

PISCES : A “Stepping Stone” to International Space Exploration and Development

Mr. Joe T. Howell

National Aeronautics and Space Administration (NASA)/Marshall Space Flight Center,
Huntsville, Alabama, United States, joe.howell@nasa.gov

Mr. Mark Henley

The Boeing Company, Huntington Beach, California, United States,
mark.w.henley@boeing.com

Mr. Frank Schowengerdt

Affiliate Professor of Physics and Astronomy and Director of PISCES
University of Hawaii at Hilo
schoweng@hawaii.edu

ABSTRACT

The Pacific International Space Center for Exploration Systems (PISCES) was initiated by the Japan/US Science, Technology and Space Application Programs (JUSTSAP) to advance research and education in space exploration technology and systems working closely with the State of Hawaii. Hawaii has a heritage with space exploration including the training of Apollo astronauts and testing of lunar rover systems in some of the most realistic terrestrial sites available. The high altitude dry environment with greater solar insolation, and the dry lunar regolith-like volcanic ash and cratered terrain make Hawaiian sites ideal to support international space exploration technology development, demonstration, education and training.

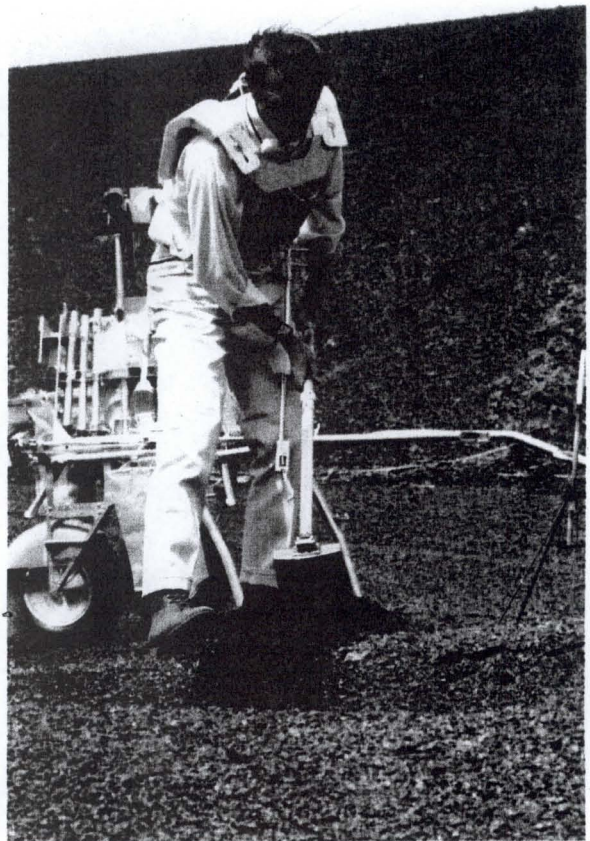
This paper will summarize development and roles of PISCES in lunar surface analogs, simulations, technology demonstrations, research and training for space exploration technology and systems.

INTRODUCTION AND BACKGROUND

Realizing the need to support advanced development for the Vision for Space Exploration the Pacific International Space Center for Exploration Systems (PISCES) was initiated by the Japan/US Science, Technology and Space Application Programs (JUSTSAP) to advance research and education in space exploration technology and systems working closely with the State of Hawaii. JUSTSAP is a bi-lateral organization founded to foster cooperation between the US and Japan in space research and applications. Hawaii has a heritage with space exploration including the training of Apollo astronauts and testing of lunar rover systems in some of the most realistic terrestrial sites available. The high altitude dry environment with greater solar radiation intensity, the lunar regolith-like volcanic ash and the location make Hawaiian sites ideal to support international space exploration technology development, demonstration, education and training.

Initial capabilities will include a test range for demonstration of robotic exploration systems on Hawaiian volcanic terrain. Subsequent capabilities will include a simulated human outpost, long duration technology test beds, a high vacuum facility, research and educational components. PISCES will be supported initially by the State of Hawaii, but is intended to become self-supporting as its user community grows.

