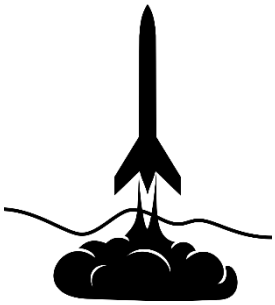

Spaceport America Cup

Intercollegiate Rocket Engineering Competition
Rules & Requirements Document

Revision History

REVISION	DESCRIPTION	DATE
2023 Version 1	1. Baseline for 2022 – changes from the previous version below 2. Added reference to Tripoli Safety Code in Chapter 2 3. Added new paragraph 2.2.3 describing the evaluation criteria for team entries 4. Added new paragraph 2.2.4 clarifying policy on teams with students from multiple institutions 5. Clarified payload weigh-in requirements in 2.3.3 6. Added clarification in 2.3.5.2 and 2.7.1.7 on requirements to get the CubeSat payload bonus. 7. Added clarification to 2.5 procedure 8. Added new paragraphs in 2.6.1 describing safety reviews for progress reports and adding an online safety review as the 3rd progress update. 9. Added wording in 2.6.2 allowing teams to use LaTeX to prepare the Project Technical Report 10. Re-added page limits in 2.6.2 11. Added clarification of expectations for the System Architecture Review in 2.6.2.3 12. Added specific requirements for the Weights and Measures appendix in 2.6.2.6 13. Added testing requirements in 2.6.2.7 to comply with DTEG 14. Added requirement in 2.6.2.10 for off-nominal procedures and for hybrid or liquid teams to have fill/vent/fault checklists 15. Told teams to not embed full CAD models into their files in 2.6.2.11 16. Added new language in 2.6.4 reiterating that Podium Session topics are limited to launch-vehicle-related items and specifically that payloads are not eligible for Podium Sessions. 17. Added new paragraph 2.6.5 which includes the requirement to meet timelines in the IMS 18. Remainder of section 2.6 renumbered accordingly 19. Revised 2.6.6.2 to clarify requirements for insurance and gave a deadline for teams not flying under TRA rules 20. Updated turn-in requirements for entry and progress updates in 2.7.1.1 21. Updated 2.7.1.4 to match “excessive damage” definition. 22. Extensive rework of judging criteria and rubrics in 2.8, rubrics moved to Appendix B 23. Matched “excessive damage” definition in 2.8.1.4 to the DTEG, Appendix A. This includes provision for components designed to be rapidly replaced 24. Removed unused acronyms from Appendix A 25. Minor edits and format changes	12/02/2022

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1.0 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.

Additional requirements for project deliverables can be found in the Integrated Master Schedule document, which is available on the ESRA website.

If any IREC team is unclear about competition rules and requirements, or has a situation not specifically addressed by the rules, they should contact ESRA with questions or concerns regarding their project plans' alignment with the spirit and intent of this IREC Rules & Requirements document.

1.1 DOCUMENTATION

The following documents include standards, guidelines, schedules, or required forms. The documents listed in this section are either applicable to the extent 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
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
TRA Safety Code	https://www.tripoli.org/content.aspx?page_id=22&club_id=795696&module_id=520420
Spaceport America Cup Waiver and Release of Liability Form	https://spaceportamericacup.com/2021-cup-liability-waiver/

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

Student teams competing in the IREC must design, build, and launch a rocket carrying a payload of no less than 8.8 lbs. to a target apogee of either 10,000 ft or 30,000 ft above ground level (AGL). Team Projects will be divided into one of the following six categories based on the type of project attempted. Teams are permitted to switch categories if required, 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

2.1 GENERAL GUIDELINES FOR DESIGN AND FLIGHT OPERATIONS

SRAD propulsion systems are defined as those designed by and manufactured by students. However due to constraints such as budget, lack of technical skills, tooling or financial, student teams may work with 3rd parties to assist in manufacturing of some components. Under no circumstances are the SRAD propellant components to be manufactured by a third party. This includes solid propellant grains

Multistage launch vehicles and all chemical propulsion disciplines (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 N_2O_4).

ESRA uses the DTEG to define and promote flight safety. The IREC utilizes national standards including NFPA 1127, FAA and other regulatory organizations. The requirements are specifically listed in the DTEG. In addition, all Solid and Hybrid Propellant categories must strictly follow Tripoli Rocketry Range Safety Rules. 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 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.

