Cube Quest Challenge

Ground Tournament Submittal Requirements and Standardized Judging Criteria

(Ground Tournament Workbook)

Revision 3– 14 January 2016

Contents

1. 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 launch vehicle safety and interface requirements – worth 60% of total score. EM-1 teams are judged in accordance with SLS requirements while non-EM-1 teams are judged in accordance with their own launch service requirements.

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 be among the top 5 winners of GT-1 or GT-2 and GT-4, and pass a series of SLS Safety Reviews, per Operations and Rules Rule 8, to be qualified for launch on EM-1.

2. Ground Tournament Instructions

Instructions to Teams

1. Teams are responsible for downloading and reading the current version of the Operations and Rules document, this Ground Tournament Work Book, the Mission Concept Registration Data Package 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 are required to submit a Notice of Intent to Compete before participating in their first Ground Tournament (GT). (Defined in Operations and Rules, Rule 2.B and Sect. 5.3).

3. Teams must submit a Registration Data Package before participating in their first GT, and must update it as necessary for each GT in which they participate. (Defined in Operations and Rules, Rules 1 and 2 and Sect. 5.3)

4. All materials required to compete in GTs must be submitted on or before due dates for each GT. Due dates are published on the Cube Quest website: www.nasa.gov/cubequest/schedule

5. To compete in each GT, teams must submit three defined documents. The three defined documents are:

   i. Mission Concept Registration Data Package. This MCRDP instructions are defined in the Rules and Operations, Section 4.1 Rule 3 and in detail in the MCRDP Document available at www.nasa.gov/cubequest/reference.

   ii. Cube Quest Design Package. The content of the CQDP is the subject of Section 9 of this GT Workbook and is fully defined in that section.

   iii. Teams stating that they intend to launch on EM-1 must submit a Safety Data Package . The Safety Data Package is defined in the SLS-SPIE-Rqmt-018 SLS Secondary Payload Deployment System, Interface Definition Requirements Document (IDRD). Otherwise, teams statin that they intend to launch on their own launch vehicle must submit the information specified in Required Data for Competitor Teams with Non-NASA Launch document. Instructions are on www.nasa.go/cubequest/reference for that document.

The three required documents must be submitted in PDF format, (three total). These three documents must contain all of the Team's information that is required by this GT Workbook, the Operations and Rules document, and the Mission Concept Registration and Data Package Definition document, for the purposes of GT judging. Only the information contained in these three documents will be eligible for GT judging and will be used by judges as the entire basis for GT scores.

6. Competitor Teams need to include in their MCDP Sect. 2.2, their complete list of all of the 4 possible Lunar Derby Prizes and all of the 4 possible Deep Space Derby Prize(s) for which they intend to compete. Judges evaluate scores in Score Card 1-Likelihood of Mission Success with respect to only the list of Prizes stated in your MCRDP Section 2.2.

7. The "Team Submittals Checklist" is offered in Section 7 of this GT Work Book as a convenient summary of the information that's required to be submitted in each the three defined documents.

However, in case of any conflict or anything is missing from the "Team Submittals Checklist, the requirements found throughout the other sections of this GT Work Book, the Operations and Rules document, and the Mission Concept Registration and Data Package Definition Document, are the definitive references.

Instructions to Judges

1. Judges will base their assessments strictly upon the rules and criteria documented in the Operations and Rules document, this Ground Tournament Workbook and related material published on the CubeQuest website.

2. Judges will receive from the Cube Quest Administrator a package of submittals from all participating teams on the date(s) specified in the Cube Quest website: www.nasa.gov/cubequest/schedule, for each ground tournament and/or in-space competition. Only materials submitted in accordance with the rules and received by the published deadline will be considered in the judge's evaluations. Only the materials submitted by teams in the three defined documents are acceptable for judging:

i. Team Registration Mission Concept Registration Data Package, which must include the list of prizes for which the team intends to be evaluated.

ii. Cube Quest Design Package

iii. Safety Data Package (for teams stating they intend to launch on EM-1; or, the Required Data for Competitor Teams with Non-NASA Launch, for those teams stating they intend to launch on their own launch vehicle

