Spaceport America Cup

Intercollegiate Rocket Engineering Competition Rules & Requirements Document

Revision History

REVISION	DESCRIPTION	DATE
Draft	Final Draft Revision release assists 2017 Teams project planning	09/25/2016
Baseline	Baseline Revision release	TBD

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1.0 INTRODUCTION

The Experimental Sounding Rocket Association (ESRA) and the New Mexico Spaceport Authority (aka Spaceport America; NMSA) have partnered to host and support the Spaceport America Cup (SAC), a week-long series of events which will set the background and provide structure for the world's largest university rocket engineering competition. This new host-event continues the Intercollegiate Rocket Engineering Competition's (IREC) legacy of inspiring student design teams from across the country and around the world.

1.1 BACKGROUND

The "smoke and fire," noise, high speeds, and sleek aerodynamics of rocketry encourage students to pursue science, technology, and mathematics based careers. They have "Rocket Fever!", and competition motivates them to extend themselves beyond the classroom to design and build the rockets themselves. These students also learn to work as a team, solving real world problems under the same pressures they'll experience in their future careers.

ESRA held the first annual IREC in 2006. The competition achieved international status in 2011 when Canadian and Brazilian universities threw their hats in the ring. These schools have since been joined by others from every continent except Antarctica. In fact the competition has roughly doubled in size every year since 2013, becoming the largest known collegiate level rocket engineering competition in the world in 2014. Attendance in 2016 included as many as 600 participants – including faculty, family, and friends of students from over 50 colleges and universities.

1.2 PURPOSE AND SCOPE

This document defines the rules and requirements governing participation in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition, as well as how non-collegiate organizations – such as high-school and industry groups – may participate in the Spaceport America Cup overall. Additional guidance for collegiate teams entered in the competition is contained in the *IREC Design, Test, & Evaluation Guide*, maintained on the ESRA website (TBD_direct URL). The *IREC Design, Test, & Evaluation Guide* provides teams with project development guidance ESRA uses to promote range safety. Departures from this guidance may negatively impact an offending team's score, and possibly even its flight status depending on the degree of severity.

1.3 REVISION

It is expected the *IREC Rules & Requirements Document* 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 ESRA and NMSA. Such revisions will be approved jointly by both organizations.

1.4 DOCUMENTATION

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

DOCUMENT	FILE LOCATION
IREC Design, Test, & Evaluation Guide	(TBD_direct URL)
SAC Integrated Master Schedule Document	(TBD_direct URL)
IREC Range Standard Operating Procedures	(TBD_direct URL)
IREC Entry Form & Progress Update	(TBD_direct URL)
IREC Project Technical Report Template	(TBD_direct URL)

DOCUMENT	FILE LOCATION
IREC Extended Abstract Template	(TBD_direct URL)
SAC NMSA Waiver & Release of Liability Form	(TBD_direct URL)
SAC ESRA Waiver & Release of Liability Form	(TBD_direct URL)
IREC Consent to Limited PII Release Form	(TBD_direct URL)
14 CFR, Part 1, 1.1 General Definitions	http://www.ecfr.gov/cgi-bin/text-idx?SID=795aaa37494b6c99641135267af8161e&mc=true&node=se14.1.1_11&rgn=div8
14 CFR, Part 101, Subpart C, 101.22 Definitions	http://www.ecfr.gov/cgi-bin/text-idx?SID=795aaa37494b6c99641135267af8161e&mc=true&node=se14.2.101_122&rgn=div8

2.0 INTERCOLLEGIATE ROCKET ENGINEERING COMPETITION OVERVIEW

In general, student teams competing in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition must design, build, and launch a rocket carrying no less than 8.8 lb of payload to a target apogee either 10,000 ft or 30,000 ft above ground level (AGL). Projects will be divided into one of the following six categories based on the type of project attempted – defined by the target apogee and selected propulsion system. Teams are permitted to switch categories as necessary prior to submitting their final Project Technical Report.

- 10,000 ft AGL apogee with commercial-off-the-shelf (COTS) solid or hybrid rocket propulsion system
- 30,000 ft AGL apogee with COTS solid or hybrid propulsion system
- 10,000 ft AGL apogee with student researched and developed (SRAD) solid rocket propulsion system
- 30,000 ft AGL apogee with SRAD solid rocket propulsion system
- 10,000 ft AGL apogee with SRAD hybrid or liquid rocket propulsion system
- 30, 000 ft AGL apogee with SRAD hybrid or liquid rocket propulsion system

Multistage 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, propane and similar, are all considered non-toxic. Toxic propellants are defined as requiring breathing apparatus, special storage and transport infrastructure, extensive personal protective equipment, etc. In the case of multi-stage launch vehicle designs, the system's category classification will be determined on a case by case basis by ESRA.

Regardless of the category in which a project is entered, ESRA encourages student research and development (including modification of COTS components) of other systems, such as airframes, fins, nosecones, and parachutes. Efforts in this regard will be positively reflected in scoring – regardless of whether fabrication is performed by students directly, or by a third party working to student supplied specifications.

An experienced judging panel will evaluate competitors for Place Awards within each competition category based on the quality of required documentation, a Poster Session held during the conference day at the Spaceport America Cup, their project's overall design and construction, and finally the system's actual flight performance demonstrated at the Spaceport America Cup. Furthermore, no less than 30_(TBR) teams will be selected to present a particular aspect of their work in a Podium Session held during the conference day at the Spaceport America Cup. These teams are eligible to receive certain Technical Achievement Awards, provided they make at least one launch attempt during the Spaceport America Cup.

Teams should avoid feeling constrained in their work, and are free to contact ESRA if they have any questions or concerns as to whether their project plans are aligned with the rules, requirements, and the spirit of the Spaceport America Cup: Intercollegiate Rocket Engineering Competition.

2.1 STUDENT TEAM MEMBER ELIGABILITY

IREC Teams shall consist of members who were matriculated undergraduate or graduate students during the previous academic year (eg former students who graduated shortly before the competition are eligible) from one or more academic institutions (eg "joint teams" are eligible). There is no limit on the number of students per team, or how many graduate students are allowed.

2.2 ONE PROJECT PER TEAM

Each team shall submit no more than one project into the IREC. Furthermore, no project may be entered in more than one category at the IREC. Although, as previously noted, teams are permitted to switch categories as necessary prior to submitting their final Project Technical Report. Finally, students are free to participate on multiple teams, so long as each team is lead by a different individual. The event organizers will track and evaluate each team separately, regardless of common membership or academic affiliation.

2.3 PAYLOAD

2.3.1 PAYLOAD MASS

The launch vehicle shall carry no less than 8.8 lb of payload. Payload is defined as being replaceable with ballast of the same mass with no change to the rocket's trajectory in reaching the target apogee. This payload may be assumed present when calculating the launch vehicle's stability. In other words, launch vehicles entered into the IREC need not be stable without the required payload mass on-board.

