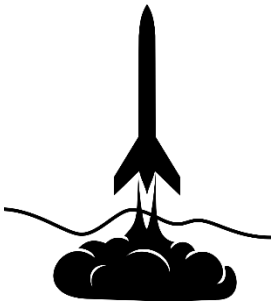

Spaceport America Cup

Intercollegiate Rocket Engineering Competition Rules & Requirements Document

Revision History

REVISION	DESCRIPTION	DATE
Baseline	Baseline Revision Last Updated	03/06/2017
Rev. A	1. Section 1.1 revised to reflect completed transition to SA Cup 2. Section 1.3 revised to allow for minor, mid-cycle updates 3. Section 1.4 revised to reflect administrative form changes a. Separate, paper ESRA and NMSA waiver forms replaced by a single, digital form b. Individual PII release form deleted 4. Section 2.0 revised for clarity 5. Section 2.1 reorganized for clarity 6. Section 2.2 (formerly Section 2.3) reorganized and revised – most notably to reflect ESRA and SDL's official stance on the spirit and intent of encouraging mature payload interfaces via the CubeSat standard a. Section 2.2.1 (formerly Section 2.3.1) amended with clarification of allowable deviation in payload weight due to calibration differences measurement devices b. Section 2.2.2 (formerly (section 2.3.2) revised to clarify differences between payload(s) and commonly confused launch vehicle subsystems c. Section 2.2.3 (formerly Section 2.3.4) revised to eliminate option for in-situ weight addition, in favor of a point penalty d. Section 2.2.5 (formerly Section 2.3.5) revised for clarity and to distinguish between functional payloads (not necessarily required to meet CubeSat form factor) and non-functional payloads (required to meet CubeSat form factor). 7. Section 2.6.2.10 (formerly Section 2.7.2.10 amended to include additional requirement that hybrid and liquid propulsion system teams included processes and procedures for cleaning 8. Section 2.6.3 (formerly Section 2.7.3) amended to include additional requirement for prominent Team ID# marking on Poster Session materials. 9. Section 2.6.4 (formerly Section 2.7.4) amended to include still more ideas for podium session topics 10. Section 2.6.5.2 added to request insurance information from schools 11. Section 2.6.5.3 (formerly Section 2.7.5.2) revised to define single, paperless NMSA and ESRA waiver and release of liability form 12. Former Section 2.7.5.3: [paper] ESRA waiver form deleted 13. Former Section 2.7.5.4: [paper] NMSA waiver form deleted 14. Section 2.7.1 (formerly Section 2.8.1) revised to clarify Place Awards eligibility within half the category target altitude 15. Section 2.7.1.1 (formerly Section 2.8.1.1) revised to adjust value to 60 pts (formerly 100 pts) 16. Section 2.7.1.2 (formerly Section 2.8.1.2) revised to permit revision of a project's "analysis" score based on competition officials' team interactions at the SA Cup, and to shift point distribution a. "Completeness" is worth 20 pts (formerly 40 pts) b. "Analysis" is worth 140 pts (formerly 120 pts)	11/12/2017

REVISION	DESCRIPTION	DATE
	17. Section 2.7.1.3 (formerly Section 2.8.1.3) revised to replace SRAD evaluation with strategic design decisions evaluation, and to shift point values and distribution a. Competency of design and quality of construction worth 180 pts (formerly 100) b. SRAD evaluation replaced with strategic design decisions evaluation worth 60 pts 18. Section 2.7.1.4 (formerly Section 2.8.1.4) revised to widen scoring band to ±30% of the category target altitude (formerly ±2,000 ft) 19. Section 2.7.1.6 added to codify payload requirement violation penalties 20. Section 2.7.1.7 added to codify bonus for eligible CubeSat payload(s) 21. Section 2.7.1.8 added to codify bonuses for efficient launch preparation 22. Section 2.7.3 (formerly 2.8.3) revised for clarity and amended to codify Hoult and Barrowman awards a. Section 2.7.3.3 added to codify Hoult Award for Mod & Sim b. Section 2.7.3.4 added to codify Barrowman Award for Flight Dynamics 23. Former Section 2.11: Sponsored Challenges deleted with intent to host content on ESRA or SA Cup website 24. Former Section 3.0: Non-competing demonstration flights deleted with intent to host content on ESRA website 25. Hyperlinked cross-references 26. Other sections renumbered as needed 27. General edits for spelling, grammar, and clarity	
Rev. A	1. Former Section 2.1.2 deleted in response to participant lobbying a. Individual student organizations may once again enter multiple teams into the IREC b. Each of these teams will continue to represent one project/rocket c. A student organization should not have multiple teams entered in a single IREC category 2. Section 2.1.2 (formerly Section 2.1.3) renumbered due to previous section's deletion	05/13/2018
Rev. B	1. Section 2.1.2 updated and renamed a. A student organization is limited to two teams with standard rationale for approving multiple teams b. A student organization may submit a third team, but the rationale is subject to additional scrutiny for approval c. A student organization may not submit more than three teams under any circumstances d. Renamed to reflect the organization limits also set forth by this section: "Team Organization & Submission Limitations" 2. Section 2.6.2 revised to show the requirement of completion /population of all fields in the document and the criteria and guidelines by which the Entry Form and Progress Updates will be reviewed 3. General edits for spelling, grammar, and clarity	11/03/2018