3. For each of the three defined documents submitted by the teams the teams:

3.1 Judges will fully review the entire content of the three defined documents.

3.2 For every element on the two Judge's Score Cards, judges will assess the three defined documents that comprise the team submittals. Assessments will be performed in accordance with the following:

- Cube Quest Challenge Operations and Rules document (current versions)
- The SLS Secondary Payload Interface Definition and Requirements Document (IDRD), for teams stating that they intend to launch on EM-1; or, the third party launch service interface and safety requirements in the format specified in the Required Data for Competitor Teams with Non-NASA Launch, for those teams stating they intend to launch on their own launch vehicle.
- Identified elements on the two Judge's Scorecards
- Evaluation Criteria identified throughout 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.

3. 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. Competitor Teams indicate their intention to compete for which Prizes as part of the Mission Concept Registration Data Package Sect 2.2.

Team Submittals – teams must submit the following documents before competing in GTs:

Notice of Intent to Compete must be submitted before participating in any Ground Tournament (GT). (defined in Operations and Rules, Rule 2.B and Sect. 5.3).

Registration Data Package before participating in their first GT, and must update it as necessary for each GT in which they participate. (Defined in Operations and Rules, Rules 1 and 2 and Sect. 5.3)

On or before the deadlines published for each GT, teams must submit three defined documents:

i. **Mission Concept Registration Data Package**. This MCRDP instructions are on www.nasa.gov/cubequest/reference
ii. **Cube Quest Design Package**. The content of the CQDP is specified in Section 8 of this GT Workbook.
iii. Either the **SLS Safety Data Package** or the **Required Data for Competitor Teams with Non-NASA Launch**

a. Safety Data Package (for teams stating they intend to launch on EM-1) is defined in the SLS-SPIE-Rqmt-018 SLS Secondary Payload Deployment System, Interface Definition Requirements Document (IDRD)
b. Required Data for Competitor Teams with Non-NASA Launch (for those teams stating they intend to launch on their own launch vehicle) instructions are on www.nasa.go/cubequest/reference

The Judge's Workbook has a handy Team Submittals Checklist tab (Tab 4).

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

Margin – as defined in Goddard Technical Standard GSFC-STD-1000E, *Rules for the Design, Development, Verification and Operation of Flight Systems*, 1.06 Resource Margins. Resource

margins are evaluated per Table 1.06-1, with system margin and contingency/reserve defined in the table, and illustrated in Figures 1.06-1 and 1.06-2. of that document. Table 1.06-2 of that document is a schedule of recommended mass contingency/reserve by subsystem.

Risk – as defined in NPR 7123.1B *NASA Systems Engineering Process and Requirements*: In the context of mission execution, the potential for performance shortfalls, which may be realized in the future, with respect to achieving explicitly established and stated performance requirements. The performance shortfalls may be related to any one or more of the following mission execution domains: (1) safety, (2) technical, (3) cost, and (4) schedule. (See NPR 8000.4, *Agency Risk Management Procedural Requirements*.)

Risk Statement – as defined in NPR 8000.4 *Agency Risk Management Procedural Requirements*: In the context of mission execution, risk is *operationally* defined as a set of triplets:

- The *scenario(s)* leading to degraded performance with respect to one or more performance measures (e.g., scenarios leading to injury, fatality, destruction of key assets; scenarios leading to exceedance of mass limits; scenarios leading to cost overruns; scenarios leading to schedule slippage).
- The *likelihood(s)* (qualitative or quantitative) of those scenarios.
- The *consequence(s)* (qualitative or quantitative severity of the performance degradation) that would result if those scenarios were to occur.

Uncertainties are included in the evaluation of likelihoods and consequences.

Hazard – as defined and used in SLS-PLAN-217 SLS Exploration Mission-1 Secondary Payload Safety Review Process

Technology Readiness Level. (TRL) - Provides a scale against which to measure the maturity of a technology. TRLs range from 1, Basic Technology Research, to 9, Systems Test, Launch, and Operations. Typically, a TRL of 6 (i.e., technology demonstrated in a relevant environment) is required for a technology to be integrated into a flight system. (See Systems Engineering Handbook NASA/SP-2007-6105 Rev 1, p. 296 for more information on TRL levels and technology assessment.)

