Drew Bell

Engineering Portfolio

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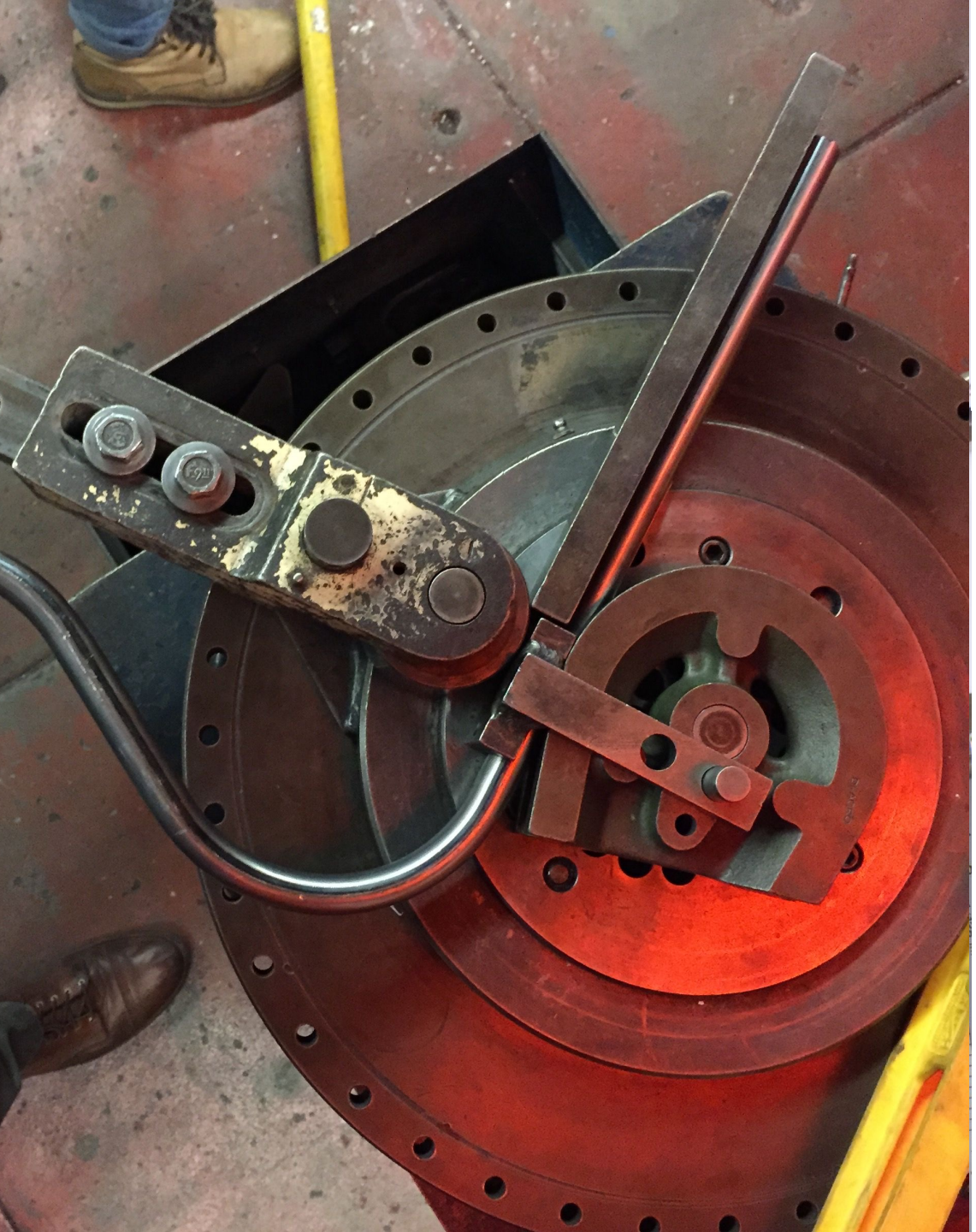
Backstory

I grew up in a small midwestern town, building things with my dad in our home workshop and listening to my grandfather's stories from his career as a civil engineer (see left).

For my bachelors at UIUC, I studied mechanical engineering because I knew I loved to build things.

My last semester at UIUC, I took a mechatronics class that opened a new world to me: the magic of using software to make physical things come to life.

It was like magic to me, and I've been chasing that ever since…



Education

2016 – 2018 Stanford University, MSME (focus on mechatronics)

2009 – 2014 University of Illinois at Urbana-Champaign, BSME

Work Experience

2024 – Current	Amber Agriculture, Sr. Mechatronics Engineer
2018 – 2024	Amber Agriculture, Sr. Research Engineer
2014 - 2016	Garmin, Mechanical Engineer - Fitness Products
2009 – 2014	Internships at Tesla Motors, Microsoft, Bosch

amber AGRICULTURE GARMIN TESLA Microsoft BOSCH

Stanford UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Embedded Systems

Ace Air

Amber Agriculture

Worked side-by-side with co-founders as core early employee in AgTech startup to prototype award-winning product concept (Best Startup at CES, 2017), iterate, find product-market fit, and scale to thousands of IoT devices deployed across North America.

What is Ace Air?
A wireless grain bin monitoring system to manage and protect crops like corn, wheat, and soybeans in bins (silos) after harvest.