2.3.2 INDEPENDANT PAYLOAD FUNCTIONALITY

Although non-functional "boiler-plate" payloads are permitted, teams are encouraged to launch creative scientific experiments and technology demonstrations; however, launch vehicles shall be designed to deliver the payload to the target apogee and recover themselves independent of any active or passive payload function(s). As previously noted, any stabilizing effects due to the payload's inert mass are exempted from this requirement.

Functional payloads entered in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition will be evaluated for awards by representatives from the Space Dynamics Laboratory (SDL) as part of the SDL Payload Challenge. Teams wishing to enter their payload(s) into the SDL Payload Challenge should consult the SDL Payload Challenge Page on the ESRA website (http://www.soundingrocket.org/sdl-payload-challenge.html).

2.3.3 PAYLOAD LOCATION AND INTERFACE

Neither the payload's location in the launch vehicle nor method of installation/removal is specified; however, competition officials will weigh payload(s) independent of all launch vehicle associated systems prior to flight. Therefore, the portion of payload associated components submitted for weighing shall not be inextricably connected to other, launch vehicle associated, components (eg the launch vehicle's recovery system) while being weighed. If the payload's design prevents it from being weighed completely independent of the launch vehicle, competition officials reserve the right to require teams integrate additional ballast to ensure the payload mass being launched is no less than required.

2.3.4 PAYLOAD GEOMETRY

The portion of payload associated components/systems submitted for weighing shall be integrated into one or more structures, whose stowed outer mold line (OML) are described by the CubeSat Standard (eg 1U, 2U, 3U, 3U+, etc).

Alternatively, the PocketQube (aka PocketQub) standard may be implemented to facilitate smaller airframe diameters. This standard uses units of "P", which are equivalent to 0.5U (ie 5 cm).

The CubeSat-style or PocketQube-style payload(s) may connect to other payload associated components (eg leads to sensors located variously throughout the airframe, deployment mechanisms, etc...) when integrated with the launch vehicle; however, the CubeSat-style assemblies alone will be weighed by competition officials.

2.3.5 RESTRICTED PAYLOAD MATERIALS

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.

2.4 FAA CLASS 2 AMATEUR ROCKET LIMITATION

Launch vehicles shall not exceed an installed total impulse of 9,208 pound-seconds (40,960 Newton-seconds), in order to meet the U.S. Federal Aviation Administration (FAA) definition of Class 2 Amateur Rocket (aka High-Power Rocket) - as per Code of Federal Regulations, Title 14 (14 CFR), Part 101, Subpart C, 101.22 Definitions.

2.5 RANGE TRACKING

Launch vehicles, and any deployable payloads, shall carry a radio beacon or similar transmitter aboard each independently recovered assembly to aid in locating them after launch. Tracking systems using the Global Positioning System (GPS) and an automatic packet reporting system (APRS) are highly encouraged.

2.6 OFFICIAL ALTITUDE LOGGING

Launch vehicles shall carry a COTS barometric pressure altimeter with on-board data storage, which will provide an official log of apogee for scoring. This sensor may be a feature of a COTS flight computer used for launch vehicle recovery system deployment. If a deployable payload is integrated on the launch vehicle, the official altitude logging system shall be mounted to the launch vehicle and not the payload.

While the on-board log is considered the primary data source for altitude reporting, telemetry – if implemented – will be accepted under certain circumstances defined in Section 2.8.1.4 of this document. If implemented, telemetric data shall originate from the same sensor source as the on-board data log.

2.7 PROJECT DELIVERABLES

The following sections define the deliverable materials (eg paperwork and presentation materials) competition officials require from teams competing in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition – including as appropriate each deliverable's format and minimum expected content. Unless otherwise noted, all deliverables will be submitted to ESRA via DropBox™. A DropBox™ account is not necessary to submit these files. The unique DropBox™ link found within each relevant deliverable description will facilitate submission of that deliverable.

The scheduled due dates of all required deliverables are recorded in the *Spaceport America Cup Integrated Master Schedule Document*, maintained on the ESRA website (TBD_direct URL).

2.7.1 ENTRY FORM AND PROGRESS UPDATES

Each team shall inform ESRA and NMSA of their intent to compete in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition by completing a provided Microsoft® Excel spreadsheet template as fully as possible at the time of submission. Teams shall submit updated versions of this spreadsheet on three specified

occasions prior to the competition. This "living document" will record changes in the project's technical characteristics during development. Competition officials understand not all technical details will be known until later in the design process. Therefore, the Entry Form and all subsequent updates prior to the final submission will be evaluated based only on their timeliness and completeness – defined as follows.

Completeness of the entry form and subsequent updates will be evaluated based on the number and type of fields completed. The template's fields are color coded to indicate the timeframe in which particular information is expected to be defined.

- ***RED:*** These fields shall be completed as accurately as possible in the entry form and all subsequent updates. These fields mostly concern the team's identifying information and the highest-level technical information. This information is expected to vary little during over the course of development.
- ***BLUE:*** These fields should always be completed "to the team's best knowledge at the time of submission", but is expected to vary with increasing accuracy and fidelity throughout development. These fields mostly concern the system's overall dimensions, and other characteristics which may be approximated early in development. Teams should begin providing such approximations no later than in the first progress update.
- ***YELLOW:*** Information contained in these fields may not be known or estimated reasonably until later in the project, but should populated as soon as possible. These fields mostly concern derived information, whose exact value depends heavily on earlier design decisions. Completely accurate information is not expected in these fields until the final progress update.

IMPORTANT: Do not reformat the template, shift fields around, or type in fields not designated for user input. Competition officials uses an automation script to import this into other spreadsheets and databases for administrative purposes. This will not work properly if the template is tampered with. The template also contains embedded comments to explain some fields. Please check these comments first before contacting ESRA for assistance completing the spreadsheet.

The *Intercollegiate Rocket Engineering Competition Entry Form & Progress Update* template is available for download on the ESRA website (TBD_direct URL).

Teams shall submit their entry form using the Drop Box™ link (TBD_submission URL), with the filename "Your Project Name_Entry Form". For example, a team named the "Reading Comprehension Rocketeers" would submit their entry form using the filename "Reading Comprehension Rocketeers_Entry Form".

Between the time when a majority of entry forms are received and the due date of the first progress update, ESRA will issue every team a numeric Team ID. Entries made later in the academic year should be accompanied by an e-mail addressed directly to ESRA (experimentalsoundingrocket@gmail.com_TBR), alerting the organizers to check for the late entry. Such entries will receive their Team ID shortly after receipt of the entry form. The Team ID is the competition officials' primary means of identifying and tracking all the many teams. Once assigned, any correspondence between a team and the organizers must contain that team's ID to enable a timely and accurate response.