2.2 TEAM COMPOSITION AND ELIGIBILITY

2.2.1 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. Individual students may only compete on a single team.

2.2.2 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: Due to the significant demand and limited availability of student team slots for the Spaceport America Cup, the number of competing teams is limited to one per university.*

2.2.3 EVALUATION OF TEAM ENTRIES

Acceptance into the Spaceport America Cup is highly selective. Teams should have previous high power rocketry flight experience, and teams with SRAD, hybrid, or liquid projects should have experience relevant to their project. Teams should also have an experienced mentor and flyer of record. Competition officials will evaluate the overall quality of the team's application, relevant experience, quality of mentor/flyer of record, team outreach efforts, along with previous Cup experience to determine which teams will be accepted.

2.2.4 TEAM COMPOSITION AND MULTI-SCHOOL TEAMS

In general, the intent is that competing teams should represent one institution. However, in circumstances where there are not enough interested students at a given institution to form a team, or where school facilities or funding are unable to fully support a team, a team can be formed using students from more than one institution. Note: this is intended for teams who are limited by funding or facilities. If an institution fields a team, students from that institution cannot join another team. Teams will document their institutional affiliation(s) via the School Participation Letter(s) specified in 2.7.6.1

2.3 PAYLOAD

2.3.1 PAYLOAD MASS

The launch vehicle shall carry no less than 8.8 lbs. 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 lbs. on the team's own scale but 8.4 lbs. on the officials' scale. Any weight greater than the specified minimum is acceptable.

2.3.2 INDEPENDENT PAYLOAD FUNCTIONALITY

Although non-functional "boiler-plate" payloads are permitted, teams are highly 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 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).

2.3.3 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 or interface with the

launch vehicle (e.g., an adaptor to mate the payload to the rocket), competition officials will impose a point penalty on the team in accordance with Section 2.7.1.6 of this document.

2.3.4 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.

2.3.5 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 2.3.5.1 defines the requirements for non-functional payloads. Section 2.3.5.2 defines the requirements for functional payloads.

2.3.5.1 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).

2.3.5.2 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 2.3.1, 2.3.2, 2.3.3, and 2.3.4 of this document. With special regard to compliance with Section 2.3.1, 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 2.3.5.1 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 physical 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. To meet this requirement, a payload will have to fit completely in a CubeSat dispenser with nothing protruding or physically connecting outside of the no less than 10cm x 10cm x ≥ 30cm (in CubeSat increments, e.g., 3U, 4U) space. Accordingly, a payload measuring 10cm x 10cm x 30cm (3U), or a payload measuring 10cm x 10cm x 40 cm (4U) would receive the bonus, but a payload measuring 10cm x 10cm x 33cm would not, since it's not in CubeSat units.

Any team entering a rocket as a high-altitude demonstration flight (that may require a Class 3 waiver) will need to coordinate with ESRA officials to ensure the team is prepared to submit required FAA Class 3 waiver applications.

2.4 GPS ROCKET TRACKING

Starting in 2021, all Spaceport America Cup launch vehicles shall carry a Global Position System (GPS) tracking system to expedite rocket recovery. GPS Tracking requirements are described in detail within the IREC Design, Test, and Evaluation Guide (DTEG), maintained on the ESRA website: (http://www.soundingrocket.org/sa-cup-documents--forms.html).

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 **s**hall 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.

All rocket recovery teams must report directly to the Postflight Inspection tent once they return with their rocket, along with any required equipment (e.g., laptop and cables) to read the altimeter data to the Postflight Inspection team. The Postflight Inspection team will first listen to the beeps from the altimeter and then verify that with the altimeter readout of the flight data. Altitude data is critical to providing a final score for your team. Failure to report directly for the Postflight Inspection could cause your team to be heavily penalized.

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 of their desire to compete in the IREC by registering as a new team on the Spaceport America Cup HeroX website: (https://www.herox.com/SpaceportAmericaCup2023). Teams shall submit progress updates via the HeroX site on two specific occasions prior to the competition. The third progress update will be held online via Zoom. These progress updates will record progression 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 per the Master Schedule and each accepted team will receive a Team ID. Once assigned, any correspondence between a team and ESRA must contain that team's ID number to enable a timely and accurate response.