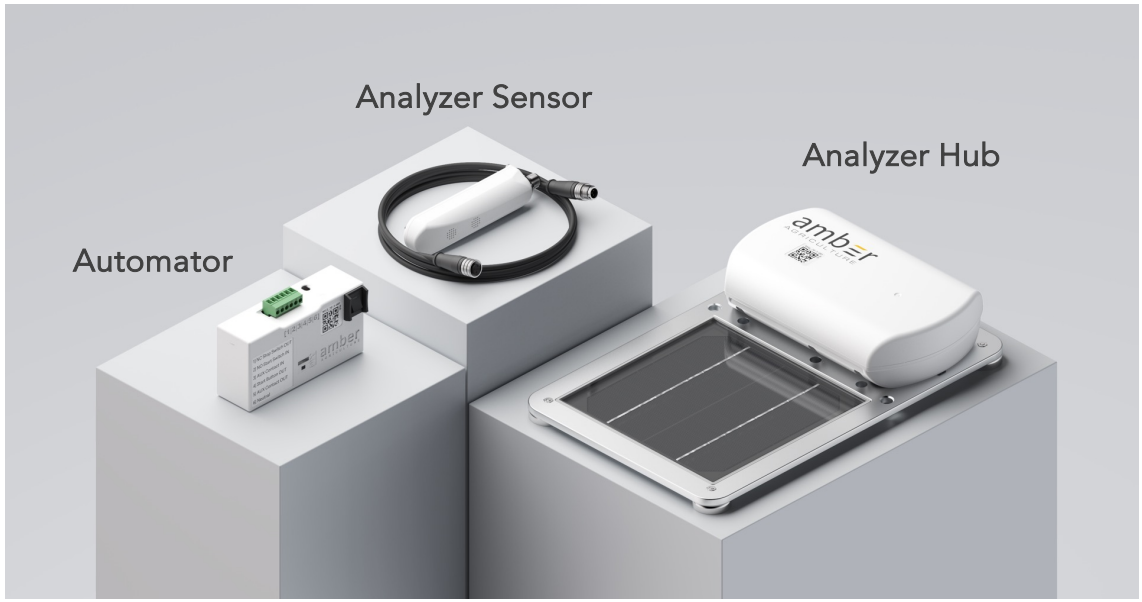
Ace Air System Components

- Analyzer Hub: solar-powered cellular module
- Analyzer Sensor: in-bin sensor monitoring Temp, RH, and CO2
- Automator: cloud-enabled industrial fan controller

My Starting Work Mix (2018)
80% mechanical design, 20% firmware

My Current Work Mix (2025)
75% firmware and software, 15% mechanical, 10% TPM

Team Size
Less than 10



Awards

Named Best Startup at the World's Largest Technology Show

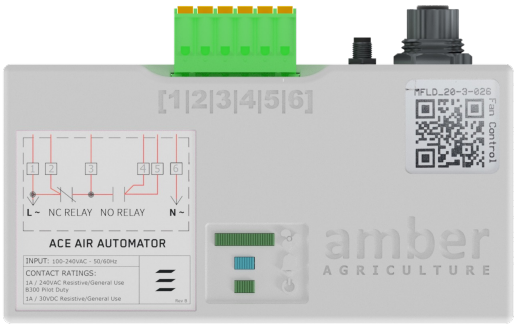
"Plenty of startups promise solutions to problems that are either overblown or don't really exist, but we can't say the same about Amber Agriculture. With Amber's array of sensors, farmers can more easily check the quality of their stored grain and get their wares to the companies that make our food at the right time. Beyond ensuring these farmers get the biggest return on their crop yields, the ability to monitor for the conditions that lead to spoilage could eventually help whole countries deal with food supply issues. Long story short: Amber's is a savvy approach to a pressing problem most people don't even know about."

Took full ownership of firmware for industrial fan controller and matured device into an integral part of Amber's product strategy.