Teams shall submit all subsequent progress updates using the Drop Box™ link (TBD_submission URL), with the filename "Your Team ID_nth Progress Update". For example, a team assigned the Team ID "42" would submit their first progress update using the filename "42_1st Progress Update", their second using the filename "42_2nd Progress Update", and so on.

2.7.2 PROJECT TECHNICAL REPORT

Each team shall submit a Project Technical Report which overviews their project for the judging panel and other competition officials. The Project Technical Report shall be formatted according to the style guide of the American Institute of Aeronautics and Astronautics (AIAA), using a provided Microsoft® Word document template.

The *Intercollegiate Rocket Engineering Competition Project Technical Report* template is available for download on the ESRA website (TBD_direct URL).

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their Project Technical Report using the Drop Box™ link (TBD_submission URL), with the file name "Your Team ID_Project Report". For example, a team assigned the Team ID "42" would submit the digital copy of their Project Report using the filename "42_Project Report". The event organizers will post these files in an online archive of the conference day proceedings. Teams will also bring a limited number of hardcopies to the Spaceport America Cup so members of the judging panel and other competition officials may consult the contents at will during interactions with the team.

The Project Technical Report's title is left to the team's discretion, however; the paper shall be subtitled "Team Your Team ID Project Technical Report for the Year IREC". For example, a team assigned the Team ID "42", competing in the 2017 IREC, would subtitle their Project Technical Report "Team 42 Project Technical Report for the 2017 IREC".

The Project Technical Report shall be no longer than 20 pages, not including figures, footnotes, sources, source endnotes, nomenclature lists, equations, explanations of variables, and appendices. The following sections overview the required minimum Project Technical Report sections and appendices in the order they should appear. Additional sections, subsections, and appendices may be added as needed.

2.7.2.1 ABSTRACT

The Project Technical Report shall contain an Abstract. At a minimum the abstract shall identify the launch vehicle's mission/category in which the team is competing, identify any unique/defining design characteristics of launch vehicle, define the payload's mission (if applicable), and provide whatever additional information may be necessary to convey any other high-level project or program goals & objectives.

2.7.2.2 INTRODUCTION

The Project Technical Report shall contain an Introduction. This section provides an overview of the academic program, stakeholders, team structure, and team management strategies. The introduction may repeat some of the content included in the abstract, because the abstract is intended to act as a standalone synopsis if necessary.

2.7.2.3 SYSTEM ARCHITECTURE OVERVIEW

The Project Technical Report shall contain a System Architecture overview. This section shall begin with a top level overview of the integrated system, including a cutaway figure depicting the fully integrated launch vehicle and it's major subsystems – configured for the mission being flown in the competition. This description shall be followed by the following subsections. Each subsection shall include detailed descriptions of each subsystem, and reflect the technical analyses used to support design and manufacturing decisions. Technical drawings of these subsystems should be included in the specified appendix.

- Propulsion Subsystems
- Aero-structures Subsystems
- Recovery Subsystems
- Payload Subsystems

2.7.2.4 MISSION CONCEPT OF OPERATIONS OVERVIEW

The Project Technical Report shall contain a Mission Concept of Operations (CONOPS) Overview. This section shall identify the mission phases, including a figure, and describe the nominal operation of all subsystems during each phase (eg a description of what is supposed to be occurring in each phase, and what subsystem[s] are responsible for accomplishing this). Furthermore, this section shall define what mission events signify a phase transition has occurred (eg "Ignition" may begin when a FIRE signal is sent to the igniter, and conclude when the propulsion system comes up to chamber pressure. Similarly, "Liftoff" may begin at vehicle first motion, and conclude when the vehicle is free of the launch rail). Phases and phase transitions are expected to vary from system to system based on specific design implementations and mission goals & objectives. However a team defines these mission phases and phase transitions, they will be used to help organize failure modes identified in a Risk Assessment Appendices.

2.7.2.5 CONCLUSIONS AND LESSONS LEARNED

The Project Technical Report shall contain Conclusions and Lessons Learned. This section shall include the lessons learned during the design, manufacture, and testing of the project, both from a team management and technical development perspective. Furthermore, this section should include strategies for corporate knowledge transfer from senior student team members to the rising underclassmen who will soon take their place.

2.7.2.6 SYSTEM WEIGHTS, MEASURES, AND PERFORMANCE DATA APPENDIX

The first Project Technical Report appendix shall contain System Weights, Measures, and Performance Data. This requirement will be satisfied by appending the Third/Final Progress Report as the first appendix of the Project Technical Report. As described in Section 2.7.1 of this document, the Third/Final Progress Report is also submitted as a separate excel file for administrative purposes.

2.7.2.7 PROJECT TEST REPORTS APPENDIX

The second Project Technical Report appendix shall contain applicable Test Reports from the minimum tests prescribed in the *IREC Design, Test, & Evaluation Guide* (TBD_direct URL). These reports shall appear in the following order. In the event any report is not applicable to the project in question, the team will include a page marked "THIS PAGE INTENTIONALLY LEFT BLANK" in its place.

- Recovery System Testing: In addition to descriptions of testing performed and the results thereof, teams shall include in this appendix a figure and supporting text describing the dual redundancy of recovery system electronics.
- SRAD Propulsion System Testing (if applicable): In addition to descriptions of testing performed and the results thereof, teams developing SRAD hybrid or liquid propulsion systems shall include in this appendix a fluid circuit diagram. This figure shall identify nominal operating pressures at various key points in the system – including the fill system.
- SRAD Pressure Vessel Testing (if applicable)

2.7.2.8 HAZARD ANALYSIS APPENDIX

The third Project Technical Report appendix shall contain a Hazard Analysis. This appendix shall address as applicable, hazardous material handling, transportation and storage procedures of propellants, and any other aspects of the design which pose potential hazards to operating personnel. A mitigation approach – by process and/or design – shall be defined for each hazard identified.

2.7.2.9 RISK ASSESSMENT APPENDIX

The fourth Project Technical Report appendix shall contain a Risk Assessment. This appendix shall summarize risk and reliability concepts associated with the project. All identified failure modes which pose a risk to mission success shall be recorded in a matrix, organized according to the mission phases identified by the CONOPS. A mitigation approach – by process and/or design – shall be defined for each risk identified. An example of such a matrix is available on the ESRA website at (TBD_direct URL).

2.7.2.10 ASSEMBLY, PREFLIGHT, AND LAUNCH CHECKLISTS APPENDIX

The fifth Project Technical Report appendix shall contain Assembly, Preflight, and Launch Checklists. This appendix shall include detailed checklist procedures for final assembly, arming, and launch operations. Furthermore, these checklists shall include alternate process flows for dis-arming/safe-ing the system based on identified failure modes. These off-nominal checklist procedures shall not conflict with the *IREC Range Standard Operating Procedures* (TBD_direct URL).

Competition officials will verify teams are following their checklists during all operations assembly, preflight, and launch operations. Therefore teams shall maintain a complete, hardcopy set of these checklist procedures with their flight hardware during all range activities.