2.6.1.1 ONLINE PROGRESS UPDATE AND SAFETY REVIEW

For the 3rd progress update, teams will discuss their rocket in an online zoom session with safety reviewers. Specific instructions will be forthcoming, but teams should expect to create a short slide presentation reviewing their current progress and to discuss issues previously raised by the safety reviewers. Teams shall have their rocket available for review (realizing that the build may not be complete).

Note: teams who have not started building their rocket by the 3rd progress update may be disqualified.

2.6.1.2 INITIAL SAFETY REVIEWS

Each progress update will be reviewed for safety, DTEG, and rules compliance. Safety reviewers will contact teams if necessary to resolve any issues or questions. Teams that are unable to satisfactorily resolve safety-related issues may be disqualified.

Note: these online safety reviews are not a substitute for the "hands-on" safety review and RSO process conducted during the actual competition.

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 similarly to the style guide of the American Institute of Aeronautics and Astronautics (AIAA), using the provided Microsoft® Word document template from the ESRA website.

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.

Teams are permitted to use other document preparation software, such as LaTeX, to prepare their Project Technical Report, but they must ensure that formatting is identical to the ESRA template.

For COTS teams, the main body of the technical report is limited to 25 pages. For SRAD and Hybrid/Liquid teams, the main body of the technical report is limited to 50 pages. The main body page limit is for text only and does not include graphics. Appendices can be of any length.

On or before a specified date prior to the event, teams shall submit a single digital PDF copy of their Project Technical Report. Technical reports exceeding 50 Megabytes in size may need to be uploaded to a cloud server as long as the permissions allow the judges unrestricted access to the document. Teams shall submit their Project Technical reports using the Hero^{X} website (https://www.herox.com/SpaceportAmericaCup2023). Teams should 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 2023 IREC, would subtitle their Project Technical Report "Team 42 Project Technical Report to the 2023 Spaceport America Cup".

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 its 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. The Project Technical Report should not just discuss what the team did, but the reasoning for their choices. These may include, but are not limited to, design goals, limitations, potential trade-offs, anticipated component loads along with safety factors. 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, include 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. If you had failures, what did you learn from them? 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. All information will be reported using Imperial units (inches, feet, pounds, Newtons, etc.) This shall include:

a. Basic rocket information, including number of stages, vehicle length, airframe diameter, number of fins, fin semi-span, fin tip and root chord, fin thickness, vehicle weight, propellant weight, empty motor case/structure weight, payload weight, liftoff weight, center of pressure and center of gravity.

b. Propulsion information, including motor type, whether it is COTS or SRAD, COTS manufacturer and designation, motor letter classification, average thrust (N), total impulse (Ns) and motor burn time.

c. Predicted flight data including launch rail length, liftoff thrust-weight ratio (X:1), rail departure velocity, minimum static margin, maximum acceleration (G), maximum velocity, fin flutter velocity, target and predicted apogee.

d. Include a flight profile graph.

e. Recovery information, including the COTS and redundant altimeters used, drogue primary and backup deployment charges, drogue deployment altitude, drogue descent rate, main primary and backup deployment charges, main deployment altitude, main descent rate, shock cords and mechanical links.

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.

a. Recovery System Testing: In addition to descriptions of testing performed in accordance with the DTEG sections 5.15 - 5.18 and the results thereof, teams shall include in this appendix a figure and supporting text describing the dual redundancy of recovery system electronics.

b. 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.

c. SRAD Pressure Vessel Testing (if applicable)

d. SRAD GPS Testing (if applicable)

e. Payload Recovery System 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, LAUNCH, RECOVERY, AND OFF-NOMINAL CHECKLISTS APPENDIX

The fifth Project Technical Report appendix shall contain Assembly, Preflight, Launch, and Recovery Checklists. This appendix shall include detailed checklist procedures for final assembly, arming, launch, and recovery operations. Furthermore, these checklists shall include alternate process flows for dis-arming/safeing the system based on identified failure modes (e.g., off-nominal situations). 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 fill and vent procedures (including fault procedures) along with procedures 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, launch, and recovery 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. To reduce file size, please do not embed full CAD models – just use a picture.