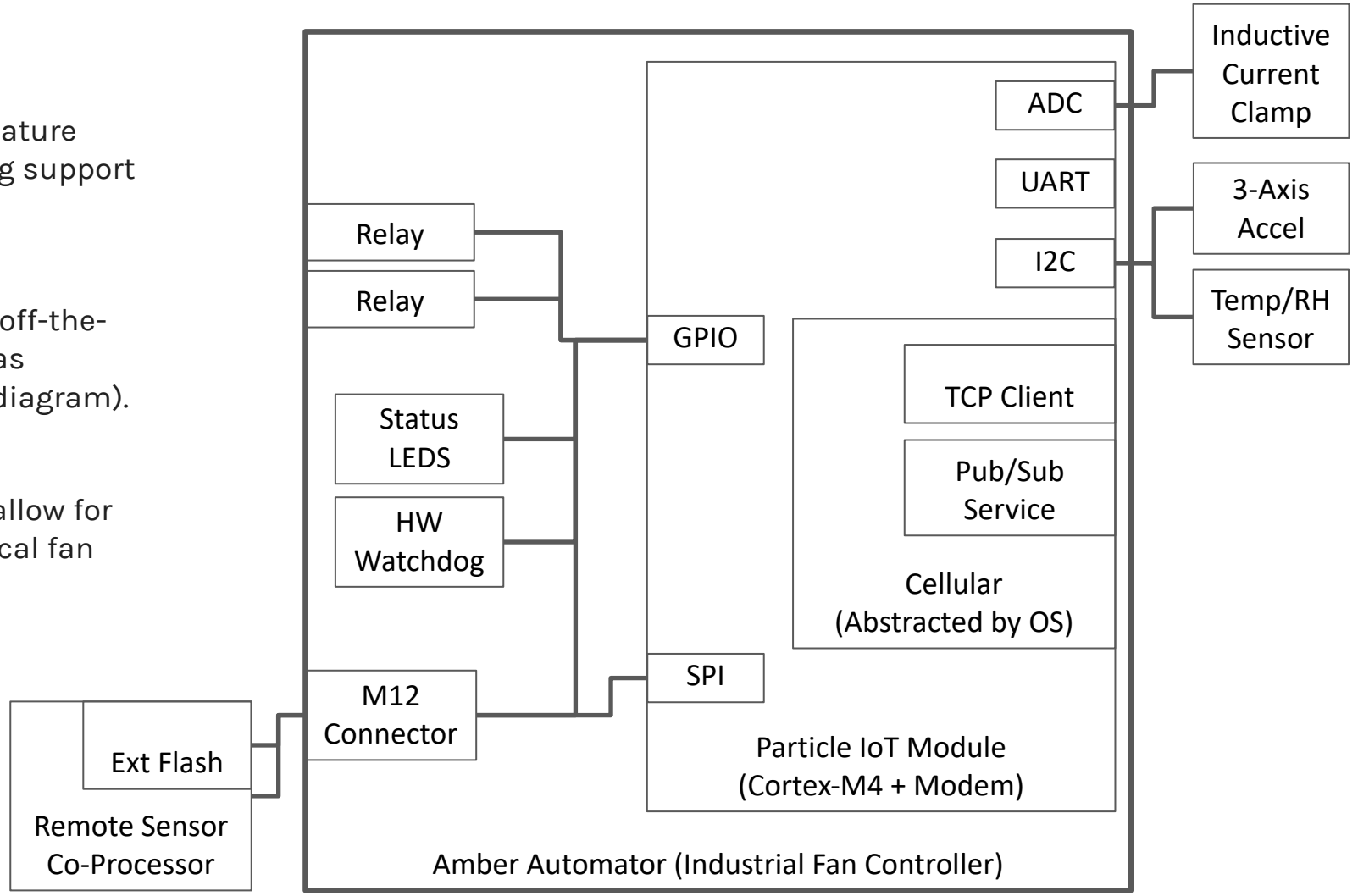
Scope
Wrote nearly all go-to-market firmware, leading feature development for 7 years. Provided customer-facing support as in-house product expert.

Microcontroller
Particle Electron (STM32) and Boron (nRF52840): off-the-shelf cellular platforms running Amber firmware as application within their FreeRTOS-based OS (see diagram).

Key Challenge
Coordinating complex device state with cloud to allow for seamless transition between remote (app) and local fan motor control.



Architectural Block Diagram



Developed python-based hardware-in-the-loop testbed to automate regression testing for Amber Automator.

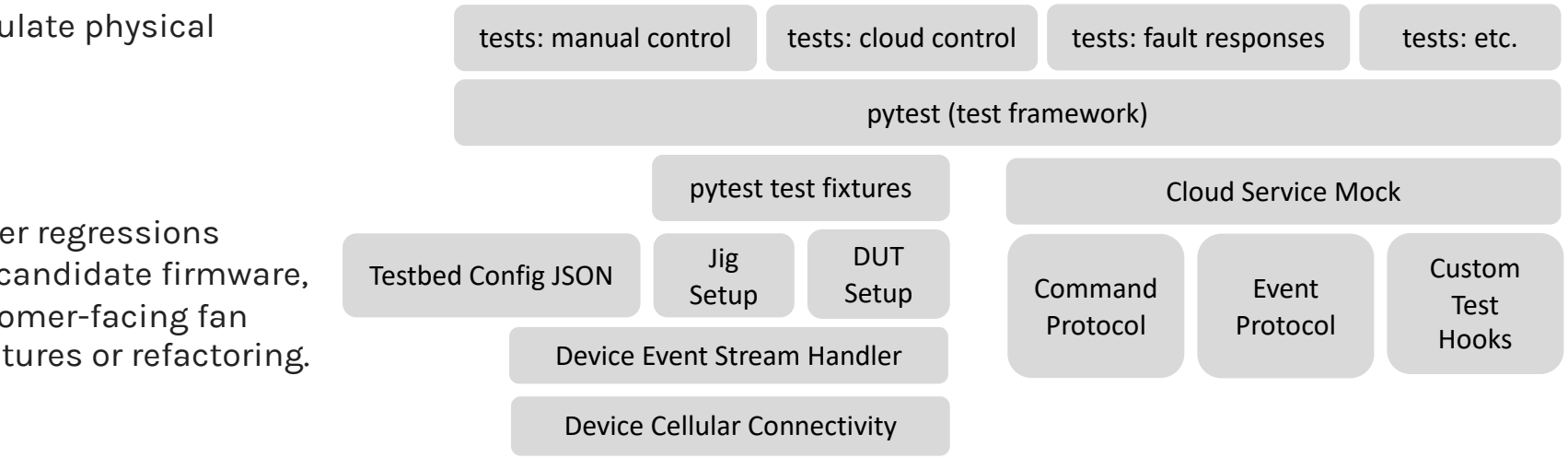
Motivation
As the number of system features expanded, doing regression testing by hand quickly became impractically arduous. By creating a pytest-based architecture (see layering diagram), tests could be efficiently written and run.

