2012 PISCES Forum - Abstract Presentation Index

Track 1: Mining, Infrastructure and Construction

Location: Naupaka Ballroom IV

Tuesday, November 13, 2012

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2012 PISCES Forum - Abstract Presentation Index

Tract 2: Technology, Robotics, Mission Concepts, EPO

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Tuesday, November 13, 2012

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Lunar Bricks from Helium3 Mining

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http://www.youtube.com/watch?v=26Y5w0vqtIU

Go to the above youtube.com website for an LTS 7 Minute Video on the Lunar Transportation Systems Concept.

Also Spacehab Inc. Kistler Aerospace, Global Outpost, Inc. Exploration Partners LLC plus other startup companies

Helium3 is an isotope of Helium impacting regolith in several top inches. University of Wisc-Madison completed bucket-wheel excavator to mine He3 at the lunar surface to recover He3 and other valuable products from a heated regolith capable of large Lunar Bricks, an early commercial product. He3 is $6-15B/ton and possibly the first resource valuable enough to be returned to the Earth's via an emerging trade route. Two other product groups can be developed for other nearer term markets, but Lunar trade routes are longer, making early capital conservation critical. BigOil cash flow techniques from Prudhoe Bay can serve/accelerate space resource markets with bucket-wheel excavator to mine He3 at the lunar surface using commercial existing cash flow techniques and innovation can reduce the logistics costs. LTS, Inc. proposes other innovative methods capable of growth and expendable unmanned logistics hardware delivering cargo lunar surface by starting small, growing larger and later becoming reusable and expanding on profits. Both growable hardware, emerging market systems and the expendable hardware can expand lunar market using profits for growth instead of the traditional big upfront NASA capital. Early hardware is expendable, but capable of evolution to reusability after trade route growth based on spending profits instead large budget traditional government funded programs. This development process is based on Earth oil resources recovery techniques at Prudhoe Bay, where early risk capital pooling innovation is used in logistics development with unmanned hardware. Communications and all hardware must start small, grow on profits rather than big upfront government funding and must be financeable by commercial or private sources. Commercial space logistics trade route opportunity exists for an unmanned hardware solutions and delivery system from LEO to the lunar surface using in-space spacecraft hardware starting small, capable of growth as mankind's next nearest business location.

Lunar Concrete Landing Pad Construction Process Development for Future Automated Construction

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Infrastructure construction on the Moon and Mars is necessary for future in situ resource utilization (ISRU) missions. Infrastructure such as road, plants for material process and power generation, shelter, landing pad has essential roles.

One of the key infrastructures for future manned/unmanned ISRU missions is landing pad. On the future lunar outpost, there will be equipment for exploration and resource development, and these will require numerous landing of landers. Apollo astronauts already experienced rocks and dusts kicked up by the rocket engine and obscure the vision. Thus there is a need to construct landing pad on the Moon to reduce blowing debris and improve safety for astronauts and equipment already exist.

Waterless lunar concrete which is comprised of lunar regolith and binder, such as sulfur, are studied and presented as one good alternative to build infrastructures on the Moon. The process uses lunar regolith mixed with polymer binder which has advantage on using less material from Earth, sufficient strength, and possibility of heat resisting.

However, building a landing pad on the Moon requires full autonomous. Therefore, construction process and structure design needs to be developing which is suitable for automated construction. One promising technology for automated construction on the Moon is layered fabrication such as 3D printing technology. It is flexible to build numerous of infrastructures and possible to be fully autonomous.

The study presents considerations for developing lunar concrete landing pad construction process for future automated construction and will introduce developed prototype to demonstrate possibilities that waterless lunar concrete is a proper material for automated lunar infrastructure construction and it would be one approach for lunar exploration.

Affordable, rapid bootstrapping of space industry and solar system civilization

Robert P, Mueller, Philip T. Metzger
(Presented by Dr. Paul Hintze)

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Affordable, rapid bootstrapping of space industry and solar system civilization

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Abstract:

Advances in robotics and additive manufacturing have become game-changing for the prospects of space industry. It has almost become feasible to bootstrap a self-sustaining, self-expanding industry at reasonably low cost. Simple modeling was developed to identify the main parameters of successful bootstrapping. This indicates that bootstrapping can be achieved with as little as 12 metric tons (MT) landed on the Moon during a period of about 20 years. The equipment will be tele-operated and then transitioned to full autonomy so the industry can spread to the asteroid belt and beyond. The strategy begins with a sub-replicating system and evolves it toward full self-sustainability (full closure) via an in situ technology spiral. The industry grows exponentially due to the free real estate, energy, and material resources of space. The mass of industrial assets at the end of bootstrapping will be 156 MT with 60 humanoid robots, or as high as 40,000 MT with as many as 100,000 humanoid robots if faster manufacturing is supported by launching a total of 41 MT to the Moon. Within another few decades with no further investment, it can have millions of times the industrial capacity of the United States. Modeling over wide parameter ranges indicates this is reasonable, but further analysis is needed. This industry promises to revolutionize the human condition.

