Dizzy n-copter

Controlled 'Chaos' in the Air

Divide and Conquer Document
EEL4914 - Senior Design I
Group 29

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Chapter 1: Project Description

1.1 Motivation & Background

In today's world, unmanned aerial systems (UAS) have become essential across research, industry, and defense. While most drones are designed for steady, stabilized flight, our project takes a fundamentally different approach. Unlike other conventional drones, our drone is engineered to continuously spin around its vertical axis. Now this unique feature of the drone isn't something that is a challenge to overcome, but the mechanism that makes it special.

High-end drone systems on the market today use specialized rotating sensors to gather data, track movement, and map out large areas. Some of them include sensors that are powerful, but financially out of reach since they can cost tens of thousands of dollars. One of the most common examples is LiDAR. Rather than employing conventional photo cameras, LiDAR sensors send out rapid laser pulses and capture the responses — using those data points to map out an area with a great deal of both precision and accuracy [1]. The base drone that includes LiDAR can exceed $10,000. To address this challenge and make data gathering more cost-efficient, our team was given an idea for a drone that spins to capture sensor data. Effectively serving as its own low-cost LIDAR system. Allowing for easier and more affordable environmental mapping, but also giving us the ability to add a unique "spin" on drone technology.

We have the privilege of working under Dr. Mike Borowczak in the Design of Resilient Architectures for Computing (DRACO) Lab at the University of Central Florida. A research group that is focused on robotics, embedded systems, and aerospace innovation. This sponsorship aligned perfectly with project ideas that we had already been brainstorming as a team, but with a unique "twist". It has given us an incredible opportunity to pursue a project idea we envisioned while benefiting from the guidance of an experienced mentor.

1.2 Review of Related Ideas (Introduce the other ideas and APPENDIXES)

Recent advancements in drone technology have demonstrated that controlled rotation around the Z-axis, or yaw, can be achieved through the coordinated use of propellers, as seen in standard quadcopter designs where opposing propellers spin in opposite directions. Beyond its traditional use for navigation, researchers have explored intentional self-rotation of drones to expand sensor coverage. For example, Droeschel et al. (2013) developed a continuously rotating lightweight 3D laser scanner for micro aerial vehicles, enabling omnidirectional perception and mapping [2]. Similarly, a more recent design introduced a self-rotating, single-actuated UAV that increased sensor field of view while maintaining controllability [3]. These works illustrate that spinning platforms can be leveraged for perception rather than movement alone.

Our project builds on these concepts by integrating a sensor system designed to function in a manner similar to LIDAR technology. By enabling the drone itself to rotate while collecting distance measurements, the system can serve as a full 360-degree scanning tool for mapping and environmental sensing. While rotating 3D LiDAR systems have been successfully implemented on drones for high-resolution mapping [4], their high cost limits broader accessibility. Research on ultrasonic-based scanning and collision avoidance provides evidence that lower-cost alternatives can still support environmental awareness, though at reduced fidelity [5][6]. This highlights the opportunity for more affordable solutions like ours, which seek to balance functionality with cost-effectiveness.

Such an approach not only connects to existing drone applications but also suggests expanded use in areas such as infrastructure inspection, environmental monitoring, and search-and-rescue operations. As demonstrated in prior work, spinning drones and rotating sensor systems provide a strong foundation for achieving reliable 360-degree scanning, and our design aims to extend these benefits in a more accessible form.

1.3 Overview of Project Goals and Objectives

The idea behind this project is to build an affordable alternative to LIDAR drones. Creating a 3D printed carbon fiber micro-drone where the main body spins around its Z-Axis while being fully maneuverable indoors.

1.3.1 Goals

Basic Goals:

- Develop a fully functional drone that maintains a constant rotational frame speed of 60 RPM.
- Communicate key telemetry such as spin rate, battery life, and flight status to a base station in real time.
- Create an Indoor-safe drone that has enclosed propellers to protect the propellers themselves as well as others around.
- Achieve a minimum 5-minute flight time through optimized battery usage.
- Keep the complete build weight of the drone under 250 g to remain compliant with sub-250 g safety classifications
- Implement basic autonomous safety features such as automatic landing on low battery or lost signal.

