Backstory

Bridging the gap – University, startup, and industry partnership to destroy per- and polyfluoroalkyl substance (PFAS) forever chemicals

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As collaborators, we were recently selected for a research grant from the Strategic Environmental Research and Development Program (SERDP), which is a subagency below the Department of Defense, the Environmental Protection Agency (EPA), and the Department of Energy, that funds basic research on promising environmental technologies. A big programmatic focus area for SERDP right now is remediation technologies for perfluoroalkyl and polyfluoroalkyl substance (PFAS) contamination at military bases. The use of firefighting foams for several decades of firefighter training activities, specifically aqueous film-forming foam (AFFF) which typically contains high quantities of PFAS, is largely responsible for the contamination.
at military bases as well as commercial airports and hydrocarbon storage facilities. Until recently, foam from firefighter training exercises was simply washed into the soil. Because PFAS are “forever chemicals,” they never break down in the environment, leading to widespread contamination of groundwater, drinking water, and soil. Military bases are a particular focus due to the number of sites and the amount of foam which has historically been discharged.

While technologies exist to remove and capture PFAS from contaminated water or soil, very few technologies can be used to break the carbon-fluorine bonds in the PFAS molecule, which is necessary for safe and effective end-of-life disposal. In the past, legacy AFFF has often been incinerated, but concerns are mounting about the efficacy of incineration; hence the need for new technology.

Considering the people involved with this collaboration, Drs. Timothy Strathmann and Rula Deeb previously worked together with their collaborator at Colorado School of Mines (CSM), Dr. Christopher Higgins, under a limited-scope SERDP grant, investigating PFAS destruction under hydrothermal conditions. During this project, the team discovered that highly alkaline conditions in compressed, high-temperature liquid water are very effective at breaking PFAS down into benign salts. This hydrothermal alkaline treatment (HALT) process can accomplish >99.99% total PFAS destruction, with exceptional performance degrading the whole family of PFAS chemicals, from short-chain (e.g., PFBA, PFBS) to long-chain (e.g., PFOS, PFOA) molecules. This is a significant advantage over many other emerging destructive technologies, which often struggle to destroy short-chain PFAS.

From these original proof-of-concept studies, this new SERDP effort is geared toward the following set of goals:
furthering our understanding of the active PFAS destruction reaction mechanisms,
- demonstrating the efficacy of this hydrothermal process for PFAS destruction in a wider range of feedstocks,
- working to advance the technology toward pilot deployments and demonstrations.

To accomplish these goals, the team was further expanded to include Dr. Igor Novosselov’s group at the University of Washington (UW) and Dr. Brian Pinkard’s team at the commercial startup Aquagga, Inc. In addition, Dr. Deeb brought her colleague from Geosyntec Consultants and Savron Solutions, Dr. David Major on board to leverage his expertise in technology transfer and commercialization of emerging remediation technologies. All participants bring their own disciplinary experience and knowledge, which is critical to an endeavor as big as bringing an end to PFAS.

Beyond our collaborative SERDP effort, our collective goal is to advance HALT from a promising bench-scale process to a full-scale environmental remediation and hazardous waste destruction technology used at PFAS-contaminated sites nationwide. A big step in accomplishing that goal is the transfer of technology from universities to industrial partners. While universities are well-equipped to conduct innovative scientific research, spinout companies are much better positioned to advance tech from the bench scale to the industrial scale, crossing the so-called “valley of death,” which refers to the time spent between starting a company and first receiving revenue.

The team at Aquagga, Inc. is leading these scale-up efforts, leveraging Small Business Innovative Research (SBIR) funding from the EPA, the National Science Foundation (NSF), and the US Air Force. These SBIR projects also involve close collaboration with Dr. Strathmann and Dr. Novoselov and are helping to derisk the technology before Aquagga becomes revenue positive. Altogether, the team is leveraging funding and support from myriad sources, with the goal of advancing this much-needed technology toward commercial readiness as quickly as possible.

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In this backstory, we provide perspective on how we formed our collaborative, multidisciplinary team and discuss some of the benefits of working both within and outside of an academic research environment to tackle big, real-world problems.

PROXIMITY
Who are the players in this project, and how did you bring everyone together?

The overall effort here is quite extensive, involving Dr. Strathmann along with several of his collaborators and students at the CSM, Dr. Novosselov and his research group at the UW, the entire team at Aquagga, Inc., and Dr. Deeb and her team at Geosyntec. We each bring a unique set of knowledge and resource to the project that so far has been a recipe for success.

The folks at CSM are world experts in PFAS chemistry and analysis techniques, which means they are well-equipped to fully probe and study the reactions taking place under hydrothermal conditions. This knowledge can then inform the prototyping and testing of larger, continuous reactor systems, which is the specialty of the group at UW. Ultimately, all of this technical development and knowledge ends up transferring to Aquagga, who can then engineer industrial-scale systems based on the research done in the lab. And finally, the folks at Geosyntec will help the team line up and execute projects through their existing sales pipelines and knowledge of the regulatory and permitting process for similar technologies.