Testbed Construction
120VAC input power, contactor, incandescent bulb as simulated load, Amber Automator as jig device to simulate physical start/stop button presses.

Outcome
- 80% reduction in dev testing time
- Improved end-user experience from fewer regressions
- Used to confidently validate all release-candidate firmware, lowering risk of highly undesirable customer-facing fan control issues when developing new features or refactoring.

```
test\test_mcfarland_events.py
--> test: remove trailing semicolon
.
--> test: remove trailing semicolon
.
--> test: loading debug event
.
--> test: loading heartbeat event
.
--> test: debug match
.
--> test: heartbeat match
.
test\test_mcfarland_interface.py .....................................
Tearing down testbed...
[OK]  DUT Teardown
[OK]  JIG Teardown


========================== 105 passed, 5 skipped in 2879.60s (0
testbed 0: pytest result = (ret_code = 0, [OK] All tests PASSED)
**********************************************************************
```



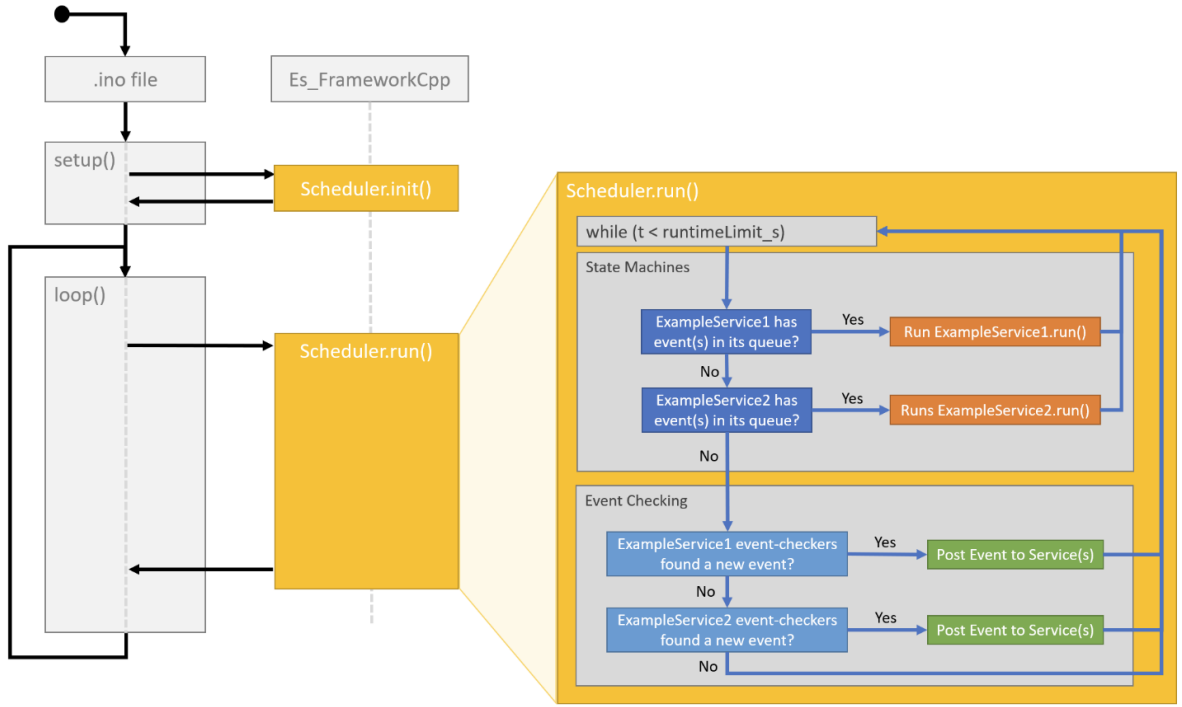
Software Architecture Layering Diagram

Wrote a lightweight, event-based task handler to run on top of simple setup() - loop() abstraction in Particle OS.

Motivation
On Particle platform, application firmware does not have full access to RTOS task primitives like queues and mailboxes. Prototype code could not multitask effectively.

Inspirations
Based on the Events and Services framework from Stanford's ME218 and "A Very Simple Arduino Scheduler" by Alan Burlison

Was Writing Our Own Scheduler a Questionable Design Choice?
Maybe. But the design is simple enough that it has been remarkably bug-free, and having event-driven, state-machine-based code has made adding features and maintaining the codebase very easy.



ME218D: Backseat Drivers

Built a wireless interface prototype for remotely controlling autonomous vehicles for ME218[1] capstone group project.

