ESMD Space Grant Program NASA Senior Design Project Ideas

NOTE: This page is under construction. We will be posting additional NASA Senior Project Ideas related to the program as they become available. Space Grant Consortium's should contact Berta Alfonso at Berta.A.Alfonso@nasa.gov to coordinate Senior Project work on these ideas. Check back soon for more.

Center	ESMD Area	Title	Description
ARC	Lunar & Planetary Surface Systems	Human-Robot Site Survey	The goal of this project is to assist development of human-robot techniques for surveying sites. In particular, we will develop techniques that combine information from orbital and descent imagery with ground truth obtained by planetary rovers. Two key topics will be addressed: (1) techniques for robot teams to perform site survey using methods similar to ones used by civil engineers on Earth and (2) techniques to enable effective humans-robot interaction (from both ground control and during surface sorties) in order to improve survey performance and effectiveness. Tests will be performed in the NASA Ames "Marscape" outdoor test site as well as in analog field environments such as Meteor Crater, Arizona.
ARC	Ground Operations	3D Surface Reconstruction from Orbital Imagery	Recently the Intelligent Robotics Group (IRG) at NASA Ames Research Center has developed software that uses stereo vision techniques to automatically reconstruct high quality 3D surface models from orbital images in a matter of hours with minimal or no human intervention. The goal of this project is to adapt IRG's surface reconstruction capability for use with the Mars Reconnaissance Orbiter, existing lunar data, and cameras planned for the Lunar Reconnaissance Orbiter. Students will have the opportunity to work closely with mission engineers and scientists and directly influence how the software addresses their needs. This project will entail significant software engineering, but the main focus will be on applied computer vision and surface reconstruction.
ARC	Lunar & Planetary Surface Systems	Non-Prehensile Mobile Manipulation	The goal of this project is to design non-prehensile robot manipulation devices for lunar surface operations, such as digging/trenching, loading, cable running, conveying, or dumping. A variety of approaches are possible including pushing, tapping, or rolling a part. These modes of manipulation require the robot to have some understanding of the physics of interacting with a part, particularly friction and contact. In addition, robotic systems should take advantage of different strategies for manipulation, such as picking up a part by pushing it

			against a fixed obstacle. This project involves electrical and mechanical engineering and some embedded system (e.g., microcontroller) programming.
ARC	Lunar & Planetary Surface Systems	Real-Time Stereo Vision for Robot Navigation	Computer vision systems are used extensively within the Intelligent Robotics Group (IRG) to perform a myriad of robotics functions. Traditionally IRG has relied on software-based approaches to stereo vision that take camera images as input and perform all higher-level computation in code. The goal of this project is to take advantage of the increased performance provided by a hardware-based stereo vision solution that performs the stereo correlation and rectification in hardware. We will develop software enhancements to the Tyzx G2 camera system to provide obstacle avoidance, navigation, and terrain reconstruction functions. This project will involve computer vision theory, cross-platform software development, and mobile robot integration work.
ARC	Lunar & Planetary Surface Systems	Enhanced Autonomous Visual Sampling	IRG uses computer vision to autonomously position scientific instruments (e.g., a microscopic imager mounted on a manipulator) for data collection. Currently, we acquire one contact image and drive away. We could, however, do more manipulation and data collection for a more complete picture of the sample. We could do autonomous detection of scientifically interesting micro-structure either for robotic search or to prioritize data for return. We could build a more complete picture of a sample by doing depth from focus, mosaicing of images, and assembling smaller stereo models into larger models. This project involves computer vision theory, software development, and mobile robot experiments.
ARC	Lunar & Planetary Surface Systems	Component Based Architecture for Planetary Rovers	RG rover software is based on a rich library of robotic classes developed jointly by JPL, IRG and CMU: CLARAty (Coupled Layer Architecture for Robotic Autonomy). IRG is currently developing a new set of CORBA-based interfaces for robot interoperability and control. We would like to use the collection of classes from CLARAty to create a component-based architecture using these new interfaces. The benefit of this component based rover software will be a faster development of new high-level robot controllers and easier integration of new components (like a new sensor for example). We envision being able to create a complete robotic system from a configuration file. The work could integrate/re-use similar approaches like MIRO or ORCA, but will be targeted at planetary missions involving autonomous robots interacting with human teams. This project involves component-based architecture, robotic software and distributed systems.