4. 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

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

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

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

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

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

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.

Conditions Contributing to Prize Achievemtn															
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			
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: 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

6. 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-2 2 - compliance with >75% < 85% of Rules Marked GT-2 3 - compliance with all Rules marked GT-2 4 - compliance with all Rules marked GT-2 and half the Rules marked GT-3-4 5 - compliance with all Rules Marked GT-2 and all Rules marked GT-3-4	
		Challenge Rules Compliance Score	
CubeSat Overview	Provide updated description of payload, TRL of systems & ability to mature to TRL6 by GT4. Update payload unique requirements/goals	1-basic description provided, TRLs determined & plan mentioned, limited requirements/goals listed; 3-thorough description, clear TRLs w/plans to mature, solid requirements/goals defined 5-description matches design, some results advancing TRL's w/ plans to mature. Requirements/goals backed w/ analysis or dev testing	
Concept of Operations **Reference: Mission Concept, Registration Data Package**	Provide updated 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 detailed mission steps w/goals at each step; 3-detailed mission steps w/goals & mission mode states 5-provide analysis/modes demo of mission ops and goals	
Hardware Design **Reference: Mission Concept, Registration Data Package**	Provide updated system schematic(s) (system/subsystem block diagrams w/high level interfaces), updated gen. hardware descriptions, initial mass properties, detail on system w/potential safety issues (i.e. propulsion, power, transmission levels, etc.)	1-top level system diag. w/details, mass properties at a system level, some systems w/safety issue identified; 3-top level system diag. & subsystem diagrams, mass properties down to component levels, all systems discussed for safety issues 5-all of the above plus development test results supporting design. COTS vs. make items identified.	
		Interface Requirements & Rules Score (average of section)	
Third-Party Launch Vehicle Interface and Safety Requirements			
Compliance with third-party launch vehicle interface and safety requirements (for teams that procure a third-party launch)		1- Required Data for Competitor Teams with Non-NASA Launch filled out. 3- Plans and compliance verification artifacts 25% complete 5- Acceptance data from launch service provider indicating completion/verification of compliance	
		Interface Requirements & Rules Score (average of section)	
SLS Interface and Safety Verification			
Hazard Analysis Verification **Reference SLS-SPIE-RQMT–018 IDRD Sect 4.0 and App B VCRM**	Submit analysis method of verification of safety hazard mitigations as defined in SLS-SPIE-RQMT–018 IDRD Sect 4.0 and App B VCRM	1-lists analysis w/plans of when performed; 3-all above & provides some initial analysis 5-all of the above plus some detailed analyses	
Hazard Analysis Test/Demonstration **Reference SLS-SPIE-RQMT–018 IDRD Sect 4.0 and App B VCRM**	Submit test or demonstration method of verification of safety hazard mitigations as defined in SLS-SPIE–RQMT–018 IDRD Sect 4.0 and App B VCRM	1-lists tests w/plans for development; 3-all above & plans for verification testing 5-all above & drat test procedures available	
Inspection **Reference SLS-SPIE-RQMT–018 IDRD Sect 4.0 and App B VCRM**	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**	Initial Safety Data Package with hazards identified	1-completed Phase 0 submission material, but no material for Phase I review 3- completed Phase 0 submission material, & draft SDP for Phase I with hazards identified 5-all of the above, plus methods to close hazards	
Schedule	Submit your development schedule, showing milestones relative to phased safety review milestones, demonstrating compliance with SLS-PLAN-217 SLS Secondary Payload Safety Review Process, Sect. 4. Detail plan to GT3 w/milestone events to other GTs	1-low confidence that SDP and payload development will be sufficiently mature for phased payload safety review; 3-adequate confidence that SDP and payload development will be mature as required for phased payload safety review milestones 5-excellent progress in SDP; excellent payload development progress relative to required phased safety review milestones	
		SLS Interface and Safety Score (average of section)	
		Overall Score (average of all sections)	