Advanced Goals:

- Develop a ground application capable of controlling the drone and displaying telemetry logs in real time.
- Use hardware PID control to stabilize spin rate and correct disturbances.
- Integrate a distance sensor payload for altitude awareness and collision prevention.
- Enhance onboard processing to support low-latency feedback control loops.
- Preserving full translational movement (forward, backward, left, right).

Stretch Goals:

- Extend flight control software to support obstacle avoidance and semi-autonomous navigation.
- Incorporate wireless charging capabilities for convenient recharging without physical connectors.
- Design a modular frame that allows rapid replacement of propellers, guards, or battery compartments.
- Enable local control as an alternative to base station commands.

1.3.2 Objectives

Basic Objectives:

- Implement a spin-stabilization system that maintains 60 RPM ±5% during sustained hover.
- Develop translational flight control algorithms that achieve commanded speeds while maintaining spin stability.
- Stream telemetry data (spin rate, battery voltage, flight mode) to a base station at a minimum of 10 Hz.
- Integrate full propeller enclosures and verify protection effectiveness during light collisions.
- Demonstrate at least 5 minutes of continuous flight time under normal operating conditions.
- Confirm that the drone's all-up weight does not exceed 250 g by final assembly.
- Implement fail-safe features including automatic landing during low-battery events or loss of communication with the base station.

Advanced Objectives:

- Develop a mobile application to send flight commands and display live telemetry.
- Offload spin-control loops to dedicated hardware PID controllers running at ≥500 Hz.
- Integrate a distance sensor capable of measuring from 0.2–2.0 m with an accuracy of ±3 cm.
- Implement simple altitude-holding logic using the distance sensor to maintain a stable hover range.
- Enhance telemetry protocols to minimize packet loss (<1%) and latency (<200 ms).

Stretch Objectives:

- Implement forward obstacle detection within a 90° arc and trigger automatic avoidance maneuvers.
- Demonstrate wireless inductive charging with at least 70% charging efficiency and successful drone docking.
- Design and validate a modular frame that allows component swaps in under 3 minutes with minimal tools.

- Integrate local manual controls with a safety lockout to prevent conflict with automated modes.

1.4 Project Functionalities

The Dizzy n-copter system is designed not only to demonstrate stable flight while spinning, but also serve as proof of a low cost LiDAR. The functionalities below show the objective of the project to ensure both safe operation and data collection. These functions will highlight how the drone will interact with its environment and transmit telemetry back to the base station.

- Continuous Spinning Flight: Maintain stable indoor flight while spinning around its Z-axis at approximately 60 RPM.

- Real-Time Sensing: Collect distance measurements using a mounted ultrasonic sensor during continuous rotations.

- Telemetry Transmission: Communicate sensor reading and spin-rate data wirelessly to a base station

- Stability Control: Utilize hardware-based PID control loops to ensure consistent spin stability (Hardware preferred)

- Safety: Enclosed propellers

- Modularity: Lightweight, modular frame design that allows for replacement or reconfiguration of components.

1.5 Requirement Specifications

Specifications	
Communication rate:	Must collect and send data at 3600 Samples per minute (1 sample per 10 degrees)
Drone	
Performance:	Must rotate at 60 RPM around the Z-axis, and must have communications with sensor
Weight:	Less than 250g
Production:	Must have a modular frame for easy replacement

Battery:	Rechargeable battery
Minimum Lifespan:	5 minutes
Flight Requirements:	Stable flight for sensors
Safety:	Must have enclosed props for indoor safety
Base Station	
Display:	Must display rotation speed and also show the data from the sensor(s) installed onto it
Drone docking:	Must have an area for the drone to sit and recharge if necessary

Figure 1. Specifications diagram

Notes: These design specifications were based on what the sponsor wanted us to fulfill. These specifications might change due to the different actions taken to make the product as desired. We must have a flying drone that meets the specifications mentioned above. Smaller details will be added into the final report, addressing any issues or changes made later on in the process.

