Cube Quest Challenge

Ground Tournament Submittal Requirements and Standardized Judging Criteria

(Ground Tournament Workbook)

Revision GT2-1 Dated 10 November 2015

Contents

Ground Tournaments

Objective

The Ground Tournaments (GTs) are a series of four ground-based activities and reviews, based on tests, engineering data, and analyses supplied by Competitor Teams. The GTs allow NASA to gain or achieve the following:

- Insight into Competitor Team's spacecraft and mission designs;
- Assess technical progress
- Evaluate the likelihood of achieving Challenge goals based on standardized assessments;
- Confirm design compliance with selected launch vehicle (e.g. SLS) and Challenge requirements;
- Incentivize progress with intermediate prize awards.

Judging

A panel of Centennial Challenge-appointed Judges will review the submitted material. Judges may consult with NASA Subject Matter Experts (SMEs), but Judges are the final arbiters for assessments of compliance with Rules and scores in accordance with the Rules. Judging criteria and expected design maturity progressively advance for each successive GT review. All Competitor Teams are judged by the same standardized criteria. After each GT, the Judges will provide Competitors numeric scores based on the standardized assessment criteria in two categories:

1) Design maturity and likelihood of achieving Challenge goals – worth 40% of total score

2) Compliance with documented Challenge Rules and documented EM-1 safety and interface requirements – worth 60% of total score

Scores will be based on a scale from 1 (low, poor) to 5 (high, superb). Competitor Team composite scores may be posted on the Challenge website after each GT.

Any Competitor Team registered for the Deep Space Derby or the Lunar Derby (or both) may participate in any or all of the GTs. Competitor Teams seeking a NASA launch opportunity on EM-1 must participate in at least the final GT (GT4) in order to be considered for EM-1 integration.

Ground Tournament Instructions

Instructions to Teams

1. Teams are responsible for downloading and reading the current version of the Operations and Rules document, the Ground Tournament Work Book containing the two Judge's Scorecards, the Mission Concept Data Packet definition document, and all other related documents from http://www.nasa.gov/cubequest/reference. The Operations and Rules document is the governing document.

2. Teams should refer to the two scorecards included in the Ground Tournament Work Book, titled "Score Card 1 – Likelihood of Success", and "Score Card 2 – Launch Vehicle Interface and Safety & Rules Compliance". Along the top of the evaluation matrix, there are lists of Team Submittals that serve as the inputs for Judge's assessments. The assessment criteria are shown in the matrix - "Likely of Achieving $\geq$ 1 Lunar Orbit", and so on.

The various required submittals are all listed in section "Team Submittals Checklist". Some required submittals have more detailed instructions in the supporting Evaluation Criteria, System and Subsystem sections of the Ground Tournament Workbook. For example, there is a long list of radio communications data requested in the "Communication Subsystem" section.

3. For the three major elements on the "Team Submittals Checklist", each team shall submit a **single, coherent PDF document**, which will include all of their information, analyses, drawings, and other data that the team proposes to be the basis of the score for each Judged Element. The respective supporting sections list required submittals and other required data details. Teams are not limited to items seen in the supporting tabs.

4. Submittals are due in the format and date specified in the Cube Quest Challenge Operations and Rules document. The current version of the document is available at: http://www.nasa.gov/sites/default/files/atoms/files/revision_b.pdf . Due date and milestones may be repeated in the "Team Submittals Checklist", but in case of any conflict or anything is missing, the Operations and Rules document is the correct definitive reference.

5. Teams will complete and submit one version of Judge's Scorecard 1 with the team name clearly indicated at the top of the document and the column titled "Team Intends to Win this Prize" filled out, marking all boxes with "YES" or "NO", as appropriate for that prize.

Instructions to Judges

1. Judges will be intimately acquainted with Operations and Rules, the Judge's Score Cards, and all supporting documents.

2. Judges will receive from the Cube Quest Administrator a package of submittals from all participating teams on the date(s) specified in the Operations and Rules document for each ground tournament and/or in-space competition.

3. For each package of submittals received from the teams:

3.1 Judges will fully review the entire collected body of the Team's submittals

3.2 For every element on the two Judge's Score Cards, judges will assess the full collection of submittals. Assessments will be performed in accordance with the following:

- Cube Quest Challenge Operations and Rules document (current versions)
- Secondary Payload Launch Vehicle Safety Requirements Document (LVSRD) for the proposed launch vehicle, or in for those teams pursuing the SLS EM-1 launch, the Secondary Payload Interface Definition and Requirements Document (IDRD)
- Identified elements on the two Judge's Scorecards
- Evaluation Criteria identified in the Ground Tournament Workbook

3.3 Judges may consult NASA Subject Matter Experts (SMEs) to perform analysis, simulation, or to advise and interpret the submitted information.

3.4 Judges will insert a numeric score based on the judging criteria of the two Judge's Score Cards: "Score Card 1 – Probability of Success", and "Score Card 2 – LVSRD & Challenge Rules Compliance". Numeric score definitions and guidance are given in the Appendix A of this Ground Tournament Workbook, Ground Tournament Success Criteria, for each respective Ground Tournament. The expected degree of progress maturity for team submittals at each ground tournament is defined in Appendix A Ground Tournament Success Criteria.

3.5 Judges will total and average the scores as follows:

a) Score Card 1 – Likelihood of Mission Success (worth 40% of total score)

1) In each light green cell in the matrix called "Likelihood of achieving each condition", enter a numeric score. Definitions of numeric scores are found in Appendix A, Ground Tournament Success Criteria.

2) Based on Team-selected list of Prizes team intends to attempt to win, which teams submit in their MCRDP Section 2.2, put a "y" in column labeled "Team intends to win this Prize (shown at right)? y/n"

3) For each row you marked with a "y", add the values entered in light green colored cells, and enter the average (total divided by number of light green cells in that row) in column labeled "Likelihood of meeting all relevant conditions"

4) Transfer the averages of each row (applicable as marked by a "y" in "Team intends to win this Prize", over to the column for the current GT.

5) Total the averages in the column for the current GT and average by dividing by the total number of Prizes intended by this team (that is, the number of rows marked "y").

b) Score Card 2 - Compliance with Challenge Rules and LVSRD (worth 60% of total score)

1) Average the scores for each section as shown on the LVSRD Scorecard.

2) The cumulative score for Scorecard 2 will be an average of all three sections.

Definitions

Ground Tournament Workbook – this document, called the Ground Tournament Submittal Requirements and Standardized Judging Criteria (aka the “Ground Tournament Workbook”).

Judge's Score Card – Comprised of two parts, the Judge’s Scorecard provides the criteria and evaluation of the Ground Tournament Workbook are the Judge's Score Cards. Part 1 is the Likelihood of Mission Success Score Card; the value on this card comprises 40% of your final Ground Tournament score. Part 2 is the Compliance with Challenge Rules and LVSRD Score Card; the value on this card comprises 60% of your final Ground Tournament score. The Judge's Score Cards tells judges how to numerically score all the team submittals. The Judge's Score Cards don't tell teams what to submit at all.

In-space Prize(s) Achievements - these are the threshold (minimum values) for in-space Prizes as defined in the Cube Quest Challenge Rules. Your "Likelihood of Mission Success" is determined by Judges. Judges determine how likely a team is to achieve all the Prizes that they indicate they intend to compete for. You indicate your intention to compete for which Prizes as part of your Team Submittals.

Team Submittals - these are documents, data, reports, analyses, that are required by: The Cube Quest Challenge Operations and Rules, the Secondary Payload User's Guide, the SLS Interface Definition Requirements Document (IDRD) or equivalent LVSRD for the launch vehicle to be used. and as listed in the Judge's Workbook in various tabs. The Judge's Workbook has a handy Team Submittals Checklist tab (Tab 4).

Team Submittals Checklist – this section of the Ground Tournament Workbook lists all the expected "submittals" - data, documents, reports, and analyses, the Judges expect to see and the milestones at which they are due.

