# Machine Tool Monitoring

CPE Capstone Final Report

Industrial and Manufacturing Engineering Department

**Haas Hooligans**

Cameron Bracken
Ryan Jacoby
Noa Johnson
Nash Segovia

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# I. Introduction

## Project Overview

The primary goal of this project is to improve the efficiency and safety of the Industrial and Manufacturing Engineering (IME) labs at Cal Poly by developing a permanent digital infrastructure. This infrastructure will allow faculty, students, and technicians to view the real-time status of lab machines and plan educational materials accordingly. By integrating data monitoring systems, this project aims to assist in maintaining the machines, extending their lifespan, and optimizing their performance.

## Client / Stakeholders

The main client for this project is Dr. Waldorf, representing the IME department, along with future department chairs and other stakeholders such as shop technicians, students, and Cal Poly ITS. This solution is designed to address the educational and operational needs of these stakeholders. Additionally, the outcomes could benefit external organizations such as Lawrence Livermore National Labs or other educational institutions interested in monitoring and analyzing machine data.

## Insights and Opportunities

The insights provided by the client emphasize the need for a user-friendly graphical interface, an ITS-sanctioned infrastructure for long-term viability, and broad applicability across most machines within the department. The project also considers future data applications, including machine learning and algorithm generation.

## Goals and Objectives

The project's goals include the creation of a permanent infrastructure for collecting, storing, and monitoring machine data. This infrastructure is designed not only to provide immediate usability but also to lay the foundation for future analysis using machine learning to generate actionable trends and insights. Additionally, hardware will be installed on the machines to gather real-time data, which will be visualized and accessible via an intuitive web portal.

To achieve these goals, the team has identified several key objectives. These include:

- Designing and building hardware components capable of primary data collection, ensuring compatibility and reliability across different machines.
- Establishing a robust physical network infrastructure to connect machines securely and reliably.
- Developing a hosting solution for the web portal, including both the database for storing data and the dashboard for user interaction.

- Creating a web-based dashboard that facilitates data hosting and access, featuring an intuitive interface for diverse users such as faculty, students, and technicians.

## Outcomes and Deliverables

The project deliverables are structured to meet the needs of all stakeholders while ensuring scalability, usability, and reliability. The key deliverables include:

- **Microcontroller with sensors:** A hardware package capable of collecting machine data with high accuracy and reliability.
- **Physical Network Infrastructure:** A robust network system enabling data transmission, supporting Power over Ethernet (PoE) or wireless communication where applicable.
- **Website for Database, GUI, and Data Visualization:** A web-based platform designed for intuitive data interaction and visualization, complete with backend infrastructure and database capabilities.

The outcomes aim to ensure that the deliverables achieve full functionality while addressing potential developmental challenges:

- **Microcontroller and Sensor Package:**
    a. All microcontrollers and sensors are designed, built, and tested to function as intended, fully integrated into the required machine tools.
    b. Partial outcomes may include hardware that is functional but requires additional testing or debugging.
- **Firmware:**
    a. Firmware will be free of bugs and operate seamlessly on the microcontrollers, ensuring data collection without errors.
- **Physical Network Infrastructure:**
    a. Complete network infrastructure that is fully implemented according to engineering constraints, with all machines requiring PoE or Ethernet connectivity integrated by Cal Poly ITS.
    b. Partial completion may involve implementing the infrastructure on select machines while leaving others pending.
    c. In some cases, the infrastructure may rely on the existing 802.11 network for connectivity.
- **Dashboard:**
    a. The dashboard should provide a user-friendly interface with a backend database and webserver implementation. Features include real-time data visualization, minimal bugs, and seamless integration with Cal Poly's Single Sign-On (SSO) system.
- **Website Backend and Database:**

a. The backend infrastructure should deliver >99% uptime, with database response times under 50ms.
b. Full integration involves connecting all hardware devices via PoE and ensuring stable internet access. The webserver will host a GUI for client interaction and an API for research and student learning. The system's codebase will be made available for future projects.

## Project Duration

- **Quarter 1, Week 6 :** Eval board hardware release
- **Quarter 1, Week 9:** Alpha infrastructure (cloud and physical)
- **Quarter 1, Week 10:** Eval hardware testing
- **Quarter 2, Week 5:**
  - Physical infrastructure completion and testing
  - Beta hardware schematic completion
- **Quarter 2, Week 6:** Dashboard creation
- **Quarter 2, Week 7:**
  - Infrastructure documentation
  - Beta hardware layout release
  - Data collection and dashboard integration/testing
- **Quarter 2, Week 10:** Beta hardware bring-up/Firmware MVP
- **Quarter 2, Week 11:** Handoff

## Team Mission and Objectives

Our team is dedicated to delivering an Internet of Things (IoT) solution that meets our client's needs for data collection, visualization, and machine shop safety monitoring. By fostering collaboration and encouraging open communication, we aim to ensure that every idea is thoroughly considered, maximizing the potential for an optimal outcome. To achieve this, we will design modular PCBAs to integrate sensor and communication hardware, write microcontroller programming for data acquisition, develop a robust database for storage, and create an intuitive web application for data access and visualization.

## Team Roles

Cameron Bracken serves as the team Liaison and Product Verification Lead, ensuring clear communication with stakeholders and maintaining hardware quality. Ryan Jacoby serves as the Procurement and Financial Officer, the System Architect and Hardware Engineer, overseeing the project's high-level technical structure and hardware development. Noa Johnson is the Project Manager and Firm Engineer, leading project planning and ensuring alignment with deliverables. Nash Segovia is the Software Engineer, crafting the programming and user interface essential to the system's functionality.

**Planning Information**

Collaboration Tools:

- Microsoft Onedrive/Sharepoint **-** Storage and office applications for writing and collaborating on our reports, charts, and documents.
- Slack – for communication between us and project overseer about important due dates
- SMS/RCS Messaging – Used for intra-team communication and meeting organization.
- Microsoft Outlook – Used for scheduling of appointments with Dan, communication with ITS, LLNL liaison, and project overseer.
- Zoom/VoIP **-** Used to work collaboratively when in person communication is not possible.
- GitHub – Project source code hosting and version control system for collaborative firmware, hardware, and software development.

## II. Related Work

When starting our project, we looked over the work of a previous team of IME students attempting to do a similar project. They used HiveMQ and MQTT to collect and display machine data from some of the Haas CNC machines. We decided not to adapt their code due to the bare-bones nature of their implementation; it was able to read data from machines but was not a complete robust system.

We also looked into MTConnect, an open standard developed by an industry coalition for transporting this kind of data. This is the interface that the Haas machines we are interfacing with uses, so we decided to base our project around this transport.

Pre-existing commercial solutions similar to our project exist as well, such as OnTimeEdge, DMG Mori CELOS, and Haas Connect. The later two are proprietary solutions for CNC machines from those companies. We seek to develop a solution that is more flexible and lower cost than these existing solutions.

## III. Formal Project Definition

### Marketing Requirements

We came up with our marking requirements after meeting with our client and working to define the scope of the project. The primary requirement of the system is to enable real-time monitoring of the machines. This can be used in the future for preventative maintenance, deep learning projects, and process analysis for class work. Other potential benefits of this system include improving energy efficiency in IME lab spaces. An important aspect of the system is building something that is easy to continue to maintain and adapt to new machines acquired by the department.

| Number | User Benefit | Requirement |
|---|---|---|
| 1 | Enable real-time monitoring of machine status and performance metrics | Remotely accessible, graphical representation of lab room |
| 2 | Collected data usable for long-term analysis and training of Deep Learning Neural Networks | A robust database to store and manage access to collected machine metrics |
| 3 | Provide enhanced oversight of student activity both during and outside of class hours to ensure safety and security | Integrate operator presence detection at each machine |
| 4 | The infrastructure is thoroughly documented and designed for long-term sustainability | Develop an infrastructure plan to ensure long-term maintainability of the project |
| 5 | Monitor machine shop power consumption to enable data-driven decisions for improving operational efficiency | Incorporate power consumption and temperature monitoring in the machine tracking system |
| 6 | Provide enhanced visibility in non-networked, older machines | Custom hardware devices for capturing and transmitting sensor data |
| 7 | New machines are added to the infrastructure as they are acquired | Easily expandable to new hardware |

Table 1: Marketing Requirements

### Engineering Requirements

We have separated our engineering requirements into separate categories by subsystem. Each marketing requirement has derived one or more engineering requirement.

| Hardware | | | | |
|---|---|---|---|---|
| **No.** | **Parameter** | **Requirements** | **Risk** | **Marketing Req.** |
| 1 | Operator Presence Detection | Must detect person at machine | Low | 3 |
| 2 | Current Sensor | Must sense current 0-50 Amps | Med | 5 |
| 3 | Temperature Sensor | Measure machine and ways temperature | Low | 5 |
| 4 | Vibration Sensor | Measure vibrational frequencies and amplitude in 3 dimensions | Med | 6 |
| 5 | RS-232 | Interface with non-networked machines | Med | 6 |
| 6 | SD Card | Store data when no network | Med | 2 |
| 7 | Networking | Must interface with any possible infrastructure outcome; must support Wi-Fi and Ethernet/PoE. | High | 1 |
| 8 | Power | Must accept power over Ethernet and DC-input | Med | 7 |
| 9 | Power Monitoring | Must monitor input DC voltage | Low | 7 |

| Firmware | | | | |
|---|---|---|---|---|
| **No.** | **Parameter** | **Requirements** | **Risk** | **Marketing Req.** |
| 10 | Communication Protocol | Must support MTConnect | High | 7 |
| 11 | Supports Hardware Selection | Firmware can power on and interface with all hardware components | Med | 6 |
| 12 | Data Collection Frequency | Must support data collection frequency of database | Low | 1 |

| Infrastructure | | | | |
|---|---|---|---|---|
| **No.** | **Parameter** | **Requirements** | **Risk** | **Marketing Req.** |
| 13 | Physical Infrastructure | Power and network plan for all machines tools and devices | High | 6 |
| 14 | Remote Access | Dashboard accessible from anywhere on internet | Med | 1 |
| 15 | Server | Permanent hosting service for dashboard and database | Med | 2 |

| | | | | |
|---|---|---|---|---|
| 16 | Maintenance Plan | Plan to maintain cloud infrastructure written | Low | 4 |
| 17 | Documentation | Physical infrastructure installed in labs must be well documented | Low | 4 |

| **Dashboard** | | | | |
|---|---|---|---|---|
| **No.** | **Parameter** | **Requirements** | **Risk** | **Marketing Req.** |
| 18 | Real Time Update | Machine data updates more than every 5 seconds | Med | 1 |
| 19 | Browser Compatibility | Functional across all modern desktop web browsers | Low | 1 |
| 20 | Concurrent Users | At least 10 users should be able to access the dashboard concurrently | Low | 1 |
| 21 | Website Maintainability | Must be able to easily implement changes as new machines are added, updated, or removed from the machine shops | Med | 6 |

| **Database** | | | | |
|---|---|---|---|---|
| **No.** | **Parameter** | **Requirements** | **Risk** | **Marketing Req.** |
| 22 | Uptime | Database must have >99.9% availability | High | 1 |
| 23 | Data Collection Frequency | Database must store data at desired 1 sample per machine per second | Low | 2 |
| 24 | Query Response Time | Database mean query time must be less than 100 ms | High | 1 |
| 25 | Data Types | Database must be able to store and handle time series data entries | Low | 2 |

Table 2: Engineering Requirements

## Customer Requirements

We highlighted several requirements from meeting with our customer that directly impact our design space.

- Connect with the existing Haas CNC machine tools

- Infrastructure is easily maintainable and permanent
- Data must be accessible and functional for process analysis

The requirement to interface with existing CNC tools constrains us to interface using the MTConnect protocol, as that is the only way to get data off these machines. Maintainable and permanent infrastructure has led us to working with Cal Poly ITS to deploy supported ethernet hardware as our primary infrastructure solution. Process analysis capabilities significantly narrowed the scope of our database search, as this requires a time-series database.

### Criteria

To select our hardware, we require that all parts must be obtainable now and should be easily obtained in the future. Also, our microcontroller selection must support our networking requirements; it must be able to interface on both Ethernet and Wi-Fi. These criteria significantly narrowed the search space. We also need our microcontroller to interface with all peripherals and not be in a BGA package. Having internal ADC removes one extra sensor and the supporting electronics from our board, so that is a positive as well. Power hardware and the device power tree must be able to supply all the other required hardware. To select our firmware architecture, we looked at microcontroller support, existing peripheral libraries for the platform, real time operating systems, and ease of use. Due to the scope of the firmware tasks, we determined that it would be beneficial to use a real time operating system to speed up development and provide logical abstractions. To pick a database, backend, and frontend, we looked at software licensing, pricing, performance, and ease of use. We also required that the database solution natively support time-series data as that significantly simplifies implementation.

## IV. Project Development and Selection

### Ideation

Our initial design ideas stemmed primarily from Ryan and Cameron, whose expertise in electronics and CNC machines guided the project's foundational direction. Their technical knowledge helped outline potential routes and features for our solution. Meanwhile, Noa and Nash, less familiar with the field, contributed by asking numerous questions to clarify and expand on specific project aspects. This inquisitiveness served as a catalyst for deeper group discussions and introduced fresh perspectives that enriched the ideation process.

To generate ideas systematically, we employed a concept fan during a dedicated class session. This exercise involved mapping out the project plan in detail—from connecting our device to the CNC machines to transmitting data, utilizing the cloud for data storage and analysis, and integrating it with the dashboard. The resulting system architecture diagram in Figure 1, captured our collective vision and provided a framework for further development.

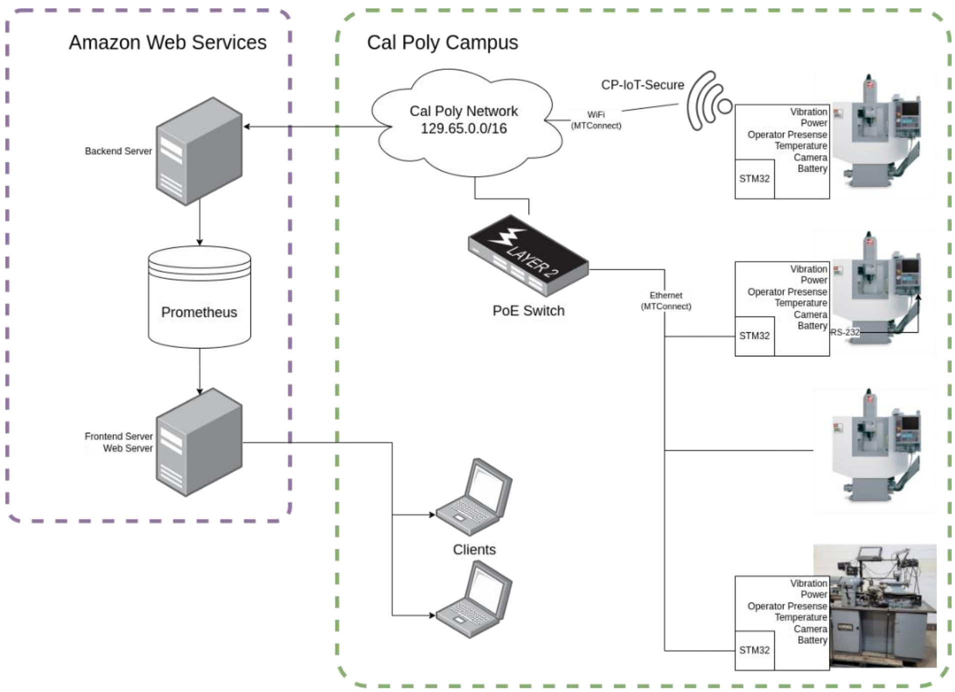



Figure 1: System Architecture Diagram

Beyond internal discussions, we sought feedback from a variety of sources, including peers with relevant interests, professors, and other field experts. Their experience with similar projects provided valuable insights into performance, reliability, and ease of implementation for various components and software. During these conversations, the "yes-and" brainstorming method was often informally incorporated, encouraging experts to expand on our ideas with creative or alternative perspectives, even when these were not the easiest routes to take. This collaborative process allowed us to refine our concepts by integrating diverse recommendations and innovative approaches.