REVISION	DESCRIPTION	DATE
Rev C	1. Removed all references to Dropbox™. All progress reports and documents are now to be uploaded to each team's Hero^X account. 2. Section 2.6.2 updated to limit Project Technical Reports file size to less than 20MB in size. Clarification that Project Technical Reports shall be submitted as a single PDF file (multiple files will not be accepted). 3. Minor formatting and grammar corrections throughout.	10/4/2019
Rev D	1. Minor formatting and grammar corrections throughout. 2. Rocket Tracking updated with new GPS requirements	11/18/19

Table of Contents

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 (SACup), 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. The next year marked the start of a new era with the inaugural Spaceport America Cup. Over 1,100 students, faculty, and representatives from 22 industry partners participated in an academic conference, rocket and payload engineering competitions, and non-competing demonstration flight tests.

1.2 PURPOSE AND SCOPE

This document defines the rules and requirements governing participation in the IREC. Additional guidance for collegiate teams entered in the IREC is contained in the *IREC Design, Test, & Evaluation Guide (DTEG)*, maintained on the ESRA website. The DTEG provides teams with project development guidance ESRA uses to promote flight safety. Departures from this guidance may negatively impact an offending team's score and flight status depending on the degree of severity.

IREC teams should avoid feeling constrained before seeking clarification and may contact ESRA with questions or concerns regarding their project plans’ alignment with the spirit and intent of this document.

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. Major revisions will be accomplished by complete document reissue. “Real world events” may require smaller revisions to this document in the months leading up to a competition. Such revisions will be reflected in updates to the document’s effective date. The authority to issue revised versions of this document rests with ESRA and NMSA. Revisions will be approved either by ESRA, or jointly by both organizations as appropriate.

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 herein or contain reference information useful in the application of this document.

DOCUMENT	FILE LOCATION
IREC Design, Test, & Evaluation Guide	http://www.soundingrocket.org/sa-cup-documents--forms.html
SA Cup Integrated Master Schedule Document	http://www.soundingrocket.org/sa-cup-documents--forms.html
SAC Range Standard Operating Procedures	http://www.soundingrocket.org/sa-cup-documents--forms.html
GPS Tracking Requirement and Recommendations	http://www.soundingrocket.org/sa-cup-documents--forms.html
IREC Project Technical Report Template	http://www.soundingrocket.org/sa-cup-documents--forms.html
IREC Extended Abstract Template	http://www.soundingrocket.org/sa-cup-documents--forms.html
Spaceport America Cup Waiver and Release of Liability Form	https://www.spaceportamericacup.com/2018-spaceport-america-cup-waiver.html
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 IREC 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

SRAD propulsion systems are defined as those designed by students – regardless of whether fabrication is performed by students directly, or by a third party working to student supplied specifications – and can include student designed modifications of COTS systems. ESRA reserves the right to change the category in which a project is initially entered based on the design presented.

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 substances, are all considered non-toxic. Toxic propellants are defined as those requiring breathing apparatus, special storage and transport infrastructure, extensive personal protective equipment, etc. (e.g. Hydrazine and N2O4).

Additional high-level design and acceptance testing requirements are contained in the DTEG, maintained on the ESRA website. ESRA uses the DTEG to promote flight safety. Departures from the DTEG may negatively impact an offending team's score and flight status, depending on the degree of severity.

Competition Officials will evaluate competitors for Place Awards within each competition category based on the quality of required project documentation, a Poster Session held during the SA Cup Conference, the quality of their system's overall design and construction, and finally the program's overall operational efficiency and performance demonstrated at the SA Cup. Furthermore, Competition Officials will select no less than 24 teams to present a particular aspect of their work in a Podium Session held during the SA Cup Conference. These teams are eligible to receive certain Technical Achievement Awards.