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 of 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/SpaceportAmericaCup2023). 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 the 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 2022 IREC, would subtitle their Extended Abstract "Team 42 Technical Presentation to the 2022 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. Note that podium sessions are limited to launch vehicle-related items (payloads are not eligible). 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

- Design, analysis, and testing of a method to greatly minimize the amount of black powder needed to parachute ejection
- Progress in a regimented iterative approach to develop ping 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/SpaceportAmericaCup2023). 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 INTEGRATED MASTER SCHEDULE MILESTONES

Each team is required to meet the timelines in the Spaceport America Cup Integrated Master Schedule. Failure to meet required timelines will result in either a point penalty or may prevent teams from flying. The Integrated Master Schedule Document can be downloaded from the ESRA website (http://www.soundingrocket.org/sa-cup-documents--forms.html).

2.6.6 ADMINISTRATIVE DOCUMENTS

2.6.6.1 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.

2.6.6.2 INSURANCE

The event's insurance policy provides liability coverage for ESRA, NMSA, and the state of New Mexico. This liability coverage does not apply to the student team or the individual students.

While some teams may be covered by their college or university, some are not. To resolve the insurance concern for solid and hybrid propulsion rocket teams ESRA and the Tripoli Rocketry Association (www.tripoli.org) are working together such that all solid and hybrid propulsion rocket flights (i.e. 10K/30K COTS, 10K/30k SRAD solid and hybrid categories) are covered under Tripoli Launch Insurance at no additional cost (except Tripoli membership fees, see below).

All teams flying under Tripoli Launch insurance shall comply with the guidance in the DTEG, section 3.

Liquid category flights are **NOT COVERED** by Tripoli Launch Insurance. These teams are required to provide their own insurance coverage and to provide documentation of coverage by the 3rd progress report. The required documentation is written proof, in English, of comprehensive general liability insurance, including advertising liability and premises liability, of no less than $1,000,000 US Dollars. Note: individual, personal, or travel insurance policies do not qualify under this position. Teams without documented insurance coverage will not be allowed to fly. ESRA is not responsible for and cannot assist in finding suitable insurance policies.

Details for the Tripoli Insurance policy can be found at: http://www.tripoli.org/Insurance

2.6.6.3 SPACEPORT AMERICA CUP WAIVER AND RELEASE OF LIABILITY

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., Spaceport America).

The *Spaceport America Cup Waiver and Release of Liability Form* is available for digital signature at the following web address: https://spaceportamericacup.com/2021-cup-liability-waiver/.

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 60 points – 6% of 1,000 total points possible. The Entry Form and subsequent updates are considered correct if they are submitted as specified in Section 2.6.1 of this Document. They will be considered complete if they are filled out in accordance with the online form on HeroX. They will be considered timely if they are received no later than 72 hours after the deadline specified in the *Spaceport America Cup Integrated Master Schedule Document*.

The 60 points are divided evenly among the four submissions (i.e. the Entry Form and three subsequent Project Updates), making each submission worth 15 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 hour 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 than 72 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 using the Technical Report Rubric in Appendix B.

Completeness is worth 10% (20 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 2.6.2 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% (140 points) 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 using the Technical Report Rubric in Appendix B. Teams should note 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.

2.7.1.3 SCORING DESIGN AND IMPLEMENTATION

Teams will be awarded as many as 240 points – 24% of 1,000 points possible – for the overall design quality, strategic design decisions, and build quality 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.

Design quality is worth 50% (120 points) of the overall value assigned to Design and 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?) This also evaluates the 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. The project's design quality and strategic design decisions will be rated using the Design Implementation Rubric in Appendix B.

Build quality is worth 50% (120 points) of the overall value assigned to Design and Implementation. This constitutes a structured qualitative assessment by the competition officials of the team's quality with which that design was constructed (e.g., Is the finished product sufficiently well-constructed to meet the needs of the underlying design and reasonably expected variation in launch conditions). The project's build quality will be rated using the Design Implementation Rubric in Appendix B.

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 immediately after recovery of their rocket to report the official altitude in accordance with 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 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 (e.g., propellants, pressurized gasses, energetic devices) were replenished, it could not be launched again safely. At competition officials' discretion, replacement of damaged fins or other airframe components specifically designed for easy, rapid replacement is allowed if such components are on hand and can reasonably be replaced within 30 minutes. 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 2.2.3 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 2.3.5.2 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 OVERALL 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 will 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 is 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 team's 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 2022 IREC by sending an e-mail entitled "TEAM 42 FORMALLY WITHDRAWS FROM THE 2022 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
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 or other airframe components specifically designed for easy, rapid replacement if such components are on hand and can reasonably be replaced within 30 minutes.
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.