Metals and Oxygen Mining from Meteorites, Asteroids and Planets using Reusable Ionic Liquids

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In order for humans to explore beyond Low Earth Orbit both safely and economically, it will be essential to learn how to make use of in situ materials and energy in an environment much different than on earth. Precursor robotic missions will be necessary to determine what resources will be available and to demonstrate the capabilities for their use. To that end, we have recently been studying acidic Ionic Liquid (IL) systems for use in a low temperature (< 200° C) process to solubilize regolith, and to extract, as water, the oxygen available in metal oxides. Using this method, we have solubilized lunar regolith simulant (JSC-1A), as well as extraterrestrial materials in the form of meteorites, and have extracted up to 80% of the available oxygen. Moreover, by using a hydrogen gas electrode, we have shown that the IL can be regenerated at the anode and metals (e.g. iron) can be plated onto the cathode. These results indicate that IL processing is an excellent candidate for extracting oxygen in situ, for life support and propulsion, and for extracting metals to be used as feedstock in fabrication processes.

We have obtained small amounts of meteorite materials believed by meteoriticists to have originated from our moon, Mars, and the asteroid Vesta, and were able to solubilize those using acidic IL systems. From the Vesta meteorite, we were able to extract about 60% of the available oxygen as water. As far as is known, this is the first time that extraterrestrial/earth “hybrid” water has been obtained. NMR analysis provided proof that the liquid retrieved is indeed water. We have also been able to electro-plate nickel and iron contained in meteorite material. By varying voltage they can be plated separately (electro-winning), and we plan to soon have sufficient quantities to form usable parts utilizing the additive manufacturing process.

IL processing of regoliths for oxygen and metal extraction has a number of advantages over other methods. An important advantage is that ILs are much "greener" and safer than conventional chemical reagents (e.g., volatile organic solvents, corrosive acids), primarily because they have very low vapor pressures, and they can exhibit good stability in harsh environments (extreme temperatures, hard vacuum, etc.). Furthermore, regolith processing can be achieved at lower temperatures than other processes such as molten oxide electrolysis or hydrogen reduction, thereby reducing initial power requirements. Efficiency of oxygen production is much greater than for hydrogen reduction because all metal oxides can be utilized. Since we have shown that the ILs can be regenerated and reused, the expense of shipping large quantities (up-mass) can be mitigated.

Transitioning Terrestrial Concentrated Solar Power for Lunar Surface Infrastructure

John Kohut and Roger Lenard

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Planetary Power, Inc (PPI) develops and fields revolutionary distributed power generation systems for customers needing electricity in remote, off-grid applications. The moon is the ultimate remote location, and its exploration and development will need significant amounts of power. PPI's SUNsparq is a unique transportable concentrated solar power system with an innovative hybrid, two-independent-staged, intercooled and reheated closed Brayton cycle (CBC) engine that produces approximately 10 kWe power with just 24 m2 of collection area. It is capable of employing conventional hydrocarbon fuels with the same CBC engine to generate power through the night or during periods of inclement weather. The system integrates Lithium-based batteries to carry loads through solar intermittencies and to provide very high peak power outputs (up to 400% of rated power) to meet short duration surge loads. For the military expeditionary market, SUNsparq must be rugged, compact, low weight and autonomous in operations, which are also critical requirements for a robust lunar power system. This paper will describe the baseline SUNsparq system, discuss its applicability to the International Lunar Research Park infrastructure development, and explore how SUNsparq could be further modified to meet the demands of the lunar environment including ways to survive and operate through the lunar night. Given PPI's commitment to low cost, weight and volume with robust autonomous operations, enhanced SUNsparq technology has real potential to provide unprecedented amounts of power on the moon.

Study on Lunar Concrete Binder for Landing Pad Construction

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Space exploration project requires large amount of investment to transport necessary equipment for survival. To minimize the cost, equipment and other necessary needs must be reduced to its least. The moon is closer than other planets; however, it still requires expense transportation cost. Thus, exploration is required to utilize resource on-site. To enable lunar exploration, an infrastructure is needed. For structure possibility, testing is mainly focus to create lunar concrete from composition of lunar soil and binder.

Initially scenario is from landing and moon takeoff. When debris occurs, creating mass-heat and pressure during landing and takeoff, it will damage facilities and areas around as well as glide to distant places due to low gravity. Extremely fine lunar dust cuts through spacesuits and is harmful to human skin. Especially, floating lunar dust during landing continues to stay drift around. From this information, pre-caution of lunar dust bring landing site to be one of the most important matter in space facility.

Research and planning were based testing on these previous factors, and research data found concrete's hardness suitability. Research plan is by considering these research trends, such as critical infrastructure facilities in the moon and materials. The suitability of other materials will be considered proceeding construction requirements with the polymer material in the series.The purpose of polymer prototypes is to produce concrete landing pad samples, a compound of mainly lunar soil and polymer. And concrete samples are going to be test for suitability application.

