Microbial Fuel Cell

A project journey

Tersa

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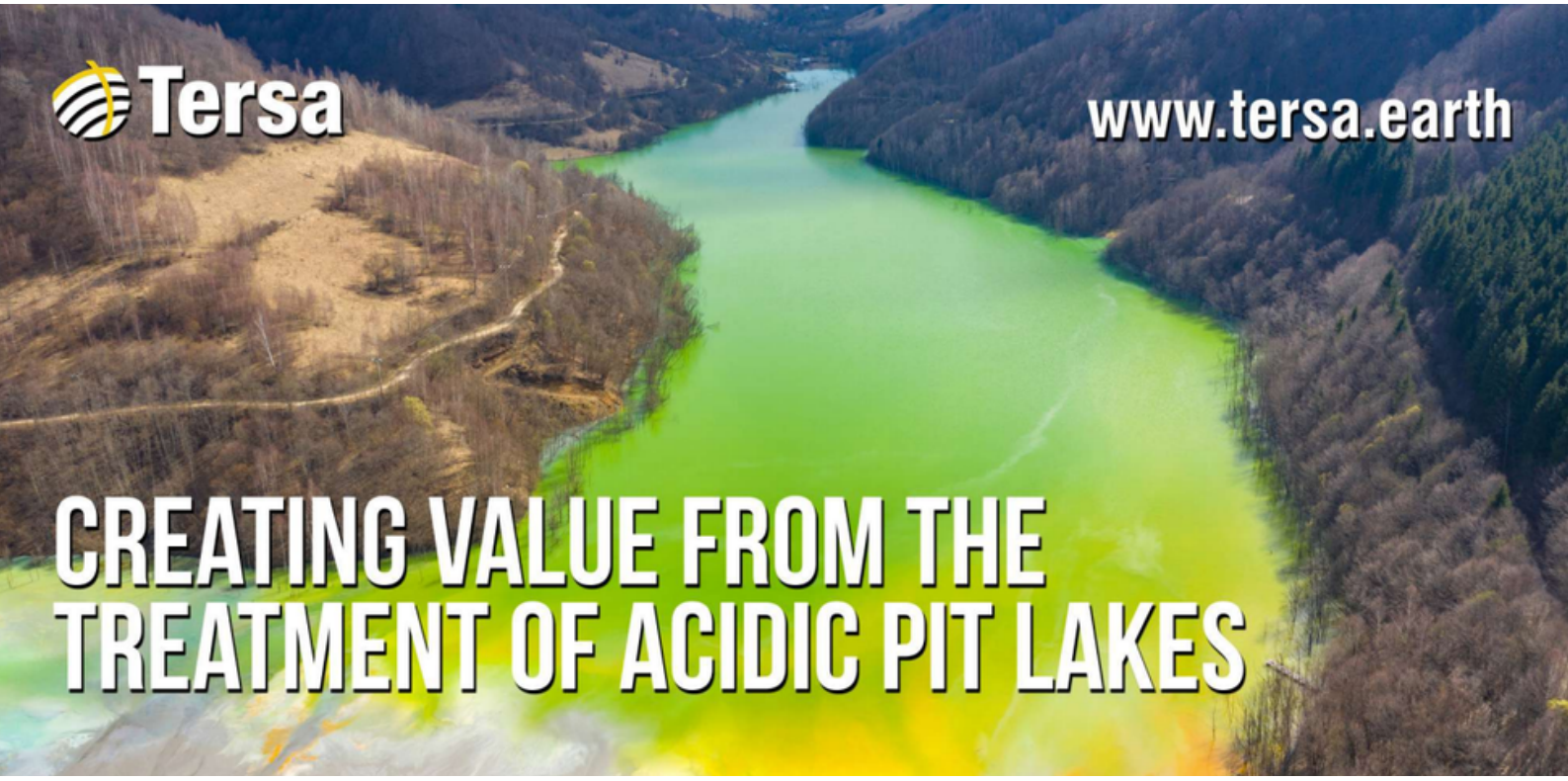
Backstory of Tersa Earth

Tersa Earth is a biotech R&D startup that had grown out of a UBC research lab. They had engineered two unique bacterial strains and a biochemical process around those strains. The process allowed them to both reclaim valuable metals in solution and treat acid rock drainage (ARD) from pit lakes in mines with low C02 emissions. These same mines produce the raw materials needed for low carbon and electrification technologies such as batteries, wind turbines and electric motors. The production of one electric car results in 150,000 litres of ARD.

Tersa had demonstrated their Microbial Fuel Cell (MFC) and Microbial Induced Carbonate Precipitation (MICP) technologies in a lab setting. With over $20B/year in North America of metals in solution in ARD and 200 megatons of greenhouse gases emitted treating the water, the enormous potential value of the technology was apparent.



The Need

A vision of things to come

Early in 2023, Motus Advisory Board member Dr. Grant Cool, met with Tersa Founder Stewart Muir. As they discussed the goals of Tersa, a vision of a product that would unlock the value in Tersa's biochemistry and process became clear as a scaled up, 1000L/day portable demonstration plant. "TersaClean", as it was dubbed, would be housed in a shipping container. The value, feasibility, and potential scalability of the Tersa technology could then be brought to mine sites to show industry and investors directly.

