Annual Report

FY 2018

APPLIED RESEARCH
WORKFORCE DEVELOPMENT
ECONOMIC DEVELOPMENT

PISCES

FY18 Annual Report

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Pacific International Space Center for Exploration Systems

The Pacific International Space Center for Exploration Systems (PISCES) is a state-funded aerospace agency operating under the Department of Business, Economic Development and Tourism (DBEDT). The center was originally founded in 2007 by Dr. Frank Schowengerdt, a former director at NASA's Research Partnership Centers.

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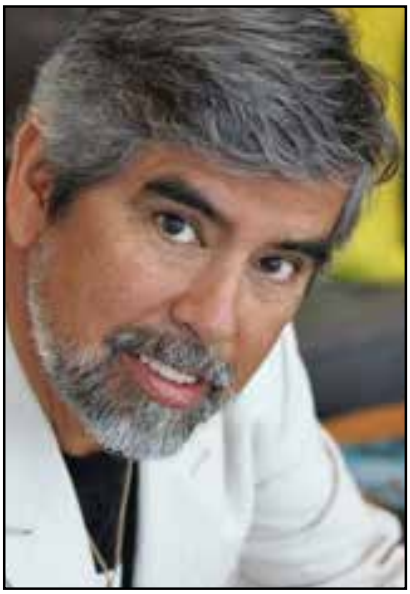
In 2012, the agency was relocated under DBEDT by the Hawaii State Legislature.

PISCES's core mission is to develop and facilitate a sustainable aerospace industry in Hawaii. The agency focuses on three main objectives to achieve this goal: Applied Research, Workforce Development and Economic Development. Through these objectives, PISCES provides hands-on experience to Hawaii's future scientists and engineers, preparing them to meet the demands of a highly competitive industry. These core objectives also benefit the local economy through job diversification and by developing innovative new products and industries.

LEADERSHIP

Letter from the Chair



Entrepreneur Henk Rogers is the founder of Blue Planet Foundation and serves as the Board Chair at PISCES.

Henk Rogers

Aloha,

I started this fiscal year by talking to each board member to come up with a plan on how to make Hawaii a global center for space exploration. I decided we needed an ambitious goal to put Hawaii on the map—an idea that could counter Hawaii's challenging business environment. But what does Hawaii have to offer?

Hawaii's unique offering is volcanic basalt that is very similar to the regolith (the layer of loose dirt covering solid rock) found on the Moon and Mars. Hawaii's oceanic volcanic rock is nearly identical in chemical composition to lunar and Martian regolith. As a state within the U.S., Hawaii also maintains a stable political environment and is relatively close to most Asian countries and cultures. It was also the target of the last great human exploration that took place on this planet: the Polynesian voyage of discovery.

For these reasons and more, Hawaii is a great place to build a prototype terrestrial Moon base. It would serve the ultimate goal of testing and developing robots before sending them to the lunar surface.

To spread the word, I have been traveling across the world and sharing this vision. This year my travels included a wide variety of conferences and industry-related visits including:

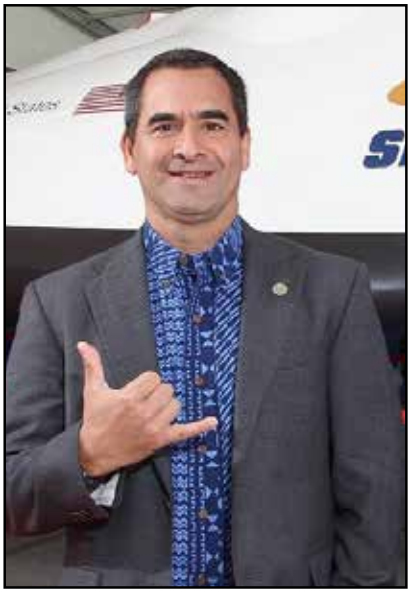
- IMS (International MoonBase Summit) – Kailua-Kona, HI
- WKF (World Knowledge Forum) - Korea
- NWC (New Worlds Conference) - Austin, TX
- LSLM (Lunar Science for Landed Missions) - NASA Ames
- ISEF (International Space
- Baikonur Space Launch Complex - Russia
- ESTEC (part of the European Space Agency) - Netherlands
- ISDC (International Space Development Conference) – Los Angeles, CA

The next steps in this ambitious project will be to secure land where we can build a Lunar Research Park as well as a Moon base prototype. This Research Park would also serve as the headquarters and lab for PISCES. So far, we are holding acreage for NASA's Lunar University, the ESA's Moon Village Project, OffWorld's lunar robotic mining project and others. We are in advanced negotiations with a federal agency to lease approximately 1,000 acres for this effort. If all goes to plan, PISCES will expand its operations and play a central role in the development of the Moon base. Within ten years, I foresee a working facility on the Moon. Through this and other projects, PISCES is fulfilling its mission to bring the business of Space Exploration to Hawaii.

Henk Rogers
PISCES Board Chair

Letter from the Director

Rodrigo Romo



Rodrigo Romo is a former Engineer and Manager for Biosphere 2 and currently serves as the Program Director at PISCES.

Aloha Kakou,

Fiscal Year 2018 (FY18) was by all measures a successful year at PISCES. Our Summer Internship Program received funding support from the State Department of Labor & Industrial Relations and employed students from Hawaii Community College, Arizona State University, University of Hawaii at Hilo and Waiakea High School. The Women's STARS program also received a grant from the Hawaii Technology Development Corporation, as well as in-kind support from institutions and companies from across the State and the mainland. Caterpillar Ltd. sent one of their Senior Engineers to participate in the program who plans to return this summer to support the week-long workshop as a full-time staffmember in support of young women in STEM.

Our research work in basalt feedstock for in-situ manufacturing moved along during the year resulting in a four-model block design that received high praise during the 2018 Earth & Space Symposium held in Cleveland, Ohio. Funds from that project—provided by a NASA STTR Phase 1 Grant in partnership with Honeybee robotics—allowed us to add our former intern and a UH Hilo graduate, Kyla Defore, to the PISCES team as a Geology Technician. In the coming year, we are setting our sights on new applications for Earth and Space using sintered basalt.