7. Team Submittals Checklist

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	Submit in Which Document?	Where/How will it be Used?
Notice of Intention to Compete	Operations & Rules, Rule 2.B and Sect. 5.3	Each team submits one Notice of Intention to Compete in the format specified in Rules Sect. 5.3, before the first Ground Tournament in which they compete	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	Each team submits a Registration Data Package in the format specified in Rules Sect. 5.3, before the first Ground Tournament in which they compete. Teams update the Registration Data Package before each subsequent Ground Tournament in which they compete.	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.
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.	Each team submits an MCRDP in the format specified in Mission Concept Registration Data Package Definition document.	Several GT Workbook Sections use materials from the MCRDP. See details following.
❑ Concept of Operations (ConOps)	Mission Concept Registration Data Package Sect. 2.1	MCRDP	Scorecard 2, and several GT Workbook Sections

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	Submit in Which Document?	Where/How will it be Used?
❑ Conceptual Mission Design	Mission Concept Registration Data Package Sect. 2.2	MCRDP	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 Note: Competitor Teams need to include in their MCDP Sect. 2.2, their complete list all of the 4 possible Lunar Derby Prizes and all of the 4 possible Deep Space Derby Prize(s) for which they intend to compete. Judges evaluate scores in Score Card 1-Likelihood of Mission Success with respect to only the list of Prizes stated in your MCRDP Section 2.2	MCRDP	Scorecard 1 – Likelihood of Mission Success
• Planned CubeSat orbit/trajectory design	Mission Concept Registration Data Package Sect. 2.2	MCRDP	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	MCRDP	Mission and spacecraft design evaluation Challenge Prize Evaluations
• CubeSat architecture description.	Mission Concept Registration Data Package Sect. 2.2	MCRDP	Mission and spacecraft design evaluation Challenge Prize Evaluations
• Ground systems architecture description.	Mission Concept Registration Data Package Sect. 2.2	MCRDP	Mission and spacecraft design evaluation Esp. Communications Subsystem Chapter Challenge Prize Evaluations
• SLS Safety Hazards List.	Mission Concept Registration Data Package Sect. 2.2	MCRDP	Scorecard 2 – Rules and LVSRD Compliance

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	Submit in Which Document?	Where/How will it be Used?
❑ 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	MCRDP	Planetary Protection Office Orbital Debris Management Office
❑ Satellite Communications Concept	Mission Concept Registration Data Package Sect. 2.4	MCRDP	Mission and spacecraft design evaluation Esp. Communications Subsystem Chapter Challenge Prize Evaluations
❑ CubeSat Overview	Mission Concept Registration Data Package Sect. 2.2	MCRDP	Mission and spacecraft design evaluation Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
❑ Concept of Operations	Mission Concept Registration Data Package Sect 2.1	MCRDP	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	MCRDP	Mission and spacecraft design evaluation Challenge Prize Evaluations Scorecard 2 – Rules and LVSRD Compliance
The below is required for Competitor Teams that indicate intention to procure a third-party launch			
❑ Required Data for Competitor Teams with Non-NASA Launch. Provide plans and artifacts that verify compliance, including acceptance data from the launch service provider.	Required Data for Competitor Teams with Non-NASA Launch – available on Cube Quest references web page.		Scorecard 2 – Rules and LVSRD Compliance
The below is required for Competitor Teams that indicate intention to launch on EM-1			
❑ Hazard Analysis	SLS –SPIE-RQMT-018 Secondary Payload Interface Definition	SLS SDP, and repeat in Cube	Scorecard 2 – Rules and LVSRD Compliance

Required Submittal & Contents (where applicable)	Where Is The Submittal Defined	Submit in Which Document?	Where/How will it be Used?
	Document (IDRD) Sect. 4.0 and App B VCRM	Quest Design Package	
❑ Hazard Test/Demonstration	SLS –SPIE-RQMT-018 Secondary Payload Interface Definition Document (IDRD) Sect. 4.0 and App B VCRM	SLS SDP, and repeat in Cube Quest Design Package	Scorecard 2 – Rules and LVSRD Compliance
❑ Inspection	SLS –SPIE-RQMT-018 Secondary Payload Interface Definition Document (IDRD) Sect. 4.0 and App B VCRM	SLS SDP, and repeat in Cube Quest Design Package	Scorecard 2 – Rules and LVSRD Compliance
❑ SLS Safety Data Package (SDP), for teams stating their intention to launch on EM-1	SLS-PLAN-217 EM-1 Secondary Payload Safety Review Process	Each team that indicates intention to launch on EM-1 must submit a Safety Data Package, defined in SLS-PLAN-217. A Phase 1 SDP template is available on the Cube Quest references web page.	Scorecard 2 – Rules and LVSRD Compliance
❑ Schedule	SLS-PLAN-217 SLS Secondary Payload Safety Review Process, Sect. 4	SLS SDP, and repeat in Cube Quest Design Package	Scorecard 2 – Rules and LVSRD Compliance
❑ Cube Quest Design Package	Ground Tournament Workbook, Section 8, titled Cube Quest Design Package		Mission and spacecraft design evaluation Challenge Prize Evaluation