Acronyms

ADCS	Attitude Determination Control System
cm	centimeter
CQC	Cube Quest Challenge
CY	Calendar Year, January to December
dpi	dots per inch
EM-1	Exploration Mission
FY	Fiscal Year, October to September
GT	Ground Tournament
GNC	Guidance and Navigation Control
GRC	Glenn Research Center
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
ICD	Interface Control Document
IDD	Interface Definition Document
IDRD	Interface Definition and Requirements Document
kg	kilogram
km	kilometer
KPP	Key Performance Parameters
KSC	Kennedy Space Center
LVSRD	Launch Vehicle Safety Requirements Document
MAF	Michoud Assembly Facility
MCR	Mission Concept Review
MCRDP	Mission Concept Registration Data Package
MPCV	Multi-Purpose Crew Vehicle
MSA	MPCV Spacecraft Adapter
MSFC	Marshall Space Flight Center
NASA	National Aeronautical and Space Administration

pdf	portable document format
RF	Radio Frequency
SLS	Space Launch System
SME	Subject Matter Expert
SDD	System Design Document
SSDD	Subsystem Design Document
SPDS	Secondary Payload Deployment System
SPIM	Secondary Payload Integration Manager
SPUG	Secondary Payload Users Guide
SRD	System (Subsystem) Requirement Document
SSC	Stennis Space Center
TLI	Trans-Lunar Injection
u	Satellite unit of measure, 1 U = 10 cm x 10 cm x 10 cm (cubic volume)
VAB	Vehicle Assembly Building
W	Watt
WFF	Wallops Flight Facility

Judge's Score Card 1 – Likelihood of Mission Success – 40% of Team Score

Judges: Assess Team Submittals per Workbook Evaluation Sections; Evaluate Results Per Workbook Success Criteria, and Follow Judges Workbook Instructions to Assign Numeric Scores for this GT

0 - Team submittals are incomplete; do not effectively address how team might achieve team-specified Prize(s); team unlikely to achieve team-specified Prizes.

1 - Team submittals just marginally adequate, do little to demonstrate how team will achieve Prize; just possible team will achieve team-specified Prize(s)

2 - Team submittals show sufficient progress and demonstrate that team could reasonably achieve specified Prize(s)

3 - Team submittals maturing well as planned and expected; are sound basis for expecting good liklihood of achieving specified Prize(s)

4 - Team submittals are substantial, ahead of expectations for this milestone; demonstrate very good chance of achieving specified Prize(s)

5 - Team submittals are superior and well exceed expectations for this milestone; submittals convincingly demonstrate excellent liklihood to

The expected degree of progress maturity for team submittals at each ground tournament is defined in Appendix A -Ground Tournament Success Criteria of the Ground Tournament Workbook.

Mission Concept Registration Data Package Sect. 2.2 - Team-selected list of Prizes team

Teams Submittals: Teams provide 30 days prior to GT. All required submittals are listed in Submittals Checklist section of GT Workbook.

Judges receive submittals above; judges assess submittals as described in referenced GT Workbook Sections

Based on assessments from the respcective GT Workbook Sections above, Judges determine liklihood of achieving for each condition listed below. Conditions colored light green are considered to be necessary contributors toward achieving associated Prize on far right.

	Likelihood of achieving ≥ 1 Lunar Orbit? Likelihood of achieving trajectory, sufficient delta V?	Likelihood of maintaining Lunar Orbit? Likelihood of station keeping, sufficient delta V?	Likelihood of surviving to reach range ≥ 4M km?	Likelihood of closing comm link from range of moon?	Likelihood of closing comm link from ≥ 4M km?	Likelihood of pointing directional elements as necessary? (Perfect score if no directional elements are required to maintain power or close comm link)	Likelihood of surviving ≥ 30 min, including power management, rad tolerance, durability of parts and other factors in GT Workbook Longevity Sect.?	Likelihood of surviving ≥ 28 days, including power management, rad tolerance, durability of parts and other factors in GT Workbook Longevity Sect.?	Liklihood of meeting all relevant conditions		Judges assign numeric scores (0-5) per Instructions for each GT				Team intends to win this Prize (shown at right)? y/n	**Prize Achievements**	
											GT-1	GT-2	GT-3	GT-4			
Team Submittals	ConOps Conceptual Mission Design Planned Orbit/trajectory Design Submittals listed in GT Workbook Section GNC & ADCS	ConOps Conceptual Mission Design PlannedOrbit/ trajectory Design Submittals listed in GT Workbook Section GNC & ADCS	CubeSat Architecture Engineering Drawings (as avail) Planned Durability and Reliability Approach Submittals listed in GT Workbook Section Longevity	CubeSat Architecture Submittals listed in GT Workbook Section Comm Submittals listed in GT Workbook Section GNC & ADCS	CubeSat Architecture Submittals listed in GT Workbook Section Comm Conceptual Mission Design Submittals listed in GT Workbook Section GNC & ADCS	CubeSat Architecture Conceptual Mission Design Submittals listed in GT Workbook Section GNC & ADCS	CubeSat Architecture Planned CubeSat Durability & Reliability Approach Submittals listed in GT Workbook Section Longevity	CubeSat Architecture Planned CubeSat Durability & Reliability Approach Submittals listed in GT Workbook Section Longevity									
Judging Process	Assess above submittals as described in GT Workbook Section GNC and ADCS	Asses above submittals as described in GT Workbook Section GNC and ADCS	Assess above submittals as described in GT Workbook Section Longevity	Assess above submittals as described in GT Workbook Section Comm	Assess above submittals as described in GT Workbook Section Comm	Assess above submittals as described in GT Workbook Section GNC and ADCS	Assess above submittals as described in GT Workbook Section Longevity	Assess above submittals as described in GT Workbook Section Longevity									
Likelihood of achieving each Condition	N/A	N/A		N/A				N/A		<- Combined likelihood of all light green cells in this row					y/n	**Best Burst Data Rate:** receives a cumulative volume of error-free data (above the minimum volume of one 1024 bit data block) from their CubeSat over a 30-minute period	Deep Space Derby
	N/A	N/A		N/A						<- Combined likelihood of all light green cells in this row					y/n	**Largest Aggregate Data Volume Sustained Over Time**: minimum volume of one thousand 1024 bit data blocks from their CubeSat over their best contiguous 28-day (calendar days) period	
	N/A	N/A		N/A						<- Combined likelihood of all light green cells in this row					y/n	**Spacecraft Longevity**: at least 28 elapsed number of competition days, between the date of their first and last, confirmed reception of error-free, 1024-bit data blocks from their CubeSat while maintaining at least the minimum required distance from Earth, and before the "End of Competition" (above the minimum number of 28 elapsed competition days)	
	N/A	N/A		N/A						<- Combined likelihood of all light green cells in this row					y/n	**Farthest Communication Distance From Earth**: at least one, error-free, 1024-bit data block, from the minimum distance of 4,000,000 km), and before the "End of Competition"	
		N/A	N/A	N/A	N/A	N/A	N/A	N/A		<- Combined likelihood of all light green cells in this row					y/n	**Lunar Propulsion**: successfully demonstrate their CubeSat has achieved at least one verifiable lunar orbit, as defined in competition Rules	Lunar Derby
		N/A	N/A		N/A			N/A		<- Combined likelihood of all light green cells in this row					y/n	**Best Burst Data Rate**: cumulative volume of error-free data (above a minimum volume of one 1024 bit data block) from their CubeSat over their best 30-minute operating period	
			N/A		N/A					<- Combined likelihood of all light green cells in this row					y/n	**Largest Aggregate Data Volume Sustained Over Time:** cumulative volume of error free data (above a minimum volume of one thousand 1024 bit data blocks) from their CubeSat over their best contiguous 28-day (calendar day) period	
			N/A		N/A					<- Combined likelihood of all light green cells in this row					y/n	**Spacecraft Longevity Contest**: elapsed number of competition days between the first and last confirmed reception (greater than a minimum number of 28 elapsed competition days), of an error-free, 1024-bit data block from their CubeSat	
										Likelihood of Mission Success -->					Total # intended Prizes		

Liklihood of mission success is sum of all cells in each column divided by number of Prize Achievements the team plans to attempt

Sum of number of number of Prize Achievements that the Team intends to attempt (total number of "y"s)

Judges Scorecard 2 – Compliance with Challenge Rules and Launch Vehicle Interface and Safety Requirements – 60% of Team Score

