Have Starship, Will Travel

The Newsletter of the Tennessee Valley Interstellar Workshop

Issue 15
Sept 2018

TVIW 2018 Scholarship Winners

Tennessee Valley Interstellar Workshop (TVIW) is proud to announce the winners of the 2018 Scholarship Program.

Following a competitive process with many high-quality applicants with intriguing essays, three students were chosen as the recipients of the 2018 scholarships. With the support of Baen Books, Rob and Ruann Hampson, and The Vershall Roy Trust, TVIW will award these deserving students two undergraduate scholarships and one graduate scholarship.

Our winners are:

Crestienne DeChaine – Crestienne will be attending the University of Virginia. She attended the Virginia Aerospace Science and Technology Scholars (VASTS) program, which continued her lifelong fascination with rockets. She hopes to contribute to space exploration through Chemical Engineering.

Bhuiyan Rifat al hadi – Bhuiyan will be going to Georgia Institute of Technology in the fall, majoring in engineering. While he is in general Engineering at present, he is looking at Artificial Intelligence as a more specific field. He hopes to continue on to graduate school after his bachelors degree.

Patrick Gray – Patrick is our graduate student winner. He will be attending Duke University, working on a PhD in Marine Science and Conservation. His research will look at developing coordinated robotic frameworks in support of marine science and to prototype technology for future space missions, systems that can operate autonomously in hostile environments.

Patrick's essay is printed at the end of this newsletter on page 4 His essay discusses his research on building new remote sensing and robotic platforms and the artificial intelligence algorithms needed to support them.

To learn more about the TVIW Scholarship Program, contact Martha Knowles at knowlesme@tviw.us.

Learn more about TVIW online, and connect via social media:

Web: https://tviw.us
Facebook:
https://www.facebook.com/TNValleyInterstellarWorkshop
Twitter: https://twitter.com/tviwus
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Newsletter Contents

TVIW Symposium on the Power of Synergy
Oak Ridge, TN | October 23-25, 2018

This October the Tennessee Valley Interstellar Workshop, in collaboration with Rather Creative Innovations Group, is hosting a special Symposium at the Y-12 New Hope Center in Oak Ridge TN that will promote safe, fast, and affordable human development of our solar system – the first real steps to becoming an interstellar civilization.

We have exciting news about our Keynote Speakers! Morgan Smith, CEO of CNS/Y-12, will open the Symposium with a talk about the transformations of the past, leading to our new transformations to come from the Symposium. He will be followed by John Vonglis, Director of DOE ARPA-E, who will talk about the transformative concepts coming out of the DOE Advanced Research Projects Agency. On Day Two, Alan Icenhour, Associate Lab Director of ORNL for Nuclear Research, will open our day with a glimpse into the exciting areas that ORNL is pursuing.

Review of the Symposium Goals

Participants from NASA, DOE ARPA-E, Oak Ridge National Laboratory, the Y-12 National Security Complex, and several private companies are being tasked with the challenge of evaluating where we stand in proposing just such an infrastructure, one including permanent lunar colonies and human trips to Mars and asteroids. The symposium will implement a synergistic approach to space advocacy, linking critical technologies that will catalyze major human space activities by 2030. Ultimately, a Solar System infrastructure could be the staging ground for the human push throughout the solar system deep into the Kuiper Belt, then the Oort Cloud and, we can hope, beyond.

There is little understanding that technologies already exist that can enable dramatically more powerful energy sources and rockets, while making space development safe and profitable for humans. If combined synergistically with other breakthrough concepts, these technologies will greatly accelerate human progress in space. Proving this is the symposium's central motivation.

Participants in the symposium will be examining, for example, high-impulse nuclear propulsion, as studied in DARPA's Timberwind Program. Political issues always swarm around nuclear ideas, but high-performance technologies realized

through upper-stage nuclear rockets, initially fired only when they have reached Earth orbit or beyond, could allow faster transit times -- enough so to make human expeditions to Mars far more practical than currently envisioned. Going nuclear has major ramifications as well in implementing space solar power and cislunar commercial operations including manufacturing.

