Report to the Hawaii State Legislature

Summarizing the progress and status of collaboration between the State of Hawaii and both public and private aerospace-related agencies and institutions, national and international, to help expand and diversify Hawaii's aerospace industry through development of the Pacific International Space Center for Exploration Systems (PISCES) as requested by HCR 277 in the Twenty-Third Legislature.

The concept of establishing a Pacific International Space Center for Exploration Systems (PISCES) in Hawaii was initially developed in 2005 by a multinational team of scientists, educators, and aerospace professionals participating in the Japan-U.S. Science, Technology & Space Applications Program (JUSTSAP)[1]. The goal of PISCES is to build upon our State's unique natural resources, resident scientific/technological expertise, strategic mid-Pacific location, multi-cultural ambience, and extensive experience in space-related research and development to establish state-of-the-art aerospace facilities and programs in Hawaii that can support future international robotic and human space exploration missions to our moon, Mars and beyond.

In support of this vision, and pursuant to the Legislative requests set forth in HCR 277, DBEDT established a point of contact within the Science & Technology Branch of DBEDT's Strategic Industries Division that has been working with key officials within JUSTSAP, the University of Hawaii (at Hilo and Manoa), the Hawaii State Legislature, the Hawaii Island Economic Development Board, Enterprise Honolulu, the National Aeronautics & Space Administration (NASA), the Japan Aerospace Exploration Agency (JAXA), the Boeing Company, Lockheed Martin Space Systems Company, Raytheon Company, the Texas Center for Advanced Materials, the Science Applications International Corporation (SAIC), the Colorado School of Mines, the California Institute of Technology, the Jet Propulsion Laboratory, the Tokyo Institute of Technology, Kobe University, and other public and private research institutions and aerospace corporations in Hawaii, the U.S. Mainland and Japan to develop a network of professionals that can provide guidance and support in the development and implementation of PISCES.

Since the adoption of HCR 277, the PISCES concept has been presented to aerospace professionals at the American Institute of Aeronautics and Astronautics (AIAA) National Space Symposium in San Jose (Sept. 2006), at Lockheed Martin Space Systems' Advanced Technology Center in Palo Alto, California (Sept. 2006), and at NASA's 2nd Space Exploration Conference in Houston, Texas (Dec. 2006). Discussions with NASA officials during these meetings have initiated formulation of a Space Act Agreement to establish a public-private partnership between the State of Hawaii and

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[1] Established in 1990 under the aegis of the U.S.-Japan Leadership Council, JUSTSAP is an ongoing forum of scientists, educators, business professionals and government officials that convenes annually in Hawaii to identify and promote opportunities for international collaboration in space exploration. The Hawaii Dept. of Business, Economic Development & Tourism (DBEDT) serves as the official Secretariat for JUSTSAP and coordinates the annual meeting in Hawaii.

NASA Ames Research Center in Palo Alto, California, to promote collaboration on the development of programs (such as PISCES) that can support NASA's vision for space exploration, the development of commercial space initiatives, and activities promoting aerospace-related research, education and workforce development. Similar Space Act Agreements for Hawaii are currently under development with the Johnson Space Center in Houston, Texas, and Marshall Space Flight Center in Huntsville, Alabama.

In addition, a PISCES Project Team was formed during the 2006 JUSTSAP Annual Symposium at the Hapuna Prince on the Island of Hawaii (Nov. 2006) to draft a formal proposal (attached with this report) that outlines the purpose, scope, timetable and budget for developing this initiative, as well as the significant scientific, educational and economic benefits this project will bring to our State. Per this proposal, PISCES is envisioned as a simulated lunar settlement on one of the lower volcanic slopes on the Big Island, where "research will be conducted, new technologies will be tested, 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."[2] Administered by the University of Hawaii at Hilo and promoted internationally through DBEDT, it will provide strategic testing and evaluation facilities for NASA, JAXA and private institutions seeking to conduct space exploration research, demonstration and training programs in "analog" lunar environments. It will serve as a major asset for institutions of higher learning, where "research and educational programs related to space exploration can be conducted with both public and private funding."[3] Finally, it will promote economic development statewide by seeding new investment and business development opportunities, as well as by enhancing education and training opportunities in science, math and engineering for Hawaii residents.

The proposed PISCES budget includes an initial investment by the State of Hawaii of approximately $1 Million per year for two years (to support preliminary field studies, educational programs, robotic demonstrations, lunar facility design and environmental assessments, and a capital fundraising program). In addition, State funding will be critical at the onset of this project to (1) demonstrate Hawaii's strong commitment to this project prior to the initiation of a major private capital fundraising effort and the submission of research and education proposals to NASA, JAXA, and other government agencies; and (2) give Hawaii a competitive edge vis-à-vis other states that will be vying for NASA, NSF, and other federal funding to develop and operate simulated environments for planetary space exploration in the near future. PISCES will grow increasingly self-sufficient in years 3-5, after which it is projected to become completely self-sustaining (i.e., independent of State funding), generating income exclusively from facility users (NASA, JAXA, other government agencies, and private industry) and through PISCES educational/public outreach programs.

For further information, please contact Jim Crisafulli, Research & Development Coordinator/DBEDT, at 586-2388/jcrisafu@dbedt.hawaii.gov.

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[2] PISCES Proposal, Executive Summary, Page 1, Paragraph 1.

[3] PISCES Proposal, Executive Summary, Page 1, Paragraph 4.

The Pacific International Space Center for Exploration Systems (PISCES)

A Proposal to the State of Hawaii
from the
Japan-US Science, Technology and Space Applications Program (JUSTSAP)
to establish an International Center for Space Exploration
on the Island of Hawaii

Executive Summary

It is proposed that a center be established in Hawaii to support space exploration and settlement. The Pacific International Center for Space Exploration Systems (PISCES) will feature a simulated lunar settlement on the Big Island, where research will be conducted, new technologies will be tested, 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.

A center of the magnitude and importance proposed here will promote economic development on the Big Island and throughout the State directly by seeding new investment and businesses development opportunities, and indirectly by enhancing education and training opportunities in science, math and engineering, thereby bolstering the technical workforce needed to attract additional high-tech industry to Hawaii.

Education and public outreach will be a major thrust of PISCES, with programs for the K-12 and 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, including tourists visiting Hawaii, who will observe experiments in progress and will learn about our future in space through interactions with PISCES staff and students.

PISCES will become an important facility for use by the National Aeronautics and Space Administration (NASA) and by the Japan Aerospace Exploration Agency (JAXA) for their space exploration research, demonstration and training programs. It will also be an important technological proving ground for private companies wishing to participate in the coming commercial opportunities in on the Moon and Mars. It will be a major asset for institutions of higher education in the US and Japan, but especially in Hawaii, as a center where research and educational programs related to space exploration can be conducted with both public and private funding.

Hawaii offers an ideal environment for PISCES, with lunar-like terrain and fine volcanic ash that is in many ways similar to lunar regolith (the topmost layer of dust and loose soil, a few meters thick, which covers the lunar bedrock). It also offers a central location for collaboration between the continental US and Japan, world-class capabilities in a broad range of space sciences, particularly astronomy and planetary science, a diverse population and an international culture.

PISCES will be administered by the University of Hawaii at Hilo and will operate research and education programs at both the Hilo and Manoa campuses, and, as appropriate, at other locations throughout the State. The simulated lunar settlement will be located in a suitable volcanic region on the Big Island, potentially on the lower slopes of Mauna Kea or Mauna Loa.

Initial funding support from the Hawaii State Legislature (approximately $1 million per year for the first two years) will be essential to help inaugurate PISCES, which would include funding to conduct preliminary geological and other field studies, launch the initial round of educational programs, demonstrate the robotic capabilities of selected field sites, design the simulated lunar facilities, conduct the required environmental assessments for the lunar settlement, and secure capital funding. It is anticipated that the Center will be self-supporting (i.e., independent of any State funding) after the first five years, with sustained income from facility users (NASA, JAXA, other government agencies, and private industry) and PISCES educational/public outreach programs.

State funding is also critical at this juncture as it will (1) demonstrate Hawaii's strong commitment to this project prior to the initiation of a major private capital fundraising effort and the submission of research and education proposals to NASA, JAXA, and other government agencies; and (2) give Hawaii a competitive edge vis a vis other states that will be vying for NASA, NSF, and other federal funding to develop and operate simulated environments for planetary space exploration in the near future.

Introduction

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 a sustained presence there and for human exploration of Mars and beyond.[1] 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) [2], and has generated strong interest and participation by other countries, particularly Japan. The US plan calls for human landings on the Moon no later than 2018, while the smaller program in Japan foresees landings somewhat later.

[1] See "President Bush Announces New Vision for Space Exploration Program", at http://www.whitehouse.gov/news/releases/2004/01/20040114-3.html, and "A Renewed Spirit of Discovery", at http://www.whitehouse.gov/space/renewed_spirit.html.
[2] See http://www.gpoaccess.gov/plaws/index.html.