Ground Tournament Products	Submittal Requirements	Scoring Criteria	Judge's Score
Challenge Rules Compliance			
Compliance with the Cube Quest Challenge Rules	Cube Quest Challenge Operations and Rules	0 - violation of any Rule 1 - compliance with < 75% of Rules marked GT-1 2 - compliance with >75% < 85% of Rules Marked GT-1 3 - compliance with all Rules marked GT-1 4 - compliance with all Rules marked GT-1 and half the Rules marked GT-2-4 5 - compliance with all Rules Marked GT-1 and all Rules marked GT-2-4	
		Challenge Rules Compliance Score	
Interface Requirements & Rules			
SPUG Questionnaire **Reference: SLS-SPIE-HDBK-005 Secondary Payload User's Guide, Appendix C**	Complete/submit questionnaire	1-< 3/4 of form filled out; 3- form filled out but info vague; 5-form filled out & info solid	
CubeSat Overview	Provide description of payload, TRL of systems & ability to mature to TRL6 by GT4, payload unique requirements/goals	1-major gaps in description, TRL not clearly defined, no unique systems defined; 3-basic description provided, TRLs determined & plan mentioned, limited requirements/goals listed; 5-thourogh description, clear TRLs w/plans to mature, solid requirements/goals defined	
Concept of Operations **Reference: Mission Concept, Registration Data Package**	Provide description of mission operation & goals (accomplishments one plans to achieve in flight, process/steps the cubesat will perform during flight, communication plans, and Mission Mode states - forerunner to s/w dev.)	1-provide basic mission goals & description; 3-provide detailed mission steps w/goals at each step; 5-detailed mission steps w/goals & mission mode states	
Hardware Design **Reference: Mission Concept, Registration Data Package & LVSRD**	Provide system schematic(s) (system/subsystem block diagrams w/high level interfaces), gen. hardware descriptions, initial mass properties, some detail on system w/potential safety issues (i.e. propulsion, power, transmission levels, etc.)	1-rough block diagram, little hardware descript., no mass breakdown, no system details; 3-top level system diag. w/details, mass properties at a system level, some systems w/safety issue identified; 5-top level system diag. & subsystem diagrams, mass properties down to component levels, all systems discussed for safety issues	
		Interface Requirements & Rules Score (average of section)	
Verification			
Analysis **Reference: IDRD or equivalent LVSRD for selected launch vehicle**	Identify planned analysis	1- only mentions analysis; 3-lists analysis w/plans of when performed; 5-all above & provides some initial analysis	
Test/Demonstration **Reference: IDRD or equivalent LVSRD for selected launch vehicle**	Identify planned testing (development & verification)	1- only mentions testing; 3-lists tests w/plans for development; 5-all above & plans for verification testing	
Inspection **Reference: IDRD or equivalent LVSRD for selected launch vehicle**	N/A	N/A	
Safety Data Package (SDP) **Reference: SLS-RQMT-216 SLSP EM-1 Safety Requirements for Secondary Payload Hardware & SLS-PLAN-217 EM-1 Secondary Payload Safety Review Process or equivalent for selected launch vehicle**	(Reader's Digest version of Hardware Design deliverables w/emphasis on possible hazards) (Presentation to include payload/cubesat design goals/intent, descriptive block diagrams of systems, planned operations, description of possible hazards, etc.)	1-provides a presentation but greatly lacking/needs to be redone; 3-provides a presentation w/minor changes required; 5-presentation is acceptable	
Schedule	Detail plan to GT2 w/milestone events to other GTs	1-provides only top level schedule; 3-provides detailed plan to GT2 & milestones to others; 5-provides details to GT2 & 3 w/milestones to others	
		Verification Score (average of section)	
		Overall Score (average of all three sections)	

Team Submittals Checklist

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
Notice of Intention to Compete	Operations & Rules, Rule 2.B and Sect. 5.3	At time of registration and NLT than 30 days before GT-1 or the first GT the team is eligible to complete in	Used to initiate registration; not used in Ground Tournaments
Registration Data Package ❑ Competitor Team Name ❑ Competitor Team affiliation ❑ Team Leader Designation ❑ Team Leader Proof of U.S. citizenship or permanent residence ❑ Company/organization proof of U.S. incorporation and address of operations ❑ List of Team Members and proof of eligibility ❑ All appropriate Competitor Team contact information ❑ Proof of liability coverage / demonstrated financial responsibility ❑ Acknowledgement to rules compliance (signature)	Operations & Rules, Rules 1 and 2, Sect 5.3	At time of registration and NLT than 30 days before GT-1 or the first GT the team is eligible to complete in	Rules Compliance; Team Leader will be the primary point of contact for Cube Quest Challenge Administrator; Ground Tournament Scores will be reported to Team Leader.

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
Mission Concept Registration Data Package (MCRDP)	Operations and Rules, Rules 3, 8.B and reference document "Mission Concept Registration Data Package Definition" document, on Cube Quest references web page.	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Several GT Workbook Sections use materials from the MCRDP. See details following.
❑ Concept of Operations (ConOps)	Mission Concept Registration Data Package Sect. 2.1	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Several GT Workbook Sections
❑ Conceptual Mission Design	Mission Concept Registration Data Package Sect. 2.2	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Several GT Workbook Sections
• List of Deep Space and Lunar Derby Prizes that the teams intend to win	Mission Concept Registration Data Package Sect. 2.2 (Judge's Scorecard 1 Team Submittal)	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 1 – Likelihood of Mission Success

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
• Planned CubeSat orbit/trajectory design	Mission Concept Registration Data Package Sect. 2.2 Workbook Design Package Evaluation	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation GT Workbook Sect. GNC and ADCS; Sect. Comm; Sect. Trajectory & Propulsion Challenge Prize Evaluations
• Planned CubeSat durability and reliability approach.	Mission Concept Registration Data Package Sect. 2.2 Workbook Design Package Evaluation	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations
• CubeSat architecture description.	Mission Concept Registration Data Package Sect. 2.2 Workbook Design Package Evaluation	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations
• Ground systems architecture description.	Mission Concept Registration Data Package Sect. 2.2 Workbook Design Package Evaluation	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Esp. Communications Subsystem Chapter Challenge Prize Evaluations

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
• Hazards List.	Mission Concept Registration Data Package Sect. 2.2	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 2 – Rules and LVSRD Compliance
❑ Conceptual method for CubeSat disposal	Mission Concept Registration Data Package Sect. 2.3; NPR 8020.12 Planetary Protection Provisions for Robotic Extraterrestrial Missions, and NASA STD 8719.14 NASA Technical Standard, Process for Limiting Orbital Debris	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	
❑ Satellite Communications Concept	Mission Concept Registration Data Package Sect. 2.4 Workbook Design Package Evaluation	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Esp. Communications Subsystem Chapter Challenge Prize Evaluations
❑ SPUG Questionnaire	SLS-SPIE-HDBK-005 SLS Secondary Payload User's Guide, Appendix C, SLS Payload Questionnaire	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 2 – Rules and LVSRD Compliance
❑ CubeSat Overview	Scorecard 2 – Rules and LVSRD Compliance	NLT than 30 days before GT-1 or the	Mission and spacecraft design evaluation

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
		first GT team is eligible to complete in	Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
❑ Concept of Operations	Mission Concept Registration Data Package Sect 2.1 Workbook Design Package Evaluation	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
❑ Hardware Design	Mission Concept Registration Data Package Sect 2.3 CubeSat Architecture, and LVSRD Workbook Design Package Evaluation	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
❑ Analysis	LVSRD Workbook Design Package Evaluation	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
❑ Test/Demonstration	LVSRD Workbook Design Package Evaluation	NLT than 30 days before 1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluations

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	When is Submitted Required?	Where/How will it be Used?
			Scorecard 2 – Rules and LVSRD Compliance
❑ Inspection	LVSRD	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 2 – Rules and LVSRD Compliance
❑ Safety Data Package (SDP)	SLS-RQMT-216 SLSP EM-1 Safety Requirements for Secondary Payload Hardware & SLS-PLAN-217 EM-1 Secondary Payload Safety Review Process	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 2 – Rules and LVSRD Compliance
❑ Schedule	Scorecard 2 – Rules and LVSRD Compliance	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Scorecard 2 – Rules and LVSRD Compliance
❑ System Design Submittal specified in GT Workbook Design Evaluation	Mission Concept Registration Data Package Sect Workbook Design Package Evaluation	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluation
❑ Subsystem Submittals specified in GT Workbook Design Evaluation	Mission Concept Registration Data Package Sect Workbook Design Package Evaluation	NLT than 30 days before GT-1 or the first GT team is eligible to complete in	Mission and spacecraft design evaluation Challenge Prize Evaluation

GT-2 Design Package Evaluation

The Judges will evaluate the team submittals according to the Judge's Scorecard #1 and Judge's Scorecard #2. Part of this process will be an evaluation of the mission concept and spacecraft design. As indicated in the Team Submittals Checklist, this evaluation will be based on:

- The Mission Concept Registration Data Package (MCRDP)
- One CubeQuest Design Document consisting of the following sections
    - System Design
    - Subsystem Design
    - Implementation Plan

Taken together, these documents should show a clear flow of requirements from the challenge goals in the MCRDP to system requirements and then to subsystem requirements. The Subsystem Design Section contains one **completely self-contained** chapter on each subsystem. Each of these chapters should describe the subsystem design and relevant analysis in sufficient detail to establish that the subsystem design will meet its requirements. These chapters should include sufficient analysis to show that if the subsystem all perform as expected, the team will be able to meet its challenge goals. The implementation plan should describe the plan for implementing the design from GT-2 through to launch. These documents and scoring rules for each are described below. A list of suggested Subsystem chapters in shown in the Table below.

IMPORTANT: Each subsystem will be evaluated based on material presented in its chapter of the Subsystem Design Section, the System Design Section and The Mission Concept Registration Data Package.

