Individual Lab Report #3

Progress Review 4

March 21st, 2025

Jet Situ

Team B

Teammates: Gweneth Ge, Lance Liu, Yi Wu, Joshua Pen

Table of Contents

Contents

1 Individual Progress

1.1 PCB Assignment

My primary work was on the PCB assignment, specifically due to the ever-changing power requirements of our drone. Our initial design, while ambitious and flexible, did not properly account for the challenges encountered by the requirements laid out to not just abide by DARPA's NDAA compliance, but the numerous additional support components that arose in order to correctly supply data and power to these components, while maintain a safe and effective vehicle.

Prior to beginning the schematic design of the PCB assignment, I made sure to check the feedback from the first PCB assignment, and make the corresponding changes, that is, add a block diagram and introduction to our project to be present in Milestone 2, which would provide additional context, thereby allowing our project to be properly illustrated. Following this, I then consulted with the team about the power supply, and looked at the new components we'd received in order to supply additional data and power. Discovering that we had far more outputs than our current sustain, I logged these changes as well, adjusting the total amount of outputs on our PCB, plus additional flexibility. Finally, I waited until our first test flight with a full integration to finally add the last change after consulting - the ability to hotswap the battery, which required the complex integration of an auxiliary battery system.

Finally, I worked directly on the PCB schematic, looking for the correct connectors that corresponded to our existing connectors to ease the transition. I then researched the diode system required to support an auxiliary battery, as well as the buck converter needed to convert our 24V to a 5V output. With these components placed, I then defined a positive and ground, and connected all the components as appropriate via the net. I also researched the correct regulating resistance and capacitance needed to support the voltage buck required, placing that into the circuit as well.

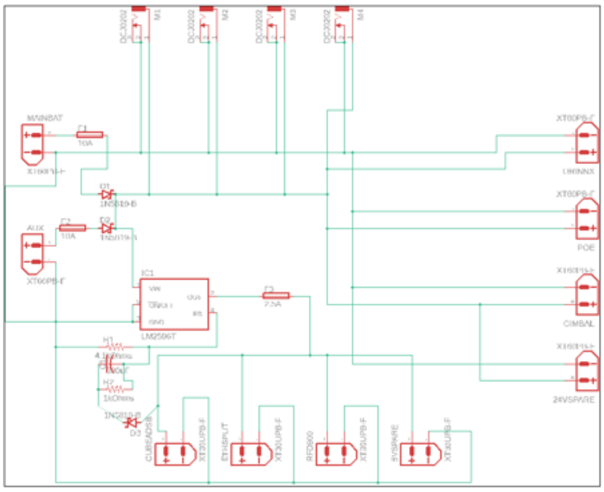

Figure 1: Schematic submitted to replace our drone's existing board

1.2 MRSD Project

For the MRSD project, my role largely consisted of the hardware/software intersection, and debugging it. In order to meet our deadlines, which were set by the DARPA Triage

Challenge Workshop occuring beginning on March 9th, we had to ensure that our systems would be able to qualify at the basic level, even if we did not intend to compete on the same level as the pre-existing drones. For the purposes of the sprint here, our goal was to render our drone mission-ready to collect data on performance and algorithm analysis at range, which can prove to be an incredibly difficult task.

In support of this, I was responsible for essentially being a group debugger, being cognizant of all three simultaneous tracks, and being able to resolve blockers and issues in any of them. This entails studying with, and performing quality testing on each track to remain in full view of the scope of the project, and to avert and prevent any conflicts with other tracks that may impede or block both.

For the hardware/mechanical track, I spent time connecting a new radio to the system, the Rajant DX2, which provided a higher bandwidth system that adequately, and most importantly, consistently provided a high-bitrate connection between our ground devices and our airborne devices, ending 2-months worth of radio debugging. I also worked on the power distribution system, supplying both power to the Rajant, but also supplying power to the onboard Ethernet splitting and routing system, allowing the Orin and the gimbal to be simultaneously airborne and transmitting, which we had not yet been able to accomplish. I then spent time in repairs - the gimbal's data cable was broken, so significant time was dedicated toward the attempted repair of the gimbal data cable, before, unfortunately, we found it impossible to recover, opting instead to order a new gimbal.