2.7.2.11 ENGINEERING DRAWINGS APPENDIX

The sixth Project Technical Report appendix shall contain Engineering Drawings. This appendix shall include any revision controlled technical drawings necessary to define significant subsystems or components – especially SRAD subsystems or components.

2.7.3 POSTER SESSION MATERIALS

Each team shall bring to the Spaceport America Cup, a poster display which overviews their project for industry representatives, the general public, other students, and members of the judging panel. The information provided should encompass the overall project's design, testing, CONOPS, and purpose. The poster shall measure approximately 36 in × 48 in, and must be self supporting on either an organizer provided table or team provided easel. No partitions or other structures for hanging posters will be provided. These displays – as well as any practicable non-energetic project hardware – will be exhibited in a Poster Session held during the conference day at the Spaceport America Cup. One or more team members are expected to remain with the display throughout the day to answer questions and present their work to industry representatives, the general public, other students, and members of the judging panel. All teams will participate in the Poster Session, regardless whether or not they are additionally selected to participate in the Podium Session described in Section 2.7.4 of this document.

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their poster display using the Drop Box™ link (TBD_submission URL), with the file name "Your Team ID_Poster". For example, a team assigned the Team ID "42" would submit the digital copy of their poster display using the filename "42_Poster". The event organizers will post these files in an online archive of the conference day proceedings.

2.7.4 PODIUM SESSION MATERIALS

Each team shall submit an Extended Abstract on a particular aspect of their work for competition officials and the judging panel to consider including in a Podium Session held during the conference day at the Spaceport America Cup. Teams whose topics are accepted into the Podium Session will be considered eligible for Technical Excellence and Innovation Awards defined in Section 2.8.3 of this document. The Extended Abstract shall be formatted according to the style guide of the American Institute of Aeronautics and Astronautics (AIAA), using a provided Microsoft® Word document template.

The *Intercollegiate Rocket Engineering Competition Extended Abstract* template is available for download on the ESRA website (TBD_direct URL).

The Extended Abstract's title is left to the team's discretion, however; the document shall be subtitled "Team Your Team ID Technical Presentation to the Year IREC". For example, a team assigned the Team ID "42", competing in the 2017 IREC, would subtitle their Extended Abstract "Team 42 Technical Presentation to the 2017 IREC".

The Extended Abstract shall be no less than 500 words long and shall not exceed two pages, not including footnotes, sources, or source endnotes. The Extended abstract should not contain any tables, figures, nomenclature lists, equations, appendices etc. The submission must include sufficient detail to demonstrate its purpose, the technical foundation for the topic discussed, any preliminary results to date, and the expected results of flight testing at the Spaceport America Cup.

The topic a team selects for their Podium Session submission should be an aspect of their launch vehicle development which they are particularly proud of, excited about, learned the most in the process of, presented creates new knowledge, advances the field's understanding of a particular area, presented a unique technical challenge they overcame, and/or otherwise best demonstrates the team's technical excellence and/or innovation in a particular aspect of their work. A few examples of student work from past IRECs which would have made strong Podium Session submissions include the following. (This list is intended to be thought provoking only, and is in no way intended to be either comprehensive, exclusive, or otherwise limiting.)

- Design, analysis, and testing of additively manufactured plastic fins for transonic and supersonic flight
- Design, analysis, and testing of plasma based electrodynamic roll control actuators
- Rigorous internal ballistics analysis of a large SRAD solid rocket propulsion system
- Design, analysis, and testing of a drag reducing aerospike equipped nosecone
- Rigorous verification & validation testing of a SRAD ignition system for simultaneous activation of parallel rocket stages comprising multiple combustion cycles
- Design, analysis, and flight demonstration of automated, active telemetry transmitter tracking by a steerable, ground based antenna
- Rigorous verification & validation testing of a SRAD propulsion system, including propellant characterization and multiple hot fire tests
- Design, analysis, and testing of "rollerons" implemented for passive roll stability augmentation
- Design, analysis, and testing of an additively manufactured liquid rocket engine combustion chamber
- Progress in a regimented iterative approach to developing and implementing an active stability augmentation system
- Rigorous post test analysis and characterization of a previously undefined hybrid rocket motor failure mode
- Design, analysis, and testing of a regenerative cooling system
- Structural design based on exquisite aerodynamic/aerothermal loads analysis
- Exquisite trajectory analysis verified by flight demonstration
- Manufacturing capabilities enabled by SRAD fiber composite filament winding technology
- Structural analysis of fiber composite laminates using non-isentropic analytic techniques

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their Extended Abstract using the Drop Box™ link (TBD_submission URL), with the file name "Your Team ID_Extended Abstract". For example, a team assigned the Team ID "42" would submit the digital copy of their Extended Abstract using the filename "42_Extended Abstract". The event organizers will post these files in an online archive of the conference day proceedings.

At the same time they submit their Extended Abstract, teams shall also submit a digital, PDF copy of any slides they wish to use in their presentation using the Drop Box™ link (TBD_submission URL), with the file name "Your Team

ID_Presentation Slides". For example, a team assigned the Team ID "42" would submit the digital copy of their slide deck using the filename "42_Presentation Slides". The event organizers will post these files in an online archive of the conference day proceedings.

No less than 30_(TBR) teams will be accepted into the Podium Session. Each presentation will last 15-20 min_(TBR) Whether accepted into the Podium Session or not, all attending teams should be prepared to participate in this activity. On the conference day itself, competition officials may ask teams whose Extended Abstracts were considered "runners up" to take the place of any selected teams who fail to attend the Spaceport America Cup.

2.7.5 ADMINISTRATIVE DOCUMENTS

2.7.5.1 SCHOOL PARTICIPATION LETTER

Each team shall have the academic institution(s) in which its members are enrolled provide a signed letter to the event organizers_(TBR), acknowledging the team's participation in the Spaceport America Cup: Intercollegiate Rocket Engineering Competition. The signature shall be that of a faculty member or other paid, non-student staff representative. This will affirm the team in question does in fact represent the academic institution(s) its members claim affiliation with. Academic institutions sending more than one team to the IREC need only write one participation letter, covering all their teams, but each included team must submit an individual copy of that letter. In the case of a joint team, comprised of students from multiple academic institutions, each affiliated institution must provide its own letter to the team.

An example Spaceport America Cup: Intercollegiate Rocket Engineering Competition School Participation Letter is available for download on the ESRA website (TBD_direct URL).

On or before a specified date prior to the event, teams shall submit digital, PDF copy(s) of their signed school participation letter(s) using the Drop Box™ link (TBD_submission URL), with the filename "Your Team ID_School Initials_School Letter". For example, a team from Starfleet Academy assigned the Team ID "42" would submit the digital copy of their signed school participation letter with the filename "42_SA_School Letter". Similarly, if this same team were one formed jointly by students from Starfleet Academy and the Vulcan Science Academy, they would submit two files. The first would use the filename "42_SA_School Letter". The second would use the filename "42_VSA_School Letter".

