



New Horizons

Developing Space Technology and Applying it on Earth

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PISCES

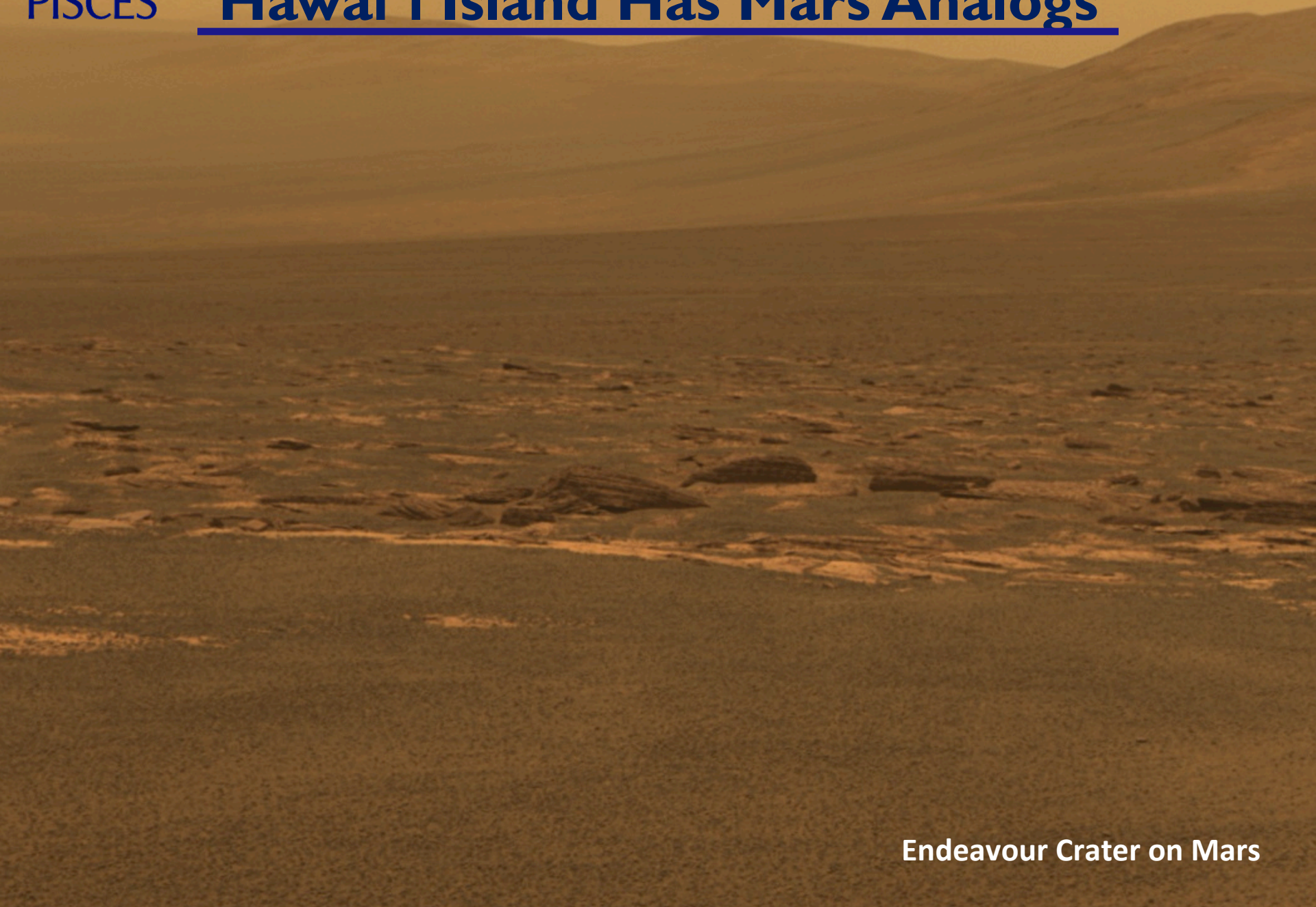
Pacific International Space Center for Exploration Systems

- Conceived by the Japan-U.S. Science, Technology & Space Applications Program (JUSTSAP)
- Formed in 2007 by the Hawaii State Legislature
- 2008, International analog field test with participants from NASA (GRC, JSC, KSC, ARC, JPL), CSA, Norcat, Neptec, Lockheed-Martin, Ontario Drive Gear, EVC, Michelin, CMU, UHM, UHH
- 2010, International analog field test with participants from NASA, CSA, NORCAT, Ontario Drive Gear, EVC, Honeybee Robotics, Orbitec, PSI, Neptec, UHH, UHM and others.
- 2012, 3rd International analog field test for RESOLVE and MMAMA

Why Hawai`i?

