# Engineering Notebook

ZEPHYRUS

1043B

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# Summary

**Project & Engineering Management (4-10)**
- Includes our team headshots, team structure and organization, task management, schedule management, and communication channels utilized.

**System Design (11-34)**
- Covers our engineering development process utilizing the V-model of the systems engineering process, researching process, conceptual designs, preliminary designs, downselection, detailed designs, testing, and revisions implemented for the designs of our AVR, RVR, DEXI, and Conex boxes. Additionally represents the engineering skills we used to optimize our components and the design influence our research had.

**Mission Planning & Strategy (35-37)**
- An outline of our estimated points per phase and specific team strategies we implement to maximize points and minimize wasted time and resources.

**Future Improvement Plans & Key Advantages Identified (38-39)**
- Focuses on major issues encountered, how we resolved them, and what we will take from these experiences to use in the future.

**Appendix (40-50)**
- Details our artistic design choices, safety, and meeting logs.

# Project and Engineering Management

# Meet The Team

## Captains

Ashley
Senior

Hudson
Senior

Brock
Senior

Angela
Junior

Bellamy
Senior

Jack
Senior

Jake
Junior

JJ
Sophomore

Keira
Senior

Matt
Senior

Max
Senior

Patrick
Sophomore

Sabrina
Sophomore

# Team Structure

## Team Captains

Brock Hudson Ashley

## Department Leads

| RVR | AVR | DEXI | Journal & Presentation | Sphero |
|---|---|---|---|---|
| Jake | Max | Jack | Bellamy | JJ |

## Pilots

| RVR | AVR | DEXI | Sphero |
|---|---|---|---|
| Jake | Hudson | Patrick | Sabrina Angela JJ |

## Reserve Pilots

| RVR | AVR | DEXI | Sphero |
|---|---|---|---|
| Sabrina | Max | Keira | Brock Matt |

## Engineering Journal & Presentation Team

JJ Angela Sabrina Matt Keira

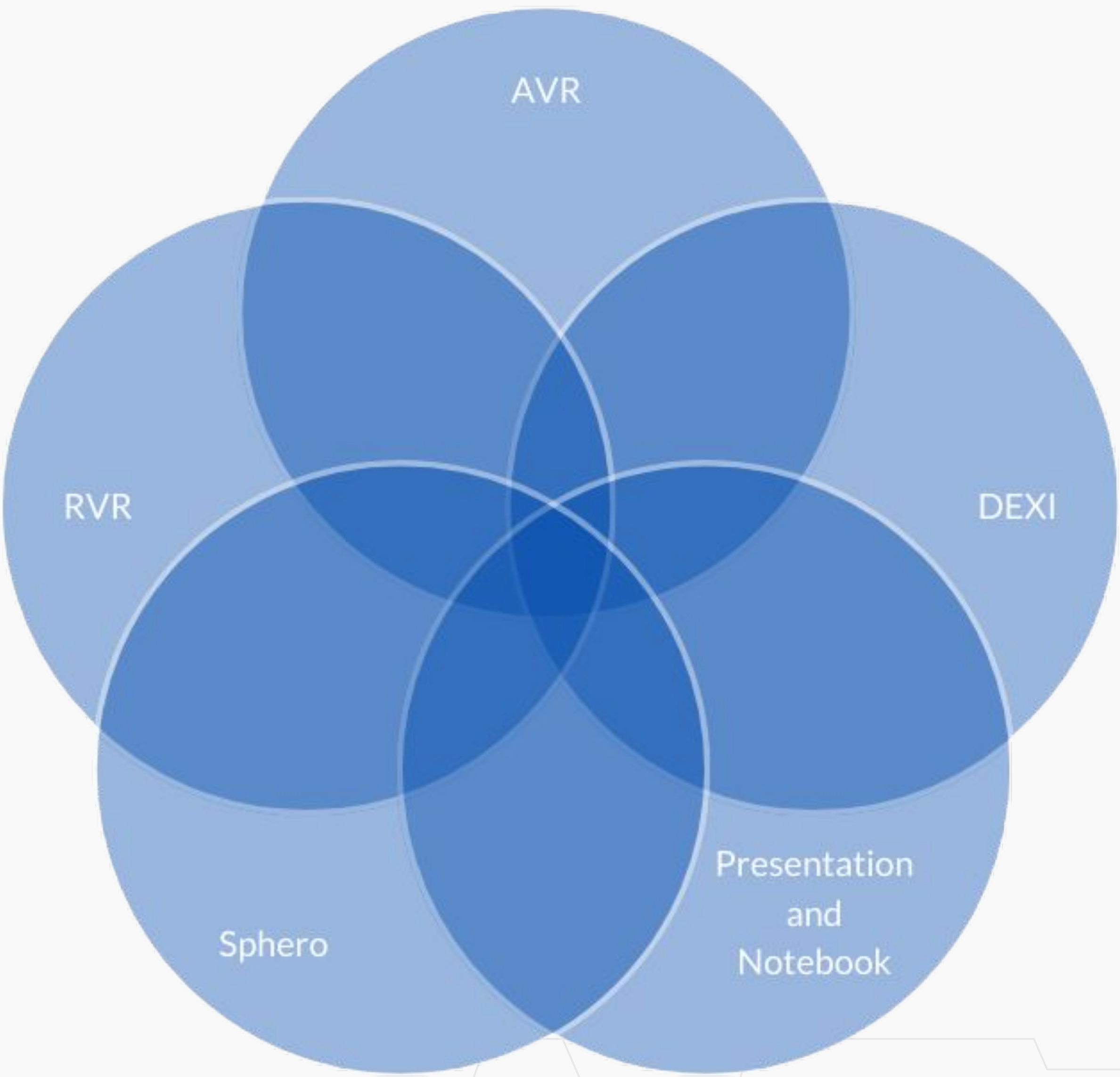
After pre-season training and captain/team selection, **roles were decided** based on **experience with Bell AVR** as well as **prior skills in coding, modeling, or assembling**. **Experience was not necessary**, rather **effort and willingness** to learn. Additionally, **captains presided over the team as a whole** - often moving between departments to **assign tasks, check on progress, and single out issues** to **ensure smooth communication** - just like real-life project managers would.

