SPRING 2021

MESSENGER

MECHANICAL ENGINEERING | UNIVERSITY of WASHINGTON

Lessons in the deep, *Pages 8-9*

CHAIR'S MESSAGE

Overcoming barriers

I write this message as the search continues for the next chair of UW ME. Delayed, deferred and disrupted are words that characterize a lot of things this year. But as the first place in the nation to feel the impacts of COVID-19, we can also look back and take pride in the scientific leadership and thoughtful decision-making that has defined the UW's response.

I can't overstate how impressed I am by what our students, faculty and staff have accomplished. Since the pandemic began, we have taught nearly 175 courses and held thousands of hours of class remotely. This June more than 300 students will receive their hard-earned diplomas. Though we've missed seeing them fill the halls this year, just like the students before them they will move to the next stage of their professional lives prepared to succeed by the skills, experiences and relationships they've acquired here at the UW.

This issue features the story of one of those students, Trevor Harrison, whose doctoral studies exemplify the hands-on, team-focused and societally driven nature of our department's work. You'll also hear from the ME student clubs and how they've adapted to the limitations necessitated by the pandemic.

Other stories highlight the promise of VR for human health, an alumnus who has helped support and shape the future of the department, and a dive into carbon fiber composites — a topic of great significance as ME plays a leadership role in building the new Advanced Composites Center. The ACC will make the UW the focal point of an international hub for composites research and workforce development.

I hope that you and those you care about are staying safe and seeing brighter days ahead. Enjoy the issue.

Per Reinhall
Mechanical Engineering Chair

Innovation challenge winners

Congratulations to ME's winning teams in the 2021 health and environmental innovation challenges, hosted by the UW Buerk Center for Entrepreneurship.

Hollomon Health Innovation Challenge

Under Pressure
A non-invasive blood pressure monitor for the operating room.

Fenwick & West Third Place Prize

Mask Seal Testing
A new test that uses thermal imaging to check for leaks in masks worn by healthcare workers.

Jim & Timmie Hollomon Best Idea for Pandemic Preparedness

OsmoProcessor
Improving urine sample diagnostics for low-resource settings.

Cambia Grove Best Idea for Addressing Health Access and Disparities Prize

EVBreathe
A new device that automatically deploys and navigates a patient's airway.

Herbert B. Jones Foundation Best Idea for a Medical Device

Direct Dose
A new device for reducing opioid use and improving pain management following spine surgery.

Connie Bourassa-Shaw Spark Award

Alaska Airlines Environmental Innovation Challenge

Clear Ascent
An aerospace startup focused on developing hydrogen fuel cell-based propulsion units for industrial transport.

Climate Challenge Prize

New research projects

NIH backs effort to RESTRICT the spread of HIV

The National Institutes of Health (NIH) awarded funding for the continued development of the REverSe TRanscrIptase Chain Termination (RESTRICT) assay, a test designed to reduce the impact and spread of human immunodeficiency virus (HIV).

ME faculty: Jonathan Posner, Ayokunle Olanrewaju

CREATE and I-LABS team up on access, mobility and the brain

The Center for Research and Education on Accessible Technology & Experiences (CREATE) is partnering with the Institute for Learning & Brain Sciences (I-LABS) on a project to study the importance of mobility technology to brain development in young children.

ME faculty: Kat Steele

DOE boosts marine renewable energy research

Two projects funded by the U.S. Department of Energy (DOE) will dive deep into the dynamics of marine energy turbines and build a model to unify factors affecting the performance of wave energy systems.

ME faculty: Brian Polagye, Steve Brunton

NASA selects futuristic space concept for further study

The NASA Innovative Advanced Concepts (NIAC) program selected a feasibility study that will examine whether a structure small enough to fit inside the nose of a rocket could expand large enough to create artificial gravity.

ME faculty: Jeffrey Lipton

Department news

Acting assistant professor **Ayokunle Olanrewaju** was named to the inaugural class of Black Trailblazers in Engineering (BTE) Fellows and included in Cell Mentor's list of 1,000 inspiring Black scientists.