## Selection

Hardware selection took two main paths. A microcontroller was chosen to communicate with the required network protocols and a rich set of sensor peripherals. Sensors were chosen to measure all of the required metrics, that are able to interface with the microcontroller. A high-speed parallel camera interface was also taken into consideration while choosing a microcontroller so video streaming could be possible. The power components were selected to provide all of the voltage rails required to the peripherals. Dr. Taufik was consulted to design the power distribution tree.

| | **STM32 + nRF7001** | **ESP32 PICO-D4** | **ESP32 P4** |
|---|---|---|---|
| Supports Ethernet and Wi-Fi | STM32 requires external Wi-Fi co-processor; nRF7001 | Yes | Yes |
| Has required peripherals | STM32 has high pin count options and STM32F777 has all required peripherals | Low pin count and poor peripheral support | Better peripheral support, similarly to PICO-D4 no camera support |
| Availability and Longevity | Good stock, ST and Nordic are stable companies | Good stock, Espressif is a decently stable company | Engineering samples only, very hard to get |

Table 3: Microcontroller Selection

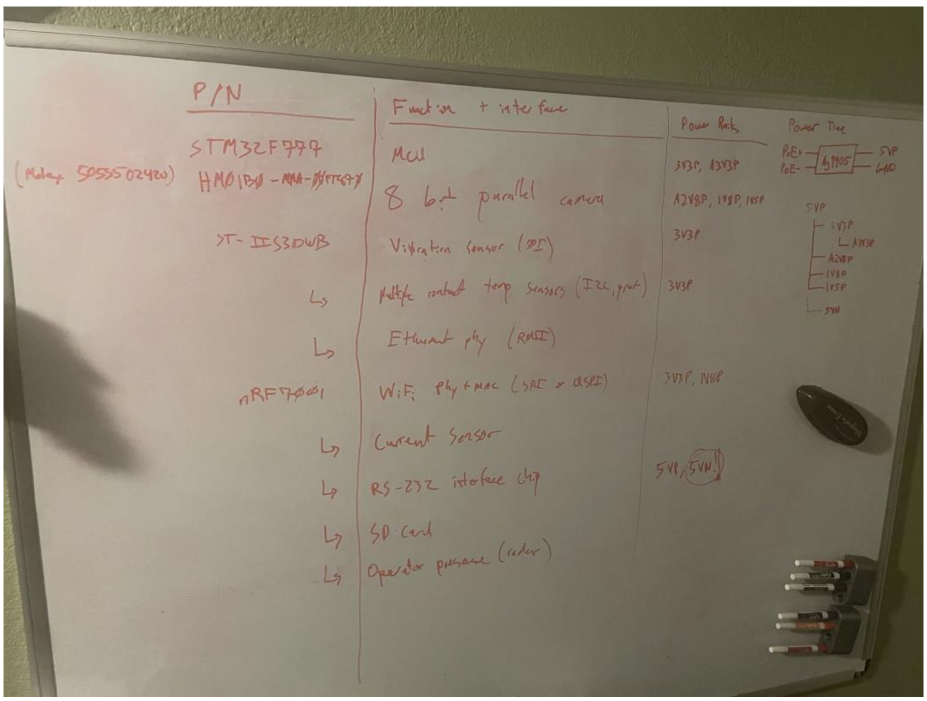



Figure 2: Hardware Selection Notes

The process for making the firmware selection was strongly tied to the hardware selection. These were done in parallel to make sure the firmware supports the hardware. The selection process required lots of research through datasheets and comparing the different options. It was well documented, and organized working from core components and outward to more peripheral modules. Overall, there were no real conflicts as all decisions were made with an engineering mindset to ensure cohesion between the hardware and firmware.

| | **Zephyr** | **FreeRTOS** | **Bare Metal** |
|---|---|---|---|
| Peripheral Compatibility | Fully compatible with peripherals especially the Wi-Fi PHY. | Mostly compatible with peripherals with the exception of the Wi-Fi PHY. | Compatible with all serial peripherals not necessarily compatible with networking peripherals. |
| Ease of Use | Well-maintained and documented with active support. | Well-maintained and thoroughly documented with long term support | Limited support and resources |

Table 4: Firmware Architecture Selection

| **MTConnect** | **Prometheus** | **Grafana** |
|---|---|---|
| MTConnect is an open communication standard that supports nearly every CNC Machine tool in the industry. | Prometheus is open source, reliable, highly documented and well-integrated with Grafana. Connectors exist for many data sources. | Grafana is open source, modular, and well documented. AWS provides a standardized instance for getting started. |
| Well-maintained and documented with active support. | Well-maintained and thoroughly documented with long term support | Limited support and resources |
| Not natively supported by Prometheus but natively supported by most of the Haas machine tools. | May not be as highly performant as other, high end solutions such as SAP S4 HANA, but will be good enough for our purposes. | Programming interface may be limiting when it comes to designing more elaborate dashboards. |

Table 5: Backend/Frontend Architecture Selection

| Criteria | AWS | GCP | Azure | Weight |
|---|---|---|---|---|
| Real-Time Data Handling | 5 | 4 | 4 | 5 |
| Data storage and longevity | 5 | 4 | 5 | 5 |

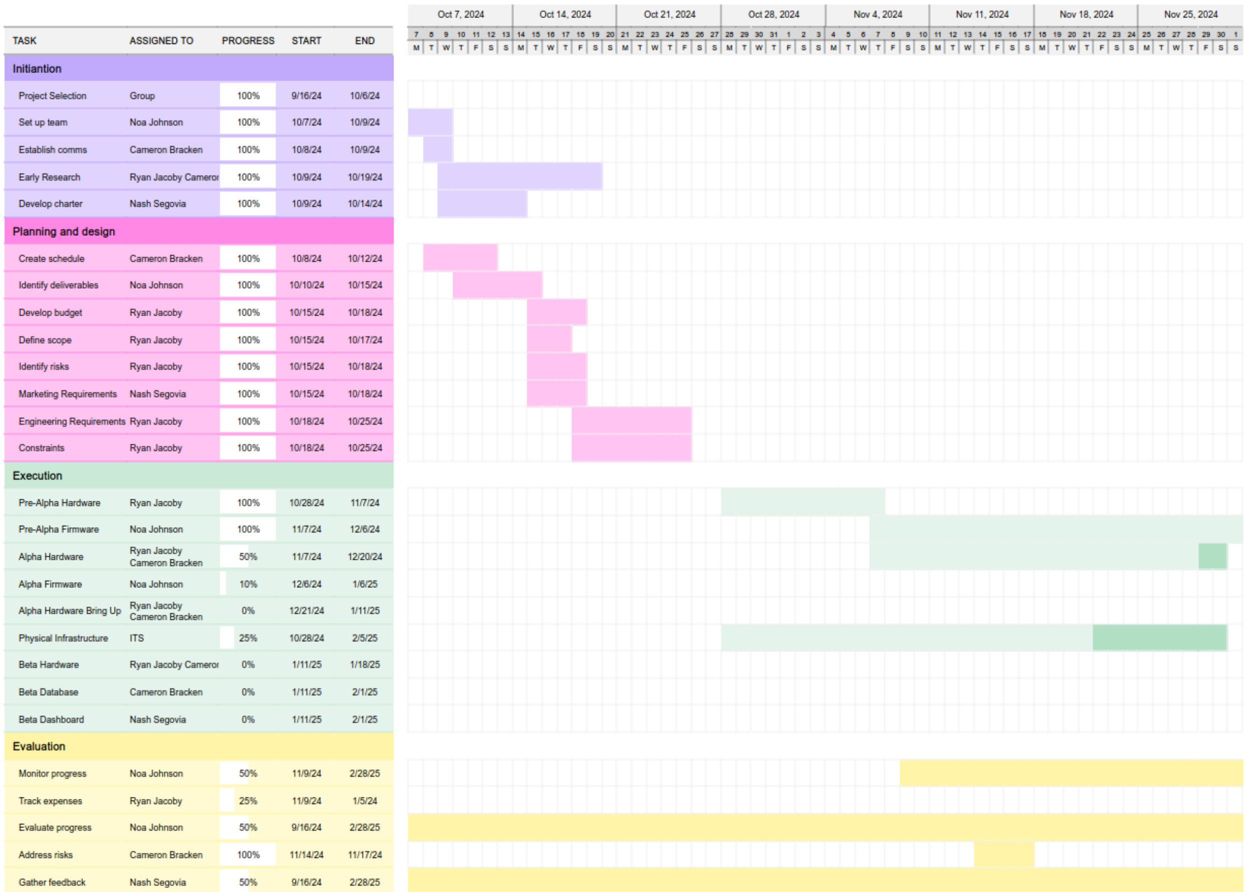
| | | | | |
|---|---|---|---|---|
| Dashboard and analytics tool | 5 | 5 | 4 | 4 |
| Long term cost effectiveness | 3 | 3 | 4 | 3 |
| Ease of use | 3 | 5 | 3 | 4 |
| IoT Services | 5 | 3 | 5 | 4 |

Table 6: Cloud Host Selection

## V. Project Planning

The project management style we have chosen is the waterfall style. This style is perfect for our project as it requires extensive initial planning which we needed to implement this project. Our design process is highly structured which is conducive to the waterfall methodology. Additionally, this was the chosen style as aspects of this project, such as the infrastructure and hardware, should be well-planned and thoroughly researched. This is required because it will be difficult to alter these aspects after they are implemented, as there is extensive lead time for ITS and the hardware manufacturers to complete certain components of work.

The Gantt chart we have provided shows our planned timeline for this project. This Gantt chart is broken down into key aspects of our project with their proposed timelines. Additionally, the chart is separated into four sections, initiation, planning and design, execution and evaluation. These sections align with the waterfall methodology and are filled with goals that correspond to the sections theme.



| TASK | ASSIGNED TO | PROGRESS | START | END |
|---|---|---|---|---|
| Initiantion | | | | |
| Project Selection | Group | 100% | 9/16/24 | 10/6/24 |
| Set up team | Noa Johnson | 100% | 10/7/24 | 10/9/24 |
| Establish comms | Cameron Bracken | 100% | 10/8/24 | 10/9/24 |
| Early Research | Ryan Jacoby Cameror | 100% | 10/9/24 | 10/19/24 |
| Develop charter | Nash Segovia | 100% | 10/9/24 | 10/14/24 |
| Planning and design | | | | |
| Create schedule | Cameron Bracken | 100% | 10/8/24 | 10/12/24 |
| Identify deliverables | Noa Johnson | 100% | 10/10/24 | 10/15/24 |
| Develop budget | Ryan Jacoby | 100% | 10/15/24 | 10/18/24 |
| Define scope | Ryan Jacoby | 100% | 10/15/24 | 10/17/24 |
| Identify risks | Ryan Jacoby | 100% | 10/15/24 | 10/18/24 |
| Marketing Requirements | Nash Segovia | 100% | 10/15/24 | 10/18/24 |
| Engineering Requirements | Ryan Jacoby | 100% | 10/18/24 | 10/25/24 |
| Constraints | Ryan Jacoby | 100% | 10/18/24 | 10/25/24 |
| Execution | | | | |
| Pre-Alpha Hardware | Ryan Jacoby | 100% | 10/28/24 | 11/7/24 |
| Pre-Alpha Firmware | Noa Johnson | 100% | 11/7/24 | 12/6/24 |
| Alpha Hardware | Ryan Jacoby Cameron Bracken | 50% | 11/7/24 | 12/20/24 |
| Alpha Firmware | Noa Johnson | 10% | 12/6/24 | 1/6/25 |
| Alpha Hardware Bring Up | Ryan Jacoby Cameron Bracken | 0% | 12/21/24 | 1/11/25 |
| Physical Infrastructure | ITS | 25% | 10/28/24 | 2/5/25 |
| Beta Hardware | Ryan Jacoby Cameror | 0% | 1/11/25 | 1/18/25 |
| Beta Database | Cameron Bracken | 0% | 1/11/25 | 2/1/25 |
| Beta Dashboard | Nash Segovia | 0% | 1/11/25 | 2/1/25 |
| Evaluation | | | | |
| Monitor progress | Noa Johnson | 50% | 11/9/24 | 2/28/25 |
| Track expenses | Ryan Jacoby | 25% | 11/9/24 | 1/5/24 |
| Evaluate progress | Noa Johnson | 50% | 9/16/24 | 2/28/25 |
| Address risks | Cameron Bracken | 100% | 11/14/24 | 11/17/24 |
| Gather feedback | Nash Segovia | 50% | 9/16/24 | 2/28/25 |



Figure 3: Gantt Chart

# VI. FMEA

| Potential Failure Modes | RPN Justification |
|---|---|
| Slow updates or freezing | There is a moderate chance of experiencing slow updates or freezing due to suboptimal query optimization and limited server resources. Although these performance issues are relatively easy to spot, the resulting delay is critical because it undermines the effectiveness of a real-time monitoring system. |
| No data received from devices | Network failures and configuration errors are fairly common, which increases the likelihood of data not being received. Even though the absence of data is easy to detect, the impact is severe since it can lead to missed alerts and leave machine status unmonitored. |
| Poor dashboard responsiveness | A slow or unresponsive dashboard can significantly compromise user experience and functionality. This issue, which may arise from inefficiencies in front-end code or resource-heavy graphics, is moderately likely but occurs less frequently than data issues. Its presence is also straightforward to identify by simply observing the dashboard's performance. |

| | |
|---|---|
| Unauthorized access to dashboard | Unauthorized access poses a serious threat as it could result in the exposure of sensitive machine data. However, due to robust security measures such as two-factor authentication and controlled login processes, this risk is relatively unlikely and easily detected. |
| No error message displayed | When error messages are missing, users may remain unaware of underlying problems. The risk of such an occurrence is moderate, especially if exception handling is not thoroughly implemented. Current measures like error logging offer some level of control over this issue. |

Table 7: Dashboard FMEA

## VII. DVP+R

| Specification | Test Description | Test Results |
|---|---|---|
| **Data Visualization:** Optimize query logic and upgrade server resources | Simulate heavy load conditions and rapid data refresh requests. Measure update speed and check for freezing or outdated information. | During testing, Grafana demonstrated a minimum refresh interval of 5 seconds. Despite this extended refresh rate, multiple queries were active, ensuring that all data collected between refresh cycles is displayed. |
| **Data Collection:** Improve network robustness | Simulate network failures. Monitor the dashboard for data reception, error logging, and missed alerts. | The system promptly alerts users through error messages if data queries fail. |
| **UI Interaction:** Streamline front-end design and optimize code | Conduct multi-browser performance testing. Measure UI load times and response to user interactions across various devices and browsers. | Since the dashboard is running locally, it currently supports only a single browser session and multi-browser testing has not been performed. |
| **Dashboard Access:** Enforce strong password policies and logins. | Perform security tests by simulating unauthorized access attempts and examining the enforcement of signing in. | At this stage, access to machine metrics is limited to users who have the dashboard code. Once Grafana is hosted on a permanent server, additional user access can be managed easily through the permissions settings. |
| **Error Reporting:** Implement clear error messages | Intentionally induce errors within the dashboard (e.g., failed data queries, UI exceptions). Verify that clear error messages are displayed and logged properly. | The system promptly alerts users through error messages if data queries fail. |

| | | |
|---|---|---|
| and robust logging | | |

Table 8: Dashboard DVP+R

## VIII. Demo

Our demo was divided into three distinct sections, each highlighting a different aspect of our project. Figure 4 shows the system architecture used to gather data directly from the CNC machines to develop the dashboard. Figure 5 showcases the temperature and acceleration data transmitted to a UART terminal using Zephyr RTOS on the Nucleo STM32F767ZI development board. The custom hardware this firmware runs on is shown in Figures 6 and 7. The MCU on that board is the same STM32F767ZI used on the Nucleo, but in a LQFP-100 package rather than the LQFP-144 included on the Nucleo. A small board shown in Figure 8 holds the vibration sensor. Various hardware verification and demonstration are shown in Figures 9 and 10. The board was assembled by hand and each piece tested as assembled. Hardware schematics, layout, and bringup notes can be found at the end of this document in the Appendix or in the git repository linked in Section 12, project resources. Figure 11 shows a screenshot from the dashboard, where data sourced from the UMC-500ss highlights key machine metrics such as spindle speed, program duration, spindle status, and the state of the emergency button. Through this project, we learned valuable lessons about large-scale project development, particularly the difference between our time estimates and the actual time required—especially in hardware and firmware development, which demanded extensive research and planning.

