# 2007/2008
# AIAA Undergraduate Team Space Transportation Design Competition

## I. RULES

1. All groups of 3 to 10 undergraduate AIAA branch or at-large Student Members are eligible and encouraged to participate.

2. An electronic copy of the report in MS Word or Adobe PDF format must be submitted on a CD or DVD to AIAA Student Programs. Total size of the file(s) cannot exceed 60 MB**. 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.

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

4. The prizes shall be:
   First place - $2,500;
   Second place - $1,500;
   Third place - $1,000.

   Certificates will be presented to members of the winning design team for display at their university and a certificate will also be presented to each team member and the faculty project advisor. One representative from the first place design team will be expected to present a summary design paper at the AIAA Space 2008 Conference in San Diego, CA.
   Reasonable airfare and lodging will be defrayed by the AIAA Foundation for the team representative.

5. More than one design may be submitted from students at any one school. Project reports shall be no more than (if it were printed) 100 double-spaced typewritten pages (including all graphs, drawings, photographs, and appendices) on 8.5" x 11.0" paper and typeset shall be no smaller than 10 pt. Times New Roman. Up to five of the 100 pages may be foldouts (11" x 22" max) as required to clearly present graphs and drawings.

6. If a design group withdraws its project from the competition, the team chairman must notify the AIAA Student Programs Department immediately!

7. Team competitions will be groups of not more than ten AIAA branch or at-large Student Members per entry. Individual competitions will consist of only 1 AIAA branch or at-large Student Member per entry.

## II. COPYRIGHT

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

Any submission that does not contain a copyright notice shall become the property of AIAA. A team desiring to maintain copyright ownership may so indicate on the signature page but nevertheless, by submitting a proposal, grants an irrevocable license to AIAA to copy, display, publish, and distribute the work and to use it for all of AIAA's current and future print and electronic uses (e.g. "Copyright © 20__ by

_____. Published by the American Institute of Aeronautics and Astronautics, Inc., with permission.).

Any submission purporting to limit or deny AIAA licensure (or copyright) will not be eligible for prizes.

## III. SCHEDULE AND ACTIVITY SEQUENCES

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

**A. Letter of Intent – 14 Mar 2008**
**B. Receipt of Proposal – 13 June 2008**
**C. Announcement of Winners – Aug 2008**

Groups intending to submit a proposal must submit a Letter of Intent (Item A), with a maximum length of one page to be received with the attached form on or before the date specified above, at the following address:

**AIAA Student Programs**
**1801 Alexander Bell Drive**
**Suite 500**
**Reston, VA 20191-4344**

## IV. 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 understood 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 proposed design concept.

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

## V. REQUEST FOR PROPOSAL

### Commercial Lunar Space Transportation System

### 1. Opportunity Description

The United States' Vision for Space Exploration (VSE) calls for implementation of a safe, sustained and affordable robotic and human program to explore and extend human presence across the solar system and beyond. To accomplish this high-level goal, the VSE has requested NASA to replace the U.S. Space Shuttle with a new exploration transportation system to continue servicing the International Space Station (ISS) and embark on new exploration missions to the surface of the Moon. In addition, the VSE calls for NASA to pursue commercial opportunities to acquire space transportation and other services in support of both ISS and Lunar exploration missions.

An example of NASA's investment in commercial opportunities is the Commercial Orbital Transportation Services (COTS) Project which was established by NASA to accelerate availability of commercial space transportation services to Low-Earth Orbit (LEO). Recently, COTS awarded two private companies, Rocketplane-Kistler and SpaceX, to develop and demonstrate reliable, cost-effective access to LEO with the goal of creating a competitive market for space transportation services to ISS.

In anticipation of similar, future commercial opportunities in support of the VSE, new commercial services should be investigated and planned out to support NASA's Lunar exploration missions. Tentative plans call for NASA's Lunar missions to lead to construction of a Lunar Outpost or Base at the Moon's South Pole with permanent presence possible by 2024. Construction and permanent occupation of this new Lunar Base will lead to the creation of many, new markets, such as, Lunar power, mining, water and fuel depots, communications, transportation, GPS, tourism, accommodations, entertainment, etc. To allow for these new Lunar markets to initiate and grow, it will be necessary to develop reliable and cost-effective commercial space transportation and packaging services to the Moon. Therefore, new commercial Lunar Space Transportation Systems will be needed to help create new competitive markets on the Moon.

## 2. Project Objective

The goal of this project is to design a commercial Lunar Space Transportation System (LSTS) to provide NASA with commercial transportation services to the Moon, in the near-term while it constructs its Lunar Base, and in the long-term, to enable future, commercial Lunar services markets to be successful on the Moon.

## 3. Design Requirements And Constraints

The undergraduate team (class) shall design a commercial LSTS to meet the following objectives:

1) The LSTS shall include a ***new*** cost-effective, and reliable launch system that will transport crew and cargo from the surface of the Earth to the surface of the Moon.
2) The LSTS shall transport a minimum of 2 crew and 2 passengers (without cargo) from the surface of the Earth to the Moon and return safely to Earth.
3) The LSTS shall transport a minimum of 500 kg of cargo (without crew) from the surface of the Earth to the surface of the Moon.
4) The LSTS shall provide for packaging services to enable delivery of at least 2 different resources needed on the Moon, such as, water, power, communications, drilling equipment, rovers, etc.
5) The LSTS shall be modular to accommodate delivery of future resources needed on the Moon to service future Lunar markets, such as, tourism and entertainment.
6) The LSTS shall support a minimum flight rate capability of 2 commercial missions to the Moon per year.
7) The LSTS shall be operational starting in 2014 and be designed to operate for a minimum of ten years.