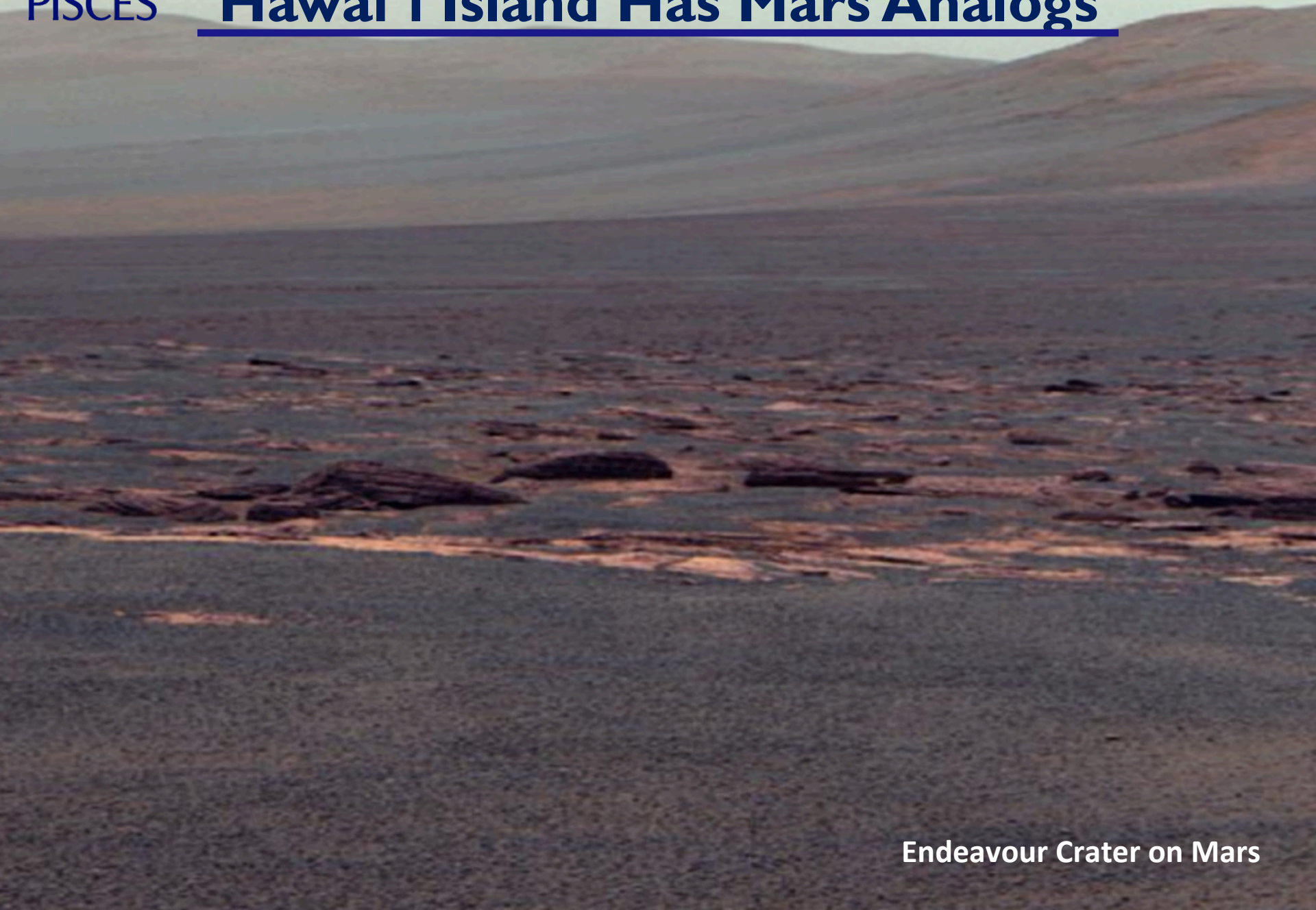


Hawai`i Island Has Mars Analogs



Endeavour Crater on Mars

Hawai`i Island Has Mars Analogs



Endeavour Crater on Mars

Hawai`i Island Has Mars Analogs



Apollo Valley in Hawai`i

...And Lunar Analogs



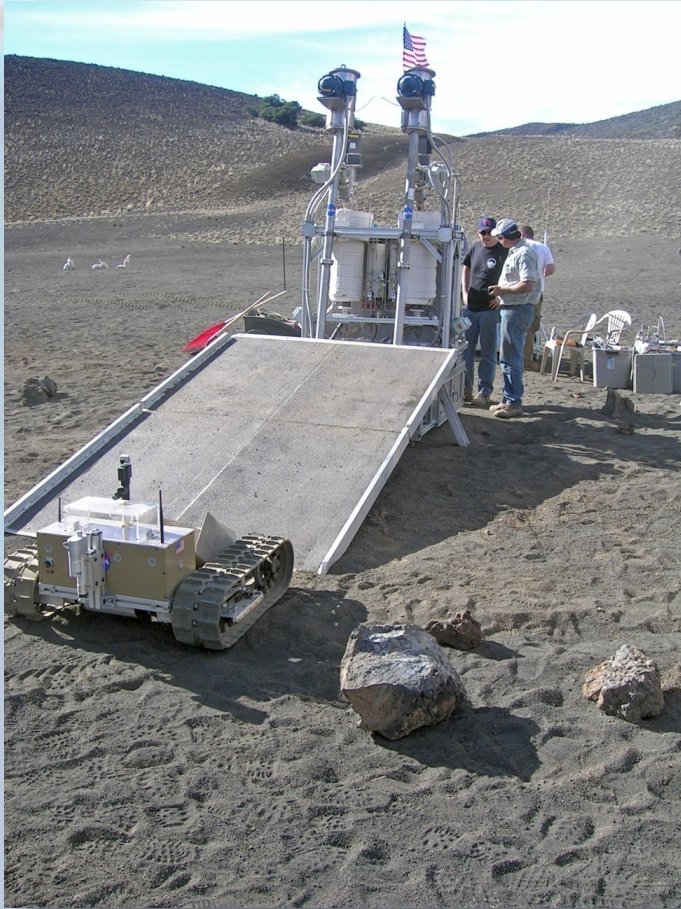
Successes in Hawai'i

Prospecting, Mining, Excavation and Site Preparation



Successes in Hawai'i

Regolith Processing



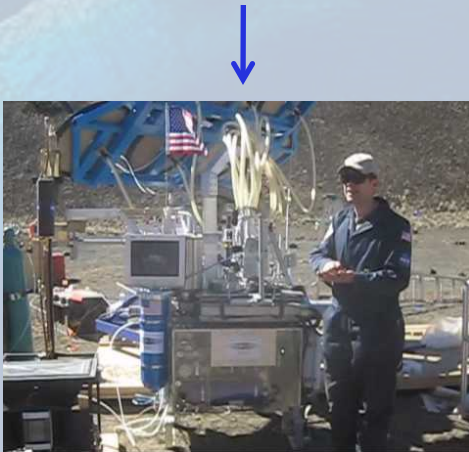
Successes in Hawai'i



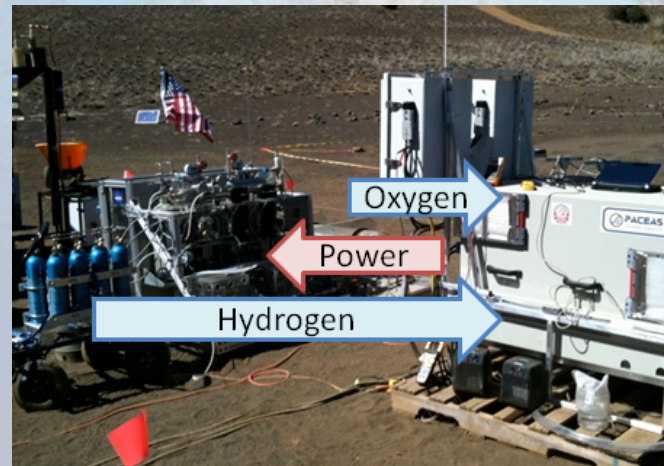
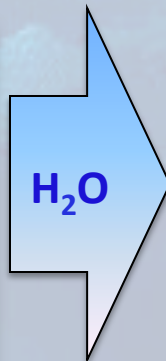
Solar Concentrator



Sintering



Extraction



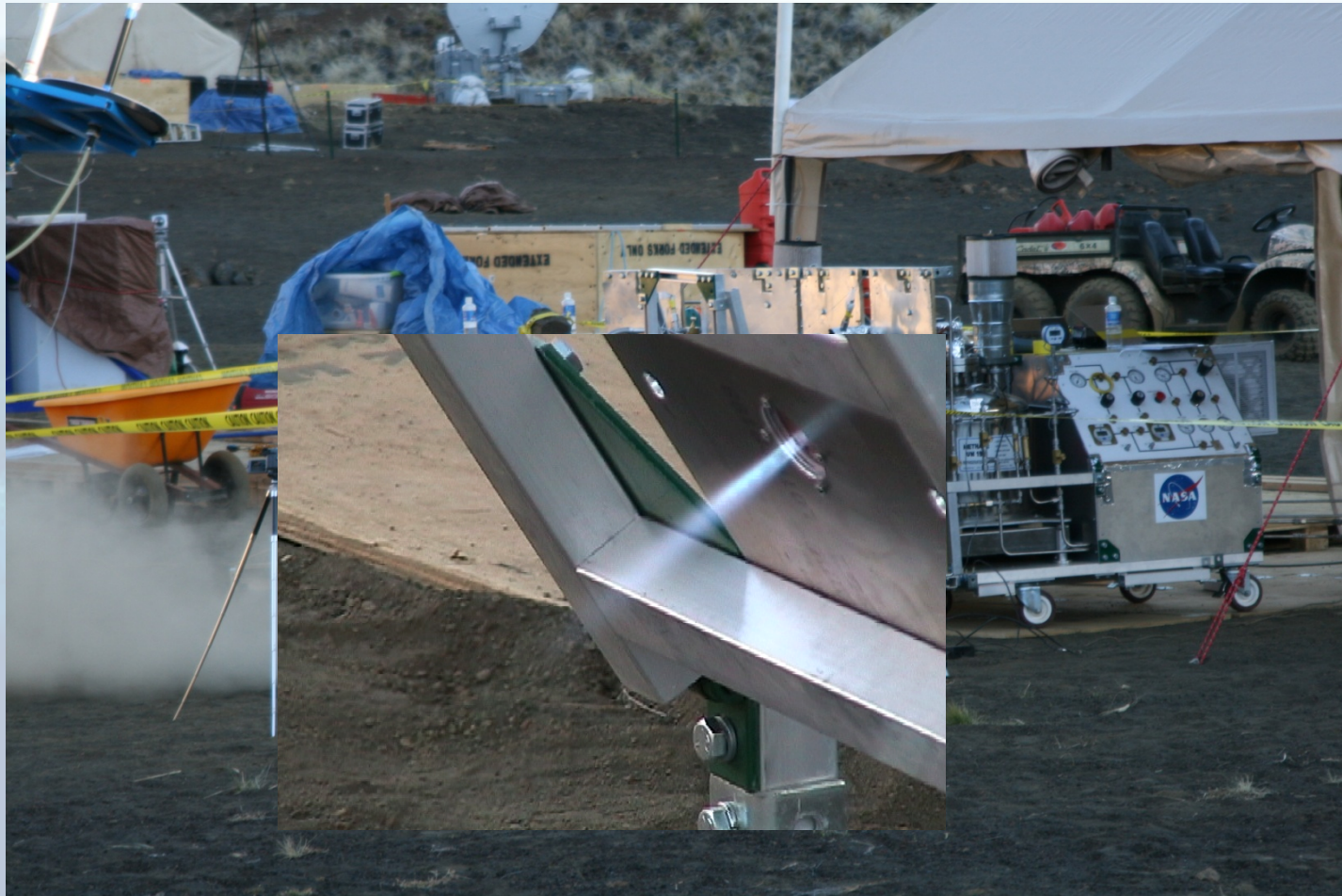
Electrolysis & Fuel Cell

Cryogenics Cart



Successes in Hawai'i

Dust to Thrust



Hilo Hawaii's Unique Properties

- Location
 - Pacific centrality makes it great for international collaboration
 - Year-round testing capability
- Terrain
 - Geologic, chemical, and morphologic analogs to the Moon and Mars
 - Sites of interest all within 1 hour of Hilo
 - Multiple sites with various size distributions of tephra
 - Lava tubes
- PISCES
 - Past successes with NASA, DLR, CSA, Lockheed, Orbitec, Honeybee Robotics, NORCAT, ODG, EVC, PSI, Michelin, Orbitec, and many others
- Transportation
 - Deepwater port in Hilo (depth can accommodate cruise and container ships)
 - Hilo International Airport (capacity for 747s, C-130s...air guard base)
 - Both Hilo facilities have underutilized infrastructure (can accommodate rapid growth with minimal, if any, capital improvements)
- High concentration of international scientific organizations
 - Astronomical Observatories (SMA, TMT, CSO, Gemini, JAC (JCMT/UKIRT), Subaru, UH88, Keck, CFHT, IRTF, VYSOS, AMOEBA (ASIAA), HAO ...)
 - Atmospheric Observatories (NOAA's MLO)
 - Geological (USGS' HVO),
 - Natural Energy lab