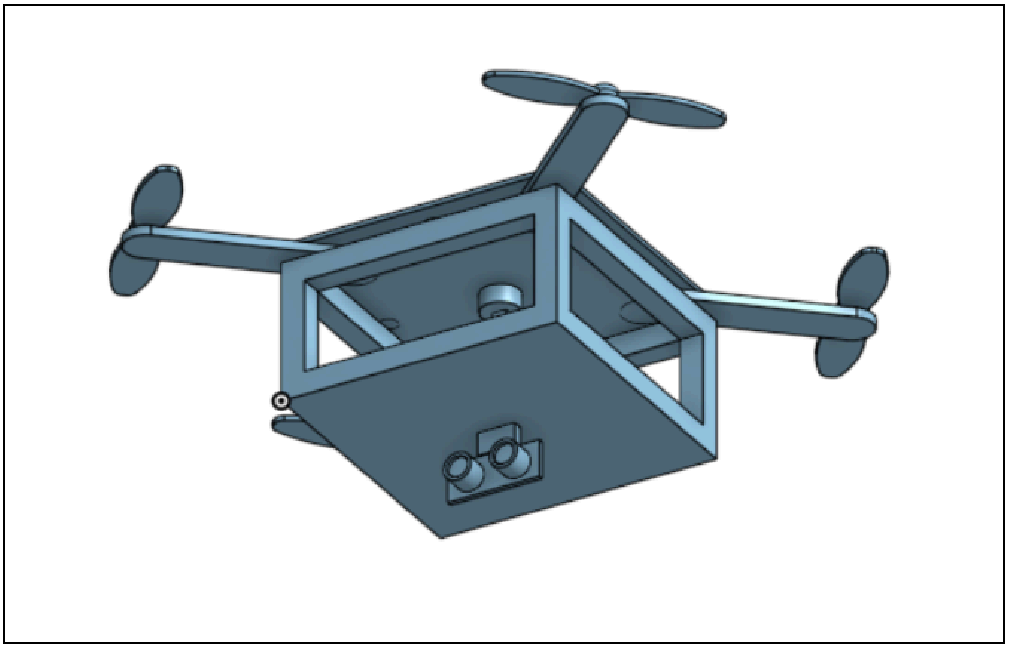


Figure 1. Drone Prototype

Rotational Scanning Requirements for Ultrasonic Sensor

Objective: Ensure reliable detection of targets during sensor rotation by defining constraints on allowable rotation speed and maximum measurable distance.

1. Critical Rotation Speed

The ultrasonic sensor may miss a target if its rotational sweep rate exceeds the time window in which the echo returns.

The critical angular speed is defined as:

$$w = \theta \cdot c / 2R$$

Where:

θ = sensor beam width (deg)

c = speed of sound in air (~343 m/s)

R = target distance (m)

Converted to rotations per minute (rpm):

$$Rpm = w / 6$$

Requirement:

The rotation speed of the ultrasonic sensor **shall not exceed rpm for the maximum intended detection range R**.

2. Maximum Detection Distance at Fixed Rotation Speed

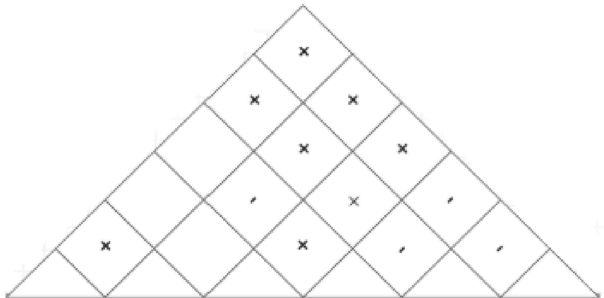
For a given rotation speed w, the maximum distance before missed detections is:
$Rmax = (\theta / w) \cdot (c / 2)$

Requirement:

At a rotation speed of **60 rpm (360°/s)** with a beam width of **15°**, the sensor shall reliably detect targets up to:

$$Rmax \approx 7.1 \text{ m}$$

1.6 House of Quality (HoQ)



	(+)Communications	(+)Battery Life	(+)Stability	(-)Amount of Motors	(-)Cost	(-)Weight
Cost(-)	↓	↓	↓	↑	↑↑	↑↑
Weight(-)	↓		↓	↑↑	↑↑	↑↑
Maneuverability(+)			↑↑	↓↓	↓↓	↓↓
Power Usage(-)	↓	↓↓		↑↑	↑↑	↑↑
Targets For Engineering Requirements	3600 samples / minute	>5 min	Spinning	<5	<$200	<250 g