The Connection

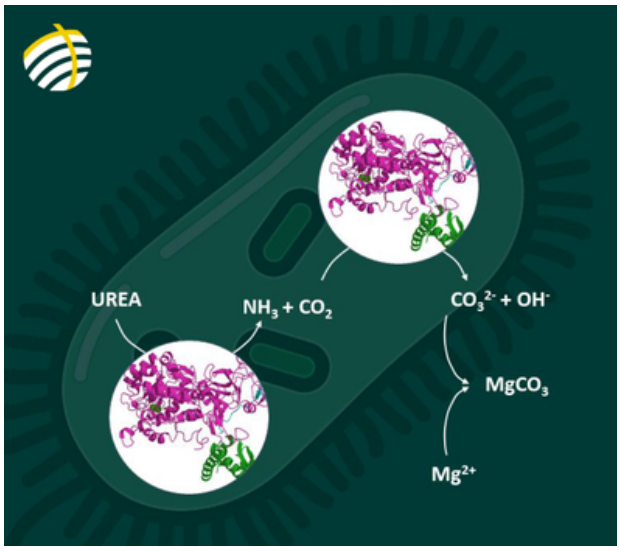
“The whole is greater than the sum of its parts”

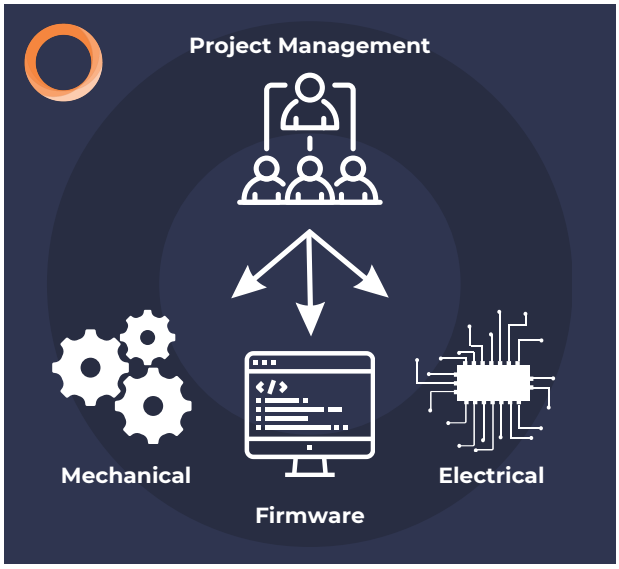
Grant and Motus CEO, Josh Erickson, travelled to Burnaby, BC in March of 2023 to meet the Tersa team and talk about product development processes and systems that could help Tersa get to where they wanted to go. We found immediate personal chemistry and an opportunity to join forces to create a new product development team with all the pieces that Tersa would need.

The Connection

Tersa, coming from a biochemistry and process R&D background, brought their intimate knowledge of the bioengineering and chemical processes for their technology, as well as an understanding of the needs of the mining industry.

Motus was able to reinforce this expertise with their own project management, technology and product development, and systems engineering process; this included all the mechanical, electronic, embedded firmware, process automation, and control expertise the team needed to create the scaled up systems and start development toward the TersaClean product.





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The Team

To bolster the Tersa team, Motus would take on the majority of the design work in it's 5500 sq ft facility in Victoria, BC. As the need for rapid prototyping and certification in the project became apparent, Motus brought on some Vancouver Island strategic partners to assist if needed and ensure the project would not experience roadblocks.

Rainhouse Manufacturing Canada Ltd. is an ISO-certified company that specializes in the design and manufacture of electronic and machined parts. This partnership with Motus ensured capacity and expertise to migrate from quick turn, low volumes, early in the project to QC/QA controlled, larger production, runs later in the project.

Timberstone Tools is an engineering consultancy that designs and builds sensors and diagnostic equipment for subsea applications and downhole applications in oil and gas. Timberstone brought additional mechanical design experience in harsh high temperature environments to the Motus team.

With the team in place, establishing clear roles, responsibilities, and lines of communication were the essential next step for a successful project.