High-energy lasers are now being considered by Breakthrough Starshot as a way to propel small sailcraft with miniaturized payloads to the Alpha Centauri triple system. Closer to home, power beaming in space can help to build a transportation network in the inner system and incentivize exploratory missions to the outer planets. Likewise transformative are high-temperature superconductors, developed for several decades at Oak Ridge National Laboratory. Magnetically inflated cable (MIC) technologies can help in the construction of large space structures. Large-scale 3D printing, another ORNL specialty, points toward manufacturing capabilities using readily available materials in space that would be a necessary part of a permanent human presence.

Rounding out the list of enabling technologies are self-replicating Von Neumann machines, solar power satellites, and lightweight large-aperture optics. Can we reach the point where small machines can build larger ones out of abundant space resources found, for example, in nearby asteroids? For that matter, can we consider asteroids themselves, suitably modified by such means, as habitats safe from dangerous radiation from cosmic rays or solar storms?

Unless the national spirit of adventure and exploration that characterized the US space program from 1957 through 1970 can be revived, our next steps for human participation will proceed slowly, if at all. Instrumented research is proceeding, but movement of large numbers of humans beyond low earth orbit is still widely regarded as expensive, dangerous, and (given the great distances, long durations, and limitations of chemical rockets) not worth the effort.

The TVIW Symposium on the Power of Synergy will advocate aggressive near-term goals for accelerated space development, emphasizing how government and private industry capabilities can catalyze breakthrough progress. The choice of Oak Ridge as the venue focuses these issues. The vast capabilities of Oak Ridge National Lab and the Y-12 National Security Complex can rapidly lead to breakthrough nuclear reactors for space propulsion and power. The ORNL 3D printing initiative has already demonstrated manufacturing of full-sized self-driving vehicles with technologies suited to space industrialization using regolith dust on the moon or materials readily harvestable from near-earth asteroids. And the industrialization of superconducting magnetic materials can open new horizons for highly efficient space systems. The symposium will show how combinations of these capabilities can greatly accelerate space development.

TVIW Symposium on the Power of Synergy Speakers

John Mankins, National Space Society Board of Directors
Chair of Theme 1: The Case for Near-Term Humans in Space

Jason Derleth, NASA - NIAC Program Executive
Chair of Theme 2: Candidate Synergistic Technologies

Matt Hollingsworth, Entrepreneur from UT and Stanford
Chair of Theme 3: Transformative Decade Plan

Catherine Asaro, Physicist and SF author
Chair of Theme 4: Science Fiction to Science Fact Relationship/Ultimate Paths to the Future

Other speakers include Arlan Andrews, Engineer and SF author; Robert Bagdigian, NASA-MSFC Deputy Chief Engineer for Human Exploration; David Brin, SF author; Franklin Chang-Diaz, Astronaut and CEO of Ad Astra Rocket Company; Jonathan Witter, BWXT Technologies; Ruth Kastner, Philosopher of Physics, University of MD; Philip Lubin, Prof of Physics, UC Santa Barbara, Directed Energy Propulsion, NASA Starlight, Breakthrough Starshot; Marc Millis, Founder of the Tau Zero Foundation, retired NASA propulsion physicist; William Peter, Director of ORNL 3D Manufacturing Demonstration Facility; Allen Steele, SF author; James Powell, Physicist, retired from Brookhaven National Laboratory; and Joel Sercel, Physicist and founder of TransAstra Corp.

The Power of Synergy can link DOE, NASA, and formerly classified DOD technologies to get humanity into space quickly, and hasten instrumented probes to the stars.

Register at tviw.us/tviw-symposium-on-the-power-of-synergy/
(Fee includes breaks, lunches, and receptions)

Until October 1, 2018 (“Regular”): $200.00
Until October 23, 2018 (“Late”): $225.00

Dr. John D. G. Rather, Symposium Chair, jrather@RCIGinc.com

If you are interested in volunteering to help with the symposium, please contact Dean Hartley, dshartley3@comcast.net.