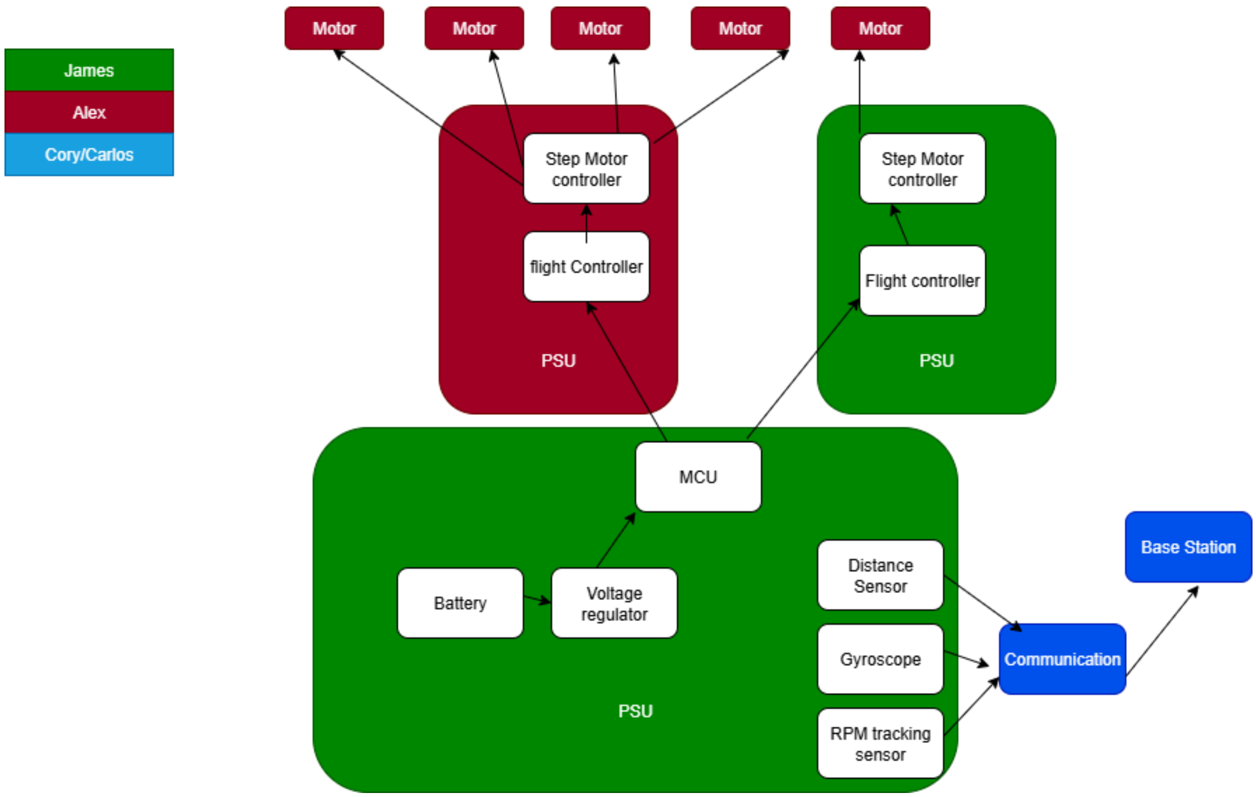
Figure 2. House of Quality

Chapter 2: Hardware (includes block diagram)

The hardware for this project will be developed by the Electrical Engineering team, with support from the Computer Engineering partners. To control the height, spin, and direction of the drone, we divided the design into three main subsections. This structure allows us to adjust the drone's motion and rotation speed based on data collected during testing.

The first subsection consists of the four primary motors and propellers that provide lift. Each propeller spins opposite to the one across from it, enabling smooth takeoff and descent, managed by the motor controller. The second subsection includes four additional motors, which are used to rotate the primary lifting propellers. This system gives us control over the drone's spin, allowing for more stable and precise flight. The third subsection is a single motor with its own controller, responsible for moving the drone across the x- and y-plane. Unlike a traditional drone, this setup eliminates the need to tilt the body for horizontal movement, enabling us to scan the ground below without compensating for tilt during motion or when coming to a stop.