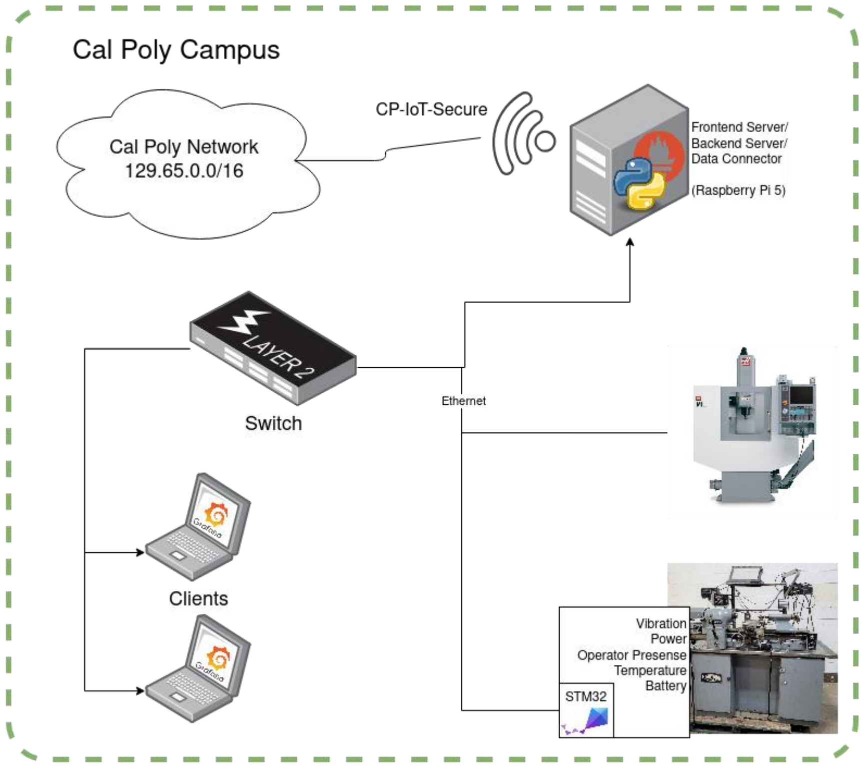



Figure 4: Reduced Scope System Architecture Diagram

```
*** Booting Zephyr OS build v4.0.0-4074-ge3a4a16594ff ***
[00:00:00.005,000] <inf> tass: Correct WHO_AM_I: 0x7b
[00:00:00.010,000] <inf> tass: Initializing IIS3DWB sensor
[00:00:00.026,000] <dbg> tass: SENS_INIT: BDU mode verified: 0x40
[00:00:00.033,000] <inf> tass: Register 0x10 set to 0xa0
[00:00:00.038,000] <inf> tass: IIS3DWB initialization complete
[00:00:00.045,000] <inf> main: Temperature: 74.602344 F
[00:00:00.050,000] <inf> main: Acceleration (g):
[00:00:00.055,000] <inf> main: X=-1.912655
[00:00:00.060,000] <inf> main: Y=-0.054351
[00:00:00.064,000] <inf> main: Z=-0.047092
[00:00:01.069,000] <inf> main: Temperature: 74.616406 F
[00:00:01.075,000] <inf> main: Acceleration (g):
[00:00:01.080,000] <inf> main: X=-1.175836
[00:00:01.084,000] <inf> main: Y=0.830881
[00:00:01.089,000] <inf> main: Z=0.003233
[00:00:02.093,000] <inf> main: Temperature: 74.686719 F
[00:00:02.099,000] <inf> main: Acceleration (g):
[00:00:02.104,000] <inf> main: X=0.893589
[00:00:02.108,000] <inf> main: Y=-1.323883
[00:00:02.113,000] <inf> main: Z=-1.316929
```

Figure 5: UART output of acceleration and temperature data on Zephyr RTOS

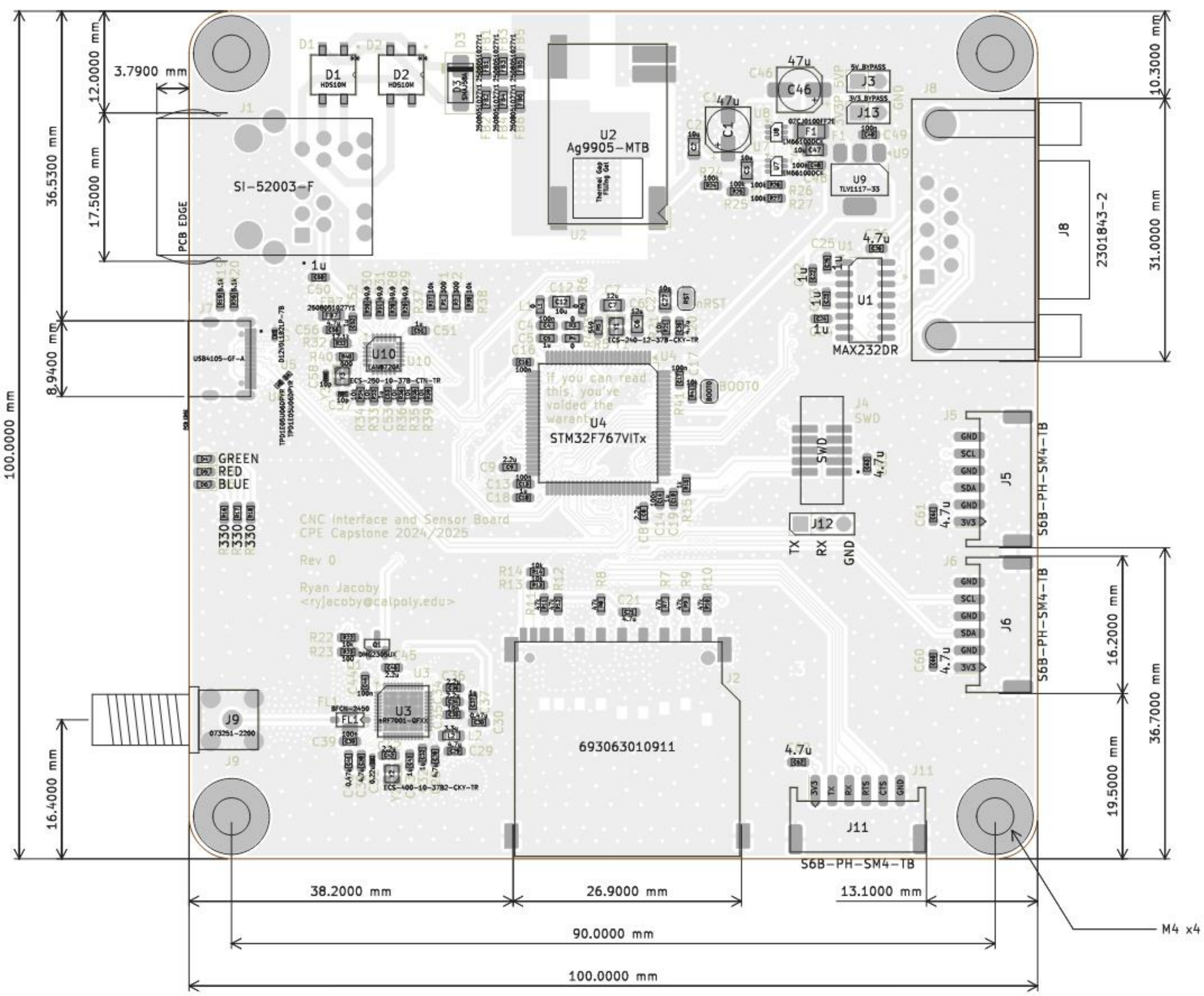


Figure 6: Alpha Hardware Front Assembly Drawing

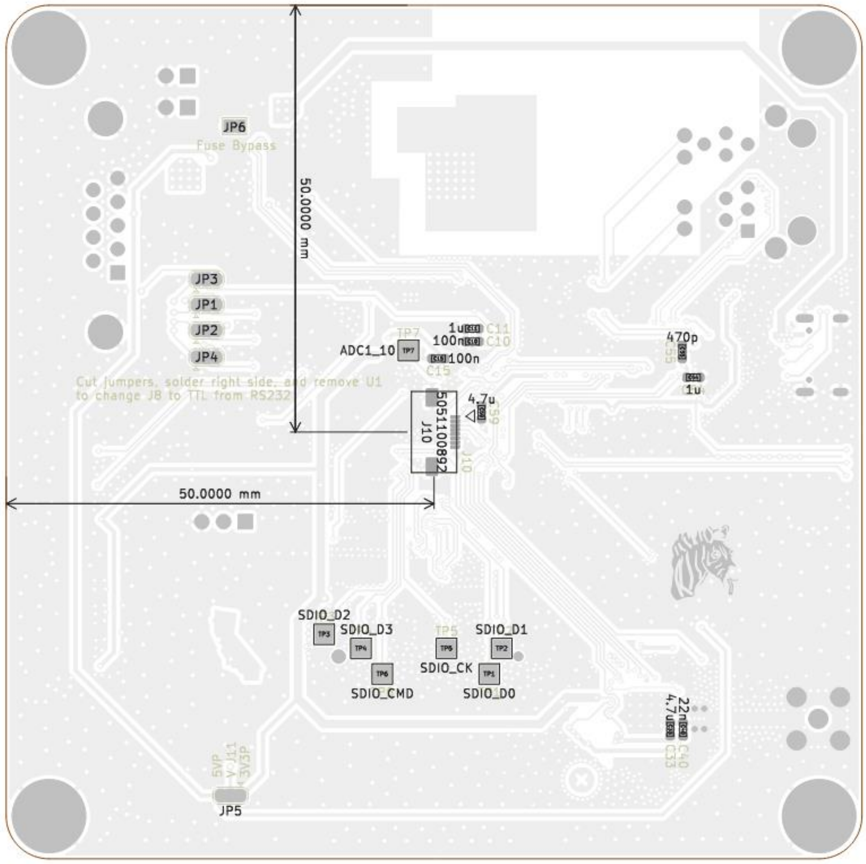



Figure 7: Alpha Hardware Back Assembly Drawing

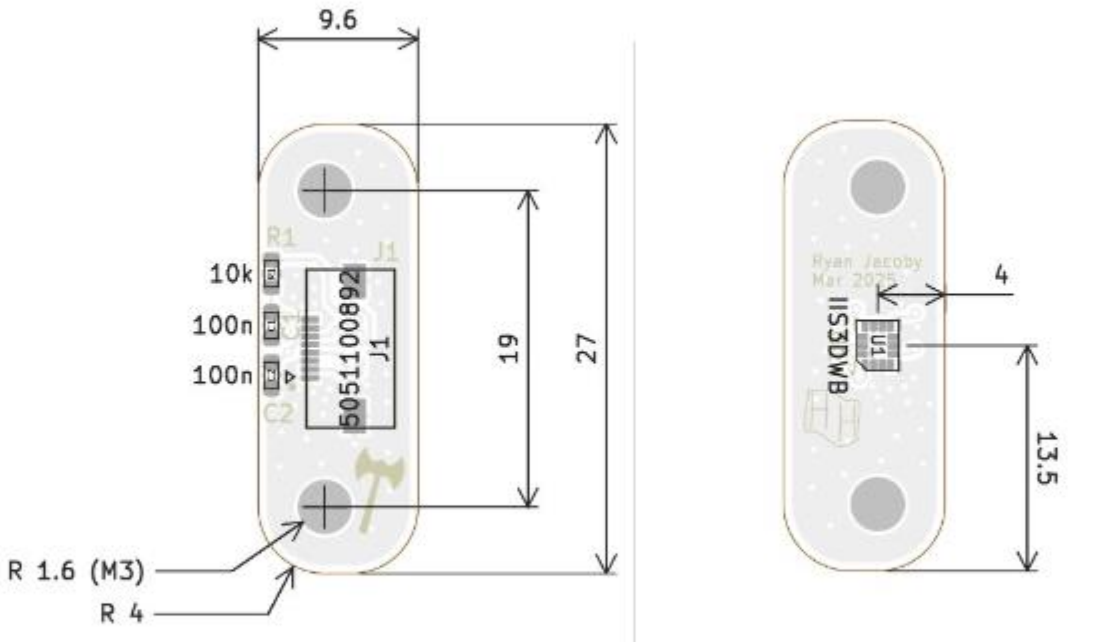



Figure 8: Beta Vibration Sensor Breakout Assembly Drawing

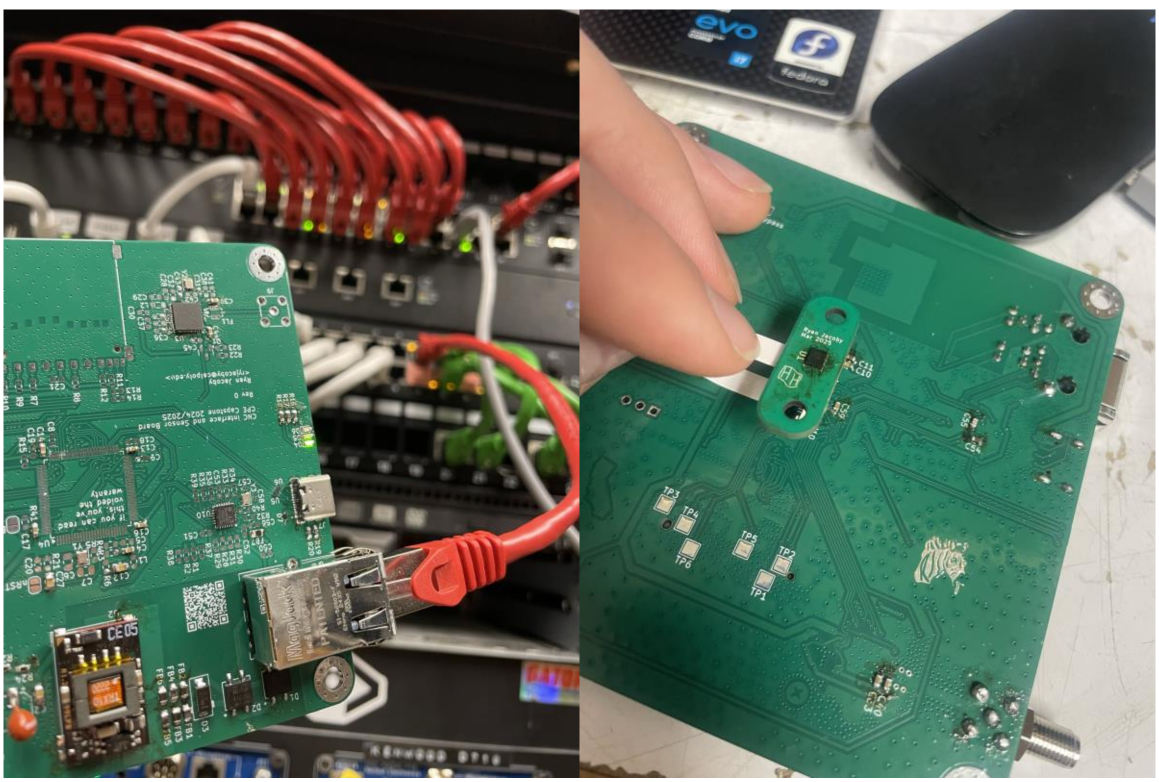


Figure 9: PoE Verification (left), Breakout Assembly on HW Bottom (right)

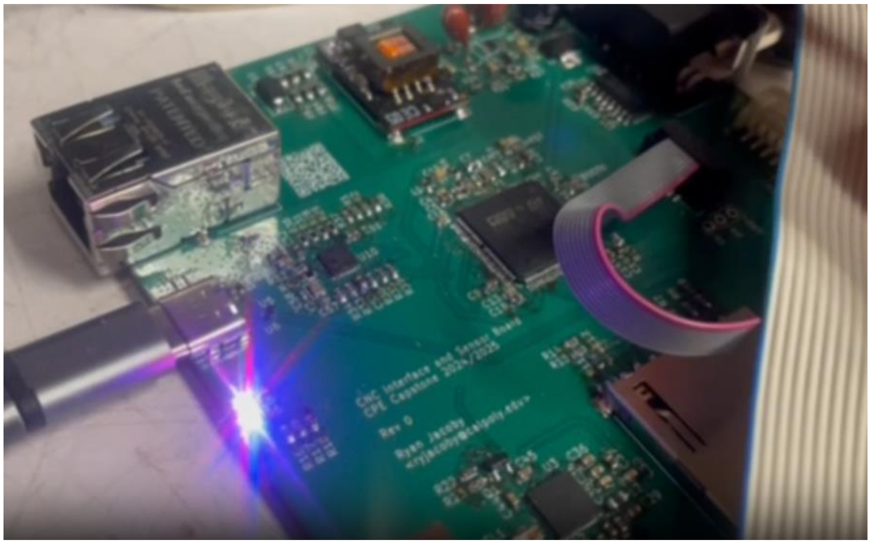


Figure 10: Verification running custom firmware



Figure 11: Dashboard Snapshot of Collected Machine Data

## IX. Teamwork

**Cameron:** My goal is to work within a team in a professional manner. This will involve responding appropriately to communication, accepting and completing tasks as they are delegated, and talking to others about potential problems and opinions on ideas and work before making any decisions myself.

**Ryan:** I aim to be more proactive in engaging with my team, initiating conversations and sharing updates unprompted, rather than solely responding to others.

**Noa:** I plan to proactively research the relevant aspects of this project to deepen my understanding of potential challenges. This will enable me to contribute meaningful ideas to the group and demonstrate my capabilities more effectively.

**Nash:** Feedback is a key indicator of focus therefore my goal moving forward is to continue asking questions. By learning more about the project, I'll gain deeper insights, which will enable me to participate more effectively in discussions and provide better feedback.