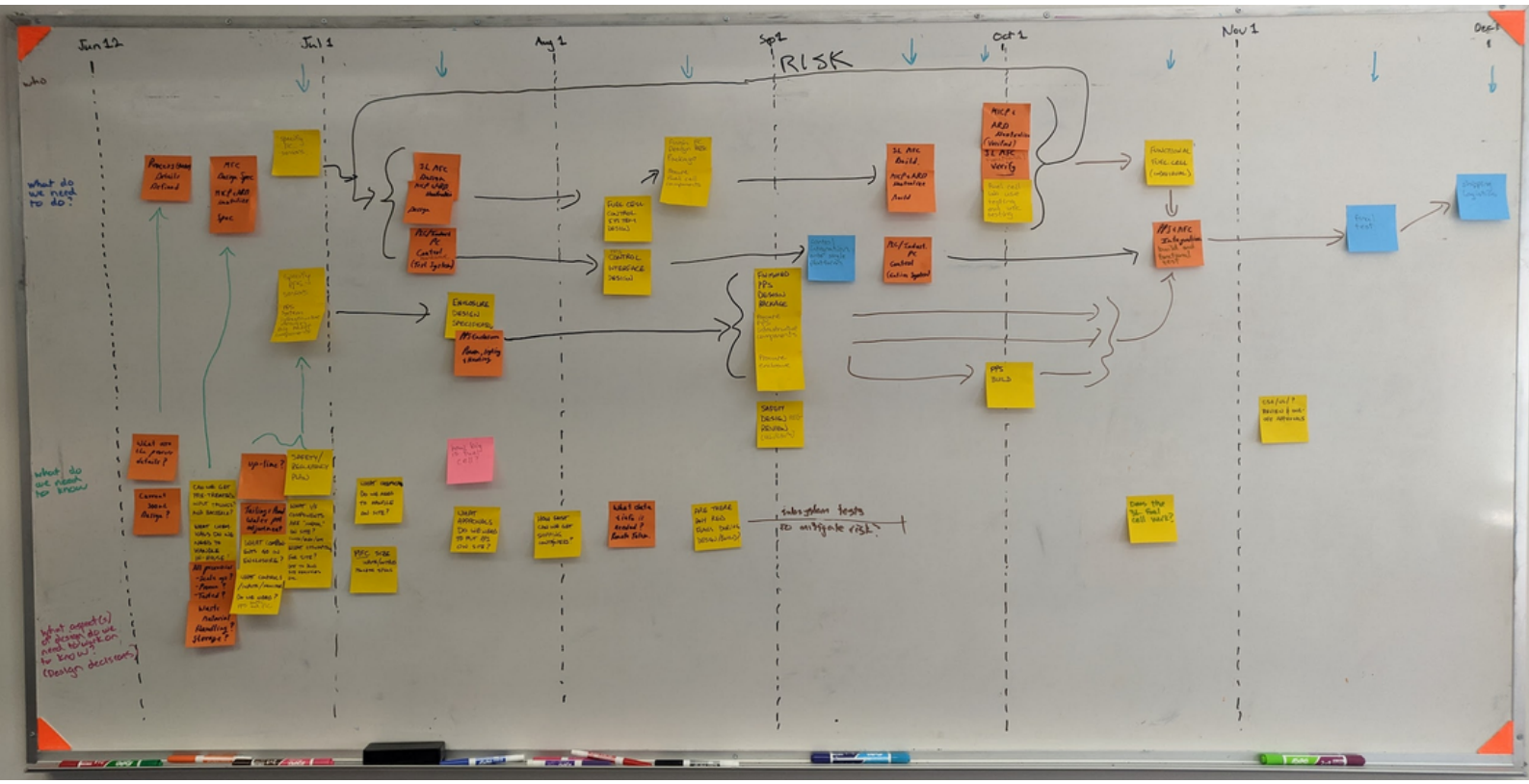
Project Roadmap

How will we get there from here?

A good technology solution starts with a project plan that takes into account the business needs of our clients and makes sure we are designing the right thing at the right time. We engaged with Tersa to build that plan - our Project Roadmap. A well prepared project roadmap is able to answer three fundamental questions:

Where are we now?
Where do we want to be?
How will we get there?

In Tersa's case, a roadmap of high quality, tangible, physical prototypes that could demonstrate the concept and progress to investors was as important to the project's success as engineering solutions. This drove several decisions on the best path forward.



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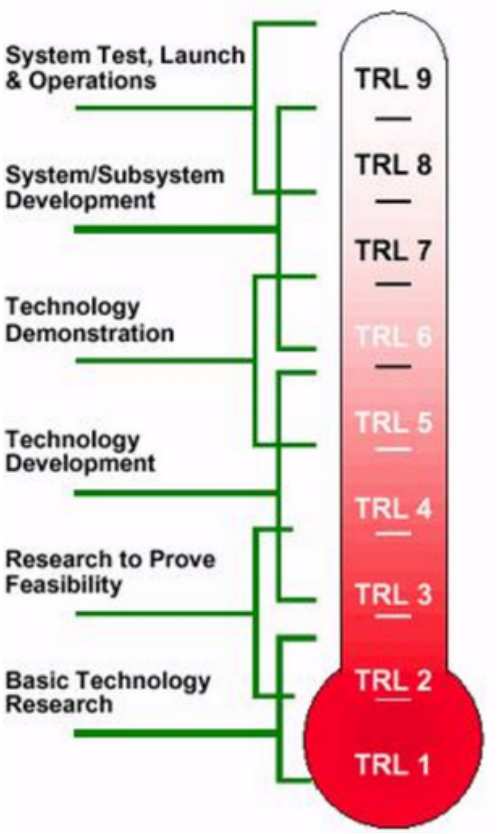
Project Roadmap

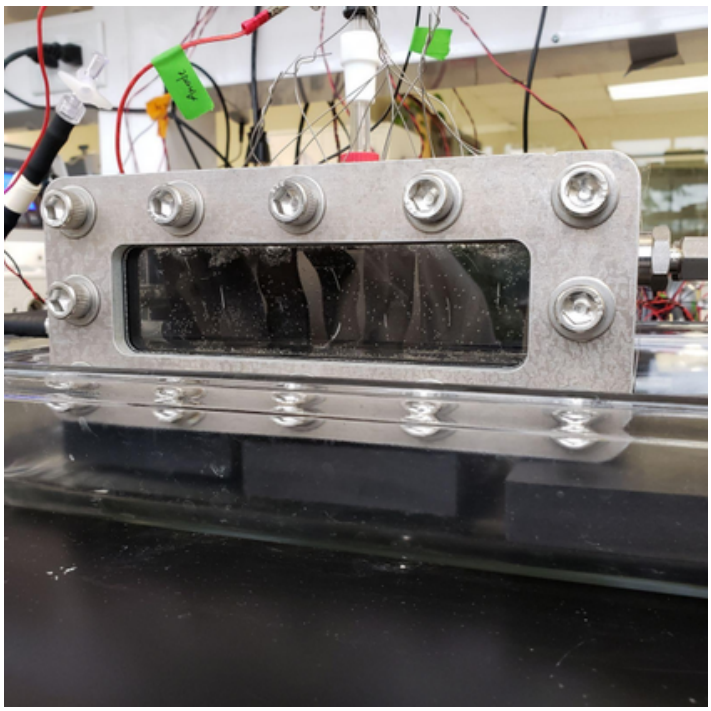
Where are we now?

Motus worked with Tersa to establish the areas of risk and applied the concept of Technology Readiness Levels (TRLs) to all the constituent technologies that had been developed toward the envisioned TersaClean system.

The majority of Tersa technology was at the TRL 3 or 4 level, and needed a roadmap of verification of engineered concepts that would deliver the process, function, feasibility, and scalability of the technology. A 1000L TersaClean system would require all systems to be at a TRL 7 level. Motus set out to create a project roadmap to bridge this gap.