APPENDIX B: JUDGING RUBRICS

Technical Report Rubric

Criteria	Ratings				
	Outstanding	Excellent	Satisfactory	Unsatisfactory	Score
Completeness (20 pts)	20 pts All required items present	Pass/fail only	Pass/fail only	0 pts One or more required items missing	/20
Style and Format (40 pts)	36-40 pts	30-35 pts	20-29 pts	< 20 pts	
Style (20 pts)	18-20 pts Writing was exceptionally clear, understandable, and concise. Sentence and paragraph organization is exceptional. Writing is free of digressions or irrelevant information.	15-17 pts Writing was clear, understandable, and concise. Overall paragraph and sentence organization were very good. Digressions or irrelevant information do not significantly detract from the report.	10-14 pts Writing was generally clear and understandable. Paragraph and sentence organization were generally good. Digressions or irrelevant information detract from the report's analysis.	<10 pts Writing was repeatedly unclear, difficult to understand or wordy. Overall paragraph and/or sentence organization were ineffective or nonexistent. Digressions and/or irrelevant information consistently detract from the analysis.	/20
Mechanics (10 pts)	9-10 pts No grammar, spelling, or mechanics errors. Scientific terms correctly used, units and dimensions consistent and correct.	7-8 pts No more than a few grammar, spelling, or usage errors. Only a few minor errors with use of scientific terms or dimensions.	5-7 pts Significant spelling, usage, and grammar errors that did not detract from readability. Significant errors with use of scientific terms or dimensions.	< 5 pts Repeated grammar or spelling errors detracted from readability. Errors with use of scientific terms or dimensions detracted from report.	/10
Format (10 pts)	9-10 pts Completely follows required template. Meets page limits.	7-8 pts Minor deviations from required template. Meets page limits.	5-7 pts Major deviations from required template. < 10% over page limits.	<5 pts No attempt at cohesive format or use of required template. More than 10% over page limits.	/10
Style and Format Total				Total	/40

Analysis (140 pts)	126-140 pts	105-125 pts	70-104 pts	< 70 pts	
Depth of Analysis (50 pts)	45-50 pts Very complete and thorough analysis. All key design decisions are discussed and based on design targets, constraints, and appropriate tradeoffs.	38-45 pts Adequate analysis with minor weaknesses. Most key design decisions are discussed and based on design targets, constraints, and appropriate tradeoffs.	25-37 pts Adequate analysis with significant gaps or weaknesses. Some key design decisions are discussed and based on design targets, constraints, and appropriate tradeoffs. Some minor incorrect statements.	< 25 pts Inadequate analysis. Few, if any key design decisions were discussed. No discussion of tradeoffs. Parts of analysis conflict with general scientific knowledge.	/50
Assumptions and Sensitivity Analysis (30 pts)	27-30 pts All assumptions are clearly stated. Sensitivity analysis is performed to quantify uncertainty in variables and assumptions.	23-26 pts Most assumptions were addressed. Some sensitivity analysis.	15-22 pts Unstated assumptions. No sensitivity analysis.	<15 pts No stated assumptions or assumptions were unreasonable. No sensitivity analysis.	/30
Verification and Validation tests (40 pts)	36-40 pts All verification and validation tests were discussed, both for the final design and key iterations leading to that design. Complete and valid conclusions were drawn from the results.	30-35 pts Most verification and validation tests are adequately discussed. Appropriate conclusions were drawn from the results, but key iterations prior to final design were not discussed.	20-29 pts Some verification and validation tests are discussed but consistent. Unclear that conclusions and decisions were drawn from testing results and analysis.	< 20 pts Unclear whether verification and validation tests were performed. Decisions and conclusions were not drawn from the analysis.	/40
Use of Charts and Figures (20 pts)	18-20 pts Tables, figures, and appendices all effectively organize and communicate information.	15-17 pts Use of tables, figures, and appendices is mostly effective.	10-14 pts Use of tables, figures, and appendices is somewhat effective with significant issues.	< 10 pts Tables, figures, and appendices were incorrect or misleading.	/20
Analysis Total (140 pts)				Total	/140
Completeness + Style & Format + Analysis Total (200 pts)					/200

