

PISCES UPDATE

Presentation

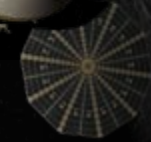
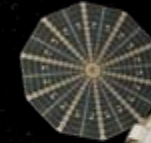
1/28/09

1:30pm

Dr. Frank Schowengerdt,
Director of PISCES



Pacific International
Space Center for
Exploration Systems



An Update

Dr. Frank Schowengerdt, Director of PISCES

*Presented to a Joint Meeting of the Higher Education and
Economic Development and Technology Committees,
Hawai`i State Senate
January 28th, 2009*

VISION

***An International Research and Education
Center Dedicated to Sustaining Life on
the Moon and Beyond***




GOALS

- **To Become an Intellectual Leader of Thought Enabling Human Settlement of Space, Focusing on Lunar Human Ecology: Consumables, Energy, Materials**
- **To Promote STEM Education**
- **To Engage in Public Outreach**
- **To Conduct Tests, Demonstrations and Astronaut Training**
- **To Build Three Major Facilities: Base, Test Site and Analog Lunar Outpost**

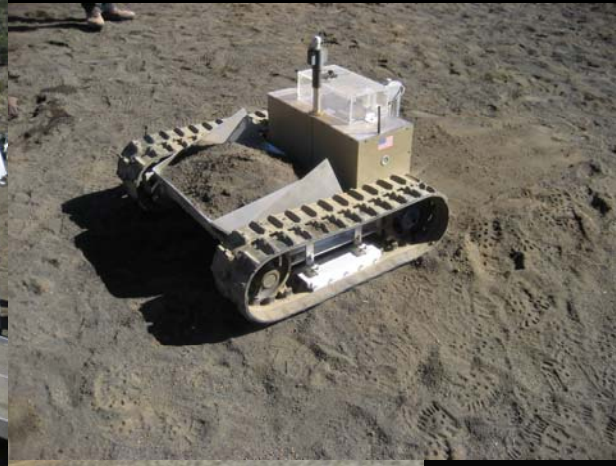
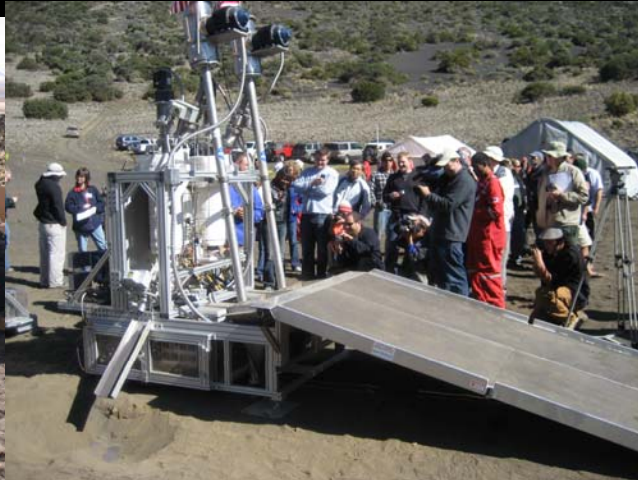
Major Developments

- **International Testing Program**
 - **Research Proposals**
 - **National Student Design Competition**
 - **National Space Seminar**
 - **Prototype UHH Space Curriculum**
 - **Public Outreach**
- 

Testing Program

- **NASA, CSA, DLR, JAXA, L-M, Others**
 - **November 2008 – 3 weeks, over \$700K**
 - **Involved over 80 scientists, engineers**
 - **Produced Oxygen and Water**
 - **Many lessons learned**
- 
- A photograph of an astronaut in a white spacesuit floating in the dark void of space. The astronaut is positioned in the lower-left quadrant, with their body angled towards the right. The background is a vast, dark expanse of space, with a thin, curved horizon line of a planet's surface visible in the upper portion of the frame. The lighting is dramatic, highlighting the astronaut's suit against the deep black background.

Test Site



Proposals

“Lunar Human Ecology” – NASA Lunar Science Institute

***In collaboration with UHH College of
Agriculture, University of Houston, Colorado
School of Mines and Lockheed Martin
\$ 4.249 million over four years (not funded, but
will be resubmitted)***

Proposals

“ Ua Ao Hawaii: The Dawning of a New Era In Human Exploration ”

***In collaboration with Aha Punana Leo
and `Imiloa Astronomy Center***

~\$ 1.6 million over four years (pending)





Pacific International
Space Center for
Exploration Systems

Proposals

“Using a mixed reality collaborative framework for sortie planning, training and execution”

In collaboration with UH Manoa

\$ 1.287 million over four years (pending)

Proposals

- **New Submissions:**
 - **Moon and Mars Analog Mission Activities (MMAMA)**
 - **Excavation (\$75K)**
 - **Drilling (\$75K)**
 - **Remote Robotic Control (\$75K)**
 - **NASA-Glenn/Honeybee Robotics (\$75K)**
 - **Honeybee Robotics/Oceanering (\$75K)**
 - **NASA/Steckler Space Grant**
 - **Research and Education for Lunar Colonization**
 - **thru Hawai`i Space Grant Consortium (~\$1M)**



Pacific International
Space Center for
Exploration Systems

Student Design

2008 Winners

**Honolulu Community College
Colorado School of Mines
University of Colorado**

2009 Winners

**Virginia Polytechnic Institute
Massachusetts Institute of Technology**



Pacific International
Space Center for
Exploration Systems

National Space Seminar

- **George Raiche**
- **Dan Rasky**
- **David Morrison**
- **Peter Schultz**
- **Pete Worden**
- **Kathy Olsen**
- **Paul Graziani**
- **George Nield**
- **Scott Hubbard**
- **Tom Crabbe**
- **Jim Ryder**
- **Lori Garver**
- **Elon Musk**
- **Yvonne Cagle**
- **Steve McLean**
- **Gary Payton**



Pacific International
Space Center for
Exploration Studies

Space Studies Curriculum

Physics/Astronomy 111

Physics/Astronomy 224

Physics Astronomy 230

Kinesiology 224

Computer Science 136

Astronomy 281 (UHM)

English 760Q (UHM)

Philosophy 255 (HonCC)

Political Science 342 (UHM)

Intro to Space Exploration

Space Flight

Applied Electronics I

Physiology and Space Flight

Computing with Robots

Astrobiology

Science Fiction

Cosmology

Space Settlements



Pacific International
Space Center for
Exploration Systems

Public Outreach



Kamehameha Schools



Pacific International
Space Center for
Exploration Systems

Public Outreach



Keakuana Schools



Pacific International
Space Center for
Exploration Systems

Public Outreach



PISCES-NASA Day at Imiloa



Pacific International
Space Center for
Exploration Systems

Public Outreach



PISCES-NASA Day at `Imiloa



Pacific International
Space Center for
Exploration Systems

Public Outreach

Other PISCES Outreach Events in Hilo:

- Onizuka Day
- Journey Through the Universe
- JTTU Family Science Day at `Imiloa
- Hawaii Science and Engineering Fair
- Hawaiian Family Affair Day
- Merrie Monarch
- Astro-Day
- Robo-Fest



Pacific International
Space Center for
Exploration Systems

Public Outreach

State and National PISCES Outreach Events:

- **Discovery Channel (upcoming)**
- **NPR Interview**
- **Channel 9 Morning Show**
- **Associated Press Interview and Article**
- **NASA Press Releases**
- **Pacific Business Journal**
- **Honolulu Advertiser**
- **Star Bulletin**
- **National Geographic**
- **MSNBC**
- **Over 60 lesser national outlets**

Benefits

- **Attract High-Tech Industry**
- **Create Space-related Jobs, Which Pay Twice The National Average**
- **Strengthen Higher Education At UH Hilo**
- **Inspire K-12 Students To Study STEM Disciplines**
- **Involve Local Community**
- **Publicize Hawai`i As Space Leader**

Summary

- **PISCES is a reality, currently Funded by the State of Hawai`i and NASA, attracting attention from all across NASA, JAXA, CSA, DLR and international industry.**
- **PISCES is a long-term proposition, with a 10-year Strategic Plan to grow into a major force for global space exploration.**
- **Education and Public Outreach are PISCES priorities**
- **PISCES depends on partnerships.**

Thank You!



From the PISCES Community

PISCES UPDATE

Presentation

1/28/09

1:30pm

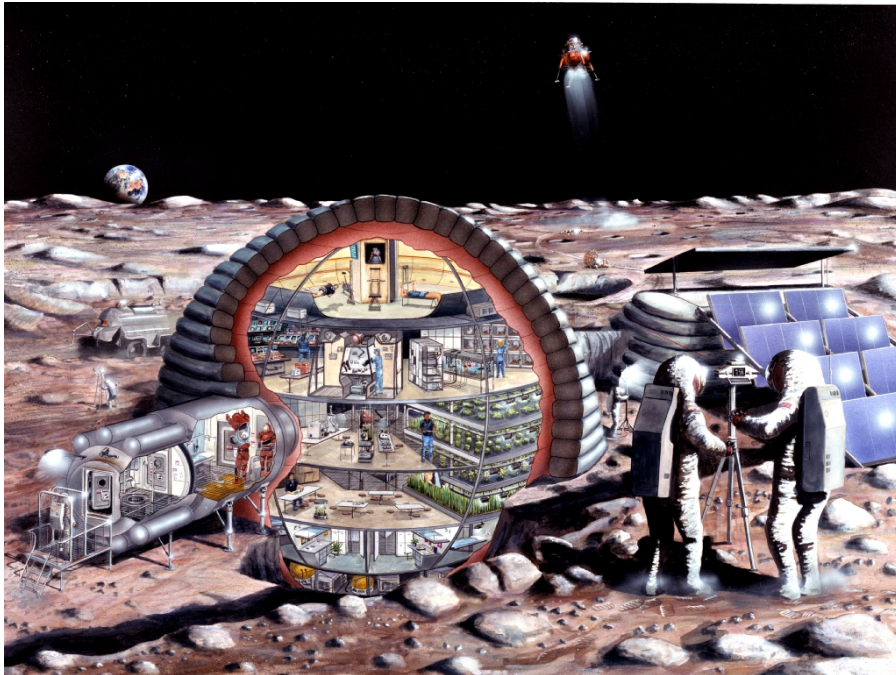
Dr. Frank Schowengerdt,
Director of PISCES



Pacific International
Space Center for
Exploration Systems

STRATEGIC PLAN

2007-2017



Artist's Conception of a Large Lunar Outpost (NASA)

June 20, 2008

Table of Contents

Executive Summary	4
Introduction.....	6
PISCES Research Program.....	7
ISRU Program Plan.....	8
Introduction.....	8
ISRU Field Demonstrations.....	8
ISRU and the Analog Lunar Outpost.....	9
ISRU Research.....	9
ISRU Education and Outreach.....	10
A Strategy For Building ISRU Capabilities in PISCES	10
Robotics Program Plan	11
Introduction.....	11
Goals	11
Implementation	11
Higher Education Program Plan	14
Introduction.....	14
Courses.....	14
Certificate and Degree Programs	14
Faculty.....	15
K-12 Education and Public Outreach Program Plan.....	16
Introduction.....	16
Common Messages	16
Key Audiences and Messages.....	16
Media Relations	19
Media Opportunities	19
Priority Action Items.....	20
Student Design Program Plan	21
Facilities Plan.....	22
Introduction.....	22
Field Test Site	22
Base Facility.....	23
Outpost.....	23
Fundraising Plan	27
Introduction.....	27
Goals of the Capital Campaign.....	27
Objectives of the Capital Campaign	27
Implementation	28
Schedule.....	29
Government and Industry Stakeholder Participation Plan.....	30
Introduction.....	30
Development of PISCES Visual Aids.....	30
Identification of Government and Industry Stakeholders	30
Initiate Stakeholder Outreach	31

Business Operating Plan 34
Introduction..... 34
Customers 34
Services..... 34
Market Analysis: Characteristics and Scope..... 36
Market and Sales Strategy 38
Development Approach 39
Operations Approach 39
Financial..... 41
Summary and Conclusions 43

Executive Summary

The Pacific International Space Center for Exploration Systems, or PISCES, is a research and education center dedicated to the development of technologies to sustain life on the Moon and beyond. The Center is based at the University of Hawai'i at Hilo. The overarching goal of PISCES is to become an intellectual leader of thought in the emerging field of research that will enable human settlement of space. PISCES is the only center in the world focused on this goal.

PISCES will pursue research, education and public outreach. Research will focus initially on *In-Situ* Resource Utilization (ISRU) and robotics, expanding to include agriculture, energy, materials and other pertinent areas in the physical and biological sciences, engineering and the social sciences. Educational activities will include a degree program in space studies based at UH-Hilo, with involvement from other UH campuses. Courses for that program are being designed and one has already been taught. Outreach to the local community, particularly the K-12 schools in Hilo and elsewhere on the Big Island, will be a prominent component of PISCES through such existing programs as SpaceClass, a web-based program offered free to schools, and others being designed. Part of the outreach effort includes a recently formed Hawaiian Cultural Advisory Council.

PISCES will build three major facilities: 1) field sites for testing rovers and ISRU systems; 2) an on-campus base facility housing classrooms, laboratories, offices, shops and assembly areas; and 3) a simulated lunar outpost featuring habitats, an agricultural area, a solar cell farm, pilot-scale processing plants, other elements of an actual lunar outpost and a public viewing station. Technologies developed in PISCES and elsewhere will be tested, matured and integrated as appropriate into the operating outpost, in collaboration with governmental space agencies, partnering universities and industry.

Capital funding will be raised through a major campaign to be conducted in the 2009-13 timeframe. Potential funding sources include individuals and foundations having interest in space exploration, economic development through high-tech research, educational enhancement and job creation on the Big Island and elsewhere in Hawai'i, the Hawai'i legislature and the federal government. The capital campaign will be overseen by a national advisory group. The campaign target is approximately \$19 million for facilities and \$6 million to partially endow new faculty positions at UH-Hilo.

The PISCES business operating plan follows the model of an industry/university/government partnership center, which is predicated on leadership by faculty members of the host institution and partnering universities, coupled with involvement of companies from the U.S., Japan and other spacefaring nations, particularly those along the Pacific Rim, and assisted by a business development office. The major sources of operational funding will include the National Aeronautics and Space Agency (NASA), the Japan Advanced Exploration Agency (JAXA) and other space agencies, particularly those along the Pacific Rim of nations, augmented by private industry from all the participating countries. Annual operating revenues and expenses are projected to be approximately \$6.5 million at the end of the 10-year planning period.

The primary customers of PISCES are the State of Hawai'i, its citizens and the residents of Hilo and the Big Island; the research and technology development program managers in NASA and other space agencies; researchers and program managers in the space-related industry; and the taxpayers of the U.S. and other spacefaring nations.

The benefits of PISCES are economic development in Hawai'i, increased educational opportunities for the residents of Hilo and the Big Island, job creation as a result of PISCES operations and spin-out companies, enhancement of visibility and prestige for Hawai'i among spacefaring nations and new technologies for space exploration and off-Earth living.

This Strategic Plan charts a course for PISCES through the year 2017, which, according to current NASA plans, will be just before the return of the U.S. to the Moon with the first manned landings and several years prior to the emplacement of an actual outpost. PISCES will thus be ready to play a major world role in the exploration and settlement of space. A schedule for the development of PISCES is shown in Figure 1.

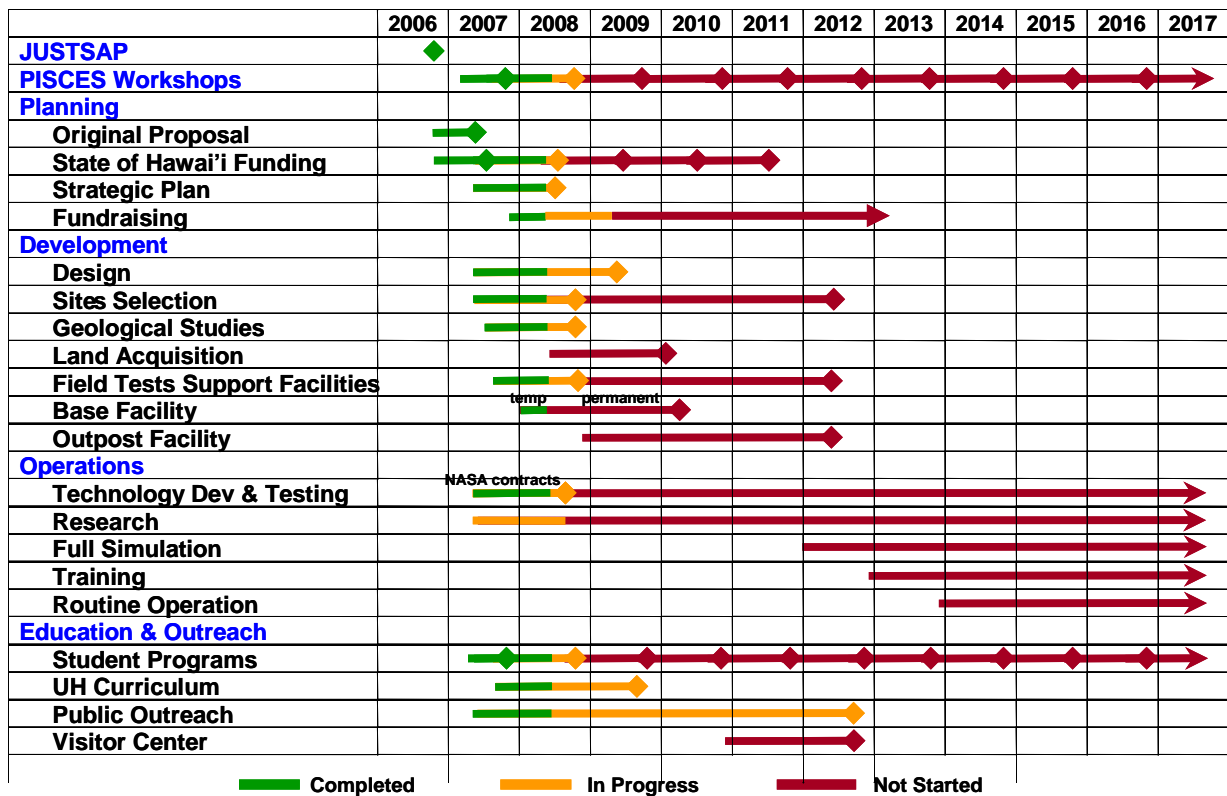


Figure 1. PISCES Developmental Roadmap

Introduction

PISCES was conceived by the Japan-U.S. Science, Technology & Space Applications Program (JUSTSAP) under the auspices of the Hawai'i State Department of Business, Economic Development & Tourism (DBEDT). An official Center was created in March 2007 at the University of Hawai'i at Hilo and was funded by the Hawai'i State Legislature in June 2007. PISCES has since received funding from NASA in the form of two projects for field testing of robotic and ISRU systems and has proposals pending for other funding.

The Center is being built on partnerships between industry, academia and the governments of space-faring nations around the world, but particularly those on the Pacific Rim, of which Hawai'i is the approximate geographic center. Five of those nations; the U.S., Russia, Japan, China and India, currently have, or are planning, missions to the Moon.

A major feature of PISCES will be a simulated lunar outpost on the Big Island of Hawai'i, where research will be conducted, new technologies will be developed, students will be educated, astronauts will be trained and the public will be invited to experience first-hand what it will be like to live and work on the Moon and, eventually, on Mars.

Accomplishments of PISCES to date include the following:

- November-December 2006: Proposal Written and Submitted through DBEDT to Hawai'i State Legislature
- January 2007: Student Design Competition Launched
- January-April 2007: SB907 Passes with unanimous support in the State Legislature - \$400K for PISCES - Governor Lingle Signs into Law June 7, 2007
- August: Student Design Winners Selected
- July-August 2007: Three Proposals Written to NASA Innovative Partnerships Program (IPP): 1) ISRU with JSC/KSC, 2) Robotic Tests with ARC, 3) "TWEEL" Tests with JPL.
- August 2007: Proposal Written to NASA's Lunar Advanced Science and Exploration Research (LASER) Program: "Advanced Materials Research at a Lunar Outpost"
- August 2007: Interviews with Local Business, Civic, Government, Education, Cultural Leaders – Much Support for PISCES
- August 2007: PISCES Director and Deputy Director on board
- August 2007: PISCES Office set up in Institute for Astronomy in the UH Hilo Technology Park

- September 2007: Space Science Course Created at UHH – First Offering Spring Semester 2008
- October 2007: Two awards received from NASA for work at and with PISCES - \$640K total.
- September-October 2007: PISCES Video Produced
- November 2006-October 2007: Eleven PISCES Papers/Presentations given at professional conferences around the world (STAIF, JAXA, JAMMS, Tokyo Tech, LPSC, NASA Ames, AIAA, IAC, LEAG, SRR)
- November 7-10, 2007: PISCES Conference, Naniloa Volcanoes Resort, Hilo, HI: Attended by ~100 space professionals from industry, academia and government, and by local business, educational, civic and cultural leaders; keynote address by Lieutenant Governor Aiona.
- December 2007: PISCES Interim Report written and submitted to DBEDT, for forwarding to State legislature.
- January 2008: PISCES Proposal for second-year funding submitted to DBEDT.
- January 2008: PISCES Operations Manager hired.
- January-April 2008: First PISCES course, "Introduction to Space Exploration" offered as part of ASTR 394 – Special Topics in Space Science, at UH-Hilo. Course was filled with enrollment at the maximum of 20 students.
- April 2008: Memorandum of Understanding signed between UH-Hilo and Colorado School of Mines (CSM) for cooperative research between PISCES and the Center for Space Resources, bringing valuable expertise in *In-Situ* Resource Utilization and Materials Science into PISCES. This MOU is the type of partnership agreement that will lead to stronger PISCES activities and greater support by funding agencies.

This Strategic Plan will take PISCES from its current startup status through major development phases to routine research, education and simulation of lunar living in preparation for those landings. In the sections below, the following elements of PISCES will be described and discussed:

- Research
- Higher Education
- K-12 Education and Public Outreach
- Student Design Program
- Facilities
- Fundraising
- Stakeholder Participation
- Business Operating Plan

Resumes of key personnel are included in the Appendix.

PISCES Research Program

For many reasons, a fundamental research program is included in the PISCES Strategic Plan. Research by faculty members and students will ensure that they are knowledgeable about the requirements of field tests. A resident research staff consisting of UH Hilo faculty can take a strategic view of the PISCES analog development program, focusing on studies that advance the long-term objective of outpost self-sufficiency. In addition, such a resident research staff will be mindful of the ways in which research and technology development for the Moon can be applied to opportunities for the use of local materials in Hawai'i, potentially providing local economic benefits.

The following sections will discuss the plans for the ISRU and robotics research programs, which are the most well developed of the PISCES programs and are involved with the upcoming NASA tests in November 2008.

However, these two research programs are just the beginning of the research that needs to be done to learn how sustain life on the Moon and beyond. As PISCES develops and grows, other research areas will be added, such as life support systems, solar energy, communications, agriculture, habitat design and human psychological factors that ultimately will have their own sections in the evolving strategic plan (parallel to the ISRU and robotics sections that are contained in this version). In this regard it should be pointed out that this Strategic Plan is meant to be a living document that will be updated from time to time (at least every other year) as new opportunities emerge and PISCES becomes stronger.



PISCES and NASA Personnel Inspect a Potential Field Test Site at Pu'u Haiwahini Crater

ISRU Program Plan

Introduction

In-situ resource utilization (ISRU) is the discipline associated with developing the processes and uses of local planetary materials in support of space exploration and development. The reuse of materials brought to the planet as part of space missions and the recycling of materials used by human explorers is an allied field. The use of local materials, sometimes called “living off the land,” is central to any plan for the long term sustenance of human outposts on the planets. A vigorous effort in ISRU will be an important part of PISCES.

The materials available on the Moon to support human activities encompass the whole range of materials available on the Earth, though the Moon has not experienced natural processes that have concentrated some rare elements, such as gold, as has been the case on Earth. The absence of an atmosphere and hydrosphere on the Moon limits the availability of volatile elements (particularly hydrogen, nitrogen and carbon) to what can be obtained from the surface rocks and soils. Generally, the abundances of these elements is on the order of 100 parts per million of lunar surface materials (however, they can generally be extracted by simple heating).

Energy in the form of solar radiation is plentiful on the lunar surface and its collection and management is included in the definition of ISRU. If, as some people believe, inexpensive systems can be designed to capture solar energy on the Moon, this energy can be used in part to process native materials in ways that can concentrate and liberate even fairly rare elements. Research in extraction processes, aiming at much-improved efficiency, is a central topic in the ISRU program currently being supported by NASA.

The PISCES strategy for ISRU has three prongs, each designed to be mutually supporting in the building of technology capabilities among the collaborating institutions:

1. Conduct demonstrations of ISRU systems developed by other institutions in PISCES field sites. This will build the community of ISRU developers with which PISCES staff can interact.
2. Incorporate ISRU capabilities into the PISCES lunar outpost simulation facility in order to test interfaces and provide training for crews and ground controllers.
3. Develop PISCES-centered ISRU capabilities at the University of Hawai'i (Hilo and Manoa) as well as in

institutions collaborating with PISCES in developing the lunar outpost simulation facility.

In addition, ISRU can be a significant part of the PISCES education and outreach program. These areas are discussed more extensively in the following paragraphs.