Information given in other documents, including other subsystem design chapters, will not be considered.

Structural Design & Mechanisms	Propulsion
Guidance, Navigation & Control	Thermal
Power	Communications
Command & Data Handling	Mission Operations/Ground Data Systems
Flight Software	Others as needed

Suggested Subsystem Design Documents

Mission Concept Registration Data Package

The complete requirements for the MCRDP are given in the Mission Concept Registration Data Package Definition Document. The following information from the MCRDP will be used in the evaluation of mission, spacecraft and subsystem designs.

- Clear definition of challenge goals
- Concept of Operations
- Conceptual Mission Design
- CubeSat Disposal Approach
- Satellite Communications Concept

Score	Assessment
0	- MCRDP is incomplete or not submitted - Challenge goals not clearly identified
1	- Challenge goals clearly identified - Concept of operations, conceptual mission design, communications concept and/or disposal plan are weak, incomplete or insufficient and do little to demonstrate that team will meet challenge goals.
2	- Challenge goals clearly identified - Concept of operations, conceptual mission design, communications concept and disposal plan are sufficient to demonstrate a reasonable likelihood that team will meet challenge goals.
3	- Challenge goals clearly identified - Concept of operations, conceptual mission design, communications concept and disposal plan are sufficient to demonstrate a good likelihood that team will meet challenge goals.
4	- Challenge goals clearly identified - Concept of operations, conceptual mission design, communications concept and disposal plan are sufficient to demonstrate a substantial likelihood that team will meet challenge goals.
5	- Challenge goals clearly identified - Concept of operations, conceptual mission design, communications concept and disposal plan are sufficient to demonstrate an excellent likelihood that team will meet challenge goals.

System Design

The first section of the CubeQuest Design Document, "System Design Section", describes how the total system (spacecraft, ground system, environment, trajectory, etc.) will meet the mission objectives. It should describe the subsystem requirements and all analysis needed to show how those requirements come together to meet the mission objectives.

- Mission objectives (goals)
- System level block diagrams (subsystem, power distribution, data distribution, etc.)
- System level design description
- Complete Subsystem Requirements
- Identification of range of operating conditions over which mission objectives will be met, in accordance with the Mission Concept Registration Data Package
- Analysis supporting completeness of subsystem requirements and demonstrating that taken together, the subsystem requirements will meet the mission objectives
- Summary of key mission risks and descriptions of mitigations being considered
- Summary of appropriate system level margins

Subsystem Design Document

Each subsequent chapter of the CubeQuest Design Document describes the subsystem design (e.g. structures, communications, etc.) and how that design will meet requirements specified in the System Design Document. Each of these chapters should start with the relevant requirements as stated in the system design and follow with a description of the subsystem design and all relevant analyses. The document should conclude with a clear statement that the design meets (or does not meet) the requirements and appropriate margins should be noted.

- One complete chapter per subsystem
- Subsystem requirements restated from System Design Document
- Identification of range of operating conditions over which subsystem requirements will be met, in accordance with the System Design Document and Mission Concept Registration Data Package
- Baseline subsystem design description, including appropriate block diagrams, part numbers and specifications
- Table summarizing the current Technology Readiness Levels or flight heritage of the hardware/software selected for the baseline design
- Analysis demonstrating that the baseline design will meet the subsystem requirements
- Summary of appropriate subsystem margins

Score	System Design Section	Subsystem Design Sections
0	- System Design not submitted	- Subsystem Design not submitted
1	- Mission objectives not clearly stated, and/or analysis and/or subsystem requirements are weak, incomplete or insufficient	- Subsystem requirements not clearly stated. - Selection, presentation and/or analysis of subsystem design not sufficient to

Score	System Design Section	Subsystem Design Sections
		meet team stated requirements for that subsystem.
2	- Flowdown of subsystem requirements from system objectives is clear. - Analysis showing that all subsystem requirements support the system objectives is sufficient to support reasonable chance of team meeting objectives.	- Subsystem requirements clearly stated. - Selection, presentation and analysis of subsystem design is sufficient to support reasonable chance of team meeting objectives - Subsystem margins clearly stated.
3	- Flowdown of subsystem requirements is clear. - Supporting analysis supports a good likelihood of meeting system objectives. System margins are adequate.	- Subsystem requirements clearly stated. - Selection, presentation and analysis of subsystem design is sufficient to support good likelihood of team meeting objectives - Subsystem margins clearly stated and adequate for current phase.
4	- Flowdown of subsystem requirements is clear. - Supporting analysis extensive and supports a substantial likelihood of meeting system objectives. System margins meet or exceed NASA guidelines for system design.	- Subsystem requirements clearly stated. - Selection, presentation and analysis of subsystem design is sufficient to support substantial likelihood of team meeting objectives - Subsystem margins clearly stated and meet or exceed NASA guidelines for current phase.
5	- Flowdown of subsystem requirements is clear. - Supporting analysis extensive and convincingly supports an excellent likelihood of meeting system objectives. System margins meet or exceed NASA guidelines for system design. - Submission is superior and well exceeds expectations for this milestone.	- Subsystem requirements clearly stated. - Selection, presentation and analysis of subsystem design is sufficient to support an excellent likelihood of team meeting objectives - Subsystem margins clearly stated and meet or exceed NASA guidelines for this phase of the project. - Submission is superior and well exceeds expectations for this milestone.

Implementation Plan

The Implementation Plan Section describes how the team plans to execute the development, fabrication and test phases of the project.

- Integration and test flow
- Test environments and test plans
- Necessary test facilities
- Key tests, both within the spacecraft bus and with external systems, including ground stations and mission operations center(s)

Score	Implementation Plan Document
0	- Implementation Plan not submitted
1	- Implementation and test plans are incomplete or insufficient
2	- Implementation and test plans support the mission objectives and are sufficient to support reasonable likelihood of team meeting objectives.
3	- Implementation and test plans support the mission objectives and are sufficient to support good likelihood of team meeting objectives.
4	- Implementation and test plans support the mission objectives and are sufficient to support substantial likelihood of team meeting objectives.
5	- Implementation and test plans support the mission objectives and convincingly supports excellent likelihood of team meeting objectives. - Submission is superior and well exceeds expectations for this milestone.

Subsystem Design Chapters - Required Layout

The subsystem design must consist of a series of single, self-contained chapters - one for each subsystem. Each chapter must contain the following information, in this order:

1. Clearly stated requirements taken from the System Design Document that are relevant to the subsystem described in that chapter. The subsystem design will be judged in part on the completeness of this set of requirements and the ability of the design to meet these self-imposed requirements.
2. Identification of the range of operating conditions over which the subsystem must meet its requirements.
3. Complete description of the baseline subsystem design, including state of design development, flight heritage, etc.
4. Analyses demonstrating ability of subsystem design to meet self-imposed requirements, including complete descriptions of the analyses performed, inputs used and results. The Judges should be able to repeat or verify your results based on the information provided **solely in the System Design Section and the relevant Subsystem Design chapter.**

The division of chapters contained in the Subsystem Design Section should reflect the overall design concept being evaluated. However, several subsystems are relevant to most, if not all, of the spacecraft that are participating in the ground tournaments.

The evaluation criteria for these subsystems are described in more detail.

1 Communications

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design: Evaluation Inputs

1. Operational timeline
   - Define ground station scheduling including operational facilities
   - Define eclipse durations if necessary (for lunar orbit)
2. End-to-end communications strategy and data architecture
3. Command and control approach
4. Communication Subsystem Architecture Description:
   - Transmitter (power, operating frequency)
   - Antenna Type (gain and directionality)

5. Ground Systems Architecture Description:

- Ground stations and antennas
- Data Recording Systems
- Planned frequency band(s) for satellite command and control, navigation, and high-speed telemetry
- Planned date(s) for filing for FCC ELA or STA license(s) (needed before transmitter operations)
- Planned number and location(s) of ground stations
- Name of owner/operator of planned ground station(s)
- Planned transmitter power, modulation method, and coding (if known at the time)
- Planned operational scenarios (overview and summary of command and control concepts, number of transmissions per day/week, etc.)