Furthermore, testing prototypes may show different outcomes when temperature and condition fluctuation occurs in atmosphere similar to the moon. In addition, the suitability for the fabrication and material test researching should be carried out by setting conditions similar to lunar environment

A Novel Concept for Landing Pad Construction Using Structural Molds and Cast Regolith

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To construct habitats on the moon, stable transportation of construction materials, equipment, and manpower is essential, thereby necessitating construction of a landing pad. Design and construction of a landing pad should be able to address various problems associated with the unique construction environment on the moon. A novel conceptual scheme for landing pad construction is proposed in this study. This scheme attempts to build a landing pad by assembling hexagonal structural units which can be manufactured and installed on site. Each structural unit consists of two parts; the hollow outer unit and the core. The material for the outer unit could be transported from the Earth since small quantity should suffice. The upper part of the hollow unit is filled with cast regolith to create the load bearing “core.” Once the structural unit is fabricated, it is placed next to the installed units and latched using the simple interlocking mechanism. This process is continued until a predetermined shape and size of the pad is reached. Any shape and size can be accommodated. It should be emphasized that the bottom part of the unit is designed in such a manner that the subgrade can be compacted and strengthened while being installed. Enough load bearing capacity can thus be mobilized without preconditioning the sub-base. Repairing the pad is easy as a damaged unit can be simply removed and replaced. It is noted that the outer units can also be manufactured with light-weight materials on Earth and transported to the moon to be assembled on site. This construction scheme can be adapted to building lunar roads and foundations for habitats.

Concepts for Robotic Lunar Infrastructures

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(Presented by Roland Rosta)

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Currently, the ratio of orbital missions to landing missions shifts more towards landing missions, where it is planned to bring instruments either on stationary landers or rovers to the lunar surface (Selene-2, Chandrayaan-2, Luna-Glob). Future missions to the Moon will gain from standardized platforms, which would be designed as reconfigurable modules or building blocks to serve either as a support for landing missions or to perform its own science with a dedicated payload on board. Modules (with a proposed standardized volume of 0,125 m3) for many different tasks are conceivable: power distribution, power storage, power generation, communication, computing or avionics, storage (rovers, samples, caches etc.), RIPS nodes (radio interferometric positioning system), absolute position modules (e.g. with star trackers), payload protection modules (for long time research), etc. The goal is to build up those modules in a generic manner with a high degree of autonomy. This will ensure that such an infrastructure can support a variety of possible future missions, in particular those with limited relay opportunities like e.g. on the far side or such placed in a challenging terrain like in craters etc. Therefore, the arrangement of the modules needs to be reconfigurable, to be tailored for the special needs of each mission. The modules also might need to have an adjustable degree of mobility.

Such an infrastructural base could be realized in a timeframe of several years. The modules could be set up in steps, to allocate the costs to several years and reduce yearly expenses. Together with new landing technologies, allowing precision landing, only limited mobility is required to place any new module to the already set-up cluster. Due to its efficient and cost-effective characteristics, the concept is an affordable alternative and can also serve as an initial point and pathfinder for future lunar infrastructures. Besides Moon and Mars, such systems will also apply to terrestrial regions like Antarctica or in the oceans, for example building up robotic maintenance infrastructure for oil drilling platforms or upcoming large offshore windparks.

Modification of volcano ash to cementitious materials for materials for Portland cement in structural concrete

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In the present study, to maximize the use of volcano ash for a concrete material, the ash was treated to form a pozzolanic materials by the process of (1) heat activating. (2) grinding to the fineness of cement and (30 supplementary addition. As a result, the oxide composition of modified volcano ash (hereinafter MVA) mainly includes siliceous oxide(SiO2) and aluminum oxide (Al2O3), accounting for 76.6 and 12.2% respectively. Also, a marginal portion of alkali metallic oxide such as Na2O, K2O, Fe2O3, CaO was taken within about 10% in the oxides, which is similar to a mixture of pulverized fuel ash and silica fume (popular cementitous materials for concrete). Then the concrete quality in terms of strength was measure for the concrete containing the MVA as being partially replaced for Portland cement ranging from 10 to 50%. The strength for MVA concrete was developed with time. In particular, at 40% of the replacement, the strength of concrete indicated the peak value, whilst other replacement ratio produced a similar range of the strength for MVA-free concrete, accounting for about 35MPa, presumably due to a latent hydration process of MVA, which often takes place in concrete containing pozzolanic materials

Mobile In-Situ Water Extractor (MISWE) for Mars, Moon, and Asteroids In Situ Resource Utilization

Kris Zacny, Phil Chu, Gale Paulsen, Jack Craft

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In-Situ Resource Utilization (ISRU) facilitates planetary exploration by drawing needed resources, such as water, from the local environment. This work presents a 3-step in-situ water recovery approach: 1) mining the soil using deep fluted auger, 2) extracting the water from soil within the flutes, and 3) discarding the soil before transporting the water to a main storage facility. Drilling in icy soil and ice has already been demonstrated in vacuum chambers by the authors. This paper focuses on the second critical step: water extraction from the icy soil or ice within the deep flutes. This paper reports on tests demonstrating efficient collection of water from ice-bearing soil under Mars conditions. The water recovery Mobile In Situ Water Extractor (MISWE) breadboard collected as much as 92% of the water initially present in the soil, and required as little as 0.9 Whr/g of energy (80% efficient compared to theoretical). The extraction process took approximately 40 min.