Core Technology

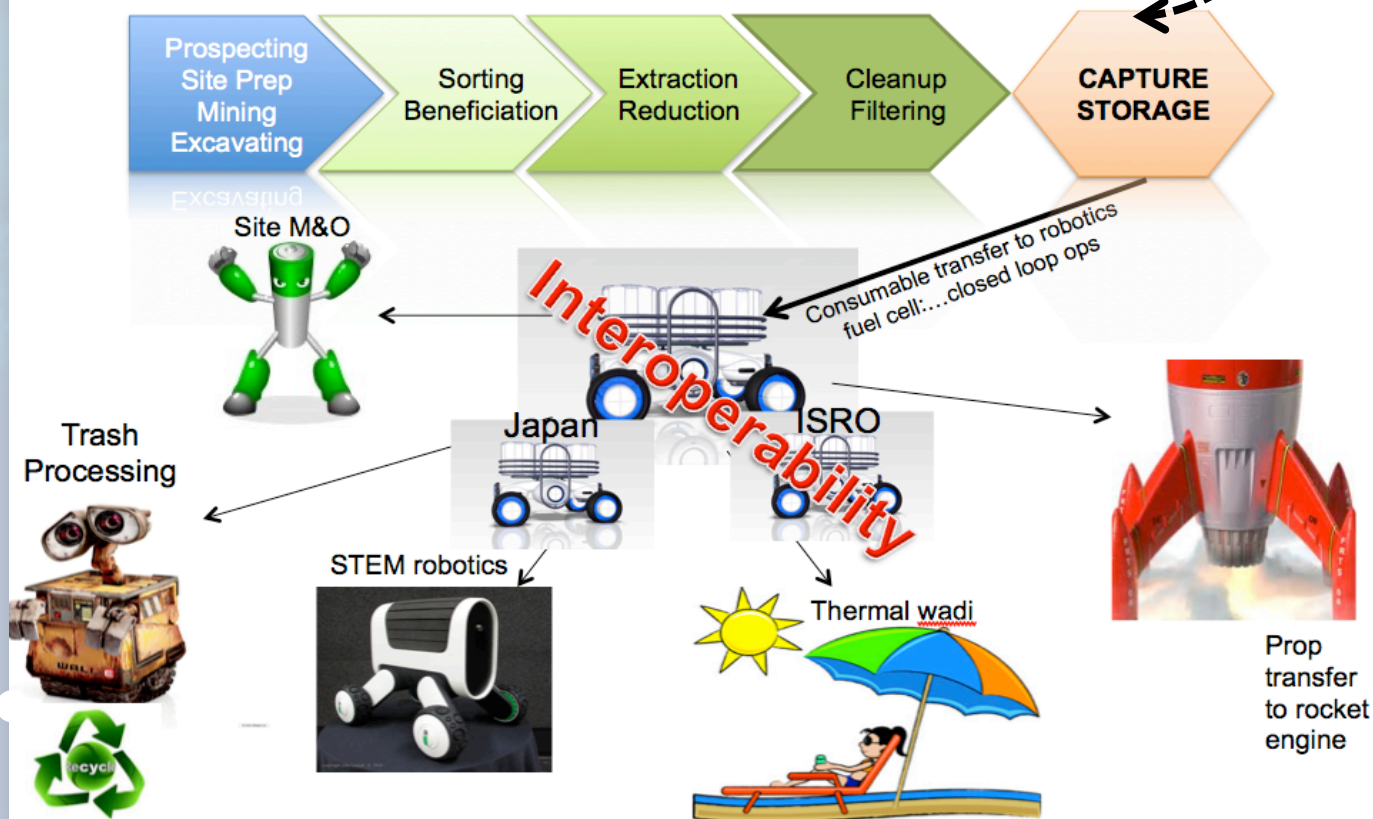
(User-Supplied)



Terrestrial Analogue Built Around ISRU

“DUST-TO-THRUST”

In Situ Resource Utilization



User-Supplied Core Technologies

ISRU-“Dust to Thrust”

- Prospecting/site prep (sintering, grading)
- Mining/excavation
- Processing
- Cryo
- Storage of product
- Propellant/consumable transfer
- Robotics
- STEM Education Interaction
- Robotic M&O
- Interoperability

Outer Ring Infrastructure Clusters

Permanent, Semi-Permanent, & Deployable

Permanent

- Base Facility
 - Located in the Research Park
 - Serves as hub for consortium
 - Standards for Interoperability
 - “Core Technology” Design, Control, & Implementation
 - Tele-operability control
 - Article repository
 - Staff and rental offices
 - Shared labs and storage

