SEDS USA-SSPI 2017-18 Chapter Competition

Designing the Robotic Space Tug

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For the past half century, the only artificial objects orbiting Earth have been manned spacecraft, space stations and satellites. As we begin to open up space to new opportunities, from new orbits to new applications, both commercial and government organizations are exploring the creation of a new orbital vehicle. It would be a multi-functional workhorse that, with minimal retrofitting, could tackle assignments from relocating objects in orbit to cleaning up space debris, servicing space stations and even shuttling between Earth and Lunar orbit. It would be, in a word, a space "tug," like the tugboats that are the workhorses of seaports around the planet. Several concepts are being researched by the "usual suspects" in aerospace, including Lockheed Martin, Airbus, Space Systems Loral, the European Space Agency and Orbital ATK.

Project Specifications

Your assignment is to envision a multi-purpose space tug designed to operate in Earth orbit and cislunar space by defining its service requirements, markets to be served, and technical capabilities, together with an estimation of deployment and operating costs.

- **Service Requirements**
  Identify the applications being proposed for a multi-purpose space tug. For each application, describe fully the problem to be solved, the capabilities that a space tug would need to address the problem, and the requirements these capabilities place on the design of the spacecraft, from sensors and actuators to fuel and thrust.
- **Market for Services**
  A sustainable space tug must serve governmental and commercial buyers willing to fund its operation. Identify by type of organization or company the most likely buyers of the services of the space tug you have specified. Explain the availability or unavailability of competing solutions. This will be a speculative exercise but is valuable in matching design to potential need.
- **Technical Capabilities**
  Select a group of applications that you will design to space tug to accomplish and define the common capabilities required to serve those applications and are feasible to design into a single spacecraft. Use this information to develop specifications for your space tug.
- **Design**
  Based on the above work, produce a high-level design for the space tug that meets the service requirements and technical specifications you have identified. Identify potential suppliers of engineering, components and assembly, relevant existing technologies and, where you believe feasible, technologies in development that have not yet proven themselves but solve a design or cost problem. Consider issues of refueling for multiple missions versus creating single-mission vehicles, communications with controllers for a vehicle in motion across the sky, regulatory and insurance considerations for orbital operation and liability for damage to objects in orbit.

- **Cost Estimate**
  Estimate on a high level the development costs for the space tug, the per-mission operating costs, and the likely launch provider and costs to put the space tug into orbit.

The final report will be judged first on the quality, depth and rigor of the work presented and secondly by the breadth of the work in terms of topics covered. In other words, the capabilities you choose for your space tug will not be a factor in evaluation of your report; it is how thoroughly and imaginatively you design it to create the capabilities that matters.

Team Specifications

Teams must be comprised entirely of students at one university. Teams will be limited to one per university, and team candidacy must be submitted through that university's SEDS USA chapter. We recommend between 3 and 8 members per team, but we encourage team leadership to include as many interested chapter members as possible. Individual team members must maintain student status at the university naming the team, and may only contribute to one project at a time.

Since this is a student project, SSPI and SEDS USA expect student team members to do the vast majority of the work. Mentors are assigned to assist teams with overcoming the learning curve, but should not do substantial work on the project, except when necessity dictates (driven by, e.g., proprietary software). All contributing team members should be credited on the team roster, which is submitted with the project.

Timeline for Submissions

Discussions with SEDS USA leadership have yielded the following schedule for the project.

Activity	Responsible	Target Date
Project announcement to chapters	SEDS USA	Nov 18, 2017
Teams indicate interest in participating	SEDS USA	Dec 22
Mentor assignment deadline	SSPI	Jan 5, 2018
First conference call on progress & problems	Teams, SEDS, SSPI	Jan 18
Final deadline for team commitment to project	Teams	Jan 31
First online meeting with mentor	Teams	Jan 15
Second conference call on progress & problems	Teams, SEDS, SSPI	Feb 16
Third conference call on progress & problems	Teams, SEDS, SSPI	March 30
Reports due to SEDS USA and SSPI for review	Teams	May 1
Completion of judging, announcement of awards	SSPI	July 31
Presentation of awards	SEDS USA, SSPI	Nov TBD