Robotic Asteroid Prospector (RAP): Overview for Deep Space Mining

Kris Zacny, Marc Cohen, Warren James, Brad Blair

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Recognizing that robotic and human asteroid exploration is a cornerstone of President Obama's "Flexible Path Strategy," the Robotic Asteroid Prospector (RAP) Team undertook an investigation the economic and technical feasibility of mining asteroids. The first major milestone accomplished was winning a NASA Innovative and Advanced Concept grant on 1 AUG 2012. This investigation begins from a deeply skeptical perspective about the viability of such a long-range space industrialization scheme.

In approaching the inquiry, the team determined that it would be necessary to make six arguments successfully to conclude that asteroid mining can become a successful enterprise:

1. That there are accessible, exploitable, and valuable minerals and possibly H20 in the asteroids.
2. That it a sustained market demands exists.
3. That the team can develop a transformational mission design to make frequent, repeated missions to an asteroid possible, and
4. That this mission design can overcome the "when you go determines where you go constraint."
5. That the team can design, develop, and produce the innovative spacecraft necessary to carry out the mission.

That the team can develop the necessary robotic mineral extraction, beneficiation, processing, and concentration technologies.

International space S&T research as an innovation pathway for Earth sustainability

Burke Burnett

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The 21st Century will see the planet warm, human populations rise toward 10b, and escalating stresses on food, water, and energy resources. As governments rise to face a series of serious and interconnected environmental, demographic, and humanitarian threats, increasingly constrained public budgets may challenge current rationales for government space programs. This need not be the case. Only through major technological advances will an expanding human population that is able to enjoy modest levels of prosperity be consistent with economic systems that do not exceed so-called “planetary boundaries”. Given the unique problem set of space exploration as well as the inherently multidisciplinary, collaborative nature of such efforts, space S&T research is one of the critical innovation pathways that can significantly advance sustainability technologies. For example, the pursuit of new and more effective technologies to keep a crew safely housed with reliable food supplies and access to energy, telemedicine, sanitation, and communication on the ultimate resource-poor “island” of the moon will surely help drive innovations that facilitate sustainability solutions for not only the island states of the Pacific, but the world. In addition, the future of science and technology research increasingly lies in cross-disciplinary collaborations that link various research networks both within and among countries. International space-related research, of which PISCES and ILRP are exemplary examples, is an important endeavor worthy of greater public appreciation and support.

Alabama Lunabotics: 2012 Lunabot Excavator Design

Justin Headley [1], Justin Baker [5], Jessica Colburn [3], Adam Melton [1], Dalen Mullenix [5], Andrew Price [1], Logan Ream [2], David Sandel [1], Mitchell Spryn [1], Stephanie Troy [4], Jason Watts [1], Matt Westberry [2], Kenneth G. Ricks [1]

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Alabama Lunabotics: 2012 Lunabot Excavator Design

The University of Alabama in collaboration with Shelton State Community College will present its award winning excavator design used in the 2012 NASA Lunabotics Mining Competition. The excavator design incorporates a modular approach featuring an independent drive module capable of supporting various excavating payloads. The specific excavating modules used include a front-end loader design as well as a bucket-wheel design. Additional aspects of the project presented will include design alternatives considered for the 2012 design cycle, design evolution from excavators used in previous years, software architecture, testing, operational characteristics, and 2012 competition results.

Team Members:

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HI-SEAS: Hawaii Space Exploration Analog and Simulation

Kim Binsted and Jean Hunter

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HI-SEAS (Hawaii Space Exploration Analog and Simulation) is a habitat on an isolated Mars-like site on the Mauna Loa side of the saddle area on the Big Island of Hawaii at approximately 8200 feet. HI-SEAS is unique, in addition to its setting in a distinctive analog environment, as:

- We select the crew to meet our research needs;
- The conditions are explicitly designed to be similar to those of a planetary exploration mission;
- The site is accessible year round, allowing longer-duration studies than at other locations;
- The Mars-like environment offers the potential for analog tasks, such as geological field work by humans and/or robots.

These characteristics make HI-SEAS ideal for studies in space-flight crew dynamics, behaviors, roles and performance, especially for long-duration missions.

HI-SEAS is funded for its first season in 2013 by a NASA grant, for research focusing on new forms of food and new food preparation strategies for long-duration space exploration. This first mission will involve six astronaut-like crew members living in the habitat for 120 days under Mars-exploration conditions. The crew was selected from over 700 applicants.

There is also great potential for testing hardware, software, and system integration for surface exploration at HI-SEAS. Each research season, we will invite proposals for research that takes advantage of the mission scenario to address NASA's priorities. During the 2013 season, such projects will include those on communications software, rover operations, anti-microbial materials and sleep disruption countermeasures, amongst others.

Finally, HI-SEAS will be a valuable resource for education and public outreach, and the project has already generated a great deal of media coverage. Potential activities include undergraduate research projects, high-school robotics competitions, visits by community groups, and so on. The habitat is portable, so could visit other Hawaiian Islands, or even sites outside of Hawaii.