**Group:** To improve our adaptability, we will break down long-term goals into smaller, actionable tasks that we can clearly communicate progress on with each other.

## X. Diversity, Equity, and Inclusion

The IEEE 802.3af standard for Power over Ethernet (PoE), ratified in 2003, enables devices to receive power and data through a single Ethernet cable. This technology, rooted in a 2000 patent by Boris Katzenberg and Joseph Deptula, simplifies device connectivity by integrating power delivery with communication. Their invention, focused on device detection and power negotiation, became the foundation for modern PoE systems. PoE is essential to our project, as it eliminates the need for separate power supplies or wireless communication, significantly reducing infrastructure and development complexity.

## XI. Ethics

The top issues from our individual ethics assignments were database and hardware security issues and hardware societal issues.

A primary concern of our system is to be low-cost and accessible to other universities as well. This leads to one hardware societal concern, as it is a large upfront cost that could prevent other groups from deploying similar systems based on our work

We are also worried about societal impact of part sourcing in creating our hardware. Often times third party vendors can source components from illegal places which violate international labor, humanitarian, and environmental laws. Certain hardware vendors will use child labor or slave labor to illegally recycle components from old electronics. This is less of a concern for mainstream parts, but some difficult to source components can often be found with less than reputable vendors selling them pulled from old products.

For security, we were primarily concerned about creating a vulnerability on a client network due to our hardware and data security in the cloud. Because we're installing new hardware on the network, this could be used as an intrusion point to attack other devices on the network. A poorly set up ethernet switch could trunk VLAN traffic into a protected L2 network, an exposed wall port could be used by an attacker to gain unauthorized access to an internal network, or a vulnerable endpoint device could be taken over to spread malware. All of these are very important concerns when deploying new computing infrastructure, especially in an environment with client data. If the machines being monitored are producing proprietary, aerospace, or otherwise clearance parts, the security of any sensor data collected is extremely important.

Similarly, once this data has been transmitted to the cloud provider, it must be secured there. Correct setup of the cloud environment must be done to prevent the data from being stolen, encrypted, or ransomed.

## XII. Project Resources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## XIII. Appendix

### Peer Review (ITP Metrics)

**1/23/25**

**Cameron**

My recent feedback points to an overall decrease in productivity this quarter. I haven't communicated properly and haven't been pulling my weight. Next sprint, I will refocus on core needs to correct course and meet deadlines. By the end of next sprint, I will have the software adapter for MTConnect supported machines between the Prometheus database and Grafana so that actual statistics may be recorded.

**Ryan**

The largest gap between self and peer ratings is in commitment. I feel like I haven't been able to commit enough time in the last short sprint with my other projects and responsibilities simultaneously. I think sticking closer to my goals in the sprint objectives table this time around can help bring these scores back together. I also would like to work on my communication this sprint as we lacked that as a team during this entire sprint. An unfortunate schedule with school lead to us not really meeting for the second half of the sprint, which would not have been a problem if we were communicating better.

**Noa**

In my recent feedback, I identified several areas for improvement. One such area of improvement would be my commitment to the team. I feel that since this quarter has started my commitments have been slightly askew as I have had to focus on certain coursework more heavily out of the gate, but I have gotten ahead of the curb and as such am ready to commit more to the team. Additionally, my communication with the team has room for improvement as I have not been communicating my progress with my teammates as effectively as I could. As a result of my attention being askew, I think my standards appeared to slip slightly, however my standards for my work relating to this team are as strong as ever and I need to communicate better to present my accomplishments to show that my standards are still at a high level.

**Nash**

In my recent feedback, I identified several areas for improvement. I've realized that I haven't been communicating effectively with my teammates, so for the next sprint, I plan to provide updates on my progress and the status of my tasks at least once a week. Additionally, I scored lower on commitment and capabilities, which I believe are closely related at this stage of the project. To address this, I aim to meet my goals and demonstrate improvement in both areas. Specifically, by the end of this sprint, I want to have the website displaying data from multiple CNC machines, showcasing my commitment and ability to deliver my part of the project.

**Haas Hooligans**

As a team, our recent feedback highlighted a need to improve our adaptability. Over the past two weeks, we focused heavily on our individual tasks, leaving little time to meet as a group and assess overall progress or offer help where needed. This lack of collaboration has impacted our adaptability as reflected in the feedback. Moving forward, we will hold regular, brief group meetings to share updates, boost team confidence, and ensure alignment on the project. These meetings will also help us identify if any adjustments are needed or if a team member requires support, keeping us on track toward our shared goals.

**2/6/25**

**Cameron**

After last sprint, my peers rated that my capabilities were significantly higher than I rated myself. This must be a blind spot, since I do not seem to be getting work done as expected. I've progressed forwards with the goal of getting the MTConnect adapter developed in that I've gathered the tools needed to provide an environment to develop such an adapter, but I have not developed the adapter as of yet. My commitment to the project was on track with what my teammates rated. My focus was slightly below what my teammates rated for me, as I was picking up the pace and moving forwards, as opposed to last sprint where I largely stagnated and became isolated. This sprint, the focus will be on developing the adapter completely and ensuring that it is a robust software solution for the database.

**Nash**

In the latest round of feedback, my peers rated my commitment and focus significantly higher than I rated myself. This discrepancy stems from my own perception of my progress—I've been stuck on the same challenge since the first week, and only recently managed to overcome it with the help of a peer. Despite this, my commitment and focus were still slightly below the standard. Moving forward, I plan to bring them up to par by doubling down on my efforts to make up for lost time. The lowest ranking in my feedback was for standards. As we approach the deadline, I've been prioritizing progress on the project over polished documentation, encouraging my team to focus on creating rough drafts for assignments rather than fully refined submissions. This approach allows us to dedicate more time to development while leaving the final documentation for the last report.

**Noa**

During this last sprint I was sick almost the entire time as such most of my ITP metrics have suffered. My commitment, communication, focus and standards metrics have dropped. Considering as I have been sick a majority of this sprint, I imagine that now that I am healthy again, I will be able to be a more active participant in our group. Specifically, I will be able to commit more time, have better focus and increase my standards. On the communication front, I will try to be a more active participant in our group conversations and will be able to attend group meetings.

**Ryan**

Similar to the last few ITP assessments, my only significant difference is in the focus category. I know that I am spending a lot of my time working on other classes and other projects for clubs and work. I feel like I don't have time for this project and that work has stalled, but clearly my group members do not feel this way. Possibly I could improve this discontinuity by working on my communication with my group members rather than improving my personal focus; they would then know where my attention has been going over the last weeks.

**Haas Hooligans**

As a team, we're performing well overall. Our communication has significantly improved, largely due to our regular short meetings where we discuss our progress. However, our adaptability score is slightly below standard, partly because of our perception of the project's progress. We've fallen behind in several areas, which has impacted our goal progression and, in turn, our overall adaptability rating. Our "relate" score remains high in our feedback, but a potential challenge moving forward is contribution equity. Individual contributions have started to fluctuate as team members juggle academic and personal responsibilities. Despite this, we're committed to maintaining strong communication, and we hope that overlapping responsibilities within the team will help distribute the workload more evenly. On the educate front, we're performing exceptionally well and will continue to build on that strength.

**2/25/25**

**Cameron**

N/A

**Ryan**

Similar to the last many ITP metrics, I rated my focus lower than my team. I've been distracted by other portions of this project and other classes and had a difficult time making progress on my own objectives. This sprint was bad; this quarter was bad. I wish I had time to just work on this project but there are so many other projects, classes, and responsibilities my focus is torn towards. Maybe spending a summer working full time has warped my perspective of what focus feels like and what's achievable in certain time frames; between running to and from class, feeding myself, running a club and a half, keeping up with homework, PolySat work, and Keysight work I have difficulty focusing on and getting serious work done for this project. Even after pouring in many hundreds of hours, I'm still behind where I want to be.

**Noa**

During this current sprint I have been considerably preoccupied with the other classes I am currently enrolled in. About 2 weeks ago I was sick for about a week and a half, which put me severely behind in my other classes. As a result, I focused on the other classes more and as their deadlines were more concrete, it has required a substantial portion of my time in making sure that those deadlines were met. Unfortunately, as reflected in my ITP metrics, across all my sections I am below the point that I would like to be. Seeing as I have finally caught up in all my other classes, I am prepared to commit as much time as necessary to put my best foot forward in completing my goals in this coming sprint. Regarding communication, I will put forth a much better effort in communicating my progress and coordinating goals with the team. As far as the other three categories I believe that by being able to commit the necessary amount of time for this project I will be able to improve those metrics across the board.

**Nash**

In the current feedback, my results have reached the desired level except in the Standards area, which has suffered due to the deadline pressure. I've been prioritizing progress over quality, but in our final sprint, I plan to strike a balance, ensuring steady advancement while maintaining high quality to deliver a strong final product.

**Haas Hooligans**

Our team metrics are looking positive overall, with our Communicate, Relate, and Educate efforts meeting satisfactory standards. Our Adapt metric has remained the same since the last sprint primarily due to increased stress and workload from other classes which has limited our ability to support our peers. Furthermore, with the deadline fast approaching, our progress toward our goals is significantly behind our initial expectations. Nonetheless, our Adapt metric has not declined, which means we remain committed to maintaining clear communication and continuing to work diligently on our individual project areas.

## Diversity, Ethics and Inclusion

The IEEE 802.3af standard was ratified by the IEEE in 2003, creating a standard of Power over Ethernet for the world to use. However, there is a patent that goes back to 2000 (US 6218930) that credits Boris Katzenberg and Joseph A. Deptula with the invention of an "Apparatus and method for remotely powering access equipment over a 10/100 switched ethernet network". It is likely that systems like this and others, like one developed by PowerDSine (Later acquired by Microchip), Cisco, and Analog Devices were the progenitors to the modern 802.3af standard that we know today. The systems developed by Cisco and Analog Devices have since flourished into proprietary versions of PoE with higher functionality than the original standard. Boris and Joseph's invention specifically implicates detection of devices and negotiation of power delivery before the device is fully connected to power.  Several companies have infringed on their patent, such as D-Link, Hewlett Packard, and Dell, which they have litigated over and won lawsuits against, requiring the infringers to purchase a license for their technology from their company, Network-1 Technologies Inc. There is not much information on Boris or Joseph, other than that Boris has left the tech industry to focus on his dog training school.

This technology is fundamental to the functioning of our project. If we were not able to send both power and data over a single cable, it would require a vast amount of external hardware and firmware development to provide function for the alternatives. We would need Wi-Fi/Zigbee implementations for our communications, and either battery or external power supplies for power. The infrastructure commitments on this front would be much greater than if we were to do just power over ethernet, since we would need to make sure there are power outlets at each individual machine, rather than to just ensure we can route ethernet cables to each machine.

## Individual Ethics

Cameron Bracken

**Ethical Considerations**

**Device Hardware**

1. **Societal**:
    a. **Access Inequities**: High costs of advanced hardware may limit access for smaller manufacturers or underdeveloped regions, exacerbating economic disparities.
2. **Ethical**:
    a. **Labor Exploitation**: Sourcing raw materials (e.g., rare earth metals) may involve unethical labor practices, such as child labor or unsafe working conditions.
3. **Political**:
    a. **Export Controls**: Restrictions or tariffs on hardware components sourced from politically sensitive regions may disrupt supply chains.
4. **Environmental**:
    a. **E-Waste Generation**: Disposal of outdated or malfunctioning hardware contributes to electronic waste, polluting ecosystems if not recycled properly.
5. **Security**:
    a. **Hardware Backdoors**: Counterfeit or compromised hardware components could introduce vulnerabilities, allowing malicious actors to exploit the system.

**Device Firmware**

1. **Societal**:
    a. **Technological Exclusion**: Poorly optimized firmware might require frequent updates that small manufacturers with limited resources struggle to implement.
2. **Ethical**:

   a. **Planned Obsolescence**: Deliberately designing firmware to necessitate frequent upgrades could be seen as exploiting users financially.
3. **Political**:
   a. **Regulatory Compliance**: Firmware must meet evolving safety, cybersecurity, and data privacy standards, varying across jurisdictions.
4. **Environmental**:
   a. **Energy Inefficiency**: Inefficient firmware design can lead to higher energy consumption by devices, increasing the project's environmental footprint.
5. **Security**:
   a. **Firmware Exploits**: Vulnerabilities in the firmware could allow attackers to take control of the system or inject malicious code.

**System Dashboard**

1. **Societal**:
   a. **Misrepresentation of Data**: Dashboards that display biased or unclear data could lead to poor decision-making, affecting workers or the community.
2. **Ethical**:
   a. **Lack of Accessibility**: Failing to design dashboards for users with disabilities may exclude certain groups, raising inclusivity concerns.
3. **Political**:
   a. **Government Scrutiny**: Real-time monitoring of critical data might attract regulatory oversight or government intervention, especially in sensitive industries.
4. **Environmental**:
   a. **Display Energy Use**: Dashboards with high-resolution, always-on displays consume significant energy, contributing to emissions.
5. **Security**:
   a. **Unauthorized Access**: Weak access controls on dashboards could allow unauthorized personnel to manipulate data or monitor operations.

**System Database**

1. **Societal**:
   a. **Workplace Monitoring Concerns**: Real-time data collection could be perceived as intrusive surveillance, leading to reduced worker trust.
2. **Ethical**:
   a. **Unclear Data Ownership**: Disputes may arise if there is no clear agreement on who owns the CNC operational data.
3. **Political**:
   a. **Cross-Border Data Conflicts**: Storing data internationally could violate data sovereignty laws, leading to regulatory challenges.
4. **Environmental**:

    a. **Energy-Intensive Servers**: Hosting large databases in energy-intensive data centers could contribute to carbon emissions.
5. **Security**:
    a. **Ransomware Attacks**: Attackers may target the database, encrypt data, and demand a ransom, disrupting operations.

**Network Infrastructure**

1. **Societal**:
    a. **Digital Divide**: Inequitable access to robust networking infrastructure could leave some regions or facilities technologically behind.
2. **Ethical**:
    a. **Privacy Violations**: Continuous data transmission over networks may expose sensitive CNC processes if improperly secured.
3. **Political**:
    a. **Geopolitical Risks**: Use of foreign-manufactured networking equipment may trigger espionage or national security concerns.
4. **Environmental**:
    a. **Infrastructure Impact**: Installing or upgrading network infrastructure may disrupt local ecosystems or consume significant resources.
5. **Security**:
    a. **Man-in-the-Middle Attacks**: Interception of unencrypted network communications could compromise the confidentiality of CNC data.

**Ranked Order of Importance:**

1. Security
2. Environmental
3. Ethical
4. Political
5. Societal

The reason the issues are ordered as they are is because security is a large component of our project. Politics, social issues, and ethical concerns are largely unintrusive for our devices, since they are to be deployed on a small scale within Cal Poly, and nowhere else (at least at the moment). Security concerns stem from unauthorized access and usage of the system, such as physical accesses and remote incursions. Environmental concerns stem from device production and operation, such as manufacturing environmental costs and operational power draw of both the hardware and the cloud infrastructure.

**Top 3 Issues**

Security is the most immediate concern for our project, as access to the dashboard and database must be restricted to only authorized students and faculty, such as editing the current machine shop layout, adding new machines, and accessing a machine shop overview. This can be mitigated with use of the Cal Poly SSO system. The second most immediate would be environmental being power consumption and device acquisition. Our devices should be cheap and built efficiently but not incur any unnecessary environmental damage from their production and operation. We can mitigate this by selecting power efficient hardware and writing well optimized code, as well as selecting a good manufacturer that adheres to a high standard of environmental impact reduction. Thirdly, there is some ethical concern for shop administrators using the dashboard to monitor the machine shop at a distance when they should be there in person to mitigate any risks to students. This can be mitigated with notices and warnings to inform the user of the responsible use and user agreement for the services so that it is not misused.

**Reflection**

It is obvious that there will be some ethical concerns with our project that we did not forsee. However, I think largely they will be much less drastic or cataclysmic than the research suggests, and the issues can be mitigated with little modification or work to our designs so that the function will largely be unaltered from the original ideas. Some may be a bit more difficult to implement (Cal Poly SSO), but would make the project more secure.

Noa Johnson

**Ethical Considerations**

**Subsystems:**

- Hardware
- Firmware
- Software Frontend
- Software Backend

**Ranking of importance:**

- **Hardware - Societal Issue:** Potential reliance on proprietary or expensive hardware, limiting accessibility for other schools or labs.
- **Hardware - Ethical Issues:** Sourcing components ethically (e.g., avoiding conflict minerals or components from unethical suppliers).
- **Software Frontend - Societal Issue:** Clarity of interface design to prevent misinterpretation of machine statuses.
- **Firmware - Political Issues:** Licensing and intellectual property concerns over firmware tools or libraries.
- **Hardware - Political Issues:** Compliance with university purchasing and procurement policies.