Last year in October, the first International Moonbase Alliance summit was held in Waikoloa on Hawaii Island. A diverse group of scientists, artists, engineers and architects came together to launch the concept of a prototype moon base project here in Hawaii. PISCES will continue to collaborate in this effort. Other fascinating projects that PISCES has initiated or been involved in during the year will be covered in detail within the contents of this report.

The hard work by PISCES staff has resulted in strong support from our State Legislators who made it possible for us to receive supplemental funds for FY19, putting PISCES in a much stronger position to succeed in the coming year.

I am proud to be a member of the PISCES team, and to help lead the agency towards what promises to be a bright future.

'A'ohe pu'u ki'eki'e ke ho'a'o 'ia e pi'l.

"No cliff is so tall it cannot be climbed" - Hawaiian Proverb

R. Romo

Rodrigo Romo
PISCES Program Director

FY 2018
Executive Summary

In 2017 the Aerospace & Defense (A&D) Industry in the U.S. generated $865 billion in economic output. Within this heavyweight industry, PISCES works within the Space Systems subsector—an industry sector seeing significant growth. Nearly $2.5 billion has been invested in small satellites in the last decade. Half of that figure was generated in the last three years. By 2021, the global small satellite market is forecasted to reach $10.10 billion, more than tripling from 2016 (BIS Research). This growth is attributed to technological advances enabling smaller, more efficient vehicles at lower costs.

With a growing demand for small space launch vehicles, the industry is constricted by a shortage of launch sites. The State of Hawaii offers a prime location to address this shortfall. Centrally located above the equator, Hawaii's low latitude is ideal for sub-orbital and orbital launches. The state's geographic position also makes it a favorable location to partner with multi-national aerospace companies and agencies from leading countries in the Asia-Pacific region like India, China, Japan and Singapore.

Recognizing this opportunity, PISCES is working with aerospace industry partners to establish a commercial small launch vehicle facility in the State of Hawaii. Such a facility would expand and diversify Hawaii's economy and create more opportunities for high-paying jobs that can support and retain a highly skilled technical workforce.

in other efforts to benefit Hawaii's economy, PISCES also secured $180,000 in state funding to conduct a market feasibility study for a Continuous Basalt Fiber manufacturing operation on Hawaii Island. The study will be completed in August 2018. PISCES also joined a task force to develop an Innovation and Manufacturing Center in East Hawaii in partnership with the University of Hawaii and Hawaii Technology Development Corporation. PISCES is part of the design group for the concept facility, which would provide new economic growth opportunities for the technology sector on Hawaii Island.

In addition to A&D, PISCES is researching Space Industry technologies utilizing ISRU (In Situ Resource Utilization) that could join the ranks of other revolutionary space tech materials. ISRU tech has the potential to improve Hawaii's economy and quality of life while paving the way for human space settlement efforts on the Moon and Mars.

In this area, PISCES successfully completed a Planetary LEGO Blocks research project in FY18 funded by a NASA STTR Phase 1 Grant in partnership with Honeybee Robotics. The project investigated vertical and horizontal construction applications using sintered volcanic basalt as a building material. The results could be used to build sustainable structures and tools, both in Hawaii using local raw materials, and on places like the Moon and Mars using in-situ regolith.

To support and cultivate the next generation of engineers, scientists and technically skilled workers who can sustain an aerospace industry in Hawaii, one of PISCES' core objectives is Workforce Development. During FY18, PISCES mentored six student interns in the fields of Robotics and Materials Science. PISCES also graduated 11 Hawaii high school girls during its fourth annual STARS (STEM Aerospace Research Scholars) Program, supporting female youth to pursue careers in aerospace and related STEM fields. PISCES also worked closely with the Maunakea Astronomy Outreach Committee in FY18 to increase attendance and participation in STEM-related community outreach events and activities that engage and inform local students, educators and members of the public.

SUMMARY OF FY18 ACTIVITY

Economic Development

- Jointly formed a working advisory group to establish a Small Satellite Launch Facility
- Contracted Basalt Fiber Market Feasibility Study in Hawaii County
- Negotiations with BridgeSat for Ground-based Laser Communication Station in Hawaii
- Joined design team for Innovation & Manufacturing Center in East Hawaii
- Partnered with Internatinal Moonbase Alliance to support prototype moon base project
- Initiated two new MOU partnerships

Applied Research

- Completed NASA Phase 1 STTR-funded Planetary LEGO Blocks project
- Upgraded operating and imaging system capabilities on Helelani planetary rover
- Completed assembly and programming of UAV for project with County of Hawaii

Workforce Development

- Graduated 11 Hawaii high school students during fourth annual Women's STARS Program
- Mentored six college interns through research projects in Robotics and Materials Science
- Summer 2017 student intern landed position at NASA JPL to work on Mars rovers
- Launched Keaukaha Robotics Program in partnership with RISE and UH Hilo

★ 37

Education & Outreach Events in FY18

★ $440K

State funds allocated in FY18 for operation costs

★ 36

Students Mentored sinced 2014

★ $180K

State funds allocated for market feasibility study

★ 5

Current Staff

★ 23

Total public/private partnerships

Core Objectives

PISCES focuses on three core objectives to achieve its goal of developing a sustainable aerospace industry in Hawaii: Applied Research, Workforce Development and Economic Development. Through innovative technologies, unique internships, education programs, community outreach and collaboration on innovative business ventures and industries, PISCES is paving the way for Hawaii's economic success in the 21st century.

APPLIED RESEARCH

Applied Research is the core focus at PISCES. These projects fuel the parallel core objectives of Workforce Development and Economic Development. Through cutting edge research and partnerships, PISCES develops technologies with applications for both Earth and space exploration while drawing supplemental funding from state and federal organizations that benefit the State of Hawaii.

Grant Funding

PISCES applied for several research grants in FY18 including:

- NASA Broad Agency Agreement - ISRU: Water and Volatile Extraction from Lunar/Mars Regolith using Microwaves;
- NASA PSTAR Grant: UAS Autonomous Systems for Lava Tube Mapping ;
- NASA SBIR: Design of a Sinusoidal Wheel Pattern for Improved Surface Mobility on Planetary Rovers;
- NASA SBIR: Design and Testing of a Hybrid Power Plant System for Planetary Rovers.