2.7.5.2 SPACEPORT AMERICA CUP NMSA WAIVER AND RELEASE OF LIABILITY FORM

Each individual affiliated with a team – including team members, faculty advisers, and other invited guests – shall provide a signed copy of the *Spaceport America Cup NMSA Waiver and Release of Liability Form* to NMSA. Individuals who do not provide a signed copy of this form will be unable to participate in any competition related activities occurring on NMSA property.

The *Spaceport America Cup NMSA Waiver and Release of Liability Form* is available for download on the ESRA website (TBD_direct URL).

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their signed *Spaceport America Cup NMSA Waiver and Release of Liability Form* using the Drop Box™ link (TBD_direct URL), with the filename "Your Team ID_Your First and Last Name_NMSA Waiver Form". For example, an individual named Inigo Montoya who belongs to a team assigned the Team ID "42" would submit the digital copy of their signed *Spaceport America Cup NMSA Waiver and Release of Liability Form* with the filename "42_Inigo Montoya_NMSA Waiver Form".

2.7.5.3 SPACEPORT AMERICA CUP ESRA WAIVER AND RELEASE OF LIABILITY FORM

Each individual affiliated with a team – including team members, faculty advisers, and other invited guests – shall provide a signed copy of the *Spaceport America Cup ESRA Waiver and Release of Liability Form* to ESRA. Individuals who do not provide a signed copy of this form will be unable to participate in any competition related activities occurring on NMSA property.

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On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their signed *Spaceport America Cup ESRA Waiver and Release of Liability Form* using the Drop Box™ link (TBD_direct URL), with the filename "Your Team ID_Your First and Last Name_ESRA Waiver Form". For example, an individual named Inigo Montoya who belongs to a team assigned the Team ID "42" would submit the digital copy of their signed *Spaceport America Cup NMSA ESRA Waiver and Release of Liability Form* with the filename "42_Inigo Montoya_ESRA Waiver Form".

2.7.5.4 CONSENT TO LIMITED PERSONAL IDENTIFYING INFORMATION RELEASE FORM

Student team members may voluntarily permit the event organizers to release their name, academic affiliation, e-mail address, and phone number to interested hiring managers and human resource department representatives from industry sponsors of the Spaceport America Cup by providing a signed *Consent to Limited Personal Identifying Information Release Form*. The event organizers will not share the personal identifying information (PII) of any student team member who does not provide consent. Furthermore, any release of consenting student team member's PII shall be limited to industry sponsors of the Spaceport America Cup only.

The *Consent to Limited Personal Identifying Information Release Form* is available for download on the ESRA website (TBD_direct URL).

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their signed *Consent to Limited Personal Identifying Information Release Form* using the Drop Box™ link (TBD_direct URL), with the filename "Your Team ID_Your First and Last Name_PII Form". For example, an individual named Inigo Montoya who belongs to a team assigned the Team ID "42" would submit the digital copy of their signed *Consent to Limited Personal Identifying Information Release Form* with the filename "42_Inigo Montoya_PII Form".

2.8 AWARDS AND SCORING

2.8.1 CATEGORY "PLACE" AWARDS

A First Place Award will be granted to the highest scoring team in each of the six categories defined in Section 2.0 of this document. A Second Place Award will be granted to the second highest scoring team in each category for which five or more competing teams attend the Spaceport America Cup. A team is considered eligible for the place award(s) in its category after launching successfully to within ±2,000 ft of the 10,000 ft or 30,000 ft target altitude.

Teams are permitted to switch categories as necessary prior to submitting their final Project Technical Report. For example, if an SRAD propulsion system project encounters insurmountable difficulties at any point during the academic year, the student team is free to defer work on the SRAD system and opt for a near-term COTS solution without dropping out of the competition; however, each team's project will be entered into only one competition category. For example, a single team may not compete in two categories in the same year by flying once using a COTS motor, then again using an SRAD motor. In the event such a possibility exists for any team, the organizers highly encourage that team to compete in an SRAD rather than a COTS category.

A judging panel, assisted by the event organizers, will award points based on their evaluation of each teams required documentation (including the Entry Form, Progress Updates, and Project Technical Report), design implementation

(observed through the team's poster display and a day in the field spent prepping for launch), and demonstrated flight performance (including reported altitude and successful recovery).

2.8.1.1 SCORING ENTRY FORM AND PROGRESS UPDATE DELIVERIES

The correct, complete, and timely delivery of a team's Entry Form and subsequent Progress Updates is awarded as many as 100 points – 10% of 1,000 total points possible. The Entry Form and subsequent updates are considered correct if they are submitted using the template specified in Section 2.7.1 of this Document. They will be considered complete if they are filled out in accordance with Section 2.7.1 of this Document. They will be considered timely if they are received within 72 hrs of the deadline specified in the *Spaceport America Cup Integrated Master Schedule Document*.

The 100 points are divided evenly among the four submissions (ie the entry form and three subsequent updates), making each submission worth 25 points. The submission is awarded these points on a pass/fail basis and must meet all three criteria – correctness, completeness, and timeliness – in order to pass. Although they will not receive points for the submission, teams which miss a 72 hr submission window are still required to make that submission as soon as possible for administrative purposes – unless that team no longer plans to attend the Spaceport America Cup.

Teams which enter the Spaceport America Cup: Intercollegiate Rocket Engineering Competition later in the academic year, after the first progress report is normally due, will receive special instructions upon entry on how their Entry Form and subsequent Progress Updates will be handled.

2.8.1.2 SCORING PROJECT TECHNICAL REPORT

Timely Project Technical Reports will be awarded as many as 200 points – 20% of 1,000 points possible – for their correctness, completeness, and analysis. Only timely Project Technical Reports will be evaluated and scored. A Project Technical Report is considered timely if it is received within 72 hrs of the deadline specified in the *Spaceport America Cup Integrated Master Schedule Document*. Although they will not receive points for the submission, teams which miss a 72 hr submission window are still required to make that submission as soon as possible for administrative purposes – unless that team no longer plans to attend the Spaceport America Cup.

Correctness is worth 20% (40 points) of the Project Technical Report's overall point value. Correctness is defined by the it's adherence to the format/style guide specified in Section 2.7.2 of this document and upholding of basic technical editing standards. The report's correctness will be rated on a scale of 1-4 as follows – where each integer corresponds to a factor of 10 points.