IREC teams should avoid feeling constrained before seeking clarification and may contact ESRA with questions or concerns regarding their project plans' alignment with the spirit and intent of this document.

2.1 TEAM COMPOSITION AND ELIGIBILITY

2.1.1 STUDENT TEAM MEMBERS

IREC Teams shall consist of members who were matriculated undergraduate or graduate students (i.e. Masters or Doctoral students) during the previous academic year (e.g. former students who graduated shortly before the competition remain eligible) from one or more academic institutions (e.g. "joint teams" are eligible). There is no limit on the overall number of students per team, or on the number of graduate students per team. Students are free to participate on multiple teams, so long as each team is led by a different individual.

2.1.2 TEAM ORGANIZATION AND SUBMISSION LIMITATIONS

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. The event organizers will track and evaluate each team separately, regardless of common student membership or academic affiliation.

> *Important: Although individual student organizations may form multiple IREC teams, these teams must be entered in separate IREC categories, and are limited to a maximum of two or three teams per individual student organization. Student organizations which submit multiple IREC teams must provide a rationale for the formation of multiple IREC teams within the "Any other pertinent information block" found at the bottom of each team's Entry Form and Progress Report described in Section 2.6.1 of this document. Such rationale typically relates to the parent organization's overall membership size and/or diversity of work – with ESRA's current policy being to grant greater consideration to arguments made based on "diversity of work" than to "overall membership size". Any student organization wishing to submit a third team will find its rationale subject to additional scrutiny and is expected to demonstrate realistic yet ambitious technical design and engineering goals. In order to foster the diversity and spirit of the competition, under no circumstances will more than three teams be accepted from any single student organization.*

2.2 PAYLOAD

2.2.1 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 launch vehicle's trajectory in reaching the target apogee, or its' successful recovery. This payload may be assumed present when calculating the launch vehicle's stability. In other words, launch vehicles entered in the IREC need not be stable without the required payload mass on-board.

Competition officials will “weigh-in” the launch vehicle’s payload(s) at the Spaceport America Cup with a scale they provide. Understanding there may be discrepancies between a team’s own scale and the official one used for weigh-in, competition officials will accept payload weigh-ins as much as 5% (~0.4 lb) less than the specified minimum without penalty. For example, competition officials will not penalize a team whose payload measured 8.8 lb on the team’s own scale but 8.4 lb on the officials’ scale. Any weight greater than the specified minimum is acceptable.

2.2.2 INDEPENDENT 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). For example, an active launch vehicle stability augmentation system is a launch vehicle subsystem – not a payload. Such launch vehicle subsystems will contribute to competition officials’ overall evaluation of a project, and may be submitted to the SA Cup Conference Podium Session described in Section 2.6.4 of this document, but they are not payloads.

Scientific experiments and technology demonstration payloads entered in the IREC may be evaluated for awards by representatives from the Space Dynamics Laboratory (SDL) as part of the SDL Payload Challenge – an Intercollegiate Payload Engineering Competition hosted at the Spaceport America Cup. 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).

2.2.3 PAYLOAD LOCATION AND INTERFACE

Neither the payload's location in the launch vehicle nor its’ method of integration and removal is specified; however, competition officials will weigh payload(s) independent of all launch vehicle associated systems prior to flight. Therefore, the payload(s) submitted for weigh-in shall not be inextricably connected to other, launch vehicle associated, components (e.g. the launch vehicle's recovery system, internal structure, or airframe) while being weighed. If the payload's design prevents it from being weighed completely independent of the launch vehicle, competition officials will impose a point penalty on the team in accordance with Section 2.7.1.6 of this document.

2.2.4 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.

2.2.5 PAYLOAD FORM FACTOR

The following sections concern the required shape and dimensions of payload(s) submitted for weigh-in. These requirements are different if the payload is a non-functional “boiler-plate” (aka mass emulator) or if it is a functional scientific experiment/technology demonstration (i.e. those entered in the SDL Payload Challenge). Section 2.2.5.1 defines the requirements for non-functional payloads. Section 2.2.5.2 defines the requirements for functional payloads.

2.2.5.1 BOILER PLATE PAYLOAD

Any launch vehicle carrying strictly non-functional, “boiler-plate” mass as it’s payload shall do so in the form of one or more CubeSats, which equal no less than 3U when stacked together. Each CubeSat shall be no less than 1U in size. One CubeSat Unit (1U) is defined as a 10cm×10cm×10cm (approx. 4in×4in×4in) cubic structure. Similarly, three CubeSat Units (3U) constitute either a single structure or a stack measuring 10cm×10cm×30cm (approx. 4in×4in×12in).