The LSTS system will include the following systems and elements: launch vehicle system, crew transfer vehicle(s), orbital, interspace, and lunar landing/take-off propulsion system(s), thermal protection system, life support system, propellant and

power systems, avionics, guidance, navigation and control system(s), radiation shielding system, Earth landing/recovery system(s), EVA equipment and support systems, vehicle health monitoring systems, abort/escape systems, and packaging and delivery system.

The elements of the LSTS system may be assembled in low-earth orbit or in a Lunar orbit or may not need assembly. Elements of the LSTS system can either be expendable or reusable. Factors such as safety, reliability, affordability, sustainability, abort capability, ground and space infrastructure required, ease of operation and maintenance should be considered when defining the final LSTS design and concept of operations.

## 4. Data Requirements

The final proposal report shall provide an overall engineering description of the LSTS "best value" design concept and detailed design information for major components and subsystems. At a minimum, the final proposal report shall demonstrate and contain data on the following:

1. Provide a cost estimate for development and production of the first LSTS as well as cost per passenger and cost per kg of cargo once operational.
2. Discuss your LSTS design and describe the operational concept in detail. Include a detailed description of the proposed flight sequence and Lunar transfer schedule for the operational LSTS system.
3. Discuss your LSTS system and describe in detail the technologies and technical approach used to meet the mission requirements.
4. Identify critical technologies and issues relating to mission success. Discuss any required technological breakthroughs or advances and estimate the cost of developing each to the necessary technology level.
5. Provide drawings of the overall vehicle and key components or subsystems.
6. Discuss subsystem design details, including issues and assumptions, analyses performed, and tradeoffs considered for the LSTS, including the following:
   - launch vehicle system, orbital propulsion, attitude control and orbital maneuvering requirements, interspace propulsion, Lunar landing/take-off propulsion
   - mass properties and structural loads
   - atmospheric entry and thermal protection requirements
   - radiation shielding requirements
   - power and propellant requirements
   - life support systems
   - Earth landing/recovery subsystem(s) and landing site selection
7. Discuss the packaging schemes proposed and choice of resources to be delivered. Discuss assembly of resources on the Moon to enable a new service. Describe the new lunar markets to benefit from your LSTS transportation and packaging services.
8. Other key features/items as warranted by the design decisions.

## 5. Additional Contacts, Data And References

All technical questions pertaining to this RFP should be directed to Dr. Allison Zuniga of NASA Ames Research Center via email at Allison.F.Zuniga@nasa.gov. Any updates to this RFP will be posted on the AIAA Space Transportation Technical Committee web site, which can be accessed directly at http://www.aiaa.org/tc/st/

**References:**

1) *Human Spaceflight: Mission Analysis and Design*, edited by Wiley J. Larson, McGraw Hill Space Technology Series.

2) *International Reference Guide to Space Launch Systems*, 4th Edition, 2004. Steven J. Isakowitz, Joseph P. Hopkins, Jr., and Joshua B. Hopkins, editors.

3) *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).

2) *Elements of Spacecraft Design*, 2002. Charles D. Brown, author.

3) *Space Vehicle Design*, 2nd Edition, 2004. Michael D. Griffin and James R. French, authors.

4) *Aerothermodynamics of Gas Turbine and Rocket Propulsion*, 3rd Edition, 1997. Gordon C. Oates, 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).

6) *Modern Engineering for Design of Liquid-Propellant Rocket Engines*, Progress in Astronautics and Aeronautics Series, 1992. Dieter K. Huzel and David H. Huang, editors.

7) Space Transportation Technical Committee Homepage located at the AIAA website, www.aiaa.org/tc/st.

## VI. BASIS FOR JUDGING

1. Technical Content (35 points)

The proposal should present in a clear and consistent manner the assumptions, theories, and models used to address the design requirements and the constraints outlined in the proposal request. Sufficient technical detail should be included to provide the evaluators with a thorough understanding of the proposed LSTS mission and vehicle system, the methods used to determine the "best value" LSTS design, and other subsystem design information as identified in the proposal request. Key assumptions must be clearly outlined and justified to the extent possible. Technical references and source material must be adequately documented.

2. Originality (25 points)

The LSTS system design proposal should clearly demonstrate the imagination and independence of thinking of the design team. The design proposal should avoid compilations of standard textbook information.

3. Practical Application and Feasibility (20 points)

The design project should provide a feasible and practical solution to the challenge posed in the proposal request. Potential technical hurdles should be clearly identified, and realistic solutions to meet those challenges should be presented and discussed. The design should assess and demonstrate the technical feasibility of the proposed baseline system concept.

4. Organization and Presentation (20 points)

The design proposal should be organized in a manner consistent with standard scientific and engineering research reports. As a minimum, proposal reports should include an executive summary, table of contents, nomenclature section, technical section, concluding remarks, and list of references.

Intent Form

2007/2008
AIAA
Undergraduate Team Space Transportation Design Competition
Request for Proposal: **Design of a**
**Commercial Lunar Space Transportation System (LSTS)**

Title of Design Proposal: _____

Name of School: _____

| **Designer's Name** | **AIAA Member #** | **Graduation Date** | **Degree** |
|---|---|---|---|
| _____ | _____ | _____ | _____ |
| Team Leader | | | |
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| Team Leader E-mail | | | |
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In order to be eligible for the 2007/2008 AIAA Undergraduate Team Space Transportation Design Competition, you must complete this form and return it to AIAA Student Programs ***before 14 March 2008***, at AIAA Headquarters, along with a one-page "Letter of Intent" as noted in Section II, "Schedule and Activity Sequences." For any nonmember listed above, a student member application and member dues payment should also be included with this form.

| _____ | _____ | _____ |
|---|---|---|
| Signature of Faculty Advisor | Signature of Project Advisor | Date |
| | | |
| Faculty Advisor – Printed | Project Advisor – Printed | Date |