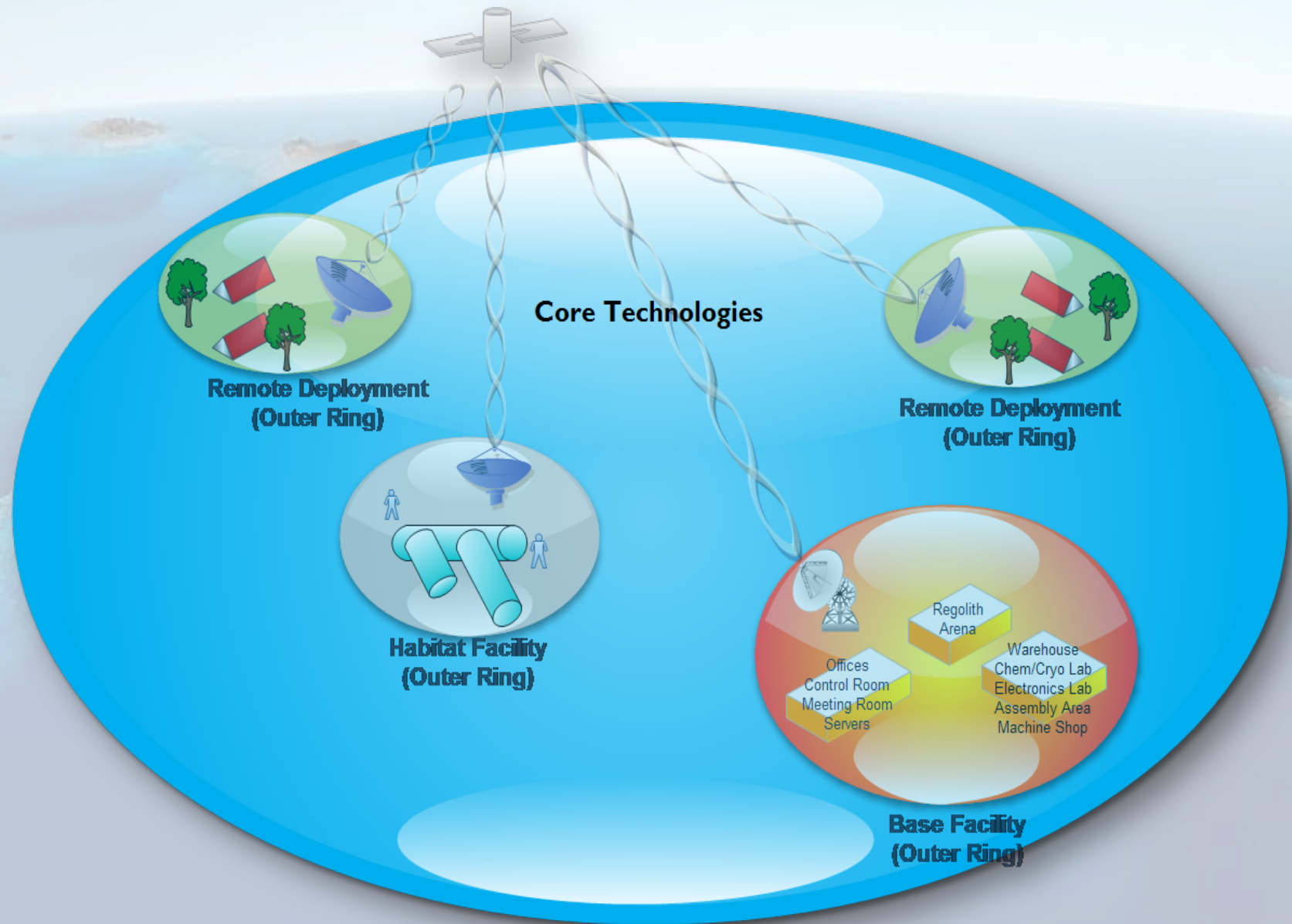
Semi-Permanent

- Habitat
 - 5+ year emplacement in the field
 - Network linked to BF
 - Satellite link in-situ
 - LAN where available

Deployable

- Remote Deployments
 - Deployed at remote sites that meet test criteria (enabling wider selection of parameters)
 - Equipment to support 2 or more concurrent deployments
 - Network linked to BF
 - Satellite link in-situ
 - LAN where available

PISCES-Provided “Outer Ring”



PISCES-Provided

“Outer Ring”

Infrastructure

- Machine Shop
- Electronics Lab
- Instrumentation Lab
- Assembly Facility
- Regolith Arena
- Control Room
- Cryo storage
- Chemistry Lab
- Warehousing
- Visitor Education Center
- AMES Regolith Bed

Equipment

- Dirty Thermal Vacuum
- Remote Field Testing Equipment
- Stake Truck
- R/T Forklift
- Bulldozer
- Regolith Crusher
- Regolith Screener

Personnel

- Director
- Deputy Director
- Operations Manager
- Research Specialist
- Field Manager
- 2 Field Technicians
- IT Technician
- Administrative Assistant
- Clerical
- ½ FTE Forklift/Dozer Operator
- Safety Officer
- EPO Officer

PISCES-Provided Support per Core Technology

Prospecting/Site Prep	Mining/Excavation	Processing	Cryo	Storage of product
<ul style="list-style-type: none"> •Regolith Arena •Remote Field Testing •Stake Truck •R/T Forklift •Bulldozer •Assembly Facility 	<ul style="list-style-type: none"> •Regolith Arena •Remote Field Testing •Stake Truck •R/T Forklift •Bulldozer •Assembly Facility 	<ul style="list-style-type: none"> •Regolith Crusher •Regolith Screener •Chemistry Lab •Instrumentation Lab •Assembly Facility •Regolith Arena •Bulldozer 	<ul style="list-style-type: none"> •Cryo storage •Chemistry Lab •Assembly Facility •Instrumentation Lab 	<ul style="list-style-type: none"> •Cryo storage •Chemistry Lab
Propellant/ Consumable Transfer	Robotics	STEM Education Interaction	Robotic M&O	Interoperability
<ul style="list-style-type: none"> •Cryo storage •Chemistry Lab •Instrumentation Lab •Assembly Facility 	<ul style="list-style-type: none"> •Regolith Arena •Machine Shop •Electronics Lab •Instrumentation Lab •Assembly Facility •Dirty Thermal Vacuum •Remote Field Testing 	<ul style="list-style-type: none"> •Visitor Education Center •AMES Regolith Bed 	<ul style="list-style-type: none"> •Regolith Arena •Remote Field Testing •Control Room •Instrumentation Lab •Electronics Lab 	<ul style="list-style-type: none"> •Regolith Arena •Machine Shop •Electronics Lab •Instrumentation Lab •Assembly Facility •Control Room