Associate professor **Kat Steele** was selected as one of the 2020 Disabilities, Opportunities, Internetworking and Technology (DO-IT) Trailblazers for her work ensuring information about disability, accessibility and universal design is included in engineering curriculum.

Graduate students **Trent Dillon** and **Katherine Van Ness** won Marine and Hydrokinetic Graduate Student Research Program Fellowships from the U.S. Department of Energy.

Graduate student **Elizabeth Rasmussen** was awarded a fellowship from the NIST-NRC Research Associateship Program overseen by the National Academies of Sciences, Engineering and Medicine.

Senior **Kaylene Pang** was selected as a Mary Gates Research Scholar, received the Office of Minority Affairs & Diversity Scholar Athlete Award and was named to the All-Pac-12 Second Team for her performance in Women's Soccer. She has played every minute of every game for the past three seasons.

Junior **Lily Vu** received the 2020 Outstanding Engineering Peer Educator Award from the UW College of Engineering.

First-year student **Merrill Keating** was named GeekWire's January 2021 Junior Geek of the Month.

Get further details on these stories and more by visiting **me.uw.edu/news** or following **@ME_at_UW** on Twitter.

Remembrance

Professor Emeritus Kurt Galle

Professor Galle taught instrumentation and control courses and served the department and its students tirelessly for 23 years before he retired in 1983. Among many contributions, he was a pioneer in introducing ME students to the intersection of engineering and medicine and helped develop the UW Bioengineering program. He passed away on December 12, 2020.

Clubs during COVID

The pandemic has forced ME's student-led clubs to break from many long traditions and creatively adapt. Initially they were required to work remotely, but the department put a student club access process in place last September, allowing a limited number of critical team members to return to their workspaces by following a set of safety protocols. Here's what they've been up to:

HuskyADAPT

HuskyADAPT fosters community around accessible design and play technology with a focus on accessible design projects, K-12 outreach and toy adaptation. This year, the club adapted to a virtual format and student design teams worked on projects to keep Seattle Children's Hospital patients active during their stay, created toys for individuals with Autism Spectrum Disorder, and developed low-cost mobility devices. The club hosted virtual workshops on modifying toys to make them accessible to individuals with disabilities, distributed free adapted toys via contactless donation events, and continued to initiate conversations about accessibility, ableism and universal design with virtual lecture events.

depts.washington.edu/adaptuw

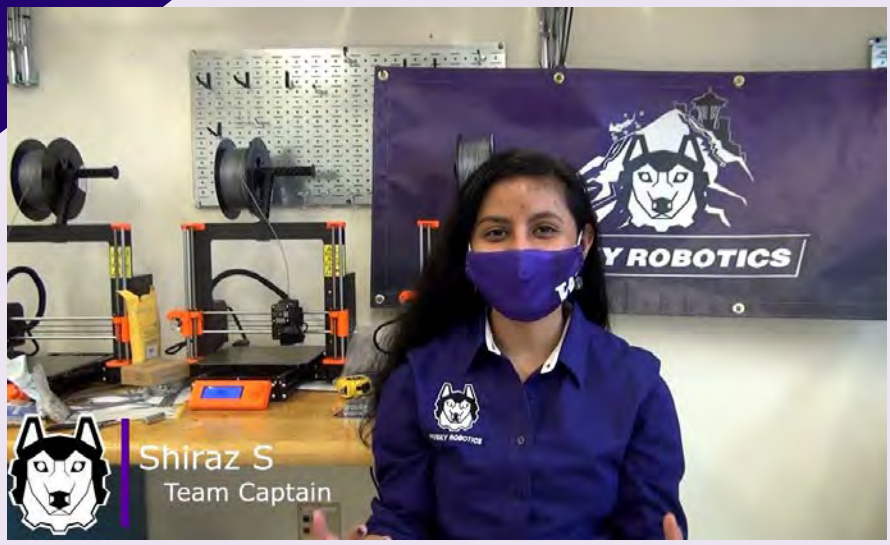
(Left) Organizations interested in receiving adapted toys for individuals with disabilities can contact HuskyADAPT. Photo by Nicole Zaino / HuskyADAPT