During Apollo, astronauts were trained there and regarded the area as the most lunar-like that they had observed. High elevations, dry weather conditions and availability of lunar regolith-like deposits of volcanic ash contribute to the similitude. The sites are easily accessible and can be afforded services by the near-by Hilo area and by the University of Hawaii campus at Hilo. Noting these possibilities, the Japan-U. S. Space Technology and Applications Program (JUSTSAP) recommended in 2006 that a



Apollo Astronaut Alan Shepard training on the Big Island of Hawaii



The Big Island of Hawaii

simulation facility be constructed that could be utilized by space agencies, industry and academic personnel to test and demonstrate exploration systems.

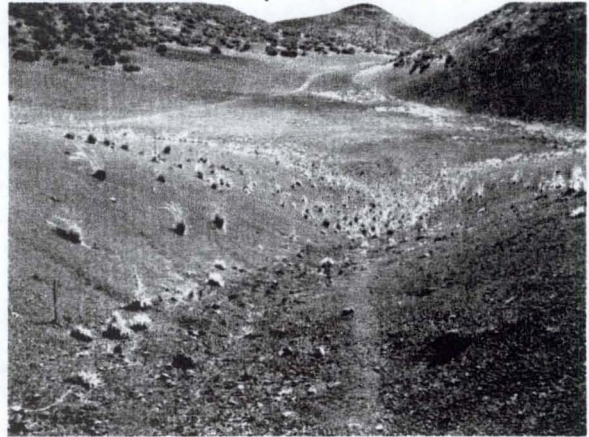
JUSTSAP emphasized the potential benefits of a Hawaiian facility for U. S. and Japan cooperation in space exploration. PISCES will be supported by the State of Hawaii and expected to have initial funding in the summer of 2007. The program will be a part of the State's efforts to build its technical and scientific capabilities associated with advanced technology and space exploration. In 2006, PISCES received a unanimous resolution of support from the Hawaii State Legislature.

In the summer of 2007 PISCES did receive initial authorization from the State of Hawaii.

PLAN AND SCOPE

PISCES will eventually feature a fully simulated lunar outpost on the Big Island of Hawaii as part of a complex for research and development of new technologies to enable long-term stays on the Moon and other extra-terrestrial bodies. Initial simulations of robotic field experiments could take place in the 2007-2008 time frame. In time, PISCES will have unique capabilities in *In-Situ* Resource Utilization (ISRU), including fully equipped laboratory facilities, pilot-scale testing on fine volcanic ash, and field areas in the moon-like setting of the Big Island volcanoes. The Center will provide an unparalleled opportunity for ISRU research and development in partnerships between industry, academia and government in both the US and Japan. Scientists and engineers will be able to move new technologies rapidly from the laboratory out into one of the highest-fidelity lunar simulation environments on Earth. Other capabilities of PISCES will include robot testing on lunar-like terrain, astronaut training in areas where the Apollo astronauts trained, and educational outreach through the auspices of the

University of Hawaii and other participating universities. A distinguishing feature of PISCES will be the promotion of