ISRU Field Demonstrations

NASA personnel supported logistically by PISCES will conduct the first field demonstrations in November 2008. The NASA Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) project will test its robotic mounted core sampling system (partly sponsored by the Canadian Space Agency) as well as an oxygen extraction system at the PISCES field site. PISCES will be responsible for providing logistics for the tests. If the tests are successful, they will be expanded to include other ISRU capabilities in 2009. By scheduling field tests well in advance, PISCES will make it possible for various groups to coordinate their field activities. It is possible but not yet confirmed that a demonstration by a Japanese team will be included in the November 2008 tests and discussions are underway to expand subsequent testing to include additional groups.

For the field tests to be carried out in November, NASA has provided the following list of requirements that must be met by PISCES and the test site.

- Site selection, permits
- Site modification plan
- Logistics support and storage
- Field personnel support (food, shelter, medical)
- Assembly, fabrication, support facility (see more detailed description)
- Power (portable) – 30 kW
- Field operations center
- Equipment mobility support (truck, fork lift, etc.)
- Data communications system
- Field communications system (walkie-talkie)

For a continuing testing function, many of these elements will be required from year to year. For that reason, PISCES is evaluating a lease or purchase decision on each of the infrastructure elements. Over a period of time, more of the infrastructure requirements will be accommodated with equipment that belongs to PISCES. The ready availability of systems to support user demonstrations will become one of the

selling points for PISCES in attracting demonstrations to the field site.

Field sites are being selected by users in part because of the existence of surface materials that resemble the fine-grained lunar regolith. PISCES is characterizing these materials from various test sites with the help of NASA's Marshall Space Flight Center and the U. S. Geological Survey. For the November 2008 field tests, PISCES will process approximately one ton of lunar analog material that has been specially dried to more closely simulate lunar materials conditions. At a later time, PISCES will be able to provide small amounts of this lunar analog material to support general ISRU development efforts. In this and all field work, PISCES will consult its Cultural Advisory Council and keep the local community fully informed of its plans.

ISRU and the Analog Lunar Outpost

A long-term goal of PISCES is the development of a full-scale integrated lunar outpost simulation. ISRU systems will be a part of that simulation facility. PISCES will develop standard interfaces between the lunar simulation facility and ISRU systems, which will allow a variety of users to test their systems in the context of a complete lunar outpost. The field tests to be carried out starting in 2008 will, over time, migrate to the analog lunar outpost, which will grow in capability as systems are added. For example, the oxygen extraction system being tested in 2008 could be installed eventually at the analog outpost. This would make very convenient the long duration testing of the hardware, as it could be monitored continuously by analog outpost inhabitants and their support crews.

Some of the capabilities required for the analog lunar outpost will evolve from the field tests. Among the ISRU support capabilities that would be provided by the analog outpost are: power, command and control, surface emplacement and transportation systems (cranes, trucks), product storage, repair and maintenance, and communications links. Observations and recording of the field tests will provide an important database for the outpost requirements

ISRU Research

The PISCES ISRU research plan will focus on the four pillars of lunar self-sufficiency: energy, materials, food and air. Means will be found to collect, distribute and store energy using local materials of the Moon. Many materials, including new materials produced in the unique lunar environment (e.g. high vacuum) will be needed in order to build structures for habitats and workspaces, convey and contain gases and liquids, manufacture utilitarian objects (e.g. wire, ceramics, glassware). Systems for growing food locally will be important for a self-

sufficient lunar outpost and will use locally produced materials both as plant substrates and for the manufacture of enclosures, plumbing systems, and other elements of a closed-loop agriculture system. Capability to generate oxygen, nitrogen and water, obtainable from lunar surface materials, to which Hawaiian volcanic materials are a good first-order analog, will be important. A wide range of material production and manufacturing research in the lunar environment is open to researchers at PISCES and has been little touched by past research.

Two approaches are proposed to build the PISCES research capability: 1) building an in-house PISCES research capability and 2) collaborating with other institutions where research capability not available in Hawai'i exists. A research program will be developed at the University of Hawai'i at Hilo, where there are currently few practitioners of ISRU research, and at Manoa, where a modest capability now exists. However, as this capability is now quite modest and the research opportunities are great, a plan for growth of local research capability in Hawai'i will be included in the PISCES goals. A scenario for that growth is discussed later in this document.

Developing collaborations with other institutions is a good way in which to build a PISCES research program. In 2007 a collaborative proposal to NASA was developed with the Colorado School of Mines. This proposal is to develop the capability to produce solar reflectors using natural materials in glass or ceramic form, shaped into solar concentrators that are given a coating of reflective metal. CSM will develop the materials technology and PISCES will demonstrate its operation in the field. In future years, additional partnerships will be sought at the same time that PISCES is developing its in-house capabilities. The fate of this proposal should be known in the spring of 2008. Others like it in key areas of PISCES interest will be developed in the coming year.

To support a vibrant local research program, new faculty will need to be added either at Hilo or at Manoa. A staff of five researchers (faculty and senior research fellows) could be very competitive in the ISRU research arena. The ability to grow this staff will depend on funding, some of which could be sought from the State of Hawai'i as part of its program to expand educational opportunities for students in Hawai'i. Other funding will be solicited from private donors. Proceeds from successful grant applications could provide operating expenses. The specific topics to be researched will depend upon the strategic goals of PISCES meshed with the interests and capabilities of the research staff. As new faculty is sought at the University of Hawai'i, people should be targeted who have both the experience to work successfully in the ISRU area and the vision to see where the best research paths lie.

In addition to staff, facilities will be required. A well-equipped shop for ISRU work would include such tools as a band saw,

milling machine and lathe, devices for cutting, bending and flaring stainless steel tubing, as well as smaller pieces of equipment. Access to laboratory areas where hardware can be set up and tested and to benches for electronics development is also needed. Computational capabilities for instrument and experiment control will also be required. In the near-term, shop facilities available at the Institute for Astronomy at the University of Hawai'i at Hilo will be sufficient with modest new tool purchases. A well equipped small machine shop containing lathes, drill presses, etc. is being constructed as part of Hilo's new Science and Technology Building. Some special purpose tools may also be included in proposals for specific research studies.

ISRU Education and Outreach

The concept of “living off the land” provides a natural avenue to attract the interest of students and the public. Although ISRU technology will develop processes and capabilities that are tailored to the Moon, the basic idea of wresting metals or water from rocks is exciting to many people and can form the basis for educational programs that emphasize physics, chemistry, geology, and other areas as basic inputs to the ISRU process. To begin this opportunity, PISCES will develop several brochures that can be distributed to visitors and students. Some current themes under consideration are: ISRU and conservation of materials, ISRU as part of pioneering the space frontier and ISRU and space business opportunities.

In addition to outreach potential, the science and practice of ISRU can become the basis for multidisciplinary courses at UH Hilo and Manoa. ISRU technologies will become part of a UH-system-wide program in Space Studies, to be described in the section on Higher Education.

A Strategy For Building ISRU Capabilities in PISCES

The plan for ISRU development at PISCES includes the following goals:

- Support one or two ISRU experiments per year in Hawai'i field locations.
- Initiate research projects on energy, materials, food and air.
- Build ISRU infrastructure (lab, shop).
- Recruit at least two ISRU faculty members for UH-Hilo.
- Introduce ISRU courses at UH-Hilo and UH-Manoa as part of the statewide Space Studies curriculum

If progress is made rapidly on obtaining infrastructure and research funding, the number of faculty members could be

increased to five. A schedule for these early activities is given below:

- 2008-09 Conduct ISRU field demonstrations; Prepare ISRU collaborative proposals; Procure or modify solar concentrator; Prepare UH-Hilo ISRU outreach brochures
- 2009-10 Continue and expand ISRU demonstrations; Prepare ISRU Course Syllabus; Prepare collaborative ISRU proposals; Conduct student design project using solar concentrator-fabrication experiment.
- 2010-2011 Offer ISRU course; Appoint first ISRU faculty position; Continue to expand field demonstrations, ISRU collaborative research; Establish UH-Hilo ISRU laboratory
- 2011-2012 Initiate full-scale ISRU manufacturing research project; Continue to expand collaborative proposal efforts, bringing more to Hilo; Plan ISRU accommodations in PISCES habitat
- 2012-2013 Accomplish goals in field tests, research and education; Initial integration of ISRU into PISCES habitat



Lunar-Like Soil at PISCES Test Site

Robotics Program Plan

Introduction

Robots are expected to play a critical role in the establishment of a permanent human presence on the Moon and beyond. While it is generally agreed that robots cannot and should not replace humans at a future lunar outpost, it is likely that they will be used extensively in cooperative roles. NASA's current plans call for hybrid approaches involving rover-mounted mobile habitats combined with robot-assisted construction and other surface operations. Rovers such as the Jet Propulsion Laboratory's (JPL's) All-Terrain Hex-Legged Extra-Terrestrial Explorer (ATHLETE), JSC's "Chariot" and Carnegie-Mellon University's "Scarab" are early prototypes of the kinds of vehicles that will be used at a lunar outpost. Such vehicles could result in savings of thousands of hours of work by humans for construction, assembly, drilling, material and human transport, repair, maintenance and scientific research and diagnostics, in addition to saving hundreds of tons of up-mass to the Moon due to decreased numbers of astronauts needed to complete the tasks.

Another system under development at NASA is called the Lunar Surface Access and Mobility Module, or LSAMM, to be installed at an early lunar outpost to conduct drilling, scooping, construction and assembly for power and life support installations. Humans will have command and control from space or Earth locations. Humans will use the robots to take over high risk or repetitive functions. Robots will enhance human safety and be teammates with people in the harsh space environment, on almost any terrain, and in almost any task, while under continuous human supervision and control.

PISCES will provide field sites to test robotic systems like these in terrain similar to that found on the Moon and Mars. The Scarab rover has already been scheduled for tests at the PISCES site in early November 2008. But beyond testing, and ultimately of far greater value to the citizens of Hawai'i and residents of the Big Island, PISCES will develop its own robotics research and program involving faculty and students of UH-Hilo and its partner institutions, researchers from participating companies and program managers from international space agencies, including NASA. The robotics research at PISCES will concentrate on developing the technologies needed at a future lunar outpost, but will also actively pursue spin-off technologies that will provide incentive for Earth-based companies to join PISCES and become involved in space-related research, thereby benefiting the local economy. Accompanying the research program will

be a robust educational program that will enhance offerings at UH-Hilo and will be a catalyst for moving the campus more rapidly into engineering education.

Goals

The goals of the program include development of technology, infrastructure and human skills, as described in the following paragraphs:

1. Technology Development: The goal is to build a comprehensive capability to design and test low-cost, efficient autonomous and/or human-supervised robotic systems to assist astronauts in space operations, and to spin off the technologies into terrestrial applications.
2. Infrastructure Development: The infrastructure goals include laboratory and shop facilities for research, assembly and bench-scale testing; high-bay areas for larger assembly and transport; and field areas for realistic test and validation of systems. The field areas will include communications, safety and emergency provisions.
3. Human Capabilities Development: It is essential for PISCES to function and grow so that strong collaboration can develop between the faculties of the University of Hawai'i at Hilo and its partner institutions. The goal is a robotics curriculum taught by experienced faculty who can attract research funding and enhanced by collaborations with other universities, international space agencies and industry.

Implementation

PISCES will develop the capability to create robotic technology for space applications, some of which can have near-term terrestrial use by industry. The long-range vision is an internationally competitive research and education capability, anchored by lunar analog facilities for testing and improving robotic mobility, for robot-assisted construction of simulated lunar settlements and for conducting in-space fabrication and assembly. This vision is closely related to what has been demonstrated on Earth through robots developed for many applications such as the manufacturing, assembly, mining and construction sectors of the economy. An important aspect of the space robotics research at PISCES will be dual-use spinoffs in these and other established areas.

1. Technology Development: PISCES will focus on developing technologies that are central to robotic assistance for humans at a lunar outpost, including:

- Advanced perception and planning
- Tactical and cooperative behaviors
- Scalable human-robotic interfaces
- Command, control and communication systems
- Systems architecture that integrates these capabilities in a robotic system that can look, plan, move, operate collaboratively and perform on command

Technical capabilities will be developed in five major categories:

- a. Material Handling: regolith excavation, drilling, extraction and transport
- b. Material Processing: beneficiation, refining, finishing and final product manufacturing
- c. Automated Construction: assembly, repair, maintenance, construction, deployment and integration of various structural elements for life support, utilities, scientific research, habitats, dismantling and stowing for use in other locations
- d. Human-Robotic Interfaces: enabling seamless cooperative activities, including robotic assistance to humans, the development of human mobility and life support systems.

2. Infrastructure Development: The following infrastructure elements will be located in the PISCES Base Facility:

- High-bay area suitable for assembly and loading of robots
- Laboratories for electronics and avionics; including wired and wireless power generation, power management and storage, wireless communication and computing shop capabilities
- Sensory laboratory for guidance, tracking and control system integration and testing

Because the final systems and architectures for the actual lunar outpost are at various stages of development by NASA and are not at this time selected, it will be necessary for PISCES personnel to be intimately familiar with the research effort that is ongoing within that community. A robotics testing facility will be located in the PISCES analog lunar outpost, to be described in later sections, in terrain similar to the intended landing site on the Moon. The facility will have such subsystems as:

- Habitats
- Power generation and storage

- Communications, computing and networking
- Life support, oxygen and hydrogen generation
- Scientific research

3. Human Capabilities Development: PISCES will assist the University of Hawai'i at Hilo in the hiring of faculty members in the areas of robotics engineering to develop the following capabilities:

- a. To identify the human support and robotics systems needed at a lunar outpost.
- b. To identify needed interfaces between humans and robots for space operations within the space environment.
- c. To identify system and sub-system requirements for a successful analog facility.
- d. To develop requirements for an integrated human-robotics research program that can contribute to space exploration and also benefit the Hawaiian economy.
- e. To create a computer modeling capability for robotic systems that will eventually exist on the Moon or Mars and that can be tested in Hawai'i.
- f. To develop a human-robotics educational component. A statewide program in Space Studies is being planned in conjunction with PISCES. A Space Robotics Systems component will be included in this program.
- g. To create partnerships involving nationally known researchers and potential users of the PISCES facilities. Toward this goal, two field demonstration projects were awarded to PISCES by NASA in October 2007. In one project, NASA-JPL, Carnegie Mellon-University (CMU) and Michelin are to validate robotics technology on the Scarab mobility platform developed by CMU, which also carries a drilling mechanism. In another project, NASA-KSC and NASA-JSC, working with Lockheed-Martin and the Northern Center for Advanced Technology (NORCAT) of Sudbury Ontario, will conduct ISRU tests and operations at the PISCES test site. PISCES will participate in the research and provide logistical support for both of these tests. If these projects are successful in November 2008, they will be expanded in 2009.

4. Schedule of Planned Activities: The following is a list of early activities planned in the robotics program:

<u>2008-09</u>	Conduct robotic mobility platform field demonstrations in support of ISRU collaborative proposals; Develop proposals for NASA Lunar Science Institute
----------------	---

2009-10

Continue and expand robotics tests and demonstrations; In collaboration with the University of Hawai'i faculty, prepare an Automation and Robotic Systems Course Syllabus; Participate in a team collaborating on the NASA-Industry Lunar Science robotic experiment; Acquire or build a simple mobility robot; Begin work with Big Island school robotics teams and sponsor high school robotics competition.

2010-2011

Offer Robotics course; Provide partial funding for a robotics faculty position; Continue to expand field

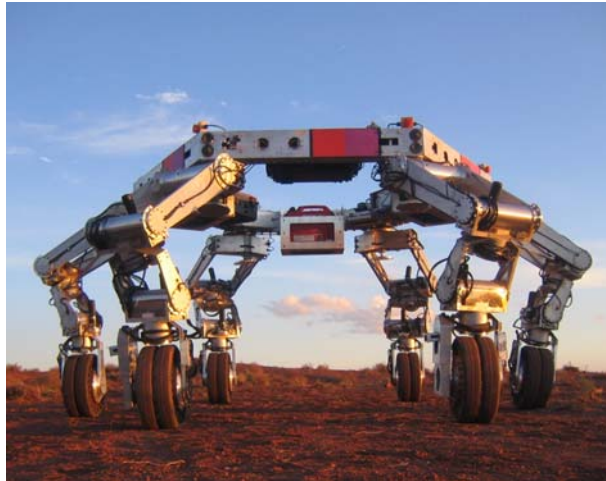
2011-2012

demonstrations, robotic collaborative research; Establish UH-Hilo Robotic Mobility laboratory

Initiate full-scale robotics research projects; Continue to expand collaborative proposal efforts; Plan communication network for remote wireless teleoperation

2012-2013

Accomplish goals for field testing, research and education; Initial integration of robotics into repair, assembly, automated manufacturing, material automated processing, habitat construction and lunar robotic science missions for PISCES



JPL's ATHLETE Rover



Carnegie-Mellon University's Scarab Rover with Canadian-Built Drill

Higher Education Program Plan

Introduction

PISCES is established as an official Center of the University of Hawai'i connected to the Department of Physics and Astronomy at UH-Hilo. The PISCES Mission states, in part:

Education ... will be a major thrust of PISCES, with programs for ... university communities, as well as the general public. With a staff of highly trained scientists and engineers, PISCES will include an active research program in planetary surface technology, with an emphasis on learning to "live off the land" on an extraterrestrial body. Exciting prospects for future planetary exploration will attract both students and the general public...who will observe experiments in progress and learn about our future in space through interactions with PISCES staff and students.

One of the long range goals of PISCES is to assist UH-Hilo in expanding its educational and research capacity into space-related subjects. While particular focus will be on the principal interests of PISCES in developing sustainable human extraterrestrial environments, these efforts will result in broadly increased capacity in the sciences, engineering and educational areas. Toward this end, PISCES envisions the establishment of a UH-Hilo School of Engineering, a UH-Hilo-based multidisciplinary major in Space Studies that can be offered to students throughout the state of Hawai'i (and, with the use of suitable instructional distance technology, around the world), and a center for analog research which makes particular use of the Big Island's unique natural assets.

Courses

PISCES has begun developing a Space Studies program at UH-Hilo by offering a Special Topics in Space Science course, taught by PISCES staff members and subsidized by the Center. In its first semester, 19 students enrolled in this junior-level course, making it the largest upper division Astronomy course on campus. The course is taught by a team consisting of PISCES staff, faculty from the University of Hawai'i at Manoa, local experts and guests from NASA. A second course, Space Flight, will be offered this summer by a faculty member from the UH-Hilo department of Physics and Astronomy.

PISCES will begin to expand the number of space-related courses at UH-Hilo by providing support funds for faculty members in other disciplines who are willing to develop new courses and for departments that are willing to incorporate these courses into their existing inventories. This approach will be used to fund course development and the first semester of each course offering. Particular effort will be made to include the widest range of suitable disciplines, including Psychology (Confined Environment Interactions), Geology (ISRU), Geography (Remote Sensing), Political Sciences (Futures), Business (Commercialization of Space), Biology, Physiology and Agriculture. The initial goal is 10-12 space-related courses. PISCES education and outreach personnel will work with the UH-Hilo department of Teacher Education to encourage the development of space-related curricula for K-12.

Certificate and Degree Programs

Initially, PISCES will support the development of a Space Studies Certificate based on the first group of newly developed courses. This certificate will be created as a first step toward a full multi-disciplinary Space Studies within the College of Arts and Sciences. Initially, the program will operate out of the Department of Physics and Astronomy, but a multi-disciplinary Space-Studies faculty will be recruited from existing disciplines to act as an academic home once the major is established.

While Space Studies incorporates interests in the social sciences and the humanities, a large portion of its instructional focus will be on science and engineering disciplines central to the establishment of sustainable extraterrestrial human presence. These disciplines are typically found in a School of Engineering. PISCES will assist the UH-Hilo administration in realizing its publicly-stated goal of establishing a School of Engineering on the UH-Hilo campus. PISCES has already assisted in the establishment of a cooperative agreement between UH-Hilo and the Colorado School of Mines (CSM). This relationship will provide UH-Hilo with expert assistance in the establishment of its new School of Engineering. PISCES staff will work with UH-Hilo faculty and administrators and CSM educators to identify the necessary steps needed to establish the new School. The UH-Hilo administration will be enlisted to provide the appropriate support within the UH system and with the State Legislature, whose support and funding will be required.

The PISCES capital improvement program described elsewhere in this plan includes a Base Facility to be located in

the UH-Hilo Technology Park. This facility will be designed to have dual use; both as a support facility for operations at the PISCES Analog Outpost and Field Test Sites and as a home for laboratories and offices for some of the new Engineering faculty. UH-Hilo will contribute office space on the ground floor of its new Science and Technology Building when it is completed in 2010.

Faculty

The establishment of a Space Studies Certificate and a Space Studies major within the College of Arts and Sciences can be accomplished with existing UH-Hilo faculty members if there is sufficient encouragement from the UH-Hilo administration. The proposed PISCES Base Facility and PISCES analog activities will provide infrastructure, instructional support and research opportunities for faculty and student research. PISCES will also seek to raise funds for the establishment of six partially endowed chairs to serve as the nucleus of the formal Space Studies major and, eventually, the School of Engineering. Half of these will be in the physical sciences and half will be in Engineering, with faculty members holding joint appointments in both the College of Arts and Science and the School of Engineering.

These six faculty members, funded partially by UH-Hilo and partially by endowments which PISCES will raise in coordination with the UH-Hilo Development Office (see the Fundraising section), will teach the courses and conduct the research necessary to build UH-Hilo into a center of space-related education and research. As faculty members begin to generate their own external support, the funds thereby released will be used to create additional faculty positions. Without any additional internal funds, this endeavor should result in approximately twelve faculty positions within the first five years of operation.

At present, the areas of concentration anticipated for the first six new faculty positions are as follows:

- Two in Physics and Astronomy with an emphasis in Lunar Science, Materials Science, Lunar-Based Astronomy or Space Exploration
- Two in Aerospace Engineering with an emphasis on Robotics, Space Operations, Lunar Surface Operations or Lunar Habitat Design
- One in Agriculture with an emphasis on hydroponics
- One in Mechanical Engineering with an emphasis in Space Robotics



Imiloa Astronomy Center at UH-Hilo, a Valuable Partner in the PISCES Higher Education Program

K-12 Education and Public Outreach Program Plan

Introduction

Education is a key function of PISCES. Therefore, a strong community education and outreach program will work in conjunction with all of the center's research and technology programs. PISCES projects will teach future space explorers how to live off the land on the moon to produce oxygen for breathing, manufacture rocket fuel, construct habitats, grow food, maintain optimum health and use sunlight for heating and electricity. In addition, PISCES will offer space technology education for students of all ages, while attracting high-tech industry and bolstering the island's technical work force through its research and training programs.

In order to develop and maintain support among the people and organizations who will determine its success, PISCES has embarked on a public awareness and education campaign to promote the center's activities and build support. The objectives of the campaign are as follows:

- Build public awareness and support of PISCES.
- Help attract, maintain and promote users/partners.
- Help guide marketing, fundraising and government relations.
- Inspire the next generation of space scientists through education programs in grades 5-12 and at the college level.

Common Messages

This plan includes messages for specifically defined audiences of PISCES, which will be discussed in a later section. Common messages for all audiences are as follows:

1. Nearly everything that humans will do in space can be an area of research at PISCES. Examples include robotics, sensors, energy and *in situ* training.
2. PISCES is new, and is looking for ideas and partners. The objective is to make it easy for companies, organizations and universities to work with us.
3. In conjunction with NASA's exploration focus, PISCES offers innovation, discovery and inspiration through dynamic education and outreach programs.
4. PISCES has more than doubled its funding from the State of Hawai'i through recent NASA projects.
5. PISCES is working with a cultural advisory group in Hawai'i, which among other things is applying Hawai'i's voyaging history toward space exploration.

Key Audiences and Messages

This plan identifies the audiences that are important to PISCES, the messages that should be conveyed to those audiences, and the vehicles proposed for the delivery of those messages. The key audience categories are:

- Community
- Government
- Education
- Business and Industry
- Space Research and Development

The appropriate messages for each of these categories are outlined in the following sub-sections:

1. Community

a. Audiences:

- Citizens of the Big Island
- Native Hawaiians
- Local business and industry
- Schools, churches and other local opinion leaders and sources for residents
- Potential partners in science, astronomy, research, education
- Major events offering public involvement and visibility

b. Messages:

- PISCES research will be conducted at a moon-base lab where the terrain is similar to the lunar surface
- PISCES develops dual-use technologies for humans to live on the moon and beyond, and to improve life on Earth
- PISCES involves local citizens and draws from the Hawaiian culture, especially regarding sustainability and voyaging
- PISCES provides educational resources for grades 5 -16

c. Vehicles:

A major tie to community audiences is our education and outreach program for grades 5 to 12, which offers free classroom resources to teachers and makes

science fun for students. Teacher workshops this summer will provide hands-on opportunities in using the interactive, web-based SpaceClass program. PISCES has hired an education specialist to build community relationships through involvement with schools. PISCES also will participate in Onizuka Day, Hawaiian Family Affair Day, Earth Day, RoboFest, and Astro Day, and will march in the Merrie Monarch Parade.