# TEAM DEPARTMENTS

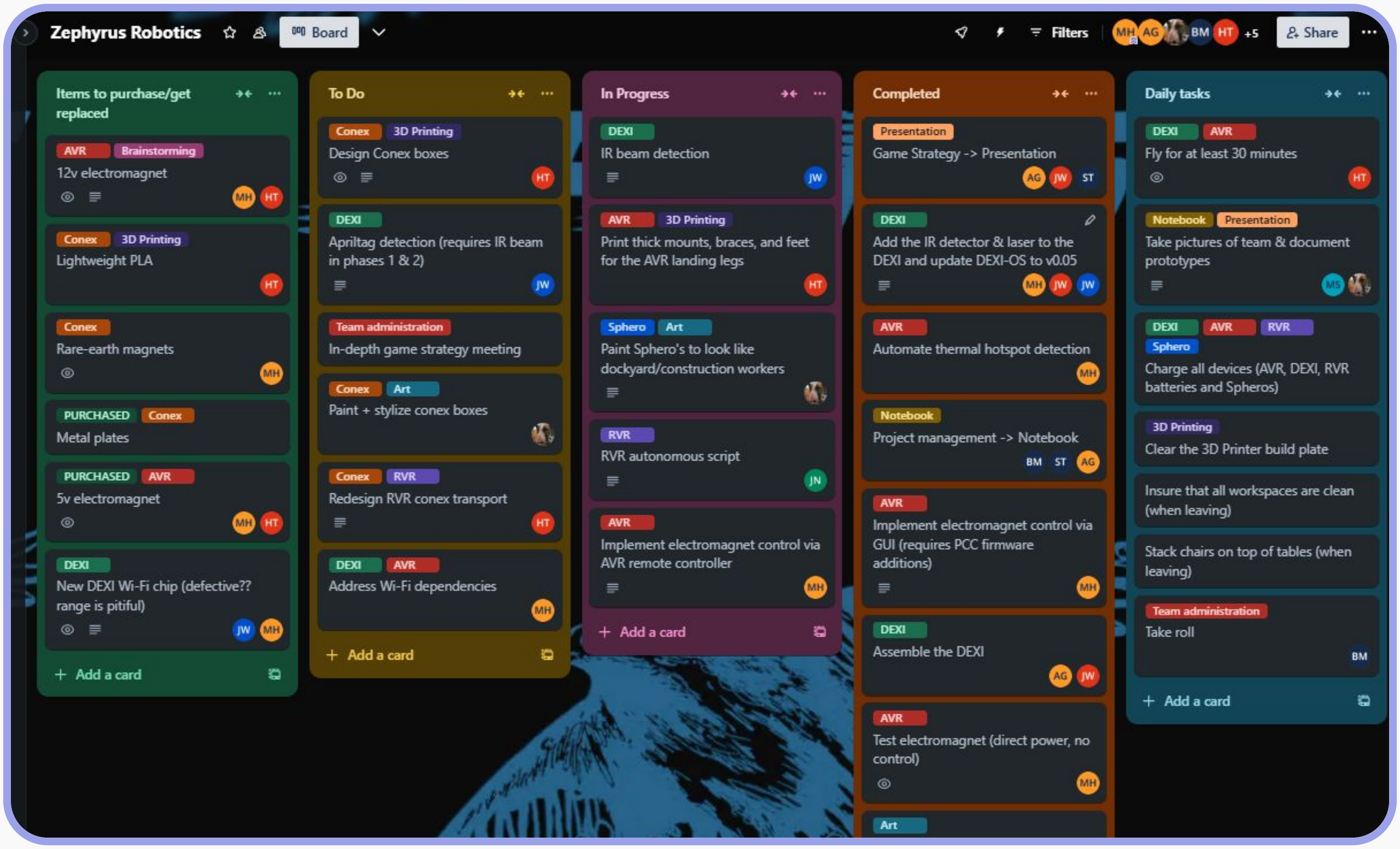
By departmentalizing our team into smaller technical groups, we are able to allocate tasks and collaborate more efficiently.

Members of each technical group would report progress to the notebook and presentation team, providing specific technical insight where necessary.

However these departments are not isolated from each other, and a significant amount of member overlap between each group ensures that no one is left in the dark on strategies or team progress. For example, all teams contributed to Conex design to ensure that all concerns were addressed