Human Powered Sub

Since 1989, the UW Human Powered Sub (HPS) team has designed, built and raced a human powered submarine at the International Submarine Races. Due to COVID-19 the team's annual competition was converted to a virtual platform for two years. UW HPS scored first place in the 2020 design report challenge and hope for another strong showing this year. Hands-on work has been limited, but with the shift in reopening phases the list of personnel allowed in the shops and workspace has gradually expanded. When conditions allow, the teams says they'll be ready for the next in-person competition.

uwhpsub.com

The UW Human Powered Sub team has begun work on Orca, a new craft they've designed with a sustainability focus. Image courtesy of UW HPS



ME student and team captain Shiraz Shahukar helped lead Husky Robotics as they improved their Hindsight rover this year. Image courtesy of Husky Robotics

Husky Robotics

Husky Robotics designs and builds Mars Rovers to compete in the international University Rover Challenge Series. This past year the team decided to continue improving the Hindsight rover it had begun before the pandemic. The team worked remotely and eventually with safe access to its new lab space the rover's systems have made good progress. Though the 2021 University Rover Challenge was canceled, team members hope to compete in the Canadian International Rover Challenge this August in Drumheller, Alberta.

huskyrobotics.me

Formula Motorsports

UW Formula Motorsports has designed, built and competed internationally with a Formula SAE race car for 32 years and was ranked the number one FSAE Electric Race Team in the U.S. in 2019. In 2020 FSAE held virtual competitions and the UW team won their design competition. Following safety protocols, the team stayed busy machining parts, assembling and validating systems, and putting it all together. Team members plan to unveil their new vehicle soon and hope to compete in an in-person validation event tentatively scheduled for June in Las Vegas, Nevada.

uwformulamotorsports.com

UW Formula Motorsports has been busy preparing to compete in FSAE's competitions. Photo courtesy of James Carskaden / UWFM

EcoCAR

The UW EcoCAR team is one of a dozen dedicated teams competing over four years on improvements to the energy efficiency, safety and consumer appeal of a 2019 Chevrolet Blazer. COVID-19 limitations put their original timeline behind schedule, but this year select students returned to work on the car while others worked remotely. As they near the end of the competition's third year, they've successfully completed several test drives of their vehicle and are excited to compete in a virtual competition at the end of May.

uwecocar.com

Hyperloop

Based on a form of rapid transportation first popularized by Elon Musk, Hyperloop teams compete to design and build the pod that travels fastest down a mile-long vacuum tube. The UW team placed first in the U.S. during the 2018 and 2019 SpaceX competitions, but since 2020 the competition has been put on hold. Through virtual collaboration and limited workspace access, the team is on track to finish their hyperloop pod prototype to compete in the European Hyperloop Week competition this July in Valencia, Spain. The team can't attend in person due to travel restrictions, but it is finishing a 30-foot aluminum test track to remotely compete.

hyperloop.io

Support the student experience

Student clubs rely on alumni support. Visit the websites listed in this story to learn how you can help.

The carbon fiber state

How Washington became a global epicenter for advanced carbon fiber composites

By Andy Freeberg

Stronger than steel and lighter than aluminum, carbon fiber materials are one of the key enabling technologies of the 21st century. They play an especially important role in Washington, the world leader in carbon fiber composite manufacturing. Just as silicon is the material that underlies the innovation ecosystem of Silicon Valley, so carbon fiber is to the state of Washington.

Advances in air travel, renewable energy, space exploration, transportation and many other industries rely on their growing use. As the state's top research institution, the UW is a leader in carbon fiber innovation — and in understanding its impacts on public health, safety and the environment. UW research promises breakthroughs in improved manufacturing techniques, better standards and validations, and support for the transition to more sustainable and versatile versions.

"Anything where quality and weight matter, these have become the materials to use," says ME professor Santosh Devasia, who directs the Advanced Composites Center (ACC), a new initiative dedicated to advanced composites research and education.

What is a carbon fiber composite?

The materials typically thought of as carbon fiber, whether in road bikes or airplane hulls, are really carbon fiber composites and are made up of two main parts: the threads of carbon themselves, and a matrix, which is the material binding them together.