> ***(4)*** *A rating of 4 indicates exemplary quality. The paper requires no substantial correction of grammatical mistakes, misspellings, mistyping, incorrect punctuation, inconsistencies in usage, poorly structured sentences, wrong scientific terms, wrong units and dimensions, inconsistency in significant figures, technical ambivalence, technical disambiguation, statements conflicting with general scientific knowledge, etc... Furthermore, the paper contains no stylistic errors deviating from the prescribed style guide.*
>
> ***(3)*** *A rating of 3 indicates at least average quality. The paper requires minimal correction of grammatical mistakes, misspellings, mistyping, incorrect punctuation, inconsistencies in usage, poorly structured sentences, wrong scientific terms, wrong units and dimensions, inconsistency in significant figures, technical ambivalence, technical disambiguation, statements conflicting with general scientific knowledge, etc... The paper may contain minimal, insubstantial deviations from the prescribed style guide.*
>
> ***(2)*** *A rating of 2 indicates no greater than average quality. Overall the paper's quality is symbolic of the proverbial "first draft". The paper requires some substantial correction of grammatical mistakes, misspellings, mistyping, incorrect punctuation, inconsistencies in usage, poorly structured sentences,*

wrong scientific terms, wrong units and dimensions, inconsistency in significant figures, technical ambivalence, technical disambiguation, statements conflicting with general scientific knowledge, etc... The paper deviates significantly from the prescribed style guide, or is formatted in accordance with another style guide entirely.

***(1)** A rating of 1 indicates poor quality. The paper requires numerous substantial corrections of grammatical mistakes, misspellings, mistyping, incorrect punctuation, inconsistencies in usage, poorly structured sentences, wrong scientific terms, wrong units and dimensions, inconsistency in significant figures, technical ambivalence, technical disambiguation, statements conflicting with general scientific knowledge, etc... The paper makes little or no attempt at cohesive formatting in accordance with either the prescribed or any other style guide.*

Completeness is worth 20% (40 points) of the Project Technical Report's overall point value. The Project Technical Report is considered complete if it contains all minimally required content defined in Section 2.7.2 of this document. Points for completeness are awarded on a pass/fail basis, and only minor omissions or ambiguity of required information is tolerated in a passing evaluation.

Analysis is worth 60% (120 points) of the Project Technical Report's overall point value. This constitutes a structured, qualitative assessment by the evaluating judge(s) of the analytic rigor demonstrated by the team during the iterative down-selection, refinement, and acceptance of all project aspects. The report's analysis will be rated on a scale of 1-4 as follows – where each integer corresponds to a factor of 30 points.

***(4)** A rating of 4 indicates exemplary quality. The paper provides adequate discussion of all key design decisions, including relevant trade space descriptions, constraints, and overall rational. Furthermore, the paper provides adequate discussion of all key verification & validation tests performed on the final design – as well as any significant progenitors – and demonstrates complete, valid conclusions were drawn from the results. Finally, the paper makes appropriate use of tables, figures, and appendices to effectively organize information and communicate it to the reader.*

***(3)** A rating of 3 indicates at least average quality. The paper provides adequate discussion of most key design decisions, including relevant trade space descriptions, constraints, and overall rational. Furthermore, the paper provides adequate discussion of most key verification & validation tests performed on the final design, and demonstrates complete, valid conclusions were drawn from the results. Finally, the paper generally makes appropriate use of tables, figures, and appendices to effectively organize information and communicate it to the reader.*

***(2)** A rating of 2 indicates no greater than average quality. Overall the paper's quality is symbolic of the proverbial "first draft". The paper provides adequate discussion of some key design decisions, including relevant trade space descriptions, constraints, and overall rational. Furthermore, the paper provides evidence of sufficient verification & validation testing performed on the final design, but does not does not consistently demonstrate complete, valid conclusions were drawn from the results. Finally, the paper would be improved by more appropriate use of tables, figures, and appendices to effectively organize information and communicate it to the reader.*

***(1)** A rating of 1 indicates poor quality. The paper lacks adequate discussion of any key design decisions, and makes little to no attempt at describing the relevant trade spaces, constraints, or overall rational. Furthermore, the paper lacks evidence sufficient verification & validation testing was performed at any point during the design process. Finally, the paper makes either no, or minimally effective, use of tables, figures, and appendices to organize information and communicate it to the reader.*

2.8.1.3 SCORING DESIGN IMPLEMENTATION

Teams will be awarded as many as 200 points – 20% of 1,000 points possible – for the overall competency of design, quality of construction, and degree of SRAD featured in their project. The judging panel will evaluate these criteria through interactions with the teams and their systems, occurring throughout the conference day Poster Session and all during the following day – spent making launch preparations in the field.

Competency of design and quality of construction are worth 50% (100 points) of the overall value assigned to Design Implementation. This constitutes a structured, qualitative assessment by the evaluating judge(s) of the team's relative competency in the physical principals governing their design (eg Did the team demonstrate they know what they're doing by designing something likely to work with a greater or lesser degree of success – provided it is sufficiently well constructed?) and the quality with which that design was constructed (eg Is the finished product sufficiently well constructed to meet the needs of the underlying design). The project's design and construction will be rated on a scale of 1-4 as follows – where each integer corresponds to a factor of 25 points.

> ***(4)*** *A rating of 4 indicates exemplary quality. All features of the project hardware reflect strong competency in the physical principals governing their design, and are of more than sufficient quality to operate as intended without risk of premature failure due to fatigue or reasonably expected loading. Wherever possible, the project hardware exhibits robust design characteristics – which decrease it's sensitivity to reasonably expected variations in "real-world" operations. Furthermore, the overall system exhibits evidence of a strong systems engineering discipline maintained throughout development (eg lacking any features which are both critical systems, and yet clearly implemented as "afterthoughts" to the intended system). Finally, the overall system complies with all expectations set by the IREC, Design, Test, & Evaluation Guide (TBD_direct URL).*
>
> ***(3)*** *A rating of 3 indicates at least average quality. All key features of the project hardware reflect adequate competency in the physical principals governing their design, and are of sufficient quality to operate as intended without risk of premature failure due to fatigue or reasonably expected loading. Furthermore, the project hardware makes at least some robust design characteristics in key areas – which decrease these components' or assemblies' sensitivity to reasonably expected variations in "real world" operations. Finally, the overall system exhibits evidence of a strong systems engineering discipline maintained throughout development (eg lacking any features which are both critical systems, and yet clearly implemented as "afterthoughts" to the intended system). Finally, the overall system complies with all expectations set by the IREC, Design, Test, & Evaluation Guide . (TBD_direct URL).*
>
> ***(2)*** *A rating of 2 indicates no greater than average quality. All key features of the project hardware reflect adequate competency in the physical principals governing their design, and are of sufficient quality to operate as intended without risk of premature failure due to fatigue or reasonably expected loading. No obvious attempts are made at robust design to decrease the system's to reasonably expected variations in "real-world" operations. Furthermore, the overall system may exhibit evidence of lapses in systems engineering discipline (eg operation of the overall system is facilitated by one or "field modifications" – which have become critical systems themselves, yet are clearly implemented as "afterthoughts" to the intended system). Finally, the overall system complies with the minimum expectations set by the IREC, Design, Test, & Evaluation Guide (TBD_direct URL).*
>
> ***(1)*** *A rating of 1 indicates poor quality. One or more key features of the project hardware reflect inadequate competency in the physical principals governing their design, and/or are of insufficient quality to operate as intended without risk of premature failure due to fatigue or reasonably expected loading. No obvious attempts are made at robust design to decrease the system's to reasonably expected variations in "real-world" operations. Furthermore, the overall system may exhibit evidence*

of lapses in systems engineering discipline (eg operation of the overall system is facilitated by one or "field modifications" – which have become critical systems themselves, yet are clearly implemented as "afterthoughts" to the intended system). Such a system fails to meet the minimum expectations set by the IREC, Design, Test, & Evaluation Guide (TBD_direct URL).