Design Implementation Rubric

Criteria	Ratings				
	Outstanding	Excellent	Satisfactory	Unsatisfactory	Score
Design Quality & Decisions (120 pts)	108-120 pts	90-107 pts	60-89 pts	< 60 pts	
Team Design Vision, Goals and System Engineering (50 pts)	45-50 pts Clearly understood and achievable design vision for the rocket along with a coherent and well-understood set of design goals. All key elements of the project address clearly defined strategic goals for the team. Strong evidence of clear systems engineering discipline throughout by all parts of design team.	37-49 pts Design vision is generally understood and mostly achievable with a generally coherent set of goals. Key elements of the project generally address strategic goals for the team. Generally good systems engineering discipline throughout development. Most of the design team works to support a generally coherent and understood set of goals.	25-36 pts Design vision is incompletely defined or questionably achievable. Unclear how elements of the project address team strategic goals. Some lapses in systems engineering discipline throughout development. Unclear that parts of the design support team goals. Some evidence of different parts of the design team working at cross-purposes.	< 25 pts Questionable or unachievable design vision for the rocket. Most elements of the project do not address team goals. Major lapses in systems engineering discipline. No team design goals, or parts of team clearly ignore stated goals. Clear evidence of different parts of the design team working at cross-purposes.	/50
SRAD components (50 pts)	45-50 pts High use of SRAD components, which are clearly chosen to achieve design or strategic goals.	38-45 pts Significant use of SRAD components. Mostly chosen to achieve design or strategic goals.	25-37 pts Some use of SRAD components. Sometimes chosen to achieve design or strategic goals.	< 25 pts Minimal use of SRAD components. No clear idea how these achieve design or strategic goals.	/50
Team Knowledge (20 pts)	18-20 Strong team understanding of the physical principles governing design and reasoning behind the design. All members of team can clearly articulate reasoning for choices.	15-17 Generally good team understanding of the physical principles governing design and reasoning behind the design. Team members defer to a few team "experts" during discussion.	10-14 Some team understanding of the physical principles governing design and reasoning behind the design. Team members defer to one or two team "experts" during discussion.	< 10 pts Inadequate team understanding of the principles governing design and reasoning behind the design. Team members defer to their Mentor or Flyer of Record during discussion.	/20
Design Quality and Decisions Total				Total	/120
	108-120 pts	90-107 pts	60-89 pts	< 60 pts	

Build Quality (120 pts)	.				
Design Quality and Robustness (30 pts)	27-30 pts Design and build quality are robust and more than sufficient to operate as intended under reasonably expected conditions.	23-26 pts Design and build quality are somewhat robust and sufficient to operate as intended under reasonably expected conditions.	15-22 pts Design and build quality are sufficient to operate as intended under specific conditions but are not robust to reasonably expected variations.	< 15 pts Design and build quality insufficient to operate as intended under expected conditions. No attempts at robust design.	/30
Manufacturing and Construction Methods (30 pts)	27-30 pts Construction methods completely understood and correctly applied. Manufacturing methods for SRAD elements are both appropriate and completely understood by the team, including cost, time, and performance.	23-26 pts Construction methods generally well understood and correctly applied. Manufacturing methods for SRAD elements are both appropriate and reasonably understood by the team, including cost, time, and performance.	15-22 pts Construction methods are appropriate, but not completely understood. Manufacturing methods for SRAD elements are appropriate, but not fully understood by the team.	< 15 pts Construction methods inappropriate or not understood. Manufacturing methods for SRAD elements are impractical or not well understood by the team.	/30
Consistent Design (30 pts)	27-30 pts Clearly consistent with team's vision. No evidence of key systems added as an afterthought.	23-26 pts Generally aligned with team's vision. No evidence of key systems added as an afterthought.	15-22 pts Somewhat aligned with team's vision. Some key systems added as afterthoughts.	< 15 pts No apparent organizing vision. Key systems added as field modifications or afterthoughts.	/30
Compliance with DTEG (30 pts)	27-30 pts Completely complies with guidance in the DTEG	23-26 pts Complies with guidance in the DTEG with a few minor issues.	15-22 pts Minimally complies with guidance in the DTEG.	< 15 pts Does not comply with guidance in the DTEG. **NOTE: A team that does not comply with the DTEG can score no higher than 60 points for Build Quality.**	/30
Build Quality Total (120 pts)				Total (Continued Next Page)	/120

Design Quality and Decisions + Build Quality Total (240 pts)	Grand Total	/240