2.2.5.2 SCIENTIFIC EXPERIMENT OR TECHNOLOGY DEMONSTRATION PAYLOAD

Any functional scientific experiment or technology demonstration payload and its associated structure (i.e. those entered in the SDL Payload Challenge) may be constructed in any form factor, provided the experiment/technology and its associated structure remain in compliance with Sections 2.2.1, 2.2.2, 2.2.3, and 2.2.4 of this document. With special regard to compliance with Section 2.2.1, the required minimum payload mass should be achieved primarily by the experiment(s)/technology and associated support structure. The payload design may incorporate a limited amount of additional "boiler-plate" mass (perhaps as much as 2.25 lbs. or just over 1/4th the required minimum) to meet the required minimum while remaining exempt from Section 2.2.5.1 above. Competition officials may impose a point penalty on any team believed to be violating the spirit and intent of this rule in accordance with Section 2.7.1.6 of this document.

Finally, despite this exemption, ESRA and SDL highly encourage teams to adopt the CubeSat standard for their payload(s) whenever possible – either as the payload structure itself, or as an adapter which the payload is mated to prior to the combined assembly's integration with the launch vehicle (such an adapter could be included in the official payload mass). To promote this encouragement, teams whose functional payloads do adopt the CubeSat physical standard will be awarded bonus points in the IREC in accordance with Section 2.7.1.7.

2.3 FAA CLASS 2 AMATEUR ROCKET LIMITATION

Launch vehicles entered in the IREC shall not exceed an installed total impulse of 9,208 pound-seconds (40,960 Newton-seconds), 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.

2.4 ROCKET TRACKING

Starting in 2020, all SA Cup launch vehicles will carry a Global Position System (GPS) tracking system to expedite rocket recovery.

A new document has been uploaded to the documents section of the www.soundingrocket.org website which provides all the details of the new GPS Tracking requirement. All teams will be expected to adhere to this new rule to minimize the number of lost rockets and expedite recovery efforts.

2.5 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 may either be a standalone COTS product or a feature of a COTS flight computer - also 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 official altitude reporting, telemetry – if implemented – may be accepted under certain circumstances defined in Section 2.7.1.4 of this document. If implemented, this telemetric data shall originate from the same sensor source as the official on-board data log.

2.6 PROJECT DELIVERABLES

The following sections define the deliverable materials (e.g. paperwork and presentation materials) competition officials require from teams competing in the IREC – including as appropriate each deliverable's format and minimum expected content. All deliverables will be submitted to ESRA per the instructions provided to the teams. Each relevant deliverable description will facilitate submission of that deliverable or will be communicated to teams as is determined by ESRA.

The scheduled due dates of all required deliverables are recorded in the *Spaceport America Cup Integrated Master Schedule Document*, maintained on the ESRA website (http://www.soundingrocket.org/sa-cup-documents--forms.html).

2.6.1 ENTRY FORM AND PROGRESS UPDATES

Each team shall inform ESRA and NMSA of their desire to compete in the IREC by registering as a new team on the Spaceport America Cup Hero^X website (https://www.herox.com/SpaceportAmericaCup2020). Teams shall submit progress updates via the Hero^X site on three specified occasions prior to the competition. These progress updates 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 Progress Updates prior to the final submission will be evaluated based only on their timeliness and completeness – defined as follows.

Total completeness of the entry form and subsequent updates is required at all times. Reasonable engineering estimates and approximations are expected during the application process but, will be subject to progressive additional scrutiny in the subsequent Progress Updates. Teams should briefly mention their ongoing discussions and analysis in the comment fields for any numerical submissions that are known to be unreasonable or remain undecided. Teams may also respond to undecided criteria by demonstrating their understanding of any applicable event guidance or best practice governing the particular detail. In general, ESRA expects technical information to change, but information must always be provided. Only teams whose application meets this standard will be evaluated for entry into the competition. Accepted teams will be announced by the release of a Team ID list approximately two after the end of the application deadline.

Between the time when Entry Forms are received and the due date of the first progress update, ESRA will issue every team a numeric Team ID. Requests for entries made later in the academic year should be accompanied by an e-mail addressed directly to ESRA (general.info@esrarocket.org). If accepted, 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 number to enable a timely and accurate response.

2.6.2 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 (http://www.soundingrocket.org/sa-cup-documents--forms.html). Always check the template maintained on the ESRA website before drafting your Project Technical Report to ensure you are using the latest version.