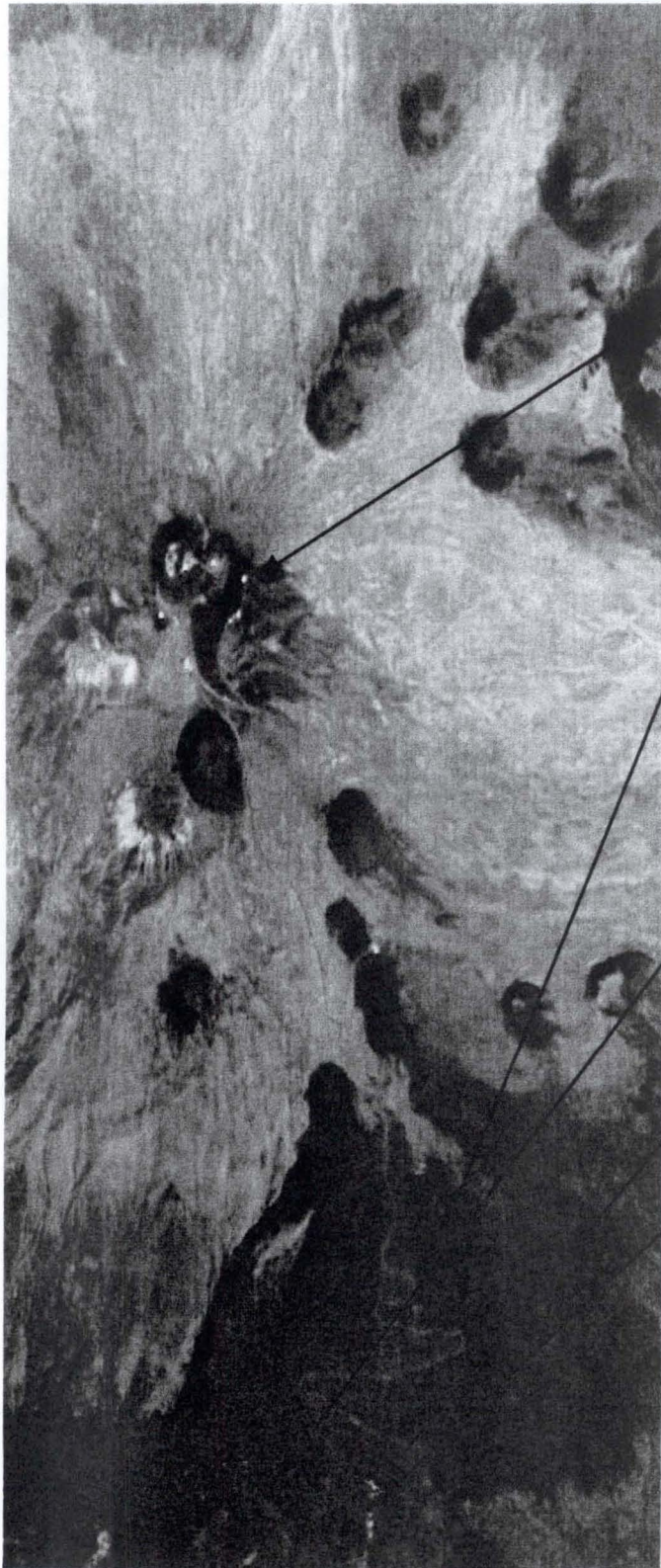
Thick deposits of volcanic ash on Hawaii's "Big Island" could simulate lunar regolith

collaborative research and education in space exploration. PISCES will be a user facility for groups located primarily in the US and Japan. A PISCES ISRU user group has currently been formed.

LOCATION

The program of PISCES is intended to be broad, including simulation, technology demonstration, research, and education. The facility will be a distributed one, in which the simulation facilities will be a principal component. A primary, permanent location could be selected within the next year, following a survey of available locations on the flanks of Mauna Loa and Mauna Kea and appropriate coordination with the local community with regard to environmental issues and Hawaiian cultural matters. Initial robotic field experiments may take place at temporary sites before selection of a permanent PISCES location. Funding for the procurement of capital equipment will be sought from private sources.

Example Analog and Simulation Sites near Mauna Kea on the Big Island of Hawaii



Mauna Kea
Observatories
(13,800 ft)