8. Cube Quest Design Package

This section of the Ground Tournament Work Book defines the materials that must be submitted by every Competitor Team in a single document in pdf format, called the *Cube Quest Design Package*. Teams must submit a *Cube Quest Design Package* for each Ground Tournament in which they compete.

This Cube Quest Design Package (CQDP) completely describes the spacecraft, ground system, mission operations and supporting systems. The Cube Quest Design Package should provide a clear description of how the team will meet their objectives, winning the Cube Quest prizes for which it is competing.

The Cube Quest Design Package consists of several required chapters. This is the required outline of the Cube Quest Design Package:

A. System Design
B. Implementation Plan
C. Ground Systems and Mission Operations Design
D. Subsystems Design
    1 Communications Subsystem
    2 Electrical Power System
    3 Command and Data Handling/Flight Software
    4 Guidance, Navigation & Control/Attitude Determination & Control Systems
    5 Structures
    6 Propulsion
    7 Thermal
    8 Additional Subsystems

The content of each chapter is specified in the following subsections.

8.A Cube Quest Design Package - System Design Chapter

The first chapter of the CubeQuest Design Document is the System Design Chapter.

Describe how the Competitor Team's total system will meet the Cube Quest mission objectives. "Total system" includes the CubeSat, the ground system, the planned trajectory, and the operational plan, etc. Cube Quest mission objectives include all the prizes for which the Competitor Team intends to compete. Competitor Teams must list in the Mission Concept Registration Data Package Sect. 2.2 all the prizes for which they intend to compete.

The general flow of this section should provide a clear story of the system level design and address the following points:

- Mission objectives (goals) (from MCDRP Sect. 2.2). Competitor Teams need to include in their MCDP Sect. 2.2, their complete list all of the 4 possible Lunar Derby Prizes and all of the 4 possible Deep Space Derby Prize(s) for which they intend to compete. Judges evaluate scores in Score Card 1-Likelihood of Mission Success with respect to only the list of Prizes stated in your MCRDP Section 2.2
- List all system-level requirements.
- System-level block diagrams (CubeSat, ground systems including ground stations, mission operations center, data center, communications networks, ground operators, etc.)
- System-level design description
- Complete Subsystem Requirements. Show how the subsystem requirements are derived from, and their relationship to, the system-level requirements. Judges will assess how subsystem design support the subsystem and system-level requirements.
- Identification of transport, storage, launch, and in-space operating environments for the CubeSat
- Analyses supporting completeness of subsystem requirements and demonstrating that taken together, the subsystem requirements will meet the mission objectives
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.
- Summary of appropriate system level margins
- Summary of key mission risks and descriptions of mitigations being considered

NOTE: Be sure to include trajectories, ranges, velocities, orbital mechanics and propulsive maneuvers analysis that support communications range and directional elements (antennas, solar arrays, pointing requirements, etc).

8.B Cube Quest Design Package - Implementation Plan Chapter

The Implementation Plan Section describes how the team plans to execute the development, fabrication and test phases of the project. This should include information, schedules and flow diagrams that establish that the team can execute the implementation of the given design and that the team understands the steps necessary to complete and test their spacecraft.