TRL Scale



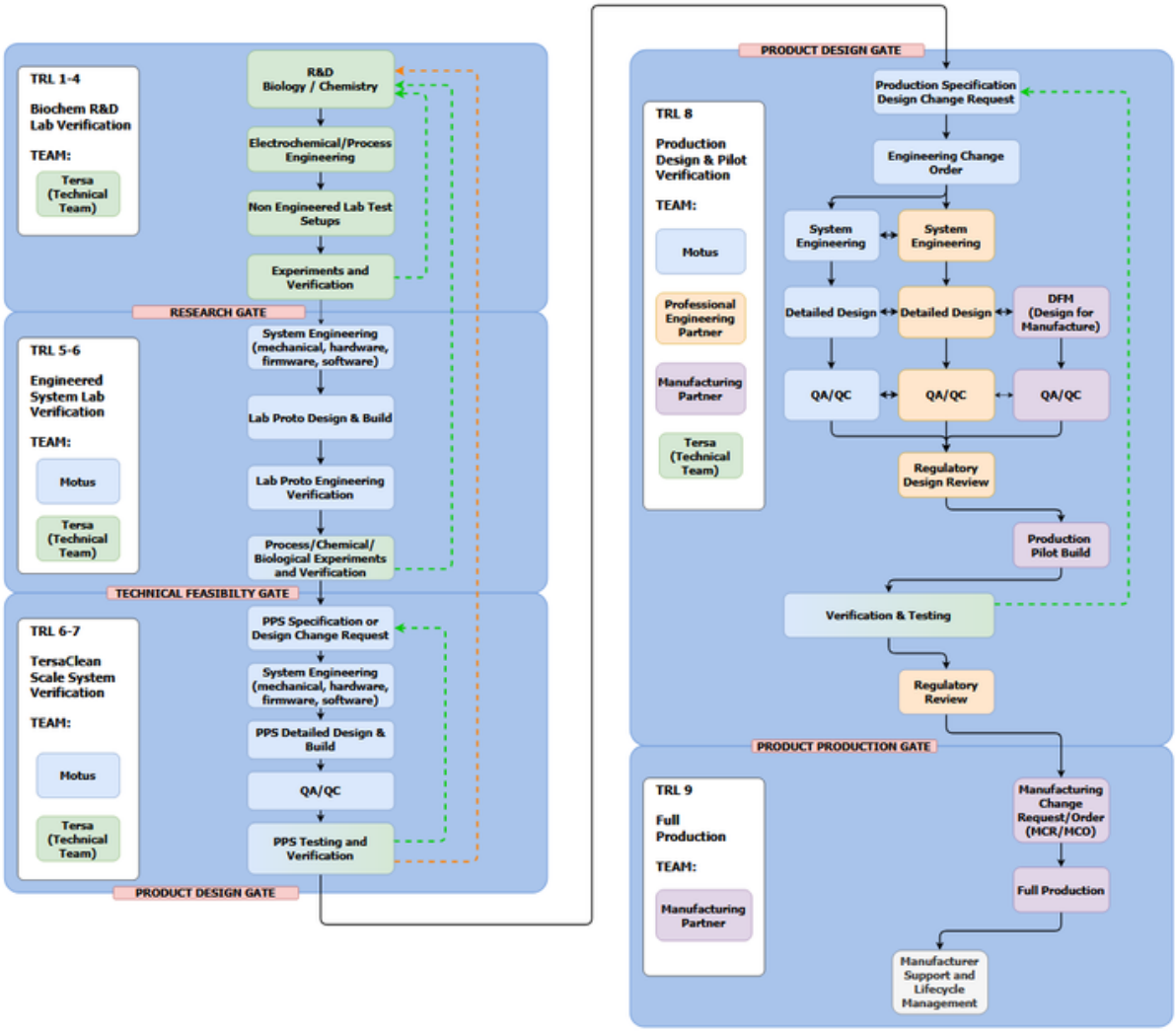
Initial Tersa Microbial Fuel Cell POC

Project Roadmap

Where do we want to be?

Motus worked with Tersa to establish the main goals for the project:

- Design and fabricate a Fuel Cell system that can process 1000L of liquid from a tailings pond, per day, for testing and demonstration purposes
- Design and fabricate a Field Trials Fuel Cell to be used for on-sight testing and demonstrations purposes for up to 4 months at a time
- Demonstrate and involve the client in the application of an Engineering Management and Design Management Process