First discovered in the 1960s, carbon fiber composite materials combine the strength of a metal with the weight of a plastic, though the truth is more complicated.

"With carbon fiber you have to know the direction your load will be applied and embrace the way you align the fibers to withstand that force," says Marco Salviato, associate professor of aeronautics and astronautics and an ACC co-director. "And in terms of the matrix, even molecular-level differences in the polymer and process that you use really matter."

Carbon fiber comes to Washington

It was clear soon after carbon fiber came out of the labs that these materials were special. But even though they rely on cheap and abundant resources, they remain relatively expensive since the process of making them involves heat, pressure and quite a bit of quality control.

The first products to widely use carbon fibers were sporting equipment like tennis rackets, golf clubs and skis, but by the 1980s the processes and materials had improved and aviation quickly became the dominant application.

Above: The front section of a Boeing 787 aircraft being fabricated from carbon fiber composites. Photo courtesy of The Boeing Company

Left: Carbon fiber used for building the Boeing 787 aircraft. The fiber is combined with a matrix that binds it into the durable composite material commonly called carbon fiber. Photo courtesy of The Boeing Company.

Here in Washington, The Boeing Company began using carbon fiber in various components and gradually an entire supply chain sprung up. At 50% composite by weight, the 787 aircraft raised the bar and showed the world what could be done. Salviato says every 1% shaved off the mass of a plane can reduce up to 3,200 tons of carbon dioxide emissions over its lifespan, the equivalent of taking 700 passenger vehicles off the road for a year.

But aviation is only one of many industries relying on these materials. Just as Silicon Valley had Apple, HP and Intel, Washington has several major companies invested in advanced carbon fiber including Blue Origin, Toray, SGL Carbon, PACCAR and Electroimpact. There are currently an estimated 1,400 companies and 130,000 jobs in the state that involve advanced composites.

Still, researchers say there's a long way to go to improve carbon fiber composites, particularly when it comes to manufacturing and recyclability.

UW's role in the carbon fiber ecosystem

To support and drive the future of carbon fiber and related materials, the UW is constructing a new 16,000 square foot facility north of campus at Magnuson Park to house the ACC. A priority for the center will be better use of data to guide the way composites are manufactured.

"Compared to metals, the properties and performance of advanced composites involves a lot more variability and uncertainty," says Navid Zobiery, assistant professor of materials science and engineering. "Data-driven approaches can enhance our understanding of this complexity and will be crucial in the stride toward high rate and automated fabrication methods that will make them cost effective for energy, automotive and other evolving markets."

Another concern is replacing materials that use a thermoset matrix — which once set is almost impossible to alter, recycle or mend — with a thermoplastic matrix.

Thermoplastic carbon fiber materials have many of the same properties as their thermoset cousins, but by heating them up they can be re-shaped and re-worked.

"As these materials become more commercialized, we have a responsibility to think about what happens when they reach the end of their lifetime," says ME professor Junlan Wang, who also co-directs the ACC. "Thermoplastics offer a path to recycling and come with benefits like the ability to weld, contour and use additive manufacturing techniques."

Researchers say one of the biggest benefits of the ACC will be acting as a hub for setting standards, validating ideas and growing the ranks of engineers experienced in these materials. UW engineers already work with the materials regularly, using them for device prototypes, student clubs like Formula Motorsports and UW Hyperloop, and an array of research projects. Those opportunities will greatly expand when the ACC is finished, cementing Washington's role as a world leader in carbon fiber for years to come.

Learn more about the ACC at
depts.washington.edu/uwacc

Above: Students on the 2019 UW Hyperloop team work on fabricating their carbon fiber pod. Photo date 5/6/19 by Mark Stone, University of Washington

LESSONS IN THE DEEP

One student's journey to build a swarm of robotic devices for underwater mapping

By Andy Freeberg

The path to Trevor Harrison's Ph.D. reached its climax in the rushing waters of Agate Pass, a narrow tidal strait northwest of Seattle. There the strong flowing currents provided the greatest test yet for a swarm of robotic sensor packages he's developed to make 3D maps of dynamic underwater environments.