Japan is also an active partner in the Japan-US Science, Technology and Space Applications Program (JUSTSAP), under whose auspices this proposal was initiated. JUSTSAP has been meeting in Hawaii annually since its founding in 1992. It exists to foster cooperation in space between Japan and the US in a variety of ways, including satellite telecommunications, disaster mitigation, experiments on the Shuttle and International Space Station, education in both countries through the University Space Student Symposium (USSS), and now in realm of space exploration through PISCES. An active collaboration between the United States and Japan, working toward eventual outposts on the Moon through research and technology development in PISCES, will benefit both nations by sharing our resources for human and robotic exploration.

Long-duration space missions and sustained presence on another body in the solar system will preclude the transport of supplies and materials from Earth and will therefore require that 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 we need with us. In the case of Mars, it will be all but impossible. Thus we will have to use the lunar and Martian soils to construct habitats, to produce oxygen for breathing, to provide energy and to propel rockets. We will have to use the existing soils as the primary constituents of beds for growing food. And we will have to use sunlight for heating and electricity. We must learn how to do all of this and more, and we must start now if we are to be ready to sustain a permanent human presence 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.

New technologies developed in PISCES and at universities and industries around the world will need to be tested in an environment simulating as closely as possible that found on the Moon. Both the US and Japan plan robotic exploration missions to the Moon in the next few years, and PISCES will be an important proving ground for hardware developed through collaborative projects in science and technology. Astronauts embarking on exploration missions and long stays on the Moon will need to be trained in the use of these new technologies to free them from the drudgery of routine chores and to increase their time for scientific and technological achievements. Astronauts may even be selected to perform these missions based partly upon how well they perform in realistic long-duration simulations of mission activities. Certainly, would-be tourists will have to undergo some such kind of training in a simulated lunar environment.

Description of PISCES

The principal physical feature of PISCES will be a central facility simulating as closely as possible a future lunar or Martian settlement. This facility will most likely be located somewhere on the lower slopes of Mauna Kea. Several sites have been proposed, including the Army's Pohakuloa Training Area on the Saddle Road and the Haiwahine Craters near the Hale Pohaku Mid-Level Facility and Onizuka Visitor Center at the 9000-

foot level. The actual location will be based on a detailed geological and cultural site review and environmental impact study, all of which will be conducted as part of the proposed development. We are fully aware of the importance of working with the local community, including the Mauna Kea Management Board and the Kahu Ku Mauna Council (its Hawaiian Cultural Advisory Board), to assure that all of our planned activities are culturally sensitive.

The slopes of Mauna Kea were used to train Apollo astronauts, and the environments presented on the mountain, including the barren terrain, high altitude, dry clear air, and deep volcanic regolith, convinced those astronauts that Mauna Kea was the most Moon–like of their training experiences. However, the lunar outpost that must be simulated for sustained human presence will include many additional features: habitation, life support, power, surface transportation, communications and navigation, resource extraction and processing, extra-vehicular activities, robotic operations and other systems that will benefit from simulation in a realistic environment. None of these system components has been defined in detail yet by Japanese and US specialists. The facility envisioned here can therefore play a central role in support of the national programs by developing standards for surface systems, testing proposed technologies and system configurations, exposing selected systems to long duration testing, and exchanging test information with system developers to improve their designs by testing on Earth, rather than requiring that the systems undergo their first integrated testing on the Moon. We have already begun this definition process through the JUSTSAP symposia and through meetings of potential user groups at other conferences.

Initially, the actual lunar facility may be developed for support of six crewmembers for periods of six months. This facility will be designed to be expandable to support larger crews for longer durations. One approach to expansion will be to have additional modules that can be added to the initial core and operated for periods of a few months to years. This same approach will be modeled and tested in PISCES.

A wide range of other capabilities will be simulated by PISCES. Tele-operated robots will rove over the realistic volcanic terrain. Test ranges for systems surface navigation, power generation and transmission, and long-distance surface travel will be available. Lunar outpost construction activities will be demonstrated inside and outside of craters. Habitats will be constructed in moon-like conditions, covered with local volcanic ash-derived regolith for simulation of radiation shielding techniques on the Moon. Long-distance power-beaming experiments will be undertaken, including the simulation of relayed communications from the Moon, where operations at PISCES are monitored by personnel in distant locations.

In addition to its simulation capabilities, PISCES will contain scientific equipment for research into new technologies needed for in-situ resource utilization (ISRU). Such facilities will include large vacuum systems with high-speed pumping and refrigeration for simulating the harsh lunar surface environment. These vacuum systems will be capable of containing dust similar to that present on the lunar surface. Dust problems proved to be severe during the Apollo missions and will have to be solved if long stays

and permanent human presence on the Moon are to become realities. Other scientific equipment in PISCES will include X-Ray diffraction, scanning electron microscopes, surface spectroscopy, particulate analysis, etc.

The details of the facility will be coordinated with NASA and JAXA officials having responsibility for defining their lunar outpost systems and with the US and Japanese industry personnel that are developing them. The facility will also be designed for use by private entrepreneurs who are planning commercial ventures on the Moon. All users of the PISCES facilities will pay fees to help support, operate and maintain it.

Research and Technology Development

PISCES will provide a central focus for the development of planetary surface system technology. The core research group will be drawn from universities, industries and government space agencies around the world, but primarily from those in Japan and the United States, who will form a users group for PISCES. Funding for individuals within the users group will be provided by their respective governments and by industry, while user fees will help provide operating support for PISCES.

The University of Hawaii, for example, has a world-class team of planetary scientists and engineers motivated by the challenges of exploring and developing planetary surface outposts. The disciplines to be emphasized will be surface exploration technology, advanced life support and surface transportation systems. A new discipline, space exploration operations technology, will be developed, which will have as its goal the definition and improvement of operations at a human outpost and will be in direct support of PISCES simulation capabilities.

As a focus for research and technology development in planetary surface systems, PISCES will provide an opportunity for collaboration with organizations in Japanese and US industry and academia. In the United States, PISCES will form close partnerships with the NASA-created Research Partnership Centers. These centers have discipline expertise in a range of relevant areas, including energy systems, advanced materials, communications, resource extraction, medical technology, life support and flight hardware development. They are academic organizations with direct links to many US industries, large and small. In Japan, JUSTSAP delegates from the Tokyo Institute of Technology and Kobe University, among others, provide discipline skills and leadership in Japanese space-related activities. Through the network of academic institutions and industries in both countries, which has been created and fostered by JUSTSAP, PISCES will promote rapid and cost-effective research and technology development, and will allow the most capable groups to be brought into play as worldwide space exploration evolves. This lunar surface “technology broker” function will support both government exploration programs and industry transfer of new products to the marketplace on Earth.

Education and Public Outreach

Facilities and programs developed for PISCES will provide attractive venues for primary and advanced education and public outreach, motivating public support for space exploration and development activities. Advanced education will be offered to students in residence at the University of Hawaii at Hilo at other universities working on PISCES technology and applications projects, including development of operations technologies. Programs that emphasize training of both US and Japanese graduate students will have highest priority and will be conducted in collaboration with home universities in the US and Japan through the auspices of JUSTSAP. With concurrence by the appropriate faculty governance bodies and university officials, a new program in Space Exploration Operations Technology will be established at UHH. This will be the only program of its kind in the world.

Primary and secondary education programs associated with PISCES will have as their goal the motivation of youth through the opening of space frontiers. These are national goals of both the US and Japan. The PISCES facility, as representative of a lunar settlement, will offer new perspectives on applications of science, mathematics and technology to the solution of practical problems that will arise in space exploration and settlement. The programs will be offered primarily to students from the US and Japan; however, the greatest impact is likely to be on students from the State of Hawaii. For that reason, the primary and secondary programs will also be based at the University of Hawaii at Hilo and will be supported through grants from government agencies and private foundations.

Outreach programs will be offered to the local public and to visiting tourists. Interactive exhibits will be developed that allow visitors to experience the planetary outpost environment and to interact with research and operations conducted at PISCES. The outreach programs will be designed to be self-supporting through grants and admission fees for tours of the simulated lunar settlement. Successful outreach programs will also support primary and secondary education activities at the Center. Hawaii is a tourist-rich state, with visitors from around the globe, and PISCES outreach programs will reach far beyond the local population.

Why Hawaii?

Hawaii is blessed with unique geographical features; in particular, volcanic terrain that can represent the lunar surface. Apollo astronauts used this environment as they trained for the lunar missions. Astronauts who subsequently journeyed to the Moon were particularly impressed by how well their training in Hawaii was correlated to their experiences on the Moon.

Hawaii's volcanic terrain offers several features analogous to lunar terrain: volcanoes themselves, with petrologic features similar to those of lunar lava flows, Aeolian deposits

of fine-grained volcanic ash that resemble the lunar regolith, Tephra deposits adjacent to cinder-cones, with interlocking grains like lunar soils, lava tubes similar to lunar lava tubes that may provide radiation shelter on the Moon, craters and ejecta (though they are from eruptions, rather than meteorite impacts) and permafrost in craters on top of Mauna Kea, akin to ice deposits in lunar polar craters.