On or before a specified date prior to the event, teams shall submit a single digital PDF copy of their Project Technical Report. The Project Technical Report shall not exceed 20 Megabytes in size. Teams shall submit their Project Technical reports using the Hero^X website (https://www.herox.com/SpaceportAmericaCup2020). The event organizers will post these files in an online archive of the conference 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 main title is left to the team's discretion, however; the paper shall be subtitled “Team Your Team ID Project Technical Report to the Year Spaceport America Cup". 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 to the 2017 Spaceport America Cup".

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.

2.6.2.1 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.

2.6.2.2 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.

2.6.2.3 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

2.6.2.4 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 (e.g. 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 (e.g. "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. No matter how a team defines these mission phases and phase transitions, they will be used to help organize failure modes identified in a Risk Assessment Appendix – described in Section 2.6.2.9 of this document.

2.6.2.5 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.

2.6.2.6 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 2.6.1 of this document, the Third/Final Progress Report is also submitted as a separate excel file for administrative purposes.

2.6.2.7 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* (http://www.soundingrocket.org/sa-cup-documents--forms.html). 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)

2.6.2.8 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. An example of such a matrix is available on the ESRA website at (http://www.soundingrocket.org/sa-cup-documents--forms.html).

2.6.2.9 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 (http://www.soundingrocket.org/sa-cup-documents--forms.html).

2.6.2.10 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*. Teams developing SRAD hybrid or liquid propulsion systems shall also include in this appendix a description of processes and procedures used for cleaning all propellent tanks and other fluid circuit components.

Competition officials will verify teams are following their checklists during all operations – including 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.

2.6.2.11 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.

2.6.3 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 inches × 48 inches 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. Finally, the poster shall prominently display the team's Team ID in the top, right corner, in bold, black, size 72 or larger, Arial font (or similar), on a white field.

These displays – as well as any practicable non-energetic project hardware – will be exhibited in a Poster Session held during the SA Cup Conference. 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 competition officials. 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 2.6.4 of this document.

On or before a specified date prior to the event, teams shall submit a digital, PDF copy of their poster display to the Spaceport America Cup Hero^{X} website (https://www.herox.com/SpaceportAmericaCup2020). The event organizers will post these files in an online archive of the conference proceedings. The submittal location and method for the Poster Session Materials is to be determined and will be communicated to the teams.

2.6.4 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 SA Cup Conference. Teams whose topics are accepted into the Podium Session will be considered eligible for Technical Achievement Awards defined in Section 2.7.3 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 (http://www.soundingrocket.org/sa-cup-documents--forms.html).Always check the template maintained on the ESRA website before drafting your Extended Abstract to ensure you are using the latest version.

The Extended Abstract's main title is left to the team's discretion, however; the document shall be subtitled "Team Your Team ID Technical Presentation to the Year Spaceport America Cup". 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 Spaceport America Cup".

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, 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 grid-fins
- 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 to the Hero^{X} website (https://www.herox.com/SpaceportAmericaCup2020). The event organizers will post these files in an online archive of the conference day proceedings. The submittal location and method for the Extended Abstract is to be determined and will be communicated to the teams.

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 to the Hero^{X} website. The event organizers will post these files in an online archive of the conference proceedings. The submittal location and method for the Presentation Slides is to be determined and will be communicated to the teams.

No less than 24 teams will be accepted into the Podium Session. Each presentation will be allotted 20 minutes, with an additional five minutes reserved for Q&A with judges and other audience members. 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.

2.6.5 ADMINISTRATIVE DOCUMENTS

2.6.5.1 SCHOOL PARTICIPATION LETTER

Each team shall have the academic institution(s) in which its members are enrolled provide a signed letter to ESRA, acknowledging the team's participation in the IREC at the Spaceport America Cup. 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 School Participation Letter is available for download on the ESRA website (http://www.soundingrocket.org/sa-cup-documents--forms.html).

On or before a specified date prior to the event, teams shall submit digital, PDF copy(s) of their signed school participation letter(s) to the Hero^{X} website. For example, a team from Starfleet Academy would submit the digital copy of their signed school participation 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.

2.6.5.2 SCHOOL PROOF OF INSURANCE

The event's insurance policy insurance covers ESRA, NMSA, and the state of New Mexico. It will pay for any accidents, damaged property, and injuries related to the event; however, there is a loophole. If a team's flight damages a person or property, and the person or property owner decides to sue the team for *additional* costs, the event's insurance does NOT protect the team from the additional lawsuit.