He calls his inventions µFloats (pronounced "microFloat" using the scientific prefix of the Greek letter *mu*).

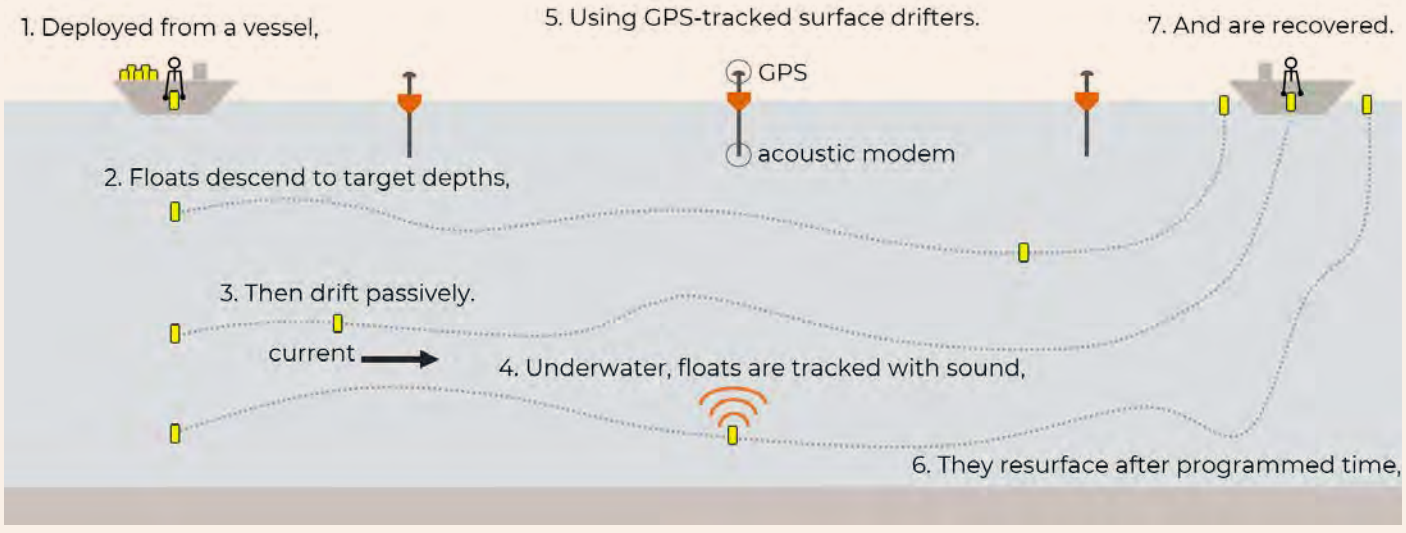
The floats are cylinders, roughly two feet long and 11 pounds each, built to do three things: adjust their buoyancy to dive to certain depths, drift with the currents, and gather data such as water speed and temperature from the environment around them. Getting quality data of this kind is currently difficult and costly for researchers who need to understand the characteristics of a particular location, such as for estimating the potential power production and environmental impacts of a tidal energy project.

Now, five years after his first prototype hit the water, Harrison has validated the µFloats as a new technology for surveying tidal flows and coastal environments.

FROM PHYSICS TO MARINE ENERGY

Harrison's undergraduate degree is in physics but while working as a research technician at the Woods Hole Oceanographic Institution he decided to switch to engineering.

"I saw scientists building cool oceanographic instrumentation and was captivated," he recalls. "I knew I wanted to go back to school to do something that felt more tangible, so I was looking for areas with a societal and sustainability impact."



How the µFloats work. Image by Trevor Harrison

He decided marine renewable energy fit his aspirations and joined ME associate professor Brian Polagye's lab as a graduate student in 2013.

There, he learned about the need for better maps of tidal and river environments to help determine the best places to put renewable energy systems like tidal power plants or in-river turbines. Tim Mundon, Vice President of Engineering at Oscilla Power and an affiliate faculty member in ME, proposed that a swarm of low-cost, free-floating sensors could be a way to improve resource maps. These are critical because even a small difference in the estimated speed of the currents means a large difference in how much electricity a site can potentially generate.