Although these proposals were not selected for an award, the NASA PSTAR Grant submission received high points in the review process and shows promise for selection in the coming year.

PISCES and its partners in the project have agreed to resubmit a revised proposal in accordance with the recommendations provided during the review.

The sinusoidal wheel design proposal also received interest from engineers at NASA's Glenn Research Center and shows promise for collaborative work in FY19.

Water and volatile extraction remains a high priority research topic for NASA. PISCES will continue to advance the project using existing resources and seek out partnerships for collaboration.

PISCES was approached by NASA Ames to provide a site and logistical support for two analog field tests in 2020 and 2021 to test hardware for future lunar missions. The proposal is currently being reviewed by NASA headquarters.

FY18 Research: Materials Science

ISRU

In 2015, PISCES began researching methods for using regolith as a feedstock for ISRU (in-situ resource utilization) manufacturing in partnership with NASA's SwampWorks. PISCES led a successful project to build a launch and landing pad robotically using only in-situ materials. Since Hawaii's basalt has strong similarities to the regolith found on the Moon and Mars, it serves as an ideal simulant for ISRU research.

In FY18, PISCES received a NASA Small Technology Transfer Research (STTR) grant award in partnership with Honeybee Robotics Spacecraft Systems to develop *Planetary LEGO Blocks* using ISRU. The project aimed to create interlocking bricks that could be used in vertical and horizontal construction. With successful results, the project was presented in research papers at the 2018 ASCE Earth & Space Conference and drew high praise from scientists and engineers in the aerospace community.

BASALT

As part of its continuing ISRU research, PISCES is collecting samples from various locations on Hawaii Island to perform chemical analysis and create an inventory of basalt compositions. The resulting database will be used to match Hawaii basalt samples with Moon and Mars simulants for various testing applications.

PISCES is also continuing to investigate basalt fiber and basalt fiber-derived products for potential uses in space applications. Basalt fiber composites are gaining increasing recognition and interest in the aerospace industry due to their unique properties. These include high temperature tolerance, chemical and erosion resistance and ultraviolent protection. PISCES plans to expand an existing Space Act Agreement with NASA to continue researching uses for basalt fiber products in space.

Planetary LEGO Blocks

APPLIED RESEARCH

FY18 Research: Robotics

Helelani Planetary Rover

PISCES maintains an Alpha Argo analog planetary rover named "Helelani" (heavenly travels). The remote-controlled rover serves as a development and testing platform for students and aerospace agencies. Each year, the rover's systems and hardware are upgraded through student intern work, built on the progress achieved by previous interns.

During the summer of 2017 and spring of 2018, PISCES interns continued Helelani's development with a new operating platform, stereoscopic imaging system, LIDAR and user interface. The rover can be operated remotely from any location with internet access. With the addition of 3D spatial mapping through LIDAR, the next phase of development will incorporate autonomous navigation capabilities.

Helelani Planetary Rover

Rover Sensors

- Voltage
- Temperature
- GPS
- Gyroscope
- Magnetometer
- Barometer
- Accelerometer
- Motor RPM

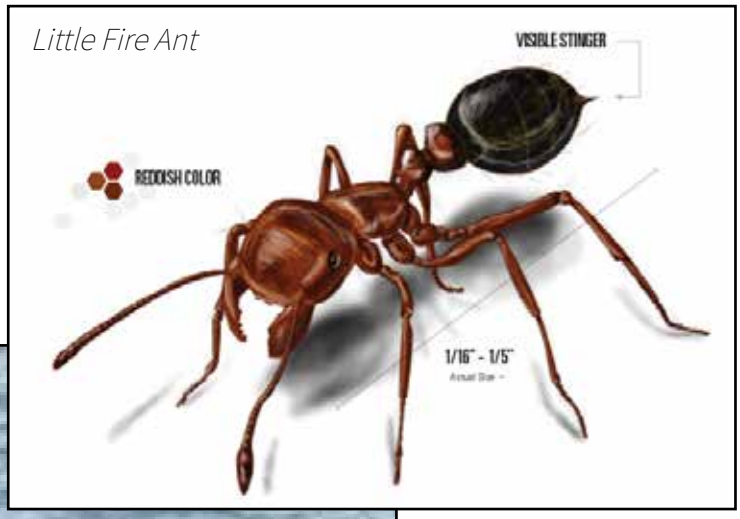
Imaging Systems

- Pan Tilt Camera
- Front view Haz Cam
- Rear view Haz Cam
- Stereoscopic Imager
- LIDAR