6. Link budgets
    - Analysis performed on selected spacecraft and ground-station hardware for the worst case nominal operational scenario, which must include:
        1. **General Requirements:** Up/Down Frequency and Data Rate, Radio details, Eb/No Margin
        2. **CubeSat** Transmitter Power (P), Transmission Line Loss (Tl), Transmit Antenna Gain (Gt), Antenna Half-Power Beam Width Angle (Theta), Carrier Frequency (Lambda), Pointing Loss (Lp), Implementation Loss (Li), Spacecraft Antenna Polarization, Receiver G/T Temp (Sr_G/T), Spacecraft Pointing Capability (deg)
        3. **Path Parameters**: Downlink Data Rate (bps), Bit Error Rate (BER), Eb/No Received, Modulation, Coding, Receiving Station's 30 minute block count during 28-day window (n), Expected Ground Station(s) View Time(s), Range(s) (km), Path Loss, **OPTIONAL:** Carrier loop bandwidth, Telemetry modulation index, Ranging modulation index, Carrier suppression by telemetry mod index, Carrier suppression by ranging mod index, Data channel suppression by telemetry mod index, Data channel suppression by ranging mod index
        4. **Ground Station** Gain/Noise Temp (Gs_G/T), Pointing Loss (Lp_gs), Polarization Loss (Lz), **OPTIONAL (if Gs_G/T provided):** Effective receive antenna aperture area (Ar), Receive antenna gain (Gr), System Noise Temperature including all contributions – antenna elevation, atmosphere, sun, hot bodies, cosmic background (SNT), Required total power/noise spectral density (P/No), Ground Station elevation angle (el), Ground station antenna polarization
    -

7. Any other relevant analyses

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the entered required communications parameters in the requested semi-standardized link budget. This standardized link budget was adapted from the Link Budget examples in section 13.3.6 "Link Budgets" in the third edition of the *Space Mission Analysis and Design* book by Wiley J. Larson and James R. Wertz and JPL's Design Control Tables from the Descanso series. The link budget and other

analyses will be verified. STK simulations may be used to verify claimed communications times and link margins.

The submittals will also be assessed on technical soundness of plan for preventing signal transmission for at least 15 seconds after deploying (SLS Secondary Payload User's Guide, SPUG).

Subsystem Margin Evaluation

Grade	GT1 (MCR/SRR) & GT2 (PDR)	GT3 (TRR) & GT4 (FRR)
0	0 dB link margin	0 dB link margin
1	< 3 dB link margin	< 1 dB link margin
2	< 5 dB link margin	< 2 dB link margin
3	5-7 dB link margin	2-4 dB link margin
4	> 7 dB link margin	> 4 dB link margin
5	> 9 dB link margin	> 6 dB link margin

Expected Submittal Progress Through Ground Tournament Process

	GT1: Mission Concept Review/System Requirements Review	GT2: Preliminary Design Review	GT3: Test Readiness Review	GT4: Flight Readiness Review
Submittal Progress	- Link budget parameters based on manufacturer and ground station information, estimates, specification sheets, user guides, etc. with explanations of any assumptions - Preliminary link budget has been completed and link closes with acceptable margin (6 dB) - Plan has been drafted to prevent signal transmission for 15 seconds after deployment, and RF inhibits per SLS Payload User's Guide	- Link budget estimates/parameters based on preliminary design documents closes link budget with acceptable level of risk and margin (6 dB) and explanations of any assumptions - Technical interfaces with power subsystem, C&DH subsystem, and attitude control subsystems have been defined, Plan to prevent signal transmission for 15 seconds after deployment, and RF inhibits per SLS Payload User's Guide has matured	- Link budget parameters based on final design documents, analyses and available tests closes link budget with acceptable level of risk and margin (3 dB) and explanations of any assumptions - Interface control documents of note to communications challenges: power, C&DH, attitude control test plan should include a plan for meeting all of the Secondary Payload User's Guide requirements, including but not limited to: EMI/EMC, preventing signal transmission for 15 seconds after deployment, and RF inhibits per SLS Payload User's Guide is complete.	- Link budget parameters based on final test results closes link budget with acceptable level of risk and margin (3 dB) and explanations of any outstanding assumptions and why they are acceptable at this stage - Plan/design to prevent signal transmission for 15 seconds after deployment, and RF inhibits per SLS Payload User's Guide has been tested and verified

2 Electrical Power System

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design

1. Provide a top level architectural diagram of the electrical power system including all interfaces to other subsystems
2. Provide circuit diagrams of the EPS which include the power generation, management, distribution and loading stages of the system.
3. Architectural diagram of the software and/or underlying operating principle for the EPS.

Subsystem Budgets & Analyses

4. A power budget for the EPS, identifying and itemizing each of the subsystems. Outline average and peak loads for each mission mode. All system losses must be quantified and level of margins must be clearly identified.
5. A performance analysis based on orbital parameters, temperature effects, spacecraft/panel orientation and regular operational degradation.

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves. STK simulations may be used to verify sun-earth geometries and potential orientations as they relate to the design of the power system.

Scoring Process

Subsystem Margin Evaluation

Power Budget Margin Evaluation

Grade	GT1 (MCR/SRR) & GT2 (PDR)	GT3 (TRR) & GT4 (FRR)
0	None provided	
1	<= 0% Margin	<= 5% Margin
2	<= 10% Margin	<= 10% Margin
3	<= 20% Margin	<= 15% Margin
4	<= 30% Margin	<= 20% Margin
5	>= 30% Margin	>= 25% Margin

Note: Appropriately justified low margins will be considered.

3 Command and Data Handling/Flight Software

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design

1. Describe the architecture of the Onboard Data System and Flight Software (FSW) for:
   - On-board computers,
   - Persistent memory modules,
   - Data buses,
   - Communication systems,
   - Sensors and actuators

NOTE: Use a unique name for each component and data bus that you will reuse in your documentation and requirements. Indicate the role of each component in relation to the mission requirements.

Architectural Diagrams

2. Unified Modeling Language (UML) package diagram
3. Unified Modeling Language (UML) class diagram
4. Establish the required resource based on the mission and other subsystem requirements
   - Minimum CPU processing power for each processor, in DMIPS
   - Maximum CPU latency for each processor (CPU deadlines), in seconds
   - Minimum program memory, in bytes

- Minimum persistent storage, in bytes
- Minimum bandwidth for each communication bus, in bytes/sec
- Minimum latency for each communication bus, in seconds

NOTE: Indicate whether the data comes from estimation, analysis or measurement. For GT4 (FRR), only measurement shall be used to determine the requirements.

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Scoring Process

Subsystem Margin Evaluation

The overall margin of your system will be determined as the minimum margining of all your requirements.

Margin Evaluation

Grade	GT1 (MCR/SRR) & GT2 (PDR)	GT3 (TRR) & GT4 (FRR)
0	0% or less	
1	0% < margin < 5%	0% < margin < 2%
2	5% < margin < 10%	2% < margin < 5%
3	10% < margin < 15%	5% < margin < 10%
4	15% < margin < 20%	10% < margin < 15%
5	20% < margin < 25%	15% < margin < 20%

Note: Appropriately justified low margins will be considered.

4 Guidance, Navigation & Control/Attitude Determination & Control Systems

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design

1. Description of the baseline design including all relevant data (picture, specs, flight history or development plans)
2. A complete description of the ADCS and GNC hardware and related algorithms, including
    a. Architecture diagram describing the ADCS and GNC hardware and their electrical interconnections
    b. Architecture diagram(s) describing the software system, control algorithms and mode switching logic
    c. Description of the baseline design including all relevant data (picture, specs, flight history or development plans).
3. Subsystem test plan with clearly defined test objectives and coverage.

Subsystem Budgets

4. Analysis related to the justification of all relevant GNC and ADCS requirements, including, but not limited to, pointing knowledge and control budgets, reaction wheel saturation analysis and sizing, reaction control thruster sizing and disturbance estimation

Conclusions

5. Conclusion and margins
    a. Active ACS stability margin of at least 6db for rigid body stability with 30deg phase margin and 12db of margin for flexible modes – or provide rationale if differing (if applicable)
    b. 30% margin on all mission critical requirements – or provide rationale if differing

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Scoring Process

Subsystem Margin Evaluation

Pointing Margin Evaluation by lowest scoring row

	GT1 (MCR/SRR) & GT2 (PDR)		GT3 (TRR) & GT4 (FRR)	
Grade	**Rigid body stability w/30 deg phase margin**	**Flexible modes stability**	**Rigid body stability w/30 deg phase margin**	**Flexible modes stability**
0	None provided			
1	< 2 dB Margin	< 9 dB Margin	< 1 dB Margin	< 3 dB Margin
2	< 4 dB Margin	< 11 dB Margin	< 2 dB Margin	< 5 dB Margin
3	4-6 dB Margin	11-13 dB Margin	2-4 dB Margin	5-7 dB Margin
4	> 6 dB Margin	> 13 dB Margin	> 4 dB Margin	> 7 dB Margin
5	> 9 dB Margin	> 15 dB Margin	> 6 dB Margin	> 9 dB Margin

Note: Appropriately justified lower margins will be considered.

5 Structures

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design: Evaluation Inputs

1. All mechanisms explicitly listed, including mechanism type
2. Mechanism test plan with clearly defined test objectives and coverage.