Following are additional ways that we will reach the community with our messages:

- Brochures
- Videos
- News coverage of community involvement.
- Demonstrations of technology.
- Talks by space experts.
- Face-to-face meetings with community and opinion leaders

2. Government

a. Audiences:

- Hawai'i governors and legislature
- Department of Business, Economic Development and Tourism (DBEDT)
- City and county governments on the Big Island
- Planning and zoning departments on the Big Island
- U.S. Mainland government leaders, including the Congress
- Special interest groups related to space industry/research

b. Messages:

- PISCES research will be conducted at a simulated moon-base lab where the terrain is similar to the lunar surface.
- PISCES develops dual-use technologies for humans to live on the moon and beyond, and to improve life on Earth.
- PISCES draws from the Hawaiian culture, especially regarding sustainability and voyaging.
- PISCES is a test-bed for planetary protection, minimizing the negative ecological effects of human habitation.
- PISCES provides educational resources for grades 5 -16.
- PISCES listens to community priorities and concerns.
- PISCES makes good use of government funds.

c. Vehicles:

- Cultural/historical exhibit at PISCES lunar outpost site.
- News coverage of success stories and partnerships.
- Demonstrations of technology.
- Face-to-face meetings with government leaders.
- Involvement in Earth Day, Space Day, and other major observances.
- Legislative reports, mailings and video distribution.
- Space Day for Legislators, an exhibit and luncheon where we show the video, update them on partners and progress.

3. Education

a. Audiences:

- Higher Education (see also separate section on Higher Education Plan):
 - University of Hawai'i:
 - Administration
 - Faculty
 - Students
 - Graduate students
 - Partner universities' space research faculty in U.S., Japan, and elsewhere
 - University student competition participants and faculty leaders
- Grades 5-12:
 - Hilo and Manoa area schools:
 - Administration
 - Science teachers
 - Students
 - Parents

b. Messages:

- PISCES research will be conducted at a moon-base lab where the terrain is similar to the lunar surface.
- PISCES develops dual-use technologies for humans to live on the moon and beyond, and to improve life on Earth.
- PISCES draws from the Hawaiian culture, especially sustainability and voyaging.
- PISCES is a test-bed for planetary protection, minimizing the footprint of human habitation.
- PISCES offers college courses in space exploration as well as graduate and undergraduate research programs in physics and astronomy.

- PISCES conducts college-level design competitions.
- PISCES provides educational resources for grades 5-16, which meet
- National Learning Standards and feature interactive learning to make science fun.

c. Vehicles:

The PISCES Education and Outreach Program is critical to the success of the center. To develop programs that meet educators' needs in Hawai'i, an education and outreach consultant is a member of the PISCES team, and a local education specialist has been hired to work with schools in Hawai'i.

This summer, PISCES is offering teacher workshops on utilizing the resources of SpaceClass, a free, web-based education program designed for grades 5-12. Teachers will have hands-on training in this program, which offers video and virtual science lab experiments on research actually being conducted for space missions. In addition, a SpaceClass lesson will be developed to educate students and the public on the research and development of technology at PISCES.

A local education specialist currently is conducting a survey among teachers, regarding additional needs and preferences for science resources that could be provided by PISCES.

Following are some of the ways that we plan to involve PISCES in education:

- Expand the physics/astronomy/engineering course offerings at UH Hilo.
- Conduct lunar habitat and vehicle design competitions for college students.
- Involve middle and high school students, as well as college students, in technology demonstrations.
- Sponsor local high school and middle school robotics activities.
- Host seminars, workshops and other events for middle and high schools.
- Invite teachers and students to stay in the PISCES moon habitat when built, perhaps offering the stay as an incentive for exceptional work.
- Connect PISCES with Earth Day, Space Day, and other major observances.
- Hold technology demonstrations
- Host seminars, workshops and other events
- Invite teachers, students to stay in moon habitat.

- Connect PISCES with Earth Day, Space Day, and other major observances.
- Develop a SpaceClass lesson about living on the moon.
- Conduct student design competitions.
- Collaborate with industry on education programs for grades 5-12.

4. Business and Industry

a. Audiences:

- Hawai'i chambers of commerce
- Potential industry partners in Hawai'i
- Potential industry partners on U.S. Mainland
- Trade organizations and chambers of commerce with technology interests
- Industries associated with Space Research Partnership Centers
- Trade shows and conferences with space and technology components
- Space tourism companies

b. Messages:

- PISCES develops dual-use technologies for humans to live on the moon and beyond, and to improve life on Earth.
- PISCES draws from the Hawai'ian culture, especially sustainability and voyaging.
- PISCES provides educational resources for grades 5-16.
- PISCES involves local citizens.
- PISCES provides opportunities for jobs and careers in space science/technology.

c. Vehicles:

Following are the ways that we plan to reach our industry partners with our messages:

- Actively engage our business and industry partners in high-visibility PISCES education and outreach programs, to position them as leaders and innovators in space exploration.
- Host an industry day at the annual PISCES conference.
- Host a business breakfast in Hilo to introduce PISCES to the business community.
- Demonstrate the technology being tested and developed through PISCES.
- Invite space experts to speak to the business groups.
- Schedule face-to-face meetings with business leaders.

- Plan industry segments of workshops and conferences.
- Involve partners in Earth Day, Space Day, and other major observances.
- Trade shows and conferences for space and technology components.

5. Space Research Community

a. Audiences:

- NASA and space agencies worldwide
- Space research centers
- Aerospace company researchers
- University researchers
- Space tourism researchers

b. Messages:

- PISCES exists to support space missions planned by all space-faring nations.
- PISCES research will be conducted at a moon-base lab where the terrain is similar to the lunar surface.
- PISCES develops dual-use technologies for humans to live on the moon and beyond, and to improve life on Earth.
- PISCES provides educational resources for grades K-16.
- Hawai'i is a good location for this research and is convenient to Pacific Rim countries.

c. Vehicles:

- PISCES video combined with one-on-one meetings.
- Website updates and electronic communication.
- News coverage of technology, success stories and partnerships.
- Demonstrations of technology.
- Visitor briefings.
- Host events, seminars.
- Web-cam allowing public to tie in to rovers, get updates, etc.
- Annual conference involving international space research community.
- Education and outreach programs involving and benefiting the space research community.

Media Relations

To support its partnership recruiting and fundraising efforts, and to build support among all of its audiences, PISCES will

aggressively pursue media coverage of milestones, partner announcements, student competitions, speakers of public interest, conferences, education programs, and special activities and events. The PISCES media database will continue to grow from the following media outlets:

1. Print media:

- Hawai'i press
- University publications
- Space publications
- "Aerospace Engineering," the SAE magazine
- USA Today
- National news magazines
- News media in states where partners are located

2. Broadcast media:

- Hawai'i television
- Network television
- *Good Morning America* and *The Today Show*
- NPR "All Things Considered"
- *CNN Science with Miles O'Brian*
- Television stations where partners are located

3. Web-based media:

- NASAwatch.com
- Space.com
- Cosmic Log at MSNBC.com
- Spaceref.com
- University of Hawai'i website (hawaii.edu and uhh.hawaii.edu)
- Partner universities' websites
- Partner industries' websites
- Space technology websites
- Chamber of Commerce website
- Websites of cultural and historical groups involved

Media Opportunities

The following are example opportunities for engaging the media to cover events related to PISCES. They will be pursued as schedules and funding allow.

1. Moon-rover ribbon-cutting ceremony: When a location is selected for the moon-base lab in Hawai'i, PISCES could hold a unique ribbon-cutting ceremony to draw media attention --- one that features a rover driving through the ribbon to cut it. The rover will then pick up some soil and take it to equipment where oxygen is made...just as it will happen on the moon. The news gathering will feature a

well-known public figure who will lend credibility to the program. Speakers also should include native Hawaiian opinion leaders, the governor, JUSTSAP director, PISCES Director and the Chancellor of UH Hilo. The event will be blessed by a Hawaiian kupuna. All of the work that PISCES intends to do in its research labs will be represented, so reporters can access everyone they want to interview. The unique aspect of this event is that the ribbon-cutting will be done by a moon rover instead of by people. That makes it interesting to news media, and we would attempt to obtain national news magazine and network television news coverage.

2. Announcements of new PISCES partners: Important media opportunities will arise when new partners join PISCES. Reporters will be invited to come and hear major announcements about new partners for PISCES. These events will also include special press gatherings with visual features for news media in the way of rovers, demonstrations of ISRU plans for the volcanic ash and news about people and programs that have not been announced before. It may encourage potential partners to engage with PISCES before November, if they know that we intend to draw extensive media coverage at the conference.
3. White paper on developing a moon settlement: The release of a summary document incorporating all major research and spaceflight activity pertaining to developing a moon settlement will position PISCES as an umbrella organization --- not solely a NASA service center --- working globally to meet challenges of moon exploration and settlement. This document will be an objective summary of the state of preparations for moon missions, with sections describing who is doing what --- and positioning PISCES as critical for developing and testing lunar technology. A news gathering timed with wide distribution of this report to the public will be held.

4. Launch of new SpaceClass lessons: New lessons developed for the SpaceClass website will be announced as they are launched. Creation of these lessons will be made possible through corporate donations and government grants.

Priority Action Items

Priority action items for the PISCES Education and Outreach program are as follows:

- Produce a video for use as a marketing and partnership-building tool. *Completed. Copies are available at the PISCES office at the UH Hilo campus.*
- Get SpaceClass, the web-based education program, in Hawai'i middle schools. *In progress. SpaceClass workshops for teachers will be held this May in Kona and Hilo, to guide teachers in using this resource in their schools.*
- Obtain news coverage on design competitions, partnership agreements, funding, workshops, and technology demonstrations. *Ongoing. PISCES obtained worldwide news coverage on its involvement in the signing of a Memorandum of Understanding between UH Hilo and the Colorado School of Mines.*
- Work closely with the Cultural Advisory Committee to engage Native Hawaiians wherever possible. *Ongoing.*
- Produce a brochure that promotes PISCES to potential research partners. *The brochure will include projects and events planned for 2009.*
- Produce materials for fundraising campaign. *To be completed in early 2009.*



SpaceClass™ Workshop Held in 2006 with NASA Participation

Student Design Program Plan

The prospect of developing facilities on other worlds that can support human beings for long periods of time, including systems such as power, closed loop life support, *in-situ* resource utilization and others, will require significant advances in technology and operations and will provide many opportunities for novel developments. Thus, it is a topic that is particularly suited to efforts by students, who are less constrained by existing space exploration practices and more likely to develop original ideas. It is with this thought in mind that PISCES has established the PISCES Student Design Program.

The Student Design Program invites teams of college students, undergraduate and graduate students, with a university faculty advisor, to submit a project of their choosing that is relevant to the long term habitation of another planet. From those submissions, several teams are selected to present their studies at the annual PISCES Conference, with expenses paid by PISCES. In 2007, three teams, from the Colorado School of Mines, Colorado University, Boulder, and Honolulu Community College were selected to make presentations. The team from Honolulu Community College was selected as making the best presentation, which showed considerable originality in thought and implementation.

The Student Design Program will be continued this year with additional financial support from NASA.

The Student Design Program competition is an excellent tool for outreach to the university community, providing an attractive venue for universities, who commonly run design programs for undergraduates, to select stimulating projects that are aimed at long-term PISCES interests. By doing this, universities better understand PISCES' development program and can better prepare themselves for working in aerospace fields associated with human exploration and development. PISCES intends to build additional relations with some of these universities that can contribute to the development of PISCES facilities and infrastructure. A direct outgrowth of the

2007 Student Design Program is a concept for a Professional – Student Design study that will be carried out in 2009 to develop preliminary concepts for permanent PISCES Outpost facilities.

The resources available to support travel of the teams to Hawaii to present their studies determine the scale of the Program. NASA's contribution of additional resources for the 2008 program will allow additional teams to be selected. Another limitation on the size of the program is the availability of time at the PISCES Annual meeting. At some number of teams greater than three (perhaps six), modifications to the program may become necessary to provide a smooth interaction between the design studies and the professional activities at the PISCES Annual Conference. This is a possibility as the number of teams, the quality of their studies, and funding for travel grow. It should be noted that in the 2007 competition, PISCES paid for travel for two students and one faculty member from each of the three schools, but two of the schools found resources to pay for the travel of up to ten people to the Conference.

Administration of the Program is not burdensome, consisting of advertising the program, communicating from time to time with the teams that join the program, and reviewing work submitted to the selecting panel. In future years, these tasks should be carried out by permanent PISCES staff.

The 2007 contribution of the Honolulu Community College was the design of an integrated facility for the support of six people on the Moon for long periods, with facilities for another six visitors (during crew change periods). The facility consisted of four large spheres (24-27 feet in diameter), with three floors each, which provided basic functions necessary to live in reasonable comfort on the Moon. Novel ideas for emplacing the spheres were suggested as well as ways to use emerging technologies to increase the efficiency of operation. A 60-page report is available from PISCES.

Facilities Plan

Introduction

PISCES is currently operating out of the Institute for Astronomy (IfA) building in the Technology Park on the campus of the University of Hawai'i at Hilo. The Center occupies an office there and has agreed-to access to several electronics and instrument shops, a high-bay area equipped with traveling overhead cranes and state-of-the-art machine shops and a clean room. The shop facilities and lodging at Hale Pohaku (the University of Hawai'i mid-level facility on Mauna Kea at an elevation of 9,000 feet) are also available for use by PISCES on a space-available basis.

While these temporary facilities will suffice for early tests and demonstrations, PISCES will need permanent space for classrooms, offices, laboratories and the simulated lunar outpost to fulfill its vision and mission as the leading research and education center in the world dedicated to developing technologies that will enable sustained human presence on the Moon and beyond.

This plan lays out the facilities needed to achieve those goals. A subsequent section on fundraising describes some of the efforts which will be directed towards realizing these goals. The following sections describe three groups of facilities: 1) the Field Site, 2) the Base Facility and 3) the Outpost. These facilities will be phased in over the next few years in accordance with the schedules given for each. The facilities are described in the approximate order in which they will be built.

Field Test Site

PISCES field test sites will provide analog terrain and soils on which space technologies, particularly those that require mobility, can be tested under realistic conditions. Tests done at PISCES field sites will also play a role in training future astronauts and ground support operators in lunar and planetary exploration techniques. The field test sites also provide a mechanism for bringing several groups together to undertake joint campaigns. The Big Island of Hawaii has a number of sites that are topographically very much like lunar terrain.

It is anticipated that there will be a need for test sites that are larger and have more varied terrain or access to different deposits of volcanic material than those at a single outpost site. Therefore, at least one and possibly more field test sites are envisioned. One particular site, which will be used by NASA for its November 2008 tests of ISRU and rovers, is near Hale

Pohaku and the Onizuka Visitors Center at approximately the 9,000-ft. level on Mauna Kea. This site will serve as a prototype for field testing areas to be developed by PISCES and is used here as a planning model.

General and project-specific requirements for the field site have been provided by NASA for the November, 2009 tests. Those requirements are too detailed for a planning document such as this, but in general they include access to varied lunar-like terrain for rover testing, access to deep deposits of fine volcanic ash for ISRU, nearby lodging and dining facilities, portable toilets, power generation, communications, emergency medical facilities and provision for evacuation. For the most part, funding to meet the field test site requirements will be provided through individual project budgets. Because many of these requirements call for portable facilities, and in keeping with the desire to minimize alteration of the test sites, there will be no permanent facilities at these sites. The following paragraphs outline general needs for site preparation and portable facilities.

1. Panel Truck with Rear Lift: This truck will be used to transport people and equipment up and down to mountain and between Hale Pohaku and the test site.
2. Site Preparation: The site selected for the November 2008 tests needs a minimum of preparation. The access road to the site will need a small amount of grading to allow passage of trucks hauling rovers and equipment between the staging area at the Hale Pohaku shops and the test site. Machine work for this task will be hired locally or from the Hale Pohaku shops. Permits and permission for all such work will be obtained in advance.
3. Portable Power: It is anticipated that there will be a need for approximately 32 kW of electrical power for all the equipment at the test site. Approximately 20 kW will be produced by generators brought to the site by NASA, with the remaining 30 kW provided by PISCES.
4. Portable Communications System: The communications requirements for the test site are not as extensive as are those for the Outpost. The requirements provided by NASA are listed below.
 - a. Satellite Links (30 watts at dish 29.5-30 GHz uplink)
 - b. EBR control link modem (902-928 MHz, 1 Watt)
 - c. Camera links (2.4 GHz)
 - d. Video (902-928 MHz, 1 Watt)

e. Computer Networks for control and internet

2. Schedule: The field site preparations for the November tests, using rented portable equipment and facilities, are currently underway and will be completed by late summer 2008. Permanent power and communications infrastructure will be developed during 2009-10.
3. Cost Estimate: Estimates for one-time capital costs of preparing the site and for permanent power, communications and sanitation facilities are given in Table 1.

Element	Labor	Equipment	Total
Site Preparation (access road grading)	\$ 15,000	\$ -	\$ 15,000
Panel Truck with Rear Lift		\$ 50,000	\$ 50,000
Portable Power Generator	\$ -	\$ 5,000	\$ 5,000
Portable Satellite Communications System	\$ -	\$ 50,000	\$ 50,000
Portable Sanitation Facilities		\$ 5,000	\$ 5,000
Total Cost			\$ 125,000

Table 1. Estimated Field Site Costs

Base Facility

The Base Facility will house the PISCES offices, classrooms, laboratories and shops. The objectives of the Base Facility are 1) to serve as the primary central location of PISCES and 2) provide working space for administration, staff, students, visiting faculty and other researchers. It will be located on or near the campus of the University of Hawai'i at Hilo (UHH), possibly in the Technology Park.

1. Design Parameters: The design parameters for the base facility are as follows:
 - a. Two classrooms, sufficient for approximately ten courses to be offered three times a week each semester, plus summer usage for special seminars and institutes.
 - b. Two laboratories, one for ISRU to include wet chemical capability and a hood, one for Habitat Design and Robotics to include electronic and mechanical fabrication capability. Examples of ISRU equipment to be procured include vacuum systems, ovens, furnaces, mechanical testing apparatus, analytical equipment and dust handling equipment. Examples of equipment to be procured for the Habitat Design and Robotics laboratory include mechanical fabrication and testing equipment, electronic circuit board fabrication and testing, computers and basic test instruments. The laboratories will also be used in conjunction with certain of the classes.
 - c. Six offices; one each for the director, deputy director, operations manager and clerical support staff, and

two for visiting researchers. The offices for visitors will be configured as customer work areas, including small lab areas where visitors can finalize research plans, prepare research equipment for transportation to the research sites, and stow or maintain research equipment before and after the field tests.

- d. One conference room for meetings of the PISCES staff, advisory groups, workshops and visitors
- e. Two instrument shops for faculty, staff and student use, each having capability for bench-scale prototype fabrication, testing, troubleshooting and repair
- f. One high-bay area with machine shop for fabrication, storage and servicing of vehicles, mobility platforms, habitats and robots

2. Schedule: The schedule for construction of the Base Facility, assuming availability of funds, is as follows:

- a. Initial Design Studies – FY2008-09
- b. Engineering-Architectural Design – FY2008-09
- c. Site Certification and Preparation – FY2009-10
- d. Construction – FY2010-11
- e. Start of Operations – FY2011

3. Cost Estimate: The estimated costs of the Base Facility, including furnishings and equipment, but not land, are shown in Table 2.

Space	Number	Size Each (Square Feet)	Total Square Feet	Cost Rate	Cost	Furnishings	Equipment	Totals
Classrooms	2	500	1000	\$ 500	\$ 500,000	\$ 20,000	\$ 10,000	\$ 530,000
Laboratories	2	750	1500	\$ 1,000	\$ 1,500,000	\$ 200,000	\$ 500,000	\$ 2,200,000
Offices	4	180	720	\$ 500	\$ 360,000	\$ 20,000	\$ 10,000	\$ 390,000
Conference Room	1	250	250	\$ 500	\$ 125,000	\$ 10,000	\$ 10,000	\$ 145,000
Reception/Lobby	1	250	250	\$ 500	\$ 125,000	\$ 5,000	\$ -	\$ 130,000
Shops (Instrument)	2	350	700	\$ 1,000	\$ 700,000	\$ 10,000	\$ 500,000	\$ 1,210,000
Shop (Machine, High-Bay)	1	4000	4000	\$ 1,200	\$ 4,800,000	\$ 50,000	\$ 1,000,000	\$ 5,850,000
Total Usable Space			8420		\$ 8,110,000	\$ 315,000	\$ 2,030,000	\$ 10,455,000
Hallways, Stairways, Utility Rooms (20% of Usable Space)					\$ 1,622,000			\$ 1,622,000
Total Cost of Base Facility								\$ 12,077,000

Table 2. Estimated Base Facility Costs

Outpost

The future centerpiece of PISCES will be a full-scale, technically valid, analog simulation of a lunar outpost. As generally envisioned by space architects, the outpost will consist of a number of modules, systems and subsystems, linked together to provide support to human crews that will perform research, operations and housekeeping tasks. The full analog facility will provide habitats, power, life support systems, communications, surface activity (EVA) support (mobility systems, analog space suits), lunar resource utilization systems (ISRU), and launch and landing support systems. to the initial outpost will expand as the number of

uses, international and industrial partners, and products increases.

The PISCES analog will have several major uses, which will dictate its design. The first and probably the dominant use will be to serve as a developmental prototype of the lunar outpost that will be established by the U. S. and other countries. This use will require the existence of a facility that mimics the design of the planned lunar outpost. If it is done faithfully, the PISCES outpost can become a place of significant interest to federally and commercially funded projects where lunar operations are developed, the operating crews (both lunar-based and on Earth) are familiarized with and trained to use the lunar outpost systems, where full-scale simulations of lunar outpost activities can be performed, and where new technologies and operations can be tested that will improve the performance of the outpost. Thus, there is a requirement for a facility that can be made available to government and commercial enterprises that is very much like the actual outpost on the Moon.

The other major aspect of the PISCES facility is related to research. Establishment of a long-term lunar outpost, capable of supporting crews for periods of 6 months to several years will require a great deal of new science, technology and system development. For example, initial habitat designs, dominated by requirements of safety and minimum mass, will evolve into habitats that are largely constructed from local materials. This evolution implies a significant research opportunity, along with significant potential for commercial use, with the need to change the facility as new ideas are proved out. In other words, the lunar outpost analog must be flexible, to allow for future modifications. It must also be flexible with respect to increasing its size. Modules could be added for special purposes, such as lunar resource utilization, agriculture, leisure activities, additional research components, and commercial opportunities. Few of these will be worked out within the Vision for Space Exploration, but will depend on the imagination and insight of future users of the Moon. This area of study will require great innovation and serious research, which can be accelerated by the existence of a representative environment for demonstration and test of systems and operations. This part of PISCES will be the advanced research element. Much of the research can be conducted by students in a variety of fields – architecture, engineering, science, space operations, and others. In addition to the inherent value of such research for humankind, it represents huge opportunities for Hawai'i's citizens to prepare for technology-related professions.

Early lunar outposts will probably support crews of six persons, perhaps with additional room for visitors. The initial phase of the Outpost will be represented by a PISCES facility that will begin with a set of modules that are based on the designs that are currently under consideration by NASA and others, either metal, similar to those of the International Space

Station, or inflatable. A growth phase will be simulated later in the development of the PISCES analog facility, in which the size of the outpost could grow to support a staff of up to fifty crewmembers for extended tours of duty and local materials are more prominently used in structures.

The objectives of the PISCES Outpost are 1) to provide a venue for testing of lunar surface operations internal to habitats and interactions with external systems (e.g. power, surface mobility, ISRU, communications), 2) to provide a training venue for lunar outpost crews, linked with ground support at PISCES or elsewhere, prior to embarking for the Moon, 3) to serve as a facility in which PISCES faculty and students can conduct original research directed toward living and working on an extraterrestrial body and 4) to attract the visiting public to experience firsthand what it will be like to live and work on the Moon.

1. Requirements: The Outpost requirements are as follows:
 - a. The Outpost must provide for high fidelity tests of lunar outpost operations including internal crew habitation and research, as well as external lunar surface logistics, maintenance and excursion operations; e.g. at least some areas must be sealable to exclude terrestrial atmosphere to establish outpost-like atmospheres.
 - b. The facility must be modular to allow for growth as well as for testing of different conceptual approaches to outpost architecture and operations concepts.
 - c. Individual elements must be compatible with space transportation capabilities and outpost assembly and re-supply methods
 - d. The Outpost must be located in an area that looks like it could be on the lunar surface (natural or manufactured).
 - e. The facility should be relatively easily accessible to crews involved in tests as well as mission control personnel.
 - f. The facility must include support capabilities external to facility to support tests.
 - g. The facility must be accessible to the public, with space for eventually building a visitors center.
 - h. The facility must be environmentally friendly and located in an area acceptable to its hosts.

The PISCES Outpost will be built on an approximately 50-acre parcel of land located near the Saddle Road on the Big Island of Hawai'i. The site will contain deep deposits of fine volcanic soil characteristic of lunar regolith in its chemical composition and physical properties. It is anticipated that there will be no costs for the use of the land, other than permitting and utility costs, since likely sites are currently under the jurisdiction of the Department of Land and Natural Resources (DLNR).

The Outpost will consist of simulated lunar habitats, both fixed and mobile; an environment control and life-support system; an enclosed space for growing food; a field area; a simulated launch and landing pad; a solar energy system featuring a large solar cell-covered area; and communications systems similar to those of a future lunar outpost. The following are notional descriptions of the Outpost facilities. A conceptual architecture will be developed through a series of studies, workshops and consultations with NASA engineers, engineer-architects, space system specialists, etc.