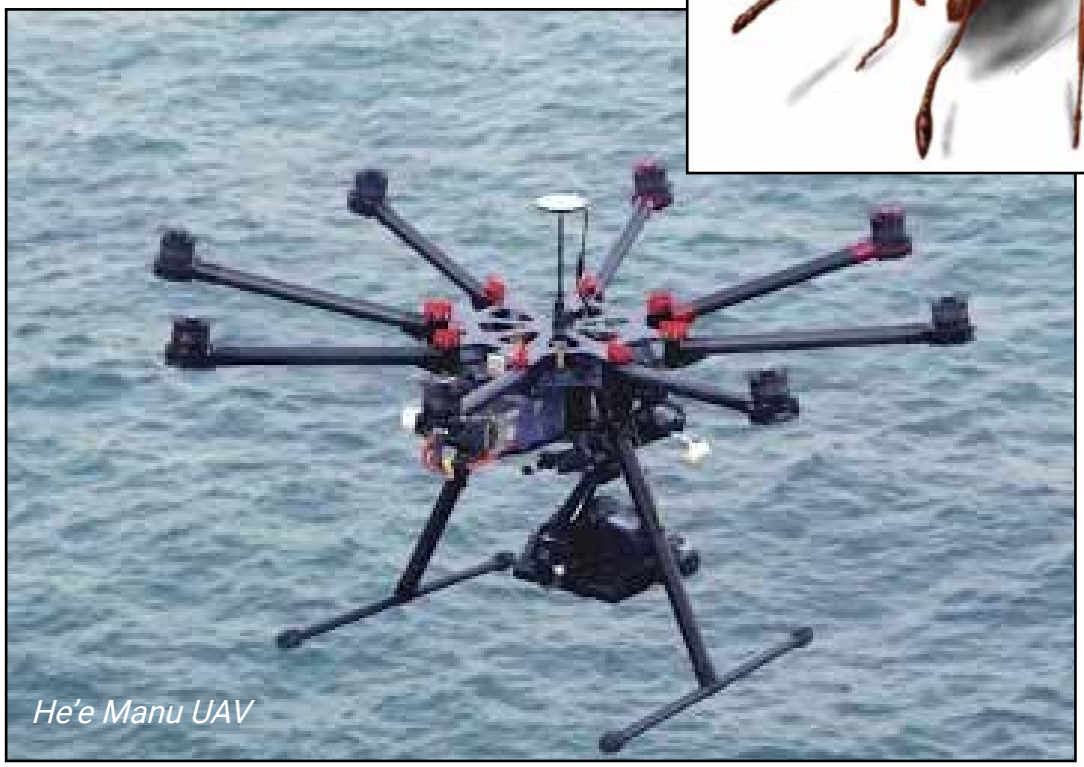
He'e Manu UAV

Under a grant from the County of Hawaii Department of Research & Development, PISCES procured a large DJI S1000 UAV (unmanned aerial vehicle) in FY18 that will be used in a little fire ant eradication project in partnership with the Hawaii Ant Lab. PISCES is developing an aerial bait dispersion system that can be mounted on the UAV (named He'e Manu, or "Flying Octupus") to treat fire ants in hard-to-reach tree canopies. The apparatus involves a tethered system that can provide power and fire ant insecticide from the ground to eliminate the time needed to recharge batteries and refill the ant bait. The project is expected to be completed at the end of 2018, and will produce a usable blueprint of the system for easy distribution and reproduction.

Little fire ant populations have been growing rapidly in Hawaii. In addition to their painful sting, the tiny red ants negatively affect the local nursery, agriculture, ranching and tourism industries. Current control methods primarily focus on ground nesting ants and largely neglect arboreal fire ant populations residing in tree canopies.



Little Fire Ant


He'e Manu UAV

UAV Specs

- Payload capacity: 11 kg
- Weight: 4.4 kg
- Hover time: 15 minutes
- 4114 pro motors
- Rotors: 8
- Battery: LiPo, 6S 15,000mAh

APPLIED RESEARCH

CONFERENCES

International Moonbase Summit, Waikoloa, HI - Oct. 1-5, 2017

Organized by the International Moonbase Alliance (IMA), the first-ever International Moonbase Summit convened a group of leading scientists, educators, entrepreneurs, architects, engineers, artists, academics and students from around the world to develop concrete steps in the creation of a prototype lunar settlement. The first objective of the IMA is to build a full-scale Moonbase analog on Hawaii Island to develop the technologies and protocols needed to successfully build and operate a manned base on the Moon. PISCES chaired the working group on Robotics & Surface System Components during the summit, and remains an active member of the IMA.

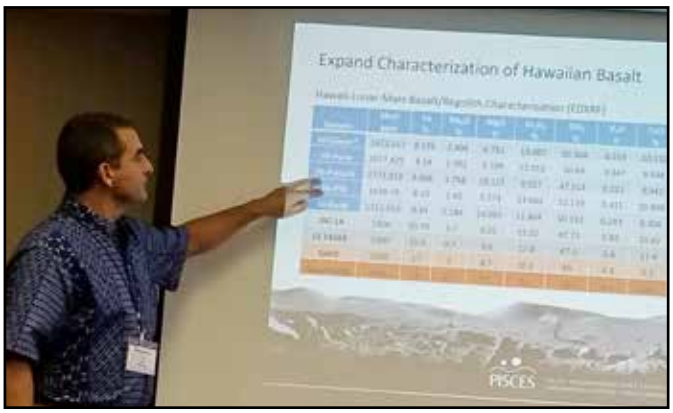
ASCE Earth & Space Conference, Cleveland, OH - April 9-12, 2018

Earth & Space is a technical conference joining leaders in civil engineering, construction, architecture, aerospace engineering, ISRU, Planetary Science and other fields to discuss and explore cutting edge technologies built for extreme environments on Earth and in space. PISCES presented two research papers on basalt characterization and utilizing basalt as a feedstock for ISRU manufacturing. Both papers received positive reviews and several parties expressed interest in collaborating.

34th Space Symposium, Colorado Springs, CO - April 16-19, 2018

Space symposium is considered the top annual event in the Space Industry. PISCES attended this conference to establish contacts with small space vehicle developers, small satellite companies, laser communication companies and additive manufacturing companies. PISCES also attended to participate in the New Generations Space Leaders track for young engineers.

(L-R) Jacqui Hoover of HIEDB, PISCES Director Rodrigo Romo and Ops. Manager Christian Andersen at the Hawaii booth during the 34th Space Symposium.



