

The *Latin American Space Challenge* (LASC) is a three-day series of events that will set the background and provide structure for the Latin America's largest experimental rocket engineering competition.

2. BACKGROUND

The noise, fire, high speeds, and the adrenaline of launching a rocket encourage people to pursue science, technology, and mathematics based careers and for the progress of the science and technology of their countries. A space competition motivates them to extend themselves beyond the classroom to design and build the rockets themselves. Students enrolled in this challenge also could learn to work as a team, solving real world problems under the same pressures they will experience in their future careers.

The *Latin American Space Challenge* (LASC) has a mission to motivate people from all Latin American countries to develop and launch a rocket with a smallsat as a payload. The vision of the LASC is provide motivation to Latin American students and enthusiasts to pursue their dream despite their countries conditions.

3. PURPOSE AND SCOPE

This document defines the minimum design, test, and evaluation criteria the event organizers expect LASC teams to meet before launching at the *Latin American Space Challenge*. 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. This document is inspired on the Intercollegiate Rocket Engineering Competition (IREC) document that incorporates several international rules and safety codes.

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 (LASC-DTEG).

4. 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.

- ***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.

- ***Will:*** This verb is used for stating facts and declarations of purpose. The authors' use these statements to clarify the spirit and intent of requirements and goals.

Note: 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 safety review 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 safety review 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.

5. REVISION

It is expected the LASC Design, Test, & Evaluation Guide may require revision in the months leading up to a competition. Also, major revisions will be accomplished by complete document reissue. Such revisions will be reflected in updates to the document's effective date.

6. DOCUMENTATION

The following documents include standards, guidelines, schedules, or required standard forms. The documents listed in this section are either applicable to the extent specified in this document, or contain reference information useful in the application of this document.

DOCUMENT	FILE LOCATION
LASC Design, Test, & Evaluation Guide	*http://lasc.space/documents-and-rules/*
LASC Master Schedule Document	*http://lasc.space/documents-and-rules/*
LASC Range Standard Operating Procedures	*http://lasc.space/documents-and-rules/*
LASC Entry Form & Progress Update	*http://lasc.space/documents-and-rules/*
LASC Project Technical Report Template	*http://lasc.space/documents-and-rules/*
LASC Extended Abstract Template	*http://lasc.space/documents-and-rules/*
LASC Waiver and Release of Liability Form	*http://lasc.space/documents-and-rules/*
LASC Safety Guide	*http://lasc.space/documents-and-rules/*

7. PROPULSION SYSTEM

7.1. NON-TOXIC PROPELLANTS

Launch vehicles entered the 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, is not permitted as a mainly part of the propellant.

7.2. 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 "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.

The LASC provided launch control system described in Section 14.2 of this document provides sufficient propulsion system arming functionality for almost all launch vehicles using single stage, solid rocket propulsion systems.

Therefore, these requirements generally concern more complex propulsion systems (i.e. hybrid and liquid systems) and all team provided launch control systems. Additional requirements for team provided launch control systems are defined in Section 15 of this document.

7.2.1. 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 launch control system 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. Only ground-start ignition circuits are permitted. Multistage rockets are not permitted at the *Latin American Space Challenge*.

7.2.2. 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.

7.3. 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 not a requirement, this date is recommended to assure teams are prepared for the *Latin American Space Challenge*.

7.3.1. COMBUSTION CHAMBER PRESSURE TESTING

All propulsion system combustion chambers *shall* be designed and tested according to the pressure vessel requirements defined in Section 9.2 of this document. Note that combustion chambers are exempted from the requirement for a relief device.

7.3.2. HYBRID AND LIQUID PROPULSION SYSTEM TANKING TESTING

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.

7.3.3. STATIC HOT-FIRE TESTING

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).

8. RECOVERY SYSTEMS AND AVIONICS

8.1. DUAL-EVENT PARACHUTE AND PARAFOIL RECOVERY

Each independently recovered launch vehicle body anticipated to reach an apogee *above 1500 meters* above ground level (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 are not permitted and side boosters shall not be used on the rocket configuration.

8.1.1. INITIAL DEPLOYMENT EVENT

The initial deployment event 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).

8.1.2. 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).

The 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.

8.1.3. EJECTION GAS PROTECTION

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

8.1.4. 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.

8.1.5. 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.

8.2. 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.

8.3. REDUNDANT ELECTRONICS

Launch vehicles *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, 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).

8.3.1. REDUNDANT COTS RECOVERY ELECTRONICS

At least one redundant recovery system electronics subsystem *shall* implement a COTS flight computer (e.g. PION Altimeter Lite, StratoLogger, G-Wiz, Raven, Parrot, Eggtimer, AIM, EasyMini, TeleMetrum, RRC3). This flight computer may also serve as the official altitude logging system specified in Section 6.5 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 researched and 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.