2. Habitats: Fixed habitats will be constructed to simulate those planned for the Moon using various materials to test their efficacy for such habitats. Eventually, and largely as a result of some of the research to be done at PISCES, habitats will be constructed mostly from existing materials at the site to simulate the eventual construction of actual lunar habitats using technologies to be developed for ISRU. Some of the fixed habitats will be covered with soil from the site to simulate and test radiation shielding techniques. Mobile habitats will be built on vehicles similar to JPL's "ATHLETE" rover, or JSC's "Chariot" mobility platform (see page 14 above). They will be assembled and tested at the PISCES Base Facility and transported to the Outpost for field testing and evaluation as potential lunar habitats.
3. Environment Control and Life Support System (ECLSS): A single ECLSS system will be developed to service all of the habitats. This system will be designed using the latest in NASA-approved space technology. It will be an entirely closed-loop system, both for simulating what will be used on the Moon and Mars and for protecting the environment at the Outpost site.
4. Agriculture Enclosure: This facility will be will be airtight, as will be required of such a facility on the Moon, but in order to keep costs down it will not be built to withstand the 14.7 psi pressure differential that will be required of an actual lunar facility, since such strength will not be needed to simulate lunar growing conditions and to conduct agricultural research at the PISCES Outpost. The enclosure will cover an area of approximately 1000 sq. ft. It will be designed for research using the natural sunlight available at the site, but will also be equipped with special lighting to simulate the spectral and intensity qualities of sunlight on the Moon. In addition, it will be equipped with processing systems to remove residual organic matter at the site to better simulate lunar regolith conditions, employing a hydroponics approach.
5. Outpost Field Area: The Outpost Field Area will consist of approximately 20 acres at the Outpost site that can be configured in a variety of ways to simulate lunar terrain; i.e., rocks and large boulders, fine regolith, small craters and cinder cones. It will be used for rover testing and pilot-scale testing of ISRU concepts. This field area will be constructed from the lava and other volcanic material present at the outpost site using earth-moving and rock-crushing machinery. Much of the field area will be covered with the finest (in the sense of particle size) material available to simulate actual lunar conditions in the landing areas of interest.
6. Simulated Launch and Landing Pad: This pad will be of a size typical of what will be needed at a lunar outpost. It will be constructed by compaction of soil at the site and will allow research into further processing of the soil to increase the pad strength and reduce dust emissions; e.g., "lunar concrete" or ceramic bricks made from Hawaiian regolith.
7. Solar Energy System: The Solar Energy System will consist of a solar cell-covered field expandable to approximately one acre in size, with connections to systems of batteries and/or fuel cells. Experiments will be conducted to learn how to make solar cells from processed soil at the site, in preparation for large-scale production of solar cells from lunar regolith at a future outpost on the Moon. Facilities will also be fabricated for transmitting and receiving energy by means of microwaves or laser beams. In addition to the photovoltaic system, provision will be made for research into producing solar concentrators from the local soil for thermal processing. Such systems could be used on the Moon for "bootstrapping" manufacturing by creating concentrators that could be used in turn for creating more concentrators, as well as construction elements and manufacturing feedstocks.
8. Communications Systems: The PISCES Outpost will be equipped with state-of-the-art systems for communication between habitats and field areas, for controlling rovers and for simulating communications between the Outpost and orbiting satellites, such as would be the case on the Moon. A system will also be developed for direct communication, monitoring, command and control from the PISCES Base Facility. This system will be capable of simulating Earth-Moon communications systems and will be important for health and safety considerations of the Outpost inhabitants, as well as for human-robot interaction research.
9. Environmental Impact Assessment: Because the Outpost will be built in a potentially sensitive environment, it will be necessary to do an environmental impact assessment. This is consistent with the basic commitment of PISCES to its environment. The EIA will be contracted out to a local firm having experience in such work on the Big Island. Because the Outpost facility systems will be

closed, no effluent; i.e., septic, system will need to be installed, thus minimizing the environmental impact.

10. **Schedule:** The schedule for development of the Outpost is as follows:

- a. Initial design studies – FY 2008-09
- b. Engineering-architect studies – FY 2009-10
- c. Site certification, preparation – FY 2010-11
- d. Construction – FY 2011-12
- e. Commence operations – FY 2013

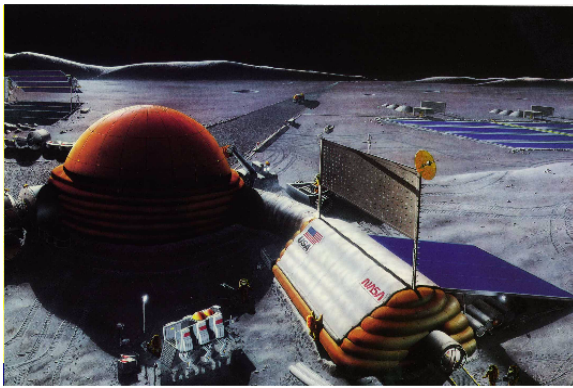
11. **Cost Estimate:** The costs of the Outpost facility are extremely difficult to estimate at this stage of the development of PISCES, simply because such a facility has never before been built by anyone, anywhere. However, by incorporating maximum modularity into the design using identical elements, it will be possible to stage the construction and development as funding allows. In this regard, it is to be noted that PISCES is a long-term

endeavor, which will be developing through successive changes in national administrations, Congresses and political will, not only of the U.S., but of other space-faring nations as well. Therefore, the available funding is expected to fluctuate over time with global support for space exploration. Table 3 lists approximate costs of the Outpost.

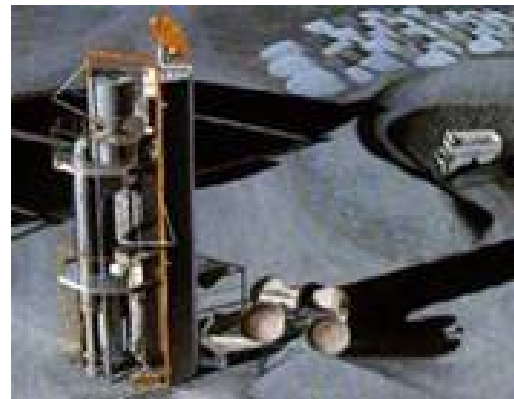
Element	Number	Size Each (Square Feet)	Total Square Feet	Cost Rate	Cost	Furnishings	Equipment	Totals
Fixed Habitats	2	150	300	\$ 2,000	\$ 600,000	\$ 20,000	\$ 10,000	\$ 630,000
Mobile Habitats	2	n/a	n/a	n/a	n/a	n/a	\$ 1,000,000	\$ 1,000,000
ECLSS	1	100	100	\$ 3,000	\$ 300,000	\$ 20,000	\$ 2,000,000	\$ 2,320,000
Agricultural Enclosure	1	1000	1000	\$ 500	\$ 500,000	\$ 10,000	\$ 150,000	\$ 660,000
Outpost Field Area*	1	n/a	n/a	n/a	\$ 300,000	\$ -	\$ -	\$ 300,000
Launch and Landing Pad	1	1000	1000	\$ 50	\$ 50,000	\$ 10,000	\$ 500,000	\$ 560,000
Solar Energy System**	1	n/a	n/a	n/a	\$ 450,000	\$ -	\$ -	\$ 450,000
Communications System***	1	n/a	n/a	n/a	\$ 1,000,000	\$ -	\$ -	\$ 500,000
Environmental Impact Statement	1	n/a	n/a	n/a	\$ 300,000	\$ -	\$ -	\$ 300,000
Total Cost of Outpost								\$ 6,720,000

Notes:
 * For three-acre field area. Cost estimate is for earth-moving and rock crushing.
 ** For 75kW system (Source: Energy Information Agency, DOE - see http://www.eia.doe.gov/cneal/solar.renewables/rea_issues/solar.html)
 *** The full cost of the communications system is unknown at the present time. The figure entered here is for a startup system.

Table 3. Estimated Outpost Costs



Artist's Conception of Habitats at a Lunar Outpost (NASA)



Artist's Conception of a Large-Scale O₂ Production Plant at a Lunar Outpost (NASA)



Model of Honolulu Community College's Winning Habitat Design in the 2007 PISCES Competition



Pu'u Nene, Possible Future Site of PISCES Outpost

Fundraising Plan

Introduction

This Fundraising Plan focuses on raising money for capital construction and faculty endowments through a major capital campaign. The acquisition of operating funds will be covered in the Business Plan section.

Goals of the Capital Campaign

The goals of the capital campaign are:

1. to raise capital sufficient to establish PISCES physically and
2. to raise capital sufficient to position the University of Hawai'i at Hilo as a global player in the coming era of space exploration and settlement and, therefore, as a major contributor to PISCES.

Objectives of the Capital Campaign

The specific fundraising objectives of the capital campaign are listed below. Each of these objectives, alone or in combination with others, will be a potential naming opportunity, as will be discussed in the implementation section.

1. PISCES Physical Facilities. The planned physical facilities and estimated costs are given below, in the approximate order in which the funds will be sought and the facilities will be built. Design requirements and justifications in the context of planned PISCES programs are given in the Facilities Plan.
 - a. PISCES Remote Field Test Site (total \$125,000 for initial permanent site – subsequent modifications for this site, as well as new sites, will be funded through operating revenues)
 - 1) Site Preparation (\$15,000)
 - 2) Panel Truck (\$50,000)
 - 3) Power Generator (\$5,000)
 - 4) Satellite Communications System (\$50,000)
 - 5) Sanitation Facilities (\$5,000)
 - b. PISCES Base Facility (total \$12,077,000), consisting of the following components:

- 1) Two classrooms (\$530,000)
- 2) Two laboratories, one for In-Situ Resource Utilization Research, one for Habitat Design and Robotics Research (\$2,200,000)
- 3) Four offices (\$390,000)
- 4) One Conference Room (\$145,000)
- 5) Reception and Lobby area (\$130,000)
- 6) Two Instrument Shops (1,210,000)
- 7) High-Bay Machine Shop and Clean Room Area (\$5,850,000)

- c. PISCES Lunar Outpost (total \$6,720,000)

- 1) Two Fixed Habitats (\$630,000)
- 2) Two Mobile Habitats (\$1,000,000)
- 3) Environmental Control and Life Support System (\$2,320,000)
- 4) Agricultural Enclosure (\$660,000)
- 5) Outpost Field Test Area (\$300,000)
- 6) Simulated Launch and Landing Pad (\$560,000)
- 7) Solar Energy System (\$450,000)
- 8) Communications System (\$500,000)
- 9) Environmental Impact Assessment (\$300,000)

2. UH-Hilo Higher Education Program. Fundraising objectives for a higher education program to support PISCES at the University of Hawai'i at Hilo are listed below. Justifications are included in the sections on Higher Education Programs and K-12 Education and Public Outreach Programs.
 - a. Two Partially Endowed PISCES Professorships in Physics and Astronomy with an emphasis in Lunar Science, Materials Science, Lunar-Based Astronomy or Space Exploration (\$2,000,000)
 - b. Two Partially Endowed PISCES Professorships in Aerospace Engineering with an emphasis on Robotics, Space Operations, Lunar Surface Operations or Lunar Habitat Design (\$2,000,000)
 - c. One Partially Endowed PISCES Professorship in Agriculture with an emphasis on hydroponics (\$1,000,000)
 - d. One Partially Endowed PISCES Professorship in Mechanical Engineering with an emphasis in Robotics (\$1,000,000)

Implementation

This section describes the philosophy that will guide the implementation of the fundraising plan, the prospective sources to be developed and the methodology to be used. Because PISCES is a creature of the University of Hawai'i at Hilo and is funded in part by the government of the State of Hawai'i, the implementation of this plan will be closely coordinated with officials from both entities.

1. Philosophy: In order for PISCES to be attractive to NASA, JAXA and other government space agencies, as well as the space industry, it must be recognized by all the potential users and collaborators as a world-class research and education center focused on development of technologies to enable sustained human presence on the Moon and beyond. This means it must have physical facilities that are unique to its mission and programs that are competitive with other institutions, but that are not in direct competition with those at NASA, JAXA, etc. PISCES facilities and programs must complement and not duplicate existing ones at the field centers. There are at present no facilities comparable to those proposed in the PISCES facilities plan at any of the NASA field centers, although there are small testing yards for rovers and expertise in ISRU and robotics at several of them. NASA currently uses undeveloped analog sites, principally at Meteor Crater, Arizona and Devon Island, Canada. These tend to be quite isolated and lack many basic facilities. The PISCES program plans call for development of capabilities that will meet NASA requirements and complement those at the NASA field centers.

In order for PISCES to be attractive to potential donors it must offer a vision that excites them and that promises to bring benefits to the people of Hawai'i in ways that appeal to the specific donors and that are compatible with their own visions for the future of the Big Island and the State. Those benefits would include enhancement of educational and employment opportunities, as well as development that will diversify the economy of the Big Island. Thus it will be important in the implementation of this plan to work closely with responsible officials in the UHH Development Office and to enlist the help of other knowledgeable local individuals from the business, civic and cultural communities as this plan is implemented.

2. Prospects: The major donor categories are individuals, foundations and governments. The PISCES campaign will cast a wide net across all three of these categories.

Individual prospects will be selected from those living or owning property on the Big Island and elsewhere in the State, particularly from among those known for

supporting science and technology projects with accompanying educational programs and, more specifically, those related to space. By concentrating on space exploration, overlap with existing campaigns at UHH should be minimized.

Foundations will be screened for presence and activity in the State, for their interest in space science and technology and for their openness to establishing new educational programs at UHH, particularly in engineering. The Foundation Center lists 422 philanthropic foundations in the State of Hawai'i, so there should be a number of them that fit these criteria.

Government prospects include the State Legislature and Federal agencies. For the former, PISCES will coordinate with the UHH Director of University of Relations to get its needs worked into the university's capital improvement priority list. For the latter, the PISCES Director will work with responsible program managers at NASA Headquarters to ensure that the facilities and program plans are in concordance with NASA's future needs. The Director will coordinate the University Relations office concerning any Congressional overtures.

3. Methodology: The capital campaign will be overseen by the PISCES Director, in coordination with the UHH Development and University Relations Offices and in consultation with a professional fundraising organization.

A PISCES Advocacy Board, consisting of prominent individuals from the educational, business and philanthropic communities in Hawai'i and nationally, will be appointed to advise and assist the campaign in all appropriate ways, including making leadership gifts. Individuals who have been involved with the center in the past, particularly those who have been strong supporters of the PISCES concept, will be tapped for leadership roles on the board.

Objectives will be drawn from this plan in the order in which they can be productively utilized by the center, coupled with the appearance of fundraising opportunities, and will be matched with particular donors drawn from the prospect list. Different lists of giving targets composed of single and multiple elements of the major objectives, complete with naming opportunities, will be drawn up to be presented to prospective donors. In this way the lists can be tailored to giving potential and interests, presenting prospects with many choices. All of these materials will be presented to the PISCES Advocacy Board for their input prior to making donor visits.

Donors from the compiled prospect lists will be approached through personal contact, invited to a dinner or other social function at which a presentation will be

made on PISCES and the goals and objectives of the capital campaign. Follow-up visits to interested donors will be made by the PISCES director, deputy director, key officials in the UHH administration or members of the UHH development office staff, in many cases accompanied by a member of the PISCES Advocacy Board or prominent individuals in the Hilo community.

PISCES will work through appropriate officials in DBEDT and the University to approach the State Legislature for capital funding. Major facilities objectives will be considered for the UHH Capital Improvement Plan, with the final decisions on such inclusion and priority to be made by the UHH Chancellor.

The PISCES director will work with officials at NASA HQ and Congress to get funding for PISCES facilities

worked into the NASA budget. These activities will be coordinated closely with the UHH administration

Schedule

The PISCES Campaign Advisory Board will be formed during the summer of 2008. The board will hold its first meeting in August 2008. The PISCES Capital Campaign will begin in a quiet phase later that month with a major donor dinner somewhere on the Big Island. Once a significant number of major donations have been pledged (roughly half the total sought) the campaign will be announced at a major fundraising event in Hilo. It is impossible to predict at this time when that announcement will occur, but if this campaign follows typical patterns, it could be announced sometime in the Fall of 2009. The campaign will then run for approximately five years.



Institute for Astronomy, University of Hawai`i at Hilo: Current Home of PISCES

Government and Industry Stakeholder Participation Plan

Introduction

It is of primary importance to proactively introduce PISCES to the broadest range of government and industry participants in the exploration programs of leading space-faring nations, or consortia of nations. Through its JUSTSAP heritage and through the efforts of the PISCES organizing team during FY2006-2008, there are emerging communications links between U.S. and Japanese space agencies and contractor industries with regards to PISCES development status and utilization opportunities. Beginning in FY 2010, it is anticipated that increased funds available to the PISCES Program will allow PISCES staff and contractors to expand their outreach to U.S. and Japanese organizations and to establish initial communications with European, Canadian and other international space agencies and aerospace industries.

During fiscal year 2008, the PISCES organizing team made substantial progress in establishing communications paths within the NASA Constellation Program Office and within JAXA as well as with several key U.S. and Japanese aerospace industry organizations. Having two representatives on the organizing team, JAMSS America, Inc. (JAI), an American subsidiary of Japan Manned Space Systems Corporation, was a principal in these efforts during FY 2008. For the coming fiscal year, JAI and the team will continue their proactive roles in introducing U.S., Japanese and other potential government and industry stakeholders to PISCES development plans and utilization opportunities.

The following is a near-term roadmap for identifying and effecting outreach to U.S. and international government and industry stakeholders in FY 2009.

Development of PISCES Visual Aids

It is a PISCES strategic objective to fund and develop an array of quality Visual Aids including a user-oriented oriented DVD.

There are many annual U.S. and international conferences, symposia and trade shows that are sponsored by space agencies, professional societies, institutes, aerospace industries and space advocacy groups. These annual events are fertile ground for:

- presentation of PISCES papers,

- presentation of visually exciting PISCES exhibits including PISCES storyboards, architectural renderings of current and future PISCES facilities, Big Island field sights representative of lunar/Mars landscapes, PISCES conference photographs, summaries of research projects completed and planned, and videos of past PISCES utilization events, and
- 1. networking discussions with aerospace industries, commercial service providers and potential monetary investors.

PISCES management personnel have begun to attend several of these forums as budget and personal schedules allow; however, visual and hardcopy information on PISCES has been limited to copies of presentation papers, limited copies of a DVD created primarily for use in securing PISCES advocacy within the State of Hawai'i as an educational facility, and a small, color brochure written as a high-level summary.

Capture of PISCES utilization, commercialization and investment opportunities will be significantly enhanced by a professional, high quality visual PISCES exhibit. Additionally, creation of a new DVD which is targeted to the scientific, technology development and operational capabilities development community is essential. Videos of the key events related to the upcoming NASA IPP technology demonstrations tests at PISCES in November, 2008 should provide excellent source material for the DVD production.

Identification of Government and Industry Stakeholders

Concurrent with the development of the set of Visual Aids, it is a PISCES strategic objective to identify and prioritize a detailed list of PISCES Stakeholders. As a part of this activity, JAI will evolve a PISCES contacts database which can be maintained and expanded from year to year as a communications tool available to all PISCES staff and participating personnel and organizations.

A target group of government and industry stakeholders will be identified for specific contact by representatives of the PISCES Management Team, including JAI, during the course of FY 2009. Principal PISCES stakeholder categories include:

- Employees and their project and program-level organizations within NASA, JAXA, ESA and CSA and other space faring nation space agencies

- State of Hawai'i governing bodies and their federal counterparts
- U.S. and international aerospace and exploration technology development corporations
- Space enthusiast groups and professional organizations comprised largely of industry employees
- Facility construction, operations and maintenance industries (largely Hawai'i-based)

The corporate experience within JAI includes management personnel with a wide range of direct experience within NASA and JAXA as well as with U.S. and Japanese commercial aerospace industries. This expertise will be utilized to identify a U.S. and Japanese subset of potential PISCES stakeholders.

Subject to funding availability, the PISCES Management Team should also facilitate direct communications with other international space agencies and industries within the traditional space faring community of nations as well as with those nations with emerging programs (e.g. China, India, and Brazil).

Importantly, there may also be government and industry organizations that are not directly involved with the development of exploration-specific hardware and lunar/Mars surface operations capabilities that could also benefit from exposure to PISCES attributes and capabilities. For example, developers of robotic devices used in remote natural environments such as those which may be found on the Big Island may find PISCES facility resources and accommodation suitable for their research and development programs (e.g. tele-operated search and rescue vehicles, remotely piloted aircraft surveillance operations, alternative power technologies, etc.).

The number of potential aerospace and non-aerospace stakeholders in PISCES is very large and an aggressive and effective outreach strategy should bear fruit within a very few years.

Initiate Stakeholder Outreach

1. NASA:

It is a PISCES strategic objective to maintain active communications with key individuals within NASA's Constellation Program and within NASA line organizations and to participate in NASA-sponsored conferences and workshops related to lunar surface operations and/or use of lunar analog locations.

During PISCES FY2009, NASA will begin to define lunar surface capability requirements (expected early in GFY 2009), subsequent lunar outpost element and systems requirements, Constellation Program-sponsored research and technology development requirements and – importantly – requirements for utilization of lunar analog sites. PISCES will interface with the Constellation Program Office As such, PISCES will establish and maintain an interactive relationship with members of the NASA Constellation team as well as participating “line organizations” at multiple NASA center locations. This will include maintaining correspondence with the various NASA center and NASA Headquarters exploration management and planning personnel who attended the first PISCES conference and who are becoming ever more aware of (and supportive of) the attributes of PISCES.

In 2007, NASA issued a renewable consulting contract to an independent expert in surface life sciences systems and operations and who has subsequently been an advisor to NASA in planning for eventual utilization of various lunar analog sites across the U.S. and Canada. PISCES has established a constructive professional relationship with this person and has facilitated his coordination with UHH PISCES leadership regarding the possibility of his serving as an Affiliate PISCES faculty member at the University of Hawai'i-Hilo while teaching a course series in Space Human Factors. PISCES will continue to build upon this relationship and to stay current on Constellation Program matters which potentially are of interest to PISCES. Specifically, PISCES will attend Constellation-sponsored lunar analog workshops held in proximity to JSC and, as funding allows, at other U.S. locations. Additionally, JAI will ensure that PISCES information currently contained within NASA's Lunar Analogs Database is maintained current as new information becomes available.

2. U.S. Industry:

It is a PISCES strategic objective for to contact a selected number of U.S. companies either through direct visit or through the electronic transmittal of some of the Visual Aids described above, to inform them about PISCES, and to identify a further subset of these companies who have a high potential for utilization of PISCES within the next one to five years. This reduced set of companies will be invited to participate in the November 2008 PISCES Conference Hawai'i.

As funding and personnel schedules permit, PISCES personnel will attend Industry-sponsored Conferences and Workshops and will utilize the Visual Aids developed above to inform participants of PISCES attributes and capabilities and to further evolve the contacts database

described above. PISCES will also continue to proactively encourage key U.S. aerospace industries such as Lockheed, Boeing, and U.S.A. to attend and participate in the annual JUSTSAP and PISCES conference forums and to serve as PISCES advocates within their own NASA Constellation contract activities.

3. JAXA:

It is a PISCES strategic objective to contact JAXA representatives, use the Visual Aids described above to inform committee members about PISCES, and to invite them to participate in the November 2008 PISCES Conference.

Within fiscal year 2009, PISCES will work to facilitate the involvement of JAXA and the Japanese aerospace and commercial technologies industries in early utilization of PISCES capabilities. JAI's parent corporation, Japan Manned Space Systems Corporation (JAMSS) is the primary operations support contractor for the Japan Aerospace Exploration Agency (JAXA) on the ISS program. This provides JAMSS and JAI unique access into top level JAXA and industry management and an opportunity to directly discuss PISCES attributes and utilization opportunities with the decision-makers who will decide on the timing and content of Japan's involvement in support of NASA's Vision for Space Exploration (VSE).

Through its daily support of JAXA's human space program as it currently pertains to the International Space Station, Representatives are already discussing PISCES with JAXA managers at multiple organizational levels. Though JAXA has not yet made a commitment to support the VSE, it has formed an exploratory committee to begin discussions with NASA Headquarters regarding a possible role for Japan in the VSE initiative. PISCES has an established professional relationship with the current chairman of this JAXA committee.

4. Japanese Industry:

It is a PISCES strategic objective to contact as many of the companies listed below as possible either through direct visit or through the electronic transmittal of some of the Visual Aids, to inform them about PISCES and to identify a further subset of these companies who JAI and JAMSS believe have a high potential for utilization of PISCES within the next one to five years. Representatives from these companies will be invited to participate in the Annual PISCES Conference in Hawai`i.

In addition to actively approaching JAXA, a continuing outreach to Japanese industry will be made. PISCES

initiated this effort during FY2008 and will continue to expand it during FY2009, subject to funding and personnel schedule constraints. PISCES has identified the following forty-three Japanese companies with whom to make specific contact:

- Mitsubishi Heavy Industries, Ltd.
- IHI Co., Ltd.
- JGC Corporation (Nikki K.K.)
- NEC Corporation
- Kawasaki Heavy Industries, Ltd.
- SORUN Corporation
- Chiyoda Corp.
- NEC TOSHIBA Space Systems, Ltd.
- Toyo Engineering Corporation
- IHI Aerospace Co., Ltd.
- Hitachi, Ltd.
- Fuji Heavy Industries, Ltd.
- Fujitsu Ltd.
- Mitsubishi Electric Corp.
- High-Reliability Engineering & Components Corporation
- Shimadzu Corp.
- Sumitomo Electric Industries, Ltd.
- Nippon Avionics Co., Ltd.
- Japan Aviation Electronics Industry, Ltd.
- Panasonic Electronic Devices Co., Ltd.
- Matsuo Electronic Co., Ltd.
- Mitsubishi Precision Co., Ltd.
- Murata Manufacturing Co., Ltd.
- Fuji Electric Systems Co., Ltd.
- Mitsubishi Cable Industries, Ltd.
- Daiko Denshi Tsushin, Ltd.
- OKI Engineering Co., Ltd.
- TORAY Research Center, Ltd.
- Matsushita Techno Research Co., Ltd.
- Mitsubishi Research Institute, Inc.
- Mitsubishi Space Software Co., Ltd.
- ITOHCHU Co.
- Sumitomo Corp.
- Marubeni Corp.
- Marubeni Aerospace Corporation
- Mitsui Bussan Aerospace Co., Ltd.
- Mitsubishi Corp.
- Shimizu Corporation
- Sumitomo Heavy Industries, Ltd.
- Sanritz Automation Co., Ltd.
- NHK Integrated Technology inc.
- NHK Promotions Inc.
- Dentsu Inc.