While the majority of teams may be covered by their college or university, some are not. Teams wishing to purchase additional insurance may do so on their own, or through the same company used by the event for $1,500 per launch. This cost increases if the launch being insured is a demonstration launch to higher altitudes than the IREC. The insurance company will negotiate costs for multiple launches and higher altitudes.

> *Note for 2019 participants: ESRA is attempting to renegotiate insurance requirements for a 3rd time for 2019. In the event ESRA is unsuccessful debating the powers that be, 2019 teams not covered under their school's insurance should budget for an additional $1,500. If ESRA is unsuccessful at negotiating with the powers that be, this additional insurance may be required of teams by NMSA for 2019..*

If purchasing additional insurance through the insurance company used by the event, contact:
Dana Smith | Assistant Vice President | JLT Aerospace (North America) Inc.
5847 San Felipe Road |Suite 2800| Houston | TX | 77057
Direct Dial: 713 325 7625 | Cell: 713 828 7319 | Fax: 713 789 0415
dana.smith@jltaerospace.com | www.jltaerospace.com

2.6.5.3 SPACEPORT AMERICA CUP WAIVER AND RELEASE OF LIABILITY FORM

Every individual attending the Spaceport America Cup – including team members, faculty advisers, and others – shall digitally sign the *Spaceport America Cup Waiver and Release of Liability Form*. Individuals who do not sign this form will be unable to participate in any activities occurring on NMSA property (i.e. the Spaceport).

The *Spaceport America Cup Waiver and Release of Liability Form* is available for digital signature at the following web address: https://www.spaceportamericacup.com/2018-spaceport-america-cup-waiver.html.

2.7 AWARDS AND SCORING

2.7.1 CATEGORY "PLACE" AWARDS

A First Place Award will be granted to the highest scoring, eligible 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, eligible team in each category. A team is considered eligible for the place award(s) in its category after launching successfully to at least half or more its 10,000 ft or 30,000 ft target altitude – depending on category. In the event no teams meet this definition in a given category, competition officials may issue Category Place Awards at their discretion based on multiple factors – including points accrued, launches attempted, and flight performance.

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.

Competition officials 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).

2.7.1.1 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 60points – 6% 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 2.6.1 of this Document. They will be considered complete if they are filled out in accordance with Section 2.6.1 of this Document. They will be considered timely if they are received no later than72 hrs. after the deadline specified in the *Spaceport America Cup Integrated Master Schedule Document*.

The 60points are divided evenly among the four submissions (i.e. the Entry Form and three subsequent Project Updates), making each submission worth 15points. 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 IREC 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.

2.7.1.2 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 no later than72 hrs. after 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 2.6.2 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 10% (20points) 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 2.6.2 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 70% (140points) of the Project Technical Report's overall point value. This constitutes a structured, qualitative assessment by the evaluating competition officials 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 35 points. Furthermore, this score may be amended at the Spaceport America Cup itself, based on the evaluators' assessment of the team's conceptual understanding during any interactions.

> ***(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 rationale. 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 rationale. 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 rationale. Furthermore, the paper provides evidence of sufficient verification & validation testing performed on the final design, but 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 rationale. 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.*

2.7.1.3 SCORING DESIGN IMPLEMENTATION

Teams will be awarded as many as 240points – 24% of 1,000 points possible – for the overall competency of design, quality of construction, and strategic design decisions exhibited by their work. Competition officials will evaluate these criteria through interactions with the teams and their systems, occurring throughout the SA Cup Conference Poster Session and all during the following day – spent making launch preparations in the field.

Competency of design and quality of construction are worth 75% (180 points) of the overall value assigned to Design Implementation. This constitutes a structured, qualitative assessment by the competition officials of the team's relative competency in the physical principals governing their design (e.g. 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 (e.g. 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 45points.

(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 its sensitivity to reasonably expected variations in "real-world" operations. Furthermore, the overall system exhibits evidence of a strong systems engineering discipline maintained throughout development (e.g. 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.*

(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 (e.g. 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.

***(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 (e.g. 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.*

***(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 (e.g. 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.*

The team's consideration of strategic design decisions is worth 25% (60 points) of the overall value assigned to Design Implementation. This constitutes a structured qualitative assessment by the competition officials of the team's due diligence in deciding how best to implement their design – in keeping with a strategic vision they can articulate clearly. In general, teams should set strategic goals for their project which extend beyond simply excelling in a particular category. ESRA places special significance on projects which leverage SRAD in a particular aspect, either to enhance the team's understanding of that subject, or to develop technology necessary for achieving a longer-term performance goal. While this evaluation can encompass a broad range of factors, the following 1-4 rating structure (where each integer corresponds to a factor of 15 points) illustrates some of the most significant factors competition officials will be coached to consider.