Key areas to consider include:

- A description of the integration and test flow with schedules and flow diagrams as deemed appropriate by the team
- Test environments and test plans
- Identification of necessary test facilities and personnel
- Key tests, both within the spacecraft bus and with external systems, including ground stations and mission operations center(s)
- Other requirements verification plans
- A development schedule. The schedule must at least, show milestones relative to phased safety review milestones and demonstrate compliance with schedules of SLS-PLAN-217 SLS Secondary Payload Safety Review Process, Sect. 4.
- SLS Safety Hazard Verification Plans and Methods as defined in SLS-SPIE-RQMT-018 IDRD Sect 4.0 and App B VCRM if the Competitor Team is requesting a launch on EM-1; or as required by the third party launch vehicle if the Competitor Team is electing for a third party launch.

8.C Cube Quest Design Package – CubeSat Subsystem Design Chapters

One chapter is required for each Cubesat subsystem. These typically include:

1. Communications Subsystem
2. Electrical Power Subsystem
3. Command and Data Handling/Flight Software
4. Guidance, Navigation and Control/Attitude Determination and Control Subsystems
5. Structures
6. Propulsion
7. Thermal Management
8. Additional Subsystems as deemed appropriate by the Competitor Team

There should be a subsystem chapter for each element in the system-level block diagram.

Each subsystem chapter must contain the following information, in this order:

1. Clearly stated requirements repeated from the System Design Chapter 8.A that are relevant to the subsystem described in the subsequent chapters. 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 requirements.
2. Complete description of the baseline subsystem design, including state of design development, flight heritage, etc.
3. Analyses demonstrating ability of subsystem design to meet 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.**
4. **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.
5. Include margin analysis as appropriate.

Evaluation and scoring criteria are given in Appendix A. More detailed guidelines for evaluation are given in subsequent chapters.

NOTE: Be sure to include trajectories, ranges, velocities, orbital mechanics and propulsive maneuvers analysis that support communications range and directional elements (antennas, solar arrays, pointing requirements, etc).

8.C.1 Cube Quest Design Package - Communications Subsystem Chapter

Subsystem Requirements

List all subsystem requirements, duplicating the requirements in the System Design Chapter that are relevant to the communications subsystem. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the subsystem design of the communications subsystem. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include Interfaces to other subsystems, relevant COTS parts cut sheets or specifications and ony other documentation necessary to fully describe the communications subsystem.

In particular, the communications subsystem design description should include:

- An operational timeline with detailed ground station schedules for each facility
- A description of the data architecture approach
- Complete descriptions of the spacecraft transmitters, receivers and antennae (including patterns)
- Complete descriptions of the ground station(s) including locations, transmitters, receivers and antenna patterns
- Planned RF frequency bands, or, for optical communications, wavelengths
- Planned transmission powers, modulation methods and coding approaches

Include supporting analysis. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating states, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the communications subsystem design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to uplink and downlink budgets, performed at the worst case distance, orientation and spacecraft operating conditions.

Link budgets must be accompanied by a full description of the analysis approach, such that the judges may reconstruct the analysis based solely on the material contained in the Cube Quest Design Package. For RF systems, these parameters would typically include:

- 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)
- **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

- **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
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency and completeness of the above-listed required inputs. Judges and SMEs will use a link budget analysis based on 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. Systems Tool Kit (STK) simulations may be used to analyze and verify communications times and link margins as submitted.

8.C.2 Cube Quest Design Package - Electrical Power Subsystem (EPS) Chapter

Subsystem Requirements

List all subsystem requirements (Duplicate the EPS requirements shown in the System Design Chapter.). Show how the subsystem requirements are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the design of the EPS. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems. Include COTS parts cut sheets and other documentation necessary to fully describe the EPS.

Include supporting analysis. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating states, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the EPS design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- Power budgets, itemized for each subsystem including peak and average loads
- Battery usage, including depth-of-discharge for the different operational modes of the spacecraft
- Power generation analysis given the spacecraft trajectory and orientation for the different operational modes
- Margin analysis
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.3 Cube Quest Design Package - Command and Data Handling (C&DH) / Flight Software (FSW) Chapter

Subsystem Requirements

List all subsystem requirements (Duplicate the C&DH and FSW requirements shown in the System Design Chapter.). Show how the subsystem requirements are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the subsystem designs of the C&DH and the FSW. Show how the subsystem designs, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the C&DH. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating states, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the C&DH and FSW design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- CPU processing power and latency for each processor
- Program and persistent memory usage
- Communications bus bandwidth and latency
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.4 Cube Quest Design Package - Guidance, Navigation & Control/Attitude Determination & Control Subsystems Chapter

Subsystem Requirements

List all subsystem requirements, duplicating the GNC/ADCS requirements shown in the Systsem Design Chapter. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the subsystem design of the GNC/ADCS. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the subsystem.