Of the above companies, JAI and JAMSS visited Sanritz Automation Co., Ltd, a subsidiary of Toyota Motors, Inc.,

in January 2008, and was pleased to discover a high level of interest in exploring the possibilities of future technology development projects using PISCES, especially in robotics remote teleoperation, including the use of proprietary technologies to reduce the operational impact of the inherent 3 second time lag in Earth-moon radio frequency communications. JAI believes that this is representative of the interest that will be discovered in visits with other Japanese “high-tech” companies.

5. Facilitate Near-term Commercial Opportunities

It is a PISCES strategic objective to identify two candidate commercial projects for PISCES. Affected organizations will be contacted and preliminary project plans defined. If possible, at least one of these projects would have a connection to the upcoming NASA PISCES tests in November.

As NASA’s space exploration program captures increased public attention with the ongoing development of the Orion and Aries exploration vehicles, the increasing publicity surrounding NASA’s use of lunar analog sites for exploration technologies development, and the landing of additional robotic vehicles on the moon and Mars by the U.S. and other space-faring nations, there will be opportunities for PISCES to contribute to the increased public excitement about space exploration through targeted commercial projects over the next five years. These projects, though not yet specifically defined, could include initiatives such as:

- Identification of an industry partner(s) to develop and market a PISCES “brand”. Ideally, this should be done concurrent with the development of the Visual Aids so as to synergize ideas pertaining to artwork, logo, business

tagline, etc. in the visual presentation material. Users of the PISCES facilities should be presented value-appropriate marketing articles (e.g. T-Shirts, caps) at the time of their event. Additional sales would be expected to the users as well as to the general public, especially within the State of Hawai`i.

- Identification of generic field site equipment that could be purchased, stored and maintained by PISCES in the PISCES facilities. The equipment could be leased to PISCES customers on a per-use basis for a fraction of the cost of their purchase and shipment to Hawai`i by customers for a one-time use.
- Explore interest in developing television documentaries by media organizations (such as NHK [a Japanese public broadcasting and video technology development company], The Discovery Channel, etc.). It would be quite beneficial for such a documentary to use footage from the November 2008 NASA tests at PISCES.
- Identify and promote a robotic PISCES mascot. As an example, the Sony Corporation has marketed a robotic puppy, AIBO, which could be custom fitted with an “EVA suit” and used as a PISCES mascot to stimulate interest in PISCES by grades K-12. AIBO has an embedded video camera and could be configured for teleoperation from the classroom. This would have the dual benefit of involving a large Japanese corporation in PISCES (with many potential applications of its robotics technologies to actual exploration objectives), major Japanese and U.S. television networks, and targeted groups of school children in the U.S. and Japan.

Business Operating Plan

Introduction

This is the business operating plan for the Pacific International Space Center for Exploration Systems (PISCES). It was presented in outline form at the 2007 PISCES Conference, where it was the subject of one of the breakout groups. Results from that conference are incorporated in the plan, along with input received over the past year from a wide range of business, civic, cultural, academic and professional groups, both local and national.

As a point of departure, it should be kept in mind that PISCES is not a for-profit business but a non-profit entity of the University of Hawai'i at Hilo (UHH), and exists for the purpose of research and education. It is built on partnerships between industry, academia and government. While its overarching goal is not to make money but to provide services to the space exploration community of nations, private industry, the State of Hawai'i and the people of the Big Island and Hilo, it is still necessary that PISCES be financially sustainable as a business entity and that a comprehensive and achievable business plan be defined and implemented.

Thus, although this plan contains many of the elements to be found in a typical for-profit business plan, its goals, which are the goals of PISCES itself, are justifiably broader than a defensible "balance sheet" and those responsible for their attainment will be a blend of PISCES employees, customers, educators, legislators, private benefactors and the resident populace.. These goals include advancing the state of knowledge in space exploration, enhancing educational opportunities at UHH, creating job opportunities for the residents of the Big Island, incorporating Hawaiian culture, involving the Hawaiian community and taking care of the land. The long-term success of PISCES will be measured by how well it meets all of these goals.

Customers

The customers of PISCES are those groups, organizations and individuals paying to conduct research and educational projects at the center, otherwise supporting the center financially and/or benefiting from its activities. The customers of PISCES, in no particular order, are as follows:

- The State of Hawai'i (its citizens, institutions and government)

- NASA (program managers at headquarters and the field centers)
- Space Agencies of Other Nations (including the Japanese Space Agency JAXA)
- Industry Partners (U.S. and international)
- Academic Partners (U.S. and international)
- Potential Philanthropic Supporters
- The People of Hilo and the Big Island (as taxpayers, included in a. above, but singled out here because they are most directly affected, either positively or negatively, depending on how PISCES approaches its mission and achieves its goals)

Services

1. Meeting Customer Requirements: The requirements of PISCES customers and the steps to be taken to meet those requirements are enumerated below.
 - a. The State of Hawai'i: The State of Hawai'i, in providing initial funding for PISCES, has shown that it views the Center as a tool for economic development. Therefore, economic development will be an important consideration in the development of PISCES. This will be done by bringing in Hawai'i-based companies as partners to work with NASA and the universities associated with PISCES and by encouraging the formation of spin-off Hawaiian companies based on work done at the Center. Some examples of terrestrial spin-offs from PISCES-developed technology include solar energy for electricity on the Big Island, advancements in agriculture on the volcanic Hawaiian soil, development of new materials from the Hawaiian soil and application of robotics in domestic industries. Enhancing educational opportunities for residents at UHH will also contribute significantly to economic growth.
 - b. NASA: Requirements for NASA research, testing, demonstration, simulation and training include provision of lunar analog test and outpost sites with infrastructure such as power and communications, development of expertise and capabilities at UHH, education and cultivation of competent students, access to shops and storage facilities and support of operations at the test sites and lunar outpost. PISCES will meet these requirements in an environmentally and culturally sensitive manner and will use State

funding, revenues from NASA contracts and industrial support to hire capable staff and students.

- c. Other Space Agencies: It is expected that requirements from other space agencies will be similar to those of NASA. However, it will take more effort to engage foreign groups simply because of the barriers to working outside their home countries. In the case of Japan, PISCES will work closely with the Japan-US Science, Technology and Space Applications Program (JUSTSAP), which meets annually in Hawai'i and under whose auspices PISCES was conceived, to encourage Japanese involvement. Also, in working with non-national groups, it will be necessary to observe restrictions imposed by U.S. Export Control regulations.
- d. Industry Partners: Requirements of industry partners include many of the same infrastructure items as for NASA and, in addition, facilitation of marketing opportunities and confidentiality with regard to intellectual property. It is highly likely that specialized non-aerospace industries will also find the capabilities of PISCES attractive. For example, companies developing terrestrial robotics devices to facilitate improvement in homeland security surveillance or search and rescue operations could use the Big Island terrain to field test their new technologies. The annual PISCES conferences will feature an "Industry Day" at which companies affiliated with the center can set up displays and make presentations on their capabilities. To protect intellectual property, PISCES personnel, including students, will be required to sign confidentiality agreements when working with sensitive products produced by industrial partners.
- e. Academic Partners: Faculty and students from academic institutions that partner with PISCES will need to use its facilities and capabilities to fulfill their roles in joint research and education projects. In addition, these academic partners will benefit from the increased visibility and contacts derived from association with the center. PISCES will strive to accommodate requests for summer internships and will conduct topical seminars involving partner institutions at its annual conferences.
- f. Philanthropic Supporters: Requirements of potential philanthropic supporters of PISCES will be as varied as their reasons for giving, and may range from fostering space exploration to enhanced education and economic development on the Big Island. By its very nature, PISCES will address requirements of all philanthropic supporters as they are identified. For example, the Center will raise money to endow new professorships at UHH, to build and equip the Base Facility in the UHH Technology Park and to construct the Outpost. PISCES will be particularly

responsive to naming requests by philanthropists, working with the university to avoid policy conflicts.

- g. The People of Hilo and the Big Island: Perhaps the earliest and most direct beneficiaries of PISCES will be the local residents. The center will make every effort to maximize awareness and involvement of the people of Hilo and the Big Island and to maximize the involvement of local interest groups in all of its activities. A cultural advisory council, called "Papa A`o A`o," has been formed and is holding meetings. Advice will be sought from this council for all issues related to PISCES, but especially those involving education, facilities and land use. Events will be organized, often in conjunction with the PISCES Annual Conferences, which will offer local residents opportunities to learn more about the center's activities and the world's efforts in space exploration and settlement. Educational activities highlighting space will be held in local schools, at the university and through the 'Imiloa Astronomy Center of Hawai'i.
2. Direct Participation in Customers' Exploration Planning: The goals of PISCES call for it to become a leader of thought in space exploration and settlement and not simply a follower of NASA or any other entity involved in space. Therefore, PISCES will conduct its own studies in all areas related to its mission and will meet regularly with key NASA officials to participate in their exploration planning. PISCES will also engage in this way with officials from JAXA and other space agencies. To this end, PISCES will maintain continuing contact with the Johnson Space Center, where NASA's exploration systems program is based, and with JAXA. NASA officials from six field centers and NASA Headquarters joined PISCES for its annual meeting in 2007 and are expected to participate fully in subsequent meetings. PISCES will place a priority on maintaining frequent contact with key officials at NASA Headquarters in Washington, DC.
 3. Evolutionary Capabilities Corresponding to Exploration Objectives: The design of the PISCES facilities, particularly the Outpost, will enable architectural evolution to adapt to changes in national and international space program objectives. Thus habitats will be modular and field areas will be expandable to meet changing needs. Research will be geared toward incorporating new technologies and systems into the Outpost architecture as soon as they are developed, but earlier than they could be incorporated at an operational outpost on the Moon.
 4. Life Cycle and Sustaining Capabilities Considerations: By steadily transferring technology developed in the research labs out to the PISCES field sites and to the

Outpost, PISCES will adopt a seamless research-to-deployment approach, bridging the so-called “technological valley of death” that results when research and applications take place in organizations separated both physically and culturally. The approach is illustrated graphically in Figure 2.

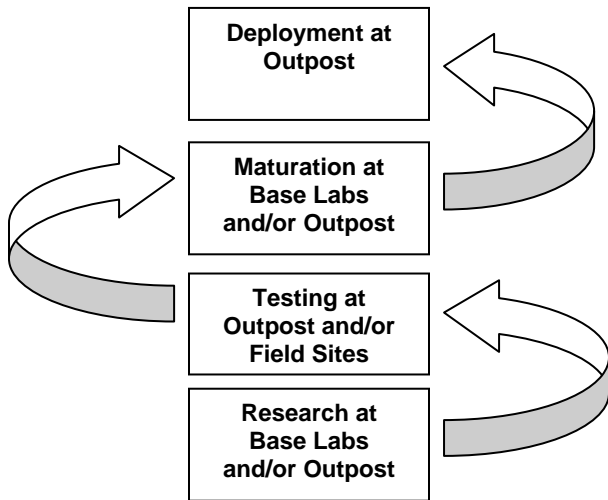


Figure 2. Spiral Technology Development at PISCES

In this way, PISCES will be able to sustain its technical capabilities through its own research and development cycles, thereby continuously refreshing and improving its ability to provide research, testing, development and educational services to its customers. Also, as new technologies are developed within NASA and other organizations, they will be adopted as feasible at the Outpost to ensure currency.

Market Analysis: Characteristics and Scope

1. Industry Description, Scope and Trends: The industry, or more broadly the community, that potentially could be served by PISCES is the space community consisting of the world’s major space agencies, companies and universities involved in space activities.

The United States has embarked on an historic era of human and robotic space exploration, spearheaded by the so-called “Vision for Space Exploration,” which calls for a return to the Moon in preparation for establishing a sustained presence there and for human exploration of Mars and beyond. The idea of a renewed emphasis on space exploration and settlement has received widespread public support in the US, culminating in the passage of the NASA Authorization Act of 2005 (Public Law 109-

155), and has generated strong interest and participation by other countries, particularly Japan. The U.S. plan calls for human landings on the Moon no later than 2018, while the smaller program in Japan foresees landings somewhat later. A total of five countries; the U.S., Russia, Japan, China and India, are currently planning manned or unmanned missions to the Moon in the next decade.

Long-duration space missions and sustained presence on other bodies in the solar system will preclude the routine transport of supplies and materials from Earth and will therefore require that many of these essential commodities be produced from resources existing on that body. This requirement for “living off the land” is what sets this new era of space exploration apart from all others in the past; this time we are going to stay. It will be neither practical nor cost-effective to take everything needed to stay there. In the case of Mars, it will be all but impossible. Thus it will be necessary to use the lunar and Martian materials to construct habitats, to produce oxygen for breathing, to provide energy and to propel rockets, as the primary constituents of beds for growing food and to generate electricity from sunlight. Development of improved, new and reliable technologies to support such challenging exploration ambitions must be started now if they are to be ready for the first human outpost on the Moon in the next decade. PISCES will be a major contributor to this effort through its research, testing, education, training and public outreach programs.

Whether or not this activity continues at its present pace in the U.S. will depend on many factors, the most important of which is the political environment. While there are doubts about the current approach to space exploration in some quarters, there appears to be strong support for continuing it, as evidenced by the overwhelming passage of the current NASA authorization bill, although there have since been isolated calls for a delay in its implementation.

There is also strong support for PISCES within NASA, as evidenced by its awarding of two contracts to PISCES and the large turnout at the first annual conference. And there is certainly strong support in Hawai’i, as evidenced by the unanimous passage of the funding legislation last year.

The traditional aerospace companies can be expected to follow NASA’s lead in space exploration, as can their counterparts in Japan and elsewhere. These companies are certain to be major customers of PISCES, along with the space agencies they serve.

There is also a large and growing sector composed of private space entrepreneurs, so-called NewSpace companies that are independently pursue opportunities in

space tourism and related areas. These companies may also become customers of PISCES, in keeping with their “can do” attitudes.

2. Major Customer Interests: Requirements of the PISCES customers were covered in Section 1 of this Business Operating Plan. Interests of the major customer categories that will provide operating funds to PISCES are listed here.

- a. NASA: Test beds for ISRU, Robotics and other experiments; space exploration research; education; astronaut geology and lunar surface operations training
- b. Traditional Aerospace Industry: Test beds for equipment and systems being developed with internal R&D funds or under contract to NASA and other space agencies; access to expertise not resident in-house; access to students as potential future employees
- c. NewSpace Companies: Test beds for equipment and systems being developed for private space ventures, including habitats and ISRU experiments; access to expertise at lower cost than available in other companies or consultants; access to students as sources of low-cost labor; access to traditional aerospace companies working in synergistic relationship on projects within the center

3. Problems, Obstacles and Opportunities: The major problems and obstacles identified to date in the development of PISCES include uncertainties in the directions that NASA and the world’s space agencies will take over the next few decades, combined with and largely driven by, the general state of the world economy. This also applies to the state of the Hawaiian economy since the legislature is providing start-up money for PISCES. The fortunes of those companies closely aligned with government space programs will rise and fall with these economic cycles. However, the NewSpace companies, which are focused on tourism and in many cases are headed by wealthy individuals who were successful in unrelated businesses, are somewhat less susceptible to economic factors. Additionally, companies with non-aerospace business goals which are compatible with PISCES capabilities will be sought out. PISCES will make special efforts to engage each of these companies in its research and education programs.

Opportunities abound for PISCES, and can be expected to increase over the long term regardless of short-term economic cycles. This is true because the movement of humans into space has been slow but inexorable and is likely to continue. With its location in Hawai`i at the center of the Pacific Rim of nations, many of which are

planning lunar missions of their own, PISCES is well positioned to take advantage of the coming opportunities in space exploration.

3. Market Research: The PISCES organizing team has been working informally over the past year to determine the market for its services among the various programs at the NASA field centers, within companies working in space exploration and in the universities that might be potential collaborators. The preliminary outcome of this market research has been that there is considerable potential for use of PISCES, although how that potential is realized will depend on the direction NASA takes over the next few years. But PISCES needs to establish a more formal market research capability if it is to be successful in the years to come. For this function, PISCES will eventually need its own Business Development Office, which will do in-house market research and, as funding grows, can contract out to professional market research organizations.

In the interim until PISCES is fully developed, there are other ways to do market research at lower cost and that can have some advantages to the host institution and the local economy. For example, PISCES will conduct early market research through the UH-Hilo College of Business and Economics, utilizing students on senior projects and summer internships. This approach will have the added benefit of more fully integrating the Center into the University. Also, some market research can be done through existing economic development organizations on the Big Island, such as the Hawai`i Island Economic Development Board (HIEBD), and through DBEDT itself, which has responsibility across the entire State.

4. Other Analog Sites - Competition or Collaboration: There are existing and potential analog sites that could possibly compete with PISCES for simple testing and demonstrations. Some of the ones currently used by NASA include Meteor Crater in Arizona and Devon Island/Haughton Crater in Canada. PISCES, however, is much more than a simple analog testbed site. It is a complete research and education center focused on learning how to sustain life on the Moon and beyond. One of its features is a simulated lunar outpost, which is also much more than a passive testbed. The outpost will enable researchers to develop and test on a pilot scale many of the technologies needed to sustain life on an extraterrestrial body. However, given the finite fiscal resources that will be available to NASA and other PISCES customers, it is expected that PISCES will indeed have to routinely compete with other analog sites for budget allocations and contracts. It will be incumbent upon current and future PISCES management to ensure that sufficient resources are allocated to periodic marketing and sales campaigns, maintain close professional relationships with existing PISCES

customers and maintain awareness of the evolving capabilities of other U.S. and international analog sites.

Market and Sales Strategy

The overriding PISCES market and sales strategy is that of an industry-university-government partnership center, and as such is predicated on the involvement of faculty members from the host and partner institutions in the form of proposal writing. The strategy is based on exploiting existing and developing relationships between these faculty members and researchers in government and industry. This overall strategy notwithstanding, it is important to maintain a proactive marketing strategy relative to industry contacts because industry Internal Research and Development (IRAD) funds should always be a target. And as previously mentioned, corporate profit opportunities and associated political overtures can help to influence government directions and requirements.

A typical process leading to business for the Center starts with a faculty member receiving notification of a Request for Proposals, or Cooperative Agreement Notice, through normal email or web-based channels. Alternatively, a government or an industry researcher will learn of an opportunity in his or her organization and contact the faculty member. A joint proposal is written, which may involve participants from all three partner categories; industry, university and government. In developing the proposal, the faculty member consults with the member of the Board of Directors who is the leader of the particular program area in which the proposal falls; i.e., ISRU, Robotics, etc., and with the director, who must approve submission of the proposal. If a grant, contract or cooperative agreement is awarded as a result of the proposal, the funds come into the central PISCES offices and are allocated to such categories as faculty, staff, students, partners (through subcontracts), operations, administrative costs and institutional overhead. All costs unique to the particular project are built in to the proposal budgets.

Two developments in the evolution of the Center will be important in implementing this market and sales strategy; 1) the creation of a viable marketing and business development function and 2) the structuring of institutional overhead policy so as to allow dedicated revenue streams to fund this and other important, but not project-specific, functions. Roles and responsibilities of the planned PISCES business development office will be discussed in the following sub-sections. Possibilities for overhead return will be discussed in the Financial section.

1. Advertising and Marketing Approach: PISCES will have a robust advertising and marketing program, which will closely link its public outreach and business development

functions. The Public Outreach Office will develop programs and materials to present to the three groups of customers; industry, university and government. Details of those programs and messages are contained in the Education and Public Outreach plan, which forms a part of this Strategic Plan. This office will work closely with the Business Development Office to target its messages to the appropriate audiences on a national level. The office will also work closely with the NASA and Industry Liaison office to tailor messages to individual program managers within NASA and both the aerospace and non-aerospace industry groups. The business development office will be responsible for making overtures to all categories of customers, working closely with individual PISCES faculty members and customer program managers to develop proposal leads, buffer the faculty members in dealing with institutional and agency financial offices, and follow up on submitted proposals.

2. Specific Sales Strategies and Techniques: Some of the specific sales strategies and techniques to be employed by PISCES are listed below. Others and additional detail can be found in the Education and Public Outreach section.
 - a. Promote the unique characteristics of the Big Island for lunar and Martian research and simulation to attract NASA, other space agencies and aerospace companies.
 - b. Emphasize dual-use technology development to attract non-aerospace companies and benefit the local economy.
 - c. Enlist faculty members with expertise to complement those existing within the current organizing team.
 - d. Partner with institutions offering complementary expertise and capabilities.
 - e. Make heavy use of the PISCES website to reach broader audiences.
 - f. Develop promotional materials such as brochures, videos, displays and web pages to appeal to different customer groups.
 - g. Aggressively pursue news coverage of major events, including new contracts, employees, partnerships, demonstrations, conferences and public events.
 - h. Host topical seminars, workshops and other public events.
 - i. Strive to make the annual PISCES/JUSTSAP conference a world class event; one that is a must-attend for countries and organizations with analog utilization interests.

team that works together synergistically to achieve common goals.

Development Approach

PISCES is currently in the first year of its initial development plan, which was submitted to the Hawai'i State Legislature in January of 2007, accepted in a bill signed by the governor in June of 2007 and implemented by a contract from the Department of Business and Economic Development at Tourism (DBEDT) in October of 2007. That plan spelled out various organization tasks, many of which have been completed, along with the writing of this Strategic Plan. However, PISCES also submitted several proposals to NASA during that time period, two of which were funded, which accelerated the developmental timetable by bringing field testing into the current year and, among other adjustments, necessitating the hiring of an operations manager. A number of other proposals are under review. Also, during this first year it has become apparent that there are even greater opportunities, encompassing a much broader range of customer interests, than previously anticipated, coupled with recognition of the need for earlier and more intimate local involvement. Thus this strategic plan differs from the original development plan in both schedule and scope. The following subsections reflect the new development approach.

1. Achieving Political and Cultural Advocacy: PISCES has thus far been successful in achieving political advocacy at the State level. Now it is imperative that the center achieve that same enthusiastic acceptance at the local and national levels. To this end a Cultural Advisory Council (CAC) has been established, consisting of native Hawaiian leaders from Hilo and Hawai'i Island. In the coming months a PISCES Advocacy Board (PAB), consisting of State and national leaders will be established to advise the center on fundraising and advocacy issues. In addition to advising the center on the upcoming capital campaign (see the Fundraising Plan section) the PAB will advise and assist the director and others involved in PISCES development with visits to local and national political leaders, including members of Congress. All visits to political leaders will be coordinated closely with the University Relations office at UH-Hilo.
2. Achieving Customer Advocacy: Customer advocacy will be achieved first and foremost by building confidence in PISCES through contract and grant performance and also by close contact with personnel at the NASA field centers, other space agencies and existing and potential industry customers. Through these contacts, customer needs will be tracked and strategies and tactics developed for meeting those needs. It will be imperative to be proactive in keeping the customer in the "PISCES evolution loop" in order to establish and maintain a PISCES-customer

3. Infrastructure Requirements Definition and Phasing: Infrastructure requirements and phasing are outlined in the Facilities Plan elsewhere in this document. As business grows and PISCES broadens its activities, it is anticipated that infrastructure needs will change somewhat, and the speed with which facilities can be brought on line will naturally vary with available resources. However, the intent is to follow as closely as possible the schedule laid out in the Facilities Plan.
4. Project Definition and Implementation Approach: Initially, projects are expected to fall into the broad categories that have defined PISCES since its inception: ISRU, Robotics, Habitat Design, Site Characterization and Education and Outreach. As the center develops, however, it is conceivable that whole new areas of research germane to living on the Moon and beyond will be added to the PISCES portfolio. These include agriculture, architecture, business plans for space development, energy, geology, lunar science, psychology, space law and many others. The process for defining and incorporating such new areas will typically start with faculty members who want to become involved with PISCES, or be suggested by a customer, or be contained in a solicitation. In all cases, the final decision on the scope of PISCES will be made by the Board of Directors.
5. Site and Facilities Definition and Development Priorities: The priorities and phasing for the PISCES base facility, and field sites and Outpost are laid out in the Facilities Plan. Overall approval of all the PISCES plans and modifications will be the responsibility of the Board of Directors. Adherence to the plan will be the responsibility of the director, with assistance from the administrative team.

Operations Approach

1. Business Model Description: The PISCES business model is that of an industry-university-government partnership. Examples of these kinds of partnerships exist in many government agencies, notably the National Science Foundation's Industry-University Research Centers and NASA's former Research Partnership Centers. The basis of the model is the entrepreneurial faculty member at UHH or one of the partner institutions, assisted by the PISCES Business Development Office, competing for and securing research and education grants, contracts or cooperative agreements from NASA, a foreign space agency, another U.S. government agency or a company.