For the behavior tree/software track, I was responsible for directly providing software architecture and QA toward the system. I first validated and tested the ROS nodes involved in MAVROS, as well as validating the Mavlink messages being sent, and the interactions between the PX4 firmware and the software. Assisting Lance, I went through his code as a second pair of eyes, finding critical junctions and marking areas of improvement, as well as coordinating between Josh and Lance about how the inter-communication between the executive branch of the drone and hashing out how the drone's numerous flight algorithms would interact, in a manner that provided software standardization and consistency, working to reduce the risk of a single point of failure.

For the gimbal control/software track, I worked with Wuyi on what algorithms to bring to the table, and how to correctly integrate her code with ROS2. I also shared the insights I gained by working on the PayloadSdk from the previous week, and debugged her PayloadSdk, allowing her to seamlessly not just stream data back to her computer on the current state of the drone, but also be able to control the gimbal with her own spun-up nodes.

2 Challenges

2.1 PCB Assignment

The challenge within the PCB assignment laid within the changing requirements as our needs continuously evolved over the past two weeks. While the initial PCB design proposed in Milestone 1 consisted of a single internal buck that could then provide reduced voltage to subsystems, our implementation of an auxiliary battery to perform a hot swap required additional research on my end, as I had never dealt with such a requirement before. I had to research the type of battery that would not only minimize the total added weight on the system, but also how the battery would operate - would it charge while the main battery is active, how could I prevent it from discharging while the main battery is active, etc. This then required me to research more into reverse current and voltage leaks, after which I was able to properly start the PCB schematic design process, inclusive of the revisions required.

2.2 MRSD Project

There were two major obstacles to our MRSD project this time around - scattered software infrastructure, and hardware failure.

Hardware failure was the most present issue. During assembly, and during repeated testing, we noticed that occasionally, our video feed would go completely gray. After a while of debugging, we discovered that one of the wires within a data cable, corresponding to a USB signal according to the pinout document, had actually disconnected. Given the gimbal's price, and the criticality to our project, we opted to immediately repair it as soon as possible.

Figure 2: Broken data cable, under a soldering microscope.

Unfortunately, despite three hours of surgical effort, we were unable to reconnect the last wire together. Fortunately, a distributor of the gimbal was in Florida, and through shipping, we were able to receive a replacement almost immediately, allowing us to resume work on the gimbal's algorithms rapidly.

The next challenge faced was the distribution of software tasks, and the difficulty of integration between them. While we had three separate software engineers, and one additional software architect/designer, a differentiation in skill/approaches meant that our code largely wasn't standardized. While earlier on, we prioritized the completion of individual features, when integrating these features into a larger network, we found more and more problems that cropped up due to a failure of direct integrated work from the beginning, which definitely slowed down progress, as individual bugs on separate components could interrupt critical links, and with only one responsible person, would then cause delays that would interrupt the critical path that prevented other software components from being tested adequately.

To address this, we stepped in to unify ROS messages and ROS topics, as well as designing tests that did not have co-dependencies, and if they did, to have quick turnarounds that allowed us to continue understanding which parts need improvement, and which parts were deemed mission-ready. Thanks to our improvements, we have been able to start running continuous integration tests in March, just barely in time for the workshop.