Hawaii's weather makes for year-round ease of operation, with very low rainfall on the leeward side of the islands and abundant sunlight for solar energy systems. Extensive, unpopulated, barren terrain (100s of square kilometers) exists at higher altitudes where simulations can be conducted at the full scale of early exploration activities on the Moon without interference from other human activities.

Hawaii is also convenient to reach from both Japan and the US mainland. Situated in the mid-Pacific, Hawaii can be reached in 5-10 hours on a flight from the continental US or in10 hours from Japan. Jet-lag effects on visitors from both sides of the Pacific are minimal.

Hawaii has an increasingly well-educated work force and its high-tech industrial base is expanding. The University of Hawaii's research base is growing very rapidly at this time, due to decisions made previously by the State and by university administrations. The University of Hawaii is considered to be a minority institution, and investments made here can help meet national equal opportunity goals. University of Hawaii faculty at both Hilo and Manoa are likely to play prominent roles in the development of PISCES. The full supporting intellectual capabilities of the State of Hawaii can be brought to bear on PISCES, including the geology, geography, physics and astronomy faculties at Hilo, supercomputing capabilities at Manoa, the worldwide astronomy community represented by observatories on Mauna Kea and Haleakala, and the Planetary Sciences personnel of the Hawaii Institute of Geophysics and Planetology at Manoa. The astronomy and planetary science capabilities of Hawaii are "world class" and will grow in strength with the inception of PISCES.

Benefits to the State of Hawaii

Hawaii will benefit in many ways from the development of PISCES. The presence PISCES will attract high-tech industries to the State, particularly to the Big Island, since that is where the principal physical facilities will be located and where the educational programs will be based. These new industries will provide a source of high-paying jobs that are much needed in Hilo and the surrounding areas. The active participation of University of Hawaii scientists and engineers will encourage spin-off industries and attract others that will be on the cutting edge of space exploration. The enhancement of educational opportunities in science, mathematics and engineering at the University of Hawaii at Hilo will benefit workforce development, which in turn will enhance the ability of Hawaii to attract more high-tech industries and diversify its economy. PISCES will also become an additional tourist attraction for the State, but one that will educate and

inspire visitors through the excitement of space exploration at the same time that it contributes to economic development on the Big Island and throughout Hawaii.

Benefits to NASA

PISCES will provide a focus for research and technology development needed for long-term stays on the Moon and Mars. Research projects funded through the NASA field centers will provide important extensions to in-house programs that will enhance NASA's constituent support base for space exploration. These projects will also provide important linkages to industries interested in their own commercial space development and thus present leveraging opportunities for NASA's scarce resources. PISCES will also provide a facility for NASA to test robotic exploration capabilities and accelerate training and certification of crews selected to return to the Moon and to develop the first lunar outpost.

Facilities established in Hawaii with State and private funding will relieve NASA of the expense of establishing similar facilities elsewhere. A collaborative working relationship between PISCES and NASA will allow new concepts to be rapidly integrated into training facilities. The new discipline of space exploration operations technology will contain NASA operations experience in its base, but will develop new techniques and train personnel that will be available for inclusion in NASA programs. Interaction between PISCES and NASA operations, with NASA personnel operating systems remotely at PISCES, will further train personnel in lunar outpost operations.

Benefits to JAXA

The benefits to JAXA will be similar to those to NASA; however they may be even more important in proportion to the scale of the JAXA program, which is smaller. Investments in infrastructure are a larger tax on Japan's space program and a share in PISCES infrastructure will free up JAXA funding for technology and procedure development.

Benefits to Industry

Industry in the United States and Japan will benefit from the focusing of concerted efforts in the PISCES program. Opportunities for demonstrating technologies in a realistic environment can be important for showcasing new technology and in obtaining certification (e.g. NASA Technology Readiness Level 6) of systems intended for application on the Moon. Standardization will be important for the lunar outpost and can be both developed and demonstrated at PISCES. The open environment of PISCES and the function of the Center acting as a technology coordinator (broker) will encourage industry participation.

Benefits to Humanity

Technology developed for the lunar outpost will have its principal application in space, an emerging but limited market dominated by the government space programs, but because most of these technologies are applicable on Earth, there are likely to be many dual-use technologies that will benefit humanity in general. In the long term, advances demonstrated and tested via PISCES will evolve into capabilities for commercial development of space, an effectively infinite field of economic development. As the President's Science Advisor, Dr. John Marburger, has put it[3], "As I see it, questions about the vision boil down to whether we want to incorporate the Solar System in our economic sphere, or not." And later in this same speech he says, "The ultimate goal is not to impress others, or merely to explore our planetary system, but to use accessible space for the benefit of humankind."

PISCES Development Plan

The basic premises of the PISCES development plan are (1) a large fundraising effort will be needed to acquire land and provide capital for building the facilities and providing infrastructure and scientific equipment and (2) PISCES will be self-supporting in five years; i.e., independent of State funding, through a combination of direct funding of proposals for research and technology development of interest to government agencies and industry, overhead return from participating universities, user fees for PISCES facilities not covered by overhead; e.g., specialized scientific equipment and pilot-scale field testing facilities, grants for educational programs and admission fees from outreach programs.

We anticipate that it will take approximately 10 years to develop PISCES into a fully operational facility for research and technology development, simulation, testing, education and outreach. This schedule is consistent with NASA's schedule for the exploration of the Moon and Mars, in which the next human sorties to the Moon will occur in 2018. However, we anticipate that educational programs can start immediately, focusing on the design of PISCES and development of the curriculum for the Space Exploration Operations Technology program.

The following plan provides for several stages, marked by the introduction of new activities into PISCES. The end of a phase, however, does not signify that the activities carried out in that phase will be discontinued. Core activities, once begun, will be able to support PISCES stakeholders according to their interests. We plan to start early with preliminary research needed for facility design, including geological studies, environmental studies and robotic demonstration. The educational programs will also begin early and concurrently with the research programs, as reflected in the following.

[3] Speech by OSTP Director John Marburger to the 44th Robert H. Goddard Memorial Symposium, March 15, 2006, see the Office of Science and Technology Policy's web site at http://www.ostp.gov/html/jhmGoddardSymp03-15-06Release.pdf,

The dates given in the plan are the latest the specified tasks will be completed. Many of them will be completed earlier, as events and funding allow.

Phase I. Planning and Startup

This phase will comprise years 1 and 2 of the project, during which time the following tasks will be completed.

a. Conduct introductory meetings with key personnel, including representatives of NASA Field Centers, JAXA, industry and academic organizations.
b. Develop a 10-year Strategic Plan. This plan will address potential customer requirements and the facilities, systems and personnel that will be needed to meet them, the future financial support of PISCES, and the initial design of the facilities. The strategic plan will be delivered to UHH, DBEDT, the State Legislature and other interested parties by June 30, 2008.
c. Conduct preliminary research at the University of Hawaii to ascertain suitability of candidate sites, including studies of the geology, soil properties and other environmental factors, cultural sensitivity, effects on telescope operations on top of Mauna Kea, and early robotic demonstrations. A report on this study will be delivered along with the Strategic Plan by June 30, 2008.
d. Initiate educational programs encouraging student participation in the design and development of PISCES. These programs would involve student competition for winning designs and are planned to be in place during the spring semester, 2007.
e. Initiate planning with appropriate faculty governance groups and university officials for a Space Exploration Operations Technology program to be instituted at the University of Hawaii at Hilo.
f. Following site selection process, secure land or existing facilities, through purchase, lease or gift, on which to place physical assets of PISCES, including lunar field area, lunar rover test facility, simulated lunar habitat, visitor center and infrastructure to include a conference center, offices, machine and instrument shops, etc. Since much of the land on Mauna Kea is owned by the State and Federal governments, the land acquisition task could be free of costs other than those associated with environmental and cultural impact assessments and site improvements.
g. Prepare architectural details for layout and construction of initial PISCES facilities, coordinating with all potential users. Architectural plans, including a model of the facility, will be complete by the end of Phase I, June 30, 2009.
h. Convene annual PISCES Conferences. These would be held in conjunction with the annual JUSTSAP Symposia so as to maintain close coordination between the US and Japan as PISCES is developed.
i. Coordinate proposals for use of PISCES through government and industry sponsors.
j. Initiate a major private fundraising campaign for capital needs and educational programs. The campaign would be guided by a professional organization having sound credentials in this area and selected as a result of a nationwide search.