8.3.2. 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.

8.4. SAFETY CRITICAL WIRING

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

8.4.1. 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.

8.4.2. 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.

8.5. 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 9 of this document.

8.6. RECOVERY 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 all recovery systems. LASC Organization recommends teams complete these tests two months before the event. While not a requirement, this date is recommended to assure teams are prepared for the *Latin American Space Challenge*.

8.6.1. GROUND TEST DEMONSTRATION

All recovery system mechanisms *shall* be successfully (without significant anomalies) tested prior to the LASC, either by flight testing, or through one or more ground tests of key subsystems. 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.

8.6.2. OPTIONAL FLIGHT TEST DEMONSTRATION

All recovery system mechanisms *shall* be successfully (without significant anomalies) tested prior to the LASC, either by flight-testing, <u>or</u> through one or more ground tests of key subsystems. While not required, a flight test demonstration may be used in place of ground testing. In the case of such a flight test, the recovery system flown will verify the intended design by implementing the same major subsystem components (e.g. flight computers and parachutes) as will be integrated into the launch vehicle intended for the LASC (i.e. a surrogate shock-cord or parachute may be used).

9. STORED-ENERGY DEVICES

9.1. ENERGETIC DEVICE SAFING AND ARMING

All energetics *shall* be on 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.

DEVICE CLASS	NON-ENERGETIC	SAFED	ARMED
Igniters/Squibs	Small igniters/squibs, nichrome, wire or similar	Large igniters with leads shunted	Large igniters with 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 7 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 7.2.1 requires propulsion systems be armed only after the launch rail area is evacuated to a specified distance, while this requirement permits personnel to arm other stored-energy devices at the launch rail.

9.1.1. 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.

9.1.2. 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.

9.2. PRESSURE VESSELS

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

9.2.1. RELIEF DEVICE

All researched, developed, and modified COTS pressure vessels *shall* implement a relief device, set to open at no greater than the proof pressure specified in the following requirements. Venting valves are considered relief devices if it could be remotely controlled. Researched and developed (including modified COTS) rocket motor propulsion system combustion chambers are exempted from this requirement.

9.2.2. BURST PRESSURE FOR METALLIC PRESSURE VESSELS

All researched, developed, 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.

9.2.3. BURST PRESSURE FOR COMPOSITE PRESSURE VESSELS

All researched and developed and modified COTS pressure vessels either constructed entirely from non-isotropic materials (e.g. fiberglass), or implementing composite overwrap of a metallic vessel (e.g. 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 prelaunch, flight, and recovery operations.

9.2.4. PRESSURE VESSEL TESTING

Teams *shall* comply with all rules, regulations, and best practices imposed by the authorities at their chosen test location(s). Unmodified COTS pressure vessels utilized for other than their advertised specifications will be considered modified, and subject to these requirements.

Researched and developed (including modified COTS) 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.

9.2.5. PROOF PRESSURE TESTING

Researched and developed (including modified COTS) pressure vessels *should* be proof pressure tested successfully (without significant anomalies) tested 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 the 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.

10. ACTIVE FLIGHT CONTROL SYSTEMS

10.1. 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.

10.2. 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 - including any control surfaces - either removed or rendered inert and mechanically locked, without becoming unstable during ascent).

Attitude control systems *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 13 of this document. LASC Organization may make additional requests for information and draft unique requirements depending on the team's specific design implementation.

10.3. DESIGNED TO FAIL SAFE

Control actuator systems *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 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).

10.4. BOOST PHASE DORMANCY

Control actuator systems *shall* mechanically lock in a neutral state until either the mission's boost phase has ended (i.e. the propulsive stage have ceased producing thrust) or the launch vehicle has crossed the point of maximum aerodynamic pressure (Max Q) in its trajectory. 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).

10.5. 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 control actuator systems commanding rather than a recovery event. These requirements and goals are defined in Sections 8.3 and 8.4 respectively of this document.

10.6. 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 9 of this document.

11. AIRFRAME STRUCTURES

11.1. 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 0.3 to 0.5 cm 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.

11.2. 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.

11.2.1. 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 km apogee categories.

11.2.2. 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.

11.2.3. IMPLEMENTING COUPLING TUBES

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

Regardless of implementation (e.g. RADAX or other join types) airframe joints *will* be "stiff" (i.e. prevent bending).

11.2.4. LAUNCH LUG MECHANICAL ATTACHMENT

Launch lugs (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.

During the Latin American Space Challenge, competition officials *may* 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 before permitting them to proceed with launch preparations.