- **Software Backend - Political Issues:** Adherence to university data governance policies.
- **Software Frontend - Political Issues:** University policies on hosting software on university-owned or external platforms.
- **Firmware - Societal Issues:** Errors in firmware could lead to unsafe machine conditions, compromising user safety.
- **Firmware - Ethical Issues:** Responsibility to ensure firmware accurately represents machine conditions and does not suppress or falsify data.
- **Software Backend - Ethical Issues:** Responsibility to ensure backend analytics are accurate and unbiased.
- **Software Frontend - Security Issues:** Exposure of sensitive information through poorly implemented authentication mechanisms.
- **Software Backend - Security Issues:** Injection attacks or vulnerabilities compromising backend data integrity.
- **Firmware - Security Issues:** Risks of firmware hacks leading to altered or false machine data.
- **Software Backend - Environmental Issues:** Lack of optimization increasing server load and energy usage.
- **Hardware - Security Issues:** Physical security risks, such as unauthorized removal of sensors.
- **Hardware - Environmental Issues:** Energy consumption of sensors and devices, especially if running continuously.
- **Firmware - Environmental Issues:** Inefficient algorithms could overuse resources or increase power draw, leading to higher environmental impact.
- **Software Frontend - Environmental Issues:** Resource-intensive frontend designs requiring high-performance devices, potentially excluding older hardware.
- **Software Backend - Societal Issues:** Displacement of student technician roles due to automation of machine monitoring.
- **Software Frontend - Ethical Issues:** Ensuring inclusivity in language and design, accommodating different cultural or educational backgrounds.

**Ranking Justification:**
I ranked these in terms of three main principles, core functionality, moral responsibility and legal responsibility. My first three choices are great examples of this as these are the greatest examples of the 3 main principles. In terms of core functionality, the ability to source the hardware is of paramount importance and being able to determine the state of each machine based on the software is also part of the core functionality. The issue of ethically and responsibly source hardware leans into moral responsibility as well as legal responsibility.
**Top 3 Issues:**

Reliance on proprietary hardware leads to a multitude of issues. One of these issues being the ability to upgrade our device or replace parts if they fail. If they are no longer available, it would require a full restructuring of the project and specifically in the case of the firmware they may require extensive modifications to the codebase. Additionally, if a component is very expensive and it is damaged during testing or fails the funds to replace the part may not be available requiring the substitution of parts leading to the previously mentioned issue of restricting the code base. When regarding the ethical sourcing of components, that is of great importance as we want to make sure that our components are not sourced from source that exploit labor of any individual. This can range from the usage of child labor or force labor in the supply chain of a component. Having a clear interface for non-technical clients is very important as ideally the system would be readable even to those lacking technical experience.

**Reflection:**

In doing this assignment, I have been made aware of some of the possible issues that could arise in not just developing this project but also any project in the embedded systems space. This will provide valuable insight into our design process not only this project but for any future projects we may be apart of.

Nash Segovia

**Ethical Considerations**

**Hardware**

- **Societal Issues**: Accessibility to new hardware may favor institutions with more funding, potentially widening the gap between well-resourced and under-resourced organizations.
- **Environmental Issues**: Manufacturing and eventual disposal of microcontrollers, sensors, and PCBs contribute to electronic waste and resource depletion.
- **Ethical Issues**: Ensuring the hardware doesn't lead to invasive monitoring of machine operators without proper consent is essential.
- **Security Issues**: If hardware is tampered with, it could introduce vulnerabilities into the system, compromising data integrity and safety.
- **Political Issues**: Ensuring compliance with institutional procurement policies and environmental regulations could delay hardware adoption.

**Firmware**

- **Societal Issues**: Improperly functioning firmware could hinder productivity, affecting students' learning and technicians' workflows.
- **Environmental Issues**: Inefficient firmware may lead to higher energy consumption by devices, indirectly increasing the project's environmental footprint.
- **Ethical Issues**: Firmware bugs or flaws could result in inaccurate data collection, which might mislead decision-making processes.

- **Security Issues**: Vulnerabilities in firmware could serve as entry points for cyberattacks, jeopardizing the entire system.
- **Political Issues**: Open-source vs. proprietary firmware choices may raise debates over intellectual property rights and collaboration policies within and beyond the institution.

**Physical Infrastructure**

- **Societal Issues**: A failure to ensure widespread access to the physical infrastructure may create inequities between machines or labs.
- **Environmental Issues**: Installation and maintenance of Ethernet hardware and other infrastructure could involve energy-intensive processes and material use.
- **Ethical Issues**: Decisions about which machines to prioritize in the network could unintentionally exclude certain groups or purposes.
- **Security Issues**: Poorly implemented infrastructure could expose the network to unauthorized access or data leaks.
- **Political Issues**: Collaboration with Cal Poly ITS might involve navigating institutional policies and approvals, potentially delaying project implementation.

**Dashboard**

- **Societal Issues**: A poorly designed dashboard could alienate less tech-savvy users, limiting its accessibility and usability.
- **Environmental Issues**: The energy demands of running a web server continuously for the dashboard could increase the project's carbon footprint.
- **Ethical Issues**: Dashboard design must ensure fair representation of data without bias or omissions that could mislead stakeholders.
- **Security Issues**: If the dashboard is not properly secured, sensitive machine and operator data could be exposed to unauthorized parties.
- **Political Issues**: Dashboard hosting on Cal Poly servers may face scrutiny over resource allocation or adherence to institutional IT policies.

**Database**

- **Societal Issues**: Data stored in the database could be used to make decisions that disproportionately favor certain users or applications, raising equity concerns.
- **Environmental Issues**: The database server's energy consumption contributes to the project's environmental impact. Optimizing database operations is crucial.
- **Ethical Issues**: Misuse of stored data, such as unauthorized sharing or analysis, could lead to privacy violations.
- **Security Issues**: A database breach could expose sensitive data, including proprietary machine operations or user activity, causing reputational and financial harm.
- **Political Issues**: The choice of cloud vs. on-premises hosting could lead to debates over data ownership, compliance with legal frameworks, and funding priorities.

**Rank-Order of Issues**

1. **Security Issues**
2. **Ethical Considerations**
3. **Societal Impacts**
4. **Environmental Concerns**
5. **Political Implications**

Security is the most critical issue because the project involves collecting and transmitting sensitive machine data through a network and cloud infrastructure. Unauthorized access or data breaches could compromise proprietary processes, machine performance data, or personal information of users. Addressing this requires robust encryption, secure protocols (e.g., MTConnect), and compliance with university IT standards. Failing to prioritize security could lead to significant reputational and operational risks.

Ethical concerns are paramount because the project involves monitoring operator activity and potentially influencing how data is used. There must be transparency in how data about users and machines is collected, stored, and analyzed to prevent misuse. Ethical lapses, such as lack of consent or improper surveillance, could violate user trust and institutional guidelines.

The societal importance of the project lies in its ability to enhance educational and operational efficiency. By enabling real-time machine monitoring, the system improves student learning experiences and technician workflows. However, unequal access to the data or over-reliance on automation could inadvertently marginalize certain groups or diminish manual skill-building opportunities.

Environmental considerations, while less direct, involve the project's potential to reduce waste and optimize resource use. By monitoring machine performance and energy consumption, the project can lead to more sustainable machine operations. However, the manufacturing and disposal of additional hardware (e.g., sensors, microcontrollers) may contribute to e-waste.

Political concerns rank lowest but are still relevant, particularly in terms of compliance with institutional policies and regulations. The project's alignment with Cal Poly ITS standards and potential for adoption in external organizations may face scrutiny regarding funding, data ownership, and cross-institutional agreements.

**Reflection**

In designing a system, I have learned that ensuring robust security is vital. Our project incorporates both hardware and software components, making it essential to secure each aspect against potential attacks. Effective security measures not only safeguard sensitive data but also prevent unauthorized access to critical systems, ensuring operational reliability.

Moreover, maintaining security is crucial for preserving the trust of our clients and stakeholders. A secure system reduces the risk of data breaches, protects intellectual property, and ensures compliance with institutional and legal standards. By prioritizing security, we also enhance the system's reputation, encourage user adoption, and minimize potential financial and reputational risks stemming from vulnerabilities.

Ryan Jacoby

**Ethics Concerns**

- Hardware(and Infrastructure)
    - Societal
        - Securely sourced components and hardware -> no slavery/child labor/illegal recycling
    - Environmental
        - Low part count
        - Reliable
        - Longevity
        - Recyclability
    - Ethical
        - Ethically sourced components -> don't fund genocide
        - Hardware IP is respected -> no stealing designs, reference designs used responsibly
        - Infrastructure firmware (running on purchased devices, routers, switches, etc.) developed ethically
    - Security
        - Hardware can resist physical access attacks (power glitching, side channels, no PII stored on device)
        - Infrastructure designed to prevent unintended use
        - Infrastructure protects client data
    - Political
        - Infrastructure and component sourcing don't fund US adversaries
        - Infrastructure and component sourcing align with all international trade laws
        - Infrastructure and component sourcing follow university guidelines
- Firmware
    - Societal
        - No exploitation of developers of any of our library dependencies
        - Any improvements to open source libraries must be pushed upstream
    - Environmental
        - Power management and low power modes on the hardware must be used

- Backend
    - Societal
        - Cloud provider
    - Environmental
        - Server side code reduces environmental impact of datacenter
- Frontend
    - Environmental
        - Frontend code runs efficiently on client device
        - Frontend is small to minimize network overhead while loading

**Top Issues**

1. Securely sourced components and hardware -> no slavery/child labor/illegal recycling
2. Hardware can resist physical access attacks (power glitching, side channels, no PII stored on device)
3. Infrastructure and component sourcing align with all international trade laws
4. No exploitation of developers of any of our library dependencies
5. Frontend code runs efficiently on client device
6. Infrastructure protects client data

**Justification**

I ranked these top issues based on my personal values. Respecting human rights everywhere and cyber security are both very important to me, so those issues ranked very high. Environmental considerations are also very important so are near the top as well.

**Top 3 Discussion**

One of the biggest problems in the electronics industry is securely sourcing components. Often times, subcontractors and resellers can purchase components from third parties who may not respect internation law and engage in slavery, child labor, or disregard environmental protections. That is why this is my top ethical issue for this project. We also must respect the needs of our clients, so hardware security concerns are very important. If we are installing this hardware on a client network, it should not be the vector to spread malware or break computer systems as IoT devices often can be.

**Reflection**

In doing this assignment, I brainstormed any potential ethical issue I could think of in our various subsystems. I refuse to use AI tools, so all of these came from myself, discussions with other people, and my own research. I mainly focused my research on the hardware subsystem as this is what I am mainly working on for this project. Ethical sourcing of components is something that I was taught about at my work over the summer and is something I will probably need to think about for my entire career.

## Presentation Slides

Link: Haas Hooligans Midpoint Slides.pdf

## MOM Test Transcript

**Cameron:** Should we go with SCADA or MTConnect?

**Waldorf:** MTConnect is written in C and does not have native Python version which was difficult to setup and communicate with our Rasberry Pi hence the previous team went with HiveMQ.

**Cameron:** The reason we're looking into that is because it's somewhat of an educational decision.  Would you like students to learn with SCADA for their projects or would it beneficial for them to use MTConnect? SCADA is a lot more flexible and industrial focused.

**Waldorf:** We have an RFID class that would benefit from that but I'm open to anything.

**Ryan:** If there aren't a lot of curriculum goals for the students to interface with, there's a possibility we could explore both.

**Waldorf:** I think for the current scope of the project we could focus on MTConnect.

In regards to the older machines, would we be using MTConnect or something else different because the newer machines can already use MTConnect?

**Ryan:** I would like for them to share the same protocol to simplify the process.

**Cameron:** There are different types of data you would like us to obtain. Do you have a priority on the types of data you would like to have?

**Waldorf:** One example would be if a machine is in use which is not necessarily the same as being turned on. This can be measured through the spindle load. A sensor to notify maintenance if a machine is not available which can be found through the machine. Anomalies would be helpful too like overload or spindle load. Anything that would raise a flag during a crash I would like to be monitored. Going back to detecting if a machine is in use could be through a camera.

**Noa:** Would you like that to be one unit that oversees all the other units or machine specific?

**Waldorf:** Preferably machine specific. Another data that could be monitored would be energy consumption. It's not an emergency but would be a good indicator to see how much we're using weekly, monthly and quarterly.

**Cameron:** Are there specific building codes and electrical procedures we should be made aware of when designing this project?

**Ryan:** We were thinking that if we were using ethernet, who's going to do all that wiring? Is that lab space something that the IME department has control over or would that fall into the College of Engineering?

**Waldorf:** That would be in our control but if say we need to open a wall port, then we would need to make a request to ITS.

**Ryan:** We were thinking of using power over ethernet to power the boxes for the machines that don't have sensors or to adapt the non-network machines. This could be done by injecting power over ethernet or flipping a switch if it's built in.

**Waldorf:** I'm not sure but ethernet is available in some of the labs. In the labs without, those could be questions that we can ask the technicians.

**Cameron:** Where would you like us to host the network?

**Waldorf:** Preferably somewhere permanent like ITS.

**Ryan:** DXHub could be a solution since it's less managed by ITS but part of their structure. It does come with a monthly fee which leads us to another question: what is the budget for the IME department?

**Waldorf:** I think anything in the 100's of dollars is easy.

**Ryan:** There's a large waiting list if we go the ITS route so an alternative could be hosting it on a student account or on our own AWS account.

**Cameron:** Do you have any ideas on how you want the dashboard to look?

**Waldorf:** I want it spatially arranged similarly to how our labs are arranged. Perhaps include a feature that allows you to monitor individual machines and one that lets you see the bigger picture.

**Noa:** When you are asking easy to look at, are you referring to a graphical representation or the hard value of the data being monitored.

**Waldorf:** I think graphical would be best. Something that would be easier to understand to someone who isn't that knowledgeable but when looking at a specific machine, perhaps raw data would be better.

## Meeting Notes

- Coolant level
- Vibration level
- Spindle load
- contamination level

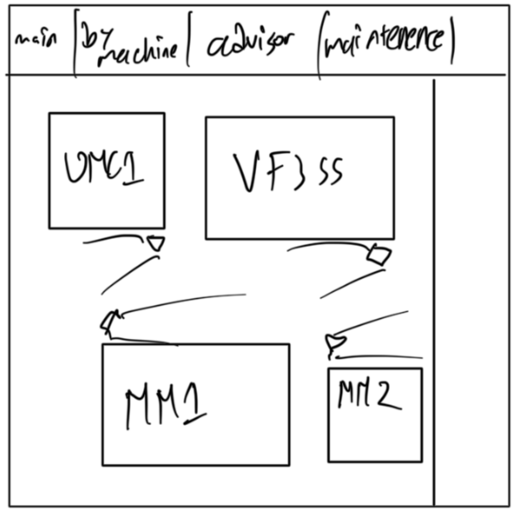
- operator presence
- cycle times
- spindle load
- maintenence status

OEE
(overall equipment effectiveness)

- It would be best for the system to monitor the labs as a whole

need UI,
make it adaptable to fit shop floor plan

website with GUI    Cameras




- machine status: Idle, use, down, needs maintenence.
- new machines are easy to implement
- older machines need retrofitting
- very old machines may need special modifications.

Learning from data over time: not just monitoring at the moment

1. machines that are already ready
2. machines that already have some intermediate devices for sensing
3. machines that have no sensing.

ITS supported Infrastructure (not on Eduroam)
(Cal poly IOT): available within IME scope, but not outside.

Previous reports:

SMART: MQTT via HiveMQ for data collection.
AstraDB for data storage (free available)

Assembly Group: vision for assembly recognition for end product.
OpenCV?

NCD.io AC current monitor

Monitoring as QC/maintenence task

Energy Monitoring is pretty important these days.

Previous resources will be made available to us.

Dash - Dashboard framework. – last project:

Home assistant? possible approach

Graphana?

Research faculty and students should be able to access it for projects and study.