"I took the idea and ran simulations that indicated that if you could put 20 to 50 sensors into the water, that'd be enough to generate a reasonably good 3D map," says Harrison.

DESIGN ITERATIONS

For the initial µFloat prototype he challenged a student capstone team to develop a "buoyancy engine" — a device that can adjust whether it sinks or floats.

The team hand-built a hollow tube with a large piston attached to a motor and computer. As the piston moved into the device, it became dense and sunk, as it moved out again, it created a hollow cavity and floated back to the surface.

In 2017, Harrison received support to do cooperative research in Australia with Matthew Dunbabin, a professor of electrical engineering and robotics at the Queensland University of Technology (QUT).

"I flew to Australia with a half-built float," he remembers. "I still had to put together the full package of sensors and controls and build out a communication system."

He succeeded and back in Seattle, with a functioning µFloat in hand, the progress was enough for teammates from the Pacific Marine Energy Center (PMEC) and UW Applied Physics Laboratory (APL) to secure funding from the Office of Naval Research to build a fleet of 30 floats.

DEPLOY, RECOVER, DEBUG, REPEAT.

Harrison and the µFloat team began testing the swarm of floats in Lake Washington and the tidal waters of Sequim Bay in 2019.

Following each outing, the µFloat data improved, building towards the key deployment at Agate Pass. There they would collect data from the µFloat swarm while Jim Thomson, an oceanographer at APL and civil and environmental engineering professor, gathered data in more traditional ways. A comparison between the two surveys would indicate how accurate and effective the µFloats are in practice.

Over the course of two days at Agate Pass, the team repeatedly deployed and retrieved the floats, amassing 340 drifting paths of tidal flow observations. One of the 20 µFloats went missing, but Harrison got a hefty dataset for the last chapter of his dissertation. As far as he's concerned, the trip was a success.

Having defended his Ph.D., Harrison will continue to explore µFloat applications with APL and through MarineSitu, a marine instrumentation company spun out of the UW.

He credits teamwork for every step of his journey.

"A lot of life happens in eight years. I benefited so much from the amazing people and facilities at the UW. I never would have gotten to this point without a ton of collaboration and support."

Learn more and watch videos of µFloat deployments at **me.uw.edu/news/microfloat**

Above: Harrison tosses a µFloat into Sequim Bay during a test deployment. Photo by Paul Murphy

Opposite page: Trevor Harrison holding his µFloat (pronounced "microFloat"). Photo by Mark Stone

ALUMNI SPOTLIGHT: Anders Brown

The Tegria managing director, ME alumnus and outgoing chair of the department's External Advisory Board (EAB) tells his ME story and explains why the EAB is excited about the future of the department.

Why did you originally choose ME and how did you end up reconnecting with the department?

It started with a talent for math and science, but as I got deeper into mechanical engineering, I found I enjoyed it more and more — so much that I stayed on and got my master's degree working with ME professor Joseph Garbini on systems and controls. After my master's I became enthralled with the software industry of the mid-90s — in particular, the new ways software could be applied to business. That led me first to Microsoft and then to entrepreneurship — starting a consulting company that built software systems for large companies.

When I moved back to Seattle to work at Microsoft, I reached out to Professor Garbini. That eventually led to an invitation to join the EAB. Around 2017 I had the idea we should build the EAB up and do more. We have this huge Seattle ecosystem, tons of passionate alumni and a great department that can plug things together. I talked to Professor Reinhall and he asked if I'd be willing to lead that effort myself, and here I am.

What is the EAB doing and how does it affect the department?

We've set ourselves up into committees to focus on three specific areas. One is recruiting and governance for the EAB itself — managing the board and making sure we're organized to be successful. The second is industry engagement. Seattle has such an incredible set of industry players; how do we plug that into the department? The last committee, promotion and advocacy, is focused on making sure we tell the right story to the state and the nation about the value of mechanical engineers.

Do you have any advice for alumni thinking about getting more involved?