The typical partnership-forming process in this model begins with a relationship that is established between a faculty member in the center and a researcher in a company, assisted by the business development arm of the center. The two researchers will write a joint proposal to a federal agency for research to be done at the Center, usually with cost-sharing provided by the company, or the faculty member will write a proposal for directed research by the company. In many centers of this type, a formal industrial partnership mechanism is put in place through a legal agreement, whereby the company pays an annual membership fee in exchange for access to the center's faculty and student expertise and to its laboratory and field facilities. The membership agreement specifies the responsibilities and benefits of membership, including the sharing of intellectual property rights, and the fee schedule. The provisions of a typical membership agreement are sketched below:

- **Benefits:**
 - Access to faculty members and students
 - Access to laboratory and field facilities on a cost-reimbursable basis
 - Sharing of generic intellectual property developed in the center (i.e., IP not restricted by agreement to another member company)
 - Confidentiality agreements from faculty and students working on IP-restricted projects
 - Option for direct funding of projects in the center above and beyond membership fees
 - Membership on Board of Directors

- **Example Membership Fees:**
 - Companies with capitalization greater than \$10B: \$30K/yr.
 - Companies with capitalization less than \$1-10B: \$20K/yr.
 - Companies with capitalization less than \$1B: \$10K/yr.

For purposes of this plan, industrial membership fees will be assumed to begin after the third year, increasing each year to become a significant source of revenue as State funding declines. With the example fees shown above, a mix consisting of five large companies, ten medium-size companies and five small companies could replace all the State funding received this year. Because the membership fees are viewed as investments in the center, as opposed to operating revenues, expenditures from such fees, as with capital expenditures, are often not charged overhead. Such a scenario is assumed in the revenue projections made in the financial section later in this plan.

2. Key Personnel / Organization: Since its inception, PISCES has been advised and coordinated by an

organizing team, which is a group of self-selected participants from the JUSTSAP Symposium, while day-to-day management has fallen to the director and deputy director. This plan envisions a more formal structure to clearly delineate the fiduciary responsibility of the university. A functional diagram of this new organization is shown in Figure 3. The Board of Directors will be nominated from members of the organizing team and the UH-Hilo administration, and will be appointed by the Chancellor. The Board will elect its own chair. They will meet periodically, but at least once per quarter, either in person or by teleconference. Responsibilities of the Board include setting the overall direction and policies of the Center, making recommendations to the Chancellor on appointments of management and staff personnel and advising the director on all aspects of PISCES operations.

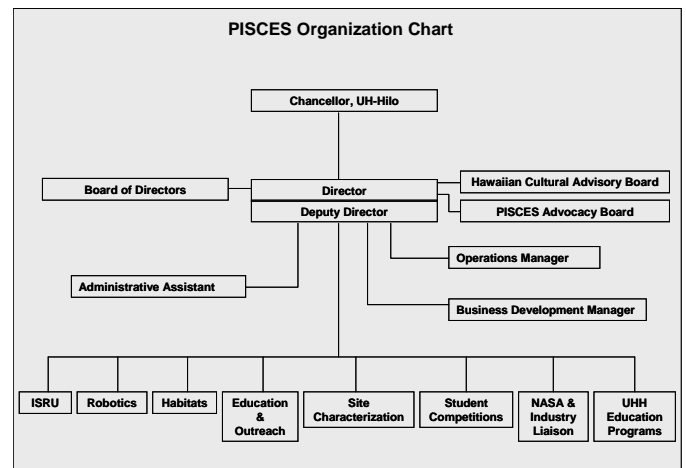


Figure 3. PISCES Organization Chart

As the center grows and expands, additional functions will be added to the chart upon approval of the Board of Directors. The current members of the organizing team and their responsibilities are listed below in the order in which they appear on the chart.

- Frank Schowengerdt, Director
- Robert Fox, Deputy Director, Higher Education
- John Hamilton, Operations Manager
- Mike Duke, General ISRU, Habitats, Student Competitions
- Neville Marzwell, Robotics
- Beth McKnight, Education and Outreach
- Mark Henley, Site Characterization, Solar Energy Systems
- Dan Bland, NASA, JAXA & Industry Liaison
- Rob Carlson, Business Development
- Alex Ignatiev, Solar Energy ISRU

Larry Clark, Oxygen ISRU
Jim Crisafulli, DBEDT Liaison
Stephen Day, JUSTSAP Liaison

Financial

3. Product and Service Delivery. The products and services of PISCES are research and education projects. These projects can be proposed by individuals on the PISCES administrative team, the Board of Directors or by any faculty member at UHH or other participating institutions such as the University of Hawai'i at Manoa, Tokyo Institute of Technology, Colorado School of Mines, or any other partnering university, as approved by the Director. Project selection will be based on the needs of PISCES and the potential for external funding, as guided by this Strategic Plan, and approved by the Director. Members of the Board of Directors who are responsible for guiding specific PISCES program areas will be consulted by the potential Principal Investigator (PI) and the Director. Projects funded through such proposals will be designated "PISCES Projects" and will fall within the fiscal and policy structure of the center. Conduct of the project, including submission of all required reports, is the responsibility of the PI.
4. Facilities/Supplies Logistics. Ensuring that facilities, including field sites, are available for use on PISCES projects and that the general supplies are available at the PISCES facilities is the overall responsibility of the Director, with assistance from the Deputy Director and the Operations Manager. Provision of lodging, transportation and project-specific supplies and equipment is the responsibility of the PI.
5. Land Use Considerations. The Operations Manager will have primary responsibility for pursuing the necessary permits for use of land on which to conduct PISCES field tests and construct habitats and other facilities, in coordination with the cognizant UHH administrative offices.
6. Native Hawaiian and Customer Integration: The integration of interests of the customers with those of native Hawaiians and others concerned with cultural issues on the Big Island will be led by the Operations Manager in consultation with the Cultural Advisory Council.
7. Human Resource Considerations: Since PISCES is a legal entity of the University of Hawai'i at Hilo, personnel matters will be handled by the Human Resources division of the university or its designee, the Research Corporation of the University of Hawai'i (RCUH). All State of Hawai'i personnel policies, including equal opportunity hiring, will be adhered to by PISCES.

1. Revenue Requirements/Sources: Revenue requirements can be separated into three general categories: 1) those of a one-time nature; e.g., for capital improvements or purchases, 2) operating revenues specified for research and education projects, and 3) operating revenues specified for maintenance and improvement of the infrastructure as required to attract new customers and deliver the requested services to all customers; e.g., administration enhancements, increased funding to business development initiatives, routine and unscheduled outpost maintenance. Sources for capital are primarily state and federal governments, private companies and private donors. Sources for projects are government agencies and companies. Sources for infrastructure maintenance and improvement are primarily indirect charges on projects (overhead), except in those cases where direct charges can be justified, as in equipment and field site usage, for example. For the indirect costs, the university must collect fees from projects to help pay for administration, space, utilities, etc. However, to the extent that the center can relieve the institution of some of these costs, a portion of the overhead can be returned to the center. There is ample precedent for such an arrangement in universities around the country. Many do it to encourage growth of research centers.

In the UHH case, the university already charges about half of its normal rate to projects that are conducted off-campus, which is the case for most PISCES projects, although the infrastructure such as administration, business development and PISCES base facility operations functions will be on campus and will be covered by PISCES. The current UHH overhead rate is 38.4% for on-campus projects and 19% for off-campus ones. It would not, therefore, be unreasonable for PISCES to charge its customers the full overhead rate and have approximately half the difference between the on-campus and off-campus rates returned by the university for maintaining the PISCES on-campus infrastructure. This arrangement will be worked out in detail with the UHH administration. For purposes of this plan, it is assumed that an overhead return rate of 10% of the total non-state awards, or roughly 1/4 of the overhead collected, will be allowed.

Based on experience in applying for and receiving NASA contracts in PISCES so far, NASA's plans for sustaining an outpost on the Moon in preparation for going on to Mars, the growing interest in space exploration and tourism in the private sector and the strong interest among researchers at UHH and its partner institutions, a total

revenue of approximately \$6.5 million per year is believed to be achievable at the end of the planning period. If space exploration activity grows as expected, all revenue streams should grow after the first few years, especially those from the private sector. Operating revenue projections for the 10-year period beginning with the current year are shown in Figure 4.

3. Value Projections for State of Hawai'i: From a strictly financial standpoint, it is apparent from the revenue projections in Figure 3 that the total return on investment to the State of Hawai'i will be huge. The ratio of non-State to State revenues rapidly increases from about one in the first year to well over 10 as the Center matures. However, the value of PISCES to the community and to the State is far greater than even this large financial leverage implies. As can be seen in the expense projections in Figure 4, almost half of the total dollars coming into the center will go directly into salaries, travel and supplies at UHH. Some of these will be existing faculty and students employed in the summer, but others will be new hires, both faculty and staff. There will thus be jobs created at UHH immediately. But as the center develops and grows and as more universities, companies and government agencies come in to do work at the center there will be increasing indirect job creation. At some point there will very likely be spin-off companies created, as has been shown to be the case at many such research centers throughout the country, which will result in further job growth. These will be good paying, high-tech jobs of the kind that will encourage local youth who receive an education at UHH to stay in the area.

4. Reporting Requirements and Methods: PISCES will submit annual reports to DBEDT for forwarding to the Legislature as long as the State provides funding. This Strategic Plan forms the first of those reports. Each of the contracts, grants and cooperative agreements will require at least annual reports, and some will require more frequent reporting. These reports will be prepared by the administrative team, submitted to the cognizant program or agency and distributed to the Board of Directors and DBEDT for information. Because PISCES is an official UHH center, periodic reports will also be required by the institution.

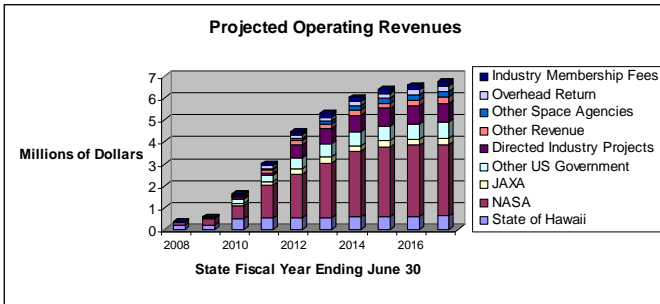


Figure 4. Projected PISCES Operating Revenues

2. Operating Expenses: Operating expenses include UHH faculty, staff and student salaries; travel; supplies; contracts to individuals and companies for services and subcontracts to partnering universities and companies as part of a larger grant or contract; and indirect costs such as facilities maintenance and operations. Because of the wide variety of projects expected in PISCES, it is not possible at this time to project the precise distribution of expenses among the different categories. For planning purposes, State funding is projected to remain stable, while a prototypical distribution is assumed for grants, contracts and cooperative agreements coming into PISCES, which are phased in over years 2 through 10. Most recurring expenses, such as salaries and supplies, are inflated at 4% annually. In addition, an approximately equal distribution of funding is assumed between UHH and subcontracts to partnering universities and companies. Projected operating expenses calculated with these assumptions, and adjusted to equal projected revenues, are shown in Figure 5.

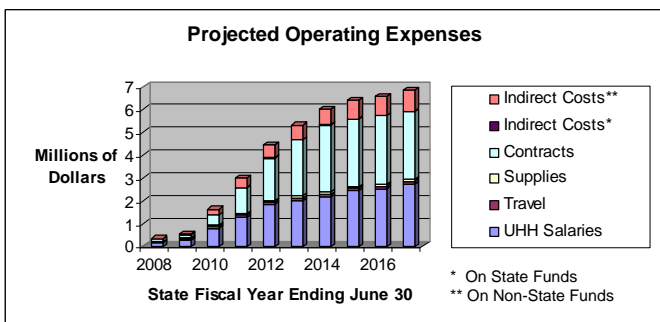


Figure 5. Projected PISCES Operating Expenses

**PISCES
STRATEGIC
PLAN
APPENDIX**

PISCES Strategic Plan - Appendix -

Resumes of the Members of the PISCES Organizing Team:

Dr. Franklin D. Schowengerdt

Professor of Physics and Director of PISCES
University of Hawai'i at Hilo
Hilo, HI 95720
Email: schoweng@hawaii.edu

Permanent Address:
709 Fitzhugh Way
Alexandria, VA 22314
Phone: (703) 519-7391
(571) 309-3815

PROFESSIONAL EXPERIENCE

Current	Professor of Physics, University of Hawaii at Hilo and Director of the Pacific International Space Center for Exploration Systems (PISCES)
Sept. 06 – Current	President, SpacePartnerships.com, a consulting firm specializing in creating and promoting partnerships between industry, academia and government for the purpose of commercializing space.
May 06 – Aug. 06	Senior Advisor, Innovative Partnerships Program National Aeronautics and Space Administration
Aug. 03 – Apr. 06	Program Executive, Space Product Development National Aeronautics and Space Administration
Jan. 05 – Aug. 05	Director, Innovative Partnerships Program National Aeronautics and Space Administration
Jan. 96 – Aug. 03	Director, Center for Commercial Applications of Combustion in Space (CCACS), Colorado School of Mines
Jan. 90 – Dec. 95	Vice President for Academic Affairs and Dean of Faculty, Colorado School of Mines
1985-90	Chairman of the Board, Colorado Advanced Materials Institute

- 1977-90** Head, Physics Department, Colorado School of Mines
- 1987-88** Distinguished Visiting Scientist, Jet Propulsion Laboratory, California Institute of Technology
- 1973-03** All professorial ranks in physics department, Colorado School of Mines:
 Dates of promotion:
 1980: to Professor of Physics
 1976: to Associate Professor of Physics
 1973: to Assistant Professor of Physics
- 1969-73** Research Associate and Visiting Assistant Professor of Physics, University of Nebraska, Lincoln, NE
- Research in atomic and molecular collisions. Teaching in undergraduate physics courses

MILITARY SERVICE

U.S. Navy, 1956-60. Honorable Discharge at Rank of 2nd Class Petty Officer, Aviation Electronics Technician

EDUCATION

Ph.D. Physics, University of Missouri-Rolla (1969)
 M.S. Physics, University of Missouri-Rolla (1967)
 B.S. Physics, University of Missouri-Rolla (1966)
 Undergraduate Studies, Washington University, St. Louis (1961-63)
 U.S. Navy Aviation Electronics, Airborne Radar and Naval Undersea Warfare Schools
 High School Diploma, Bellflower High School, Bellflower, MO (1954)

HONORS AND AWARDS

Dean's List all semesters in attendance, University of Missouri-Rolla
 Sigma Pi Sigma National Physics Honor Society, 1965
 Phi Kappa Phi National Honor Society, 1965
 NSF Undergraduate Research Award, 1966
 NASA Graduate Fellow, 1966-69
 National Research Council Senior Research Fellowship, 1987
 Distinguished Visiting Scientist, Jet Propulsion Laboratory, California Institute of Technology, 1987-88

Science as a Christian Vocation, Presbyterian Association on Science, Technology and the Christian Faith, 1999

MEMBERSHIPS AND OFFICES HELD

American Physical Society
American Vacuum Society
Chairman, Rocky Mountain Chapter, American Vacuum Society, 1988-1991
Chairman of the Board, Colorado Advanced Materials Institute
Materials Research Society
Presbyterian Association on Science, Technology and the Christian Faith
Sigma Xi

RECENT RELEVANT PUBLICATIONS

“PISCES, ISRU Research and Demonstration Plan,” M.D. Duke and F.D. Schowengerdt, *Space Resources Roundtable XIII*, Colorado School of Mines, Golden, CO, October 2007

“The Pacific International Space Center for Exploration Systems (PISCES) as an Example of the Role that the States Can Play in Space Exploration,” *Lunar Exploration Advisory Group, Lunar and Planetary Society*, Houston, October 2007

“PISCES: A ‘Stepping Stone’ to International Space Exploration and Development,” J.T. Howell, M. Henley and F.D. Schowengerdt, *International Astronautics Conference*, Hyberadad, India, September 2007

“PISCES: Developing Technologies for Sustained Human Presence on the Moon and Mars,” F.D. Schowengerdt, R.A. Fox, M.B. Duke, N. Marzwell, B. McKnight, *Space 2007, American Institute of Aeronautics and Astronautics*, Long Beach, September 2007.

“PISCES: A Lunar Outpost for ISRU Partnerships,” F.D. Schowengerdt, M.B. Duke, R.A. Fox, M. Henley, N.I. Marzwell, J. Crisafulli, S.M.D. Day, *Space Technology and Applications International Forum – 2007*, February 2007

“Space Exploration: The Role of the Innovative Partnerships Program,” F.D. Schowengerdt, *Technology Innovation*, Vol. 12, No. 1, 2005, p. 8.

“Toward Sustainable and Affordable Space Exploration: The Role of NASA's Space Product Development Program”, *Space Technology and Applications International Forum – 2005*, February 2005, AIAA Abstract, p. 205

Dr. Robert A. Fox

Chair, Department of Physics and Astronomy
University of Hawai'i at Hilo
200 W. Kawili Street
Hilo, Hawaii 96720

808-974-7731 (office)
808-974-7693 (fax)
rfox@hawaii.edu (e-mail)

EDUCATION

B.S., 1964, New York University
Major in Physics, Minor in History

M.A., 1971, New York University
Experimental Physics

Ph.D., 1971, New York University
Experimental Physics

CURRENT POSITIONS

Professor and Chairman
Department of Physics and Astronomy
University of Hawaii at Hilo

Deputy Director
Pacific International Space Center for Exploration Systems

Co-Director
University of Hawaii Charter School Resource Center

RECENT PUBLICATIONS

Hamilton, J. and Fox, R., (2008), Hoku Kea-Educational 1 meter Telescope on Mauna Kea, presented at the American Astronomical Society Meeting, January, 2008, Austin, Texas

Fox, R. and Schowengerdt, F., PISCES: An International Incubator for Entrepreneurship in Space Exploration and Settlement. (author order tentative), submitted to the International Astronautical Congress, Glasgow, UK, September 2008.

Marzwell, N., Larson, W., Duke, M., Fox, R., and Schowengerdt, F. (2008) PISCES: Developing New Design, Materials and Technologies for Sustained Human Presence on the Moon and Mars, Earth and Space 2008, Long Beach, CA March 3-5, 2008

M. B. Duke, F. D. Schowengerdt, J. Crisafulli, S. M. D. Day, R. A. Fox, M. Henley, N. I. Marzwell, (2007) PISCES: Hawaii Facility for Simulation and Training, Space Foundation National Symposium, April, 2007, Colorado

F.D. Schowengerdt, M.B. Duke, R.A. Fox, M. Henley, N.I. Marzwell, B. McKnight, J. Crisafulli, S.M.D. Day, (2007), PISCES: Developing Technologies for Sustained Human Presence on the Moon and Mars, Space 2007 Conference and Exhibition, American Institute of Aeronautics and Astronautics, September 2007, Long Beach, CA

F.D. Schowengerdt, M.B. Duke, R.A. Fox, M. Henley, N.I. Marzwell, J. Crisafulli, S.M.D. Day, (2007), PISCES: A Lunar Outpost for ISRU Partnerships Space Technology Applications International Forum, February 2007, Albuquerque, NM

M. B. Duke, F. D. Schowengerdt, J. Crisafulli, S. M. D. Day, R. A. Fox, M. Henley, N. I. Marzwell. (2007), PISCES: HAWAII FACILITY FOR SIMULATION AND TRAINING, 38th Lunar & Planetary Science Meeting, March 13, 2007, League City, Tx.

John Hamilton, R.A. Fox, M. Sasaki, and Y. Asaoka, (2008) Ashra (All-Sky Survey High Resolution Air-shower detector): Current Status on Mauna Loa, Hawai'i, American Astronomical Society Meeting, June 2008, St. Louis, MO. (authors not listed alphabetically)

Aita, Y., Fox, R., Watanabe, Y. (2007), The Ashra Experiment, 5th Fluorescence Workshop, El Escorial, Spain, 17 September 2007

Aita, Y., Fox, R., Watanabe, Y. (2007), Ashra Mauna Loa Observatory and Slow Control System, 30th International Cosmic Ray Conference, Merida, Mexico, July, 2007

Aita, Y., Fox, R., Watanabe, Y. (2007), Hybrid Photo Detector as the Ashra trigger sensor, 30th International Cosmic Ray Conference, Merida, Mexico, July, 2007

Aita, Y., Fox, R., Huang, M.; (2006a); ASHRA PROJECT, Report I, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Aita, Y., Fox, R., Huang, M.; (2006b) Ashra Report 2: Current Status, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Aita, Y., Fox, R., Huang, M.;(2006c); Ashra Report 3, Hybrid Photo Pixel Detector as the Trigger Sensor, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Aita, Y., Fox, R., Huang, M.;(2006d) Ashra Report 4: VHE Neutrino Detection, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, October, 2006

Aita, Y., Fox, R., Huang, M.;(2006e) Ashra Report 5: VHE Gamma-ray Detection, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, October, 2006

Aita, Y., Fox, R., Huang, M.;(2006f) Ashra: All-Sky High Resolution Air Shower Detector, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 30 October, 2006

Hardman, J., Aita, Y., Fox, R., Watanabe, Y. Huang, M.;(2006e)., Construction of the Ashra Detector, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 30 October, 2006

Book Reviews [since 2006 only]

Fox, R.A., (2008), Book Review of: “Moving Every Child Ahead: From NCLB Hype to Meaningful Educational Opportunity,” Michael A. Rebell & Jessica R. Wolff, CHOICE, Current Reviews for Academic Libraries, American Library Association, in press

Fox, R.A., (2008), Book Review of: “The End of School Reform,” Maurice R. Berube & Claire T. Berube, CHOICE, Current Reviews for Academic Libraries, American Library Association, January, 2008.

Fox, R.A., (2007), Book Review of: “Liberty & Learning: Milton Friedman’s voucher idea at fifty,” Robert C. Enlow and Lenore T. Ealy, eds., CHOICE, Current Reviews for Academic Libraries, American Library Association, (in press)

Fox, R.A., (2005) Book Review of: “The Charter School Dust-up: Examining the Evidence on Enrollment and Achievement,” Carnoy, M., Jacobsen, R., Mishel, L., and Rothstein, R., Teachers College Press, Volume 108, No. 5, May, 2006 (see, also, electronic citation below)

Fox, R.A., (2005) Book Review of: “The Charter School Dust-up: Examining the Evidence on Enrollment and Achievement,” Carnoy, M., Jacobsen, R., Mishel, L., and Rothstein, R., Teachers College Press, August 29, 2005, New York. available at <http://www.tcrecord.org> ID Number: 12129

Journal Articles and Books [since 2006 only]

Fox, R.A, and Buchanan, N.K., (2008), School Choice in the Republic of Ireland: An Unqualified Commitment to Parental Choice, submitted to Comparative Education Review.

Buchanan, N.K. and Fox, R.A., (2008), Teaching in an Ethos of Choice, submitted to the Journal of Teacher Education

Buchanan, N. K and Fox, R. A., (2008), Every School a School of Choice: What American Education Can Learn from a Small Country Like Ireland, Irish National Studies, in press.

Fox, R.A. and Buchanan, N.K., (2008), It’s Easier to See from 3,000 miles Away: A Comparison of Education in the United States and the Republic of Ireland, Teachers College Press, (title and author order tentative), book under negotiation.

Fox, R.A. and Buchanan, N.K., (2007), A Charter School Law in Transition, submitted to School Choice and the Law, special issue of the Journal of School Choice, Volume 1, Number 3, (2007)

Fox, R. A., Editor, School Choice and the Law, special issue of Journal of School Choice, Volume 1, Number 3 (2007)

Papers and Presentations [since 2006 only]

Fox, R.A, and Buchanan, N.K., (2008), School Choice in the Republic of Ireland, 2008 American Educational Research Association, 2008 Annual Meeting, New York

Buchanan, N.K. and Fox, R.A. (2008), Teaching in an Ethos of Choice: Life in Irish Primary Schools, 2008 American Educational Research Association, 2008 Annual Meeting, New York

Alyan, N., Buchanan, N.K., Fox, R.A., Eidelman, G. and Garber, B., (2007), Charter School Movement: An International Perspective, (presented at the 2007 National Charter School Conference, Albuquerque, NM)

Non Refereed Presentations [since 2006 only]

Fox, R.A. and Buchanan, N.K. (2007), A Comparison of Education Systems,

Ireland, United States and Hawai'i, (presented to the Education Committee of the Irish National Teachers Organization, Dublin, Ireland, March 15, 2007)

Buchanan, N.K. and Fox, R.A. (2006), The Charter School Option for Ka'u, Hawaii, (presented to the community of Naalehu, Hawaii, November 11, 2006)

Buchanan, N.K. and Fox, R.A. (2006), The Charter School Option for Ka'u, Hawaii, (presented to the community of Hawaiian Ocean View, Hawaii, November 4, 2006)

Fox, R.A. and Buchanan, N.K. (2006), Local School Board Training Session II, Lanikai Elementary Public Charter School, Lanikai, Hawaii, November 3, 2006

Fox, R.A. and Buchanan, N.K. (2006), Local School Board Training Session I, Lanikai Elementary Public Charter School, Lanikai, Hawaii, October 27, 2006

Fox, R.A. and Buchanan, N.K. (2006), Education in Laupahoehoe; Are Charter Schools the Answer, (presented to the community of Laupahoehoe, Hawaii, May 15, 2006)

John Carl Hamilton

Instructor

Department of Physics and Astronomy

University of Hawai`i at Hilo

200 W. Kawili St.

Hilo, Hawai`i 96720

- 2008-present** Research Operations Manager – Pacific International Center for Space Explorations Systems (PISCES) (50% FTE)
- 2007 Fall-present** Associate Director – Hoku Kea (1 Meter Telescope Project)
- 2006 Spring** Interim Department Chair – Department of Physics & Astronomy
- 2003 – present** University of Hawai`i – Hilo – Department of Physics & Astronomy Instructor: Conduct instruction in Physics and Astronomy Undergraduate classes, Active participation in Outreach with Astro-Talks, Onizuka Day, Astro-Day, County Fair, Journey Through The Universe
- 1998 – 2003** Gemini Observatory Hilo, Hawai`i
System Support Associate: Science staff member responsible for the safe and efficient operation of 8.0-meter telescope on summit of Mauna Kea. Also operate 8.0-meter telescope on Cerro Pachon, Chile during annual exchange program. Responsible for safety of all personnel at night. Duties included assisting staff & visiting astronomers in use of instruments, weather monitoring, cryogenic transfers, and training of new operator staff (7).
- 1983 – 1998** Canada-France-Hawai`i Telescope Corp. (CFHT) Kamuela, HI
Senior Observing Asst. / Observing Asst. / Telescope Operator: Science staff member responsible for the safe and efficient operation of 3.8-meter telescope on summit of Mauna Kea and safety of all personnel at night. Duties included training and assisting visiting astronomers in use of instruments, weather monitoring, cryogenic transfers, and training of new operator staff
- 1982 – 1983** NASA Infrared Telescope Facility (IRTF) Hilo, Hawai`i
Telescope Operator: Technical staff member responsible for the safe & efficient operation of 3.0-meter telescope on summit of Mauna Kea. Responsible for safety of all personnel at night. Duties included cryogenic (LN & LHe) transfers, weather monitoring, program observing (comets), training of new operator staff.
- 1981 – 1982** Univ. Hawai`i Lunar Ranging Experiment (LURE) Kula, Maui,
Hawai`I Research Associate IV / III, Member of 4-person team using high-powered lasers to distance range a variety of satellites for the purposes of updating the geo-metrodynamic model of the earth's gravitational field.