## FMEA

Original document: FMEA.xlsx

**Hardware**

Failure Mode and Effects Analysis - Hardware

| Process Step | Potential Failure Mode | Failure Effect | Severity (1-10) | Potential Cause | Occurrence (1-10) | Current Control | Detection (1-10) | RPN | Recommended Action |
|---|---|---|---|---|---|---|---|---|---|
| Sensor Operation | Sensor failure (e.g., vibration, temperature) | Inaccurate or missing machine data | 6 | Hardware defect, wear | 4 | Periodic calibration; self-diagnostic tests | 5 | 120 | Use more reliable components; improve testing |
| Power Delivery | Power failure in sensor units | Partial or entire hardware stops functioning | 8 | Marginal design, Loose connections, overload | 3 | Circuit protection; PoE monitoring | 3 | 72 | Add power redundancy; monitor voltage levels |
| Data Transmission | Poor electromagnetic compatibility | Intermittent data loss | 5 | Bad PCB layout | 3 | PCB Design rules; connector inspection | 4 | 60 | Improve cable shielding and use robust connectors |
| PCB Design | Overheating | Device malfunction or failure | 9 | High current, poor thermal design | 3 | Design reviews; thermal simulations | 2 | 54 | Improve PCB design and include thermal protection |
| Vibration Sensors | Not properly couple to chassis | Incorrect data collection | 6 | Improper installation | 4 | Visual inspections during assembly | 3 | 72 | Use better mounts; improve installation process |
| Grounding | Ground potential difference | Wide-area system instability and large scale hardware failure | 10 | Ground loop, isolated grounds shorted | 1 | Grounding plan during design | 2 | 20 | Research and design time into grounding |

## Firmware

Failure Mode and Effects Analysis - Firmware

| Process Step | Potential Failure Mode | Failure Effect | Severity (1-10) | Potential Cause | Occurrence (1-10) | Current Control | Detection (1-10) | RPN | Recommended Action |
|---|---|---|---|---|---|---|---|---|---|
| Data Collection Timing | Incorrect sampling intervals | Inconsistent data on dashboard | 7 | Timer drift, coding error | 4 | Validated libraries, timing calibration | 3 | 84 | Add redundant checks, use robust timers |
| Device Bootup | Failure to initialize sensors | No data collected at startup | 9 | Firmware bugs | 3 | Testing during integration | 3 | 81 | Improve boot testing and validation |
| Communication Protocol | API communication failure | Data transmission halted | 8 | Protocol mismatch | 4 | Regular API tests | 3 | 96 | Validate protocol compatibility |
| Error Handling | Missing error reporting | Failure undetected by system | 6 | Lack of exception handling | 3 | Logging mechanisms | 2 | 36 | Add detailed error-handling mechanisms |
| Power Efficiency | Inefficient power consumption | Shortened device lifespan | 5 | Poor code optimization | 3 | Firmware optimization | 3 | 45 | Use low-power modes and optimized routines |

## Network Infrastructure

### Failure Mode and Effects Analysis - Network Infrastructure

| Process Step | Potential Failure Mode | Failure Effect | Severity (1-10) | Potential Cause | Occurrence (1-10) |
|---|---|---|---|---|---|
| Data Transmission | Network disconnection | Machine data unavailable | 9 | Faulty cabling, interference | 5 |
| Switch Configuration | Misconfigured network switch | Inconsistent data flow | 8 | Manual setup errors | 4 |
| Bandwidth Allocation | Network congestion | Data delays | 7 | Insufficient bandwidth | 5 |
| Network Security | Unauthorized network access | Data compromised | 10 | Weak encryption | 3 |

| Current Control | Detection (1-10) | RPN | Recommended Action |
|---|---|---|---|
| Redundant connections, cable tests | 4 | 180 | Improve cable quality |
| Regular audits of network settings | 3 | 96 | Automate configuration validation |
| Bandwidth monitoring | 3 | 105 | Increase bandwidth capacity |
| Use encrypted protocols | 2 | 60 | Enforce strong encryption standards |

## System Database

### Failure Mode and Effects Analysis - System Database

| Process Step | Potential Failure Mode | Failure Effect | Severity (1-10) | Potential Cause | Occurrence (1-10) |
|---|---|---|---|---|---|
| Data Storage | Data corruption | Loss of historical data | 9 | Hardware failure, bugs | 3 |
| Data Retrieval | Slow query response | Delays in dashboard updates | 7 | Inefficient indexing | 4 |
| Concurrent Users | Overloaded database | System downtime | 8 | Too many active users | 4 |
| Security Breach | Unauthorized access | Data compromised | 10 | Weak authentication | 3 |
| Data Consistency | Mismatched or missing entries | Inaccurate analysis | 8 | Software bug | 3 |

| Current Control | Detection (1-10) | RPN | Recommended Action |
|---|---|---|---|
| Regular database backups | 2 | 54 | Use RAID and automated backup systems |
| Query optimization | 3 | 84 | Optimize database indexes |
| Monitor database usage | 3 | 96 | Increase server capacity |
| Encrypted connections | 2 | 60 | Implement multi-factor authentication |
| Validation scripts | 3 | 72 | Enhance data validation during input |

## Dashboard

### Failure Mode and Effects Analysis - Dashboard

| Process Step | Potential Failure Mode | Failure Effect | Severity (1-10) | Potential Cause | Occurrence (1-10) |
|---|---|---|---|---|---|
| Data Visualization | Slow updates or freezing | Inaccurate or outdated data shown | 8 | Poor query optimization, insufficient server resources | 5 |
| Data Collection | No data received from devices | Missed alerts or machine status unavailable | 9 | Network failure, incorrect API configuration | 6 |
| UI Interaction | Poor dashboard responsiveness | Frustrated users and inability to interact with data | 7 | Inefficient front-end code, heavy graphics | 4 |
| Dashboard Access | Unauthorized access to dashboard | Sensitive machine data compromised | 10 | Weak authentication methods | 3 |
| Error Reporting | No error message displayed | User unaware of issues | 6 | Missing exception handling in code | 4 |

| Current Control | Detection (1-10) | RPN | Recommended Action |
|---|---|---|---|
| Database query tuning, load testing | 4 | 160 | Optimize query logic and upgrade server resources |
| Redundant networking, periodic API testing | 3 | 162 | Improve network robustness and API logging |
| Browser compatibility testing | 3 | 84 | Streamline front-end design and optimize code |
| Two factor authentification, Cal Poly login | 2 | 60 | Enforce strong password policies |
| Error logging in backend | 3 | 72 | Implement clear error messages and robust logging |

## DVP+R

Original document: DVP + R.xlsx

### Hardware

| | | | | | |
|---|---|---|---|---|---|
| 1 | **Sensor Operation:** Reliable sensor performance under vibration and temperature extremes | Subject sensors to accelerated stress tests (controlled vibration and temperature variations) while monitoring data accuracy | Sensor outputs remain within specified tolerance with no missing or inaccurate data | Ryan Jacoby | Prototype/Design Verification |
| 2 | **Power Delivery:** Stable power under nominal and fault conditions | Simulate power failure and overload scenarios; evaluate circuit protection and backup power redundancy through voltage monitoring | Sensor units continue functioning; voltage levels remain within safe limits without interruption | Ryan Jacoby | Prototype/Design Verification |
| 3 | **Data Transmission:** Robust electromagnetic compatibility | Perform EMI/EMC testing with simulated interference; evaluate cable shielding and connector robustness | Intermittent data loss is eliminated or reduced to within acceptable error margins; data integrity maintained | Ryan Jacoby | Prototype/Design Verification |
| 4 | **PCB Design:** Effective thermal management to prevent overheating | Run thermal simulations and conduct physical load tests on the PCB to monitor temperature rise under high current conditions | PCB temperatures remain within design limits; no device malfunction or performance degradation due to heat | Ryan Jacoby | Prototype/Design Verification |
| 5 | **Vibration Sensors:** Secure coupling and proper installation of vibration sensors | Execute mechanical vibration tests to simulate operational conditions and verify that sensors remain firmly mounted | Sensors remain securely coupled with consistent and accurate data output during and after vibration exposure | Ryan Jacoby | Prototype/Design Verification |
| 6 | **Grounding:** Stable grounding to prevent wide-area system instability | Conduct electrical tests to simulate ground loop scenarios and assess the grounding plan under load conditions | Ground potential differences remain minimal; overall system stability is maintained with no large-scale failures | Ryan Jacoby | Prototype/Design Verification |

### Firmware

| | | | | | |
|---|---|---|---|---|---|
| 1 | **Data Collection Timing:** Ensure accurate sampling intervals for consistent dashboard data | Run firmware under simulated operational conditions; inject timer drift and coding error scenarios; log sampling intervals and compare against nominal values | Sampling intervals remain within ±5% of nominal value and data consistency is maintained on the dashboard | Noa Johnson | Prototype/Design Verification |
| 2 | **Device Bootup:** Successful initialization of all sensors at startup | Perform multiple boot cycles under varying environmental and fault conditions; simulate sensor faults during boot; monitor initialization sequence | All sensors initialize successfully in >99% of boot cycles with proper logging of any initialization issues | Noa Johnson | Prototype/Design Verification |
| 3 | **Communication Protocol:** Maintain reliable API communication with backend systems | Simulate API calls under nominal and stressed conditions; introduce protocol mismatch scenarios to trigger error handling; monitor recovery and log responses | API communication remains stable with <1% failure rate; recovery routines trigger appropriately upon communication errors | Noa Johnson | Integration/Design Verification |
| 4 | **Error Handling:** Comprehensive error reporting and logging | Inject various error conditions (e.g., sensor failure, communication error); monitor the firmware's logging and exception handling mechanisms; verify detailed error messages | All injected errors are correctly logged with detailed information; no unhandled exceptions occur | Noa Johnson | Prototype/Design Verification |
| 5 | **Power Efficiency:** Optimize firmware for low-power consumption and efficient routines | Operate devices in different modes (active, sleep); measure power consumption using power analysis tools; compare against baseline consumption; verify low-power mode activation | Firmware reduces power consumption by at least 20% in low-power modes compared to baseline, without impacting overall performance | Noa Johnson | Prototype/Design Verification |

### Network Infrastructure

| | | | | | |
|---|---|---|---|---|---|
| 1 | **Data Transmission:** Maintain continuous connectivity and data availability | Simulate network disconnection events by introducing cable interference and deliberate disconnection in a controlled testbed environment | System automatically detects disconnection and seamlessly fails over to redundant connections; no machine data unavailability | Cameron Bracken | Prototype/Design Verification |
| 2 | **Switch Configuration:** Ensure network switch settings support consistent data flow | Execute automated configuration validation using scripts and simulate manual misconfigurations to observe system behavior during configuration errors | Automated validation detects and corrects misconfigurations; data flow remains consistent with error rate <1% | Cameron Bracken | Integration/Design Verification |
| 3 | **Bandwidth Allocation:** Prevent congestion under high network load | Stress-test the network by simulating peak load conditions and bandwidth saturation using traffic generators and monitoring tools | Network throughput meets target levels; data delays remain within defined limits and congestion does not interrupt critical data flow | Cameron Bracken | Prototype/Design Verification |
| 4 | **Network Security:** Thwart unauthorized access and ensure data integrity | Conduct penetration testing and vulnerability assessments by simulating unauthorized access attempts while monitoring encryption protocols and firewall responses | No unauthorized access is successful; encryption standards remain robust and all security tests are passed without data compromise | Cameron Bracken | Prototype/Design Verification |

## System Database

| | | | | | |
|---|---|---|---|---|---|
| 1 | **Data Storage:** Prevent data corruption using RAID and automated backup systems | Simulate disk failures and software-induced errors while monitoring data integrity; verify that RAID arrays and backup systems restore historical data | No data corruption; historical data remains intact and recovery is achieved within defined limits | Cameron Bracken | Prototype/Design Verification |
| 2 | **Data Retrieval:** Optimize query performance through proper indexing | Execute standard queries under simulated load conditions; measure response times with various indexing configurations | Query response times remain below the defined threshold (e.g., <200ms) under normal load | Cameron Bracken | Prototype/Design Verification |
| 3 | **Concurrent Users:** Ensure database remains operational under high user loads | Simulate high numbers of concurrent users using load testing tools; monitor system performance and stability during peak loads | Database remains operational with acceptable performance (response times and error rates within limits) | Yexelle Nash Segovia | Prototype/Design Verification |
| 4 | **Security Breach:** Prevent unauthorized access using multi-factor authentication and encryption | Conduct penetration tests and vulnerability assessments; attempt unauthorized access and verify enforcement of multi-factor authentication and encryption protocols | All unauthorized access attempts are blocked; multi-factor authentication and encryption remain enforced | Yexelle Nash Segovia | Prototype/Design Verification |
| 5 | **Data Consistency:** Maintain consistent, complete records with robust data validation | Input a range of valid and edge-case data scenarios; verify that validation scripts prevent mismatches or missing entries | All records are accurate, consistent, and complete; no mismatches or missing entries are found | Yexelle Nash Segovia | Prototype/Design Verification |

## Dashboard

| | | | | |
|---|---|---|---|---|
| 1 | **Data Visualization:** Optimize query logic and upgrade server resources | Simulate heavy load conditions and rapid data refresh requests. Measure update speed and check for freezing or outdated information. | Dashboard updates within target response time (e.g. <2 seconds) and shows current data without freezing. | Yexelle Nash Segovia |
| 2 | **Data Collection:** Improve network robustness | Simulate network failures. Monitor the dashboard for data reception, error logging, and missed alerts. | Dashboard logs errors and displays an alert when data is not received; critical machine status is not lost. | Yexelle Nash Segovia |
| 3 | **UI Interaction:** Streamline front-end design and optimize code | Conduct multi-browser performance testing. Measure UI load times and response to user interactions across various devices and browsers. | UI response times are within acceptable limits (e.g. <200ms per interaction) on all tested platforms. | Yexelle Nash Segovia |
| 4 | **Dashboard Access**Enforce strong password policies and logins | Perform security tests by simulating unauthorized access attempts and examining the enforcement of logins. | All unauthorized access attempts are blocked; security logs indicate user logins. | Yexelle Nash Segovia |
| 5 | **Error Reporting:** Implement clear error messages and robust logging | Intentionally induce errors within the dashboard (e.g., failed data queries, UI exceptions). Verify that clear error messages are displayed and logged properly. | Error messages are clear and prompt; backend logs capture complete details of each error event. | Yexelle Nash Segovia |

| | | | | | |
|---|---|---|---|---|---|
| Prototype/Design Verification | | | | | During testing, Grafana demonstrated a minimum refresh interval of 5 seconds. Despite this extended refresh rate, multiple queries were active, ensuring that all data collected between refresh cycles is displayed. |
| Prototype/Design Verification | | | | | The system promptly alerts users through error messages if data queries fail. |
| Prototype/Design Verification | | | | | Since the dashboard is running locally, it currently supports only a single browser session and multi-browser testing has not been performed. |
| Prototype/Design Verification | | | | | At this stage, access to machine metrics is limited to users who have the dashboard code. Once Grafana is hosted on a permanent server, additional user access can be managed easily through the permissions settings. |
| Prototype/Design Verification | | | | | The system promptly alerts users through error messages if data queries fail. |

Connectors

File: connectors.kicad_sch

Connectors-2

File: connectors2.kicad_sch

MCU

File: mcu.kicad_sch

WiFi

File: wifi.kicad_sch

Ethernet

File: ethernet.kicad_sch

SD

File: sdio.kicad_sch

RS-232

File: rs232.kicad_sch

Ryan Jacoby
**Haas Hooligans**

Sheet: /
File: hw_alpha.kicad_sch

***Title: Data Board PoE Main Page***

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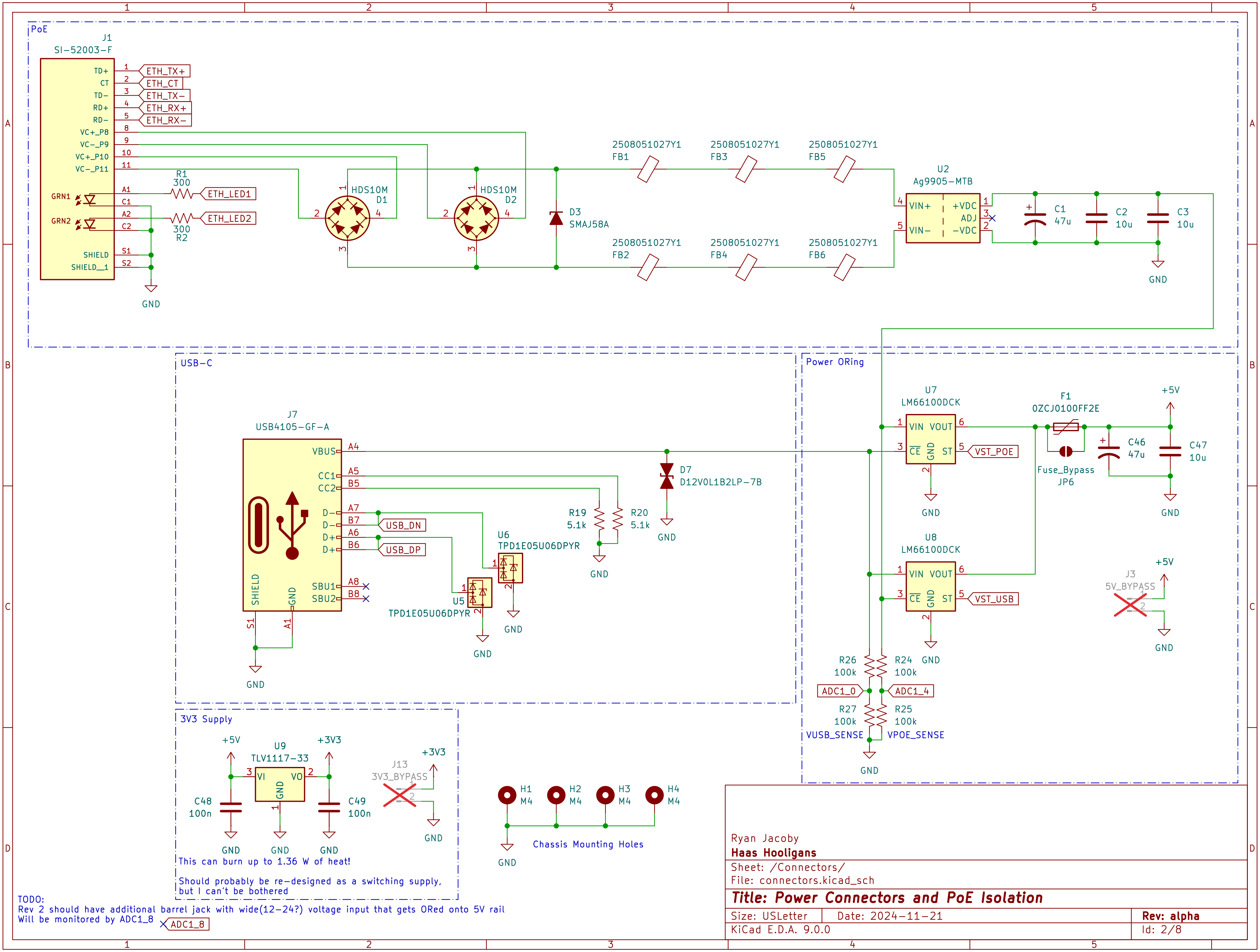