ARC	Lunar & Planetary Surface Systems	Rover Architecture for Reactive Planetary Rovers	Current planetary rovers typically operate at low speed and are not interacting with other systems or humans (single rover mode). IRG successfully demonstrated last year the benefit of multiple robots cooperating with a human team in a very reactive manner. However the demonstration was focused on human robot collaboration and did not yet leverage IRG s expertise of reliable outdoor rovers operating in unstructured environments. We would like to define a rover architecture that integrates the current technology of rover operations with a more dynamic model allowing the rover to respond in real time to humans/other-rovers interactions. The work will involve designing an architecture supporting these challenging requirements and implementing a demonstrator using existing rover software modules. The project involves software architecture, mobile robot behaviors and human-robot interactions.
ARC	Ground Operations	User Interfaces for Controlling Multiple Cooperating Robots	VizExplorer (VizEx) was developed by IRG as a tool for immersive visualization of remote environments. It allows mission operations teams to construct 3-D models of a remote environment from 2-D stereoscopic images to support robotic operations and maintenance tasks. We have constructed various interfaces over the years for assembling robot command sequences from information derived from our 3-D models. However, they have typically been composed from various loosely integrated 2-D and 3-D tools, and have not been designed for simultaneous control of multiple cooperating robots. Some possible ideas for improving our robot control capabilities include: Designing integrated command composition tools for multiple robots with some "optimal" combination of 2-D and 3-D displays and controls. This work involves software development of multi-threaded, distributed applications, user interface design, and an understanding of 3-D graphics theory and applications.
ARC	Lunar & Planetary Surface Systems	Personal Exploration Rover Toolkit	The Personal Exploration Rover (PER) is a miniature six-wheeled mobile robot jointly developed by NASA and Carnegie Mellon University. Originally created in 2003-2004 to raise public interest in the Mars Exploration Rover missions, PER exhibits have been installed in many American science centers and museums, including the Smithsonian National Air and Space Museum and the San Francisco Exploratorium. The goal of this project is to develop software tools so that the PER can be used for general-purpose robot research. This work will be done together with the Robotics Institute at Carnegie Mellon University and will focus on design and implementation of low-level programming libraries, graphical user interfaces, and physics-based simulation (using the Player/Stage/Gazebo open-source software). This project involves software development and experimentation with multiple PERs at NASA Ames.

ARC	Spacecraft	Small Spacecraft Design Concepts	Small spacecraft show great promise for future NASA missions. Because of their nature, these spacecraft typically have very low margins in mass, power, and propulsion. In order to make these systems viable, NASA needs evaluate what is possible with innovative concepts for microspacecraft landers, rovers, and communications relays that could be used for very low cost robotic lunar precursor missions.
GRC	Lunar & Planetary Surface Systems	Star Tracker Algorithm	In order to navigate successfully on the Lunar surface within a global and local view of reference, it is essential to have a passive navigation aid that can provide heading. Our branch would like to investigate the design of a radiation hardened star tracker for use on lunar vehicles. The proposed senior project is to design a computer image processing algorithm that will take an image of the stars and compare to a group of onboard images. The algorithm will determine the best fit and output a given heading and attitude from this fit.
GRC	Lunar & Planetary Surface Systems	In-Situ Resource Utilization (ISRU) Surface Robot Behavior	A robotic behavioral programming algorithm to allow multiple robotics platforms to wander, search for and locate interesting locations, protect themselves, interact with humans and other robots. This will model multiple robots mining regolith in a lunar situation. Ideally the robotics demonstration platform will be simple mobile robot with simple to use development system. Academic development robot platforms are recommended. Algorithms thus developed will be portable to flight grade robots and their precursors.
GSFC	Lunar & Planetary Surface Systems	Design of a Spacecraft to Support a Lunar Mission	Engineers would give the students a set of instruments and a lunar orbit and let them design the spacecraft to support the mission. This project would be suitable for a class where the student already knows something of designing spacecraft.
GSFC	Spacecraft	Dynamic Effects of Main Engine Firing on CEV Solar Panels	Students will analyze the structural dynamic effects of main engine firing on the solar arrays on the CEV and make recommendations on mitigation.
GSFC	Lunar & Planetary Surface Systems	Thermal Control System (TCS) For Lunar (or Mars) Rovers	For future rovers a robust, simple, lightweight thermal control system will be required. The conventional thermal architecture uses a pumped fluid loop and was used on Mars Pathfinder and Mars Exploration Rover (MER). An alternative system using a miniature loop heat pipe (LHP) system has been proposed, which is an order of magnitude lighter, less costly and has no moving parts. The students will be asked to perform trade studies on this and other possible solutions, taking into account weight, reliability, cost, ease of integration etc, as part of their approach. They will be asked to determine the environment and perform thermal analysis to show that temperature limits have not been exceeded during 1) interplanetary cruise 2) descent and landing 3) surface operations. Mechanical or CAD drawings will be