11.2.5. AFT MOST LAUNCH LUG

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

During the Latin American Space Challenge, competition officials may 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 before permitting them to proceed with launch preparations.

11.3. 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.

11.4. 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.

12. PAYLOAD

12.1. 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 while deployable payloads implementing a parachute or parafoil based recovery system are *not* required to comply with the dual-event requirements described in Section 8.1 of this document.

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.

12.1.1. PAYLOAD RECOVERY SYSTEM ELECTRONICS AND SAFETY CRITICAL WIRING

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 Sections 8.3 and 8.4 respectively of this document.

12.1.2. 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 8.6 of this document.

12.2. PAYLOAD ENERGETIC DEVICES

All stored-energy devices (e.g. energetics) used in payload systems *shall* comply with the energetic device requirements defined in Section 9 of this document.

13. LAUNCH AND ASCENT TRAJECTORY REQUIREMENTS

13.1. 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 70° if possible flight safety issues are identified during pre-launch activities.

13.2. 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.

Note that LASC Organization will provide teams with launch rails measuring at least 6 meters in length. Teams whose designs anticipate requiring a longer launch rail to achieve stability during launch must provide their own. The requirements for team provided launch rails are defined in Section 15 of this document. Section 14.1 of this document describes LASC provided launch rails.

13.3. ASCENT STABILITY

Launch vehicles *shall* remain "stable" for the entire ascent. Stable is defined as maintaining a static margin of at least 1.5 to 2 body calibers, 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).

Not falling below 2 body calibers *will* be considered nominal, while falling *below* 1.5 body calibers will be considered a loss of stability.

13.4. 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).

14. LASC PROVIDED LAUNCH SUPPORT EQUIPMENT

14.1. LASC-PROVIDED LAUNCH RAILS

LASC Organization will provide launch rails that feature at least 6 meters long, 40 mm x 40 mm aluminum guide rails. More details are in Appendix B. These rails will accommodate almost 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.

At LASC, Competition officials may 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 before permitting them to proceed with launch preparations.

14.2. LASC-PROVIDED LAUNCH CONTROL SYSTEM

LASC Organization will provide the PION Remote Launch Control Unit (RLCU) which 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.

15. TEAM-PROVIDED LAUNCH SUPPORT EQUIPMENT

15.1. EQUIPMENT PORTABILITY

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

15.2. LAUNCH RAIL ELEVATION

Team provided launch rails *shall* implement the nominal launch elevation specified in Section 13.1 of this document and, if adjustable, not permit launch at angles either greater than the nominal elevation or lower than 70°.

15.3. OPERATIONAL RANGE

All team provided launch control systems *shall* be electronically operated and have a maximum operational range of no less than 200 meters from the launch rail. A 500 meters operational range is preferred. The maximum operational range is defined as the range at which launch may be commanded reliably.

15.4. 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, key to be kept in possession of the arming crew during arming, remove before flight system) in series with the launch switch.

15.5. SAFETY CRITICAL SWITCHES

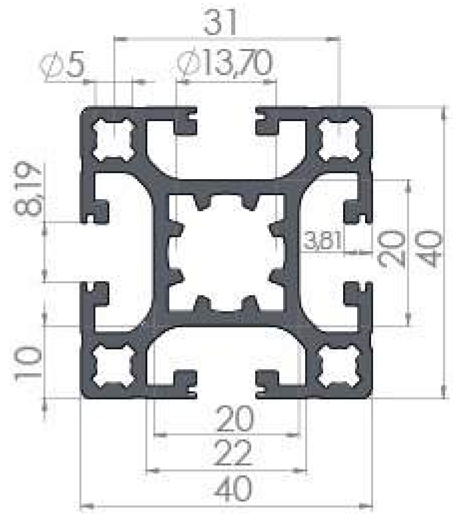
All team provided launch control systems *shall* implement ignition switches of the momentary, normally open type so that they will remove the signal when released. Mercury or "pressure roller" switches are not permitted anywhere in team provided launch control systems.

APPENDIX A: ACRONYMS, ABBREVIATIONS, AND TERMS

ACRONYMS & ABBREVIATIONS	
AGL	**Above Ground Level**
APCP	**Ammonium Perchlorate Composite Propellant**
CG	**Center of Gravity**
CP	**Center of Pressure**
CONOPS	**Concept of Operations**
COPV	**Composite Overwrapped Pressure Vessel**
COTS	**Commercial Off-the-Shelf**
GPS	**Global Positioning System**
LASC	**Latin American Space Challenge**
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.

APPENDIX B: LASC-PROVIDED LAUNCH RAILS

ALUMINUM GUIDE RAILS 40X40
 (Dimensions in millimeters)