2024-2025 AIAA Undergraduate Team Space Design Competition

I. RULES

1. All undergraduate AIAA branch or at-large Student Members are eligible and encouraged to participate.

2. An electronic copy of the report in Adobe PDF format must be submitted to AIAA Student Programs. All materials, including letters of intent and final reports, **must be submitted online via www.aiaa-awards.org – AIAA will not accept for submission any materials mailed to the AIAA office.**

3. A "Signature" page must be included in the report and indicate all participants, including faculty and project advisors, along with their AIAA member numbers.

3. Design projects that are used as part of an organized classroom requirement are eligible and encouraged for competition. Designs submitted must be the work of the students, but guidance may come from the Faculty/Project Advisor and should be accurately acknowledged.

4. The top three design teams will be awarded certificates for their accomplishment. Money awards pending funding availability. Certificates will be presented to the winning design teams for display at their universities, and a certificate also will be presented to each team member and the faculty/project advisor. Representative from each of the top three place design teams will be offered an opportunity to present the team's work at one of AIAA's Forum or Conference. Teams are responsible for their own travel arrangements and conference registration. AIAA may provide a small stipend, pending funding availability.

5. Report should be *no more than 100 (total) double-spaced typewritten pages and typeset should be no smaller than 10 pt Times* (including graphs, drawings, photographs, and appendices) on 8.5" x 11.0" paper. Up to five of the 100 pages may be foldouts (11" x 17" max).

6. More than one design may be submitted from students at any one school. Team competitions will be groups of not more than ten (10) AIAA branch or at-large Student Members per entry. Individual competitions will consist of only one (1) AIAA branch or at-large Student Member per entry.

II. PROPOSAL REQUIREMENTS

The technical proposal is the most important factor in the award of a contract. It should be specific and complete. While it is realized that all of the technical factors cannot be included in advance, the following should be included and keyed accordingly:

1. Demonstrate a thorough understanding of the Request for Proposal (RFP) requirements.

2. Describe the proposed technical approaches to comply with each of the requirements specified in the RFP, including phasing of tasks. Legibility, clarity, and completeness of the technical approach are primary factors in evaluation of the proposals.

3. Particular emphasis should be directed at identification of critical, technical problem areas. Descriptions, sketches, drawings, systems analyses, method of attack, and discussions of new techniques should be presented in sufficient detail to permit engineering evaluation of the proposal. Exceptions to proposed technical requirements should be identified and explained.

4. Include tradeoff studies performed to arrive at the final design and provide clear and concise rationale for decisions.

5. Provide a description of automated design tools used to develop the design.

III. BASIS FOR JUDGING

The AIAA Technical Committee that developed the RFP will serve as the judges of the final reports. They will evaluate the reports using the categories and scoring listed below. The judges reserve the right to not award all three places. Judges' decisions are final.

1. Technical Content (35 points)
This concerns the correctness of theory, validity of reasoning used, apparent understanding and grasp of the subject, etc. Are all major factors considered and a reasonably accurate evaluation of these factors presented?

2. Organization and Presentation (20 points)
The description of the design as an instrument of communication is a strong factor on judging. Organization of written design, clarity, and inclusion of pertinent information are major factors.

3. Originality (20 points)
The design proposal should avoid standard textbook information, and should show the independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the method show an adaptation or creation of automated design tools?

4. Practical Application and Feasibility (25 points)
The proposal should present conclusions or recommendations that are feasible and practical, and not merely lead the evaluators into further difficult or insolvable problems.

IV. Request for Proposal

Mars Exploration Surveyors to Enable Human Exploration

Background

Human exploration of Mars has long been a goal for the global space exploration. In order to understand the potential architecture options to achieve scientific and exploration goals, it is paramount to investigate and collect more data about Mars. Our understanding of the planet has been aided tremendously by missions such as the Mars Global Surveyor, Mars Reconnaissance Orbiter, and the numerous rovers and lander that have travel to the red planet.

To support an eventual Human Mars exploration campaign, specific data to characterize Mars' atmosphere, geography, and potential physical makeups are all critical to enable detailed mission planning and accurate architecting to maximize the potential to achieve exploration objectives.

Design Requirements and Constraints

- Design an integrated comprehensive mission to send one or more exploration assets to Mars vicinity with the primary objective to accurately characterize the atmospheric composition, detailed geographic survey, and/or determine the potential subsurface resources that may exist on Mars. The designed mission must address at minimum one of these primary objectives:
    - Characterization of the atmospheric composition and detailed density profile will provide mission planners the necessary data to plan and design the entry, descent, and landing system to support human exploration.
    - Detailed geographic survey, including terrain and elevation profile of the entire Martian surface will provide mission planner the ability to pinpoint potential landing location and traverse paths for each mission to maximize the potential to achieve exploration objectives.

- Investigation, identification, and quantification of potential surface and subsurface resources will enable mission planners to determine the potential of utilizing such resources in support of the human exploration activities.

- The designed mission must be able to provide data on at least one primary objective area with minimum of 75% coverage of the entire Mars globe at the conclusion of the primary mission phase.