Architectural Diagrams

3. CAD exploded view diagram of entire spacecraft showing fasteners, brackets, etc.

Subsystem Budgets and Analyses

4. Mass and Volume Budget
5. Relevant analyses showing that the design will meet system strength and stiffness requirements

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Scoring Process

Subsystem Margin Evaluation

Structure Margin Evaluation by lowest scoring row

Grade	GT1 (MCR/SRR) & GT2 (PDR)		GT3 (TRR) & GT4 (FRR)	
	Mass or Volume	Mechanisms	Mass or Volume	Mechanisms
0	None provided			
1	> 5% Mass > 0% Volume	> 2	> 0% Mass > 0% Volume	> 2
2	> 10% Mass > 5% Volume	<= 2	> 2% Mass > 2% Volume	<= 2
3	> 15% Mass > 10% Volume	<= 2	> 5% Mass > 5% Volume	<= 2
4	> 20% Mass > 15% Volume	<= 1	> 7% Mass > 7% Volume	<= 1
5	> 25% Mass > 20% Volume	0	> 10% Mass > 10% Volume	0

Note: Appropriately justified low margins will be considered.

6 Propulsion

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design: Evaluation Inputs

1. Description of the baseline trajectory design including all relevant data (picture, specs, flight history or development plans).
2. Subsystem test plan with clearly defined test objectives and coverage.

Architectural Diagrams

3. Propulsion module and component diagrams
   - Propulsion hardware explicitly defined including descriptions of propulsion system components
   - Discussion of safety related issues including pressure vessels, activation inhibits, propellant type, etc.
   - Layout, position and orientation of propulsion hardware within spacecraft
4. Propulsion hardware TRL advancement plan or flight heritage as applicable

Subsystem Budget

5. Delta V/Propellant Mass Budget and related analyses

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Scoring Process

Subsystem Margin Evaluation

Propellant Mass Margin Evaluation

Grade	GT1 (MCR/SRR) & GT2 (PDR) Propellant Mass	GT3 (TRR) & GT4 (FRR) Propellant Mass
0	None provided	
1	> 0% Margin	> 0% Margin
2	> 5% Margin	> 2% Margin

3	> 10% Margin	> 5% Margin
4	> 15% Margin	> 7% Margin
5	> 20% Margin	> 10% Margin

Note: Appropriately justified low margins will be considered.

7 Thermal

Subsystem Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design: Evaluation Inputs

1. Description of the baseline design including all relevant data (picture, specs, flight history or development plans).
2. Subsystem test plan with clearly defined test objectives and coverage.

Architectural Diagrams

3. Thermal Control System diagram
    1. Include locations of radiators and heaters

Subsystem Analyses

4. Table(s) describing worst case hot and cold power states of spacecraft
5. Thermal analyses for all driving hot and cold cases showing temperatures of key components and margin against allowable temperatures for that component.

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Scoring Process

Subsystem Margin Evaluation

Thermal Control Margin Evaluation

Grade	GT1 (MCR/SRR) & GT2 (PDR)	GT3 (TRR) &GT4 (FRR)
	Heat Dissipation/Generation to maintain Operational and Survival Temp Windows	Heat Dissipation/Generation to maintain Operational and Survival Temp Windows

0	None provided	
1	> 10% Op & 5% Survival Margin	> 5% Op & 0% Survival Margin
2	> 15% Op & 7% Survival Margin	> 7% Op & 2% Survival Margin
3	> 20% Op & 10% Survival Margin	> 10% Op & 5% Survival Margin
4	> 25% Op & 15% Survival Margin	> 12% Op & 7% Survival Margin
5	> 30% Op & 20% Survival Margin	> 15% Op & 10% Survival Margin

Note: Appropriately justified low margins will be considered.

8+ Additional Subsystems

Subsystem Critical Requirements

State any and all subsystem requirements that are imposed in the System Design Document. Demonstrate the ability to meet critical requirements by explicitly defining any analysis needed to show that the subsystem meets these requirements including but not limited to: environment characterization, margins, uncertainties, and assumptions. Note: each chapter should be self-contained, but in the interest of brevity, tables and figures in other sections may be referenced to avoid unnecessary replication of material. However, submitters are advised to be clear about the description of inputs used in the analyses relevant to the subsystem being reviewed. In addition to these this self-specified analysis, the additional data inputs are **required**.

Baseline Subsystem Design: Evaluation Inputs

1. Description of the baseline design including all relevant data (picture, specs, flight history or development plans)
2. Subsystem test plan with clearly defined test objectives and coverage

Architectural Diagrams

3. Any subsystem diagrams as necessary

Subsystem Budget

4. Any subsystem budget as required

Evaluation Process

The submittals will be assessed based on the maturity of the design (and related risk), ability of the design to meet the subsystem requirements, margin(s) against the design requirements and the consistency and completeness of the inputs to the analyses and the quality of the analyses themselves.

Submittal Evaluation Criteria

Rules Verification Evaluation

The Challenge Rules verification will be completed by the Cube Quest Challenge Administrator.

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
Eligibility and Registration								
1.A	***Team Leader US Citizen***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.B	***Foreign National Team Participation***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.C	***Designated Countries***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.D	***Federal Employee/Entity***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.E	***Contractor Employee/Entity***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.F	***Prize Award to US Citizen***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
1.G	***Single CubeSat Submission***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
Competitor Team Responsibilities and Agreements								
2.A	***Regulation & Law Compliance for Foreign Students/Employees***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
2.B	***Notice of Intent to Compete***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
2.C	***Liability Insurance***		Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package	Confirmed in Registration Data Package		
2.D	***Use of NASA Name and Insignia***		Evaluation of websites, submitted materials, etc	Evaluation of websites, submitted materials, etc	Evaluation of websites, submitted materials, etc	Evaluation of websites, submitted materials, etc	Evaluation of websites, submitted materials, etc	Evaluation of websites, submitted materials, etc
2.E	***Compliance w/ existing Laws***		Notifications from Law Enforcement or Legal	Notifications from Law Enforcement or Legal	Notifications from Law Enforcement or Legal	Notifications from Law Enforcement or Legal	Notifications from Law Enforcement or Legal	Notifications from Law Enforcement or Legal
2.F	***Monthly Reporting***		Monthly Reports Submitted	Monthly Reports Submitted	Monthly Reports Submitted	Monthly Reports Submitted	Monthly Reports Submitted	Monthly Reports Submitted
2.G	***Media Rights***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire
2.H	***Purchase/Sales Rights***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire
2.I	***Intellectual Property Rights***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire
2.J	***Delay, Cancellation, Termination***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire
Mission Concept Registration Data Package								
3	***On-time MCRDP***		60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to compete in	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to compete in	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to compete in	60 calendars days after acceptance of registration data package and NLT than 30 days before GT-1 or the first GT team is eligible to compete in		
CubeSat Mass, Volume, & Interface Requirements								

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
4.A	***IDRD/LVSRD Requirements***		IDRD/LVSRD Compliance Score > 0	IDRD/LVSRD Compliance Score > 0	IDRD/LVSRD Compliance Score > 0	IDRD/LVSRD Compliance Score > 0	IDRD/LVSRD Compliance Score > 0	IDRD/LVSRD Compliance Score > 0
4.B	***SPUG Requirements***		SPUG Compliance Score >0	SPUG Compliance Score >0	SPUG Compliance Score >0	SPUG Compliance Score >0	SPUG Compliance Score >0	SPUG Compliance Score >0
4.C	***Size & Mass Requirements***		Concepts and plans for 6U	Concepts and plans for 6U	Concepts and plans for 6U	Concepts and plans for 6U	Concepts and plans for 6U	Concepts and plans for 6U
4.D	***Single Payload***		Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans
4.E	***3rd Party Launch Provider Requirements***		Team shows plans for meeting launch service provider requirements	Team shows plans for meeting launch service provider requirements	Team shows plans for meeting launch service provider requirements	Team shows plans for meeting launch service provider requirements	Team shows plans for meeting launch service provider requirements	Team shows plans for meeting launch service provider requirements
4.F	***Volume/Mass Precedence – 3rd Party v EM-1***		Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans
4.G	***3rd Party Launch Inspections***		Plans to submit	Plans to submit	Plans to submit	Plans to submit	Plans to submit	Plans to submit
Radio Frequency Authorization								
5.A	***RF in accordance with US and Intl laws/regulations***		Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans
5.B	***Allowable Electromagnetic Spectrum Frequency***		Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans
5.C	***RF Operating Licenses***		Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans	Concepts and plans
Monitoring and Inspection								
6	**Non-invasive Monitoring any Space-based Communication**						Verbal/Written Questionnaire	Verbal/Written Questionnaire