Anything matters — time, talent or treasure. Pay attention to what's happening on campus. Never underestimate the little things and remember that reflecting your energy and passion to young people is incredibly meaningful. For me it stems from a love of engineering and academics, but it's a lot of fun, too.

Stay connected. Get involved.
me.uw.edu/alumni

Four virtual worlds and the future of VR for health

ME senior research scientist Hunter Hoffman has been studying virtual reality (VR) in health settings for two and a half decades. Here we highlight four of the applications Hoffman and his collaborators have developed and tested at the UW to help illustrate how VR can offer health care "worlds" of possibility.

SnowWorld: VR for pain

The primary thread of Hoffman's work is using VR for pain treatment, which he and UW pain researcher David Patterson were the first to discover and scientifically test. Today studies by researchers across a range of scenarios have demonstrated that VR can dramatically reduce pain, discomfort and the need for opioids by distracting patients during procedures like burn wound treatment or minor surgery.

SpiderWorld: VR for therapy

VR can offer a safe space for patients to confront things that cause them emotional pain in the physical world. SpiderWorld was designed to test whether VR could help people overcome arachnophobia. Under a therapist's supervision, a patient gradually approaches an object or situation that causes them distress until they eventually overcome their fear.

World Trade Center World: VR for trauma

Like SpiderWorld, World Trade Center World was created to treat patients using gradual VR exposure therapy. In this case the world was designed for post-traumatic stress disorder (PTSD) following the September 11th terrorist attacks.

RiverWorld: VR for mindfulness

A collaboration with renowned UW clinical psychologist Marsha Linehan, Mindfulness RiverWorld is an attempt to bridge Linehan's therapeutic treatments with Hoffman's VR techniques. In RiverWorld, VR helps patients with anxiety, depression and conditions like borderline personality disorder maintain attention while they learn effective mindfulness skills.

These virtual worlds and their associated research have inspired growing applications of VR as a health and wellness solution and represent only a few examples of how virtual technology is improving medicine. With the latest headsets getting cheaper and better each year, Hoffman says opportunities for collaboration and innovation are greater than ever.

Read more about Hoffman's work at **me.uw.edu/news/VRworlds**

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2021 GRADUATION

This year ME awarded nearly 160 bachelor's, 130 master's and 20 doctoral degrees to the ME class of 2021. The graduation ceremony was held in a live virtual format, and the department appreciates the friends and family who came together to celebrate.

A special thank you to this year's graduation speaker, Bich Le. As the Senior Vice President and General Manager of Ultrasound and Head of Precision Diagnosis Ventures at Philips, Bich leads an international team of 4,500 people dedicated to improving health care access, technology and services.

Bich shared her personal and engineering path with this year's graduates — one that has taken her to many different corners of the globe to understand the real-world aspects of advancing health outcomes through engineering and business innovation.

Thank you, speakers

Chair's Distinguished Industry Lecture Series:

Justin Brynestad (BSME '03), Blue Origin; Ellen Lee, Ford; Robyn McLaughlin, Microsoft; David Kim, Apple

Boeing Advanced Research Center Seminar Series:

Marvi Matos Rodriguez, Boeing; Sayata Ghose, Boeing

Leadership Seminar Series:

Anders Brown (BSME '92, MSME '94), Tegria; Steve Chisholm (BSME '86), Boeing; Lesley Low (MSME '98, PhD '02), Boeing; Erin McCusker, LIXIL; Beverly Wyse (BSME '85, MBA '05), Boeing; Sally Jewell (BSME '78), The Nature Conservancy; Nyle Miyamoto (BSME '91), Boeing; David Song (PhD '08), Blue Origin; Davide Ricci, Novo Nordisk

Department Seminar Series:

Travis Lange, SLAC National Accelerator Laboratory; Kamili Shaw, NASA Stennis Space Center; Eleftheria Roumeli, UW Materials Science & Engineering; Krishna Nadella, Vesicus; Brian K. Spears, Lawrence Livermore National Laboratory; Neera Jain, Purdue University; W. Hong Yeo (MSME '08, PhD ME '11), Georgia Institute of Technology, Martin Thuo, Iowa State University; Mona Eskandari, University of California, Riverside

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