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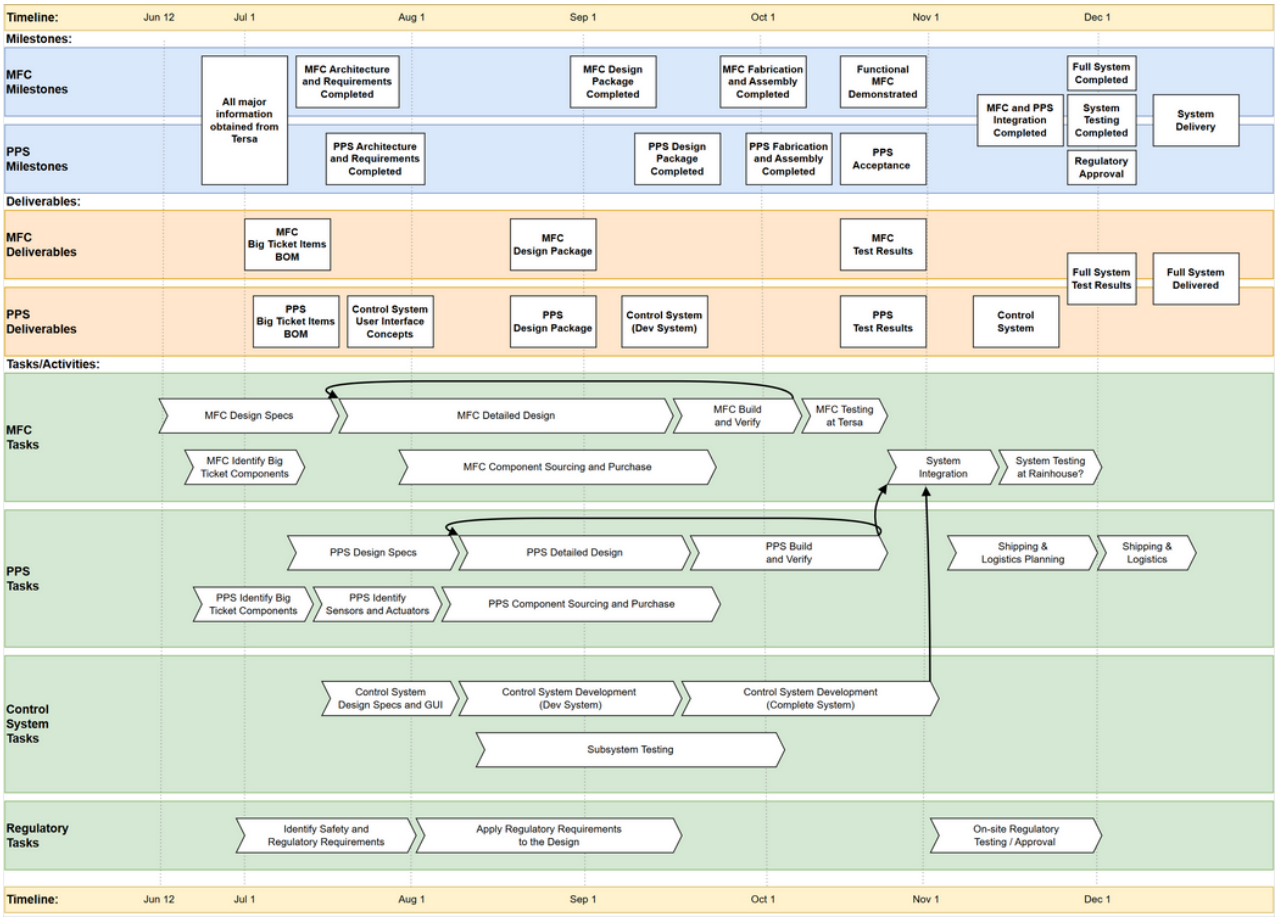
Project Roadmap

How will we get there?

The Microbial Fuel Cell was identified as THE key “big ticket” subsystem. This subsystem is at the core of Tersa’s unique value proposition of reclaiming valuable metals from mine ARD ponds. Testing, de-risking, optimization, and demonstrating that Tersa’s Microbial Fuel Cell process could be scaled in a system configuration suitable for industrial applications would require a number of iterations and verification steps. A strategy of building, testing, and improving increasingly larger and more sophisticated lab systems was decided on, in order to move the technology to where it would be ready to be deployed in the portable TersaClean system. The development process provided several opportunities to demonstrate refinements in the technology to investors. Priority would be given to moving the design of this Microbial Fuel Cell subsystem forward, while the design of the full 1000L TersaClean shipping container system would occur concurrently.



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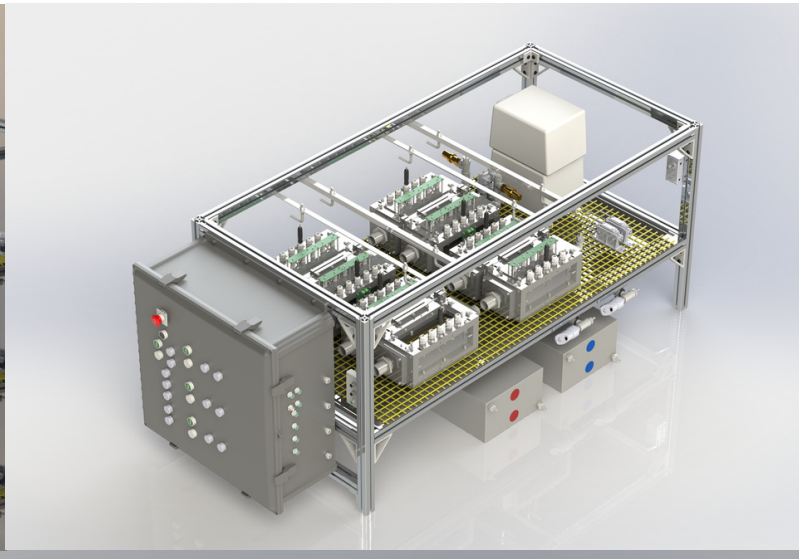
Design

TersaClean System

In concert with the focused design of the Microbial Fuel Cell, the plan was to explore and detail the 1000L/day TersaClean system. This involved defining the overall system size, architecting several of the lower risk subsystems, pricing and sourcing big ticket components, considering human factors for machine interfaces, anticipating user workflows and ergonomics, incorporating automation, and designing programmable logic controllers (PLC) and SCADA systems. Several pre-processing subsystems were designed in detail, down to P&ID process, mechanical, electrical, automation systems, and control panels. All this work gave context for eventual system integration of the Microbial Fuel Cell, and refined several requirement parameters on the size and scaling strategy.