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
7	***NASA* Visits *for Inspection***		Verbal/Written Questionnaire; Access Provided	Verbal/Written Questionnaire; Access Provided	Verbal/Written Questionnaire; Access Provided	Verbal/Written Questionnaire; Access Provided	Verbal/Written Questionnaire; Access Provided	Verbal/Written Questionnaire; A ccess Provided
Constraints on Ground Tournament Participation								
8.A	**GT Participation**		Mission Concept Registration Data Package	Mission Concept Registration Data Package	Mission Concept Registration Data Package	Mission Concept Registration Data Package		
8.B	**Mission Concept Registration Data Package**		30 days prior to participation if first GT	30 days prior to participation if first GT	30 days prior to participation if first GT	30 days prior to participation if first GT		
8.C	**Intent to Compete – In-space Competitions**		Prior to each GT	Prior to each GT	Prior to each GT	Prior to each GT		
8.D	**Intent to Compete for EM-1**		Prior to each GT up to GT4	Prior to each GT up to GT4	Prior to each GT up to GT4	Prior to each GT up to GT4		
8.E	**GT-4 Participate for EM-1 Consideration**					Must compete for EM-1 consideration		
Ground Tournament Judging								
9.A	***Team Submission Requirements***		GT-1 Submittals 30 days prior to participation if first GT	GT-2 Submittals30 days prior to participation if first GT	GT-3 Submittals 30 days prior to participation if first GT	GT-4 Submittals 30 days prior to participation if first GT		
9.B	***Site Inspections***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire		
9.C	***Competition Score Public Posting***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire		
9.D	***Scoring Criteria for All Teams***		Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire	Verbal/Written Questionnaire		
9.E	***Likelihood of Mission Success***		Judges Scorecard 1	Judges Scorecard 1	Judges Scorecard 1	Judges Scorecard 1		

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9.F	***Compliance with LVSRD and Challenge Rules***		Judges Scorecard 2	Judges Scorecard 2	Judges Scorecard 2	Judges Scorecard 2		
Rules and Requirements for GT-1								
10	***GT-1 Participation***		GT-1 Submittals per Judge's scorecard, GT workbook, and Operations and Rules					
Rules and Requirements for GT Two								
11	***GT-2 Participation***			GT-3 Submittals per Judge's scorecard, GT workbook, and Operations and Rules				
Rules and Requirements for GT Three								
12	***GT-3 Participation***				GT-3 Submittals per Judge's scorecard, GT workbook, and Operations and Rules			
Rules and Requirements for GT Four								
13.A	***Final Intention for EM-1 or 3rd Party Launch***					GT-4 Submittals		

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
13.B	***GT-4 Participation***					GT-3 Submittals per Judge's scorecard, GT workbook, and Operations and Rules		
13.C	***EM-1 Compliance Requirements***					GT-4 < 3 GT-4 Submittals / SLS Requirements		
13.D	***Team Declaration for EM-1***					Prior to entry to GT-4 / Submittals		
Availability of EM-1 Secondary Payload Slots								
14.A	***Judges Ranking of GT4 Competitors***					Judges Scorecard 1 and 2		
14.B	***Top 3 Teams for EM-1 Integration***					Judges Scorecard 1 and 2		
14.C	***Backfill Competitors for EM-1***					Judges Scorecard 1 and 2		
In-Space Competition								
15.A	***3rd Party Launch Notification***						Team Notification	Team Notification
15.B	***EM-1 Deployment***						Positive Deployment	Positive Deployment
Competitor Ground Stations								
16.A	***CubeSat Communications***						No restrictions on quantity of communications	No restrictions on quantity of communications
16.B	***Number of Ground Stations***						Team Submittals	Team Submittals
16.C	***Use of Government Controlled Stations***						Team Submittals	Team Submittals

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
16.D	***Monitoring by Government Controlled Stations***						Team Submittals	Team Submittals
16.E	***Ground Station Operators***						Team Submittals	Team Submittals
Planetary Protection								
17.A	***Submission of ODARS & EOMPS***		Team Submittal	Team Submittal	Team Submittal	Team Submittal		
17.B	***OARD and EOMP Submission***		No later than GT-4	No later than GT-4	No later than GT-4	No later than GT-4		
17.C	***Lunar Orbit End of Mission***					Team Submittal		Team Submittal
17.D	***Missions Designs & Planetary Protection***					Team Submittal	Team Submittal	Team Submittal
17.E	***Planetary Protection Plans***		Team Submittal	Team Submittal	Team Submittal	Team Submittal	Team Submittal	Team Submittal
Communications Competition: In-space Challenges								
18.A	***Start of Operating Period***						Team Notification	Team Notification
18.B	***Communications Methodology***						Team Submittals	Team Submittals
18.C	***Communications Log***						Team Submittals	Team Submittals
18.D	***Protocol for Transmission***						Team Submittals	Team Submittals
18.E	***Data Block Receipts***						Team Submittals	Team Submittals
18.F	***Data Block Delivery for Judging***						Team Submittals	Team Submittals
18.G	***Transmission Achievement Evidence***						Team Submittals	Team Submittals

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
Competition End: In-space Challenges								
19.A	***3rd Party Launches***						365 days from EM-1 Launch	365 days from EM-1 Launch
19.B	***EM-1 Launch***						365 days from EM-1 Launch	365 days from EM-1 Launch
19.C	***Activity after Competition Days***						365 days from EM-1 Launch	365 days from EM-1 Launch
19.D	***3rd Party Longevity Competitions***						Team Submittal	Team Submittal
EM-1 Deployment								
20	***Failure to Deployment from EM-1***						Ineligible for Prizes	Ineligible for Prizes
NASA Rights to Share Team Information								
21	***NASA Rights to share Competitor Accomplishments and Progress***							
Deep Space Derby: Verifiable Minimum Distance								
22.A	***Achieve and maintain 4M km distance***						Team Submittal / Independent Verification	
22.B	***Evidence of Spacecraft Distance***						Team Submittal	
22.C	***No verifiable minimum distance / end of contest***						365 days of EM-1 Launch	
Deep Space Derby: Prizes								

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
23.A	***Best Burst Data Rate***						Team Submittal / Independent Verification	
23.B	***Largest Aggregate Data Volume***						Team Submittal / Independent Verification	
23.C	***Spacecraft Longevity***						Team Submittal / Independent Verification	
23.D	***Farthest Comm distance from earth***						Team Submittal / Independent Verification	
Lunar Derby: Verifiable Lunar Orbit								
24.A	***Verifiable Lunar orbit***							Team Submittal / Independent Verification
24.B	***Lunar orbit definition***							Team Submittal / Independent Verification
24.C	***Evidence of lunar orbit***							Team Submittal / Independent Verification
24.D	***Evidence for minimum altitude***							Team Submittal / Independent Verification
24.E	***Evidence of maintaining lunar orbit***							Team Submittal / Independent Verification
24.F	***No verifiable / end of contest***							Team Submittal / Independent Verification
Lunar Derby: Prizes								
25.A	***Lunar Propulsion***							Team Submittal / Independent Verification

Rule	Rule Title	Meets ☑	GT One Information for Judges to Consider	GT Two Information for Judges to Consider	GT Three Information for Judges to Consider	GT Four Information for Judges to Consider	Deep Space Derby Information for Judges to Consider	Lunar Derby Information for Judges to Consider
25.B	***Best Burst Data Rate***							Team Submittal / Independent Verification
25.C	***Largest Aggregate Data Volume***							Team Submittal / Independent Verification
25.D	***Spacecraft Longevity***							Team Submittal / Independent Verification
Rules Modification								
26	***Additional Challenge Rules***							

Appendix A Ground Tournament Success Criteria

Success Criteria - Ground Tournament One (GT-1)

GT-1 Purpose:

Given the team's proposed in-space Prize(s) they intend to compete for, demonstrate the team's CubeSat and ground systems design approaches and operations concepts for meeting those Prize achievements; determine if the architecture and the concept are likely to accomplish the minimum threshold achievements for Prize(s) as defined in the Rules; and to assess plans and progress toward compliance with Challenge Rules, required SPUG inputs, and SLS interface requirements as documented in the LAUNCH VEHICLE INTERFACE AND SAFETY REQUIREMENTS.

Judges Evaluation Criteria for GT-1:

- Team in-space Prize(s) objectives are clearly defined and stated.
- Accomplishment of minimum Prize achievements, as defined in Operations and Rules for each in-space Prize selected by the team is, or appears, to be feasible per Judge's assessment of submitted materials. A solution has been identified by the team that is, or appears, to be technically feasible.
- System and subsystem design approaches and operational concepts exist and are consistent with the requirements.
- Development schedule estimate is credible.
- Planning is sufficient to proceed to the next phase.
- Major risk and mitigation strategies have been identified and are acceptable based on technical risk assessments
- Requirements definition is complete with respect to top-level mission requirements; interfaces with external entities and between major internal elements have been defined.
- Requirements allocation and flow down of key driving requirements have been defined down to subsystems.
- Preliminary approaches have been determined for how requirements will be verified and validated down to subsystem level.

