Mars Sample Return System
1. **Opportunity Description**

A survey of planetary scientists, completed for the National Research Council in 2011, identified caching of Martian samples for future return to Earth as the top-priority large mission for the 2013-2022 decade. In 2014, NASA announced plans for a new robotic science rover capable, among other tasks, of caching rock and soil samples. The rover is expected to launch in 2020. Caching of scientifically selected samples was proposed as the first step in a multipart effort to eventually return samples from the planet. The next step, which is the objective of this project, is the return of the collected sample back to Earth. Successful return of Martian samples to laboratories on Earth could help determine whether the planet ever supported life and answer questions about its geologic and climatic history.

2. **Project Objective**

The objective of this project is to design an unmanned interplanetary transfer vehicle to transport a sample cache from the surface of Mars to the surface of Earth.

3. **Design Requirements And Constraints**

The undergraduate team (class) shall design a Mars Sample Return System (MSRS) to meet the following objectives:

1) The MSRS shall transport Mars ascent vehicle to any designated location (Mawrth Vallis or Eberswalde Crater are two possible locations) on the Martian surface, receive sample cache from a pre-positioned robotic science rover, and return it to the surface of Earth.

2) Proposed MSRS mission architecture and timeline shall assume that the robotic science rover will land on Mars in February 2021 and be able to operate on the surface of Mars at least two Earth years.

3) The MSRS Mars descent vehicle shall be capable of landing within 5 km of the present position of the science rover.

4) The MSRS Mars ascent vehicle shall be able to remain on the surface of Mars for at least 50 Earth days to allow for cache transportation by the science rover.

5) The robotic science rover will explore the landing site region, gather a set of rock and soil samples, and assemble them into a sealed container. After MSRS landing on Mars, the rover will deliver the container to the Mars ascent vehicle. Assume that the rover arm can position the sample container up to 2 m high from the surface. Design of the robotic science rover is not an objective of this project.

6) The MSRS shall be able to transport a cylindrical sample container 15 cm in diameter and 15 cm long. The mass of the sample including the container will not exceed 3 kg.
7) Although avionics, guidance, navigation, control, and communication subsystems are not the focus of this assignment, the mass of those components on the Mars ascent vehicle is expected to have a significant impact on MSRS architecture. The team can choose to either assume that the minimum mass of those components is 15 kg or provide justification for using a lower mass.

8) As a way to reduce sample contamination concerns, consider Earth orbit capture and initial on orbit examination (on board the ISS for instance) as an alternative to Earth landing/recovery.

The MSRS will include the following elements and subsystems: interplanetary transfer vehicle(s), Mars descent/ascent vehicle(s), orbital, interplanetary, and Martian landing/take-off propulsion subsystem(s), cache storage and delivery subsystem, Earth landing/recovery subsystem(s), thermal protection subsystem, propellant and power subsystems, vehicle health monitoring subsystem(s).

Although the earth-based launch vehicle system is not an element of the MSRS system, a launch system capability should be selected to define the initial conditions of the originating low-earth orbit (such as orbit inclination and altitude) for the MSRS, and the total mass constraints of the MSRS system. A trade-study should be conducted to determine and compare the performance capabilities and cost of existing US and International launch systems versus future launch system capabilities. Justification for selection of the launch system and number of launches required should be included in the final report.

The elements of the MSRS system may be assembled in the originating low-earth orbit or in a Martian orbit. Factors such as reliability, affordability, ground and space infrastructure required, and ease of operation should be considered when defining the final MSRS design and concept of operations.

While the economics of any design is critical to its success, the emphasis of this project is on the technical aspects of the MSRS architecture. The project will require a multi-disciplinary team of students. Traditional aerospace engineering disciplines such as structures, propulsion, flight mechanics, orbital mechanics, and optimization will be involved. Teams will make significant design decisions regarding the configuration and characteristics of their preferred system. The design team should also identify and address any risks and challenges that are unique to the proposed system.

4. Data Requirements

The final proposal report shall provide an overall engineering description of the design concept and detailed design information for major components and subsystems. At a minimum, the final proposal report shall contain the following:
1. Key trade studies and a justification for selection of the overall concept and each of the major subsystems.

2. Discussion of design and concept of operation. Systems that are unique to the proposed design should be addressed in considerable detail. Subsystems, which are not the focus of this project, do not require as much attention.

3. Description of delivery of the MSRS or its components to LEO, its assembly, and proposed flight sequence including propellant loading, flight trajectory, Mars landing/ascent, cache retrieval, and Earth landing/recovery.

4. Details of propulsion, vehicle sizing, trajectory, loads, structural, and payload capability analysis. Critical technologies and their current Technology Readiness Level (TRL). Discussion of any required technological breakthroughs or plans for developing technologies to the required maturity.

5. Discussion of risk mitigation strategies for key technical and programmatic risks.

6. Drawings of the overall vehicle and key components or subsystems.

7. Estimate of development and operation life cycle cost.

5. Additional Contacts, Data And References

All technical questions pertaining to this RFP should be directed to Miroslav Sir of the Aerospace Corporation via email at miroslav.sir@aero.org. Any updates to this RFP will be posted on the AIAA Space Transportation Technical Committee web site, which can be accessed directly at https://info.aiaa.org/tac/SMG/STTC/

References:


2) Title 14 Code of Federal Regulations Parts 400-499, Chapter III Commercial Space Transportation

AIAA Education Series

1) Design Methodologies for Space Transportation Systems, 2001. Walter E. Hammond, author. (Note: design software is included with the textbook).


5) *Spacecraft Propulsion*, 1996. Charles D. Brown, author. (Note: design software is included with the textbook).


**Rules and Guidelines**

**I. General Rules**

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

2. Teams will be groups of **not more than ten** AIAA or at-large Student Members per entry.

3. The report in Adobe PDF format must be submitted online to AIAA Student Programs. Total size of the file(s) cannot exceed 60 MB, which must also fit on 100 pages when printed. **The file title should include the team name and university. A “Signature” page must be included in the report and indicate all participants, including faculty and project advisors, along with their AIAA member numbers.** Designs that are submitted must be the work of the students, but guidance may come from the Faculty/Project Advisor and should be accurately acknowledged. **Graduate student participation in any form is prohibited.**

4. Design projects that are used as part of an organized classroom requirement are eligible and encouraged for competition.

5. More than one design may be submitted from students at any one school.

6. If a design group withdraws their project from the competition, the team chairman must notify AIAA Headquarters immediately!

7. The prizes shall be: First place-$500; Second place-$250; Third place-$125 (US dollars). Certificates will be presented to the winning design teams for display at their university and a certificate will also be presented to each team member and the faculty/project advisor.
II. Copyright

All submissions to the competition shall be the original work of the team members.

Authors retain copyright ownership of all written works submitted to the competition. By virtue of participating in the competition, team members and report authors grant AIAA a non-exclusive license to reproduce submissions, in whole or in part, for all of AIAA’s current and future print and electronic uses. Appropriate acknowledgment will accompany any reuse of materials.

III. Schedule & Activity Sequences

Significant activities, dates, and addresses for submission of proposal and related materials are as follows:

A. Letter of Intent – March 14, 2016

B. Receipt of Proposal – May 16, 2016

C. Winners Announced-August 2016

IV. Proposal Requirements

The technical proposal is the most important criterion 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 analysis, 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.

5. Provide a description of automated design tools used to develop the design.
V. Basis for Judging

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 independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the approach 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.