			developed to show how the system will be integrated into a typical rover concept, such as Pathfinder or MER as well as how the TCS interfaces with other supporting sub-systems such as Power and C&DH.
GSFC	Lunar & Planetary Surface Systems	Design Of Helium-3 Mining Equipment for the Moon	Design challenge: process Lunar regolith and extract volatiles. This will involve the digging of gritty material, screening it, moving it, heating to 700 C, sequestering the volatiles, and discharging it. All this must be done in the Lunar environment using extremely reliable equipment with very long useful lifetimes that is solar powered and easily maintained by a combination of a few astronauts and robots controlled from Earth. The key problem of sequestering the volatiles and the maintenance problems associated with machines that handle gritty material, like chicken feed, are topics for investigation. Students would design a Lunar He-3 miner that shows clear respect for the Lunar environment, treats each individual gas molecule and microscopic dust particle as an independent entity, models their movement as a particle migration, is reliable, and addresses the problems of handling lunar grit. The problem would be to detail a full scale miner and engineer it down to a small rover that could be sent to the Moon and test the key concepts of the larger design.
GSFC	Spacecraft	Exploration Systems Architectural Study (ESAS) Mission Design	Engineering students would be provided with the current ESAS documents and evaluate the current strategy and provide recommendations.
GSFC	Spacecraft	SuitSat Follow On	Engineering students will provide recommendations designs of instruments on SuitSat follow on that are in alignment with Exploration goals and objectives, for example a radiation shielding or monitoring experiment. http://science.nasa.gov/headlines/y2006/26jan_suitsat.htm
HQ	Lunar & Planetary Surface Systems	Medical Diagnostics	What Medical Diagnostics, Monitoring and Treatment Tools can/should be provided for Explorers? Astronaut explorers will be far from home and will need to have capabilities for medical care that are independent of Earth.
HQ	Lunar & Planetary Surface Systems	Countermeasures to Combat The Negative Effects of Spaceflight on Humans	What are the best countermeasures to combat the negative effects of spaceflight on humans? In the absence of body loading and contact forces that are present on Earth, muscles, bones and the heart atrophy, and fluid-electrolyte systems are disrupted.