(4) A rating of 4 indicates exemplary strategic consideration given to the COTS and SRAD elements of the project. Interactions with team members demonstrate a clear, achievable vision for how challenges were selected to advance strategic goals, and the project's design implementation mirrors this. Furthermore, the manufacturing methods used in SRAD aspects of the project, such as additive manufacturing for example, are generally appropriate for the intended use and well understood by the team. This understanding extends not only to how the method works, but also its impact on project timelines, cost, and physical performance.

(3) A rating of 3 indicates at least average strategic consideration given to the COTS and SRAD elements of the project. Interactions with team members demonstrate a relatively clear, achievable vision for how challenges were selected to advance strategic goals, and the project's design implementation generally mirrors this. Furthermore, the manufacturing methods used in SRAD aspects of the project, such as additive manufacturing for example, are generally appropriate for the intended use and reasonably well understood by the team. This understanding extends to how the method works, and also its impact on project timelines, cost, and physical performance – in at least the most rudimentary sense.

(2)A rating of 2 indicates no better than average strategic consideration given to the COTS and SRAD elements of the project. Interactions with team members demonstrate an unrefined or questionably achievable vision for how challenges were selected to advance strategic goals, and the project's design implementation generally mirrors this. Furthermore, the manufacturing methods used in SRAD aspects of the project, such as additive manufacturing for example, are generally appropriate for the intended use, but may not be fully understood by the team. Their understanding extends in only the most limited ways to how the method works, its impact on project timelines, cost, and physical performance – and may be even more lacking in some areas.

(1) A rating of 1 indicates poor strategic consideration given to the COTS and SRAD elements of the project. Interactions with team members demonstrate little-to-no or completely unachievable vision for how challenges were selected to advance strategic goals, and the project's design implementation generally mirrors this. Furthermore, the manufacturing methods used in SRAD aspects of the project, such as additive manufacturing for example, are either impractical for the intended use or not well understood by the team. Their understanding in severely lacking in how the method works, as well as its impact on project timelines, cost, and physical performance.

2.7.1.4 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 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 ±30% of the 10,000 ft AGL or 30,000 ft target apogee according to the following formula.

$$Points = 350 - \left(\frac{350}{0.3 \times Apogee_{Target}}\right) \times \left|Apogee_{Target} - Apogee_{Actual}\right|$$

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

Teams shall report in person to competition officials the apogee logged by the official altitude logging system after it's retrieval and return to the designated basecamp area, prior to the end of eligible launch operations on the final launch day. The official altitude logging system is defined in Section 2.5 of this document.

If telemetry data from the official altitude logging system is available, teams may report the apogee revealed in this telemetry to competition officials if and when a 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 eligible 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. Competition officials will visually inspect the launch vehicle upon its return to the designated basecamp area and award these points on a pass/fail basis.

2.7.1.5 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 (e.g. judges, volunteers, or staff members). Unsafe conduct includes, but is not limited to, violating the *IREC Range Standard Operating Procedures*, failure to use checklists during operations, violating NMSA motor vehicle traffic safety rules, and failure to use appropriate personal protective equipment.

Unsportsmanlike conduct includes, but is not limited to, hostility shown towards any 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.

2.7.1.6 PENALTIES FOR VIOLATING PAYLOAD REQUIREMENTS

Teams will be penalized 100 points off their total earned score for each of the five payload requirements described in Section 2.2 of this document in spirit or intent. These include Mass, Independent Function, Location & Interface, Restricted Materials, and Form Factor. With regard to mass, due to the allowance made for differences in measuring devices, teams will not be permitted to modify their payloads with additional mass to avoid penalty at the event.

2.7.1.7 BONUSES FOR CUBESAT BASED PAYLOADS

Teams whose payload(s) qualify for the form factor exemption described in Section 2.2.5.2 of this document, yet still adopt the CubeSat standard form factor, will be awarded 50 bonus points in addition to their total earned score. This promotes ESRA and SDL's encouragement that teams adopt the CubeSat standard for their payload(s) whenever possible – either as the payload structure itself, or as an adapter which the payload is mated to prior to the combined assembly's integration with the launch vehicle (such an adapter could be included in the official payload mass).

2.7.1.8 BONUSES FOR EFFICIENT LAUNCH PREPARATIONS

Teams whose preparedness, efficient operations, and hassle-free design permit their being launched in a timely manner will be awarded bonus points in addition to their total earned score according to the following tiered system. Launch readiness is declared when competition officials managing Launch Control receive the team's completed Flight Card. No bonus points will be awarded for launch attempts ending in catastrophic failures (CATO).