Economic Viability

- Move from “government-led” to an “economic-centered” model with broader opportunities
 - Space focused ISRU technologies that fulfill a terrestrial market demand.
 - Local applications (for State of Hawai`i buy-in)
 - Other corporate ROIs

Value Proposition Matrix

Element	PISCES	Society
Regolith processing	<ul style="list-style-type: none"> •Launch pads •3-D printing •Thermal “Wadi” •“Rocks to Blocks” 	<ul style="list-style-type: none"> •Bricks/ Architecture •Non-Asphalt roads •Cheaper and Faster Construction
Energy	<ul style="list-style-type: none"> •Use of renewable energy at site 	<ul style="list-style-type: none"> •Energy Sustainability •Energy Storage/Load Shift •Power Beaming •Improved Grid Management
Habitats	<ul style="list-style-type: none"> •Tele-medicine •Closed system test-bed •Crew Duration Studies 	<ul style="list-style-type: none"> •Tele-medicine •Tele-Science •“Off-grid” living
Education	<ul style="list-style-type: none"> •Strengthens STEM •Supports a “Labor Pipeline” •Increases Funding Streams •Increases International Involvement 	<ul style="list-style-type: none"> •Strengthens STEM education in •Workforce development •Expanded sphere of education •Countries with little or no space presence get a buy-in

Value Proposition Matrix

Element	PISCES	Society
Waste/Trash Processing	<ul style="list-style-type: none"> •Processing biowaste for energy, feedstock, etc. •Closing the cycle for waste 	<ul style="list-style-type: none"> •Reduced need for waste/trash storage •Improved Recycling •Trash and Waste Reclamation
Robotics	<ul style="list-style-type: none"> •Site Prep./Construction •Prospecting •Processing •Interoperability •Mobility & Operation 	<ul style="list-style-type: none"> •Increases in efficiencies across multiple sectors •“sexy” STEM gateway
Research Cluster	<ul style="list-style-type: none"> •Revenue stream •Synergistic Cooperation 	<ul style="list-style-type: none"> •Customer base for broadband •Broader local expertise •Public-Private partnerships
Communication	<ul style="list-style-type: none"> •Define protocols •Interoperability •Tele-presence 	<ul style="list-style-type: none"> •Tele-presence for rural areas •Adds customer-based demand for broadband

3 Year Build-Out With Ramping Up of Capabilities

Year 1

- Remote Deployment (field-site)
- Electronics/Instrumentation Lab
- Chemistry/Cryo Lab
- Assembly Area
- Field Habitat
- Leasable Office Space & Warehousing