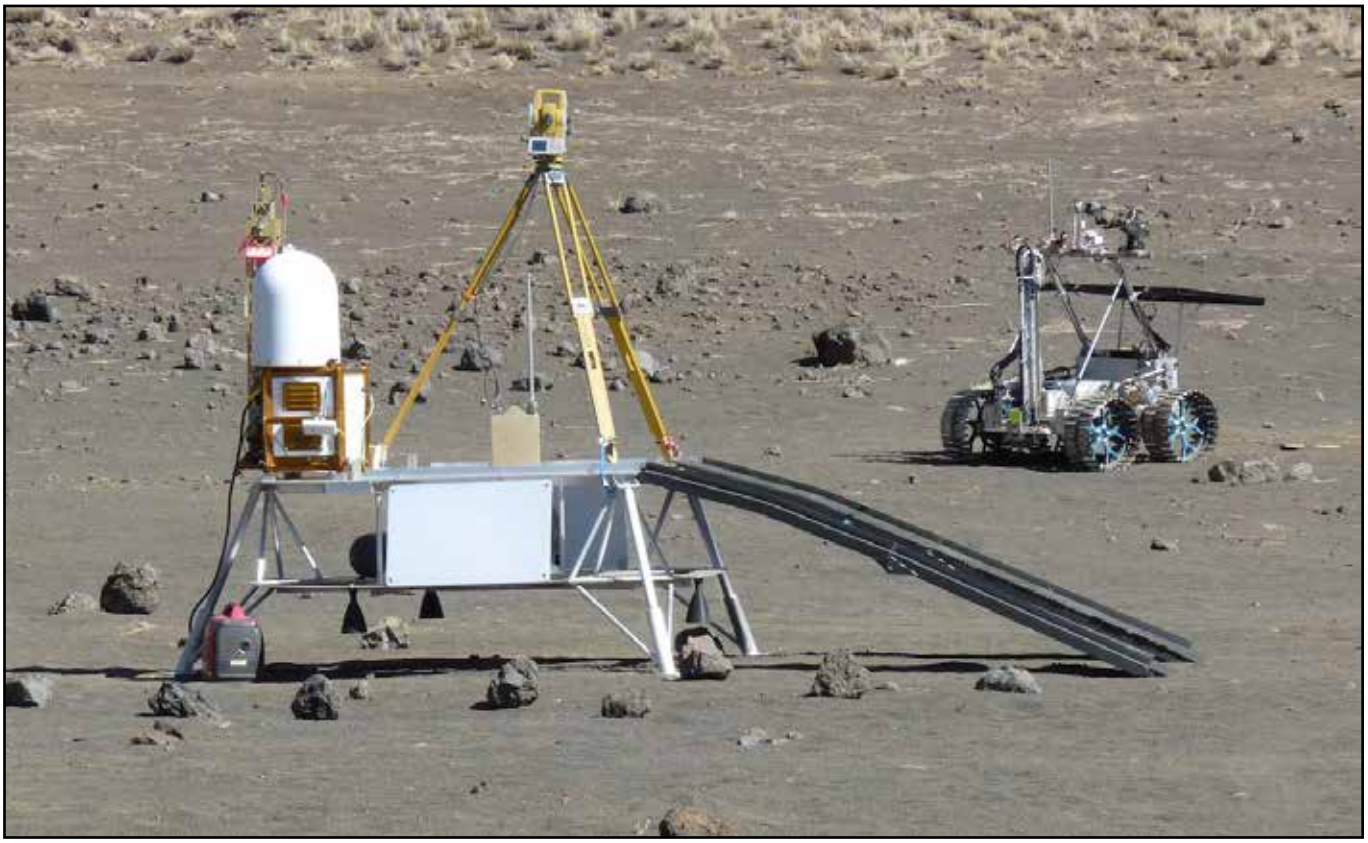
PISCES Director Rodrigo Romo presented on Hawaii basalt characterization for ISRU during ASCE's Earth & Space Conference in Cleveland, OH.

Planetary Analog Test sites

From its inception, PISCES has facilitated and provided logistical support for space exploration testing at planetary analog test sites on Hawaii Island. Hawaii's rugged basalt terrain provides world-class simulation environments to test robotic spacecrafts prior to launch. PISCES works to protect these diverse physical and cultural landscapes, as well as the large population of endangered and threatened plants and animals that inhabit them, practicing environmental sensitivity and minimizing impacts.

In 2008, 2010, and 2012, PISCES conducted several successful campaigns with international agencies at a test site on the slopes of Maunakea. During 2012, the area was also used by NASA researchers to test a series of instruments aboardthe Juno II Rover for the Moon and Mars Analog Mission Activities (MMAMA) program.

The current U.S. administration has set its sight on returning to the surface of the Moon, sparking renewed interest in performing field tests in Hawaii. PISCES is currently working with NASA Ames to conduct two field tests on Hawaii Island in 2020 and 2021.



The Juno II rover outfitted with analysis instruments during a field test on Hawaii Island in 2012.

WORKFORCE DEVELOPMENT

Internship Program

PISCES offers a paid summer internship and credit-based internship in one of two learning tracks: Planetary Robotics and Materials Science. Students earn a salary or college credits while cultivating the skills they need to be successful in highly technical careers. The program is limited to Hawaii-based students—either those who study at the University of Hawaii or those who return home from an out-of-state university during the summer months.

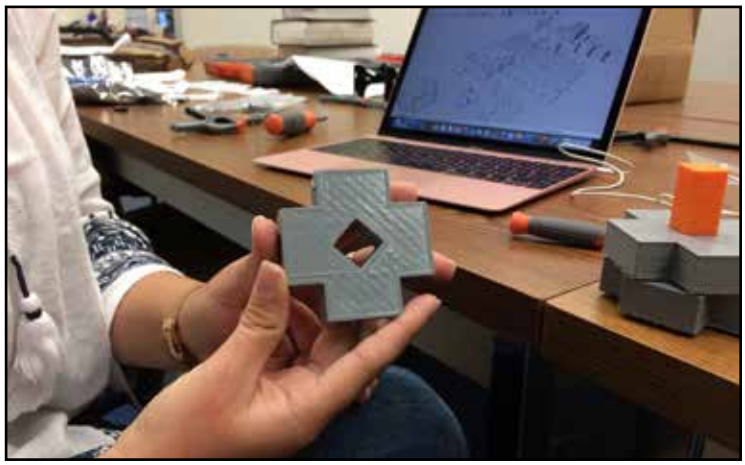
Robotics

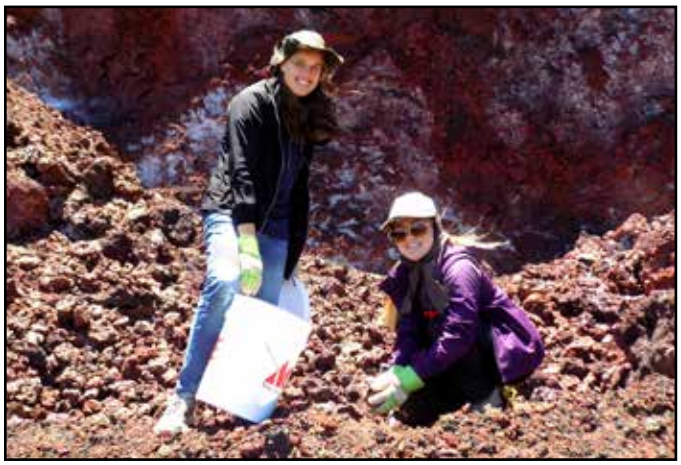
During the summer of 2017, three interns completely redesigned the Helelani rover's Graphic User Interface (GUI), Navigation System and Telemetry. These students also restored data channels from the CAN Bus and Command & Control Systems, and developed a Stereoscopic Imaging System to capture 3D pictures.