- 1980 – 1981** Wailea Beach Hotel Wailea, Maui, Hawai'i. Public Lecturer Led astronomy lecture and stargazing activities for hotel guests and general public with a variety of portable telescopes
- 1980 – 1981** Univ. Hawai'i Mees Solar Observatory Kula, Maui, Hawai'i Research Associate II / I Solar observer (solo) with data collection and analysis of real-time data for the NASA Solar Max satellite in coordination with worldwide ground support. Duties included film handling and developing methods, optics cleaning, and detailed record keeping.
- 1979 – 1980** Univ. Hawai'i-Mānoa Institute for Astronomy (IfA) Honolulu, Hawai'i, Graduate Research Assistant Assisted in various astronomical observations and data reduction on NASA IRTF 3.0m, UH 2.24m and both UH 0.6m telescopes on Mauna Kea. Assembled and optimized cryo-dewar in Infrared Lab and manufactured custom 30-micron IR filter.
- 1977 – 1979** Univ. Hawai'i-Mānoa Dept. of Physics & Astronomy, Graduate Teaching Assistant Taught Lab sections for PHY 100L – Physics for Non-Science Majors for four semesters. Developed laboratory exercises, lectured on experiment background, assisted students in execution of experiments, graded lab reports. Taught PHY 100 lecture section during summer using the text Conceptual Physics - Hewitt. Led numerous stargazing parties for students.
- 1974 – 1977** Univ. Texas at Austin Dept. of Astronomy Austin, Texas Laboratory Research Assistant Organized and maintained the department astronomy library.

EDUCATION

- 1979** – Master of Science (M.S.) – Astronomy Department of Physics & Astronomy / Institute For Astronomy University of Hawai'i – Mānoa, Honolulu, Hawai'i
- 1977** – Bachelor of Science (B.S.) with Honors in Physics Department of Physics, University of Texas at Austin, Austin, Texas
- 1977** – Bachelor of Arts (B.A.) with Honors in Astronomy Department of Astronomy, University of Texas at Austin Austin, Texas

PUBLICATIONS

Hamilton, J, Robert Fox, Makoto Sasaki, and Yoichi Asaoka – “Ashra – A Progress Report”, poster at AAS 212nd Meeting, St. Louis MO

Hamilton, J and Robert Fox – “Hoku Kea – A 1 Meter Instructional Telescope on Mauna Kea” – poster at AAS 211st Meeting, Austin Tx

Hamilton, J (UHH). “Construction Status of Ashra” (2007) The 6th International Workshop on Very High Energy Particle Astronomy - Connection between Wide Field Survey and Cosmic Ray Observation

Trang, D (UHH)., Hamilton, J., Fox, R., and Asaoka, Y. (2006) Ashra: “All-Sky High Resolution Air Shower Detector”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 30 October, 2006

Hardman, J (UHH)., Hamilton, J., Fox, R., and Asaoka, Y., “Construction of the Ashra Detector” , Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 30 October, 2006

Learned, J (UH-Mānoa) et al. “Ashra Project”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Hamilton, J (UHH)., Fox, R., Sasaki, M., and Asaoka, Y., (2006) “Ashra Report 2: Current Status”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Masuda, Masataka (ICRR) et al, “Ashra Report 3: Hybrid Photo Pixel Detector As the Trigger Sensor”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Okumura, Akira (ICRR) et al, “Ashra Report 4 : VHE Gamma Ray Detection”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Noda, Koji (ICRR) et al, “Ashra Report 5: VHE Neutrino Detection”, Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 31 October, 2006

Sasaki, M. (ICRR), et. al., “Status of Ashra (All-sky Survey High Resolution Air shower detector) Project, 29th International Cosmic Ray Conference (ICRC)., Pune, India, 101-106 (2005)

Hamilton, J, “Observatory, Astronomical” – The McGraw-Hill Encyclopedia of Science & Technology (2000, 2007)

Hamilton, J, “Observatory, Astronomical”, in AccessScience@McGraw-Hill, <http://www.accessscience.com>, DOI 10.1036/1097-8542.057500

Hamilton, J, “Gemini Observatory” – The McGraw-Hill Encyclopedia of Science & Technology (2000, 2007)

Hamilton, J, “Gemini Observatory”, in AccessScience@McGraw-Hill,

Dr. Michael B. Duke

EXPERIENCE

- Career Summary Dr. Duke is a planetary scientist with over thirty years of service as a scientist and manager of science programs for NASA and academia.
- June 2006 to present **Consultant** in lunar exploration and space resource utilization systems
- 2003 to June 2006** **Director, Center for Commercial Applications of Combustion in Space**, Colorado School of Mines, Golden, Colorado. Leads a group of nine faculty members and ten to twelve graduate students in research dealing with a wide range of combustion and chemical reactions in space projects, as well as research into techniques for extracting and utilizing space resources. In the development of space resources, his group is a leader in the development of engineering-economic models to evaluate the economic benefits of lunar resource extraction. He is working on research projects for the NASA Exploration Systems Directorate dealing with excavation technology and the production of oxygen from lunar regolith materials.
- 1998 to 2006** **Research Professor**
- 1993 to 1998** Lunar and Planetary Institute, Houston, Texas.
Senior Project Coordinator. Organized and managed a program to link university faculty and students more closely with NASA's efforts in the human exploration and development of space.
- 1989 to 1993** National Aeronautics and Space Administration
Participated in the development of NASA exploration programs, including robotic exploration of Mars and plans for human exploration of the Moon and Mars. Led the development of the science portion of the 90-day study of the Human Exploration of the Moon and Mars, prepared by NASA following the announcement of the Space Exploration Initiative in 1989.
- 1976 to 1989** **Chief of the Planetary and Earth Science Division**, Johnson Space Center, Houston, Texas. Developed programs and facilities for the conduct of research on planetary materials and the space environment. Became a leader in science programs associated with the human exploration of space beyond low Earth orbit, leading many conferences, workshops, and research tasks.

1970 to 1976

Scientific Investigator and Curator of sample collection, Apollo Program, Johnson Space Center, Houston, Texas

EDUCATION

- BS in Geology, California Institute of Technology, 1957
- PhD in Geochemistry, California Institute of Technology, 1963
- PhD thesis: Petrology of Basaltic Achondrite Meteorites

COMMITTEE MEMBERSHIP

- National Research Council – Committee for Lunar Exploration Strategy
- NASA Advisory Council Lunar Human and Robotic Strategic Roadmap Committee
- Lunar Exploration Analysis Group
- Mars Exploration Program Analysis Group
- Space Power Committee of the International Federation of Astronautics
- AIAA Space Colonization Technical Committee
- Full member, International Academy of Astronautics

RELATED PUBLICATIONS

1. M. B. Duke, S.J. Hoffman and K. Snook (2003) “Lunar Surface Reference Missions: A Description of Human and Robotic Surface Activities” NASA/TP-2003-210793, 122 pp., NASA Johnson Space Center, Houston.
2. Duke, M. B. (2003) Sample Return from the Lunar South Pole – Aitken Basin, *Advances in Space Research*, in press.
3. B. R. Blair, J. Diaz, M.B. Duke, E. Lamassoure, R. Easter, M. Oderman, M. Vaucher (2002), *Space Resource Economic Analysis Toolkit: The Case for Commercial Lunar Ice Mining*, Final Report to the NASA Exploration Team, December 20, 2002.
4. Muff, T., Sikorski, A., Johnson, L., Anderson, L., Softley, C., Martinez-Schiferl, M., Smelker, R., Dyar, D., Rice, D., Bridges, C., Bedford, M., Wolden, C., Sutton, D., Clark, D. L., Duke, M. (2002) *Mining Lunar Polar Ice*, International Astronautical Federation, World Space Congress, Houston, TX
5. Duke, M. B., A. Ignatiev, Al Freundlich, S. D. Rosenberg, and D. Makel (2001) *Silicon PV Cell Production on the Moon as the Basis for a New Architecture for Space Exploration*, Proc. Space Technology & Applications International Forum (STAIIF-2001), University of New Mexico, Albuquerque.
6. Pieters, C. M., J.W. Head III, L. Gaddis, M. B. Duke et al. (2001) Rock types of South Pole – Aitken basin and extent of basaltic volcanism, *J. Geophys. Res.*, **106**, 28,001-28,022

7. Duke, M. B. et al (2000) South Pole – Aitken Basin Sample Return Mission, in Foing, B., and Perry, M. (eds.) Proceedings of the Fourth International Conference on Exploration and Utilisation of the Moon, ESA SP-462, European Space Agency, Noordwijk, The Netherlands, pp. 137-140.

Dr. Neville I. Marzwell

Manager of Advanced Concepts – Technology Innovations (NASA- JPL/California Institute of Technology) 1995- present

Senior Adjunct Professor of Strategic Planning and Entrepreneurship, University of La Verne, La Verne, California, 1980-present

Adjunct Professor of Physics and Robotics, University of Hawai`i at Hilo, Hilo, HI 95720, January 2008 - present

Permanent Address:
2217 Grand Avenue
Claremont, CA 91711
Phone: (909) 621-2517
(818) 354-6543

PROFESSIONAL EXPERIENCE

8/10/95 to present: Advanced Concepts and Technology Innovation Manager, Space Mission Technology Development Program, and Avionic Systems Engineering Section. Develop strategic decision models, simulations and metrics to identify performance and technology gaps to optimize value earned on cost and returns. Neville has acted as the JPL point of contact for innovative technology interface with NASA-HQ, NOAA and the Department of Defense. From 1999 to 2003 was the lead for NASA Next Decadal Planning, Revolutionary Aerospace Technology Working Group, visiting all NASA Centers, Universities, Industry, National Laboratories, and Department of Defense to assess the state of the art in technology and evaluate demonstrated capabilities. Serves on many National panels to assess state of the foreign technologies and foreign research priorities

3/5/87 to 8/9/95 Project Manager (Section Staff), in the Robotic Systems and Advanced Computer Technology Section for Flight Demonstrations in the following areas: Structure Dynamics, Controls, Space Servicing, Teleoperation, Robotics, and On-Orbit Constructions in the Electronics and Controls Division, Jet Propulsion Laboratory – California Institute of Technology, Pasadena, CA. Managed for NASA Commercialization Office, The NASA Aerospace Industry Technology Program (\$20M per year) and created the NASA Robotic Engineering Consortium at Carnegie Mellon University which he managed for 5 years, starting with \$5M from NASA and leveraged the NASA funds to create

matching partnerships with industry to a final robust base of \$50M without NASA support (automated mining, harvesting, gas pipeline inspection, etc)

10/6/84 to 3/5/87 Group Supervisor of the Systems Design and Integration of the Automated Systems Section.

2/7/83 to 10/6/84 Group Supervisor Laser Systems Group.

Manage the technology development and implementation of two major thrusts: (1) Automation and Controls of large flexible structures. The major technology development thrusts in Automation are: (a) autonomous spacecraft control; (b) automated mission operation support; (c) automated space construction and assembly; (d) teleoperator technology elements such as sensing and perception, end effectors and manipulators, control execution, operator interface and system architecture and integration; (e) space based intelligent robot, and (f) planetary rovers and autonomous land vehicles. In the Controls of Large Flexible Structures, the major technology thrusts were in (a) space station advanced controls; (b) space defense spacecrafts; (c) distributed modeling/control structure interactions; (d) large diameter reflectors and antenna; (e) advanced attitude control components.

Other efforts included are Pointing, Tracking and Acquisition, Systems Requirements and Trades, Surveillance Satellites, Survivability and Hardenability of Space Systems.

Served on many Space Station and SDI technology panels, workshops, and committees in the areas of Systems Design, Dynamics and Controls, Hardenability and Vulnerability, Systems Trades and Acquisition, Tracking and Pointing. Member of the government review panel on Space Assembly, Maintenance and Servicing (SAMS) project. Appointed point of contact between NASA/HQ (Code M) and the AF/SDIO for Satellite Servicing Projects. Strong interfaces with NASA-HQ in Codes R and S.

2/5/79 – 2/4/83 Program Management, Active and Passive Control Systems in support of adaptive optics. High Energy Laser Programs. RocketDyne Division of Rockwell International.

Managed the Advanced Benchless Laser Program (WPAFB), the Segmented Mirror Program (DARPA/RADC), Digital Heterodyne Interferometer (DARPA/MICOM) and Vibration Control of Space Structure VICOSS (WPAFB). Most work included the interface between structure, sensors, forcers and control algorithms, wave

front sensing and correction, as well as data processing. Established strategy to capture new business markets and business ventures. Managed the company resources for proposal activities IR&D programs. Recommended possible teaming relationship assessed competitive position and implemented marketing strategy. Later, became Manager of Strategic Business Plans for Optics and Lasers Business Segments (60M) and Program Manager for Advanced Technology Projects (10M/year).

12/12/77 to 2/2/79

Technical Staff Specialist at Aerojet Electro-Systems – Department of Optical Technology and Special Design

Work involved laser technology, sensor evolution technology, optical and sensor protection. Laser protection devices for surveillance satellites. Forcers and Actuators technology devices. Computer algorithms for processing sensors data.

1973 – 1977

Honeywell Corporate Research Center, Bloomington, Minnesota.

Research work associated with Holographic Memory. Development of holographic tapes and disks. Amorphous Magnetic Bubble Memory, Fiber and Integrated Optics, detector array technology (HgCdTe, PbSnTe, etc.), and electro-optical materials (PLZT, SBN, etc.) and system design. Member of Technology Council in charge of Planning Optics, Electro-optics, and Computer Business segments of the Company Strategic Plans. Acquisition and foreign contracts for above business segments.

1970 – 1973

Theodore von Karman Fellow at California Institute of Technology.

Worked on magnetic and optical accessed memories in amorphous alloys thin films. Magnetic bubbles. High strength materials, superconductivity, structure, electric and magnetic characteristics of amorphous ferromagnets. Built a magnetometer able to measure a susceptibility of 10^{-9} emu/g, as well as low temperature resistivity and heat capacity equipment.

1968 – 1970

University of Pittsburgh – Research Assistant.

Studied the thermodynamics, magnetic, and electric characteristics of intermetallic compounds containing rare earth elements. Obtained two patents on rare earth permanent magnets.

1968 – 1970

Point Park College, Pittsburgh, Pennsylvania – Lecturer in Mathematics (Junior level).

1967 – 1968 University of Pittsburgh, Pennsylvania – Lecturer in Physical Chemistry.

1965 -1968 Senior Member of the World Bank in charge of projects for developing nations. Developed economical models, market analysis, and market forecasts. Managed multi-million dollars projects in Europe, Asia and Africa.

EDUCATION

B.S.: Chemistry, American University (1966)

M.S.: Materials Science, California Institute of Technology (1971)

Ph.D.: Applied Physics, Materials Science - California Institute of Technology (1973)

PhD: International Economics and Business Administration, California Institute of Technology (1973)

Follow-on Courses: Strategic Management, Project Management Now and in the New Millennium, Artificial Intelligence, LISP, PASCAL, Expert Systems, Automation, Robotics.

Security Classification: TOP SECRET

MEMBERSHIPS AND OFFICES HELD

California Space Authority, Science and Technology Lead, 1993- 2008

American Robotic Association

Lunar and Planetary Society

Mars Society

American Optical Society

RECENT RELEVANT PUBLICATIONS

“PISCES: Developing Technologies for Sustained Human Presence on the Moon and Mars,” F.D. Schowengerdt, R.A. Fox, M.B. Duke, N. Marzwell, B. McKnight, *Space 2007, American Institute of Aeronautics and Astronautics*, Long Beach, September 2007.

“PISCES: A Lunar Outpost for ISRU Partnerships,” F.D. Schowengerdt, M.B. Duke, R.A. Fox, M. Henley, N.I. Marzwell, J. Crisafulli, S.M.D. Day, *Space Technology and Applications International Forum – 2007*, February 2007

“Rainbow’s array of promises – A new solar array concept promises ultrahigh efficiency in converting sunlight into energy for powering spacecraft”, *Aerospace America*, January 1999, page 48

“ Handbook of Pattern Recognition and Computer Vision” World Scientific Publishing. Co-authored book chapter in Part 3 – Recognition Applications “Multi-Sensory Opto-Electronic Feature Extraction Neural Associative Retriever”, pages 535-566, 2nd Edition, 1999.

“Inflatable Membrane Reflectors for Multiple-Purpose Applications”, NASA Tech Briefs, May 1999, page 69.

“Robot Strips Chips Without Slips” Space Com, April 15, 2000

“NASA’s “Snakebots” Slither to Life” Space Com, May 4, 2000

“Robofrogs: Hopping Robots Built for Mars” Space Com, September 14, 2000

“Solar Sailing: The Next Space Craze?” California Institute of Technology, Engineering and Science, page 19 –29, Volume LXIII, 2000

“Optical Pattern Recognition via a Translation Sensitive Adjustable compact Optical Correlator” Recent Res. Devel. Optical Eng., (2000):77-88, ISBN: 81-7736-035-3

“Revolutionary Concepts Through Evolutionary Progress: Modular Robotics for Space Exploration and Expeditions”, AIAA 2001-6755

“An Economic Analysis of Space Solar Power and Its Cost Competitiveness as a Supplemental Source of Energy for Space and Ground markets”, IAF-02-R.3.05, 53rd International Astronautical Congress. The World Space Congress 2002, 10-19 October, Houston, Texas.

“Robotic Construction of a Large Telescope on the Moon: A Conceptual Approach” International Conference on “Systems and technologies for Future Exploration and development of Space”, International Science and Technology Center (ISTC), International Academy of Astronautics (IAA), 9-11 June, 2003 Moscow Russia

Beth McKnight

941 Ninebark Lane
Longmont, CO 80503
Phone: 720-494-8989

QUALIFICATIONS:

Media relations, education and outreach, internal and external public relations, and video production. Areas of expertise include creative and proactive communication with diverse audiences, translating technical language into layman's terms.

PROFESSIONAL EXPERIENCE:

McKnight Communications, Boulder, CO

Public Relations and Education/Outreach Consultant, 1993-Present

Develop and implement public relations, marketing, and promotional programs. Produce recruiting and fundraising videos and CD-ROMs. Involve and promote partners, maintain budgets, produce effective educational and fundraising materials, and obtain extensive media coverage. Manage and produce SpaceClass, a web-based education program featuring videos and virtual labs, designed to make science fun and inspire the next generation of space scientists.

Client list includes Ball Aerospace, NASA, National Jewish Medical and Research Center, Lutheran Hospital, Colorado School of Mines, Center for Space Resources, BioServe Center for Space Technologies at the University of Colorado, The Conservation Fund, and Great Outdoors Colorado --- allocating lottery funds for public recreation areas.

Promoted and publicized NASA Space Research Partnership Centers at 10 universities throughout the U.S. Obtained extensive media coverage for the Colorado School of Mines Center for Space Resources, including a fire-suppression experiment that flew on Space Shuttle Columbia. Represented KMGH-TV, Channel 7 in Denver, flying on a zero-gravity jet used to train astronauts.

For National Jewish, designed and implemented projects to support marketing and fundraising efforts for research and treatment programs. Positioned a tuberculosis physician as the nation's leader in this field. Created and directed a fundraising video that won a statewide award. Wrote proposals, annual reports, white papers, news releases and newsletters.

The Nature Conservancy, Washington, D.C. and Boulder, CO

Field Communications Manager, 1989-93

Managed communications and partnership-building programs for Conservancy field offices throughout the U.S. The organization's objective was to buy or protect land harboring endangered plants and animals and their habitats. Worked with EPA, National Forest Service, Department of Interior, and other government agencies as well as with other conservation groups and business partners. Developed and presented workshops on developing and strengthening relationships with partners, volunteers and communities. Wrote proposals, public relations plans, news releases, newsletters, and brochures.

Worked with field staff to create local programs supporting large-scale land protection projects in the Yellowstone area, Upper Colorado River Basin, Florida Keys, West Texas, and along Ohio's Big Darby River. Created and coordinated an Earth Day project in which 71,000 acres were protected throughout the nation – all on one day, Earth Day. The project enhanced state programs and partnerships while providing a platform for both local and national publicity.

The Southland Corporation, Denver, CO and Pleasanton, CA

Communications Manager, 1985-89

Directed public relations and community relations for 7-Eleven stores in Colorado, Utah, New Mexico and California, and managed the company's Muscular Dystrophy fundraising campaign, offering incentives for employees and franchisees. Worked with community groups, schools, franchise owners, operations staff, and diverse interest groups in two 500-store divisions. Created and produced employee newsletters.

Created and managed a "River Otter Reading Program" for Denver Public Schools, using 7-Eleven stores to build awareness of the need to save the river otter, endangered in Colorado. The Southland-sponsored program raised enough money for the Colorado Division of Wildlife to relocate river otters to Colorado from Wisconsin.

EDUCATION AND AFFILIATIONS:

BA in Journalism, University of Georgia, Athens, GA.

Accredited through the National Public Relations Society of America.

Member: Board of Directors, Carriage House Homeless Resource Center.

Former Member: Board of Directors, American Lung Association of Colorado and Humane Society of Boulder Valley.

Mark W. Henley

Boeing Phantom Works

P.O. Box 999, Topanga, CA 90290

Email: Mark.W.Henley@Boeing.com; Mark.W.Henley@gmail.com

Phone: (714) 625-6426 / (310) 433-1463

PROFESSIONAL EXPERIENCE

1994 – Current: The Boeing Company (& Rockwell Aerospace, acquired by Boeing)
Business development for solar / renewable energy technology applications on Earth
Program manager for NASA In-Space Cryogenic Propellant Depot contracts
Co-Investigator for JPL All Terrain Hex-Legged Extra Terrestrial Explorer robot
Task leader for JPL in assessing lunar and Mars nuclear power system applications
Assessed infrastructure, 1 km power transmission & day-night effects
Program manager for NASA Space Solar Power technology development
Led NASA contracts (JPL, MSFC, GRC) & internal research & development
Principal Investigator in planned, multi-national satellite system for Space Station
German “Inspector” satellite with US transportation and Russian interfaces
Engineering design leader for USAF Launch Vehicle cryogenic upper stage study
Internal research and development to commercialize Ukrainian rockets & satellites
1983-1993: General Dynamics Convair & Space Systems Divisions
Chief Engineering for Atlas & Titan-Centaur use in advanced applications
Led studies (dual payload, Soyuz capsule, Space Station, lunar Lander, ...)
Commercial Launch Services Mission Development for Atlas launch vehicle
Led studies and proposals to launch NASA and communications spacecraft
Strategic Planning for Atlas expendable launch vehicle commercialization
Developed Division’s weekly reports to Corporation
Engineering for design, development, test and evaluation of space flight hardware
Qualified components for propulsion, pressurization, and range safety
Tested new flight hardware in cryogenic liquid hydrogen and nitrogen
Preliminary design studies and technology development for advanced programs
1978-1983: Scripps Institution of Oceanography:
California Space Institute: Assessed secondary uses of Space Shuttle External Tank
Hydraulics Laboratory: Developed facilities and supported fluid dynamics research
Center for Coastal Studies: Supervised computer operations for geological research

EDUCATION

Master of Science in Aerospace Engineering, University of California San Diego, 1988

- Thesis on advanced technologies for Earth-Moon transportation

Bachelor of Arts in Physics & Earth Science, University of California San Diego, 1982

MEMBERSHIPS AND OFFICES HELD

American Institute of Aeronautics and Astronautics: Space Transportation Committee
International Astronautical Federation: Space Transportation & Power Committees
Japan-US Science, Technology, Space Applications Program (JUSTSAP)
Topanga Community Club: Service as President and Vice President for fundraising

RELEVANT PUBLICATIONS

Howell, J., Henley, M., and Schowengerdt, F., PISCES: “A ‘Stepping Stone’ to International Space Exploration and Development,” 38th International Astronautical Congress, Hyderabad, India, September, 2008

Grayson, G. and Henley, M., “Controlled Thermal Transfer Method and Switch” (pat pend)

Grayson, G. and Henley, M., “Thermally-Integrated Fluid Storage and Pressurization System” (patent pending)

Schowengerdt, F.D., Duke, M.B., Fox, R.A., Henley, M., Marzwell, N.I., Crisafulli, J. and Day, S.M.D., PISCES: “A Lunar Outpost for ISRU Partnerships, Space Technology and Applications International Forum”, Albuquerque, NM, March 2007

Duke, M.B., Schowengerdt, F.D., Crisafulli, J., Day, S.M.D., Fox, R.A., Henley, M., and Marzwell, N.I., “PISCES: Hawaii Facility for Simulation and Training. Lunar and Planetary Science Conference,” Houston TX, February 2007

Fikes, J., Howell, J. and Henley M., “In-Space Cryogenic Propellant Depot (ISCPD) Architecture Definitions and Systems Studies,” 57th International Astronautical Congress, October, 2006

Zillmer, A., Henley, M., Schmitt, H., Kulcinski, G. and Santarius, J. “Use of Nuclear Power on the Lunar or Martian Surface, ANS Space Nuclear Conference,” San Diego, CA, June 2005

Laser-Photo-Voltaic Wireless Power Transmission, Final Report, Contract NAS8-02056, Task 2: 30 November, 2004

Jupiter Icy Moons Orbiter Derivative Mission Concepts for Study, Follow-on Mission Study Report; Volume 1. Lunar Power Station, and Volume 3. Mars Power Station; JPL contract 1250529, July 2004

Henley, M., Potter, S., Howell, J., and Mankins, J., “Wireless Power Transmission Options for Space Solar Power”, 53rd International Astronautical Congress, October, 2003

Henley, M., Fikes, J., Howell, J., and Mankins, J., “Space Solar Power Technology Demonstration for Lunar Polar Applications”, - 53rd International Astronautical Congress, Houston, TX, October, 2003

Henley, M. et al, “Laser-Photovoltaic Wireless Power Transmission”, Air Force Maui Optical & Supercomputing Conference, Wailea, HI, 16 September, 2003.