HQ	Lunar & Planetary Surface Systems	Informatics and Information	How can Informatics and information capture best be done and utilized rapidly in problem solving?
HQ	Lunar & Planetary Surface Systems	Tools, Techniques And Technologies Designed to Facilitate Human-Machine Interactions	What kind of tools, Techniques/Technologies can be designed to Facilitate Human-Machine Interactions? What solutions can be engineered to maximize human explorers' health and productivity in weightlessness?
JSC	Spacecraft	CEV Exercise	This is a request for Senior Engineering Design projects related to the design and development of exercise hardware systems for the Constellation Program based on the current resource specifications and spacecraft constraints allotted to this function. This system must be capable of providing on-orbit exercise that mitigates deconditioning effects related to space flight to preserve crew health, performance and safety. Generally, astronauts experience space-induced deconditioning that progressively worsens as mission durations lengthen. Historically, in-flight exercise has provided a holistic approach to sustain crew health and performance. The goal for the project is to identify concepts and designs for an exercise device to be used in the Crew Exploration Vehicle (CEV) and/or Lunar Surface Access Module (LSAM) during lunar missions greater than 8 days in duration.
JSC	Lunar & Planetary Surface Systems	Advanced Airlock and Dust Mitigating System	Design of a minimum gas loss and low power EVA airlock that provides quick exit and entry for space- suited crewmembers and provides dust mitigation capabilities. CHALLENGE GOALS AND OBJECTIVES: The task would be to design a future airlock that can accommodate one or two crew members. This airlock would be an element of a future planetary lander, or human pressurized rover. The goal would be to minimize the gas that is lost during depressurization by creatively designing the layout and the operation of the inner and outer airlock hatches. Pumps to recover the gas are very heavy and require a large amount of power; therefore, they are not part of this design. The Advanced EVA Technology Group will provide information on the current airlock on the Space Shuttle, the International Space Station, and some concepts from previous studies. Small models of advanced airlocks that have been proposed could also be provided. High level design requirements for airlocks from NASA design standards would also be provided.

JSC	Lunar & Planetary Surface Systems	Advanced Lunar Pressurized Rover	Design of a 2-4 person rover for lunar exploration with both robotic manipulator capability and EVA capability. Rover would include minimum gas loss and low power EVA airlock and dust mitigation capabilities. CHALLENGE GOALS AND OBJECTIVES: The task would be to design a future lunar pressurized rover that can accommodate 2-4 crew members. This rover would be an element of a future planetary lander. The goal would be to perform surface exploration by creatively designing the layout and the operation of the pressurized rover. The Advanced EVA Technology Group will provide information on concepts from previous studies. Small models of advanced airlocks for rovers that have been proposed could also be provided. High level design requirements for Rovers and airlocks from NASA design standards would also be provided.
JSC	Lunar & Planetary Surface Systems	Lunar Lander Large Cargo Unloading System	Design of a robotic/EVA assisted system to unload and move large cargo/modules from a lunar lander. CHALLENGE GOALS AND OBJECTIVES: The task would be to design a future lunar lander large cargo unloading system that can robotically or EVA assisted robotically unload and position cargo and modules. This large cargo handling system would be an element of a future planetary lander. The goal would be to minimize the overall, mass and weight of a lunar lander large cargo handling system. The Advanced EVA Technology Group will provide information on the previous designs of large cargo handling systems and some concepts from previous studies.
JSC	Lunar & Planetary Surface Systems	Lunar Lander EVA Crew and Small Cargo Lifting System	Design of a system for routinely and safely transporting the EVA crew and small cargo up and down from the airlock to the surface and back, including innovative ladder designs and lifts. CHALLENGE GOALS AND OBJECTIVES: The task would be to design a future lunar lander EVA crew and small cargo lifting system. This EVA crew and small cargo lifting system would be an element of a future planetary lander. The goal would be to minimize the overall, mass and weight of a lunar lander crew and small cargo lifting system. The Advanced EVA Technology Group will provide information on the previous designs of crew ladders and some concepts from previous studies.