Two of the interns were Hawaii Community College students who went on to graduate from the Electronics Technology Program with honors. One of these students—who has continued development work on Helelani since his summer internship—will transfer to the University of Hawaii at Hilo to pursue a degree in Computer Science. After working with PISCES, the third intern secured a position working with Dr. Jim Bell at Arizona State University for the Mars 2020 rover project. He later landed a summer internship position with NASA JPL to continue working on Mars rover software platforms.

Top Left: Intern Lily Leyva (L) built and programmed the He'e Manu UAV for a project with County of Hawaii. Top Right: PISCES summer interns and volunteers pose with Helelani at a field test site in July 2017. PISCES intern Jack Andersen shares the results of his Robotics work during a presentation to local lawmakers, educators, students and PISCES staff at Big Island Workforce Connection in Hilo in August 2017.

Materials Science





Left: Materials Science Intern Lily Leyva created an innovative block design for PISCES' Planetary LEGO Blocks project using a 3D printer. Right: Interns collect basalt samples at a fissure near the HI-SEAS Mars Habitat on Mauna Loa during Summer 2018.

The Materials Science track of PISCES' internship program primarily focuses on applied research to create sintered basalt pavers for a vertical launch/landing pad for lunar/Mars applications. Summer 2018 interns include two junior volunteers and one AKAMAI intern who are contributing heavily to the completion of the NASA STTR grant project and final report. The students are working in three phases designed to teach them how to conduct sound research and work safely in a lab, machine shop and in the field:

1) Research and Field Work

Participants learn about In-Situ Resource Utilization (ISRU) and how locally sourced, raw materials can be used to extract resources like oxygen, water and rocket propellant. Students will also learn how to identify various rock forms and soil compositions in the local terrain, while using remote sensing to locate potential planetary analog sites for sampling. Once identified, students will "ground-truth" these areas by visiting them in person with survey equipment to collect samples.

2) Lab Work

Students determine the chemical composition of their collections using an Energy Dispersive X-Ray Fluorescence (EDXRF) analyzer, allowing the student to break down their soil samples into individual chemical components. Other lab activities include measuring for particle sizes, heat capacity, density and thermal conductivity.

3) Manufacturing

Once all data is gathered, students fabricate usable bricks by sintering their samples in a mold at high temperatures for sustained periods of time and recording the results that yield the most durable and cohesive products.

WORKFORCE DEVELOPMENT

Women's STARS Program

PISCES has held the Women's STARS (STEM Aerospace Research Scholars) Program every year since 2014. The week-long summer program is designed to encourage Hawaii high school women to pursue studies and careers in STEM field related to astronomy, aerospace and engineering. The program has grown each year, accommodating more local students and partnering with a growing number of organizations and presenters to support young women in the sciences and address existing challenges. Feedback surveys completed by participating students show the program is making an impact. In 2017, 90 percent of students responded that the program inspired them to pursue a career in STEM.

The 2017 Women's STARS Program graduated 11 Hawaii high school women. Based on survey feedback, the 2018 program was planned to include overnight accommodations for all students, allowing a summer camp feel while providing students from all islands the opportunity to participate. Scheduled in July, the 2018 program received grant funding from the Hawaii Technology Development Corporation and Women's Fund of Hawaii.

The STARS Program offers:

- Tours & presentations at Maunakea Observatories
- Talks by leading female astronomers & aerospace engineers
- Hands-on activities including robotics & engineering exercises
- Insider tours at world-class telescopes at the summit of Maunakea
- Overnight accommodations at the HI-SEAS Mars simulation habitat

Top: STARS students build smart robots during a workshop with UH Hilo Robotics Team Leader Marc Roberts. Left: Students pose during a geology hike at the summit of Maunakea. Right: USGS HVO Lead Scientist Tina Neal shows students monitoring instruments at Hawaii Volcanoes National Park.

Grant Awards

In FY18, PISCES received grant awards from the Hawaii Technology Development Corporation and Women's Fund of Hawaii to fund the 2018 Women's STARS Program. The supplemental funds provide for meals, accommodations, transportations and student supplies.

$4,000

$1,250

Outreach & Education

PISCES participated in 37 outreach and education events during FY18. Working closely with the Maunakea Astronomy Outreach Committee, the agency increased its participation in community events to reach the public, students and educators in STEM related activities. The events included:

- 2017 AstroDay East Hawaii
- Maunakea Skies at 'Imiloa Astronomy Center
- Ellison Onizuka Day
- 2018 Journey Through The Universe Week
- Hokulea Homecoming in Hilo
- Maunakea Wonders Education Workshop
- Earth Day at Pohakuloa Training Area
- 2017 AstroDay West Hawaii
- 'Imiloa Anniversary Public Celebration
- CFH Telescope Manufacturing Day
- Hawaii District Science & Engineering Fair
- Hawaii Community College Career Fair

Left: PISCES Geology Technician Kyla Defore visits with students at Ha'a Heo Elementary School during Journey Through the Universe Week in Spring 2018 to talk about space exploration and Mars colonization. Right: PISCES and Maunakea Observatories staff share their projects and programs with visitors at the Hokulea Homecoming celebration in Hilo on April 21, 2018.

WORKFORCE DEVELOPMENT

Keaukaha Robotics Program

Above: Volunteers Joel Paye and Tayeh Madjeska introduce Keaukaha youth to VEX IQ robot kits during the first RISE robotics class held in November 2017.