Sponsor
General Motors

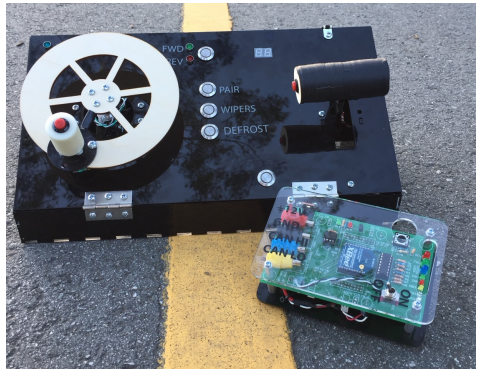
Test Vehicle
Chevy Bolt

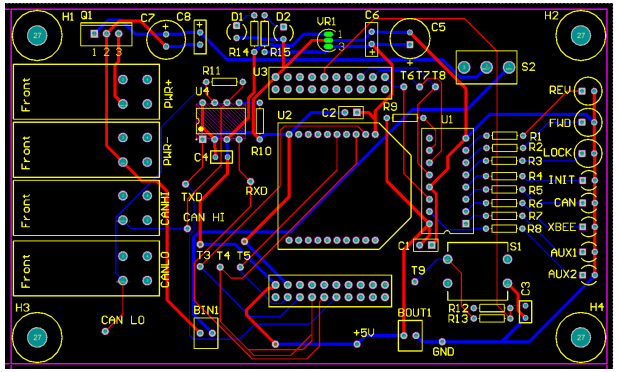
Challenge
Design, build, and test system in vehicle in 10 weeks

Team Size
4

Favorite Contribution
Built a haptic steering wheel that provided steering torque feedback proportional to steering angle despite. Used a brushed gear motor with magnetic encoder, running bare metal firmware on TI Cortex-M4F.

[1] Fourth quarter of Stanford graduate mechatronics sequence





Co-Designed Car-Side Node in Altium

[Class Project. ME218, Stanford University, 2017-2018]

Ongoing Embedded Learning

Recent Reads (2024 & 2025)
- Better Embedded System Software, Koopman
- Making Embedded Systems, White
- Hands-On RTOS with Microcontrollers, Amos

Current Reads
- The Definitive Guide to ARM Cortex M3/M4 Processors, Yiu
- Programming the 6502, Zaks
- Mastering Embedded Linux Programming, Vasquez

Training
- 2025 Embedded Online Conference

Podcasts in the Rotation
- embedded.fm
- Interrupt by Memfault

Mechanical and Electro-mechanical

Ace Air Product Portfolio

Amber Agriculture

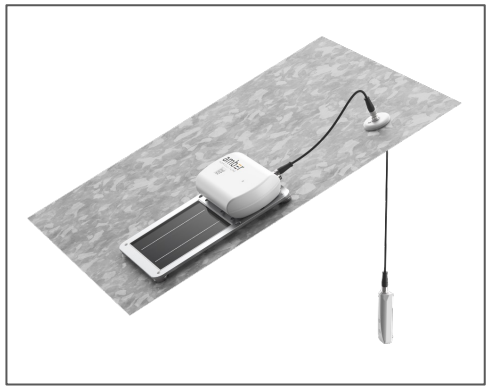
Owned all mechanical design work over 7 years to transform initial R&D product concept into the commercialized product portfolio below.

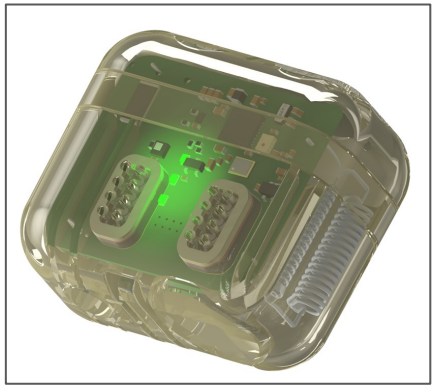
Portfolio Highlights

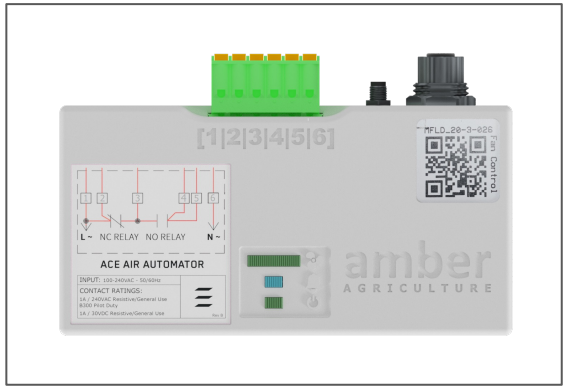
Top Row
- Left — Initial Ace Air Product, 2019
- Center — UL-Certified Intrinsically Safe Sensor Pellet, 2019
- Right — 8th-Generation Automator, 2025

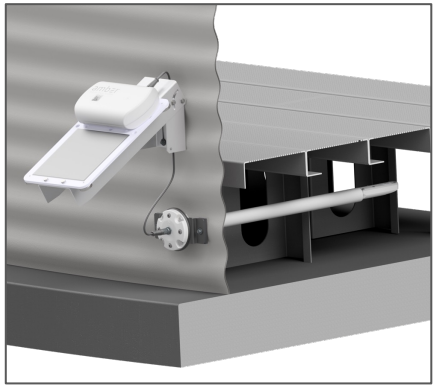
Middle Row
- Left — Ace Air with Lidar Level Sensor, 2024
- Center — Ace Air Plenum Sensor, 2022
- Right — Automator with Plenum Integration, 2023