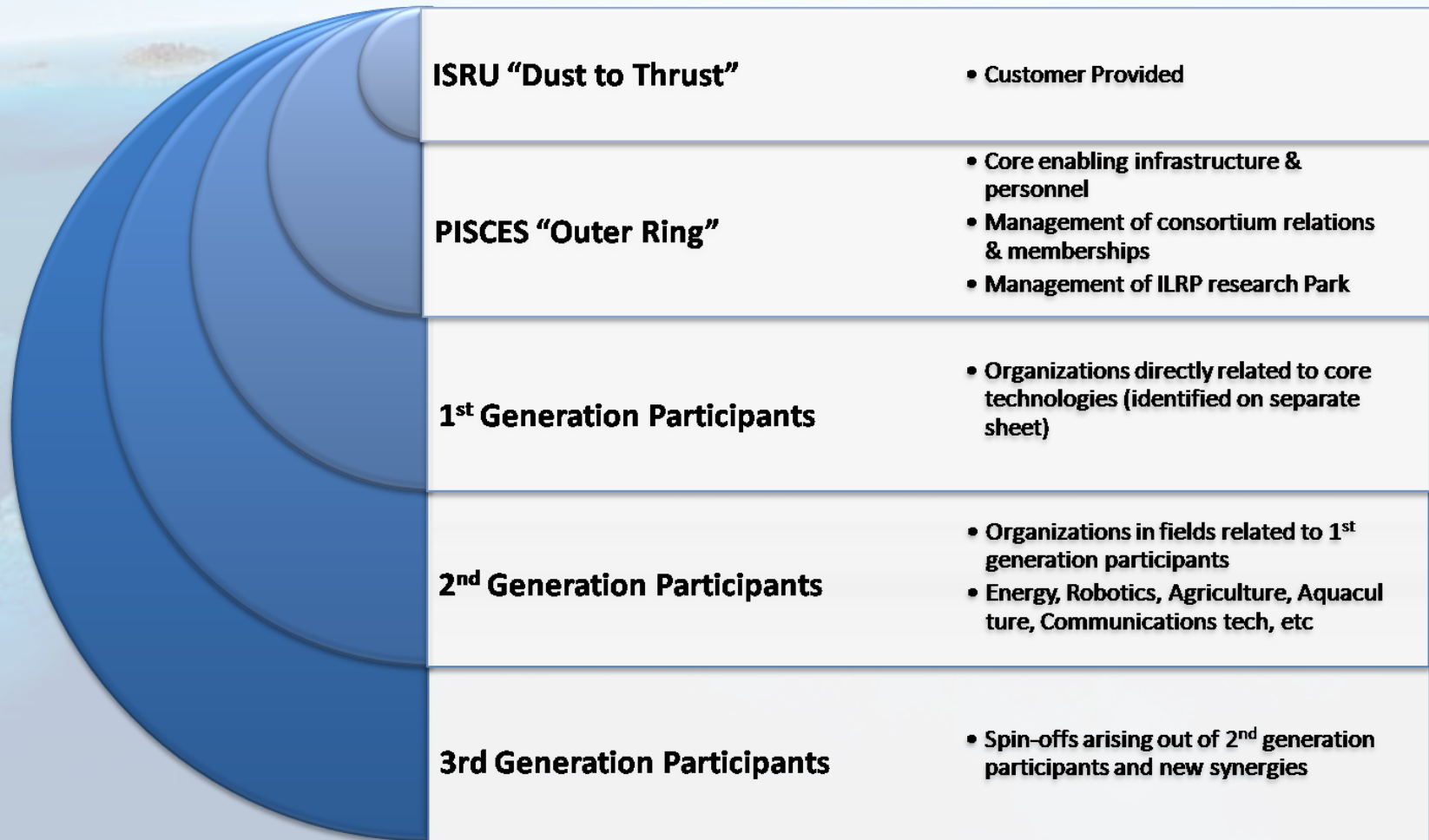
Year 2

- Interoperability testing (Base Facility)
- Limited Design, Control, & Implementation (Base Facility)
- M&O, Site Prep, & Mining Testing (Base Facility)
- Data Storage/Access for Consortium Members
- Situational awareness and control capabilities from base facility
- Dirty Thermal Vacuum Testing

Year 3

- Visitor Education Center
- Machine shop equipped and operational
- Large-Scale Regolith Screening
- On-Site Design, Control, & Implementation (Base Facility)
- Base facility and remote deployments “off the grid”
- Core need infrastructure finalized

From a Strong Foundation Comes Innovation



Location, Location, Location

- 485 acre general industry zone
- Enterprise Zoned
- Approximately 160 Acres Developed to Date
- 3rd Largest Industrial Park in the State
- Largest Private Industrial Park on the Island of Hawai'i
- Proximity to Airport/Port Infrastructures
 - Hilo International Airport (9 Miles)
 - Hilo Deep Water Port (9 Miles)
- Proximity to University of Hawai'i, Hilo



Limitations On PISCES

- MOUs, MOIs, Contracts must move through the University of Hawaii from campus level to system level.
 - ~1 year turnaround time
 - Not sufficiently reactive to pace of private sector
- CIP funding through the state must make it to the top of the campus CIP priorities, then to the top of the system CIP funds
 - Campus and system in growth spurt 10 – 20 year wait for CIP likely
- Operations funds must come through the university's legislative budget
- All fundraising must be run through UH Foundation and is subject to their "blacklist".

Legislative Solution

HB2873/SB3037

- Reorganizes PISCES as an attachment to Hawaii State's Department of Business, Economic Development and Tourism (DBEDT)
- Board of Governors
- CIP and operations funding requests in a direct manner
- Ability to "play offense" and run more like a business

SCR137

- Promotes an aerospace partnership between Hawaii and Alaska
- PISCES added to resolution

HB2319

- Venture accelerator funding program under the Hawaii Strategic Development Corporation
- Aerospace added as a qualifying sector

HB2872

- Allows aerospace as a permitted use in Urban and Agricultural (poor soil grades) land use districts.
- Establishes tax-credits for aerospace companies in Hawaii County

Status

HB2873

- Passed both houses unanimously
- Requested funds granted in HB2873 and the Hawaii State Budget
- Passed with the understanding that the CIP requests will continue for 3 years and operational funding will ramp-up over that same period
- Awaiting the Governor's signature