In partnership with RISE (Revealing Individual Strength through Excellence), PISCES initiated Keaukaha's first afterschool robotics program for elementary students on Nov. 13, 2017. The program provides local youth an opportunity to build, program and compete with their own robots. It was conceived through a collaborative effort between PISCES' Program Director Rodrigo Romo, PUEO (Perpetuating Unique Educational Opportunities) President Keahi Warfield, and the University of Hawaii at Hilo's Vulcan Robotics Team Lead Marc Roberts. The inaugural program was led by two college student volunteers—Joel Paye of UH Hilo and Tayeh Madjeska of Hawaii Community College—and provided VEX IQ robotics kits for each student through a grant from the TMT THINK Fund. Due to its success, the robotics program is expected to continue as part of a long-term effort to provide Keaukaha youth with more access to extracurricular activities. Students will compete in the local VexIQ Robotics League in 2018.

RISE is an afterschool program serving Native Hawaiian youth between the ages of 8 and 18. The program is part of a long-term effort to provide Hawaii youth with more career and education opportunities on-island. Many students leave Hawaii upon graduation to pursue a wider range of opportunities in both career and educational pursuits.

Students from the Keaukaha robotics program demonstrated their robots during an outreach event with PISCES held at Keaukaha Elementary School's 'Ohana Night in April 2018. They instructed fellow students on how to operate the robots using handheld controllers with support from their mentors, Joel and Tayeh.

MoonRIDERS Program

Above: Kealakehe High School students crafted a mock-up spacecraft in 2015 for their MoonRIDERS field test.

PISCES launched the MoonRIDERS (Research Investigating Dust Expulsion Removal Systems) program in 2014 to engage Hawaii high school students in a real-life, lunar flight experiment in partnership with NASA's Kennedy Space Center (KSC). Participating students from Kealakehe High School and 'Iolani High School built mock spacecrafts and conducted field tests with a NASA-built technology called the Electrodynamic Dust Shield (EDS). The EDS is designed to repel the highly corrosive dust from surfaces like spacesuits, solar panels and spacecrafts. Currently, the project is awaiting a private launch vehicle to land on the Moon. The initial launch date was expected in late 2017 under the Google Lunar XPrize (GLXP) Challenge. Due to technical delays, the launch has been pushed back to 2021.

Roughly 85 high school students have participated in MoonRIDERS since the program began, including a dozen who tested their designs at NASA's KSC. Fourteen Kealakehe students involved in the program have received university scholarships and fellowships. MoonRIDERS is made possible through grant awards by the County of Hawaii Department of R&D.

Right: A scaled-down model of GLXP team Astrobotic's spacecraft during a field test on Hawaii Island in March 2015. The mock-up was built by 'Iolani High School students to test NASA's EDS technology.

ECONOMIC DEVELOPMENT

Innovation & Manufacturing Center

The Hawaii State Legislature has appropriated $11 million in Capital Improvement Funds (CIP) to the Department of Labor and Industrial Relations (DLIR) to create an Innovation and Manufacturing Center (IMC) to grow and support the technology sector in East Hawaii.

In 2016, the Hawaii Technology Development Corporation, DLIR and University of Hawaii agreed to collectively fund a third-party feasibility study to assess Hilo's economic climate and determine how to draw support for local companies. HTDC managed the collective funds and administered the study. In 2017, the study concluded such an IMC facility was in high demand and procured a list of industries that would benefit. The report also recommended the Foreign Trade Zone 9 (FTZ 9) near Hilo International Airport as a suitable location for the project. A working group was formed comprised of stakeholders and experts, including PISCES staff. PISCES is part of the design group and is involved assessing the needs of the facility and guiding its direction. HTDC has partnered with the UH Community Design Center (UHCDC) to provide proof of concept research, analysis, planning, design and cost estimates for the IMC.

Small Satellite Launch Facility

Small and ultra-small satellite launch sites in the U.S. and throughout the world are in high demand from the commercial satellite industry. SpaceWorks' 2017 Market Forecast indicates nearly 2,400 nano- and micro-satellites will launch between 2017 and 2023. Hawaii (especially East Hawaii) offers an ideal location for equatorial orbit launches.

An advisory group has been formed between PISCES, a U.S. Launch Complex, a Hawaii-based company, the Hawaii Space Flight Lab (SFL) and the Hawaii Island Economic Development Board (HIEDB) to facilitate a Small Satellite Launch Facility. The spaceport would be called the Pacific Spaceport Complex Hawaii (PSCH) and would support vertical launch small space vehicles for equatorial orbit.

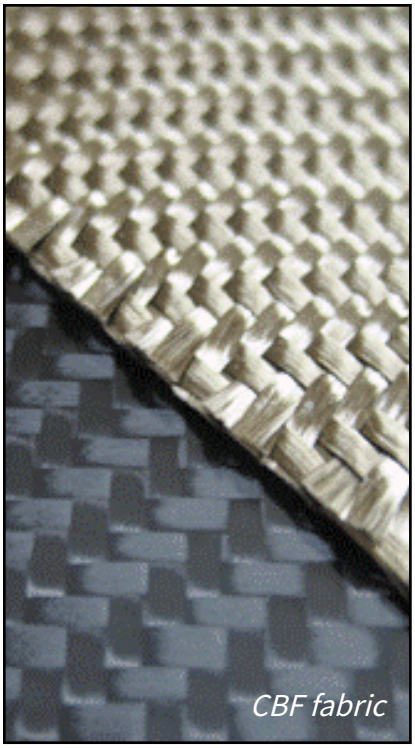
In FY18, the Hawaii State Legislature appropriated $250,000 in matching funds to conduct an Environmental Assessment which is currently in place. The target date for a working facility is 2020.

Basalt Fiber Market Study

Hawaii possesses a unique form of volcanic basalt with the chemical composition needed to produce Continuous Basalt Fiber (CBF) products. PISCES has been investigating Hawaii's volcanic basalt for use as an ISRU building material and discovered it possesses these unique properties in the process.

In December 2017, the Hawaii State Legislature appropriated funding for PISCES to contract a comprehensive market feasibility study that will assess whether a CBF manufacturing operation on Hawaii Island could benefit the local economy. After issuing a Request for Proposals in December 2017, PISCES selected SMA to conduct the study. The results are expected in August 2018.