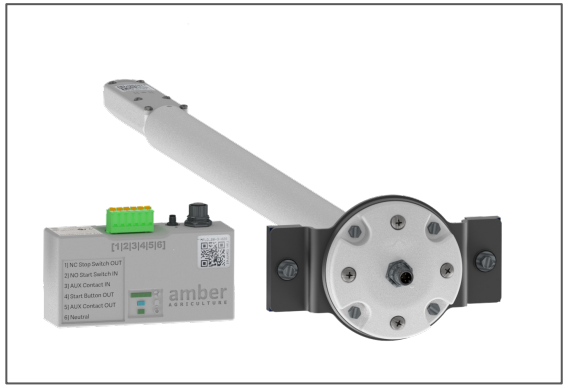
Bottom Row
- Left — Ace Air with Dual Lidar and RS-485 Link, 2025
- Center — 480VAC Control Harness, 2022
- Right — Automator I/O Expander for PLCs, 2024

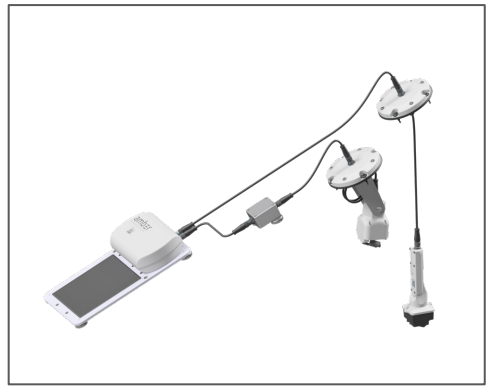


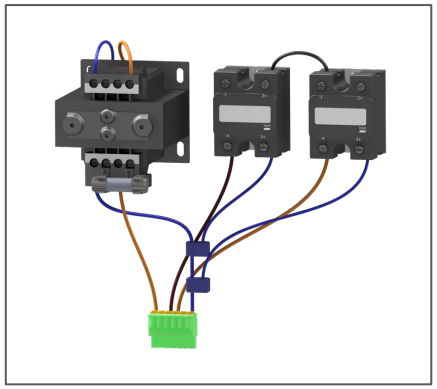


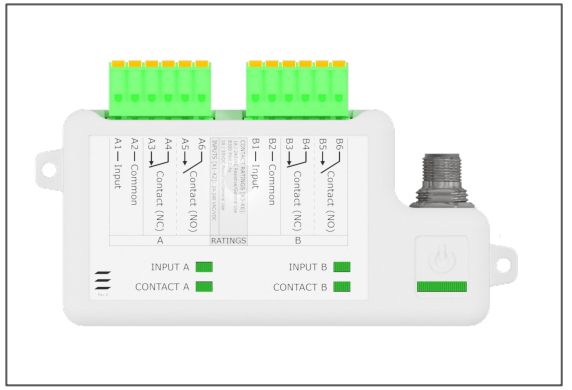












[Design]

Long-Term Product Development

Transformed prototype of Grain Storage Monitoring System into production design, owning all aspects of mechanical design and manufacturing. Sustained and incrementally improved over 5+ development cycles.

Major Elements

- Injection-molded waterproof case
- ME/EE PCB packaging
- Connector selection and wire harness design
- Solar panel sub-assembly

Materials

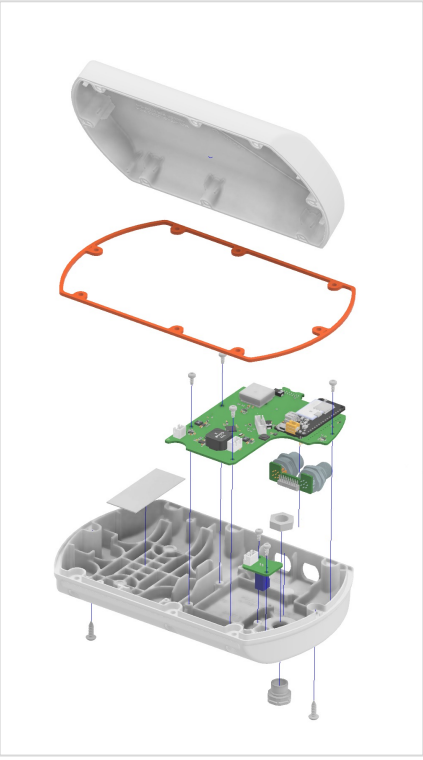
UV-Stabilized PC, 6061 Aluminum, 304 SS Sheet, PCBA

Processes

Injection molding, machining, SMT, adhesive dispense

Challenges

Design for injection molding, PC stress cracking, silicon shortage of 2020-2021, moisture management



Initial Prototype (2018)

Production (2020+)

US-Based Final Assembly

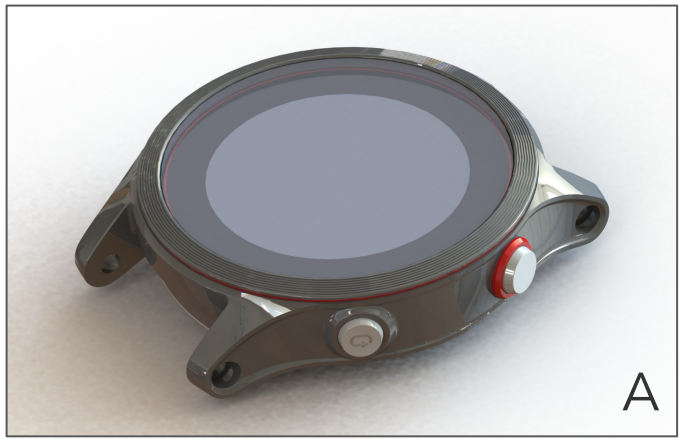
Next Generation Garmin Triathlon Watch

Co-designed the third generation of Garmin's industry-leading triathlon GPS watch to succeed the Forerunner 920XT.