SCR137

- Adopted

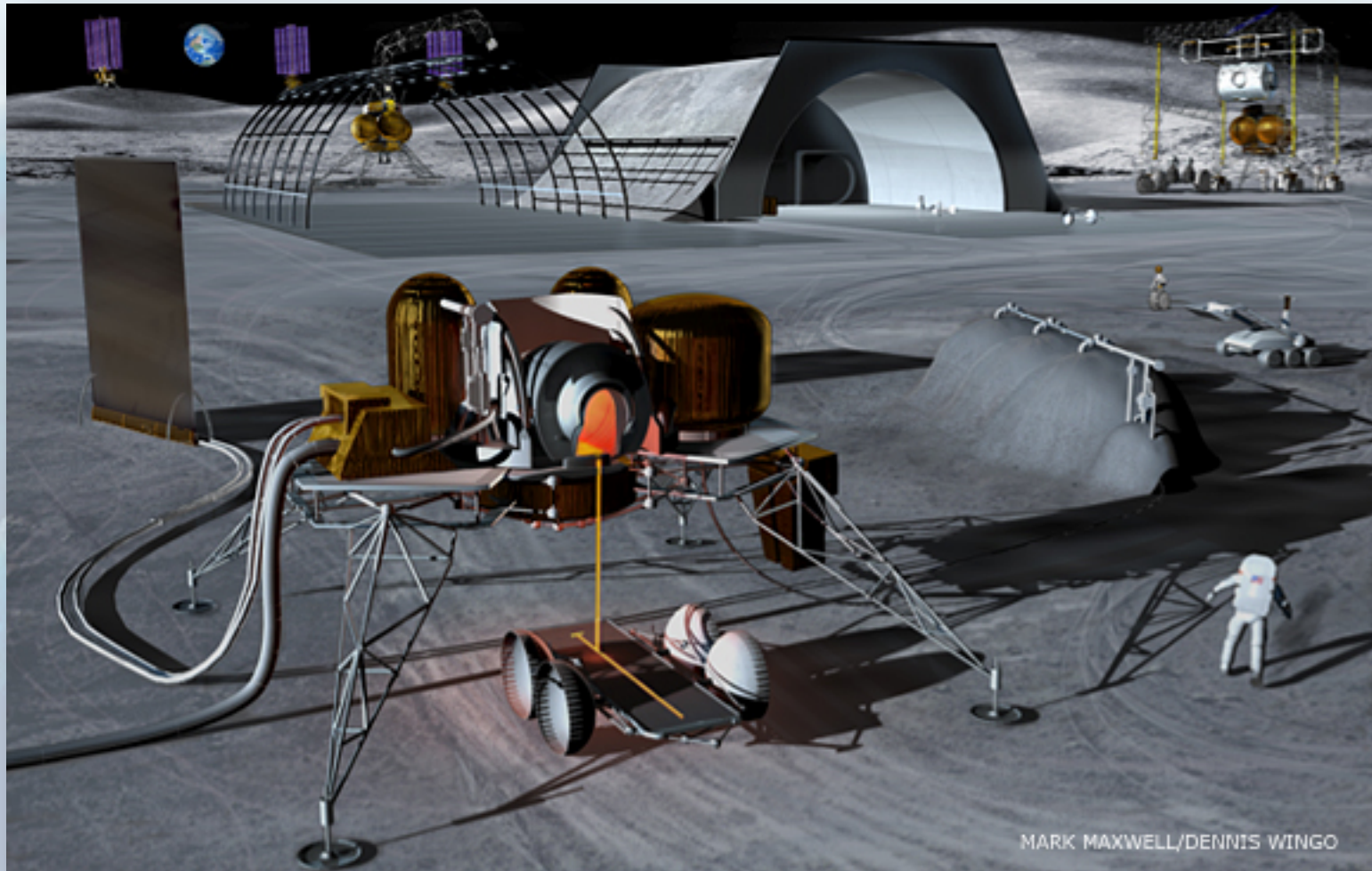
HB2319

- Passed House unanimously, passed Senate with 1 no vote
- Awaiting the Governor's signature

HB2872

- Made it through committees with no opposition
- Sat in committee due to last minute state budget adoption

“Rocks to Blocks”

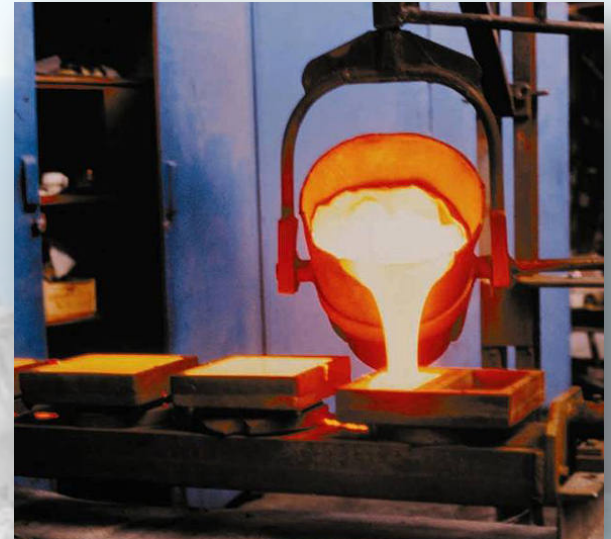
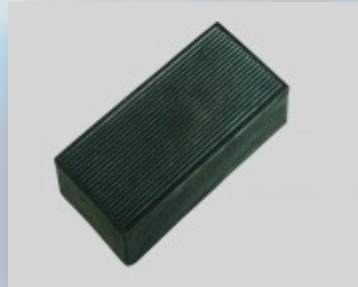


MARK MAXWELL/DENNIS WINGO

“Rocks to Blocks”

First Steps

- Basalt can be melted and cast into a variety of construction materials



- Basalt has also received attention for weaving geo-textiles, and as concrete and plastic reinforcement
- Basalt concretes



“Lunar Concrete” Focus / Objective

1. Technology Demonstration

- both lunar surface stabilization and preparation of landing pad surfaces by first testing these technologies on the volcano of the Big Island of Hawai'i.

2. Industrial construction

- the State of Hawai'i has parallel interest in using similar processes for basalt construction materials (ala 'lunar bricks') from the volcanic basalt located on the Big Island for bricks, slabs/foundations, roads and houses.

Who is working in “Lunar concrete”?

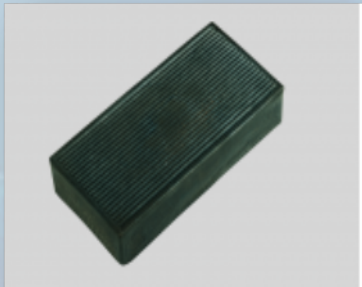
- NASA Kennedy Space Center
 - good experience with regolith brick making
 - seen as viable technology for building planetary infrastructure such as landing pads and other structures.
 - KSC has been experimenting with sintering, microwaves and polymer binders and has a NIAC award for fabricating regolith derived heat shields.
 - Last year KSC had a Phase II SBIR with Adherent Technologies and they actually delivered a polymer binder brick making machine
- Italians (ASI): have expressed an interest in regolith brick making.
- Canadian Space Agency: interested in a demo at the last ISRU PISCES field test.
- Hanyang University (Korea) has shown interest.
- The University of Southern California is also interested in contour crafting with regolith using robotics.
- JPL was interested in using the ATHLETE platform with special regolith forming end effectors as a positioning device.

Collaborative Pilot Project in “Lunar Concrete”

Basalt Construction Materials and Techniques



“Lunar Concrete” Pipeline



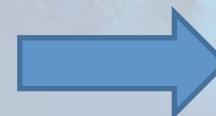
Component-level

Basalt brick



Subsystem-level

Slab, extrusion,
thermal wadi



System-level

Shelter, launch pad

November PISCES Conference

**November 11-15, 2012
in Honolulu, Hawai`i**

- Track 1: Defining technical interfaces & standards for planetary analog test sites
- Track 2: Developing Lunar Concrete-“Rocks to Blocks”
- Track 3: Education and Public Outreach
- Waste Management and Recycling/ Energy



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Space Center for
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2012 PISCES Symposium

Pioneering International Interoperability,
ISRU and Manufacturing Technologies
for Exploration Beyond LEO

Honolulu, Hawai'i November 11-15
pisc.es.hawaii-conference.com

ILRP

International Lunar Research Park

Developing Space Technologies and Applying Them on Earth