# Task Management

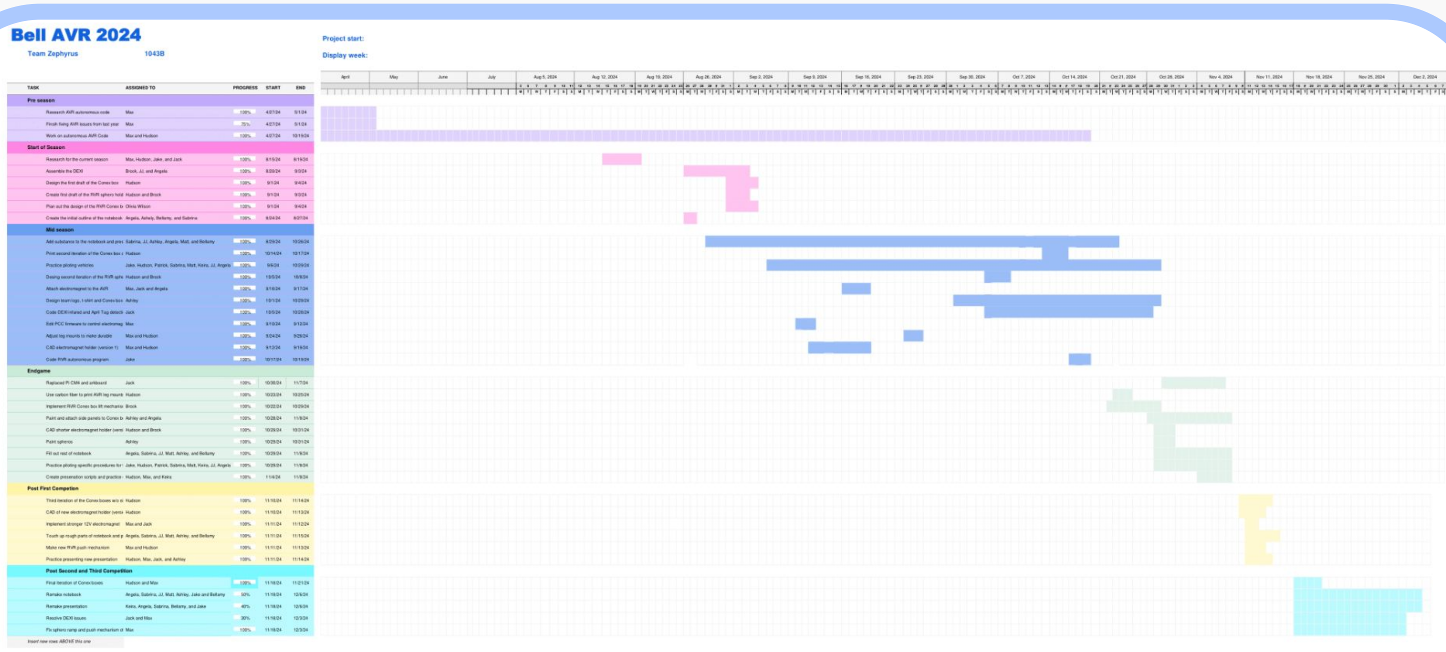



Our team uses Trello for task management by tracking and organizing required tasks into lists based on completion status. Each card represents a task, labeled by area, and team members can self-assign tasks or be assigned to one by a department head. Unassigned tasks are shared responsibility among the whole team.

# Task Management (cont.)

Our team also uses Google Chats and SMS for standard communication, Discord for photo/video transfer and long messages (i.e. progress logs), and Github for code management

This Gantt chart is a rough outline of how our task progression unfolded throughout the season.



# Major Milestones

**AVR**

| 5/20 | 9/16 | 10/10 | 11/1 | 11/10 |
|---|---|---|---|---|
| First autonomous flight | Tested and installed electromagnet | Automatically scan thermal hotspots | Pilot can control electromagnet with the controller | Installed stronger electromagnet |

**DEXI**

| 9/3 | 9/6 | 10/5 | 10/19 | 10/25 | 10/30 | 11/7 |
|---|---|---|---|---|---|---|
| Completed building | Started flying | Began Programming | Scan IR beams | Scan April Tags | Replaced Pi CM4 | Replaced Arkboard |