In total, the system will use four PCBs: two main PCBs for communication and power distribution, one dedicated PCB to control the single central propeller, and one PCB in the base station for communication. Power will be distributed through the two main PCBs, while the separate propeller PCB operates as an independent control unit. The central propeller is mounted on a bearing, preventing it from spinning with the rest of the drone and ensuring stable operation during rotation. The drone body will be built from a lightweight, low-cost 3D-printed frame designed to hold the components and support the bearing assembly. Similarly, the base station will use a 3D-printed body and will also include an LCD screen for user interaction.



Motors 1-4 are for flight, Motors 5-8 are for spin, and the centralized motor is for forward propulsion.

2.1 Bill of Materials

Component	Name	Price ($/per part)	Quantity
Mechanical			
3D printed main body	Printed plastic	3	2
Bearing/Gyroscope	Bearing	0.5 - 1	1
propellor	Fpv props	0.50 - 2	5

Screws (for PCB boards)	M8x0.5	0.03	10
Electrical			
motor	Servo motor	2 - 8 Per motor	9
Gyroscope sensor	Arduino sensor	10	1
Microcontroller	TBD	15	1
Antenna	TBD	0.5	1
Wires/wiring	TBD	3	1ft of wire (estimated)
PCB boards	Custom	20	4
Total			$197.8

Chapter 3: Flow Charts (Communication)

The communication for this device will primarily occur between the drone and the base station. The drone will include multiple sensors connected to a dedicated PCB designed for both sensor integration and communication with the base station. Since the drone operates at 90 RPM, we need to collect at least one data point every 10 degrees of rotation, resulting in 36 samples per full turn. This sampling rate will determine the minimum communication speed required. In addition to these rotational data points, other sensors will provide information such as orientation, battery life, and rotational speed. Sensor communication within the drone will be handled using I2C due to its simplicity and compatibility. Transmission of the collected data to the base station will use a different protocol, which is still being determined.

Beyond the sensor communication, there is also a direct communication link between the base station and the drone's single fan, which is responsible for movement. This fan operates as a separate subsystem with its own PCB and battery, functioning as an independent entity within the overall design.