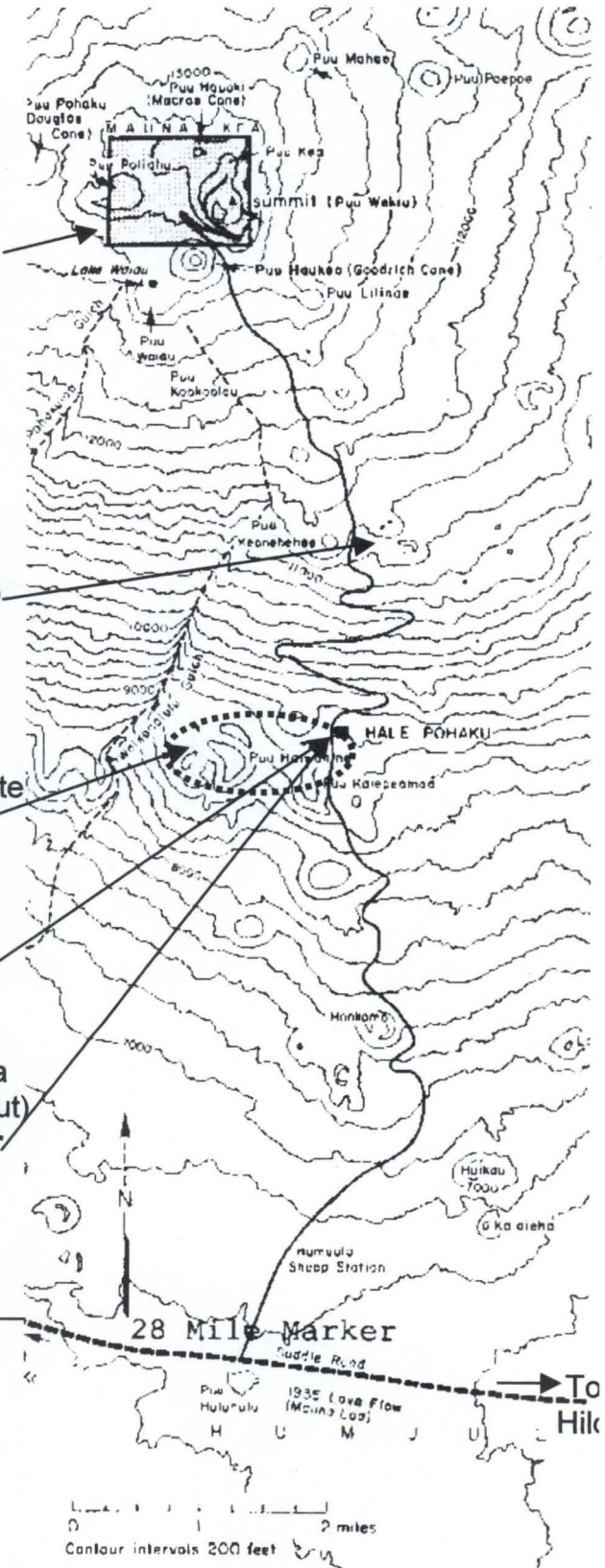
Example Area
Used for Apollo
"Moon Valley"
(11,000 ft)

Example Moderate
Altitude
Area
(9,000 ft)

"Hale Pohaku"
Hotel

Ellison Onizuka
(Shuttle Astronaut)
Visitor Center

Saddle Road
To Kona
& Waimea

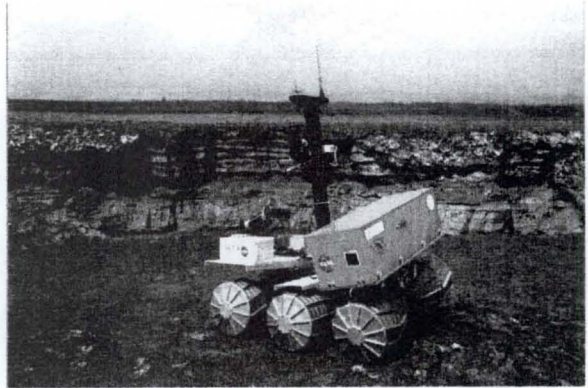


SIMULATION CAPABILITIES

For robotic field simulations, a location will be selected that will allow equipment to be tested over 1 kilometers in range and on slopes of 20-30 degrees, including small craters. Infrastructure capabilities will include solar power and communications links. Investigators will be expected to provide their own documentation equipment. Over the first three years of PISCES buildup, a simulated lunar outpost will be designed and implemented. The outpost will include lunar habitats, life support, power, communications, ISRU processing, and other principal systems of an early lunar outpost. An initial facility may be sized for 6 crewmembers; as funding allows, and additional facilities may be added in time to represent a full lunar base.