TVIW © RCIG

TVIW 2019 SIXTH INTERSTELLAR SYMPOSIUM AND INTERSTELLAR PROPULSION WORKSHOP

WICHITA, KANSAS | NOVEMBER 10-15, 2019

TVIW, in collaboration with NASA, will present its Sixth Interstellar Symposium on November 10-15, 2019, in Wichita, Kansas, hosted jointly by Wichita State University and Ad Astra Kansas Foundation. The first two and a half days will be the Interstellar Symposium, with all the great presentations you’ve come to expect. This will be followed by a workshop on Interstellar Propulsion, led by NASA and TVIW.

We will be at the Hotel at Oldtown, utilizing their conference facilities. A tour to the Cosmosphere, in Henderson, KS, will be available (date TBD). And the old favorites of a stellar program, the Sunday seminars (Nov. 10), the Hospitality Suite, and lots of time to talk to colleagues and new friends will be part of our symposium experience.

Check our web site for the Call for Papers. Other information (hotel, seminars, registration) will be coming soon.

For more information on the host or tour:

Wichita State University: http://www.wichita.edu/

Ad Astra Kansas Foundation - http://adastra-ks.org/

Cosmosphere - https://www.cosmo.org/

TVIW SOAPBOX

On May 18, 2018, TVIW officially launched a new initiative called Soapbox, which aims to tie together points of discussion directly relevant to the space community at large, and the interstellar community in particular. The first post on the section, "Paying for the Stars," concerns economic hurdles that exist before humanity can really reach for the planets and stars in earnest. It considers the critical contribution of trans-generational wealth-management practices in the near term to bring about lofty spacefaring goals, and how we might envision different economic models to overcome the barriers in our path. Two contributors, Armen Papazian (CEO of Finoptek) and author Nick Nielsen, provide an incredible amount of context and grounding for this inaugural article and we hope to see more such high quality posts from our contributors.

The posts are lightly moderated, there is no requirement to be associated with TVIW or with any other interstellar organization. We only require that there be no libelous content toward any individual or organization, that the articles have some meaningful connection to interstellar exploration, and that the language used not be profane. Submissions that don't meet these guidelines, or for which there is some question about their applicability, will be returned to the writer for modification. To submit content for a Soapbox post, just send a message to soapbox@tviw.us with the Soapbox content and title in the body of the message, and a subject of "Soapbox submission."

TVIW's vision for *Soapbox* is to provide a platform dedicated to thoughtful public discussion about plans to make definite, concrete steps to reach the ultimate frontier by whatever energy individually motivates us. Join us at the table. Let us know what you think. This is *your* Soapbox.

UPCOMING INTERSTELLAR AND SPACE EVENTS

September 25-27, 2018 (Boston, MA). NASA Innovative Advanced Concepts (NIAC) Program's 2018 Symposium will be held at the Omni Parker House Hotel.

October 1-5, 2018 (Bremen, Germany). 69th International Astronautical Conference (IAC2018).

October 21-26, 2018 (Knoxville, TN). AAS Division of Planetary Science 50th Annual Meeting. Website: dps.aas.org

October 23-25, 2018 (Oak Ridge, TN). TVIW Symposium on The Power of Synergy. Website: tviw.us/tviw-symposium-onthe-power-of-synergy/

November 2018 (Gloucestershire, UK). Initiative for Interstellar Studies: Definitive Conference on Interstellar Spaceflight. Website: I4IS.org

January 6-10, 2019 (Phoenix, AZ). 16th Conference on Space Weather, at the American Meteorological Society (AMS) 99th Annual Meeting.

January 13-17, 2019 (Ka'anapali, HI). 29th AAS/AIAA Space Flight Mechanics Meeting.

March 2-9, 2019 (Big Sky, MT). IEEE Aerospace Conference.

July 9-11, 2019 (Wales, UK). UK Space Conference 2019.

October 21-25, 2019 (Washington, DC). 70th International Astronautical Congress 2019.

November 10-13, 2019 (Wichita, KS). TVIW's 6th Interstellar Symposium. Website: tviw.us/

SEEKING INPUTS FOR UPCOMING ISSUES OF HSWT

We invite your contribution to this newsletter of nominally 200-500 words, written on an Interstellar topic that you think is of compelling importance, or a topic that you think that we may actually be overlooking.