- 100 bonus points will be awarded to teams declared launch ready by the end of the designated field preparation day and flown by the end of the first launch day. They remain eligible to receive these points until the end of the first launch day, or until their first launch attempt ending in a scrub – at which point the team is no longer eligible for the 100 point bonus, but may still achieve bonus points awarded for teams declared launch ready on the first launch day.
- 50 bonus points will be awarded to teams declared launch ready and flown during the first launch day. They remain eligible to receive these points until the end of the first launch day. or until their first launch attempt ending in a scrub – at which point the team may attempt to regain eligibility by attempting a return to launch readiness by the end of the day. Otherwise, the team is no longer eligible for the 50 point bonus, but may still achieve bonus points awarded for teams declared launch ready on the second launch day
- 25 bonus points will be awarded to teams declared launch ready and flown during the second launch day. They remain eligible to receive these points until the end of the second launch day. or until their first launch attempt ending in a scrub – at which point the team may attempt to regain eligibility by attempting a return to launch readiness by the end of the day. Otherwise, the team is no longer eligible for bonus points.
- 0 bonus points will be awarded to teams declared launch ready and flown during the third launch day.

2.7.2 JUDGES CHOICE AND OVERAL WINNER AWARD

One team among the First Place Award winners in the six categories defined in Section 2.0of this document will be named the overall winner of the Spaceport America Cup: Intercollegiate Rocket Engineering Competition, and receive their own copy of the Genesis Cup trophy! A perpetual trophy rendition of the Genesis Cup is displayed in the Gateway Gallery at Spaceport America. The recipient of this prestigious award is determined by qualitative assessments of the competition officials made throughout the entire event.

2.7.3 TECHNICAL ACHIEVEMENT AWARDS

ESRA presents four awards recognizing technical achievement to deserving teams competing in the IREC. Three of these are awarded based on the competition officials' qualitative assessments made during the Podium Session held during the SA Cup Conference, and interactions the following day – spent making launch preparations in the field. The final award awarded to any IREC team based on flight performance.

2.7.3.1 JIM FURFARO AWARD FOR TECHNICAL EXCELLENCE

The Jim Furfaro Award for Technical Excellence recognizes a team which demonstrates exceptional overall 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. Deference is given to eligible teams which 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.

2.7.3.2 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", "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. Deference is given to eligible teams which 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.

2.7.3.3 CHARLES HOULT AWARD FOR MODELING & SIMULATION

The Charles Hoult Award for Modeling & Simulation recognizes a team demonstrating excellence in math modeling and computational analyses. A team is considered eligible for the Charles Hoult Award if they are accepted into – and participate in – the Podium Session held during the conference day at the Spaceport America Cup. Deference is given to eligible teams which 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.

2.7.3.4 JAMES BARROWMAN AWARD FOR FLIGHT DYNAMICS

The James Barrowman Award for Flight Dynamics recognizes a team demonstrating exquisite trajectory analysis. This will be evaluated by comparing the percent error between each teams actual and predicted apogee – the predicted apogee being a value declared prior to launch, based on a team's trajectory analysis. The award is given to the team with the smallest percent error. All teams with successful launch attempts that provide apogee data will be eligible for this award.

2.7.4 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.

2.7.4.1 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.

2.7.4.2 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.

2.8 DISQUALIFICATION FROM CONSIDERATION FOR ANY AWARD

A limited number of criteria constitute grounds for disqualification from consideration for any award. These can include a failure to meet the defining IREC mission requirements recorded in Sections 2.0 through 2.5 of this document, failure to submit a Project Technical Report or third/final progress update at any time prior to the Spaceport America Cup (or otherwise failing to provide adequate project details in required deliverables), 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.

2.9 WITHDRAWAL FROM COMPETITION

Teams which decide to formally withdraw from the IREC 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 general.info@esrarocket.org. 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 general.info@esrarocket.org.

3.0 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). The Spaceport America Cup is intended as an ITAR-free event. 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 (e.g. propellants, pressurizing gasses, energetic devices), and may be extended to include replacement of damaged fins specifically designed for easy, rapid replacement.
FAA Class 2 Amateur Rocket	14 CFR, Part 101, Subpart C, 101.22 defines a Class 2 Amateur Rocket (aka High Power Rocket) as "an amateur rocket other than a model rocket that is propelled by a motor or motors having a combined total impulse of 40,960 Newton-seconds (9,208 pound-seconds) or less."
Non-toxic Propellants	For the purposes of the 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.