Micro-Rover Design and Navigation with Minimal Sensors

Britton, Nathan J.; Yoshida, Kazuya; Walker, John D.; Haninger, Kevin; Nagatani, Keiji

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A 10kg lunar rover prototype, code-named Moonraker, is being developed to investigate potential low-power, low-mass, and low-cost solutions for lunar exploration in the near future. It is equipped with four wheels, a hyperbolic mirror omni-camera and a MEMS mirror based laser rangefinder (FX8). The Google Lunar X-Prize (GLXP) team White Label Space (WLS) shared their mission requirements in order to help the Moonraker team ground the project's research to a near-future practical case study.

Achieving optimal travel performance over the soft, loose regolith found on the Moon and Mars is essential, since slippage on such soil can lead to wasted energy and immobilization. Moonraker was therefore designed with a high wheel diameter to body size ratio to minimize slippage. Grousers attached to the surface of the wheel are used to increase traction.

An optical-flow algorithm, which tracks features found around the rover as it moves, is implemented with images from the omni-camera. This algorithm estimates the distanced traveled, also using data from an IMU and odometry from the motor's wheels. The FX8 laser rangefinder, with a fixed 50 x 60 degree field of view, gathers snapshots of 3D point cloud data from the environment directly in front of the rover. This information is used for close-proximity obstacle avoidance.

This information from the sensors helps the rover operators to more quickly and easily understand the location of the rover and its immediate environment with a minimal set of lightweight sensors. Moonraker was taken for field tests to Izu-Oshima in Japan to assess the mobility and sensor systems and the results are presented here.

International Observatory Association November 2012, 4 Mission Update

Steve Durst, Joseph Sulla, Phil Merrell

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International Lunar Observatory Association, Space Age Publishing Company, Galaxy Forum program

With four active lunar missions and a robust 21st Century Education program, ILOA continues to establish its position as a leader in the field of Observation / Astronomy from the Moon. These four missions will allow the International ILOA team the opportunity to observe the Galaxy / Stars, local lunar environment and Earth with various wavelengths and from various lunar locations, while also helping to secure Hawai`i's leadership in Astronomy for the next 100 years.

ILO-1, the original ILOA mission will see a multifunctional 2-meter dish observatory placed on a PEL near the South Pole of the Moon. The mission (NET 2014) will conduct radio astronomy, including Galaxy First Light Imaging Program; and Commercial Communications, including Space Calendar Lunar Broadcasting, while serving as a catalyst for lunar base buildout.

ILOA is teaming with the Google Lunar XPrize Team Moon Express on a precursor mission known as ILO-X. For this mission, ILOA will place a 10-cm optical telescope on the team's lunar lander scheduled for 2014.

In September 2012, ILOA signed a MoU with the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC-CAS) allowing ILOA scientists to conduct Galaxy Observations with the UV telescope set to fly on the Chang'e-3 lunar lander in 2013.

Galaxy Forum is a successful 21st Century Education Program held regularly in cities and countries all over the world. Already active in Asia, North America, Europe, Africa and Hawaii, the program will expand to South America, Antarctica and Southeast Asia 2013-2014. The Forums connect Galaxy researchers and local educators to help bring Galacticity / Galaxy consciousness into classrooms.

ILOA is now part of a distinguished team of organizations conducting a cutting-edge study on achieving an Independent Human Moon mission within the decade.
In 2013, ILOA will continue to advance / expand its Global Headquarters on Hawaii Island

Interorbital Systems' NEPTUNE Modular Rocket and Personal Satellite Kit-and-Launch Program: Revolutionizing Low-Cost Space Access

Randa Relich Milliron

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Randa Relich Milliron, Interorbital Systems' Co-Founder, is also the corporation's Chief Executive Officer. Her professional experience spans the space industry, the television and film industries, and academia. She served as a Television News Director and Producer at AFN Berlin. For over a decade, Ms. Milliron has taught televi¬sion production, communication, and science courses at colleges in Europe and America, and is currently on faculty with the University of Phoenix. Randa holds a BA in Psychology and an MA in African Languages from Duquesne University, with additional studies in Chemistry at Cal Poly Pomona. An award-winning television director/ producer, Randa is in charge of all Interorbital Systems' marketing and public relations. In an engineering capacity, she specializes in the development and use of high-temperature composite materials.

The expense of buying passage for a small satellite payload--- tens to hundreds of thousands of dollars--is often more than a small business or an academic institution can afford, and usually more than a government or military entity would like to spend. Waiting for an opportunity to launch as a secondary payload is often a frustrating, if not endless process. Global competitions among hundreds of student satellite projects for these rare flights leave all but the one or two lucky winners without a ride to orbit. An inexpensive, dedicated rocket and low-cost launch services are urgently needed to carry small experimental, academic, government, and military payloads to orbit. Interorbital Systems' NEPTUNE modular rocket, and its TubeSat and CubeSat Personal Satellite Kits will fill that need. The NEPTUNE rockets can be configured from 7 to 36 modules to meet any mission requirement from LEO lift to Lunar cargo and passenger needs. Interorbital plans to operate its initial launches from the ocean, using a California port for polar launches and an Hawaiian port for equatorial launches. The NEPTUNE rocket is designed to launch up to 30 picosats at a time, for as little as $8,000 each (academic kit-and-launch price). With breakthrough, game-changing technology that provides low-cost access to space, Interorbital' satellite kit-and-launch system will serve as an enabler for orbital space-science experimentation. Academia, citizen scientists, artists, musicians, corporate researchers, and the military have purchased kits and launches for some 45 small satellite projects. The kit-and-launch program promotes discovery through real experimentation instead of simulation; it provides a platform for the integration of scientific theory and praxis through hands-on science; it encourages the application of operational mechanisms and new student-designed uses for spacecraft; and it is currently serving as a STEM tool for use from Middle School through University levels curricula worldwide.