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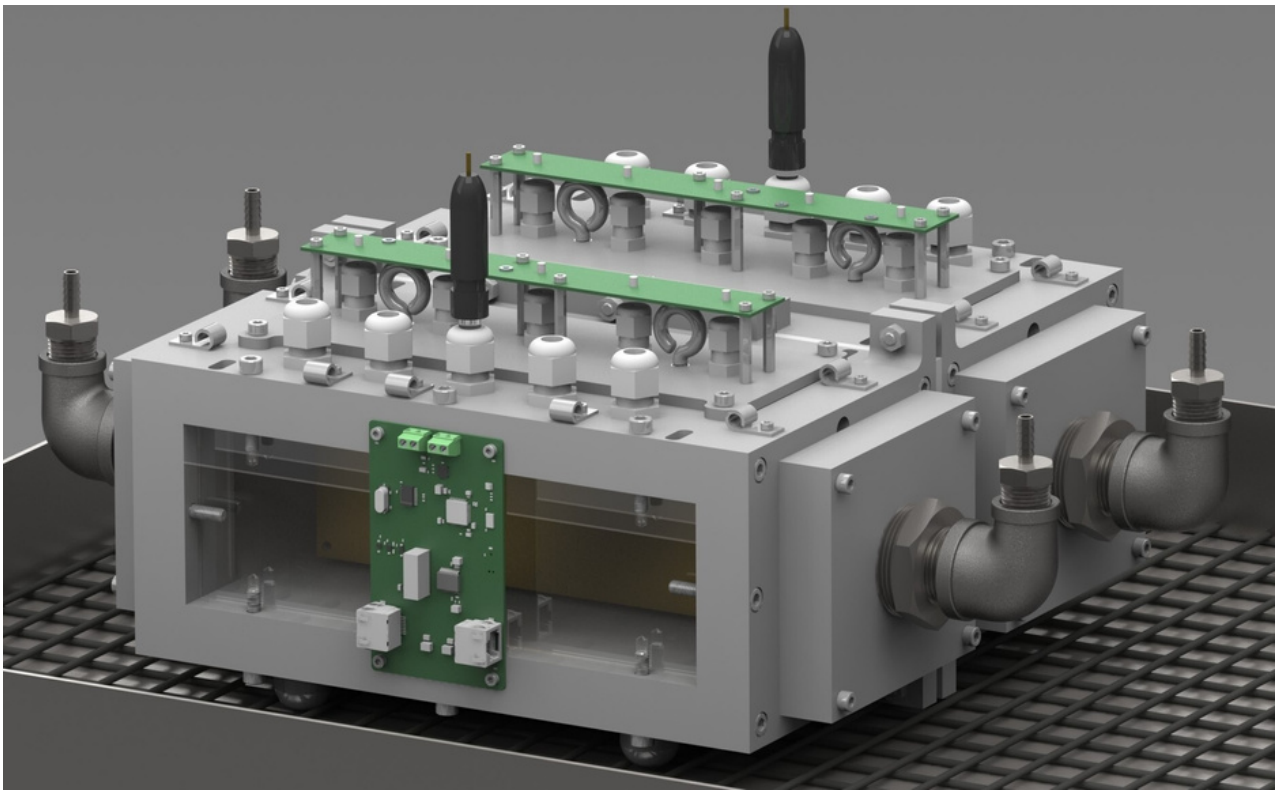
Design

Microbial Fuel Cell

Scaling up the Microbial Fuel Cell technology required scaling Tersa's proof of concept lab prototype by a factor of 10. This size increase would facilitate the 1000L-2500L target for processing the ARD water in the TersaClean system. There were several aspects of the scaled fuel cell that we anticipated to require multiple iterations, as well as extensive in-lab testing and data collection by Tersa to verify operation. In-lab experimentation of this type is extremely time consuming, so we needed a way to accelerate and automate the process. We set out to design both the 10x scaled up Microbial Fuel Cell and a small, self contained, highly instrumented closed loop system with automated data collection into Tersa's database. This would allow Tersa to quickly explore, refine, and verify various aspects of the electro-chemical operation and material selection with a high turnover rate of experiments.