Submission Details

Teams are expected to thoroughly document their progress through their project:

First Meeting

Team leadership should meet with their assigned mentor and submit brief documentation by the deadlines above. The documentation should include the following:

- Project overview (round-number estimates of basic engineering goals)
- Team roster
- How you will address the key headings under Project Specifications above, which you expect to be most challenging (and why), and a couple of scope reduction options.
- Brief timeline for project completion
- "Wish List" from SSPI/SEDS USA

These items should all be discussed among team leadership before the mentor meeting.

Final Submission

The final submission should address each heading under Project Specifications, including brief descriptions where appropriate of why items were not treated in the project as a whole. Your submission should "tell a story," more or less. The overall submission should be built around a Project Overview document, which should reference documents like:

- Technical Drawings
- Artist's rendering of competed vehicle
- Operating scenarios

Final submission should reference modern scientific literature, much like a research paper. Additionally, the project must include a team roster, preferably with each team member credited with general areas of contribution. Teams are encouraged to assist and seek assistance from one another during that session.

How to Structure the Report

Use the following outline as a template for your report. You need not follow this exact order or include every item, but an effective report will use this outline as a guideline.

1. Introduction
    a. Description of the space tug concept and the range of applications envisioned for this new vehicle
    b. Description of the applications you have chosen for your space tug, the problems they will solve, and your rationale for focusing on this set of applications
    c. Description of the markets to be served by the space tug, their needs and the availability or unavailability of competing solutions
2. Vehicle design
    a. Definition of the capabilities of the vehicle that will enable it to accomplish the targeted applications on a single or multiple missions per vehicle
    b. Outline of the specifications required to achieve those capabilities

   c. Discussion of existing and potential technologies required to produce, launch and operate the space tug, and the operational requirements for fuel, onboard power, sensors, actuators, navigation, communications and remote operation
   d. Design of the vehicle
3. Launch and operation
   a. Selection of launch vehicle with rationale and estimated per-launch cost
   b. Mission parameters: per-mission launch, multiple missions in orbit, vehicle maintenance
   c. Ground facilities and operations required
   d. Regulatory, insurance and liability constraints and opportunities
4. Cost analysis
5. Conclusions

Awards

SSPI is making available up to three cash prizes payable to the chapters of the top-scoring teams in the competition. The first prize is $750, second prize is $500 and third prize is $250.

Resources to Get You Started

The following is a list of articles published online about governmental and commercial space tug projects that will acquaint you with the applications being envisioned and the R&D conducted to date:

Airbus to Challenge SSL, Orbital ATK with New Space Tug Business
http://spacenews.com/airbus-to-challenge-ssl-orbital-atk-with-new-space-tug-business/

Lockheed's "Jupiter" Space Tug Could Fly to Space Station, Moon and Beyond
https://www.space.com/28817-jupiter-system-space-station-cargo-exploration.html

Magnetic Space Tug Could Target Dead Satellites
http://www.esa.int/Our_Activities/Space_Engineering_Technology/Magnetic_space_tug_could_target_dead_satellites

Electric-Powered Lunar Space Tug Could Facilitate Future Moon Missions
https://www.seeker.com/space/electric-powered-lunar-space-tug-could-facilitate-future-moon-missions

Spaceflight Unveils SHERPA In-Space Tug
http://www.parabolicarc.com/2012/05/07/spaceflight-unveils-sherpa-in-space-tug/

What Happened to SpaceFlight's Sherpa?
https://space.stackexchange.com/questions/22784/what-ever-happened-to-sherpa

Parom (Russian Space Tug)
http://www.russianspaceweb.com/parom.html

Variable Specific Impulse Magnetoplasma Rocket (VASIMR)
https://en.wikipedia.org/wiki/Variable_Specific_Impulse_Magnetoplasma_Rocket#Use_as_a_space_tug_or_orbital_transfer_vehicle

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