The degree of SRAD featured in a project is worth 50% (100 points) of the overall value assigned to Design Implementation. Components are considered SRAD if they are either designed and manufactured by students, or designed by students and manufactured by a third party working to student supplied specifications. Substantial modification of COTS components (eg student reinforcement of COTS airframe components to withstand predicted loads) will also be considered SRAD. Note that only non-propulsion systems/components are considered in this evaluation, propulsion system being a determining factor in the project's competition category. The degree of SRAD featured in a project will be rated on a scale of 1-4 as follows – where each integer corresponds to a factor of 25 points.

***(4)** A rating of 4 indicates extensive SRAD throughout the project. All the following launch vehicle systems/components meet the SRAD definition: fins (including associated mounting structures); airframe; aerodynamic fairings (including nosecones, tail cones, skirts, transitions and similar structures); any parachutes (including parafoils, or similar recovery devices). SRAD of systems/components beyond those listed here may be used as positive points-of-differentiation between similarly rated projects.*

***(3)** A rating of 3 indicates significant SRAD throughout the project. At least three of the following launch vehicle systems/components meet the SRAD definition: fins (including associated mounting structures); airframe; aerodynamic fairings (including nosecones, tail cones, skirts, transitions and similar structures); any parachutes (including parafoils, or similar recovery devices).*

***(2)** A rating of 2 indicates moderate SRAD throughout the project. At least two of the following launch vehicle systems/components meet the SRAD definition: fins (including associated mounting structures); airframe; aerodynamic fairings (including nosecones, tail cones, skirts, transitions and similar structures); any parachutes (including parafoils, or similar recovery devices).*

***(1)** A rating of 1 indicates minimal SRAD throughout the project. No more than one of the following launch vehicle systems/components meet the SRAD definition: fins (including associated mounting structures); airframe; aerodynamic fairings (including nosecones, tail cones, skirts, transitions and similar structures); any parachutes (including parafoils, or similar recovery devices). A rating of 0 may be given if none of the aforementioned meet the SRAD definition.*

2.8.1.4 SCORING FLIGHT PERFORMANCE

Team's will be awarded as many as 500 points – 50% of 1,000 points possible – for their project's flight performance during the three days allotted for launches at the Spaceport America Cup, demonstrated by altitude achieved relative to the target apogee and successful recovery.

The accuracy of the launch vehicle's actual apogee achieved relative to the target apogee is worth 70% (350 points) of the overall value assigned to flight performance. Precise Trajectory planning is important. Points will be awarded for apogees within ±2,000 ft of the 10,000 ft AGL or 30,000 ft target apogee according to the following formula.

$$Points = 350 - \left(\frac{350}{2{,}000}\right) \times \left|Apogee_{Target} - Apogee_{Actual}\right|$$

where $Apogee_{Target}$ *may equal either 10,000 ft AGL or 30,000 ft AGL*

Teams will nominally report in person to a judge the apogee logged on board the launch vehicle by the official altitude logging system after it's retrieval and return to the designated basecamp area prior to the end of launch operations on the final scheduled launch day. The official altitude logging system is defined in Section 2.6 of this document.

If telemetry data from the official altitude logging system is available, teams may report the apogee revealed in this telemetry to a competition official if and when a visual confirmation of nominal ascent and recovery system deployment events is possible. This information will be used for scoring only in the event the launch vehicle is not recovered prior to the end of launch operations on the final scheduled launch day.

The successful recovery of the launch vehicle is worth 30% (150 points) of the overall value assigned to flight performance. A recovery operation is considered successful if it does not result in excessive damage to the launch vehicle. 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. The evaluating judge(s) will visually inspect the launch vehicle upon its return to the designated basecamp area, and award these points on a pass/fail basis.

2.8.1.5 PENALTIES FOR UNSAFE OR UNSPORTSMANLIKE CONDUCT

Teams will be penalized 20 points off their total earned score for every instance of unsafe or unsportsmanlike conduct recorded by competition officials (eg judges, staff, volunteers, or staff members). Unsafe conduct includes, but is not limited to, violating the *IREC Range Standard Operating Procedures* (TBD_direct URL), failure to use checklists during operations, violating NMSA motor vehicle traffic safety rules, and failure to use personal protective equipment prescribed in the *IREC Design, Test, & Evaluation Guide* (TBD_direct URL). Unsportsmanlike conduct includes, but is not limited to, hostility shown towards any Spaceport America Cup Participant, intentional misrepresentation of facts to any competition official, intentional failure to comply with any reasonable instruction given by a competition official.

2.8.2 JUDGES CHOICE AND OVERAL WINNER AWARD

One team among the First Place Award winners in the six categories defined in Section 2.0 of this document will be named the overall winner of the Spaceport America Cup: Intercollegiate Rocket Engineering Competition, and receive a subscale version of The Spaceport America Cup! The recipient of this prestigious award is determined by qualitative assessments of the judging panel made throughout the entire event.

2.8.3 TECHNICAL EXCELLENCE AND INNOVATION AWARDS

ESRA presents two awards recognizing innovation and overall technical excellence to deserving teams competing in the IREC. The recipients of these awards are determined by qualitative assessments of the judging panel made during the Podium Session held during the conference day at the Spaceport America Cup, and interactions the following day – spent making launch preparations in the field.

2.8.3.1 JIM FURFARO AWARD FOR TECHNICAL EXCELLENCE

The Jim Furfaro Award for Technical Excellence recognizes a team which demonstrates exceptional engineering discipline and technical skill through their analyses and conclusions, project or program planning and execution, operational procedure, manufacturing processes, iterative improvement, systems engineering methodology, robust design, etc. A team is considered eligible for the Jim Furfaro Award if they are accepted into – and participate in – the Podium Session held during the conference day at the Spaceport America Cup, and if they complete at least one launch attempt at the Spaceport America Cup. A launch attempt is minimally defined as an attempted ignition of the launch vehicle propulsion system with the intent of executing the launch vehicle's designed mission CONOPS.

