NASA Exploration System Mission Directorate Higher Education Project

Proposal for Project Funding

Lunar Regolith Excavator Student Competition

FAMU-FSU College of Engineering
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Tallahassee, Florida 32310

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Team Roster

The team members listed have made a commitment to design, fabricate, and test a Lunar Regolith Excavator in time to compete at the Kennedy Space Center in May 2010. This is a current listing of team members, but this may not be the final composition. The team is currently in the process of locating Civil Engineers for design of the excavation subsystems.

FAMU-FSU College of Engineering Lunar Regolith Excavator Team

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Systems Engineering Plan

The design team will be applying the systems engineering approach to the development of the robotic platform for this competition. The approach of incorporating a multidisciplinary engineering team is the first step towards successful systems engineering. Subsystems of the project will be identified in the first meetings and general requirements and definitions for each will be outlined in a set schedule.

The competition design team will incorporate the project into a Senior Design Capstone project which focuses on and encourages the use of Systems Engineering for the development of senior projects. As part of the Capstone class, regular team and class meetings will be conducted with reports due on a set schedule that follows a systems engineering approach to engineering design.

In the current early stages of design, the project team has discussed subsystem categories for teams to develop and integrate into the final architecture. These subsystems include an electronics subsystem for circuitry and motor control boards, a control subsystem for programming and autonomy of the platform, a mechanics subsystem incorporating actuated and static mechanical components of the platform, and an excavation and payload subsystem focusing on efficiency of excavation. These subsystem categories are expected to be expanded upon and defined in greater detail as the team continues to meet and to plan the design of the Lunar Excavator.

The team will not only apply the systems engineering approach to the design and fabrication of the Lunar Excavator, but will also consider the life cycle of the platform. These considerations include verifying that the excavator performs the specified functions in the intended, designed manner as well as review the operational controls and autonomous functions. The team will also ensure the robotic platform's interchangeability during design by using standard electrical fittings and circuit boards, reducing the amount of custom made parts, and allowing for easier adaptability and repair of the robot. As required by the Senior Design Capstone Project that this excavator will be part of, the design team will document and report all steps of the design, fabrication, and operations of the excavator via photographs, video, papers, and operations manuals.

Outreach Plan

The design team has three proposed outreach plans for the Tallahassee Community as well as local area Middle Schools. The outreach plans will work to stimulate interest in science, engineering, and mathematics in the general public. The team will partner with several organizations at the College of Engineering: The Scansorial and Terrestrial Robotics and Integrated Design Laboratory (STRIDe Lab), the school chapter of Tau Beta Pi, and the school chapter of the National Society of Black Engineers. These partnerships will be beneficial to the effectiveness of the outreach programs.

The design team will be participating in scientific presentations and demonstrations with the STRIDe Lab and the school chapter of Tau Beta Pi at the Mary Brogan Museum of Art and Science. Current plans include presentation of research and prototypes, and demonstrations of robotics and integrated systems related to the Lunar Excavator design project as well as scientific principles in general.

The second proposed program will assist and expand the STRIDe Lab's current program to introduce engineering principles to Middle School students through the design, fabrication, and programming of the Lego Mindstorms Robotic platform to accomplish specific tasks. The program is currently being developed at a local, underserved, minority middle school. The school's chapter of the National Society of Black Engineers will also be volunteering in conjunction with the design team.

The FAMU-FSU College of Engineering is also a partner in the Tallahassee Area Challenger Learning Center. The center is a K-12 outreach facility that uses aerospace subjects to stress the importance of math, science, and technology. The design team will be working to present entertaining, educational demonstrations of robotics and engineering at the center that focus on the importance of math, science, and technology and also emphasize the importance of further space exploration. The team is currently working to develop an outreach program that would be suitable for the center.

Budget Request and Plan

The basic components necessary to accomplish the tasks as outlined for the competition have been itemized and listed categorically. The items are not considered a complete reflection of the total cost of the robot, but can be used as rough estimate for the development. The total amount of funding requested from the National Space Grant Foundation is $5,000. The budget for the project is expected to exceed the $5,000 grant from the National Space Grant Foundation, but departments within the College are offering sponsorships with a limited amount of funding to assist in development of the robot. An itemized table of general categories and costs is outlined in Table 1; these costs are estimations for a basic robotic platform of design competition specifications.

Category	**Description**	**Cost**
Motors	2 Primary Drive Motors, 2 Excavation Motors, 1 Actuation Motor	$1,500
Raw Materials	Aluminum Stock, Steel Stock, Polyurethane	$500
Electronics / Motor Control / Sensors	Motor Control Boards, Sensors, Circuit Boards	$2,000
Testing Area	Lumber, Regolith Simulant, Tarp, Sand	$1,000
Travel	5 People, 5 Nights, 2 vehicles, 600 miles	$1,500
	Total	**$6,500**

Table 1. Schedule of Expenses for Robot Development

Basic design plans for the robot call for a minimum of 5 motors for the locomotion and actuation of the system. Estimated cost for motors that can perform at the specifications required is $1,500. The primary materials considered for the fabrication of the rigid portions of the robot will be aluminum and steel. Other materials considered for inclusion in the design are polyurethanes for Shape Deposition Manufacturing of compliant parts. The estimated cost for aluminum, steel, and polyurethane is $500.