Henley, M., “In-Space Cryogenic Propellant Production Depot”, Final Report; Contract NAS8-02056, Task 1, 30 June 2003

Potter, S., Henley, M., Gutierrez, S., Fikes, J., Carrington, C., Smitherman, D., Gerry, M., “A Cryogenic Propellant Production Depot for Low Earth Orbit”, International Space Development Conference, Albuquerque, NM, 24-28 May 2001

Potter, S., Henley, M., and McClanahan, J., “The Power Plug: A Near-Term Space Solar Power Concept,” Space 2000 Conference, Long Beach, CA, Sept., 2000

Donahue, B., Martin, J., Potter, S., and Henley, M., “Human Mars Transportation Applications Using Solar Electric Propulsion,” AIAA-2000-5360, AIAA Space 2000 Conference, Long Beach, CA, Sept. 19-21, 2000

Potter, S., Willenberg, H., Henley, M., and McCullough, E. Science Mission “Opportunities Using Space Solar Power Technology,” 50th International Astronautical Congress, Amsterdam, Holland, Oct 3-7, 1999

Potter, S., Willenberg, H., Henley, M., and Kent, S., “Architecture Options for Space Solar Power,” *International Space Development Conference*, Houston, TX, 27-31 May, 1999.

Evaluation of Alternative Space Solar Power System Architectures: Final report, JPL 961617; December, 1998

Space Solar Power End-to-End Architecture Study, Final Report, NAS8-98244, Jan, 1999

Willenberg, H., M. Henley, S. Potter, and S. Kent, “Space Solar Power End-to-End Architecture Study,” 16th Symposium on Space Nuclear Power and Propulsion, Albuquerque, NM, 31 Jan – 4 Feb 1999.

Henley, M.W., “Ukrainian Space Systems and Technology,” Rockwell International Space Systems Division Internal Technical Plan, February, 1996.

Daniel A. Bland

President, JAMSS America, Inc.
16055 Space Center Blvd. Suite 240
Houston, TX 77062
Email: dbland@jamssamerica.com

Permanent Address:
3402 Queensburg Lane
Friendswood, TX 77546
Phone: (281) 332-4767
(281) 520-5397

PROFESSIONAL EXPERIENCE

- Current** President of Japan Manned Space Systems Corporation (JAMSS) America, Inc. (JAI), a Texas registered, wholly owned subsidiary of JAMSS Corporation, Tokyo, Japan. Company business includes support to the Japan Aerospace Exploration Agency's human space initiatives.
- Oct '94 – Current** Senior Vice President, SPACEHAB, Inc. (SHI), a commercial space services company based in Houston, Texas specializing in the development and operation of pressurized crew modules and unpressurized cargo and experiment pallets flying aboard the NASA Space Shuttle.
- Dec '90 - Oct '94** Served as NASA Project Manager, Commercial Middeck Augmentation Office, managing NASA's first contract with SHI from the Johnson Space Center (JSC) in Houston, Texas.
- July '66-- Dec '90** Held various NASA management and staff positions at JSC and Kennedy Space Center including serving on the Space Station Operations Task Force ('87-'88), serving as Shuttle Flight Data File Manager ('75-'83), trained US/Russian Apollo-Soyuz project crewmembers in joint flight (docked) operations ('73-'75), developed lunar surface Extravehicular Activity (EVA) procedures for Apollo 16 and 17 missions ('71-'72), and trained Apollo 1-15 astronauts on the Apollo Command Module simulator.

EDUCATION

NASA Management Development Program, University of Houston, Clear Lake (1976-79)

B.S. Aerospace Engineering, N.C. State University (1966)

HONORS AND AWARDS

April, 1994	NASA Group Achievement Award, SPACEHAB Implementation Team
December, 1992	NASA JSC Group Achievement Award, SPACEHAB Desktop Trainer Development
March, 1992	NASA Group Achievement Award, SPACREHAB Source Evaluation Board
December, 1987	NASA Certificate of Commendation, ISS Operations Task Force
September, 1981	NASA Certificate of Appreciation, STS-1 Flight Data File Development and Management
December, 1975	NASA Apollo Soyuz Test Project Joint Procedures Development

MEMBERSHIPS AND OFFICES HELD

Elder, Clear Lake Presbyterian Church

Robert R. Carlson

(Home)
2408 Daytona Court
Friendswood, Texas 77546
carlson53@comcast.net

(Work)
16055 Space Center Blvd., Suite 240
Houston, Texas 77062
carlson@jamssamerica.com

EDUCATION

1978-1979	Master of International Management American Graduate School of International Management Glendale, Arizona
1975-1978, 1972-1973	B.A., Economics (minor in Japanese) Brigham Young University Provo, Utah

TRAINING

2000	Venture Catalyst Program (certificate) Mitsubishi internal training program
1994-1998	Executrain computer training courses (certificates) 11 courses in computer system and applications software
1996	Global Leadership Program I (certificate) Mitsubishi internal training program
1982	Management Training and Development Program (certificate) Mitsubishi internal training program

LANGUAGE

Fluent in spoken Japanese; working knowledge of written Japanese
Occasional interpreting in business, technical and social settings
Occasional translation of business and technical correspondence and documents
Two years working in Japanese language at Mitsubishi Corporation in Tokyo; ne year at Japan Manned Space Systems Corporation
Undergraduate minor in Japanese from Brigham Young University
Two years working in language as a representative of the Church of Jesus Christ of Latter-day Saints in Japan

EMPLOYMENT

2006 – present	Vice President JAMSS America, Inc. Houston, Texas
2005 – 2006	General Manager, International Business Development Japan Manned Space Systems Corporation Tokyo, Japan
2002 – 2006	President Access Management Corporation Madison, Alabama
2001 – 2002	VP, GM-Huntsville Office, Space Business Unit Manager Mitsubishi International Corporation Huntsville, Alabama
1992 – 2001	Vice President, GM-Huntsville Office Mitsubishi International Corporation Huntsville, Alabama
1990 – 1992	General Manager-Huntsville Office Mitsubishi International Corporation Huntsville, Alabama
1987 – 1990	Deputy General Manager, Information Systems & Machinery Division Mitsubishi International Corporation Los Angeles, California
1985-1987	Assistant Manager, Space Systems Team, Aerospace Department Mitsubishi Corporation Tokyo, Japan
1981-1985	Manager, Business Development, Machinery Division Mitsubishi International Corporation Los Angeles, California
1979-1981	Contract Administrator, Machinery Division Mitsubishi International Corporation Los Angeles, California

EXPERIENCE

Management

- Full responsibility for all business functions at JAMSS America; including business development, contracting, teaming, and administration (financial and personnel), as well as primary corporate interface with parent company in Japan
- Incorporated and established Access to provide bridging services for U.S.-Japan bilateral business dealings.
- Full responsibility for Mitsubishi International Corporation's (MIC) space business; managing Space Business Unit programs, personnel (located in Los

Angeles and Huntsville) and profitability; reported to a senior vice president. Annual transaction amounts of \$40-50 million.

- Worked closely with corporate management as one of four non-Japanese Business Unit managers within MIC.
- Established the Huntsville Office of MIC to support aerospace work in Huntsville and space activities throughout the eastern U.S.
- Responsible for personnel issues and work assignments as Deputy Division Manager in MIC Los Angeles (1987-1990); division included 16 people.

Business Development / Investment

- Lead responsibility at Japan Manned Space Systems for developing and implementing a concept for a unique teaming agreement between an agency of the Japanese government and a leading U.S. aerospace to bid on a NASA contract.
- Developed strategies for expansion of MC's space business as a consultant to the corporation.
- Trained a Japanese client on the nature of alliances and led their efforts to establish a strategic alliance with a U.S. software company.
- Worked closely with U.S. aerospace clients to develop and implement marketing programs to Japanese government and industry. Responsible for clients receiving contracts in excess of \$30 million.
- Championed two six-figure investments in U.S. start-up companies to support long-term corporate objectives in the space industry.
- Early career experiences included developing and implementing a marketing campaign for Japanese soft-ground tunneling equipment in the U.S., marketing & contracting of components for nuclear power plants to Japan and establishing cooperative new energy R&D programs.
- Developed and taught "A Business Perspective of Japan" seminar to provide a one-day introductory overview to Japan and Japanese business practices.
- Advisor to Global Leadership Program II sessions in 2000 and 2001-02, working with participants from throughout the world during several months of remote coaching and weeklong intensive training
- Develop and present Japanese business, culture and language awareness seminars to U.S. clients and at various seminars.

PUBLICATIONS, COURSES & PRESENTATIONS

Overview of Pacific international Space Center for Exploration Systems Co-author and presenter of paper at the 26th International Symposium on Space Technology and Science, Hamamatsu, Japan, June 2008.

Implications of Globalization for Business Guest speaker at University of Alabama in Huntsville, Huntsville, Alabama, November 2007.

U.S. Space Utilization in the Field of Applied Life Science Article in the Japanese language journal Bio Industry, pages 89-97, Tokyo, Japan, May 2005. (Researched and authored the English language manuscript.)

Mitsubishi Corporation – the Impact of Globalization Guest speaker at University of Alabama in Huntsville, Huntsville, Alabama, November 2004.

Leadership Theory and Practice – Perspectives on Japanese Management Practices
Guest speaker at University of Alabama in Huntsville, Huntsville, Alabama, November 2004

Japan: Insights for Avocent: Taught a continuing education course to employees of Avocent Corp. for the Continuing Education Department of the University of Alabama in Huntsville, Shannon, Ireland, April 2004

International Protocol Issues: Presented at the Economic Development Association of Alabama Winter Conference, Birmingham, Alabama, January 2004

Leadership Theory and Practice – Perspectives on Japanese Management Practices:
Guest speaker at University of Alabama in Huntsville, Huntsville, Alabama, October 2003

Motivating American Employees: Presented at the “Update on Employment Issues for Japanese Management” seminar for Japanese executives (presented in Japanese language), Birmingham, Alabama, November 2003

Doing Business Issues from a Japanese Company Perspective segment of “Preparing for New Opportunities with Japanese Firms” seminar: Presented at NAITA seminar, Huntsville, Alabama, October 2003

Selling and Servicing Japanese Corporations, Executives and Families: A seminar for Service Excellence. Presented as part of the NAITA Trade Education Tour, Cullman, Alabama, June 2003

Mitsubishi Corporation – Lessons from International Business Operations Experience:
Presented to NASA Mission Systems 2002 Conference, Houston, Texas 2002

Mitsubishi Corporation – Global Leadership Program Overview: Presented to NASA Mission Systems 2002 Conference, Houston, Texas, 2002

Mitsubishi Corporation and the Globalization of Space Activities: Presented at the International Space University – Japan Day! 2000 Celebration, Valparaiso, Chile, 2000

Mitsubishi Corporation and the Globalization of Space Activities: Presented to SWAPRA Meeting, Houston, Texas, 2000

Roles of Japanese General Trading Companies in Creating Strategic Alliances: Presented at JETRO/NAITA Seminar, Huntsville, Alabama, 1999

Working with the Japanese: Presented to The University of Alabama at Birmingham, Birmingham, Alabama, 1996

Language and Cultural Differences in Dealing with the Japanese: Presented to McDonnell Douglas Corporation, Huntsville, Alabama, 1995

Doing Business with Japan: Language and Cultural Differences: Presented at JETRO/AITC Seminar, Birmingham, Alabama, 1994

Dr. Alex Ignatiev

Director, Center for Advanced Materials

Distinguished University Professor of Physics, Chemistry,
and Electrical and Computer Engineering

724 Science & Research I

University of Houston

Houston, TX 77204-5004

713-743-3621

713-743-3630

713-747-7724 FAX

Ignatiev@uh.edu

PROFESSIONAL EXPERIENCE

- | | |
|-----------------------|---|
| 2007 – Present | CEO, Solid State Energy and Lighting Institute, Houston, TX |
| 2005 - Present | Director, Center for Advanced Materials, University of Houston |
| 2003 – Present | Distinguished University Professor of Physics, Chemistry, and Electrical and Computer Engineering |
| 2002-2005 | Director, Texas Center for Superconductivity and Advanced Materials, University of Houston |
| 2001 - Present | Chief Technology Officer, Metal Oxide Technologies, Inc., Houston, TX |
| 1998-2003 | Professor of Physics, Chemistry and Electrical and Computer Engineering, University of Houston |
| 1988-2002 | Director, Space Vacuum Epitaxy Center, University of Houston |
| 1987-Present | Task Leader, Texas Center for Superconductivity |
| 1986-1988 | Associate Director, Space Vacuum Epitaxy Center, University of Houston |
| | 1984-1989 Associate Director, Magnetic Information Research Laboratory, University of Houston |
| 1983-present | Professor of Physics and Chemistry, University of Houston |
| 1983 | Senior Fulbright Scholar, University of Split, Yugoslavia |
| 1982-1983 | Professor of Physics, University of Houston |
| 1977-1978 | Visiting Lektor/Associate Professor, Institute of Physics, Aarhus University, Aarhus, Denmark |
| 1977-1982 | Associate Professor of Physics, University of Houston |
| 1974-2000 | Member, Energy Laboratory, University of Houston |

1974-1977 Assistant Professor of Physics, University of Houston
1972-1974 Research Associate, State University of New York at Stony Brook
1966 Industrial Consultant, Pope Scientific Company, Menomenee Falls, Wisconsin

EDUCATION

Ph.D.	Cornell University	1972	Materials Science
B.S.	University of Wisconsin-Milwaukee	1966	Applied Mathematics and Engineering Physics

CREDITS

Honors:

2000 Elected to the International Academy for Astronautics
 1997 Texas State Senate Recognition Award
 1995 City of Houston Science Recognition Award
 1994 UH Alumni Award - Dallas Area UH Alumni Group
 1994 UH College of Natural Science and Mathematics Alumni Achievement Award
 1994 City of Houston "Alex Ignatiev Day" Recognition Award
 1994 NASA - JSC Group Achievement Award

Editorial:

Associate Editor "Vacuum"
 Associate Editor "Space Forum"
 Associate Editor "Research Trends"
 Associate Editor "SCIENCE First Hand EURASIA"

PROFESSIONAL AND HONORARY SOCIETIES

American Physical Society
 American Vacuum Society
 Sigma Xi
 The American Association for the Advancement of Science
 American Chemical Society
 The Materials Research Society
 American Institute of Aeronautics and Astronautics
 American Astronautical Society
 International Society of Optical Engineering

Institute for Electrical and Electronic Engineers
American Society of Mechanical Engineers
Sunsat Energy Council

PATENTS: Fifteen US Patents awarded and two foreign patents awarded

REFEREED PUBLICATIONS:

Dr. Ignatiev has published over 300 refereed publications, with selected ones listed below.

A. Ignatiev, "The Wake Shield Facility and Space-Based Thin Film Science and Technology", *Earth Space Review*, 4, 10 (1995).

C. Horton, A. Ignatiev, M. Sterling, a. Bensaoula, A. Freundlich, S. Pei, R. Sega, "III-V Compound Semiconductor Film Growth in Low Earth Orbit on the Wake Shield Facility", *AIP Conf. Proc.* 325, 305 (1995).

G. Neu, M. Tessiere, A. Freundlich, C. Horton, A. Ignatiev, "Donor acceptor pair spectroscopy of GaAs grown in space ultra vacuum", *Applied Physics Letters*, 74, 3341 (1999)

A. Ignatiev and A. Freundlich, "Solar Cell Development on the Surface of the Moon", *Proc. 49th International Astronautical Congress, IAA-98-IAA. 13.2.03* (1998)

A. Freundlich, M. Vilela, C. Monier, and A. Ignatiev, "High Efficiency Radiation Hard Solar Cells for Space Power Satellites" *Proc. 49th International Astronautical Congress, IAF-98-R. 1.08* (1998)

A. Freundlich, T. Kubricht and A. Ignatiev, "Lunar Regolith Thin Films: Vacuum Evaporation and Properties", *AIP Proceeding* 420, p660 (1998).

A. Freundlich, C. Horton, M. Vilela, M. Sterling, A. Ignatiev, G. Neu, and M. Teisseire, "Photoluminescence of GaAs grown by metallorganic molecular beam epitaxy in space Ultra-vacuum", *J. Crystal Growth*, 209, 435 (2000).

A. Ignatiev, "Advanced Thin Film Materials Processing in the Ultra-vacuum of Space", *Acta Astronautica*, 48, 115 (2001).

Michael B. Duke, Alex Ignatiev, Alex Freundlich, Sanders Rosenberg, and Darby Makel, "Silicon PV Cell Production on the Moon", *J. Aerosp. Engrg.* 14, 77 (2001)

X. Chen, N.J. Wu, L. Smith, and A. Ignatiev, "Thin Film Heterostructure Solid Oxide Fuel Cells", *Appl Phys. Letters*, 84, 2700 (2004)

Alexandre Freundlich, Alex Ignatiev, Charles Horton, Mike Duke, Peter Curreri, and Laurent Sibille, "Manufacture of Solar Cell on the Moon", *IEEE Photovoltaic Specialists Conf*, 31, 794 (2005).

C. Horton, C. Gramajo, A. Alemu, L. Williams, A. Ignatiev and A. Freundlich "First Demonstration of Photovoltaic Diodes on Lunar Regolith Based Substrate", *Acta Astronautica*, 56, 537 (2005).

X. Chen, J. Strozier, N.J. Wu, A. Ignatiev, "Direct Resistance switching profile on a symmetric electrical pulse induced resistance change device", *Appl. Phys. Letters*, **87**, 233506 (2005) .

X. Chen, N. J. Wu, L. Smith, J. R. Li, and A. Ignatiev, "Ultra Thin Solid Oxide Fuel Cells with High Power Density", *Transactions on Electronics* **3**, 28 (2006).

A. Ignatiev, N. J. Wu, X. Chen, S. Q. Liu, C. Papagianni, J. Strozier, "Resistance switching in Perovskite thin films", *Phys. Stat. Sol.* **243**, 2089-2097, (2006).

Y. B. Nian, J. Strozier, N. J. Wu, X. Chen, A. Ignatiev, "Evidance for an Oxygen Diffusion Model for the Electric Pulse Induced Resistance Change Effect in Oxides," *Phys. Rev. Lett.* **98**, 146403 (2007).

A. Ignatiev, K. Heiss and P. van Susante, "ISRU-based development of a lunar water astroparticle observatory", *Acta Astronautica*, **61**, 496 (2007)

Z.W. Xing, N.J. Wu, and A. Ignatiev, "Electric Pulse Induced Resistive Switching effect Enhancement by a Ferroelectric Buffer on the $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ Thin Film", *Appl. Phys Letters*, **91**, 1 (2007)

S. Agilan, D. Managalaraj, Sa.K. Narayandass, S. Velumani, and A. Ignatiev, "Structural and optical characterization of CuInSe_2 films deposited by hot wall vacuum evaporation method", *Vacuum*, **81**, 813 (2007)

Stephen Day

Mr. Day brings over thirty years experience in sales, marketing, strategy, and general management in the telecommunications, chemical, textiles, and electronics industry in the US, European and Japanese markets (IVA LTD, COMSAT, DuPont and Courtaulds).

He is CEO and founder of International Ventures Associates (IVA LTD.), a private consulting and investment company providing Strategic Advice and Alliance/Investment support for Telecoms/IT/software industries. Customers have included major Telcos, telecom equipment and software companies in the U.S., Western Europe and Asia/Pacific, e.g. NTT, Deutsche Telekom, France Telecom, Siemens, Verizon, Cap Gemini, Matsushita, Sumitomo, Mitsubishi, Marubeni, TI, Sun Microsystems, and smaller venture firms seeking corporate equity investment.

Before founding IVA in 1991, Mr. Day spent nine years at COMSAT in a variety of senior management positions, including VP Ventures where he directed the commercialization of COMSAT's technology through licensing, joint ventures, new business spin-offs, and technology relationships. He worked closely with COMSAT's R&D group to identify products and technologies for commercialization (e.g. nickel/hydrogen batteries), and implemented joint ventures with multinationals in the U.S., Japan and Taiwan, in addition to negotiating several licensing deals (batteries, video compression and SatCom technology). Mr. Day was also VP Corporate Development & Marketing, VP and General Manager, Satellite Business Networks, and VP Administration and Marketing for Comsat General. Mr. Day sold multiple businesses while at COMSAT resulting in a substantial positive net impact on corporate earnings and the balance sheet.

From 1969 to 1982 Mr. Day worked at E.I. DuPont in a variety of positions and locations ranging from European Sales and Product Director of an electronics business, to Corporate Planning/strategy for DuPont's Executive Committee in Wilmington, and a variety of sales and marketing positions. Mr. Day performed some of the original market research for Kevlar, where he worked closely with DuPont's research and development personnel.

Originally, a native of the UK, Mr. Day started his career at Courtaulds in 1966 where he was Assistant Technical Manager performing Research and Development and economic evaluations for new manufacturing technologies to be integrated into the Courtaulds Group. Mr. Day received a patent for a new spinning technology he developed at the Company's Textile Development Unit.

Mr. Day has a master's degree from Georgia Tech and a Bachelors degree from Leeds University in England. He is a board member of a high growth software company (www.icims.com); has been a member of two NASA external advisory boards; is chairman of JUSTSAP, the Japan-U.S. Science, Technology and Space Applications Programs organization; is an adjunct professor for the MBA program at the Kogod business school at American University; and a member of the Arts Advisory Council at American University. Mr. Day resides in Washington, DC with his wife.

Summary and Conclusions

In just one year, PISCES has moved from concept to reality, with funding from both the State of Hawai'i and NASA. It has gone from an unknown quantity emerging from the JUSTSAP Symposium to a viable research and education center with wide name recognition within the space exploration community. The fact that Hawai'i stepped up to fund PISCES initially at the \$400K level last year has attracted the attention of space professionals and organizations worldwide and, if that funding continues through its early development phase, as projected here, will cement the State as a major player in the coming era of space exploration.

PISCES will support lunar and Martian exploration programs of the U.S., Japan and other spacefaring nations. NASA, JAXA and other space agencies, and companies from all the countries, will be invited to become members of PISCES, as outlined in this plan. They will benefit by close, synergistic association with faculty and students from the University of Hawai'i and partnering universities, as well as with researchers from the other members. PISCES will provide central facilities for development of planetary surface system technology, and its programs will support primary, secondary

and advanced education. PISCES Public Outreach programs will promote space exploration to the local population and visiting tourists from the US, Japan, and other nations around the globe.

Hawai'i is a convenient location for PISCES, offering an unparalleled simulation environment for lunar and Martian exploration research, education and operation. Hawai'i's natural terrain offers unique analogies to features on the Moon, including volcanoes, lava flows, fine-grained soils, cinders, lava tubes, craters, ejecta and even permafrost (atop the highest peaks, akin to ice hypothesized near the lunar poles). Hawai'i's weather allows year-round operations in expansive areas of dry, barren terrain, with abundant sunlight for solar power.

This Strategic Plan offers a phased, affordable and sustainable approach to developing and using the unique capabilities offered by Hawai'i, and charts a future for the Center from its creation and initial funding by the State to one of stable growth with support from government, industry and the private sector.



PISCES Inaugural Conference, November 2007