EDUCATION

One of PISCES' programmatic objectives is education at all levels. PISCES plans to support the exploration and settlement of space through research and education directed toward the development of technologies needed to sustain human life on extraterrestrial bodies. This will be achieved through the Center established at UH-Hilo, with field locations to be determined on the Big Island. UH-Hilo faculty, students, affiliated personnel and resident and visiting staff of the Center will work toward the development of a simulated lunar outpost 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. The Center will function in two general ways. First, it will conduct its own research, develop its own educational programs and provide opportunities for students of UH-Hilo and the broader community. Second, it will serve as a venue for research and educational outreach conducted by visiting personnel,



NASA, the University of Hawaii, and Boeing have already demonstrated benefits of using Hawaii's volcanic terrain in Hawaii for robotic field experiments

and institutions whose presence will enhance the already-growing programs at UH-Hilo. Visitors will bring with them both financial and intellectual capital that will contribute both to UH-Hilo and to the continuation of PISCES as a viable entity. Hawaiian school children will be introduced to space exploration through observation of field experiments and crew simulations. Undergraduate and graduate science and engineering students can take advantage of PISCES' student design competition to define the characteristics of a lunar outpost and its terrestrial simulation. For more details see the PISCES web site (<http://www.pisces.hilo.hawaii.edu>).

PISCES will extend developing curriculum at UH-Hilo in Astronomy, Geology and related education programs in preparation for the coming era of space exploration and settlement. It will provide funding for students and faculty to carry out research and to participate in educational programs relevant to the purposes of PISCES. These research and education programs will strengthen the Science, Technology, Engineering and Mathematics (STEM) programs at UH-Hilo. They will inspire students, including students of Hawaiian and Pacific Island ancestry, to enter the STEM disciplines through the excitement of

being a part of the movement of humankind into space on a permanent basis. With the concurrence of the relevant faculty and administrative bodies, a new program in Space Exploration Technology will become available to the UH-Hilo curriculum, which will build upon existing courses in the Departments of Physics and Astronomy, Geology and Geography. Participants from the U.S. and around the World, will come to the Big Island to work on PISCES projects, will help teach UH-Hilo students and act as role models. Undergraduates will be employed as interns in PISCES.

CONCLUSION

By 2011, a fully developed PISCES human outpost simulation facility will be available, in time to develop capabilities for the Vision for Space Exploration's projects planned for the mid to late 2010's. This vigorous program of simulation and education for lunar outpost operations, both on the Moon and on Earth, will become a centerpiece of the Pacific International Space Center for Exploration Systems (PISCES).

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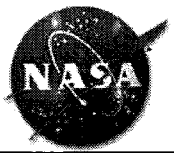
PISCES : A “Stepping Stone” to International Space Exploration and Development

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**Presented by: Joe Howell
NASA, Marshall Space Flight Center**

**Co-Author: Mark Henley
The Boeing Company, Huntington Beach, California**

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- ◆ **Introduction and Background**
- ◆ **Plan and Scope**
- ◆ **Location**
- ◆ **Simulation Capabilities**
- ◆ **Education**
- ◆ **Conclusion**

PISCES Introduction and Background



- ◆ **Apollo astronauts trained and regarded the area as the most lunar-like; also, tested the lunar rover systems in the lunar regolith-like volcanic ash**
- ◆ **Japan/US Science, Technology and Space Application Program (JUSTSAP) realized the need to support advanced development for the Vision for Space Exploration and initiated the Pacific International Space Center for Exploration Systems (PISCES)**
- ◆ **Initial capabilities will include a test range for demonstration of robotic exploration systems on Hawaiian volcanic terrain. Subsequent capabilities will include a simulated human outpost, long duration technology test beds, a high vacuum facility, research and educational components**

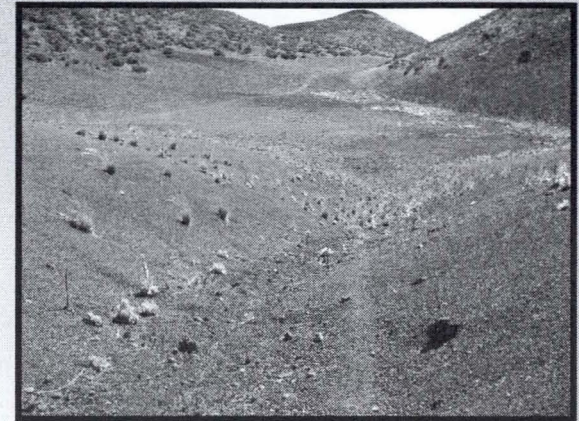


The basic goal: utilize some of the most realistic terrestrial sites available with high altitude dry environment, greater solar radiation intensity, lunar regolith-like volcanic ash, etc., to support international space exploration technology development, demonstration, training and education.