The electronics, motor control boards, and sensors are estimated to cost $2,000. The programming for the platform will be as succinct as possible, but control of an estimated 5 motors will require a high level of computational power. Sensing abilities of the robot will be kept to a minimum to aid in simplicity and robustness of the design.

A series of tests have been devised for assessment of the platform. A sandbox of competition dimensions will be built to test the locomotion capabilities of the robot; sand with approximate density of lunar regolith will be used to fill the box to control costs. For the assessment of the excavation properties, a small scale box will be built with regolith simulant for proper testing. Estimated cost of materials for the testing portion of the project is $1,000.

The design team is committed to competing in the competition in May. Estimated cost of traveling includes a hotel room stay for 5 nights, for a possible 5 to 6 people (team and advisor), as well as 2 vehicles to transport the team and robot over 600 miles from Tallahassee to Kennedy Space Center and back. Estimated cost for travel and stay is $1,500.

Total estimated cost for development of the robot is $6,500. The Mechanical Engineering Department and College of Engineering has offered to supplement funding for the project. The total requested funds from the National Space Grant Foundation would be $5,000.

Schedule for Completion

The design competition will be conducted as a Senior Design Capstone Project. As such, the project will have deliverables due on a set, rigid schedule in accordance with class deadlines. The design team will follow a design schedule adapted from the Capstone Project schedule to conform to class deadlines while completing important project milestones at designated times in the design process. The Capstone class will end in late April of 2010, one month before the official design competition at Kennedy Space Center. The Senior Design Capstone Class syllabus and description can be found at http://www.eng.fsu.edu/ME_senior_design/.

Due Date	Type	Description	Entity
1-Aug	Proposal	Funding Proposal	NASA
15-Sep	Report	Needs Assessment / Project Scope	Class
29-Sep	Report	Product Specification	Class
29-Sep	Schedule	Project Plan	Class
13-Oct	Report	Concept Generation and Selection	Class
1-Dec	Report	Final Design Package	Class
1-Dec	Proposal	Spring Fabrication Proposals	Class
12-Jan	Report	Restated Project Scope & Project Plan	Class
30-Mar	Notification	Collaboration Notification	NASA
30-Mar	Registration	Competition Registration Deadline	NASA
6-Apr	Product	Robot Completion	Class
6-Apr	Manual	Operations Manual	Class
6-Apr	Website	Project Website	Class
6-Apr	Report	Final Project Report	Class
13-Apr	Presentation	Project Presentation	Class
15-Apr	Report	Systems Engineering Paper	NASA
15-Apr	Presentation	Slide Presentation	NASA
15-Apr	Report	Outreach Report	NASA
25-May	Practice	Practice Day	NASA
27-May	Competition	Excavator Competition	NASA

Table 2. Proposed Schedule for Completion of Project

Collaboration with Minority University

The FAMU-FSU College of Engineering partners the Florida State University with the historically black university of the Florida Agricultural & Mechanical University. The design team consists of students from both Florida State University and Florida A&M University. Completion of the project will also include collaborations with other organizations within the College of Engineering including student organizations such as Tau Beta Pi Engineering Honor Society, the National Society of Black Engineers, and Pi Tau Sigma Mechanical Engineering Honor Society. These organizations include students from both Florida State University and Florida A&M University.

Plan for Multidisciplinary Engineering Team

The current structure of the design team includes Mechanical Engineers for the design and fabrication of the robotic platform and Electrical Engineers for the development of the electronic architecture. The design team is still looking to add Civil Engineers for the design and implementation of the excavation systems. The combination of the multiple disciplines will lead to a better end product; each subsystem will be designed by students specializing in that area.

Plan for Recording Video of the Project

The team will document all design and fabrication steps using still and video cameras. All portions of the project will include documentation, keeping with good scientific practice. The design team will have access to a Casio Exifilm Digital camera capable of taking HD video and high speed video. The design team will also collaborate with the Computer and Multimedia Services department of the College of Engineering for higher quality video resources.

Commitment to Compete

The team, through submission of this proposal, makes a commitment to compete in the NASA Exploration Systems Mission Directorate Lunar Regolith Excavator Student Competition. The team will attend the competition set to be May 25-28, 2010, at the Astronaut Hall of Fame at the Kennedy Space Center, Florida. Through its commitment to compete, the design team will follow all competition rules and regulations as set forth by the NASA ESMD Program.