Phase II. Robotic Field Demonstrations and Technology Development

The focus in Phase II (years 3-5) will be on using prepared and well-characterized field locations to simulate environments for the next robotic missions to the Moon. This will include the capability for teleoperation of robotic mobility systems, operation of lunar resource experiments and nighttime operations to simulate permanently shadowed terrain on the Moon. As these initial simulations are being performed, facilities for simulation of human habitation will be in development. Also during this phase, a vigorous research and technology development program in surface systems for the Moon (and eventually Mars) will be undertaken. This program will include the development of the Space Exploration Operations Technology curriculum that will provide the educational basis for operators of future lunar outposts. Phase II tasks will include the following:

a. Conduct field exercises with NASA and JAXA lunar robotic exploration systems.
b. Develop habitat simulation facilities.
c. Conduct University of Hawaii technology research in key areas, including exploration tools, robotics and automation, surface mobility, advanced life support, habitation, and others. Coordinate this technology program with those of the collaborating organizations, leading to the incorporation of new technology into the facility during the next stages of PISCES programs.
d. Institute a core educational curriculum in Space Exploration Operations Technology at the University of Hawaii at Hilo to ensure that a pool of students will be available for operating PISCES as well as for government and industry employers.
e. Construct or otherwise obtain visitor support facilities.
f. Conduct annual PISCES conferences.

Phase III. Simulation and Training

The detailed program in this period will be developed through coordination with the collaborating space agencies, industries and universities. The planned activities are roughly as follows:

a. First dedicated lunar outpost simulations (2011) utilizing hardware developed by PISCES and its government, industry and academic collaborators.
b. Tests focused on hardware to be used in lunar sortie missions as well as initial long-duration tests of lunar outpost technologies
c. Significant simulation missions conducted according to space agency and/or industry specifications.

Phase IV. Lunar Outpost Prototype Operations

The detailed program for this phase will also be coordinated with the participating space agencies, industry and academia and will depend to some extent on progress of the overall space exploration programs in both the US and Japan. The anticipated program of activities is as follows:

a. Starting in 2014, advanced lunar outpost simulations will be undertaken to test alternative approaches to lunar outpost operations.
b. Training exercises for astronaut candidates from space agencies and/or entrepreneurial (so-called New Space companies), for lunar missions.
c. Demonstration and utilization of newly developed technologies for "living off the land." For example, oxygen and hydrogen extraction, propellant synthesis and food production will be ready to demonstrate on a pilot scale. If successful, these technologies will be utilized for sustained operation of PISCES.

Budget Parameters

Phase I will require $1 million in State funding per year for two years, decreasing to zero after five years, to start the PISCES planning and development activities. A private fundraising campaign will be undertaken during this time to obtain capital funding for the physical facilities, including infrastructure elements, and for visitor and education and outreach programs.

Phase II is budgeted at a total of $2-5 million per year. A funding base of $2 million per year will be solicited from sponsoring members in the U.S. and Japan. Additional resources for technology development will be sought through competitive proposals. Some State funding will be required during this period, but will be phased out at the end of the 5-year period (see table and chart at the end of the next section).

Phase III is budgeted at $5 million dollars per year, none of which will come from the State, to support active simulations of lunar sortie and outpost missions and to provide infrastructure hardware that would be made available for specific users of the facility. Funding for this phase will come from national space agencies wishing to conduct simulations in PISCES, industry groups interested in testing their hardware in the facility, and user fees from funded research projects making use of the facilities. Visitor and educational programs are expected to self-supporting through grants and fees.

Phase IV is budgeted at $5 million dollars or more per year. Funding for this phase will again come from national space agencies conducting simulations in PISCES and industry groups that testing their hardware in the facility. None of it will come from the State. Visitor and educational programs are self-supporting. Expansion of facilities, and related budgets, will be based on the needs of participants and the success of the program.

Revenues

As discussed above, funding for Phase I, the first two years, will come primarily from the State of Hawaii and will be used to establish the center and conduct a major fundraising campaign for private and public funds. State funding will be reduced during Phase II and eliminated after the center has been in operation for a total of five years. Planned sources of funding are listed in Table 1 and presented graphically in Figure 1.

Source of Funds	Year 1	Year 2	Year 3	Year 4	Year 5	5-Year Totals
Operating Funds:						
State of Hawaii	$ 1,000,000	$1,000,000	$ 750,000	$ 500,000	$ 250,000	$ 3,500,000
NASA		$ 300,000	$ 800,000	$ 1,600,000	$2,000,000	$ 4,700,000
JAXA		$ 50,000	$ 100,000	$ 200,000	$ 250,000	$ 600,000
Other Government Agencies		$ 150,000	$ 200,000	$ 300,000	$ 500,000	$ 1,150,000
Private Companies		$ 150,000	$ 200,000	$ 400,000	$ 600,000	$ 1,350,000
Revenue from Operations			$ 20,000	$ 160,000	$ 180,000	$ 360,000
Total Operating	$ 1,000,000	$1,650,000	$ 2,070,000	$ 3,160,000	$3,780,000	$ 11,660,000
Capital Funds:						
Individuals		$ 500,000	$ 2,000,000	$ 3,000,000	$2,000,000	$ 7,500,000
Foundations			$ 1,000,000	$ 2,000,000	$2,000,000	$ 5,000,000
Total Capital	$ -	$ 500,000	$ 3,000,000	$ 5,000,000	$4,000,000	$ 12,500,000
Notes:						
"Other Government Agencies" includes NSF, DOE, DOD, etc.						
"Revenue from Operations" includes User Fees, Admissions, Overhead Return and Other Non-Designated Revenues						

Table 1. Planned Operating plus Capital Revenues

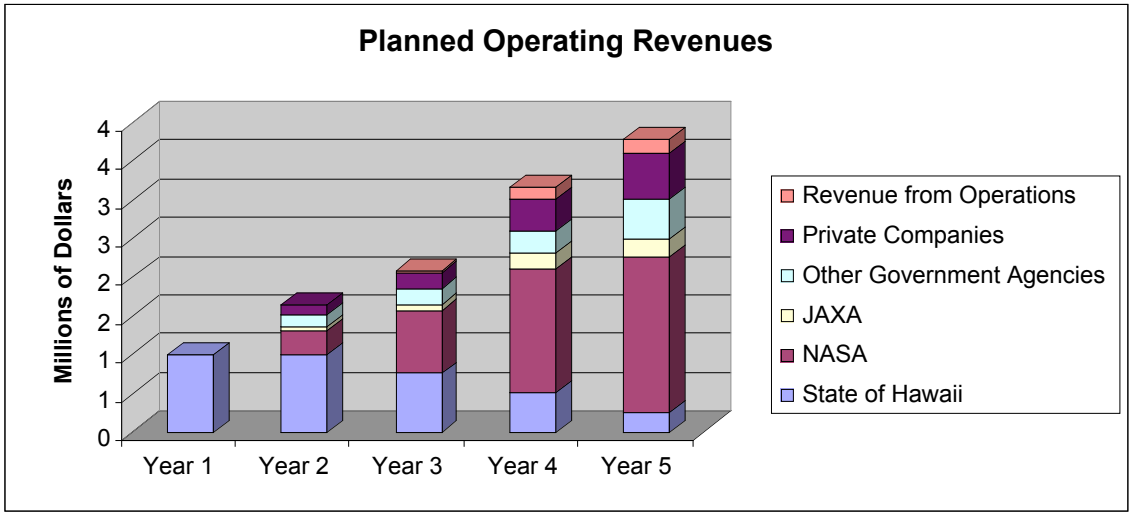

Figure 1. Planned Operating Revenues

Operating funds shown in Table 1 and Figure 1 from NASA, JAXA and private companies will all go to fund research and technology development and educational programs undertaken by faculty at the University of Hawaii and other universities in the

US and Japan that are participating in PISCES. Operating funds shown under the category "Revenue from Operations" will include revenue sharing with UHH; i.e., partial overhead return for unique expenses, which will not start until Phase II, plus user fees and other revenues resulting from operations but not directly supporting the research and educational functions of the center. It is expected that this category will grow steadily during years 3-5 to become a significant portion of the center's fungible revenue during its steady-state operations. PISCES will thus pay its own way after five years and will represent a significant return on the State's investment in terms of both its own operations and its impact on economic development on the Big Island.

Expenses, Phase I

Budget details are presented in Table 2 for the first two years of operation, presumed to start July 1, 2007. Details for the subsequent years will be developed as part of the Strategic Plan to be completed in Phase I. We plan to start with a non-resident part-time interim director while a national search is conducted for a resident full-time director. Both the interim and permanent directors will be faculty members at the University of Hawaii at Hilo. Support staff will also be employees of UHH. Student expenses will cover students from UHH and other universities in the US and Japan, as appropriate. Administrative overhead will accrue to UHH, a small portion of which will begin to return to the center as revenues from operations in Phase II, as discussed above.