TRANS LUNAR RESEARCH: ACTUALIZING PRIVATE SECTOR MOON MISSIONS

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Trans Lunar Research (TLR) is working toward the creation of a permanently inhabited lunar station. Components of the TLR plan include using a low-cost rocket transportation system for cargo and passengers (Interorbital Systems' NEPTUNE launchers); establishing a lunar base, and creating outpost power, water, and oxygen utilities. The program is currently self-funded by a series of planned lunar sample return missions and numerous satellite projects. The mission's primary hardware component is the RIPPER or Robotic Interplanetary Prospector Excavator and Retriever. RIPPER is an autonomous system, designed to soft-land on the moon or any other body in the Solar System, select surface samples, then excavate and retrieve them for return to Earth. It is an automated two-stage spacecraft and Earth Reentry Capsule (ERC) designed to land on and return samples from the smaller extraterrestrial bodies in the Solar System, including moons, asteroids, and comets. RIPPER weighs 1,400-Lbs. (635-Kgs). It will be launched by the IOS Neptune 36 (N36) rocket. RIPPER will land on the Moon without going into lunar orbit (Lunar-Direct Landing). RIPPER will spend several hours on the surface of the Moon collecting and storing samples before the RIPPER Earth Return Stage (ERS) is started. The ERS will launch the Earth Reentry Capsule (ERC) on an Earth Direct Trajectory (EDT) and land by parachutes. RIPPER's first stage will remain on the Moon carrying out photographic activity, and transmitting the pictures to Earth. These off-world samples will be the rarest minerals on Earth, and will be made available to research institutions and private collectors at a fair price. Eight orders are already in place for the first mission's harvest. Interorbital Systems is also the launch provider for the Google Lunar X-PRIZE Team, SYNERGY MOON.

Lunabotics Mining Competition: Inspiration through Accomplishment

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ABSTRACT

NASA's Lunabotics Mining Competition is designed to promote the development of interest in space activities and STEM (Science, Technology, Engineering, and Mathematics) fields. The competition uses excavation, a necessary first step towards extracting resources from the regolith and building bases on the moon. The unique physical properties of lunar regolith and the reduced 1/6th gravity, vacuum environment make excavation a difficult technical challenge. Advances in lunar regolith mining have the potential to significantly contribute to our nation's space vision and NASA space exploration operations.

The competition is conducted annually by NASA at the Kennedy Space Center Visitor Complex. The teams that can use telerobotic or autonomous operation to excavate a lunar regolith geotechnical simulant, herein after referred to as Black Point-1 (or BP-1) and score the most points (calculated as an average of two separate 10-minute timed competition attempts) will earn points towards the Joe Kosmo Award for Excellence and the scores will reflect ranking in the on-site mining category of the competition. The minimum excavation requirement is 10.0 kg during each competition attempt and the robotic excavator, referred to as the "Lunabot", must meet all specifications.

This paper will review the achievements of the Lunabotics Mining Competition in 2010 and 2011, 2012 and present the new rules for 2013. By providing a framework for robotic design and fabrication, which culminates in a live competition event, university students have been able to produce sophisticated Lunabots which are tele-operated. Multi-disciplinary teams are encouraged and the extreme sense of accomplishment provides a unique source of inspiration to the participating students, which has been shown to translate into increased interest in STEM careers.

Our industrial sponsors (Caterpillar, Newmont Mining, Harris, Honeybee Robotics) have all stated that there is a strong need for skills in the workforce related to robotics and automated machines. In 2010, 22 United States (US) universities competed, and in May 2011 the competition was opened to international participation, with 46 Universities attending. There were 12 international teams and 34 US teams. In 2012, 55 teams participated with 19 International teams from 8 countries. Over 600 students participated / 3,000 viewers average on NASA Edge Streaming. Over 100 community volunteers were at the 2012 competition including 17 Judges from across the USA.

Many more students and the public were engaged via internet broadcasting and social networking media. This is expected to be of value for actual future space missions, as knowledge is gained from testing many innovative prototypes in simulated lunar regolith.

More information is available at www.nasa.gov/lunabotics/.

In Situ Resource Exploration by Humans in Planetary Analog Environments

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Planetary surface exploration holds the key to furthering our understanding of other worlds, paving the way for resource exploitation and eventual human inhabitation. Mission simulations in analog environments on Earth play an important role in developing technologies and procedures to ensure maximum return on future planetary missions. This presentation highlights two analog missions aimed at searching for subsurface water and highlights examples of analog exploration in Hawaii. The author welcomes opportunities for collaboration on projects related to planetary surface exploration and manned mission simulation.