TODO:
Rev 2 should have additional barrel jack with wide(12-24?) voltage input that gets ORed onto 5V rail
Will be monitored by ADC1_8 ADC1_8

Ryan Jacoby
**Haas Hooligans**
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File: connectors.kicad_sch
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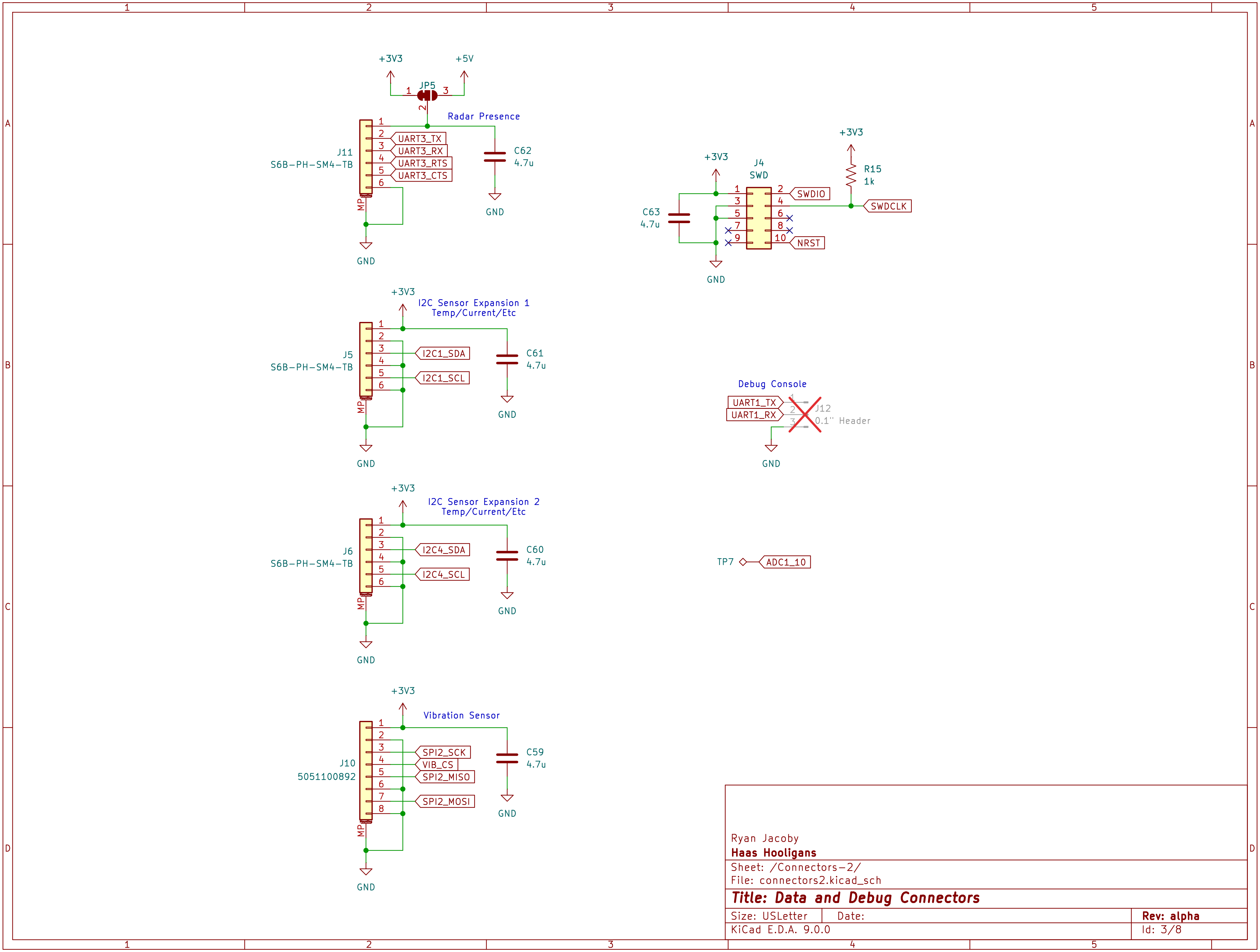
Size: USLetter Date: 2024-11-21 **Rev: alpha**
KiCad E.D.A. 9.0.0 Id: 2/8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+5V
JP5
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J11
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UART3_RX
UART3_RTS
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C62
4.7u
GND
+3V3
R15
1k
J4
SWD
SWDIO
SWDCLK
NRST
C63
4.7u
I2C Sensor Expansion 1
Temp/Current/Etc
J5
S6B-PH-SM4-TB
I2C1_SDA
I2C1_SCL
C61
4.7u
Debug Console
UART1_TX
UART1_RX
J12
0.1" Header
I2C Sensor Expansion 2
Temp/Current/Etc
J6
S6B-PH-SM4-TB
I2C4_SDA
I2C4_SCL
C60
4.7u
TP7
ADC1_10
Vibration Sensor
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VIB_CS
SPI2_MISO
SPI2_MOSI
C59
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Ryan Jacoby
Haas Hooligans
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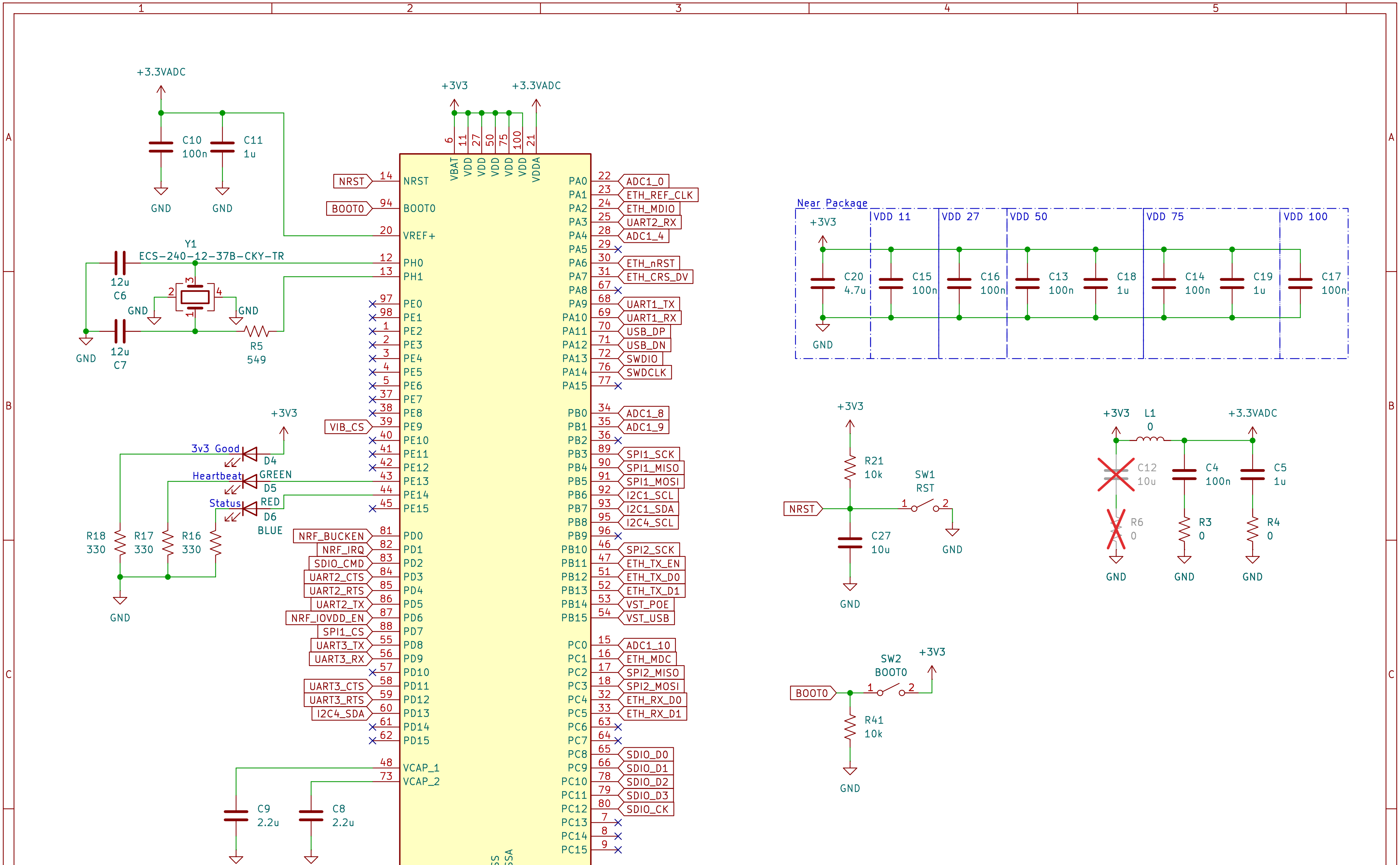


Ryan Jacoby
**Haas Hooligans**
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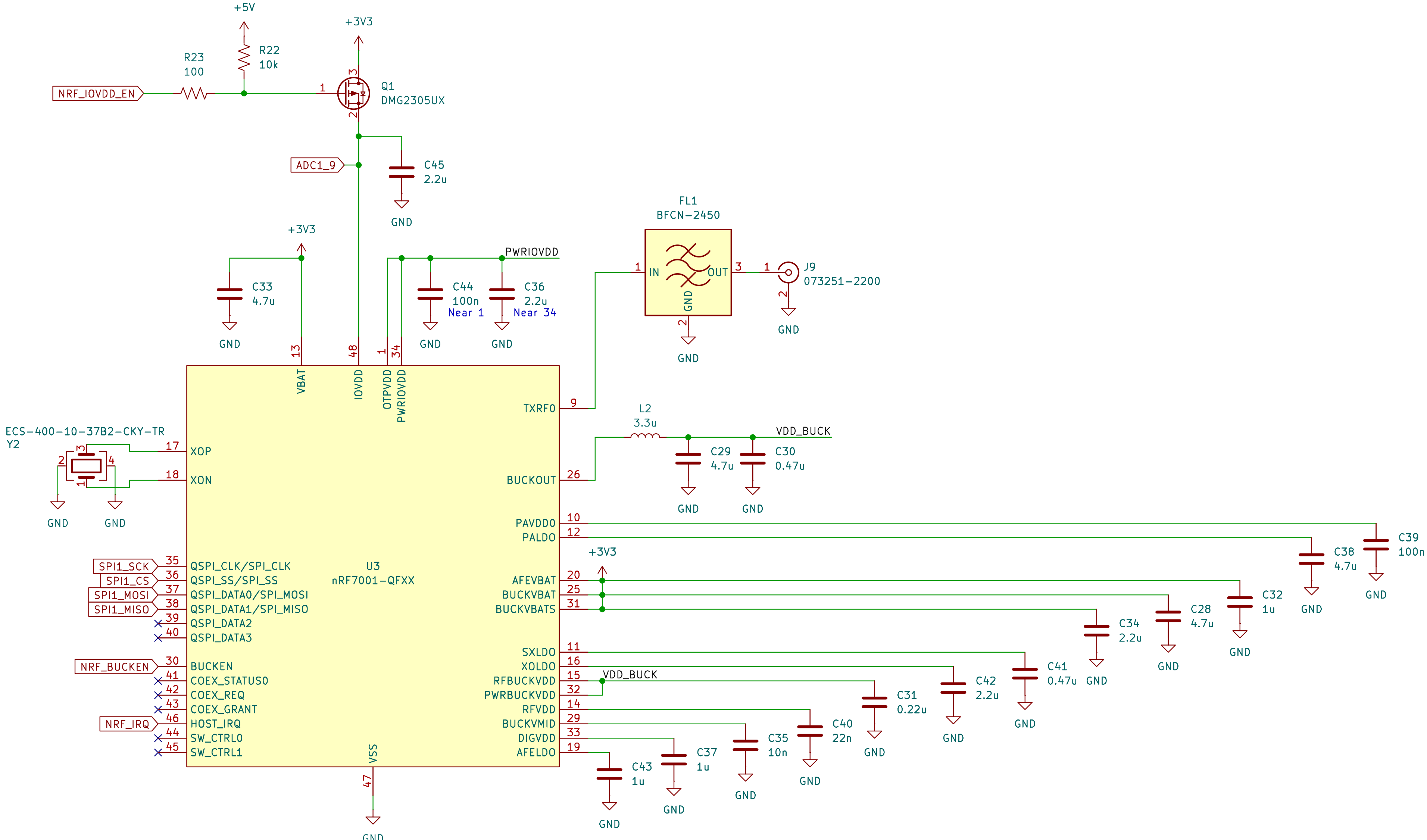


Ryan Jacoby
**Haas Hooligans**
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***Title: WiFi Coprocessor***

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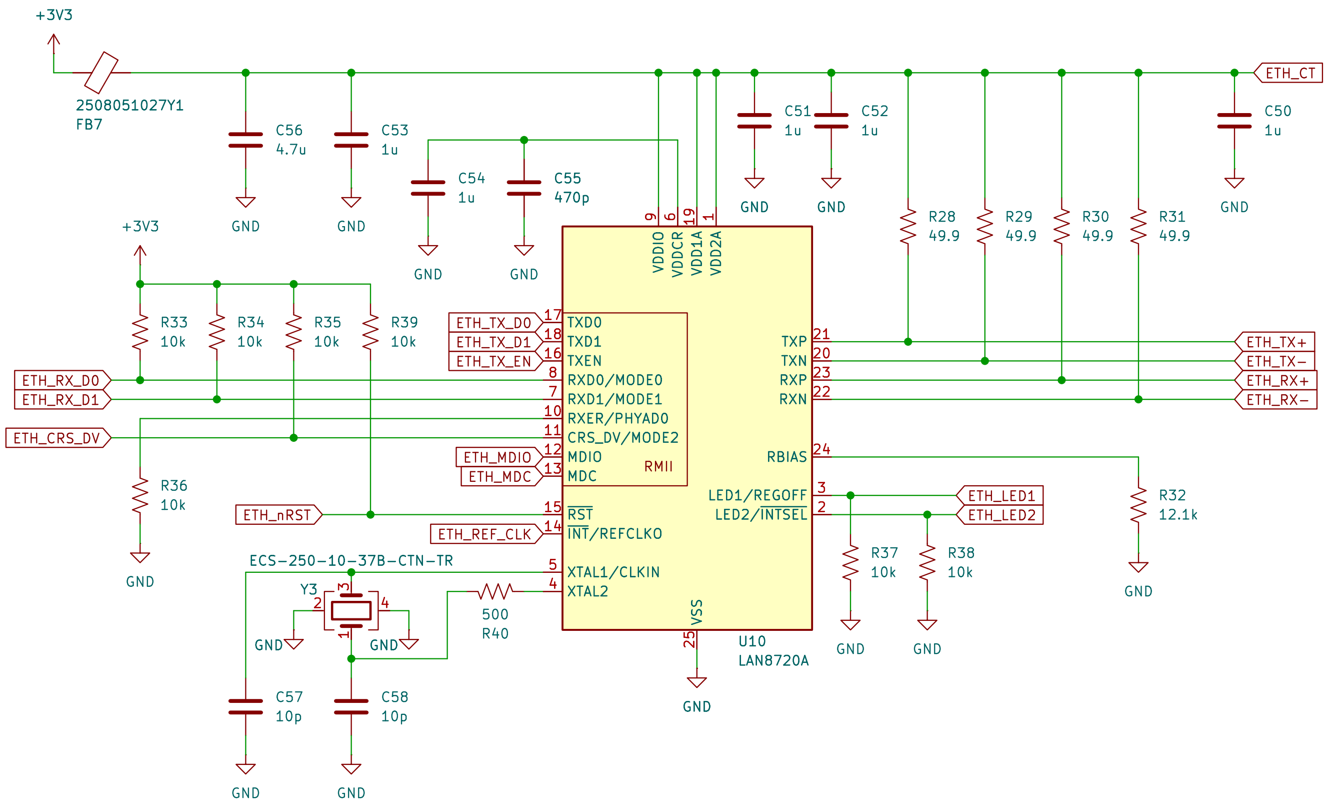