Worked extremely closely with electrical engineering and industrial design to navigate tradeoffs for highly space-constrained product with critical wireless communication performance.

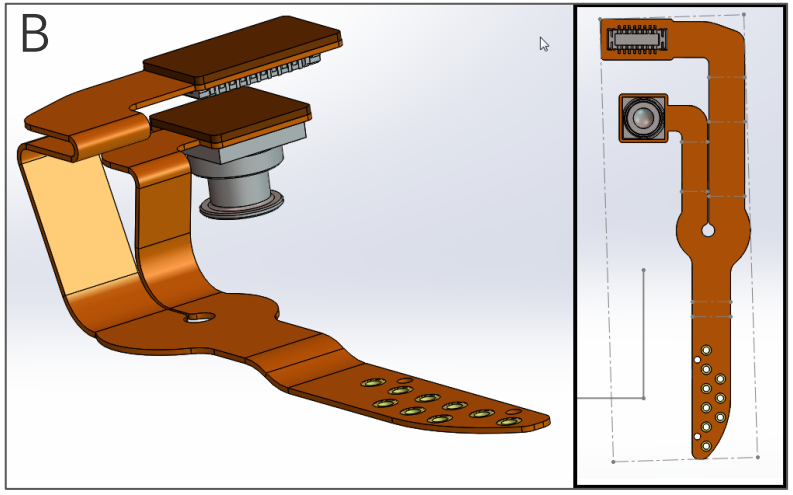
Quick Notes:

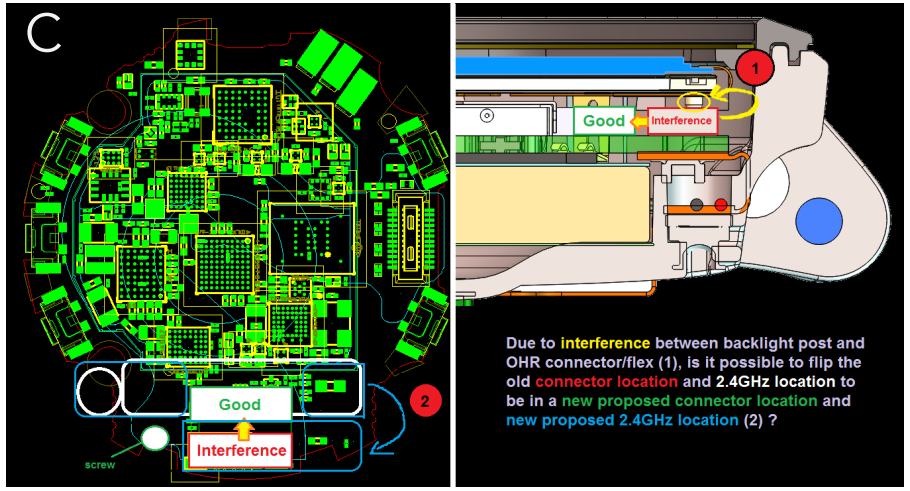
- Served as ME in core team 2 ME's, 1 EE, 1 Industrial Designer
- Designed 10 mechanical parts, 2 flex PCBs, 1 rigid PCB
- Product shipped mid-2017



Images

A. Render of a preliminary design
B. Flex circuit for connecting internal PCBs
C. Example of trade-off communication with electrical engineer