Scoring:

0 - insufficient information to determine likelihood of achieving Prize
1 - Little consideration in how to achieve; not likely to achieve Prize
2 - Some considerations in some aspects of achieving; might achieve Prize
3 - Considerations into many aspects; reasonable likelihood of achieving Prize
4 - Substantial thought into plans; most aspects needed to achieve are considered; good plans to achieve Prize
5 - Very detailed plans; concepts and trades thoroughly evaluated, significant analysis performed, and very likely to achieve Prize

Success Criteria - Ground Tournament Two (GT2)

GT-2 Purpose:

Given the team's proposed in-space Prize(s) they intend to compete for, demonstrate that teams will achieve stated in-space Prize(s) with reasonable technical risk and within schedule constraints and are ready to proceed to detailed design and GT-3. Teams can show that appropriate design options have been selected, interfaces have been identified, and verification methods have been described. Teams show acceptable progress and plans for complying with Cube Quest Rules and with the SLS interface requirements.

Judges Evaluation Criteria for GT-2:

- The top-level requirements - including Derby success criteria, TPMs and Rules and Launch Vehicle Interface and Safety Requirements constraints are agreed upon, finalized, stated clearly and are consistent with the preliminary design.
- Preliminary design is expected to meet the requirements at an acceptable level of risk.
    - System design shows a complete set of requirements, that if met in aggregate by the subsystem designs shows that the mission goals will be met.
    - Subsystems have clearly defined requirements and preliminary designs have been shown to meet those requirements
- Definition of the technical interfaces is consistent with the overall technical maturity and provides an acceptable level of risk.
- Adequate technical interfaces are consistent with the overall technical maturity and provide an acceptable level of risk.
- Adequate technical margins exist with respect to TPMs.
- Team risks are understood and have been credibly assessed, and plans, process and resources exist to effectively manage them.
- SLS safety have been adequately addressed in preliminary designs and any applicable system safety analysis could be approved.
- The operational concept is technically sound, includes (where appropriate) human factors, and includes the flow down of requirements for its execution.

Scoring

0 - insufficient information to determine likelihood of achieving Prize

1 -Preliminary design, requirements, risk plans, operating concepts, interface definition, test plans do little to demonstrate how team will achieve Prize; not likely to achieve Prize

2 -Preliminary design, requirements, risk plans, operating concepts, interface definition, test plans demonstrate team might achieve Prize; might achieve Prize

3 - Preliminary design, requirements, risk plans, operating concepts, interface definition, test plans demonstrate reasonable likelihood of achieving Prize

4 - Preliminary design, requirements, risk plans, operating concepts, interface definition, test plans are substantial and demonstrate most aspects needed to achieve Prize are considered; good chance to achieve Prize

5 - Preliminary design, requirements, risk plans, operating concepts, interface definition, test plans demonstrate excellent likelihood to achieve Prize

Success Criteria - Ground Tournament Three (GT3)

GT-3 Purpose:

Given the team's proposed in-space Prize(s) they intend to compete for, demonstrate that the Team's design maturity is appropriate to proceed with fabrication, assembly, integration and test; determine that the technical effort is on track to complete the CubeSat and ground system development and in-space operations, to achieve selected in-space Prize Achievements, and be completed in time to deliver for integration with SLS, or another launch opportunity specified by the team. Demonstrate good progress and plans for compliance with Cube Quest Challenge Rules, and with the Launch Vehicle Interface and Safety Requirements.

Judges Evaluation Criteria for GT-3:

- The CubeSat and Ground Segment detailed designs are expected to accomplish selected Prize achievements with adequate margins.
- Interfaces (CubeSat, Ground, SLS, Environmental) control documents are sufficiently mature to proceed with fabrication, assembly, integration, and test, and plans are in place to manage any open items.
- The team schedule estimates are credible to achieve the next GT and CubeSat delivery dates
- High confidence exists in the CubeSat/Ground Segment baseline, and adequate documentation exists or will exist in a timely manner to allow proceeding with fabrication, assembly, integration, and test.
- The CubeSat/Ground Segment verification and product validation requirements and plans are complete.
- The testing approach is comprehensive, and the planning for system assembly, integration, test, and launch site and Cube Quest operations is sufficient to progress into the next phase.
- Adequate technical margins (e.g., mass, power, memory) exist to complete the development within schedule, and known technical risks.
- Risks to achieving selected Prizes are understood and credibly assessed, and plans and resources exist to effectively manage them.
- Durability and longevity (e.g., reliability, quality, and parts) have been adequately addressed in system and operational designs (e.g., PRA, and failure modes and effects analysis) meet requirements, are at the appropriate maturity level for this phase of the team's life cycle, and indicate that the team reliability residual risks will be at an acceptable level.
- The team has demonstrated compliance with applicable NASA and implementing Center requirements, standards, processes, and procedures.
- TBD and TBR items are clearly identified with acceptable plans and schedule for their disposition.
- Engineering test units, life test units, and/or modeling and simulations have been developed and tested per plan.
- Material properties tests are completed along with analyses of loads, stress, fracture control, contamination generation, etc.
- Appropriate parts have been selected, and planned testing and delivery will support build schedules.
- The operational concept has matured, is at a GT-3 level of detail, and has been considered in test planning.

Scoring

0 - insufficient information to determine likelihood of achieving Prize(s)

1 -CubeSat and Ground System detailed designs, plans and procedures and other submittals do little to demonstrate how team will achieve Prize; not likely to achieve Prize(s)

2 -CubeSat and Ground System detailed designs, plans and procedures and other submittals demonstrate team might achieve Prize; might achieve Prize(s)

3 - CubeSat and Ground System detailed designs, plans and procedures and other submittals demonstrate reasonable likelihood of achieving Prize(s)

4 - CubeSat and Ground System detailed designs, plans and procedures and other submittals are substantial and demonstrate good chance to achieve specified Prize(s)

5 - CubeSat and Ground System detailed designs, plans and procedures and other submittals demonstrate excellent likelihood to achieve specified Prize(s)

Success Criteria - Ground Tournament Four (GT4)

GT-4 Purpose:

Given the team's proposed in-space Prize(s) they intend to compete for, verify the completeness of the CubeSat and ground systems and to assess compliance with all Challenge Rules and Launch Vehicle Interface and Safety Requirements; to examine the CubeSat, ground systems, documentation and test data and analyses that support verification; ensure that CubeSat is ready for shipment to the SLS; verify that the Team has complied with all Cube Quest Challenge Rules; verify the team has complied with all launch vehicle interface requirements per the relevant Launch Vehicle Interface and Safety Requirements document (e.g. IDRD for SLS launches). The top-performing teams will be offered the opportunity to fly on SLS EM-1 mission.

Judges Evaluation Criteria for GT-4:

- Required tests and analyses are complete and indicate that the CubeSat and Ground Segment will perform properly in the expected operational environment.
- Risks are known and manageable.
- CubeSat and Ground Segment meet the established acceptance criteria.
- The team has demonstrated compliance with Challenge Rules and Launch Vehicle Interface and Safety Requirements.
- TBD and TBR items are resolved.
- Technical data package is complete and reflects the final CubeSat and Ground Segment design
- The CubeSat and Ground Segment, including all enabling products, is determined to be ready to be placed in an operational status.
- Systems hardware, software, personnel, and procedures are in place to support operations.
- Operations plans and schedules are consistent with selected team Prize achievements/objectives.
- Team risks have been identified, planned mitigations are adequate, and residual risks are accepted by the team
- Testing is consistent with the expected operational environment.

Scoring

0 - insufficient information to determine likelihood of achieving Prize(s)

1 -CubeSat and Ground System test results, demonstrations, analyses, operating plans, and procedures and other submittals do little to demonstrate how team will achieve Prize; not likely to achieve Prize(s)

2 -CubeSat and Ground System test results, demonstrations, analyses, operating plans, and procedures and other submittals demonstrate team might achieve Prize; might achieve Prize(s)

3 - CubeSat and Ground System test results, demonstrations, analyses, operating plans, and procedures and other submittals demonstrate reasonable likelihood of achieving Prize(s)

4 - CubeSat and Ground System test results, demonstrations, analyses, operating plans, and procedures and other submittals are substantial and demonstrate good chance to achieve specified Prize(s)

5 - CubeSat and Ground System test results, demonstrations, analyses, operating plans, and procedures and other submittals demonstrate excellent likelihood to achieve specified Prize(s)