Ryan Jacoby

**Haas Hooligans**

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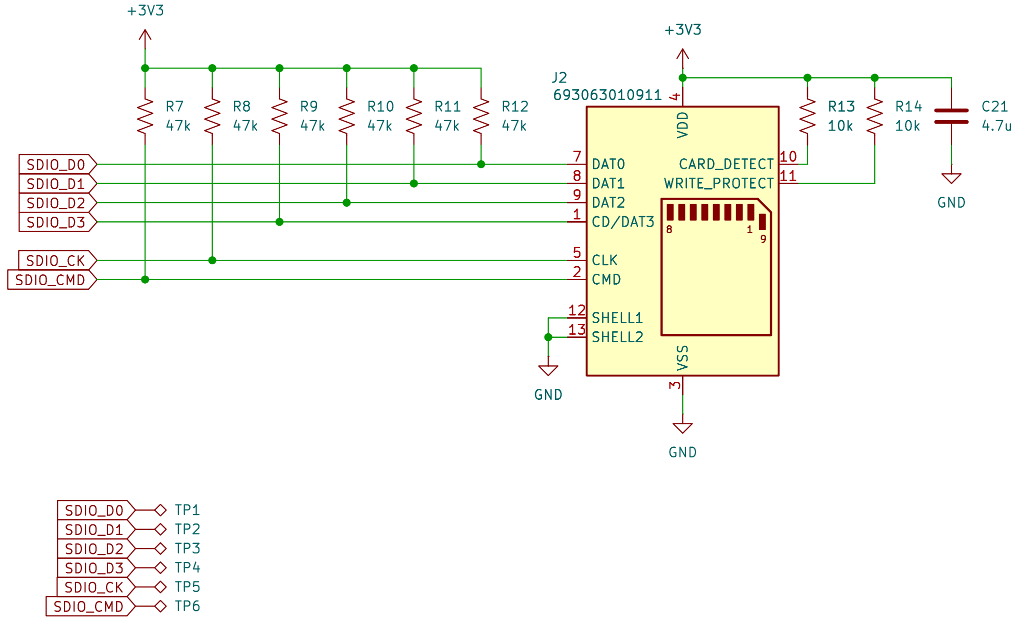


Ryan Jacoby
**Haas Hooligans**
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**Title: SD Card**

Size: USLetter Date:
**Rev: alpha**
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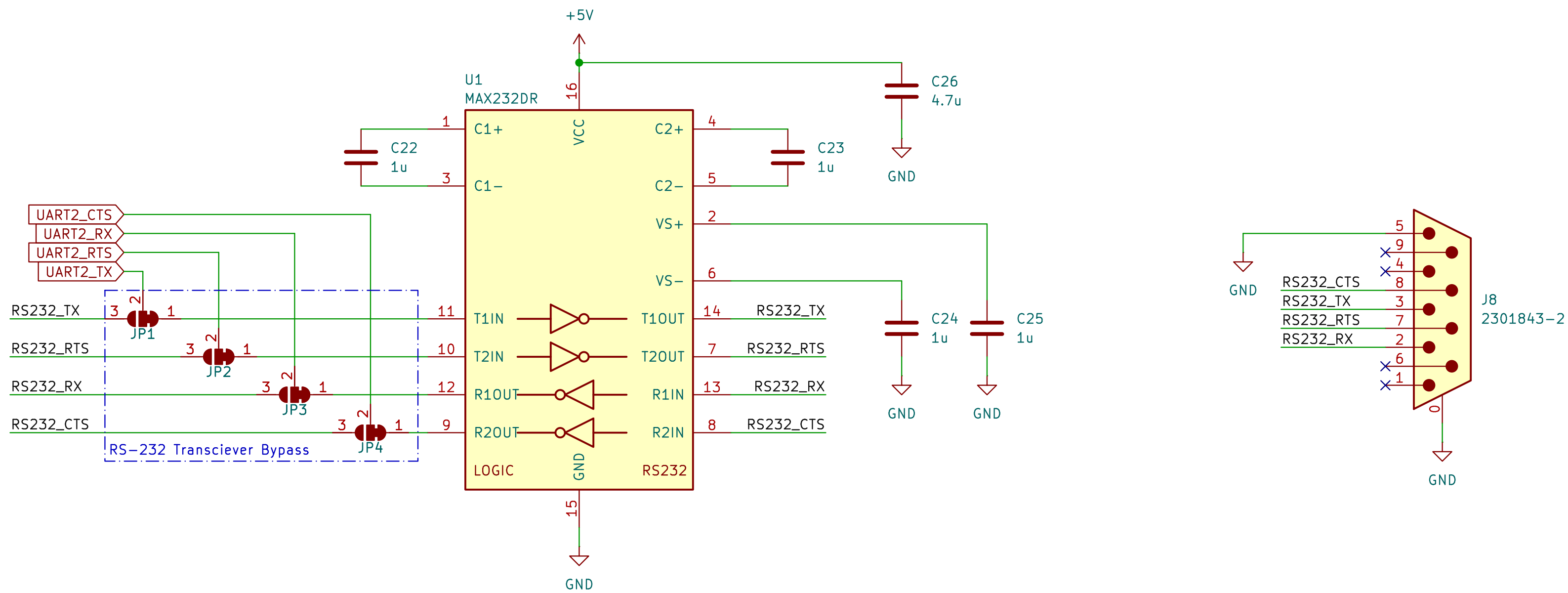
Id: 7/8




Ryan Jacoby

**Haas Hooligans**

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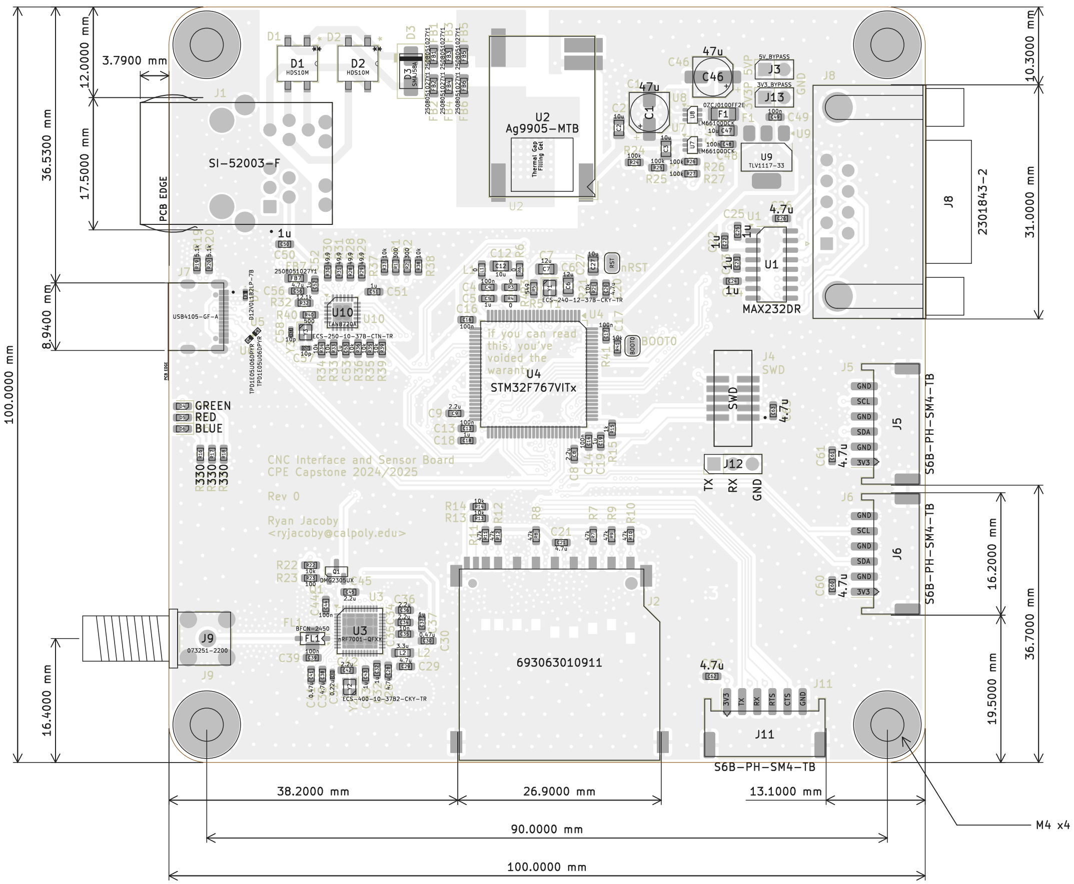


Board2Pdf: Light Colors Placement TOP – Page 1/2

Ryan Jacoby

**Haas Hooligans**

Sheet: Light Colors Placement TOP

File: hw_alpha.kicad_pcb

***Title: PoE/WiFi Sensor and Interface Board***

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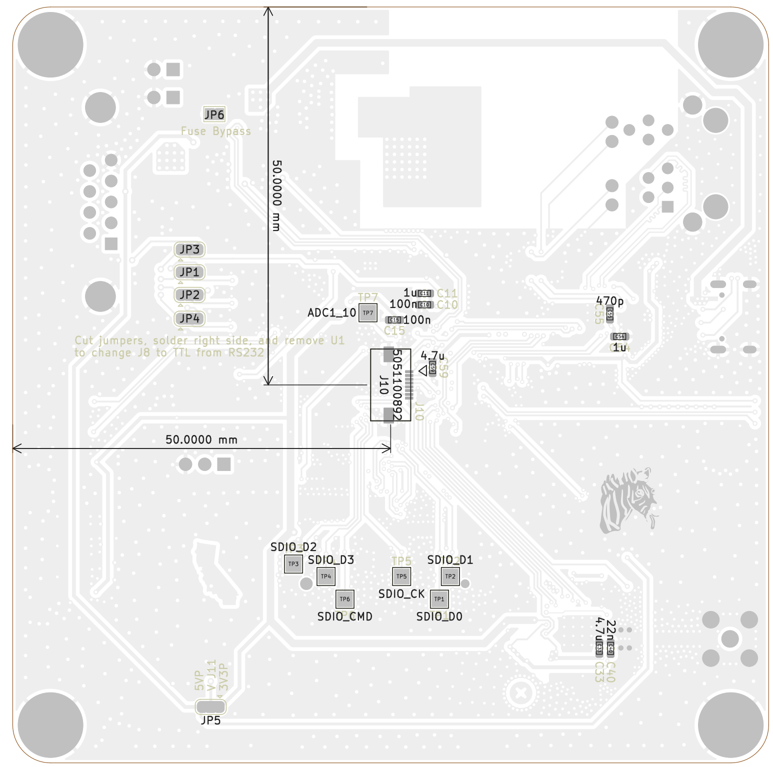


Board2Pdf: Light Colors Placement BOT – Page 2/2

Ryan Jacoby
**Haas Hooligans**

Sheet: Light Colors Placement BOT
File: hw_alpha.kicad_pcb

***Title: PoE/WiFi Sensor and Interface Board***

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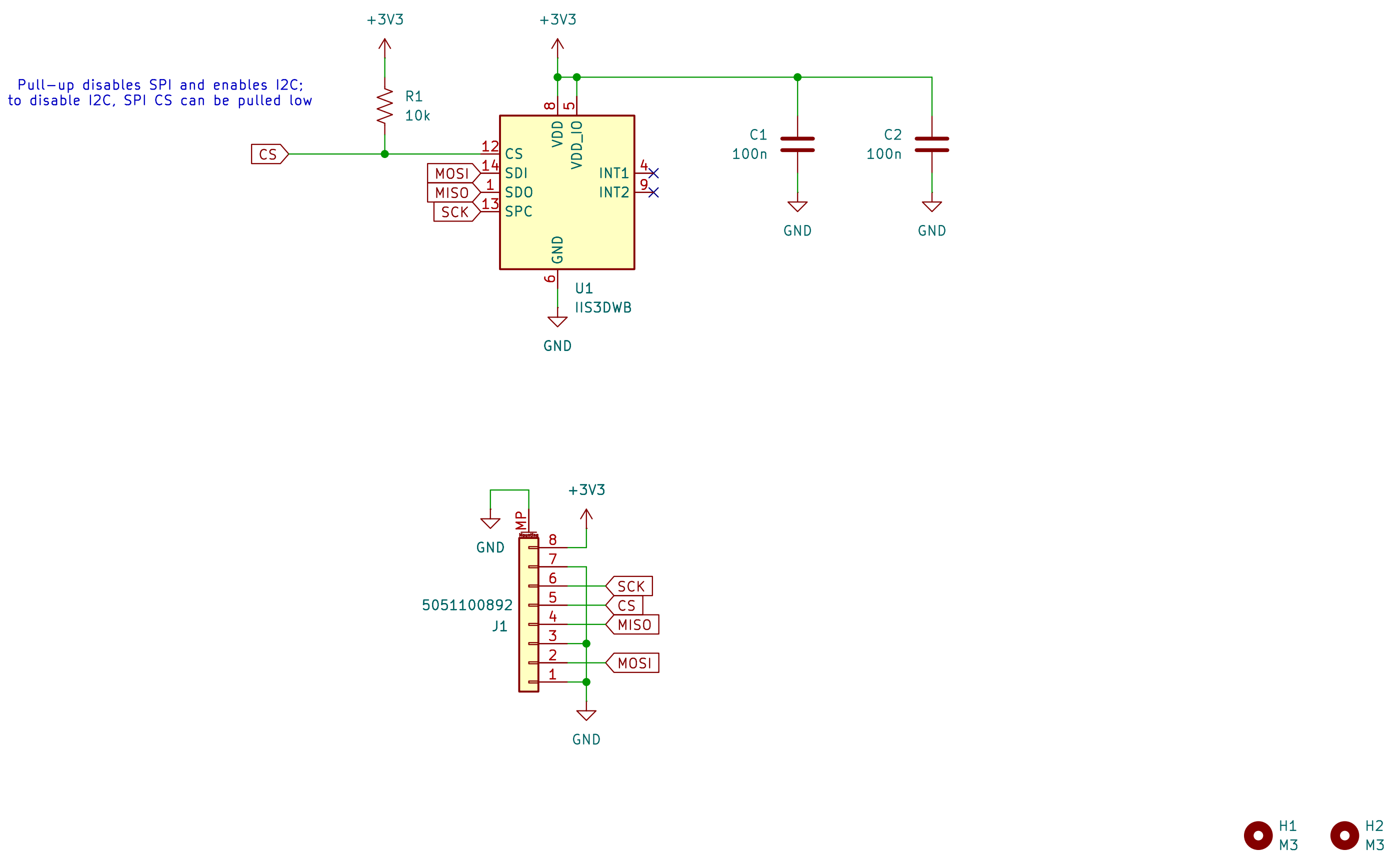


Ryan Jacoby
**Haas Hooligans**

Sheet: /
File: IIS3DWB_breakout_beta.kicad_sch

***Title: IIS3DWB Vibration Sensor Breakout***

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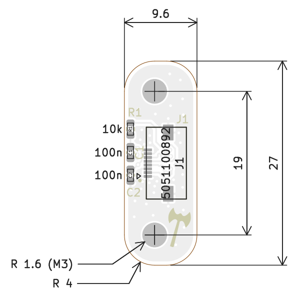


Board2Pdf: Light Colors Placement TOP — Page 1/2

Ryan Jacoby
**Haas Hooligans**

Sheet: Light Colors Placement TOP
File: IIS3DWB_breakout_beta.kicad_pcb

***Title: IIS3DWB Breakout***

| | | |
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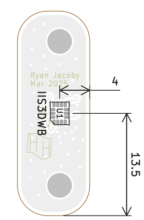


Board2Pdf: Light Colors Placement BOT – Page 2/2

Ryan Jacoby
**Haas Hooligans**

Sheet: Light Colors Placement BOT
File: IIS3DWB_breakout_beta.kicad_pcb

**_Title: IIS3DWB Breakout_**

| | | |
|---|---|---|
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