PISCES Plan and Scope



- ◆ Initial simulations of robotic field experiments could take place as early as the 2007-2008 time frame.
- ◆ In time, PISCES will have unique capabilities in *In-Situ* Resource Utilization (ISRU), including fully equipped laboratory facilities, pilot-scale testing on fine volcanic ash, and field areas in the moon-like setting of the Big Island volcanoes.
- ◆ Scientists and engineers will be able to move new technologies rapidly from the laboratory out into one of the highest-fidelity lunar simulation environments on Earth.
- ◆ Other capabilities of PISCES will include robot testing on lunar-like terrain, astronaut training in areas where the Apollo astronauts trained, and educational outreach through the auspices of the University of Hawaii and other participating universities. A distinguishing feature of PISCES will be the promotion of collaborative research and education in space exploration.
- ◆ PISCES will eventually feature a fully simulated lunar outpost on the Big Island of Hawaii as part of a complex for research and development of new technologies to enable long-term stays on the Moon and other extra-terrestrial bodies.



Thick deposits of volcanic ash on Hawaii's "Big Island" could simulate lunar regolith

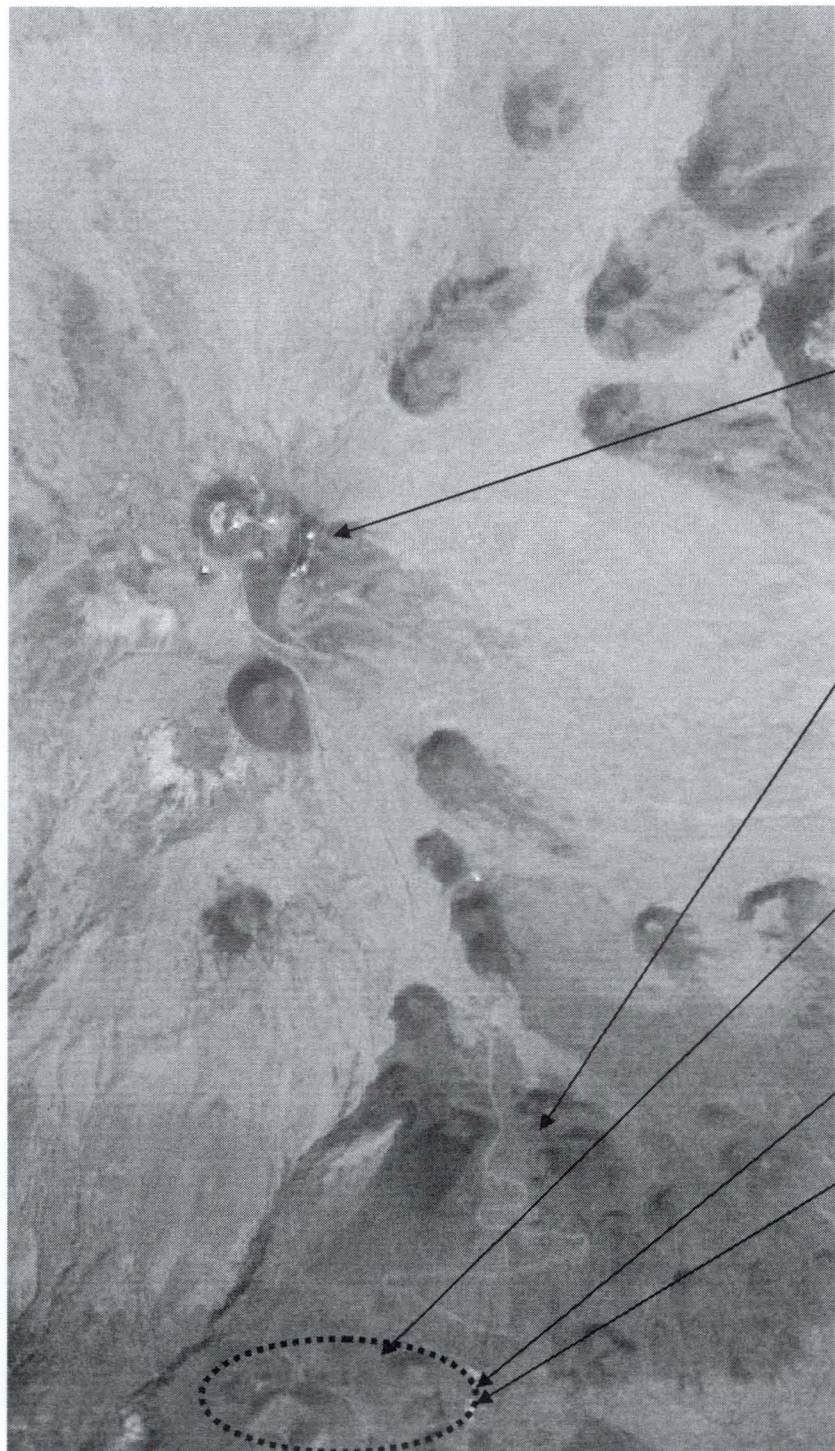


The Big Island of Hawaii

PISCES Location



- ◆ **PISCES is intended to be broad, including simulation, technology demonstration, research, and education.**
- ◆ **The facility will be a distributed one, in which the simulation facilities will be a principal component.**
- ◆ **A primary, permanent location could be selected within the next year, following a survey of available locations on the flanks of Mauna Loa and Mauna Kea and appropriate coordination with the local community with regard to environmental issues and Hawaiian cultural matters.**
- ◆ **Initial robotic field experiments may take place at temporary sites before selection of a permanent PISCES location.**
- ◆ **PISCES potential example analog and simulation sites near Mauna Kea on the Big Island of Hawaii are depicted on the following slide**



Mauna Kea Observatories
(13,800 ft)

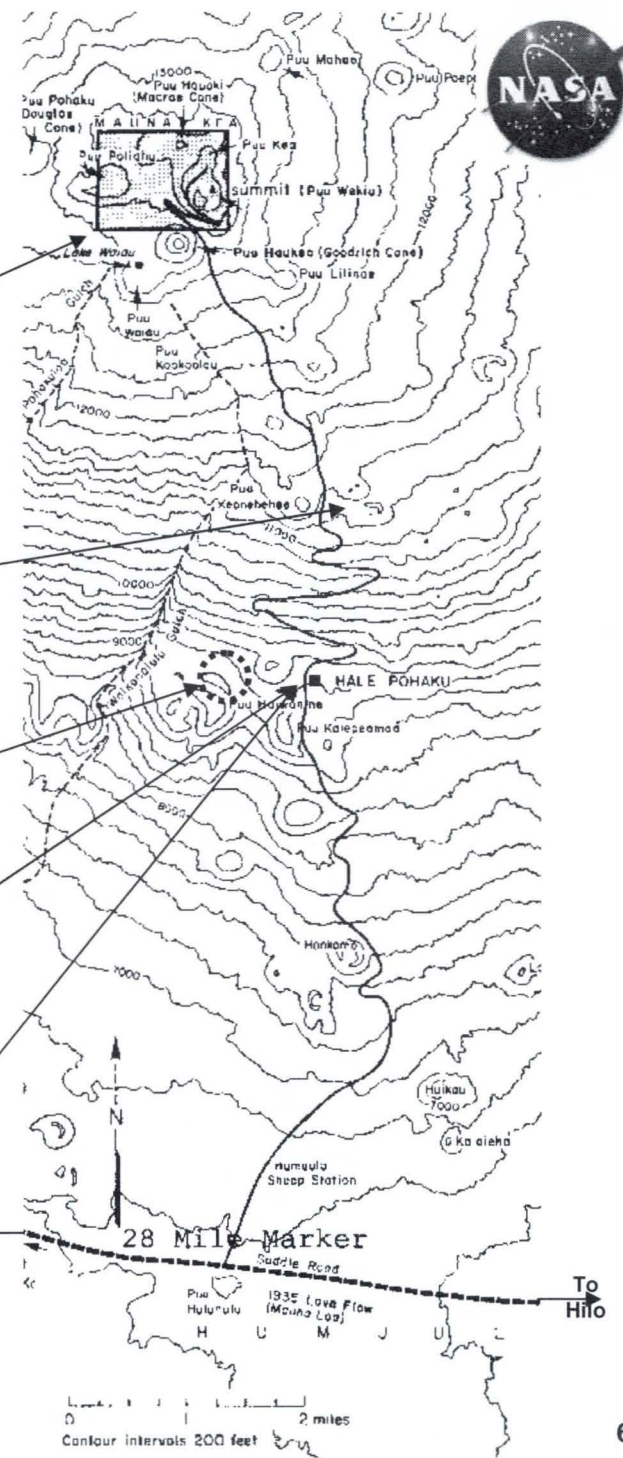
Area of Apollo "Moon Valley"
(11,000 ft)