JSC	Spacecraft	Flight Demonstration of Autonomous Rendezvous & Docking *This Is Anticipated To Be An Eight Year Program With A Launch Of The University Satellites Approximately Every Two Years.*	The United States space program has never demonstrated two spacecraft to autonomously rendezvous and dock in space. The purpose of this University Design Project for two universities - the University of Texas and Texas A&M University - to each build a satellite that will ultimately rendezvous and dock with each other in space without the benefit of human intervention. Because the two satellites must be compatible, the students have had to learn to work across geographical distances, deal with cultural differences, and understand that while the spacecraft is made up of individual subsystems; optimization of the overall "satellite system" provides a tremendous opportunity for students to learn the art of project management. Some of the objectives of the project include the following:(1) Demonstrate precision relative navigation; (2) Demonstrate precision real-time navigation; (3) Provide orbit determination; (4) Mission duration shall be a minimum of 24 hours; (5) Data collection and downlink over 75% of the mission duration.
JSC	Lunar & Planetary Surface Systems	Planetary Eva Suit Fuel Cell	Design a complete 1kW fuel cell powerplant for EVA suit applications. Design should optimize on specific power and system specific energy within the constraints of a defined operational life and duty cycle. Project includes selection of electrolyte chemistry, membrane electrode assembly design, and fuel cell accessory section.
KSC	Ground Operations	Packetized Telemetry Converter	Utilizing reconfigurable logic devices, develop a system that accepts packetized telemetry and outputs a PCM stream compatible with IRIG-106-05 Ch.4 for input to existing ground based telemetry processors. The intent of this project is to determine whether existing KSC telemetry processing devices can be utilized in the Constellation packet telemetry environment or if all the PCM based devices need to be replaced. The use of FPGA type devices provide the flexibility to update the translation routines without requiring hardware change-out.
KSC	Lunar & Planetary Surface Systems	Senior Biological Engineer	The goal of this senior design project is the design, integration, and evaluation of components, subsystems, and systems of a prototype habitat module. NASA could then validate and test concepts for the ultimate design of a "Surface Habitat Module" to be used on the Moon or Mars. The focus will be on the design of components, subsystems, and systems to reduce resupply of life support elements (i.e., air, water, and food), and incrementally evolve and integrate current resupply methods and physical-chemical technologies with bioregenerative technologies. This project should emphasize the critical system selection criteria of minimum launch mass, efficient utilization of volume and power, and minimization of crew labor time and lifecycle costs.

KSC	Lunar & Planetary Surface Systems	Lunar Regolith Processing Challenges For Oxygen Production	KT-D has been a member of a multi-center NASA project team to develop and experiment to go into the permanently shadowed craters of the lunar poles to make a determination on the quantity and form of hydrogen seen from orbit. In the first year, KSC ran a University Competition on the topic of ISRU and allowed Senior-level design teams from across the country to compete to propose a design solution to a portion of this problem. ISRU has a multitude of technical challenges that would fit nicely into this Senior Design realm, from Reaction Chamber Seals, Regolith Transfer, Regolith Excavation, Regolith Reduction for Oxygen Production, etc.
KSC	Ground Operations	Simulation-Based Product Realization	NASA supports simulation for life-cycle activities: planning, design, analysis, test, check-out operations, review and training. Consciously maturing an imagined workable idea through framing it to optimization ,building, testing and realizing the product—using simulation throughout-- provides us with an important approach to innovation and project success. We want to address integration of visualization into discrete event simulation so that it truly brings data to life. Simulation supports analysis but not synthesis. We have identified that we need simulation supporting synthesis, making it easier for engineers to use simulation for test and evaluation. These are examples of design challenges that we are addressing in developing a balanced approach to the NASA Product Development Hierarchy visualization and presentation and in the development of approaches to enhance collaboration among teams that must operate across vast distances over, perhaps, a hundred years as teams, missions and technology changes.
MSFC	Spacecraft	Design for Reliability And Safety	Safety and Reliability is a top priority for NASA in the development of new launch systems. There is a need to define and develop a process that describes how to "design for reliability and safety". This is a system engineering design project that addresses all what needs to be done throughout all the phase of a program (quantitative and qualitative) to design highly reliable and safe launch systems. This includes identification of products, tools, approaches, etc.. by program phase.
MSFC	Lunar & Planetary Surface Systems	In-Situ Utilization	In-Situ Resource Utilization (ISRU) is often described as “living of the land”, but the “land” happens to be the Moon or Mars. Marshall Space Flight center has been active in the area of ISRU oxygen production form both Lunar and Martian resources. Oxygen is clearly important for both life support and propellant production. Lunar regolith contains oxides that can be separated by molten oxide electrolysis (MOE). This technique can produce oxygen, silicon and a variety of metals. The Martian atmosphere consists mainly of carbon dioxide. Thus, a great deal of oxygen is available on Mars if one can break the chemical bonds. This can be accomplished thermally or by using radio frequency (R.F.) plasmas. These methods of oxygen