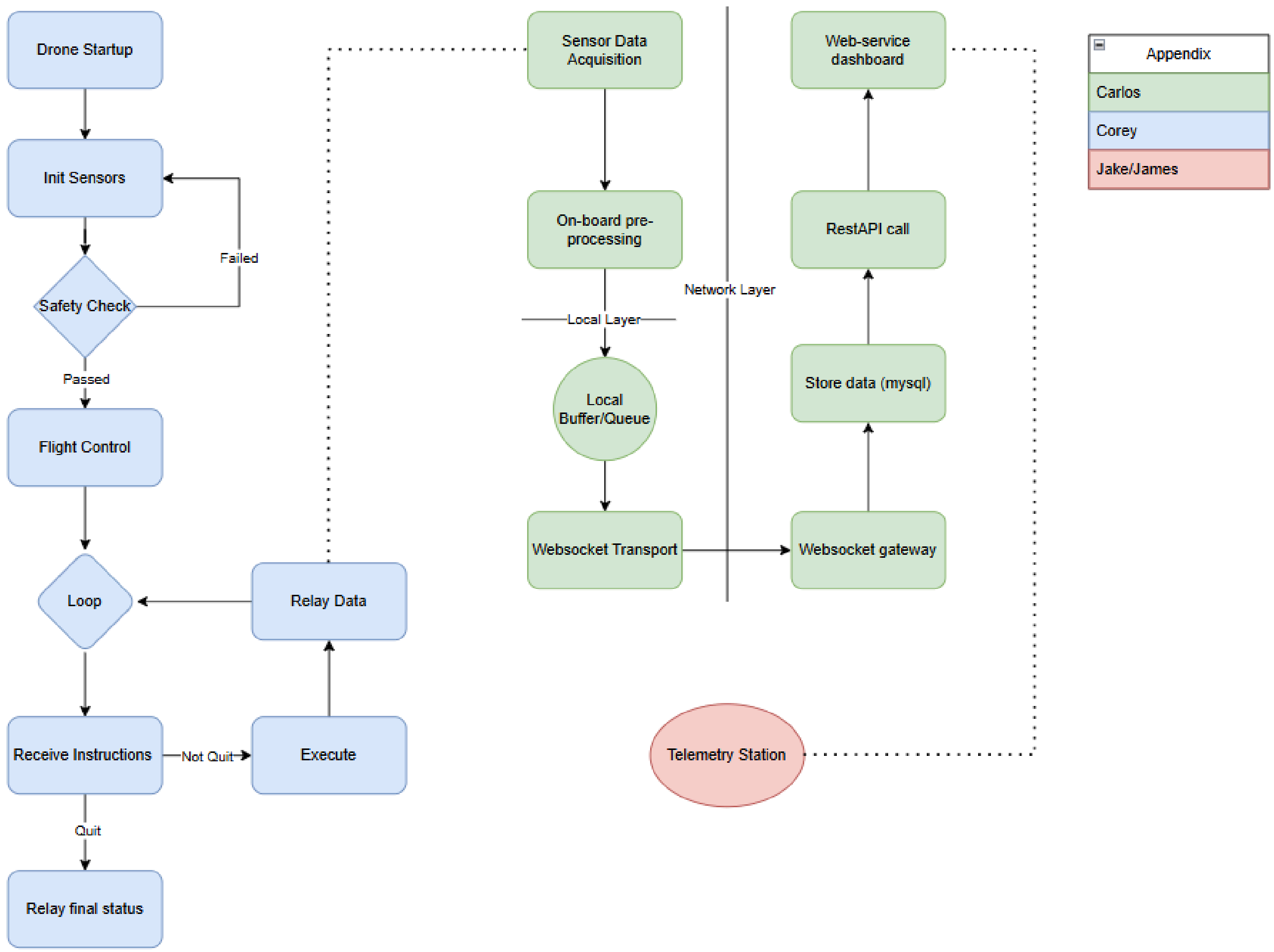


Figure 4. Software-Oriented Flow chart

Chapter 4: Financing

The financing of the drone design and development project is being supported through sponsorship from the DRACO Lab, which has provided the primary funding to cover research, materials, and prototyping expenses. This sponsorship ensures that the team has access to the necessary resources for both the technical and logistical aspects of the project, including hardware components, testing facilities, and development tools. The current estimate for **one** drone is **$197.80**. This, however, would not include defective parts, testing accidents, or software requirements. The DRACO lab would finance our project up to **$250**, with any extra reimbursement occurring at the end of the spring semester if there is any funds left.

Chapter 5: Project Milestones

To ensure that our project stays on track my team implemented a table of projected milestones. This table will include anticipated time frames throughout the next two semesters, so Senior Design 1 and Senior Design 2. Creating this table will help us be able to visibility see what our time frame looks like over the next few months and hopefully prevent our project from falling behind.

Table 1: Senior Design I Project Milestones

Task	Time Period	Dates	Responsibility
Project Proposal	1 Week	8/18 - 8/22	All
Research Drones	3 Weeks	8/22 - 9/10	All
D&C Document	2 Weeks	8/22 - 9/5	All
D&C Meeting	30 Min	9/10	All
Research Flight Controllers	2 Weeks	9/5 - 9/19	James / Alex
Research Autonomy / Navigation	2 Weeks	9/5 - 9/19	Corey / Carlos
Research Communication Systems	2 Weeks	9/5 - 9/19	Corey / Carlos
Research Sensor Integration	2 Weeks	9/5 - 9/19	James / Alex
30-Page Milestone	2 Weeks	9/5 - 9/19	All
Start PCB Design	2 Weeks	9/19 - 10/6	James / Alex
CAD Designing	2 Weeks	9/19 - 10/6	Corey / Alex
60-Page Milestone	3 Weeks	9/19 - 10/10	All
Order Drone Components / PCB	1 Week	10/6 - 10/13	All
90-Page Milestone	3 Weeks	10/10 - 10/31	All
Assemble Project Prototype	5 Weeks	10/20 - 11/25	All

120-Page Milestone	2.5 Weeks	10/31 - 11/19	All
Final Document	Ongoing	9/5 - 11/25	All

Table 2: Senior Design II Project Milestones

Task	Time Period	Dates	Responsibility
Prototype Assembled	2 Weeks	01/12 - 1/26	All
Prototype Testing	2 Weeks	1/26 - 2/9	All
Prototype Adjustments	2 Weeks	2/9 - 2/20	All
Project Demo	TBD	TBD	All
Final Team Meeting before Presentation	TBD	TBD	All
Final Documentation	TBD	TBD	All
Final Presentation	TBD	TBD	All

Appendices

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