2.8.3.2 DR. GIL MOORE AWARD FOR INNOVATION

The Dr. Gil Moore Award for Innovation recognizes a team whose project includes one or more features (including analytic or operational processes as well as components or assemblies) the judging panel finds genuinely "novel", "novel", "inventive", or solving a unique problem identified by the team. A team is considered eligible for the Dr. Gil Moore Award if they are accepted into – and participate in – the Podium Session held during the conference day at the Spaceport America Cup, and if they complete at least one launch attempt at the Spaceport America Cup. A launch attempt is minimally defined as an attempted ignition of the launch vehicle propulsion system with the intent of executing the launch vehicle's designed mission CONOPS.

2.8.4 TEAM CONDUCT AWARDS

ESRA presents two awards recognizing teams competing in the IREC whose conduct throughout the Spaceport America Cup is exemplary of goals and ideals held by the event organizers. The Spaceport America Cup should be an event where academia, industry, and the public may come together to preserve, popularize, and advance the science of rocketry in a collaborative environment energized by friendly competition.

2.8.4.1 TEAM SPORTSMANSHIP AWARD

The Team Sportsmanship Award recognizes a team which goes above and beyond to assist their fellow teams and the event organizers assure the Spaceport America Cup: Intercollegiate Rocket Engineering Competition is a productive, safe, and enjoyable experience for all involved. They may do this in many ways, such as making themselves available to lend-a-hand whenever and however they can (whether they are asked to or not), being positive role models for their fellow teams, and generally being a "force for good" in every activity in which they involve themselves. A team is considered eligible for the Team Sportsmanship Award by being present at the Spaceport America Cup.

2.8.4.2 TEAM SPIRIT AWARD

The Team Spirit Award recognizes a team which arrives at the Spaceport America Cup with proverbial (or literal) smiles on their face, a school flag in their hand, and never lets either waiver throughout the event. They show great pride in their work, learn from their mistakes, remain positive when things don't go their way, engage members of the general public with respect and enthusiasm, and show respect for invited guests by attending and participating guest speaker presentations whenever possible. A team is considered eligible for the Team Sportsmanship Award by being present at the Spaceport America Cup.

2.9 DISQUALIFICATION FROM CONSIDERATION FOR ANY AWARD

A limited number of criteria constitute grounds for disqualification from consideration for any award. These include a failure to meet the defining IREC mission requirements recorded in Sections 2.0 through 2.6 of this document, failure to submit a Project Technical Report and third/final progress update at any time prior to the Spaceport America Cup, and failure to send eligible team member representatives to the Spaceport America Cup. Finally, any Team found to have accrued at least 10 safety or unsportsmanlike conduct infractions at any time during the Spaceport America Cup will be disqualified. Any individual observed committing a single, severe safety or unsportsmanlike conduct infraction may be summarily removed and barred from participation in the remainder of the Spaceport America Cup.

2.10 WITHDRAWAL FROM COMPETITION

Teams which decide to formally withdraw from the Spaceport America Cup: Intercollegiate Rocket Engineering Competition at any time prior to the event must send an e-mail entitled "TEAM Your Team ID FORMALLY WITHDRAWS FROM THE Competition Year IREC" to (TBD_e-mail address). For example, a team assigned the

Team ID "42" would withdraw from the 2017 IREC by sending an e-mail entitled "TEAM 42 FORMALLY WITHDRAWS FROM THE 2017 IREC" to (TBD_e-mail address).

2.11 SPONSORED CHALLENGES

In addition to the six categories defining the general competition, the Spaceport America Cup: intercollegiate rocket Engineering competition may host any number of "Challenge Categories" administered by sponsoring organizations. ESRA considers a "challenge" to be any unique technical/performance requirement levied on participating teams within the regulatory limits of the event. ESRA will work with the sponsoring organization to ensure their Challenge requirement(s) are feasible within the limits of the event. Otherwise, Challenge sponsors are entirely responsible for administering their Challenge. They will define its judging criteria, answer participating team's questions, and may set reporting criteria beyond those defined by ESRA.

Teams will find the current list of available Challenges, including an executive summary of each and contact information for the sponsoring organization on the ESRA website (TBD_direct url).

3.0 NON-COMPETING EXHIBITION AND DEMONSTRATION FLIGHT PARTICIPATION

Sponsoring industry groups, colleges, universities, and high schools are all also welcome to participate in the Spaceport America Cup with projects intended for non competing, exhibition/demonstration flights. These groups must either restrict their flight activities to the maximum altitude set for the IREC, or pursue their own waiver. Otherwise these groups are generally exempt from the rules and requirements defined in Section 2.0; however, they must contact the event organizers, who will inform them what rules and requirements they are required to follow as they proceed. High school teams taking advantage of this STEM education opportunity must do so under the supervision/guidance of either National Association of Rocketry (NAR)/Tripoli Rocketry Association (TRA) Level 3 certified individual(s), or industry mentors. Finally, despite being exempt, non-competing exhibition and demonstration teams are highly encouraged to participate in the conference day Poster Session, and submit a Project Technical Report for online publication.

4.0 INTERNATIONAL TRAFFIC IN ARMS REGULATIONS

Speakers and attendees of the Spaceport America Cup are reminded that some topics discussed at conferences could be controlled by the International Traffic in Arms Regulations (ITAR). U.S. persons (U.S. citizens and permanent residents) are responsible for ensuring that technical data they present in open sessions to non-U.S. persons in attendance or in conference proceedings are not export restricted by the ITAR. U.S. persons are likewise responsible for ensuring that they do not discuss ITAR export-restricted information with non-U.S. nationals in attendance. Similarly, US person authors of IREC Project Technical Reports as well as Podium Session submissions and associated slide decks are responsible for ensuring the content of their materials does not exceed the interpretation of "fundamental research" and the ITAR established by their affiliated academic institution(s).

APPENDIX A: ACRONYMS, ABBREVIATIONS, AND TERMS

ACRONYMS & ABBREVIATIONS	
AGL	Above Ground Level
AIAA	American Institute of Aeronautics and Astronautics
APCP	Ammonium Perchlorate Composite Propellant
APRS	Automatic Packet Reporting System
CFR	Code of Federal Regulations
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
ESRA	Experimental Sounding Rocket Association
FAA	Federal Aviation Administration
GPS	Global Positioning System
HPR	High Power Rocket *or* Rocketry
IREC	Intercollegiate Rocket Engineering Competition
ITAR	International Traffic in Arms Regulations
LOX	Liquid Oxygen
NAR	National Association of Rocketry
NMSA	New Mexico Spaceport Authority; aka Spaceport America
OML	Outer Mold Line
PII	Personally Identifiable Information
SAC	Spaceport America Cup
SDL	Space Dynamics Laboratory
SRAD	Student Researched & Developed
STEM	Science, Technology, Engineering, and Mathematics
TBD	To Be Determined
TBR	To Be Resolved
TRA	Tripoli Rocketry Association

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 (eg 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 Spaceport America Cup: IREC, 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.