Expense Category	Year 1	Year 2	2-Year Totals
Salaries			
Interim Director	$ 75,000	$ 25,000	$ 100,000
Director	$ 25,000	$ 150,000	$ 175,000
Faculty Time for Research	$ 100,000	$ 200,000	$ 300,000
Faculty Time for Education	$ 100,000	$ 200,000	$ 300,000
Clerical Support	$ 50,000	$ 75,000	$ 125,000
Student Help	$ 50,000	$ 100,000	$ 150,000
Total Salaries	$ 400,000	$ 750,000	$ 1,150,000
Travel			
Design Teams	$ 20,000	$ 20,000	$ 40,000
User Group Organization	$ 10,000	$ 20,000	$ 30,000
Fundraising	$ 20,000	$ 50,000	$ 70,000
Total Travel	$ 50,000	$ 90,000	$ 140,000
Laboratory and Office Supplies	$ 10,000	$ 20,000	$ 30,000
Overhead			
3.5% of Salaries+Travel+Supplies	$ 16,100	$ 30,100	$ 46,200
Contracts			
ISRU Design	$ 30,000	$ 30,000	$ 60,000
Solar Power Design	$ 30,000	$ 30,000	$ 60,000
Field Testing Area Design	$ 30,000	$ 30,000	$ 60,000
Education Program Development	$ 30,000	$ 30,000	$ 60,000
Media Relations and Public Outreach	$ 40,000	$ 40,000	$ 80,000
Publicity Materials	$ 50,000	$ 50,000	$ 100,000
Fundraising	$ 323,900	$ 279,900	$ 603,800
Total Contracts	$ 533,900	$ 489,900	$ 1,023,800
Total Operating Expenses	$ 1,000,000	$ 1,360,000	$ 2,360,000
Capital Construction			
Environmental Assessments		$ 350,000	$ 350,000
Architect Fees		$ 240,000	$ 240,000
Site Preparation for Field Tests		$ 100,000	$ 100,000
Test Habitat Construction		$ 50,000	$ 50,000
Visitor Center Construction			
Total Capital Construction		$ 740,000	$ 740,000
Capital Equipment		$ 50,000	$ 50,000
Total Capital Expenses		$ 790,000	$ 790,000
Total Expenses for PISCES Project	$ 1,000,000	$ 2,150,000	$ 3,150,000

Table 2. Planned Expenses for Phase I (First Two Years)

In addition to new funds for staffing, student employment and overhead, there are other significant benefits to the University of Hawaii at Hilo that should be pointed out in the budget presented in Table 2. Some of the faculty release time for research and most of the faculty release time for education will go to UHH, since that is where the preliminary geological and other studies will be done and where the education programs will be based. The ancillary benefits to students at UHH will likewise be significant, since they will have new educational opportunities in the programs of PISCES, which can result in employment opportunities upon graduation. And finally, the added prestige of hosting a major space center like PISCES will attract new students, new research funding and added attention from private foundations and industry that will greatly enhance the reputation of the institution and its programs.

The enhancements discussed above will build on existing UHH strengths such as the NSF Science, Technology, Engineering and Mathematics (STEM) grant, called Keahaloa, and other minority education programs. UHH has a very high proportion of native Hawaiians and specializes in bringing science careers to local people. UHH has the fourth largest undergraduate astronomy program in the country and is currently building a $25 million Science and Technology Building. The institution also has an external grant for about $500k to build an instructional 0.9 m telescope on the mountain. UHH is a partner with the IfA at Manoa, MIT and several others in the *Pan*oramic *S*urvey *T*elescope and *R*apid *R*esponse *S*ystem (PanSTARRS) program. Thus the state will get a big bang for its buck by funding PISCES at UHH because it will be building on existing programs, not starting new ones from scratch.

We plan to operate the center on a unified budget. That is, all revenues will be pooled as they are received and used for all expenses except where restrictions are explicit in the appropriations or gifts. As shown in Figure 2, all the State funding will be used to cover operating expenses in Year 1, while the center is being established. In Year 2, only $1 million of operating expenses will be covered by State funds, while the other $650,000 will be covered by other revenues shown in Figure 1. It is not possible at this time to predict with any accuracy which funds will be used for which expenditures, except to stipulate that any restrictions placed on the funds as they are received will be observed. This is an important issue because many philanthropic donors and foundations place such restrictions on the funds they dispense, as does the State in some categories. In order to preserve naming opportunities for key facilities in PISCES, we will deliberately solicit donations for specific items such as a habitat, laboratory, scientific equipment or educational programs.

We will recruit professional help for the technical design of PISCES and its programs, as well as for such important tasks as fundraising, preparation of environmental and cultural impact statements, architectural planning and facilities construction. All of these expenditures are shown under the “Contracts” category in Table II and, as is customary at most institutions, are not subject to overhead.

Summary

The State of Hawaii is asked to fund the development of PISCES in order to attract private capital from individuals, industry and philanthropic foundations, and thereby to gain its active use and support by NASA, JAXA, their affiliated companies and other industries engaged in space commerce. The State of Hawaii will benefit greatly through economic development, especially on the Big Island. By inspiring students to study science, math and engineering through the excitement of space exploration, PISCES will help create the future technical workforce that can attract additional high-tech industry and foster economic development throughout the State.

PISCES will support lunar and Martian exploration programs of the US and Japan, including other nations where appropriate. NASA and JAXA, and companies from both countries, will be invited to use PISCES for field testing of robotic exploration systems for missions to the Moon planned in the next few years, and of human exploration systems for missions in the following decade.

PISCES will provide central facilities, midway between the US and Japan, for development of planetary surface system technology. PISCES facilities and programs will support primary and advanced education. PISCES Public Outreach programs will promote space exploration interests for the local population for visiting tourists from the US, Japan, and other nations around the globe.

Hawaii is a convenient location for both US and Japanese participants and offers an unparalleled simulation environment for lunar and Martian surface operations. Apollo astronauts trained in Hawaii and considered it to be the most moon–like of their training experiences. Lunar and planetary prototype rovers have also been tested in Hawaii, including remote telerobotic control from the US mainland. Hawaii'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). Hawaii's weather allows year-round operations in expansive areas of dry, barren terrain, with abundant sunlight for solar power. Hawaii can be reached in 5-10 hours from the continental US or 6-7 hours from Japan. Hawaii's astronomical and planetary science capabilities are world-class.

PISCES will benefit the State of Hawaii, NASA, JAXA and industry, sharing resources to prove out capabilities for robotic and human exploration in a simulated lunar environment. The proposed implementation plan offers a phased, affordable approach to developing and using the unique capabilities offered by the State of Hawaii, while at the same time getting PISCES off to a quick start with scientific studies critical to site selection and new educational programs to be based at UHH that will inspire and educate the next generation of space explorers.

PISCES Proposal
Appendix

Administration

The Pacific International Space Center for Exploration Systems will be administratively housed at the University of Hawaii at Hilo, reporting through its regular structure for centers. All funds for PISCES will flow through the normal UHH financial structure and will be subject to the accountability standards of the University. Reports on both the programs and their financial status will be presented to the State Legislature annually, as well as to other stakeholders.

Management

As discussed in the budget section, PISCES will operate on a unified budget. All funds coming into the Center that are not otherwise designated as to purpose will be pooled for use as determined initially by the interim director, with help from the organizing team, which is listed in the Personnel section below. Disbursement of funds will be made according to the proposed budget, modified in detail as necessary and as proposed by the interim director and concurred in by the organizing team. As soon as a permanent director is brought on board, a permanent management team and a board of advisors will be nominated by principals involved in PISCES and appointed by the UHH Chancellor.

Management responsibility for PISCES will rest initially with the interim director, ultimately with the permanent director, both of whom will be aided by the management team and advised by the board of advisors. The management team will design PISCES, develop the research and education programs and oversee the public outreach and fundraising activities. Individuals on both the management team and the board of advisors may be called upon to help directly with the fundraising activities, which will be guided by a professional fundraising organization.

Research and education programs and projects intended for inclusion in PISCES can be proposed by individuals on the management team or by any faculty member at UHH, UH-Manoa, Tokyo Institute of Technology, Kobe University, or any other qualified university in the US or Japan, as determined by the organizing team or, once the permanent management structure is in place, by the management team. Program and project selection will be based on the needs of PISCES and potential for external funding, as guided by the proposal initially and the Strategy Plan ultimately, and evolved by the management team and board of advisors. The management team will actively encourage submission of proposals by university faculty.

PISCES funding from the original State of Hawaii budget will be treated as seed funding to attract outside support.

Personnel

Initially, the principals in PISCES will consist of individuals involved in the organizing team, who are listed below, along with their anticipated roles in the Center and resumes.

Frank Schowengerdt – Team Lead and Interim Director
Jim Crisafulli – DBEDT and State of Hawaii Liaison
Stephen Day – JUSTSAP Liaison
Mike Duke – Higher Education Programs and Design for ISRU
Robert Fox - UHH Liaison and Higher Education Programs
Ken Hon – Geological Studies
Mark Henley – Site Studies and Site Selection
Neville Marzwell – Design for Robotic Testing
Beth McKnight – K-12 Educational Programs and Media Relations
Osamu Odawara – JAXA and Japan Liaison

Résumés

Individual resumes of the principals involved in PISCES are included in the following pages.

Dr. Franklin D. Schowengerdt

President, SpacePartnerships.com
709 Fitzhugh Way
Alexandria, VA 22314
Phone: (703) 519-7391
(571) 309-3815
Email: fschowen@spacepartnerships.com

PROFESSIONAL EXPERIENCE

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.