Include supporting analysis. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating states, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the GNC/ADCS design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- Pointing knowledge analyses and/or budgets
- Pointing control analyses, budgets or simulations
- Reaction wheel and thruster sizing
- Reaction wheel saturation and momentum storage analysis
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.5 Cube Quest Design Package - Structures Chapter

Subsystem Requirements

List all subsystem requirements, duplicating requirements shown in the System Design Chapter that are relevant to the structural design. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the spacecraft structural design. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the spacecraft structure and its layout.

Subsystem Analysis

The analysis that is the subject of this chapter should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Provide any analyses that are needed to show that the EPS design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- Mass budgets
- Volume budgets
- Strength and stiffness analyses
- Mechanism motion, clearance and reliability analyses
- Margin Analysis
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.6 Cube Quest Design Package - Propulsion Chapter

Subsystem Requirements

List all subsystem requirements, duplicating the propulsion system subsystem requirements shown in the System Design Chapter. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the design of the propulsion system. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the propulsion system.

Include supporting analysis. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating state, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the propulsion system design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- Delta-V/propellant mass budgets
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

Trajectory analyses relevant to delta-V maneuvers Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.7 Cube Quest Design Package - Thermal Management Chapter

Subsystem Requirements

List all subsystem requirements, duplicating those in the System Design Chapter that are relevant to the thermal management subsystem. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the thermal management design. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the thermal management subsystem. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating state, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the thermal management design will meet all of the requirements listed at the beginning of the chapter. Typical analyses include, but are not limited to:

- Worst case hot and cold thermal conditions
- Active thermal control power needs
- Thermal transient analysis
- Thermal steady-state analysis
- **Technology Readiness Level (TRL):** As defined in NASA/SP-2007-6105 Rev 1 pg 296. Include rational for stated TRL.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

8.C.8 Cube Quest Design Package - Additional Subsystems Chapter(s)

Subsystem Requirements

List all subsystem requirements, duplicating those listed in the System Design Chapter that are relevant to the subsystem in question. Show how they are derived from, and their relationships to, the system-level requirements that are listed in the System Design Chapter.

Subsystem Design

Describe and illustrate the design of the subsystem. Show how the subsystem design, once fully implemented, will satisfy all subsystem requirements. Include interfaces to other subsystems as well as COTS parts cut sheets and other documentation necessary to fully describe the subsystem.

Include supporting analysis. Analysis should include environmental conditions, margins, uncertainties, assumptions, and operating states, modes and phases.

Subsystem Analysis

Provide any analyses that are needed to show that the subsystem design meets all of the requirements identified at the start of the chapter.

It is up to the Competitor Team to identify which analyses are appropriate. The analyses should be self-contained; however to avoid duplication, tables and figures from other sections may be referenced. Teams are advised to be clear about the completeness of, and the referenced location of, all information that serves as basis for analysis in each chapter.

Evaluation Process

Evaluation and scoring criteria for each of the four Ground Tournaments are given in Appendix A. More detailed guidelines for evaluation of this subsystem:

The submittals will be assessed and evaluated against expected maturity of the design, the risk of the design to achieving mission success, the ability of the design to meet the subsystem requirements, and the consistency, quality and completeness of the subsystem requirements and related analyses.

9. Compliance with Challenge Rules - Evaluation Criteria

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		
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

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.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								
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

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
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
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		

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
9.E	***Likelihood of Mission Success***		Judges Scorecard 1	Judges Scorecard 1	Judges Scorecard 1	Judges Scorecard 1		
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		
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		

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
Availability of EM-1 Secondary Payload Slots								
14. A	***Judges Ranking of GT4 Competitors***					Judges Scorecard 1 and 2		
14.	***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
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

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
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
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								

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
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								
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***							

10. 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)