Please send your submissions in MSWord format to Abby Sherriff, TVIW Newsletter Editor, and to Paul Gilster, TVIW Director at Large

abigail.sherriff@gmail.com

Paul.Gilster@tviw.us

USE AMAZONSMILE TO BENEFIT TVIW

An exciting opportunity to support the great work that TVIW is doing is to use the AmazonSmile program. Every dollar counts for non-profit groups. TVIW can benefit from each purchase you make at no additional charge to you. Amazon donates 0.5% of each purchase to the non-profit organizations of your choice and the TVIW is one of those organizations. This is a painless way to support us.

To participate, go to smile.amazon.com. Sign into your account and a "pop up" page will appear. On the right side of the page, at the bottom is a "search" window. Type in: Tennessee Valley Interstellar Workshop and click the search button. Click on the top one and you are done. Your donations will be automatic for any purchase within the Amazon Smile program (which is most merchandise). You can also use the following link.

https://smile.amazon.com/ch/46-4572727

PATRICK GRAY SCHOLARSHIP WINNING ESSAY

This essay was submitted by Patrick Gray as a part of his application for the 2018 TVIW Scholarship Program for the graduate level scholarship.

Introduction

In its simplest form, my research centers around building new remote sensing and robotic platforms, and the artificial intelligence algorithms to support them, that help answer the NASA Science Mission Directorate's fundamental Earth Science question: "How is the planet changing and what are the consequences for life on Earth?" Doing so is a complex and pressing task, yet the technical development and research breakthroughs that may lead from this work need not be isolated in the ivory towers of academia nor restricted in applicability to the study of Earth. My research vision is to use the ocean and Antarctic environment as a testbed, improving our understanding of our world and its incredible biodiversity, while proving out the platforms and technologies we will send to other planetary bodies and nearby stars.

My PhD work has three primary components. First is the application of novel and rapidly improving artificial intelligence algorithms to remotely sensed data. Satellites and observatories are our primary tool for understanding the composition of stars, asteroids, and exoplanets, but they are also the only way to comprehensively monitor our own world in real-time. It only makes sense to collaboratively push forward analysis capabilities using lessons learned in both fields. Second, I am developing new drone platforms and advancing the logistics for deploying drones in extreme marine environments such as the Southern Ocean and around Palmer Station on the Western Antarctic Peninsula. This work is advancing our knowledge of the Earth's polar regions and will support the critical need to advance the instruments and vehicles that will aid explorers on new worlds and help maintain long-term interstellar craft. The third and final objective of my PhD is to understand how the tools we use to monitor our dynamic oceans should be coordinated, using the multi-faceted Ocean Observatories Initiative as a case study. Satellites, long endurance aerial drones, and in-situ robotic assets, such as underwater vehicles and rovers, all supply necessary pieces of the puzzle to understanding our oceans. But how should they be coordinated, and how can they best complement each other? This is a question we must answer in order to effectively monitor our own world, and to doing so will help us decide what tools we will send out beyond it.

Drs. Kevin Hand and Chris German, from NASA Jet Propulsion Laboratory and Woods Hole Oceanographic Institute, put it well in a recent paper calling for more collaboration between planetary scientists and oceanographers: "Long before rovers carved tracks on Mars, scientists and engineers tested similar rovers in a variety of deserts here on Earth. Similarly, before we send robotic explorers to distant worlds, we will have the opportunity to test the platforms and instruments in analogous environments here on Earth. Robotic vehicles and instruments for planetary and ocean exploration will first be tested and utilized in Earth's ocean; and on, within and beneath Earth's cryosphere. Developing technologies for ocean exploration is a win–win for Earth science, planetary science and astrobiology. Clearly, much of the investment for the exploration of other planetary bodies could be leveraged to improve exploration capabilities here on Earth." (Hand and German, 2018)

Isolated ocean and polar environments provide the ideal space to quickly and cost-effectively test out the technologies, logistics, and psychological requirements for humanity to venture out into the cosmos, while simultaneously developing the systems and science that will ensure our current home remains healthy long into the future.