Geophysical methods are the primary noninvasive means to explore a planet's interior and search for resources. The author carried out three geophysical experiments in analog environments in order to better understand the challenges future astronauts will face when conducting similar surveys on Mars or the Moon. The experiments included a passive seismometer deployment and a time domain electromagnetic survey at the Flashline Mars Arctic Research Station (FMARS) on Devon Island, Canada during July 2009 and an active seismic refraction survey at the Mars Desert Research Station (MDRS) in southeastern Utah during February 2010. The seismometer offered useful lessons for installing and operating the equipment by astronauts wearing space suits. The electromagnetic survey provided estimates of subsurface resistivity and depth to the groundwater table. The active seismic survey utilized a rover-towed geophone land streamer and ground-penetrating radar to identify a buried paleochannel feature analogous to those observed on Mars. Future areas of development relate to astronaut user interface improvements and robotic automation.

With its diverse geology and year-round mild climate, Hawaii has a long history serving as a planetary analog testbed stretching back to the Apollo program in the 1960s. The PISCES organization facilitated in situ resource utilization technology field tests on Mauna Kea with partners from NASA, CSA, and private industry during field campaigns in 2008, 2010, and 2012. It is also helping to enable the HI-SEAS project, which will carry out a 120-day crewed mission simulation on Mauna Loa in 2013. There is a tantalizing opportunity for merging these technology demonstration and human missions together in future field campaigns. In addition, with Hawaii's strong relationship to NASA and its status as a world leader in oceanographic innovation, it stands to reason that the ill-fated NOAA/NASA NEEMO underwater analog mission simulation program could find a new home in the Aloha State.

Engaging in PISCES Research & Development with Aloha

Rice, K. 1

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Science and engineering facilities in Hawai'i have substantial numbers of researchers and technicians who come to the Islands to work. Conflicts, real and imagined, existing between the local culture and the scientific community is well known, with an "a`ole Maunakea"¸or "get off our mountain," undercurrent persisting across many communities. Through interactions with kama `aina, and related literature surveys, an active and purposeful strategy to implement explicit efforts that can serve to help heal an Island - science conflict. We are working with communities to develop a limited, but highly respectful, professional development program for residential and visiting scientists and engineers, to help them come to understand the vital relationships between science, technology and Hawaiian culture. Pono is a Hawaiian concept that doesn't translate very well into English; it means "right," but can also be understood to mean "whole" or "healthy." One can be pono, have pono, or make a situation or other person pono. It is clear that most Island scientists and engineers, as well as visitors, are well aware that things are not quite pono, and genuinely desire to become more educated about the intimate relationships between the island and culture. This program will be open to researchers and others involved in island operations, first through PISCES facilities, then to the larger scientific community at professional conferences. The CAPER Center for Astronomy & Physics Education Research will begin with face-to-face programming on Island, and will expand to pre-conference workshops at American Astronomical Society (AAS), spring meetings of LPSC, summer meetings of NLSI, fall meetings of DPS, as examples, with the potential extending reach even farther with virtual training programming. Participants will receive "certification" when they complete the program.

A Collaboratively Developed PISCES & CAPER Plan for Education, Outreach, and Workforce Development

Stephanie J. Slater

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The initiation of PISCES presents a unique opportunity to develop, from the ground-up, a coherent and effective strategic plan to develop the upcoming work force, provide educational opportunities, and conduct public outreach across the Pacific basin. As PISCES is in many ways an engineering-based endeavor, a PISCES & CAPER STEM education portfolio can be engineered to reflect current cognitive and education research in the learning sciences. Working closely with cultural, education, and business stakeholders in Hawai'i, the CAPER Center for Astronomy & Physics Education Research is committed to collaboratively implementing, and rapidly scaling, initiatives of: a broad-spectrum support program to grow engagement in contiguous K-12 engineering robotics programs; create an annual STEM Congress supporting community members to engage in research relevant to Island sustainability, the PISCES mission, and their own local communities, highlighted by an annual meeting of the Congress for sharing of information and lessons learned; a Young Scholars summer Program engaging 12-15 year old students as interns with Island-based technicians, engineers and scientists; a remote STEM research program for 16-19 year old students; a community oriented mentoring program of college students helping younger students along a technical career pathway; a clearing house and training center sharing cross-disciplinary, culturally appropriate, STEM curriculum materials for the K-12 classrooms; cultural training programs for researchers working on the Island, and a public engagement program throughout the year at Hawai'i community events, including an Island-style "Punkin Chunkin" event called "Coconut Catapults" where teams of high school students collaborate with their families, friends, and teachers to create catapults, trebuchets, and rockets.

Need for and Function of a Proposed STEM Advancement Foundation

Slater, T.F. and Slater, S.J.