Basalt Fiber is gaining popularity around the globe as a viable alternative to s-glass and some carbon composite materials. CBF products possess favorable characteristics including resistance to corrosion and heat, and high tensile strength. Products include structural mesh, fabric, insulating material, hydroponic growth media and basalt rebar. Globally, CBF manufacturing is valued at roughly $100 million and expected to double in the coming decade according to estimates.


CBF fabric

BridgeSat Laser Communication Station

PISCES has been working closely with BridgeSat (a subsidiary of Boston-based incubator Allied Minds) since July 2017 to establish a ground-based laser communication station in Hawaii. Laser technology is the next generation in space communication hardware and can deliver high volumes of data at faster rates for a lower cost than traditional radio frequency hardware. Negotiations for the project are currently underway between the National Oceanic and Atmospheric Administration, Hawaii State Department of Land and Natural Resources, BridgeSat and PISCES.

ECONOMIC DEVELOPMENT

International Moon Base Project

The first International Moonbase Summit (IMS) was held on Hawaii Island in October 2017 to create a plan to build the world's first prototype lunar base in the State of Hawaii. Led by PISCES Board Chair Henk Rogers, the summit drew space scientists, engineers, architects, artists, students, academics, government officials and members of the private sector to explore concrete steps in the creation of an Earth-based analog facility that space agencies from all over the world could use for pre-mission studies.

The summit concluded with three resolutions: build the terrestrial analog base (called "Mahina Lani") on Hawaii Island where terrain conditions closely mimic the lunar surface; build the real Moon base near the lunar south pole where conditions resemble those found on Hawaii Island; and fund the Mahina Lani analog through a self-sustaining business model. PISCES continues to collaborate and be involved in the project. Rogers is currently assessing a sight location for the base.

Above: Moonbase Summit attendees visited the HI-SEAS Mars habitat during the conference on Hawaii Island.

MOU Partnerships

PISCES holds 23 Memoranda of Understanding (MOUs) with private and public companies throughout the world. In FY18, PISCES formed three new MOU partnerships with:

- Shark Wheel: an innovative wheel manufacturing and design company based in California. PISCES partnered with Shark Wheel to collaboratively research advanced rover mobility system designs;
- Sky Blue Pictures: A professional photography and media company based on Oahu Island partnered with PISCES to provide media and other documentary services;
- Bolton, Inc: A Kailua-Kona based construction company collaborating with PISCES to evaluate potential uses for volcanic basalt in local construction applications.

FINANCIAL REPORT

Overview of FY18 State of Hawaii Funding

FY18 Budget Ops Request ----------$900K
FY18 Ops Funds Appropriated ----------$400K
FY18 Ops Funds Allocated ---------- $440K*

FY18 Feasibility Study Funds Request ----------$200K
FY18 Feasibility Study Funds Appropriated ----------$200K
FY18 Feasibility Study Funds Allocated ----------$180K

FY18 Total State Funds Allocated to PISCES ----------$620K

**PISCES core operating funds in excess of the specified PISCES appropriation were provided by the Office of Aerospace Development general allocation.*

Source of State Funds for FY18 Operations

Description	PISCES General Ops.	Basalt Feasibility Study	Total State Funds
FY18 Funds Allocated	$440.0K	$180.0K	$620.0K
FY17 State Funds carried into FY18	$227.2K		$227.2K
Total Funds available	$667.2K	$180.0K	$847.2K

PISCES Operating Costs in FY18

Description	PISCES General Ops.	Basalt Feasibility Study	Total Ops. Costs in FY18
Cost Category	*Amount / % of Total*	*Amount*	*Amount*
Labor	$340.5K / 79.6%		$340.5K
Facilities	$46.3K / 10.8%		$46.3K
Consultant		$95.3K	$95.3K
Other	$40.9K / 9.6%		$40.9K
Total Costs	$427.7K / 100.0%	$95.3K	$523.0K

STAFF

Rodrigo Romo
Program Director

Rodrigo Romo was appointed Program Director by the PISCES Board of Directors in May 2016. In this role he supervises day-to-day operations for the agency's personnel, finance, budgeting and ongoing projects in planetary robotics and in-situ resource utilization (ISRU) technology.

Polly Roth
Admin. Specialist

As Administrative Specialist, Polly Roth serves the primary role in accounting, human resources, finances, and correspondence with DBEDT, as well the Research Corporation of the University of Hawaii (RCUH).

Christian Andersen
Operations Manager

Christian Andersen leads PISCES' Materials Science research work in ISRU. As Operations Manager, he's worked on a variety of PISCES projects in transitioning aerospace technologies to terrestrial applications and analog field testing.

PISCES employs a total of five staff members (three full-time employees and two part-time employees) including a Program Director, Administrative Specialist, Operations Manager, Public Information Officer & Outreach Coordinator and Geology Technician.

The Board of Directors consists of nine members who provide guidance on mission-oriented initiatives and executive decisions for PISCES.

Chris Yoakum
PIO/Outreach Coordinator

Chris Yoakum serves the role of Public Information Officer/Outreach Coordinator, communicating agency news to the public while organizing and executing education and outreach events in the community.

Kyla Defore
Geology Technician

Kyla Defore is a three-time former PISCES intern who joined the team as a full-time Geology Technician in FY18. Defore is tasked with developing the agency's Materials Science research work for ISRU applications. She also oversees the Materials Science track for the Summer Internship Program, serving as a mentor for participating students.

Board of Directors

Henk Rogers, Chair
Senate Nominee
Term: 2014—2018

Vacant
Ex-Officio, Exec. Dir.
Term: 2013—present

Dr. Kim Binsted
Senate Nominee
Term: 2016—2020

Luke Flynn
Governor Nominee
Term: 2016—2019

Dennis Gibson
Governor Nominee
Term: 2018—2022

David Lassner
Ex-Officio, UH President
Donald Straney, Designated Alternative
UH Hilo Chancellor
Term: 2013—present

Luis Salaveria
Ex-Officio, DBEDT Director
Mary Alice Evans, Designated Alternative
DBEDT Deputy Director
Term: 2015—2018

Vacant
House Nominee
Term: 2014—2019

Patrick Sullivan
House Nominee
Term: 2014—2018

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