			production (Lunar and Martian) have been demonstrated in the laboratory, and need to be engineered into practical devices. Engineering design criteria must include the oxygen production rate, power consumption, energy sources, reliability and the cost of transporting terrestrial consumables. Designs may be autonomous or require human interaction.
MSFC	Lunar & Planetary Surface Systems	Thermal Power Plant for Lunar Development	The prospect of finding frozen water in perpetually shaded craters on the moon establishes a site near one of the poles as a preferred location for a lunar base. Energy required for the development and operation of a continuously inhabited lunar base will require a self-sustaining supply of power. The high percentage of sunlight near the poles and large variations in temperature between the rim and floor of perpetually shaded craters, such as Peary near the North Pole or Shackleton in the south, suggest the possibility of utilizing a heat engine to generate electrical power. This temperature gradient will allow for potentially high thermal cycle efficiencies. The design team will be responsible for evaluating potential cycles, choosing an efficient and transportable working fluid, optimizing the thermal efficiency of the whole system, and testing system concepts. The development process will also include a feasibility study of a start-up plant for the powering of construction equipment (~10kW) versus a permanent habitat plant (~200kW).
MSFC	Lunar & Planetary Surface Systems	Systems Engineering Trades for Robotic Lunar Precursors to Human Lunar Flight Missions.	This design project is to assess different architectural and mission configurations for robotic lander precursors to human lunar flight missions. The trade space includes architectural implications of different landing sites (poles, equatorial, far side, near side or boundary regions), system autonomy, propulsion, power, and communication architectures, surface mobility, system health management, thermal control, etc.
MSFC	Lunar & Planetary Surface Systems	Lunar Precursor Robotics Program	Mobility systems are needed to identify and characterize the resources available on the lunar surface. Specifically, large craters at the lunar poles. Rover designs capable of navigating in near complete darkness, obtaining the required number of samples, and surviving 50K temperatures is an extreme challenge. The design team would be tasked to investigate various low light vision systems for telerobotic operation and combinations of power and thermal control systems to operate in the dark and in sunlit conditions.

MSFC	Propulsion	Nuclear Fission Surface Power Design	This project will focus on the design and potential utilization of a 20–40 kWe Fission Surface Power System for use anywhere on the surface of the moon or Mars. The project will include performing a top level design of the Fission Surface Power System, including the reactor, shield, power conversion, power management and distribution, and radiator. Potential uses of the electrical or thermal energy from the reactor should be identified. Methods for emplacing and deploying the system should also be discussed. Emphasis should be on systems that minimize programmatic risk and utilize well proven technologies.
MSFC	Lunar & Planetary Surface Systems	Optical Techniques For Guidance And Navigation During Landing	Optical correlation techniques are currently being investigated for unmanned vehicle to international space station robot docking. Early results indicate that the technique is robust and matches well with the current 3-D rendering software now available. The technique could be applied equally well to landing by unmanned vehicles at a site that has either been mapped well or that has been mapped sparsely and can be rendered in 3-D. The optical correlation technique has been well characterized in the past and is now finding its way into many applications.
MSFC	Lunar & Planetary Surface Systems	Implementing a Fully Integrated Digital Design-to-Manufacturing Environment	Opportunities for participation will include: Digital manufacturing; Generation and translation of CAD models between distinct environments; Development of virtual environment for development and production facilities, trade studies and facility limitation/impacts; Simulations and manufacturing process development, and coordinated motions programming and controls; Modeling/reverse engineering on exiting tools and hardware; Validation of assembly sequences and related human factors operations; Manufacturing process optimization; Validation of assembly and flight hardware transportation