Aug. 03 – Aug. 06 Program Executive, Space Product Development
National Aeronautics and Space Administration

Responsible for the Space Product Development (SPD) program, the mission of which is to develop products and services through dual-use research partnerships with industry, academia and government for the benefit of both NASA and the public. The SPD program oversees the Research Partnership Centers (RPCs), which are cooperative research and development centers located at universities around the U.S. Research sponsored in these centers includes advanced materials, biotechnology, communications, electronics, energy conversion and storage, imaging, pharmaceutical development, space medicine, space power, spacecraft technology and thermal control. As of 2005, the RPCs' total operating budgets were in excess of $80 million, less than $20 million of which came from the SPD program. The rest was leveraging provided by the private sector, the NASA mission directorates and other federal agencies.

Jan. 96 – Aug. 03 Director, Center for Commercial Applications of Combustion in Space (CCACS), Colorado School of Mines

Founded and directed CCACS, which is an RPC specializing in applied research and development in combustion-related phenomena and processes, including fundamental combustion, catalytic combustion, flame synthesis of powders, fire suppression and combustion synthesis of advanced materials. This center, which was the first space research center at the Colorado School of Mines, grew from a small seed grant to a $5 million enterprise over

the course of six years. Center researchers and students flew the water mist fire suppression experiment on the ill-fated Columbia Shuttle mission. Despite the tragic end to that mission, the experiment was fully successful and data from it formed the basis of a new and more effective fire suppression method for spacecraft, aircraft, ships and buildings.

Jan. 90 – Dec. 95 Vice President for Academic Affairs and Dean of Faculty, Colorado School of Mines

Responsible for all academic programs, including all 11 degree-granting departments, plus athletics, the library and the computing center at the Colorado School of Mines. Accomplishments included establishment of five new academic degree-granting programs: M.S. and Ph.D. in Engineering Systems, M.S. and Ph.D. in Environmental Science and Engineering, and B.S. in Economics. Fostered creation of new research centers and institutes and promoted increased research activity throughout the university, resulting in a 50% increase in external research funding. Initiated a complete undergraduate curriculum reform effort, which resulted in a strengthening of the liberal arts and a new emphasis on systems courses integrating basic sciences and engineering.

1985-90 Chairman of the Board, Colorado Advanced Materials Institute

Founded, and was first board chairman of, this institute, which brought together Colorado's five research universities and most of the prominent high-technology companies in Colorado in a large effort to conduct materials research of interest to the private sector and strengthen materials research and education in the state.

1977-90 Head, Physics Department, Colorado School of Mines

Responsible for all academic programs in the physics department, encompassing the B.S. in Engineering Physics, which is one of the largest undergraduate physics programs in the U.S., and M.S. and Ph.D. programs in Applied Physics. Received the first research grant in the history of the department that built laboratories and funded students. Achieved accreditation of the B.S. program by the Accreditation Board for Engineering and Technology (ABET). The program is now one of only about a dozen accredited engineering physics programs in the country.

1987-88 Distinguished Visiting Scientist, Jet Propulsion Laboratory, California Institute of Technology

Research in surface physics associated with molecular beam epitaxy of III-IV semiconductor superlattices laser and photon detector applications and II-VI silicides for IR applications.

1973-03 All professorial ranks in physics department, Colorado School of Mines:
Taught almost all undergraduate and graduate courses offered by the department, from general physics through advanced undergraduate modern physics courses, to graduate-level mechanics, atomic, nuclear and surface physics. 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

RELEVANT PUBLICATIONS

1. "The Center for Commercial Applications of Combustion in Space (CCACS); A Partnership for Space Commercialization at the Colorado School of Mines", F.D. Schowengerdt, Bob Kee, Mark Linne, Tom McKinnon, John Moore, Terry Parker, Dennis Readey, John E. Tilton, Joe Helble, in *Space Technology and Applications International Forum - 1997*, American Institute of Physics, New York, p. 679 (1997)
2. "Commercial Applications of Combustion: A Vision for the Colorado School of Mines in Space", F.D. Schowengerdt, *CSM Quarterly*, October, 1997
3. "The Potential of Space Research for Improving Fire Suppression Systems", F.D. Schowengerdt, *Proceedings of the International Conference on Fire Safety,* ***Vol 25****,* p. 125, 1998
4. "The Role of Commercial Space Centers in Space Resources Development", F.D. Schowengerdt, J.J. Moore and A. Abbud-Madrid, *International Space Development Conference 2002* (2002)
5. "New SPD Initiatives at NASA", *Japan-US Science, Technology and Space Applications Program (JUSTSAP) Workshop* (2003)
6. "NASA's Space Product Development Program", *Japan-US Science, Technology and Space Applications Program (JUSTSAP) Workshop* (2003)
7. "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
8. "Space Exploration: The Role of the Innovative Partnerships Program," F.D. Schowengerdt, *Technology Innovation,* Vol. 12, No. 1, 2005, p. 8.

Dr. Robert A. Fox

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Hilo, Hawaii 96720

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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 POSITION

Co-Director
University of Hawaii Charter School Resource Center

The University of Hawaii Charter School Resource Center is a University-Chartered, statewide Center for the study and advancement of New Century Charter Schools. As Co-Director, I provide training for Charter Schools parent groups and local school Boards, serve directly on the Board of Directors of the Hawaii Academy of Arts and Sciences Public Charter School, organize statewide conferences and workshops, etc. I also conduct research into charter school issues with particular focus on state law and policy matters.

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

Responsible for teaching a full range of undergraduate physics courses in a liberal arts setting. Manage department budget and personnel. Responsible for course scheduling, resource allocation, etc. Also participate in campus governance as a member of the Faculty Senate, the University Faculty Congress and the University of Hawaii Ethics Committee

RELEVANT PUBLICATIONS

1. Hamilton, J., 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

2. Trang, D., 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

3. Hardman, J., Hamilton, J., Fox, R., and Asaoka, Y., "Construction of the ASHRA Detector," Joint Meeting of Pacific Particle Physics Communities, Honolulu Hawaii, 30 October, 2006

4. Buchanan, N.K. and Fox, R.A., (2005), "Recent Developments in Hawai'i Ethnocentric Charter Schools," in "School Choice and Progressive Politics," (title of panel presentation approximate). (presented at the 2005 meeting of the American Educational Research Association meeting in Montreal, April 2005)

5. Buchanan, N.K. & Fox, R.A., (2005), "Multiple Motives, Different Strokes for Different Folks; Hawaii's Charter School Landscape," invited presentation as part of "The Sociology of School Choice: Public Policy & Public Debate", Pacific Sociological Association, Portland, OR, April 2005

6. Buchanan, N.K., Fox, R.A., and Martin, D., (2006), "Challenging Gifted and Talented Students in Charter Schools," Journal of School Choice, Volume 1, No. 2, (in press)

7. Fox, R. A. & Buchanan, N. K. (2006), "Charter School Attitudes and Practices in States with Diverse Public Sector Bargaining Laws": Arizona, Hawai'i and Minnesota, Journal of School Choice, Volume 1, No. 1, January, 2006

8. Fox, R.A., (2005) Book Review of: "The Charter School Dust-uo: 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

9. Fox, R.A. & Buchanan, N.K. (2004) "The Impact of Collective Bargaining on Charter Schools in Hawaii; One State's Story," (June 2004) Hawaii Educational Policy Center, Available from http://www.hawaii.edu/hepc/pdf/Reports/Impact_ClctvBrgngCharterSchlsHawaii.pdf

CURRENT RESEARCH (EDUCATIONAL POLICY)

School Description/Student Performance Correlations using the Schools and Staffing Survey and the National Assessment of Educational Progress, The development of a predictive model using hierarchical linear regression base on SASS and NAEP databases. (In progress)

A Qualitative Analysis of America's Charter School Laws, A statute-by-statute summary of charter school laws in 42 states accompanied by a content analysis and comparison of application procedures, renewal and revocation regulations, collective bargaining requirements, etc. Designed to accompany the annual Center for Education Reform Charter School Report Card. (In progress)

CURRENT RESEARCH (PHYSICS)

All-sky Survey High Resolution Air-shower Detector, Co-Principal Investigator-Hilo, An international collaboration experiment using high resolution, wide field-of-view cherenkov and fluorescence detectors to track ultra-high energy cosmic radiation.