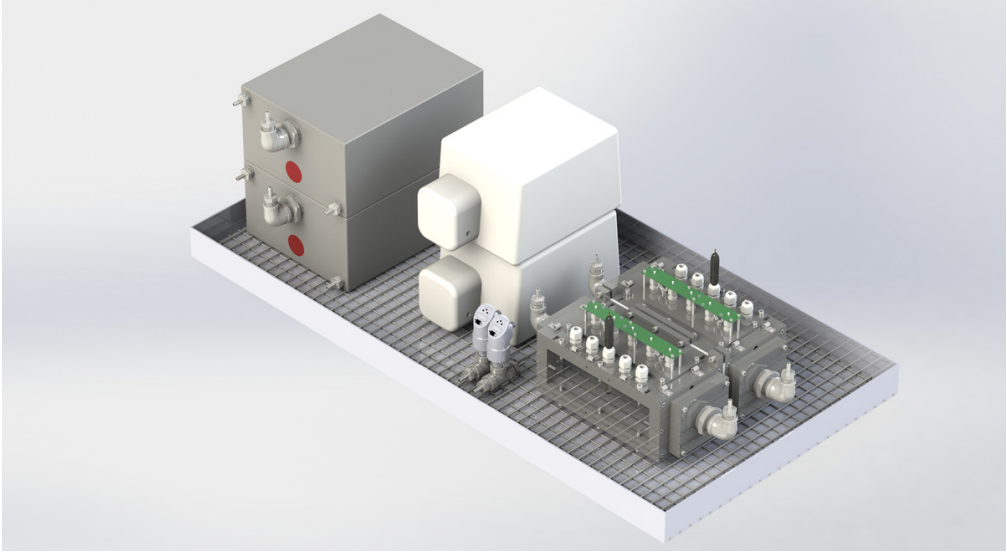


10x scaled up Microbial Fuel Cell concept

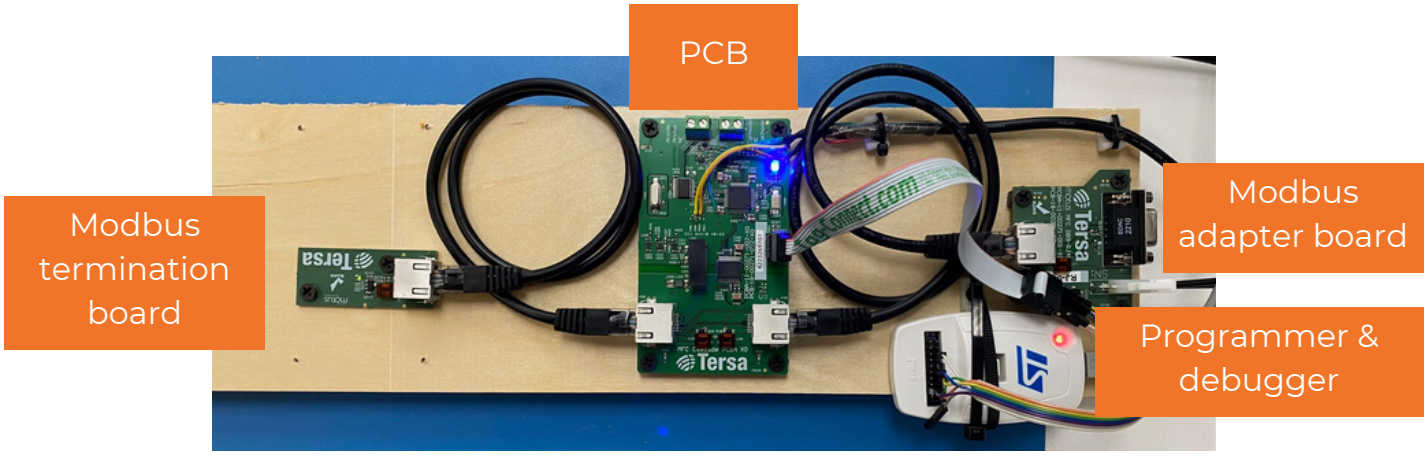
Design

Microbial Fuel Cell Lab System

The Motus team got to work on the 10x scaled up Microbial Fuel Cell design and the Microbial Fuel Cell Lab Verification System. With constant feedback from Tersa, we explored and refined various mechanical concepts, analysed fluid dynamics to improve electrochemical performance, designed custom electronics, developed a custom modbus interface, a PLC/SCADA system, and a custom interface to Tersa's database.



Design concept for Lab Verification System



Firmware development system of MFC Control PCB

Building & Testing

With the development complete, Motus coordinated vendors and partners to build the various components of the system. The electronic and firmware verification, as well as assembly and testing were all done in-house at Motus.

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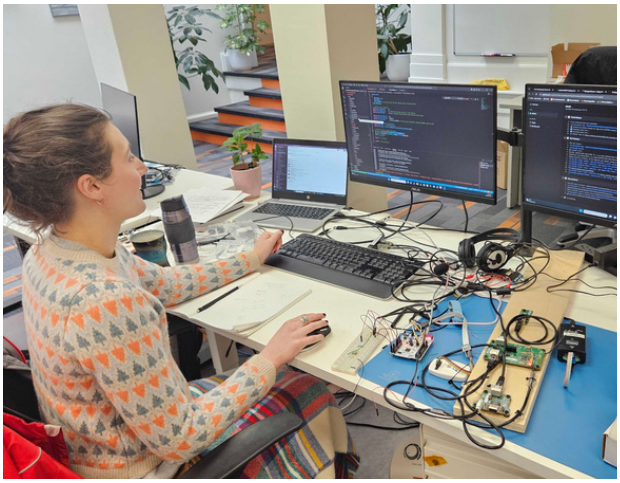
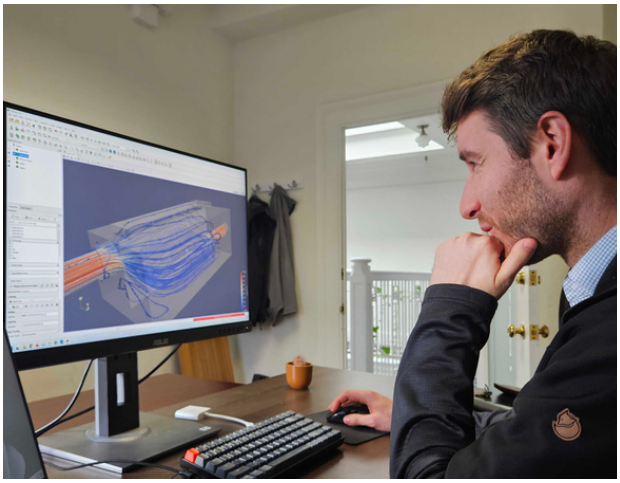
Matt working on PCB controller

Alex populating & testing PCBs



Sally developing MFC firmware

Cam writing PLC & SCADA software



Jeff performing CFD simulations

Matthew assembling MFC chamber

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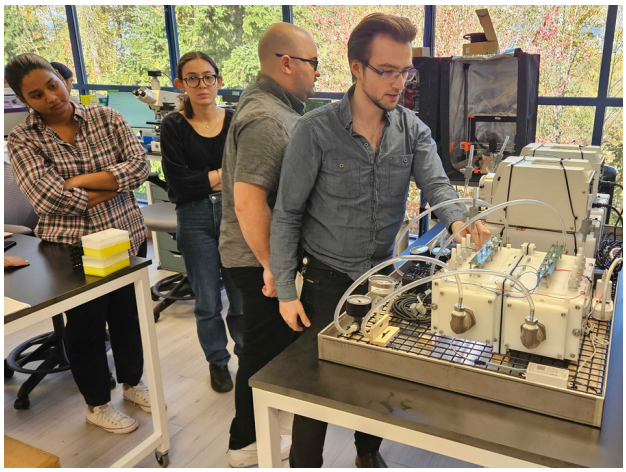
Delivery