Research Components

I. Applying machine learning to remote sensing data

In order to build the critical mass of funding and support necessary for an interstellar mission, it needs a destination. Finding a destination will require advances in both our ability to see into other solar systems, and our ability to analyze what we're seeing. A more near-term task that will help boost us to another star, prospecting for resources in our own solar system, has similar requirements: remote sensing advances on our satellite platforms and an increase in the amount of data we're able to process rapidly. Before setting sail beyond Sol, we will need to understand what resources are contained within our own system and at our destination. An early step in this process, a major component of my PhD funded by NASA's North Carolina Space Grant, and the focus of my next 6 months, is to develop a deep learning based convolutional neural network to identify objects of interests, such as whales, ice floes, and mineral deposits, on the Western Antarctic Peninsula from satellite imagery.

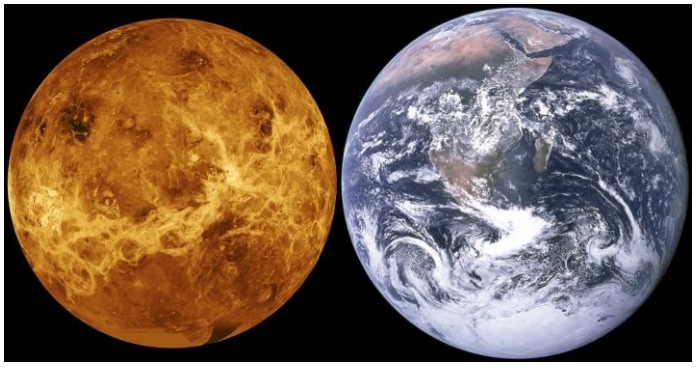

Figure 1. Earth and Venus to scale: satellite remote sensing allows us to better understand our own planet and our neighbors near and far. Photo Credit: NASA / JPL.

Technological trends within satellite remote sensing toward higher spatial and spectral resolution, faster revisit rates, and increased data availability to researchers are permitting novel projects such as space-based observation of whales, monitoring individual ships, and monitoring vegetation or mineral change in real-time (Fretwell et al., 2014). With satellite spatial resolution now sufficient to detect these small objects of interest, the sheer area of ocean is an obstacle. Our inability to process this amount of data is hampering effective management, for example, preventing population level insight of endangered species or blocking proper situational awareness of sea ice to ensure maritime safety in the Southern Ocean. New analysis techniques beyond manual inspection are required.

Convolutional neural networks (CNNs) are a subset of deep learning, inspired by the neural connections in the human brain, that have been particularly successful in analyzing imagery (LeCun et al., 1999). Beginning with computer vision and image processing, CNNs are now powering advances in research and industry ranging from exoplanet detection to natural language processing to pharmaceutical discovery. CNNS are a promising

detection method and make it feasible to continuously analyze large spatial expanses of our ocean or other planetary bodies.

My research group, the Duke Marine Robotics and Remote Sensing Lab, has significant expertise in geospatial analysis and oceanographic remote sensing. I have the support of the lab's resources and expert personnel throughout this project. This work is also facilitated by my lab's membership in the Palmer Antarctica Long Term Ecological Research (LTER) program, by access to WorldView-3 satellite imagery at two-week intervals from the Polar Geospatial Center, and by access to weekly Planet satellite imagery as a member of the Planet Research and Education Program.

II. Building new drones and autonomous systems

NASA recently announced it will be sending a small drone, the Mars Helicopter, to the Red Planet along with the Mars 2020 Rover. Another drone mission, Dragonfly, is in the final selection round of NASA's New Frontiers program to explore Titan from the air. NASA has already deployed its SPHERES robots to the ISS, semi-autonomous drones that aid astronauts with tasks and allow remote researchers to access the Station. The next generation of SPHERES, Astrobee, is planned for launch in 2019. Small platforms, both remote controlled and fully autonomous, capable of operating in harsh environments from the Martian atmosphere to hard vacuum, will be critical for exploring new worlds and maintaining large scale spacecraft that could sustain life on the journey to another star. They will be vital for ensuring safety of both humans during extra-vehicular activities (EVAs) and the health of the spacecraft.

Figure 2. Astronaut Scott Kelly and NASA's SPHERES semi-autonomous robots. Photo Credit: NASA.