**RVR**

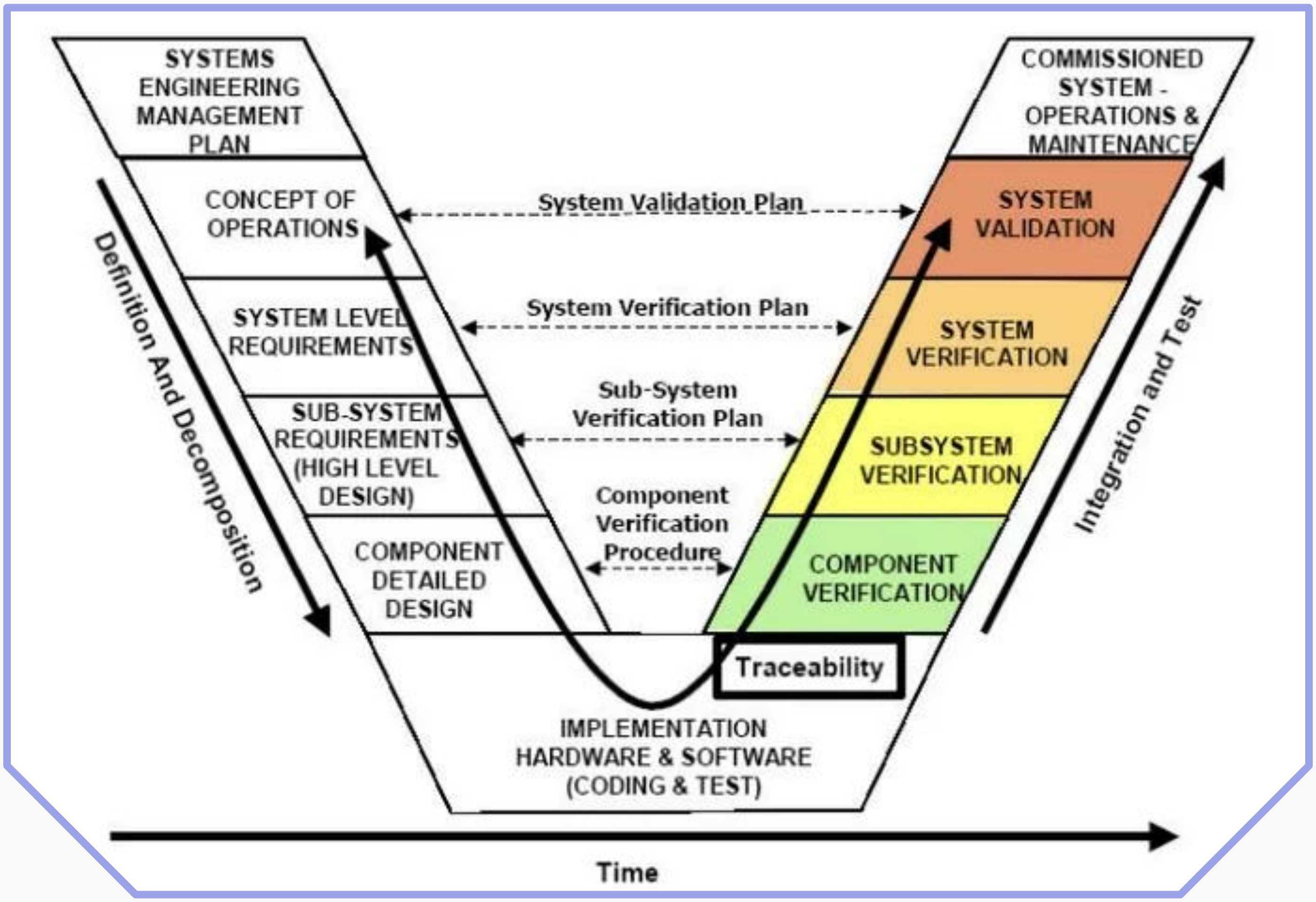
| 9/3 | 11/3 | 11/14 | 11/16 | 12/03 |
|---|---|---|---|---|
| Begin engineering RVR mechanism | Initial mechanism implemented | Box Pickup V2 implemented | Box pusher implemented | Fork mechanism implemented |

**Conex**

| 9/1 | 9/17 | 10/3 | 10/14 | 10/29 | 11/18 |
|---|---|---|---|---|---|
| Initial box design created | Improved ramp | Added Sphero holder | Box Redesigned | Side Panels Removed | Box Redesigned |

# System Design

# Engineering Development Process




Our team implemented the Systems Engineering V when it came to designing our operations. Different subdivisions of software and hardware made up the subsystems of our devices, culminating in point-scoring systems and streamlined operations mechanisms that work together in unison to complete field objectives.

Rigorous tests on the components of each subsystem verify that all pieces of the puzzle are functioning correctly, and the repeatability of these tests can help diagnose potential problems in the field.

# AVR System Architecture

## AVR Drone

Flight Control System
- Accelerometers
- ZED Mini

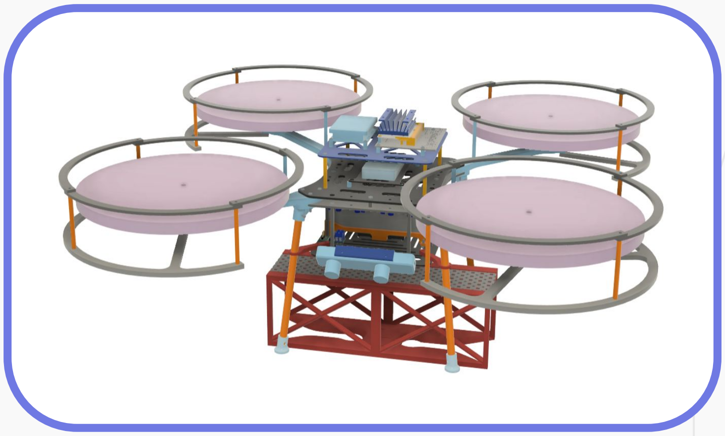
Electromagnet Pick-Up System
- Electromagnet
- Electromagnet Control