Member of the Pacific International Space Center for Experimental Systems, Japanese United States Technology and Space Applications Program

Member of the International Executive Board and UH Hilo Principal Investigator, All-sky Survey High Resolution Air Shower Detector (Ashra) Project

UH Hilo Work Package Manager and local Principal Investigator, Panoramic Survey Telescope and Rapid Response System (PanSTARRS)

RELATED PROFESSIONAL ACTIVITIES (PHYSICS)

Grant Reviewer; U.S. Civilian Research and Development Foundation; 2005

Chairman, Host Committee, Third International Collaboration Meeting, Ashra Neutrino Collaboration, Hilo Hawaii, March 2005

Chairman, Local Host Committee, KAMLand International Collaboration Meeting, Hilo Hawaii, October 2004

Elected member of International Collaboration Executive Committee, Ashra Neutrino Collaboration, Tokyo Japan, 2004

External Reviewer for the Department of Physics, University of Alaska at Anchorage, 2004

Grantee, University of Hawaii President's Fund, for travel associated with All-sky Survey High Resolution Air Shower Detector (ASHRA), March 2004

Grantee, Matson Navigation Company, for equipment associated with All-sky Survey High Resolution Air Shower Detector (ASHRA), March 2004

Grantee, VCAA Instructional Improvement Small Grant, for purchase of Einstruction Classroom Performance System, 2004

Appointed member, University of Hawaii Ethics Committee, 2004-2006

RECENT GRANTS

Principal Investigator, Panoramic Survey Telescope and Rapid Response System, Hilo Work Group, United States Air Force, current, $60,000.

Principal Investigator, Hawaii Charter School LSB Training Project, Hawaii Charter School Administrative Office, current, $15,000.

Principal Investigator, Intra-mural travel grant, 2005, $2,000

Principal Investigator, Intra-mural Educational Research Software grant, 2005, $1,800.

Principal Investigator, All-sky High Resolution Air shower detector, UH Presidential grant, 2004, $7,500.

Principal Investigator, Intra-mural travel grant, 2004, $2,000

ADMINISTRATIVE EXPERIENCE

Chairman, Department of Physics and Astronomy – University of Hawai'i at Hilo, 2003 - present

Manage budget, faculty and staff of academic department. Responsible for evaluation of programs and faculty.

Administrative Director, NASA Space Grant College - University of Hawaii at Hilo, 1992 - 1996

Responsible for recruiting faculty and student participants, budget administration, program evaluation and review for federally funded student fellowship program.

Director, Freshman Year Programs - University of Hawaii at Hilo, 1989 - 1992

Responsible for Freshman Orientation, advising and retention. Supervised up to 18

faculty advisors and up to 12 Freshman Seminar Instructors. Administered support programs through liaison with academic colleges and student support personnel. Supervised student workers, prepared and administered budget, prepared annual reports, evaluated programs, and represented the campus on system wide articulation committees. Reported directly to the Chancellor.

Coordinator of Academic Support Services, College of Arts and Sciences - University of Hawaii at Hilo, 1986 - 1989

Provided support to the Office of the Dean. Responsible for faculty-based academic advising and for the development and implementation of academic regulations. Prepared annual revisions to the catalog, wrote the College Advising Handbook and the Faculty Procedures Handbook. Analyzed academic issues and explored options for the Dean.

Chairman of the Natural Sciences Division - University of Hawaii at Hilo, 1983 - 1986

Responsible for the coordination of 23 full-time faculty members, 15 lecturers and 2 clerical staff members. Approximately $60,000 annual budget. Conducted personnel evaluation (faculty and clerical), curriculum coordination, and supply budget allocation. Represented the Division before other faculty groups and the public. Responsible for working with--and helping to focus--the diverse views of faculty members.

RELATED EXPERIENCE

Volunteer Mediator, Neighborhood Justice Center of Honolulu and Kuikahi medication Center, 1982 - present

For more than fifteen years, I have been involved in Hawaii community mediation as a mediator, trainer of mediators, Chairman of the Kuikahi Mediation Center Steering Committee, and officer in Mediation Centers of Hawaii (funded in part by the State Judiciary.

Elected Member, Hawaii State Board of Education, 1992 - 1996

The Hawaii State Board of Education is established by State Constitution to manage all public schools in the State of Hawaii. Members are elected to four year terms. As such, members have direct responsibility for 186,000 children and an annual budget in excess of one billion dollars. I have served as Chairman of Board Committees on: Student Services, Curriculum, Collective Bargaining, and Special Education. Membership on the Board of Education provides a unique exposure to current public problems and solutions and to the political process.

President, University of Hawaii Professional Assembly, 1982 - 1986

The University of Hawaii Professional Assembly in the collective bargaining agent for the 2700 member faculty of Hawaii's public higher education institutions. As elected President (and Acting Executive Director for eighteen months) I was responsible for negotiations, contract management, budget preparation and implementation and political representation.

RELATED COMMUNITY SERVICE

Over the years, I have served on the Board of Directors of Aloha United Way, Hawaii Island United Way, LaHikina Community Association, Waiakea Settlement YMCA (where I served as President for two years), Aloha Aquatic Club, the Rotary Club of Hilo, the Hilo Yacht Club (where I served as Commodore), the Collective Bargaining Congress of the American Association of University Professors (where I served as National Vice Chairman), the Higher Education Caucus of the National Education Association (where I served as National Chairman), and many others Boards and committees.

Related Training

In addition to completing numerous training workshops in mediation, domestic disputes and small claims mediation, I have completed training courses in *Meeting Facilitation* (Hawaii State Judiciary), *Advanced Collective Bargaining* (U.S. Department of Labor), *Verbal Skills in Negotiation* (National Education Association), *Academic Advising* (American College Testing, Inc.), *Evaluation in Higher Education* (National Center for Higher Education Management Systems) and the *Myers-Briggs Type Inventory* (Association for Psychological Type.

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.
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.
	National Aeronautics and Space Administration
1989 to 1993	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 (STAIF-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 Utilization of the Moon, ESA SP-462, European Space Agency, Noordwijk, The Netherlands, pp. 137-140.

Dr. Neville Marzwell

Dr. Neville Marzwell is the Manager for Advanced Concepts and Technology Innovation at NASA-Jet propulsion Laboratory, California Institute of Technology in Pasadena, California. Dr. Marzwell has 31 years experience in defense and aerospace systems technologies in which he initiated various technology breakthroughs and paradigm innovations. His work expertise is in the area of robotics, sensors, guidance, navigations and controls. He has expertise in expediting concepts to prototype hardware to verify and validate the technology. Other technology developments include and are not limited to space solar power, space based lasers, smart mechanisms, large optical systems for imaging far fainted objects, and high energy systems. He has developed adaptive, distributive and hierarchical control systems for large space structures. He has done a multitude of hardware and software developments in the area of autonomous space systems, robotics, and teleoperated systems. He was the NASA manager of the NASA Robotic Engineering Consortium at Carnegie Mellon University in which he grew the industrial partnership funding from $5M to $25M/year while graduating 25 students per year with BS, MS, and PhD degrees. Before joining JPL, he was program manager of Advanced Technology with the High Energy Laser research at the Rockedyne Division of Rockwell International where he developed innovative wavefront sensing and correction systems, and optical and sensor protection systems for surveillance satellites. At Honeywell Research Center he was instrumental in advances in infra-red detector technology, electro-optical materials and fiber optical systems. Before working in Industry be worked for 6 years at the Industrial Division of the World Bank associated with projects in Europe and Asia. Dr. Marzwell was a Josephine de Karman fellow at the California Institute of Technology and holds a Ph.D. in Applied Physics, and Materials Science from Caltech, a MS in Materials Science, a BSc in Chemistry, and a PhD in International Economics, with a minor in Strategic management. He has published 119 papers in refereed and professional journal and served on various national and international panels, workshop, conferences and symposium committees. He taught courses in Strategic Management, International Economics, Business and Finance, Financial Audit at various universities in the last 30 years (University of Minnesota, University of Southern California, and the Peter Drucker Institute of Management). He is now, Senior Adjunct Professor of Business and Technology Strategy at the University of La Verne, in California and Department Associate in the School of Business and Public Management.

Dr. Ken Hon

Associate Professor of Geology
University of Hawaii at Hilo

EDUCATION

Ph.D. Geology, 1987 Specialty: Volcanology / Petrology
University of Colorado Boulder
B.A. Geology, 1976
University of Colorado, Boulder

PROFESSIONAL POSITIONS HELD

Associate Professor,
University of Hawaii at Hilo (2002-present)

Assistant Professor,
University of Hawaii at Hilo (1997-2002)

Volcanologist/Videographer
Volcano Video Productions (1996-present)

Geologist/Volcanologist
U.S. Geological Survey (1981-1996)
USGS Hawaiian Volcano Observatory (1987-1990)

Graduate Student/Teaching Assistant
University of Colorado (1981-1987)

Field Assistant
U.S. Geological Survey (1979)

Exploration Geologist
Cotter Corporation (1976-1978)

Botany Research Assistant
Institute of Arctic and Alpine Research, University of Colorado
(Summers 1973, 1974, 1975)

PROFESSIONAL SOCIETIES

International Association for Volcanology and Chemistry of the Earth's Interior; American Geophysical Union; Geological Society of America

RESEARCH INTERESTS AND EXPERIENCE

Formation and Emplacement of Lava Flows
Development of Lava Tubes
Lava Delta Formation and Collapse
Evolution of Magma Chambers and Caldera Formation
Mitigation of Volcanic Hazards
Public Education about Volcanic Hazards
Producing Educational Films of Volcanic Processes

GRANTS [PI and PARTICIPANT]

NSF Major Research Instrumentation Grant, $144,000 for a EDXRF Geoarcheology Laboratory, Peter Mills PI, Ken Hon co–PI (2003-2006)
DOE Educational Grant "Ola Ka Honua: Volcanoes Alive" Kathy Betram Berry, Alaska Geophysical Institute PI, Ken Hon participant. (2004–2008)
NSF STEM Grant, Sonia Juvik PI, Ken Hon participant (2002–2007)
NSF Major Research Instrumentation Grant, $143,901 for "Development of an Electron Microprobe Teaching and Research Facility at UHH" (2001-2004)
USGS Grant, $59,500 for Upgrading the Microprobe Computer and Machine Control Systems (2000)
NASA Space Grant, $6,000 for Susie Shaw (1998-1999)
NASA Space Grant, $6,000 for Tobias Hewitt (1999-2000)

OUTREACH ACTIVITIES

I am continually involved in make the theater film for Hawai‘i Volcanoes National Park that explains the ongoing eruptive activity of the Pu‘u eruption to park visitors.
I have been working with Hawai‘i County to develop a Volcano Guide Program that integrates scientific knowledge of Hawaiian Volcanoes with a Hawaiian cultural perspectives on volcanoes.