3 Team Work

3.1 MRSD Project

Name	Contribution
Jet Situ	Represented the MRSD team at the DARPA Triage Workshop 2 event in Georgia, working alongside Lockheed Martin engineers to integrate their drone prior to competition data collection. Then worked to coordinate drone flight permissions and capability prior to the Team Chiron Demo Day event. Acted as safety pilot and speaker during the Industry Demo Day, and performed flight testing on the days prior for drone endurance and capability integration. Designed and submitted the PCB final draft creation materials.
Joshua Pen	Assisted in fully integrating and test Path Planner for searching the Geofence Zone and Local Search of Patient Planner with behavior tree (also integrate with Patient Detection), Design, integrate and test Triage Planner. Triage Data Collection from Test Flight. Design new mount for Rajant DX2 radio. Contribute to wire management. Contributed to project management and logistics. Helped Setup Industry Demo day, and create slides for Demo Day presentation. Helped construct presentation for PDR and PR3. Helped construct SVD and FVD one-page description.
Lance Liu	1. Autonomy: Resolved takeoff interruption issues through EKF sensor data analysis; Debugged compass instability; Assisted in drone battery monitoring module; Supported Foxglove UI development; Integrated improved geofence mapping algorithm; Initiated NDAA-compliant RTK integration; Refined overall autonomy system robustness. 2. Detection System Enhancements: Tested multiple detection models with flight recording; Optimized person detection model deployment (30x faster inference); Configured Docker for PyTorch on edge devices; Improved gimbal lock functionality for detected persons (in progress); Initiated intelligent autonomy pipeline (in progress); Enhanced thermal detection through data augmentation and model fine-tuning; Established real-time casualty GPS coordinate estimation and transmission pipeline. 3. Ground Control Implementation: Deployed ground control station with reliable drone communication; Ensured robust command execution; Resolved ROS2 FastDDS middleware issues between containers. 4. Additionals: one-line autonomy launching draft; preflight checklist draft; power distribution PCB board and tracing; Initiated ATAK integration; Provided technical support for demonstrations and workshops.
Gweneth Ge	Provided operational support including communication with airlab and media for the Industry Day demo, making slides for Jet presentation, and video review and editing of collecting data from various test flights and darpa workshop. In addition, I primarily contributed to the issue tracking and presentations required by MRSD project including SVD, FVD, project mangaments, and PR 1, 2, 3.
Yi Wu	Debugged the low latency issue of the people detection algorithm with Lance. Wrapped up the gimbal code for DARPA Workshop. Assist Lance with the thermal detection algorithm. Volunteered as the casualty in the AirLab Industry Demo Day.

4 Plans

4.1 MRSD Project

Name	Contribution
Jet Situ	Will work on robustness and cleaning procedures prior to SVD flight tests. Will coordinate and work on integrating gimbal software with Lockheed Martin and Lance. Will work with Wuyi and Lance on software reorganization and documentation prior to SVD. Will assist Josh on mechanical redesign of drone to increase performance.
Joshua Pen	Contributed to project management and logistics. Design new mount for all components on drone (to reorganize components and drone wiring). Help design the Inter-UAV De-conflict algorithm.
Lance Liu	1. PX4 Autonomy Enhancement: Complete NDAA-compliant RTK integration; Further refine autonomy system robustness through comprehensive testing; 2. Detection System Completion: Finalize person detection model optimization; Complete gimbal lock functionality for detected persons; Implement and test intelligent autonomy pipeline in field conditions; Explore ID&Re-ID capabilities beyond person detection. 3. System Integration: Complete ATAK integration for drone control; Finalize GPS coordinates estimation accuracy for detected casualties; Optimize real-time data transmission pipeline; Integrate all subsystems more cohesively. 4. Testing: Conduct extensive field testing
Gweneth Ge	I will continue working on overall project management and communication with airlab, potential media/sponsors as well as NREC/Mill19. In addition, I will help with Josh on reorganizing components and drone wiring, along with the inter-uav deconflict algorithm.
Yi Wu	Integrate the human pose detection algorithm in the perception module; upgrade the pose detection with known gimbal specs like intrinsic matrix. Working with Lance, check if AirLab has implemented the Re-ID algorithm; if not, review SOTA Re-ID algorithm and wrap it into ROS2 pkg.

Table 1: Team Members and Their Plans