The second component of my PhD, and a project that just received full funding from the Wildlife Conservation Society, is to develop an aerial drone platform that is capable of locating and tracking a single radio signal and navigating to that radio signal in order to rapidly download data that is contained at a sensor at that location. Our specific use case is to find animals such as birds, insects, and small mammals that have been tagged with a complex sensor package to better understand their ecology. These sensor packages are often too small to include a satellite transponder to connect to GPS or uplink the data to satellite, thus needing a local uplink, such as a nearby drone, to act as the data mule. The parallels of this system to resource prospecting and atmospheric exploration on other planets is incredibly exciting.

Our work will support critical conservation priorities here on Earth, endangered birds in Southeast Asia and threatened seals in the Antarctic are the first two study species. Our modular system of flight-proven open-source components will allow future scientists and engineers to further develop this system and pull useful modules into their own work. Success here will prove out another use of autonomous aerial systems and open the door for future applications.

One potential use case would be during the deployment of a large number of low-cost, non-guided, in-situ sensors over a low gravity asteroid where they bounce to disperse across a large study area. Replacing the need for comprehensive coverage from an orbiting satellite, a small autonomous craft could zero in on signals from these dispersed sensors and act as a data mule for the information collected by these small robots.

Another use case could be a similar deployment of low weight, highly energy efficient, floating sensors in the oceans of Titan or Europa. Making these sensors small and low power increases the number that can be brought on a single mission. A single aerial drone could provide uplink capability that would otherwise be limited without numerous orbiting craft and could solve the communication issues inherent in a thick atmosphere such as Titan's by flying low to collect data and flying high for uplink back to an orbiter or communication relay in deep space.

Finally, this category of platforms, tested on Earth and in low Earth orbit, will likely be the predecessors for a new generation of maintenance drones, similar to NASA's Astrobee, that will be critical for maintaining large spacecraft and preventing human residents of an interstellar craft from needing to do frequent, high risk, EVAs. This work is part of a larger movement to provide explorers and future astronauts with semi-autonomous robotic assistants and it is incredibly exciting to see the advances in intelligence, power storage, and sensor technology of the last decade that are making these robots an enabler for humans to live in and explore new environments.

III. Coordinating across different levels of remote sensing and robotics

When building technical systems for exploration, whether it is Antarctica, Europa, or TRAPPIST-1e, no single platform will be sufficient to understand whether or not that area has useful resources, contains life, or could potentially support it. The final component of my PhD is building out our understanding of how different remote sensing platforms, in-situ robots, and human operators should coordinate their work, both for studying our oceans here on Earth and for planning what we will send into the cosmos.

The Ocean Observatories Initiative (OOI) is a suite of instruments and platforms that study the physical, chemical, biological, and geological properties of the ocean (Smith et al., 2018). The OOI merges monitoring across domains from satellites gathering oceanographic scale data on a daily basis, to deep-sea platforms focused on a single hydrothermal vent, to ship based scientists conducting more varied and complex sampling but only for short periods. Given the expense and risk of sending new platforms out beyond Earth's gravity well, systems like the OOI provide an ideal testbed for coordinating the role different robotic systems can play, understanding where humans are still necessary, and prototyping new technologies. My specific work with the OOI uses multispectral satellites, long endurance drones, and oceanographic gliders to track great whales across the Southern Ocean. In this system, which is still being developed, satellite imagery, analyzed by a CNN, will be used to map whale locations at a weekly time step. Oceanographic gliders are underwater robots that can stay out in the field for months at a time with a wide array of sensors.

The satellite data will guide gilders to whale location hotspots where the gliders will collect environmental data and use acoustic sensors to locate whales that may be miles from their initial satellite derived location. The gliders will pinpoint the whale locations and communicate this in real-time to a swarm of aerial drones which will rapidly arrive to collect imagery of the whale pod and microbiome health data from the breath of the animals. This system is being funded as a part of the National Science Foundation's Palmer Antarctic Station ecological research directive and is setting the stage for further integration of different robotic systems and increasingly complicated coordination between platforms.

As we begin to implement the next generation of long-term semi-autonomous monitoring systems across our own solar system and decide what we will equip spacecraft with for long duration human spaceflight, understanding the tradeoffs among different technologies, and where humans fit into the system, will be of the utmost importance. The expense and risk of testing these tradeoffs in space is simply not tolerable in our current political and financial climate.