We all met rather fortuitously. Dr. Novosselov was Dr. Pinkard’s PhD advisor while the Aquagga team was going through the national NSF I-Corps program (October–December 2019). I-Corps is a prestigious entrepreneurial training program, where entrepreneurially minded scientists and innovators are funded to travel and perform extensive customer discovery efforts with members of industry. At that time, PFAS was not even on Aquagga’s radar – the company was actually interested in the commercial potential of using hydrothermal processing for sewage sludge disposal. But as the Aquagga team spoke with folks in the water and wastewater industry, PFAS kept coming up as the most pressing challenge facing the industry. So, Aquagga pivoted to focus on PFAS destruction.

Around that same time, the CSM and Geosyntec team’s paper on the destruction of PFAS under hydrothermal conditions had just been published (Wu et al., 2019). Understanding what the CSM and Geosyntec group had demonstrated, the Aquagga team felt confident that hydrothermal processing is a good fit to solve the PFAS problem. Toward the end of 2019, Dr. Novosselov was also able to meet Dr. Strathmann at the SERDP conference in Washington D.C., where the idea of collaboratively pursuing tech development together was born.

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The relationship was really cemented through our various wins in securing support and funding. When the pandemic hit, the Aquagga team focused on taking home prizes in several business competitions, including the Grand Prize in the Alaska Airlines Environmental Innovation Challenge, and participating in business accelerators, such as the Cascadia Cleantech Accelerator, and the Launch Alaska program. Despite being without physical laboratory access, huge strides were made in derisking the business model. We also wrote a lot of grant proposals, which is how the project team began 2021 with three funded SBIR awards, an upcoming SERDP project, and likely an Environmental Security Technology Certification Program (ESTCP) demonstration in the not-too-distant future.

Startups need researchers who can push the boundary of new technologies. Researchers also need startups, in order for their inventions to see widespread adoption. Although university environments are great for investigating new technologies, startups are able to access the capital and talent needed to perform the business development and engineering scale-up activities necessary for bringing a new product to market. Due to funding, reporting, and time constraints, it is nearly impossible for researchers to take the necessary steps toward commercialization without breaking out of the academic research environment, at least for some period of time. There is a synergistic relationship, and we are all very proud of the way we have combined our efforts to pursue the collective achievement. Academia and startup culture both promote competition, but we can usually accomplish so much more when we openly collaborate.

**LANGUAGE**

*Have you encountered any challenges or any benefits of working with people from different backgrounds and expertise?*

Crossing the threshold between the academic and the business world is always a challenge. In the academic world, the metrics of success are publications, grant dollars, appointments, etc. – while in the business world, the goal is always to meet the need of the customer. In any partnership between academia and
industry, there will always be a natural competition between diving deeper scientifically and moving forward with a technology when it is sufficiently mature to meet the customer’s needs. We believe that these competing interests are healthy and motivate focused technical development. Ultimately, the team’s shared desire to find innovative solutions to the pressing challenges posed by PFAS “forever chemicals” provides a solid foundation to support this growing relationship.

RESEARCH METHODS
Does this project require tailoring your research methods to adjust to working interdisciplinarily?
Absolutely – we all have our areas of expertise, and what may seem routine to one group may be completely foreign to the other. For example, the UW team is a world expert in constructing and running experimental hydrothermal reactors, whereas the team at CSM is a world expert in PFAS sampling and analysis. Making sure that the UW team understands the sample processing requirements for analysis is important, as is ensuring that the group at CSM understands how the experimental reactors are operated and the corresponding experimental constraints.

How did the decision of starting your own company come about? What impacts did it have on your career (recognition, funding, etc.)?
Pinkard: Aquagga was born out of necessity. While going through I-Corps, we heard loud and clear from dozens of industry experts that no commercially viable PFAS destruction was available to meet their needs. When faced with such a massive environmental problem, one that we have the technical knowledge to solve, we took the logical step of forming a company to transition the technology from the laboratory to the field.

I have never personally sought out entrepreneurship. Forming a startup company is hard work, which often does not lead to any major rewards. But in this case, forming a company was the right thing to do to confront this PFAS problem, and as an engineer, I am always driven to do what it takes to solve a problem.
The positive benefits of starting a company have been a pleasant surprise for me – expanded professional networks, more autonomy over my work, more opportunities to make a direct societal impact (as opposed to the often indirect impact of academia), and lots of variety in my work. On a small team you have the opportunity to wear many hats, which is a great learning experience. On top of all of that, we have been able to access tremendous funding support from the SBIR program and received lots of outstanding mentorship from various startup networks in our area, all of which would be largely absent from a traditional academic or industry career progression.

FINAL THOUGHTS
What have you learned about interdisciplinary research from the project and what advice would you give to anyone considering undertaking such work?

The slowest way to figure something out (scientifically) is to perform an experimental study. Better is to find an answer in the literature, if possible. Best is to make connections to world experts in the field, who likely have the answer, or at least know the best way to conduct the experiments.

We have seen tremendous value in forming research partnerships like this one, and world experts are often more approachable and willing to help than we might assume. It never hurts to reach out and explore a collaborative effort – you never know where it might lead.

REFERENCES
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