- Perform trade studies on various mission designs at the architecture and system levels to demonstrate the fitness of the chosen mission and system design. Trades should include system architecture, launch vehicles, instruments, orbital mechanics, spacecraft subsystem level designs, and other mission level system trades, including analysis of single vs multiple assets. It is highly desirable to use technologies that are already demonstrated on previous programs or currently in the NASA technology development portfolio. Trades should be assessed on the bases of benefit, risk, and cost.

- Perform mission analysis to evaluate the flight profile for the asset(s) and describe the mission profile for observation measurement and to show how the mission provide adequate coverage as specified by the RFP.

- Discuss selection of subsystem components and the values of each of the selection and how the design requirements or scientific objectives drove the selection of the subsystem.

- Discuss the instruments selected to address the primary objectives, and the data collection, analysis, and transmission process to address the objectives.

- The cost for the mission and capability development in support of its activities shall not exceed $1.0 Billion US Dollar (in FY24), including development, hardware, launch, and operation cost of the mission through the primary mission phase.

- The mission should complete deployment and primary data gathering activities no later than December 31, 2033, with the system designed to operate into the late 2030s, though operation cost past the primary mission phase will be outside the scope of this RFP.

Deliverables

This project will require a multi-disciplinary team of students. Traditional aerospace engineering disciplines such as structures, propulsion, flight mechanics, orbital mechanics, thermal, electric power, attitude control, communications, sensors, environmental control, and system design optimization will be necessary. In addition, economics and schedule will play a major role in determining design viability. Teams will make significant design decisions regarding the configuration and characteristics of their preferred system. Choices must be justified based both on technical and economic grounds with a view to the extensibility and heritage of any capability being developed.

The following is a list of information to be included in the final report. Students are free, however, to arrange the information in as clear and logical a way as they wish with the exception of the 5 page executive summary which must be place at the beginning of the report.

1) Requirements Definition – the report should include the mission and design requirements at the vehicle, system, and subsystem level. The requirements definition should demonstrate the team's understanding of the *RFP Design Requirements and Constraints* and lay the foundation for the design decisions that follow.

2) Concept of Operation – A detailed concept of mission operation should be included to describe all phases of the mission and to demonstrate the realization of the mission requirements in the *RFP Design Requirements and*

Constraints. The report should show that the team has performed historical analysis of similar concepts to evaluate the merits and deficiencies of previous designs, and demonstrate that alternative concepts were considered while providing justification for the chosen concept.

3) Trade Studies – the report should include the trade studies for the vehicle architecture, mission operations, and subsystem selections, and must discuss in detail how the system level requirement are developed from mission requirements by describing the pro and cons of each subsystem options. The report must discuss how each subsystem level decision is made, with description of the selection metrics and their associated weightings when appropriate, and provide detailed discussions on how each decision impact system level metrics such as cost, schedule, and risk.

4) Design Integration and Operation – The report should discuss how the trades selected in section 3 are integrated into a complete architecture. This section should discuss design of all subsystems: structures, mechanisms, thermal, attitude control, telemetry, tracking, and command, electric power, propulsion, payload and sensors, and the mission concept of operations. Discussion on the extensibility of the overall system design and how it can support future exploration mission should be included. The report must clearly describe all of the tools and methods utilized for the system and subsystem design and provide brief description of the inputs, outputs, and assumptions for the design. A discussion on the validation of the tools and methods must be included.

5) Cost Estimate – a top level cost estimate covering the life cycle for all cost elements should be included. A Work Breakdown Structure (WBS) should be prepared to capture each cost element including all flight hardware, ground systems, test facilities, and other requirements for the design. Estimates should cover design, development, manufacture, assembly, integration and test, launch operations and checkout, in-space operations, and final delivery to the Martian surface and return to the Earth. Use of existing/commercial off-the-shelf hardware is strongly encouraged. Advanced technology utilization must be fully costed with appropriate cost margin applied. A summary table should be prepared showing costs for all WBS elements distributed across the various project life cycle phases. The report should discuss the cost model employed and describe the cost modeling methods and associated assumptions in the cost model. The cost analysis should provide the appropriate cost margin based on industry standards.

6) Mission and operation summary – an integrated roll up of all the subsystems into a mass and power Work Breakdown Structure, showing mass and power budget, broken into subsystems, with description of the margin assigned to each system based on industry standards. A summary table should be prepared showing all mass, power, and other resource requirements for all flight elements/subsystems with the appropriate mass and power margins clearly labeled and discussed.

7) Schedule – A mission development and operation schedule should be included to demonstrate the mission meets the schedule deadline established in the RFP. Schedule margin should be applied to appropriate areas with funded schedule reserve detailed in the cost estimate. Any advanced technology assumption should have corresponding technology development schedules and costs associated with the technology and appropriate contingency plans should be discussed.

8) Summary and References. A concise, 5 page "Executive Summary" of the full report must be included and clearly marked as the summary at the beginning of the report. The executive summary should provide a clear sense of the project's motivation, process, and results. References should be included at the end. A compliance matrix, listing the page numbers in the report where each these section as well as the items identified under the *Design Requirements and Constraints* and *Deliverables* sections can be found, is mandatory.

Supporting Data

Technical questions can be directed to Patrick Chai (patrick.r.chai@nasa.gov) or studentprogram@aiaa.org