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A collaborative PISCES & CAPER workforce development, education, and outreach program is well positioned pursue funding opportunities, through extramural and philanthropic sources. Such development efforts can grow and extend PISCES & CAPER programmatic reach, allowing us to increase the size of students and teacher cohorts, and the number of program sites. We argue that this can be better rounded out by the creation of a nimble and straightforward non-profit foundation in rapid-response and flexible ways that University- or corporate-based entities cannot. While some of these partnerships may result in dollars for programs, equally valuable are others which can result in in-kind contributions. For instance, refreshments are an important part of any student or teacher gathering, and funds will be required for our student groups that may need to travel, on- or off-Island. PISCES & CAPER can partner with a local business to provide after school program snacks, treats at Family Astro Events, travel scholarships to students competitions, etc. While these funds will be unlikely to represent a large portion of any core operating budget, such Island-based partnerships are important for other reasons. For PISCES profile in Hawai'i, it is more consistent with the Hawaiian way to promote a workshop for teachers is sponsored by, for example, Big Island Toyota and PISCES, that an underwater vehicle robotics team is sponsored by, for example, Kona Subway and PISCES, or that a science fair student's travel is being supported to an international science fair by, for example, Subaru and PISCES. On the Islands, laulima, or the idea that "we do this together," is core to the culture, and attempts to collaborate and lend a hand through in-kind contributions, is itself an important and highly valuable form of engaging with the Island community

Multiple reflected seismic lunar waves and core of the Moon

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The initial stage of development of nonlinear seismology was sufficient for attempt to transfer terrestrial experience on studying of lunar seismicity and the analysis lunar seismograms. Features of geological structures of the Moon and the form of records seismograms became the precondition and the certificate of existence strong modulation effect. As well as in the general physics modulation in lunar seismology (as well as in terrestrial) - change under the known law (the law of external influence) in time of parameters of a seismic wave field. Therefore understanding of that and the account of nonlinearly of processes have resulted in reception of significant results on cosmology and to an internal structure of the Moon. The above-stated results and the common understanding have allowed to accept not only nonlinear model of seismicity of the Moon but also existence of seismic acoustic processes and first time seismic acoustic emission. Studying of forms and structures seismograms allows to draw the following conclusions: (1) lunar seismogram as records of a seismic signal or event usually consist of one or several parts of which duration and quantity is connected to energy of initial event; (2) the characteristic forms of lunar seismogram similar to forms of seismic acoustic emission on records of seismic acoustic noise on the Earth especially for seismic active zones and during activation of the nearest faults; (3) lunar sites of records seismogram as well as envelope of seismic acoustic emission signals on the Earth records satisfy to the typified forms of signals inherent in processes of micro - and macro destruction and plastic deformation of a firm body and rocks, and are characterized by a similar range of frequencies and energy. Therefore for lunar records of signals with the big amplitude the seismogram will analize on three components. This is a clue for search and select of lunar seismograms which is a result of a multiple reflected waves (MRW) exist. Deep faults of the Moon will help to existing of that waves. In accordance to property of MRW and lunar faults only code of Z component of seismic signal will be contents peculiarity which connect with existing of MRW. Really despite of a lot of significant spectral peaks of realization codes X components kepstrum of this spectrum has not strongly pronounced significant peaks and represents smooth enough falling down curve that testifies to absence in researched process of multiple waves, or proves absence of lamination (reflecting borders) in a direction X component. Thus spectral peaks are caused or free Moon oscillation, or own oscillations of registration region. On the other hand, the spectrum of realizations Z making has powerful strongly pronounced spectral peaks, as well as its kepstrum. The last proves existence of horizontal lateral lamination or reflecting borders in region of registration which are the

reason appear of a multiple reflected waves too. The seismic data of two impact of meteorites was used. Statistic analyze (spectrums, kepstrums) of all seismograms was presented on 10 tables but the results of discovered of a multiple reflected waves presents by one table where is the comparison between the recorded characteristics times (periods) of that waves and known periods which received from known geologic models of the Moon .

The general conclusions.

1. Deep breaks of the Moon promote formation from powerful impact sources of multiple waves such as type PKiKP, and also PcP etc.
2. Time characteristics processes of modulation by lunar oscillations and multiple waves are an authentic material for research of an internal structure of the Moon.
3. The place of landing of lunar stations is necessary for choosing in view of registration of multiple waves.

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Lunar seismicity, solar wind, solar oscillation.

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Total primary energy impact of solar flares on the moon has several components and can be compared with the kinetic energy of a large meteorite. Because the meteorite impacks is an important part of the seismicity of the total lunar, the search of solar lunar seismicity is equally important scientific interest, especially as previously noted the connection between the Sun and the solar activity and lunar seismicity [1…3]. The most targeted results are presented in [3]. Further research should be expanded to more widespread use of Nakamura's Catalogue (CN) and the parameters of the new features of the Sun and the solar wind [4]. Therefore, in addition to searching seismograms, the consequences of exposure to the lunar surface of interplanetary shock waves (MSY) flare origin, should be analyzed and the characteristics of the wave field (the duration of the seismograms) and assess the prospects of using the Moon as a detector of external influences. The end result of the proposed study was the discovery of seismograms with durations that coincide with periods of the oscillations of the Sun's own, their connection with solar activity (flares), and the prospect of using the Moon as a detector of solar activity.

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