Automated Thermal Scanning System
- Thermal Image Processor
- Hotspot Detection & Reaction

Communication System
- 2.4 Ghz Remote Control Protocol

Propulsion System
- ESC
- Motors
- Propellers

AVR Structure
- Chassis
- Landing Gear
- Prop Guards



# AVR Operations

## Electromagnet Pick-Up System

This system is responsible for picking up Conex boxes, with a focus on snappy response times and high lifting strength

## Electromagnet Control Subsystem

**Subsystem Purpose**

The Electromagnet Control Subsystem is in charge of controlling the flow of power to the electromagnet, allowing us to turn it on and off at will.

**Behind-the-scenes**

The PCC receives a command and tells the MOSFET to allow or deny electrical passthrough to the electromagnet, thereby turning it on or off. This allows us to pickup and drop Conex boxes at will, with lightning fast response times.

**Components:**

- ➢ Electromagnet (Tested by directly connecting to power)
- ➢ MOSFET (Tested by measuring electrical passthrough when a signal is received)
- ➢ Peripheral Control Computer (Tested by verifying that the proper signal is sent to the MOSFET when a certain command is received)

12 volt electromagnet w/ inline mount

# AVR Operations

## Electromagnet Pick-Up System (cont.)

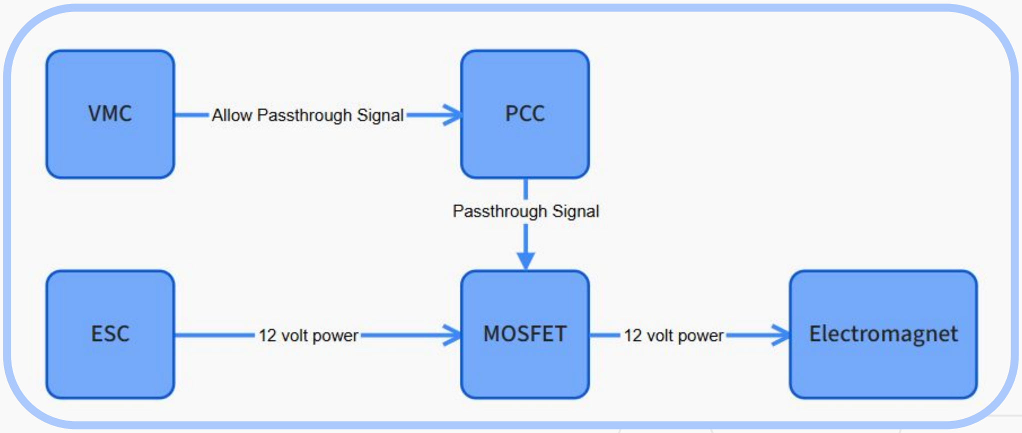
### AVR Integration Subsystem

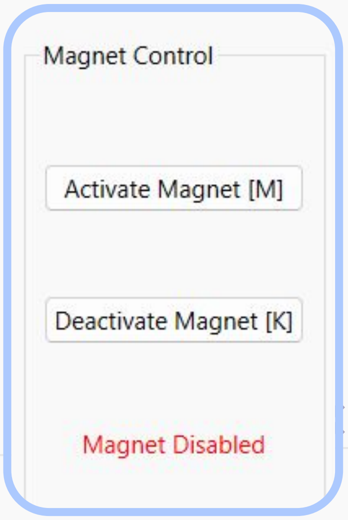
**Subsystem Purpose**
The AVR Integration subsystem is responsible for receiving API messages from the ground control station or other devices (more on that later) and sending commands to the PCC in order to control the electromagnet.

**Behind-the-scenes**
This subsystem takes messages sent over the MQTT API and translates them into internal commands for the PCC to either engage or disengage the electromagnet.