TEACHING EXPERIENCE

Lecture Courses: Physical Geology, Geology of the Hawaiian Islands, Mineralogy, Optical Mineralogy, Petrology, Volcanology, Electron Microprobe Analysis and Imaging, Natural Sciences Seminar

Laboratory Courses: Physical Geology Laboratory, Mineralogy, Optical Mineralogy, Petrology, Field Methods, Volcanology, Electron Microprobe Analysis and Imaging,

OTHER Courses: Co-taught summer field course on Geology of Mauna Kea, Coordinator and Instructor for a UHH-CSAV volcanoes symposium for K-12 grade teachers on Kauai. Co-coordinator for teacher re-certification courses offered through the Denver Museum of Natural History and the Colorado School of Mines.

RELEVANT PUBLICATIONS

1. Kauahikaua, Jim , Cashman, Katharine V., Mattox, Tari N., Heliker, Christina, Hon, Ken A., Mangan, Margaret T., Thornber, Carl R., 1998, "Observations on basaltic lava streams in tubes from Kilauea Volcanic, Island of Hawai'i*,"* Journal of Geophysical Research, B, Solid Earth and Planets, 103 (11), p. 27,303-27,323.

2. Reynolds, J., Clague, D., Hon, K. Dixon, J. and , 2001, "Observations on the Origin of Submarine Volcanic Cone Morphologies in Hawai`i." Transactions of the American Geophysical Union (EOS), Fall 2001 Meeting, 1 p.

3. Kauahikaua, Jim, Sherrod, D. R., Cashman, K. V., Heliker, Christina, Hon, Ken, Mattox, T. N., and Johnson, J. A., 2003, "Hawaiian Lava–Flow Dynamics During the Pu‘u Oo–K_paianaha Eruption: A Tale of Two Decades:" in, Heliker, C., Swanson, D. A., and Takahashi, T. J., The Pu‘u ‘_‘_ – Kupaianha Eruptioin of Kilauea Volcano, Hawai‘i: The First 20 Years, U.S. Geological Survey Professional Paper 1676, p.63–88

4. Helz, R. T., Heliker, Christina, Hon, Ken and Mangan, Margaret, 2003, Thermal "Efficiency of Lava Tubes in the Pu‘u Oo–K_paianaha Eruption": in, Heliker, C., Swanson, D. A., and Takahashi, T. J., The Pu‘u ‘_‘_ – Kupaianha Eruption of Kilauea Volcano, Hawai‘i: The First 20 Years, U.S. Geological Survey Professional Paper 1676, p.105–120

5. Hon, Ken, Gansecki, Cheryl, and Kauahikaua, Jim, 2003, "The Transition from ‘A‘_ to P_hoehoe Crust on Flows Emplaced During the Pu‘u ‘_‘_ – K_paianaha Eruption": in, Heliker, C., Swanson, D. A., and Takahashi, T. J., The Pu‘u ‘_‘_ – Kupaianha Eruption of Kilauea Volcano, Hawai‘i: The First 20 Years, U.S. Geological Survey Professional Paper 1676, p. 89–104

6. Hon, Ken, Gansecki, Cheryl, and Kauahikaua, Jim, 2003, "The Transition from ‘A‘_ to P_hoehoe Crust on Flows Emplaced During the Pu‘u ‘_‘_ – K_paianaha Eruption": in Proceeding of Cities on Volcanoes 3, University of Hawai‘i, [abs].

7. D.A.,Clague, B. Cousens, A. Davis, J. Dixon, K. Hon, J. Moore, J. Reynolds, 2003, "Submarine Rejuvenated-Stage Lavas Offshore Molokai, Oahu, Kauai, and Niihau, Hawai‘i:" Transactions of the American Geophysical Union (EOS), Fall 2003 Meeting, 1 p. [abs.]

8. Hon, Ken, Gansecki, Cheryl, and Kauahikaua, Jim, 2004, "Electron Microprobe Investigations of Partial Melting and Crystallization in Hawaiian Lava Tubes: Evidence for Thermal Erosion and the Role of High Oxygen Fugacity": Transactions of the American Geophysical Union (EOS), v.85, no. 28, July 2004 Western Pacific Geophysics Meeting, p. 174 [abs.]

9. Hon, Ken, 2005, “Deciphering Hawaiian Magma Chambers Using Electron Microprobe Analyses”: in Price et al. (ed.), Proceedings Microscopy and Microanalysis 2005: Microscopy and Microanalysis, v. 11, Supplement 2, p. 188-189.

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.

Mark Henley

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EXPERIENCE

The Boeing Company (+ former Rockwell Space Systems Division) 1994-2006

Managed In-Space Cryogenic Propellant Depot architecture/system study
Co-Investigator on JPL All Terrain Hex-Legged Extra Terrestrial Explorer robot
Led assessment of lunar and Mars nuclear power system applications for JPL
- Assessed infrastructure, 1 km power transmission & day-night effects

Managed advanced technology contracts for NASA Space Solar Power program
- Organized inter-related Boeing activities (Seattle, California, Huntsville)
- Developed and demonstrated of new technology (MSFC & GRC)
- Studied advanced power systems & architectures (MSFC & JPL)
- Wrote Power Relay Satellite white paper for Congressman Rohrabacher

Managed multi-national project on satellite to be based at the Space Station
- German "Inspector" satellite with US transportation and Russian interfaces

Led cryogenic upper stage design for USAF Evolved Expendable Launch Vehicle
Led internal research for potential commercialization of Ukrainian space systems
- Launch systems (Zenit, Cyclone, Soyuz; Fregat, ICBMs) and satellites

General Dynamics Space Systems Division 1983-1993

Assessed advanced Atlas & Titan-Centaur applications
- Studied launches of Soyuz capsule, lunar landers, ISS payloads, etc.

Developed commercial missions on Atlas expendable launch vehicles
- Led technical proposal for first Atlas IIAS launch sold to NASA

Planned strategy for Atlas expendable launch vehicle commercialization
- Ghost writer for General Manager's weekly reports to Corporation

Designed, developed, tested and evaluated space flight hardware
- Qualified new components for propulsion, pressurization, and range safety
- Tested flight hardware in cryogenic liquid hydrogen and nitrogen

Performed numerous conceptual studies and planned technology development

Scripps Institution of Oceanography: Calif. Space Inst./Hydraulics Lab. 1978-1983

Analyzed Space Shuttle External Tank and radiation shielding in orbit
Developed Fleishmann Flow Channel (fluid dynamics research facility)
Operated mainframe computer for near-shore sediment transport studies

EDUCATION

Master of Science in Aerospace Engineering, UC San Diego, 1988
Thesis on advanced technologies for Earth-Moon transportation

Bachelor of Arts in Physics and Earth Science, UC San Diego, 1982
Minor in "Frontiers of Science"

AFFILIATIONS

International Astronautical Federation (IAF) Space Power Committee
Japan-US Science, Technology, Space Applications Program (JUSTSAP)
Outstanding Service Award for "exceptional, sustained contributions toward advancing international dialogue & collaboration"

PUBLICATIONS

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

2. 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

3. Boeing (Henley), 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

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

5. 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

6. M. Henley, M. Skinner, J. Fikes, J. Howell, J. Rosenberg; M. Cross, T. Nagao, G. O'Mahony, K. Ota, E. Verner, L. Hardaway; B. Anderson, A. Arsenault, S. Beck, N. Kanizay, D. Matthews, Laser-Photovoltaic Wireless Power Transmission, Air Force Maui Optical & Supercomputing Conference, Wailea, HI, 16 September, 2003.

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

8. Seth D. Potter, Mark W. Henley, and James A. McClanahan The Power Plug: A Near-Term Space Solar Power Concept, Space 2000 Conference, Long Beach, CA, Sept., 2000

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.