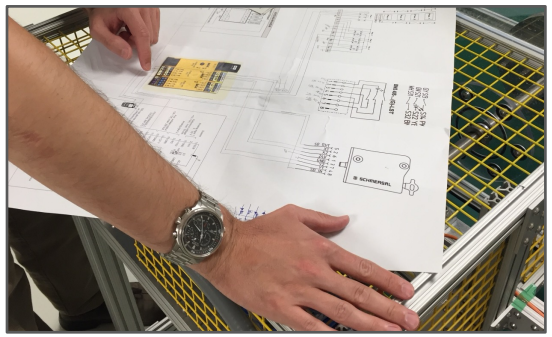


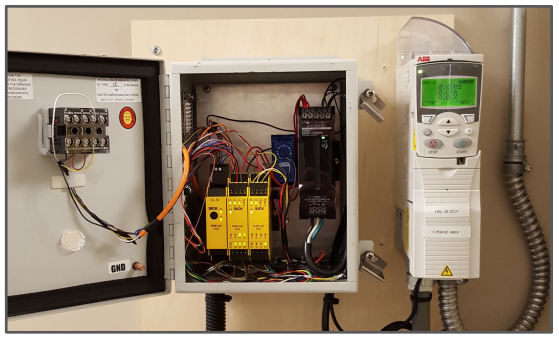


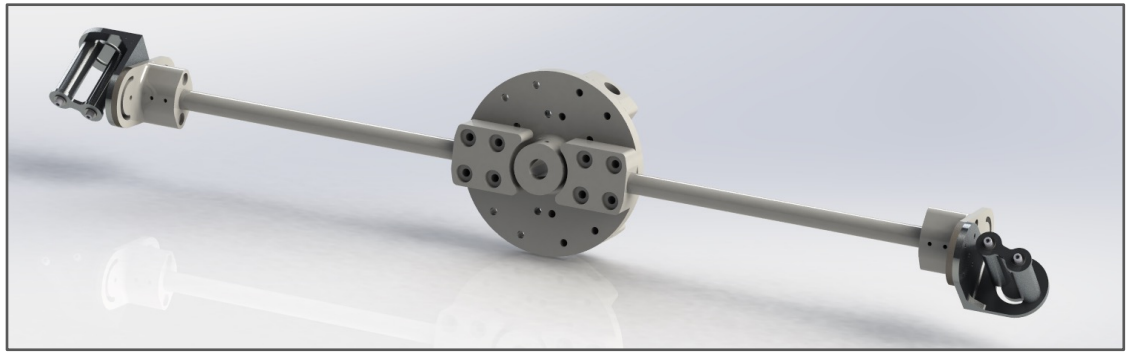
Objective: to create a test machine to stress sealing interfaces of wearable swimming, outdoor, and triathlon watches.

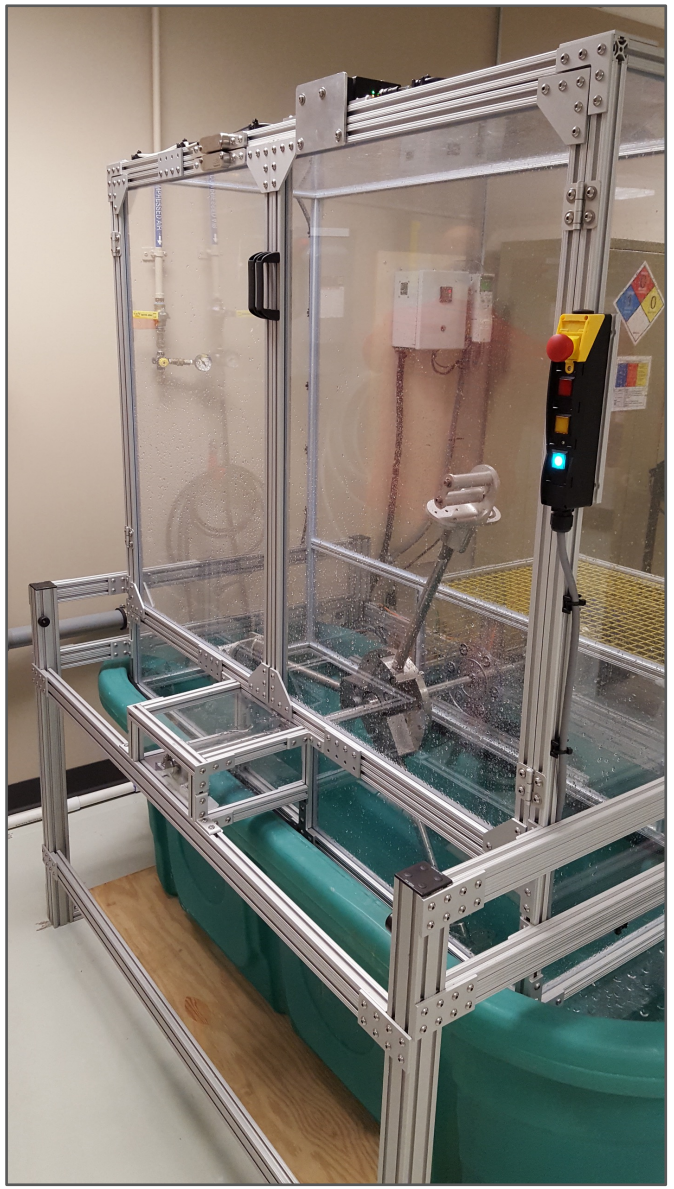
Quick Notes:

- Team size: 2.5
- Synthesized test requirements from high-level test concept
- Designed system from 80/20 framing, off-the-shelf motor and drivetrain, and 13 custom 303SS and 6061-T6 AL parts
- Specified, sourced, and installed PLd-rated industrial safety system
- Assembled, debugged, and validated full system









Continuous Flavor

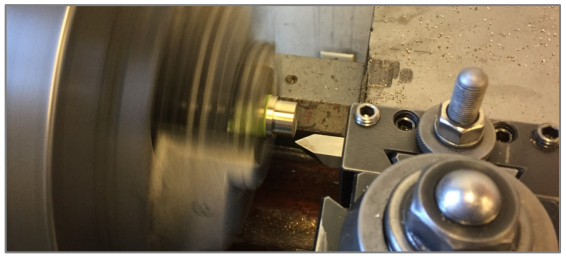
An organically-shaped steel herb planter.

Materials
Steel, Brass

Processes
Tube Forming, TIG Welding, Turning, Brazing, Sanding, Finishing, Powdercoating

Design Goals
To create an aesthetic form from steel tubing that simultaneously embraced the harshness of the steel yet showed its ability to be transformed into a complex, organic shape.

Challenges
Imprecise manual tube bending on a relatively large length scale made assembly and welding tricky, especially for someone without previous tube welding experience.



[Class Project. ME203, Stanford University]

Thank you.

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