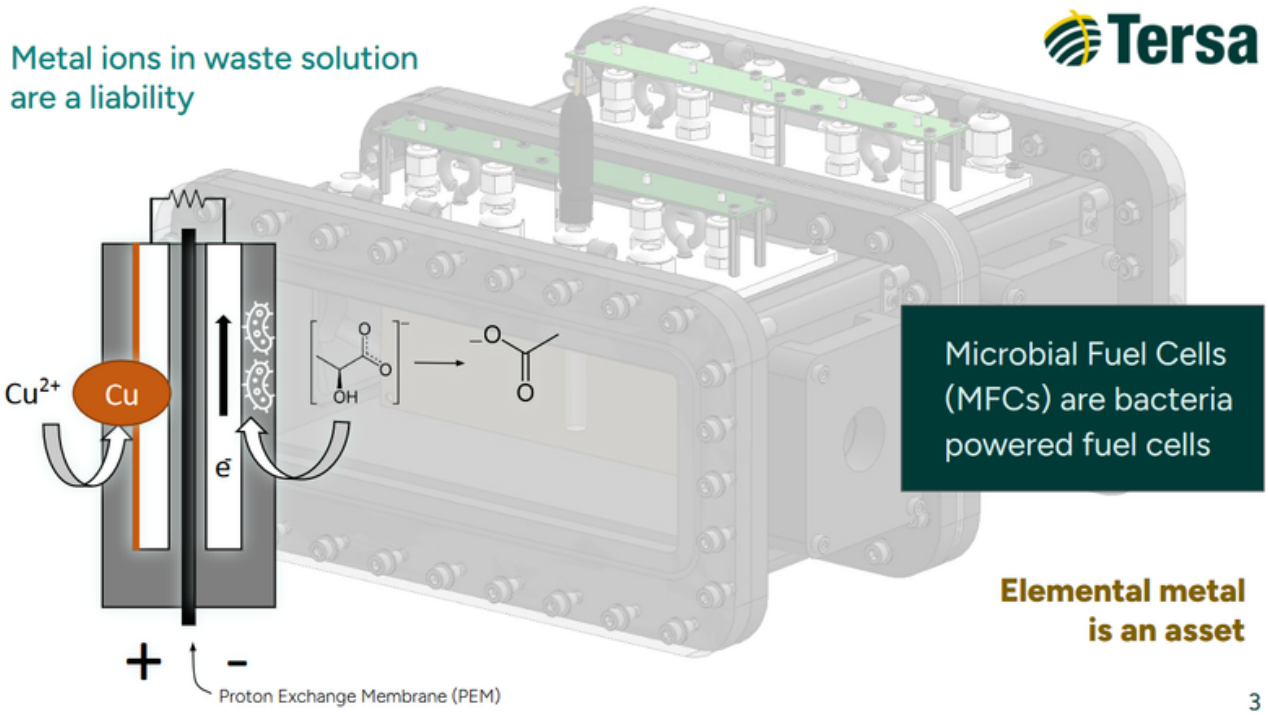
1st delivery November 2023

4 months after project launch, in early November of 2023, Motus delivered the instrumented Microbial Fuel Cell Lab system to Tersa Earth.



Microbial Fuel Cell Lab System V2

Experimental verification uncovered several potential improvements that could be incorporated into an updated design of the Microbial Fuel Cell. Motus set out to iterate the design to improve modularity and reliability, migrating the Microbial Fuel Cell case design to one that could be plastic welded to minimize the need for gaskets and o-rings. Several issues involving managing differential pressure limits and sealing of the proton exchange membrane were also addressed with a combination of improved mechanical design and additional sensors.



V2 Design Updates

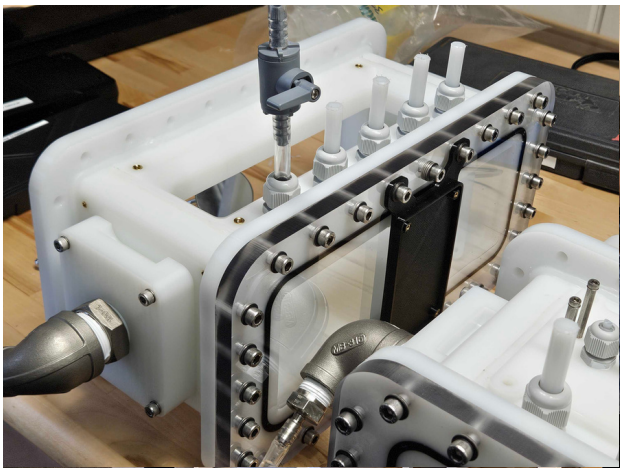
Fluid flow performance, improved electrode materials, and revised structural design were explored in conjunction with port and chamber shape. These changes aimed to improve laminar flow characteristics of the anode and cathode solutions across the electrodes.

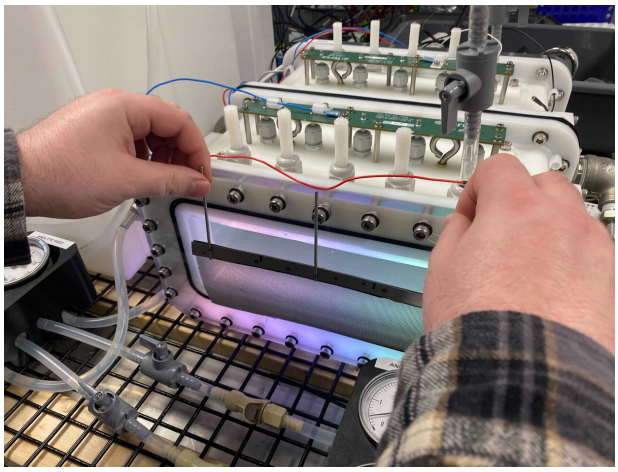
On a user workflow level, we workshopped through sterilization, flushing, priming, and experimental procedures in detail with Tersa. These steps were taken to ensure all Human Machine Interface (HMI) interactions were safe, ergonomic, and that all of the necessary detailed features were included in order to facilitate these procedures in the lab.

The updated version also received several improvements to automate and schedule the experimentation/verification process, which would save significant time for the Tersa team in the lab. This included digitally controlled load resistance, automation of flow rates, a new SCADA interface, and improved integration across all sensor recordings.

V2 Building & Testing

Building and testing was again done at Motus. Two configurations of the pumps and tanks were tested before arriving at the optimal configuration for the Microbial Fuel Cell System.





Delivery

Version 2 delivered January 2024

The final Microbial Fuel Cell Lab System V2 was delivered to Tersa in early January 2024, for Tersa to continue their in lab optimization and validation experiments.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Thank you.

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