Candidate Area for "PISCES"
(9,000 ft)

"Hale Pohaku"
Hotel

Onizuka
Visitor Center

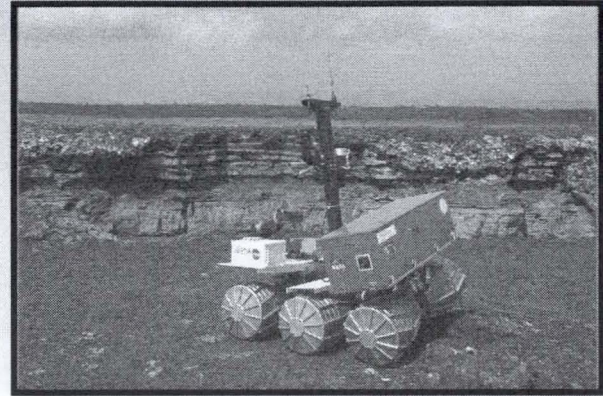
Saddle Road
To Kona
& Waimea



PISCES Simulation Capabilities



- ◆ **A location will be selected for robotic field simulations that will allow equipment to be tested over 1 kilometers in range and on slopes of 20-30 degrees, including small craters.**
- ◆ **Infrastructure capabilities will include solar power and communications links. Investigators will be expected to provide their own documentation equipment.**
- ◆ **Over the first three years of PISCES buildup, a simulated lunar outpost will be designed and implemented. The outpost will include lunar habitats, life support, power, communications, ISRU processing, and other principal systems of an early lunar outpost.**
- ◆ **An initial facility may be sized for 6 crewmembers and additional facilities may be added in time to represent a full lunar base.**



NASA, the University of Hawaii, and Boeing have already demonstrated benefits of using Hawaii's volcanic terrain in Hawaii for robotic field experiments



- ◆ **One of PISCES' programmatic objectives is education at all levels.**
- ◆ **PISCES plans to support the exploration and settlement of space through research and education directed toward the development of technologies needed to sustain human life on extraterrestrial bodies through the Center established at UH-Hilo, with field locations to be determined on the Big Island.**
- ◆ **UH-Hilo faculty, students, affiliated personnel and resident and visiting staff of the Center will work toward the development of a simulated lunar outpost 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.**
- ◆ **The Center will conduct its own research, develop its own educational programs and provide opportunities for students of UH-Hilo and the broader community. Second, it will serve as a venue for research and educational outreach conducted by visiting personnel, and institutions whose presence will enhance the already-growing programs at UH-Hilo.**
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Conclusion



- ◆ **By 2011, a fully developed PISCES human outpost simulation facility will be available, in time to develop capabilities for the Vision for Space Exploration's projects planned for the mid to late 2010's.**
- ◆ **The vigorous program of simulation and education for lunar outpost operations will become a centerpiece of the Pacific International Space Center for Exploration Systems (PISCES).**
- ◆ **For more information, see the PISCES web site (<http://www.pisces.hilo.hawaii.edu>).**