The need to test these systems in our oceans draws up a romantic quote written by the Antarctic explorer Ernest Shackleton nearly a century ago. "Unlike the land, where courage and the simple will to endure can often see a man through, the struggle against the sea is an act of physical combat, and there is no escape. It is a battle against a tireless enemy in which man never actually wins; the most that he can hope for is not to be defeated." While this was true at the turn of the 20th century, it is no longer the case. We now have the means to endure, survive, and thrive on the sea for indefinite periods of time. Technologists are planning out long term "sea-steading" communities and we travel from pole to pole without issue. This transformation in our capability to thrive on the world's oceans came from constant testing, rapid iteration, and the relatively low cost of failure of any specific vessel or platform design. Now in the 21st century, Shackleton's quote stands true not for humans on the sea but for humans in space. And it is with many of the lessons we are learning today from the incredibly diverse array of platforms, ships, and robotic systems, all working together to ensure the safety of the maritime world and help us understand its dynamic nature, that we can bring the same reality to human life in space.

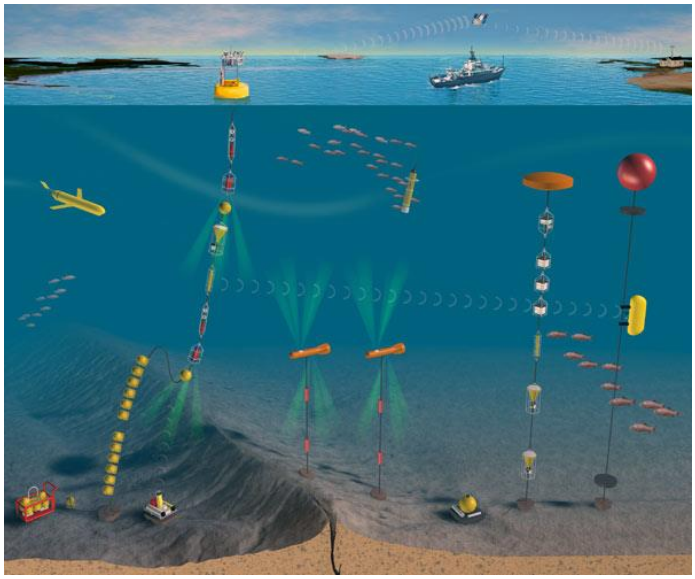

Figure 3. The Ocean Observatories Initiative's many robotic components. Photo credit: Woods Hole Oceanographic Institute

Conclusion

Finishing up with another quote from Hand and German "We should leverage the scientific and technological lessons learned from both Earth and planetary exploration. Moving forward, the opportunity to make great discoveries in our ocean and beyond will be advanced best by a shared vision for exploration." (Hand and German, 2018) I believe this shared vision for exploration is absolutely possible, has growing momentum from the scientific community, and will take us to the stars. Beyond that, we must maintain our own world in order to succeed in our interstellar ambitions.

This grant will provide vital funding for me to attend ocean and space focused to conferences presenting my work and learning from both communities. It will additionally support my time over the coming months as we develop novel drone platforms to explore the Antarctic. I am thrilled at the opportunity to represent TVIW at these conferences and in the platforms we build, communicating our shared vision, and working towards an interstellar future together.

References

Fretwell, P.T., Staniland, I.J., Forcada, J., 2014. Whales from space: Counting southern right whales by satellite. PLoS One 9, 1–9. https://doi.org/10.1371/journal.pone.0088655

Hand, K.P., German, C.R., 2018. Exploring ocean worlds on Earth and beyond. Nature 11, 2017–2019.

LeCun, Y., Haffner, P., Bottou, L., Bengio, Y., 1999. Object Recognition with Gradient-Based Learning 319–345. https://doi.org/10.1007/3-540-46805-6_19

Smith, L.M., Barth, J.A., Kelley, D.S., Plueddemann, A., Rodero, I., Ulses, G.A., Vardaro, M.F., Weller., R., 2018. The Ocean Observatories Initiative. Oceanography 31, 16–35.