**Components:**

- ➢ Peripheral Control Computer - MOSFET Control (Tested by verifying that it can receive signals from the VMC)
- ➢ Vehicle Management Computer - PCC Serial Connection (Tested by verifying it can handle and react to API messages)
- ➢ Ground Control Station (Tested capability to send API messages to the AVR)



# AVR Operations

## Automated Thermal Scanning System

This system is responsible for analyzing operational data collected by the thermal camera to detect and indicate hotspots

## Thermal Camera Processing Subsystem

**Subsystem Purpose**

Process the thermal camera output and turn in into useable data before packing & shipping it to other software modules.

**Behind-the-scenes**

Thermal camera output is processed into grid of pixels, where each pixel's color correlates to a temperature value. This grid is then encoded and sent over MQTT.

**Components:**

➢ Thermal Camera (Tested by ensuring that data is sent to the VMC)

➢ Vehicle Management Computer - Thermal Camera Processing Software (Tested by ensuring that processed data is being broadcast)

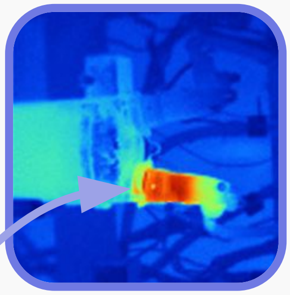
**Turn this:**

FBMSExMTExMUE
xMTFBMTEhMTEx
ISExMSExISExM
TExMUExMSExQU
FBQSEhMTHBkTF
BMTExMUFBQSEh
ITFBMTEw==

(Actual thermal camera output, produced by scanning a power pylon during competition)

**Into this:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 19 | 18 | 19 | 19 | 19 | 19 | 19 |
| 20 | 19 | 19 | 19 | 20 | 19 | 19 | 18 |
| 19 | 19 | 19 | 18 | 18 | 19 | 19 | 18 |
| 19 | 18 | 18 | 19 | 19 | 19 | 19 | 19 |
| 20 | 19 | 19 | 18 | 19 | 20 | 20 | 20 |
| 20 | 18 | 18 | 19 | 19 | 28 | 25 | [illegible] |
| 20 | 19 | 19 | 19 | 19 | 20 | 20 | 20 |
| 18 | 18 | 18 | 19 | 20 | 19 | 19 | 19 |



(What the thermal camera is "seeing")

# AVR Operations

## Automated Thermal Scanning System (cont.)

### Hot Spot Detection Subsystem

**Subsystem Purpose**
Receive thermal data messages and identify hotspots, before indicating them using an LED flash sequence.

**Behind-the-scenes**
The thermal camera processing module provides relevant thermal data in the form of temperature values, these values are analyzed and if a threshold is met, a message is sent to the PCC to flash the LEDs white.

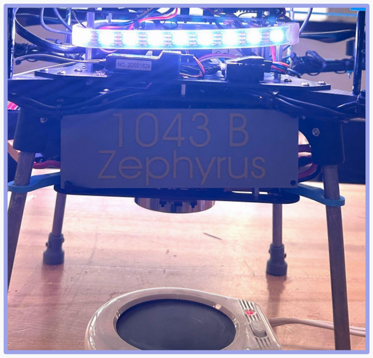
Components:

- ➢ Vehicle Management Computer - Thermal Hotspot Detection Software (Tested by logging simple message when a hotspot is found)
- ➢ Peripheral Control Computer - LED Strip (Tested by building test flash buttons into GUI)

**Turn this:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 19 | 18 | 19 | 19 | 19 | 19 | 19 |
| 20 | 19 | 19 | 19 | 20 | 19 | 19 | 18 |
| 19 | 19 | 19 | 18 | 18 | 19 | 19 | 18 |
| 19 | 18 | 18 | 19 | 19 | 19 | 19 | 19 |
| 20 | 19 | 19 | 18 | 19 | 20 | 20 | 20 |
| 20 | 18 | 18 | 19 | 19 | 28 | 25 | 19 |
| 20 | 19 | 19 | 19 | 19 | 20 | 20 | 20 |
| 18 | 18 | 18 | 19 | 20 | 19 | 19 | 19 |

**Into this:**




(LEDs flash between white and cyan in one second intervals when a hotspot is detected)

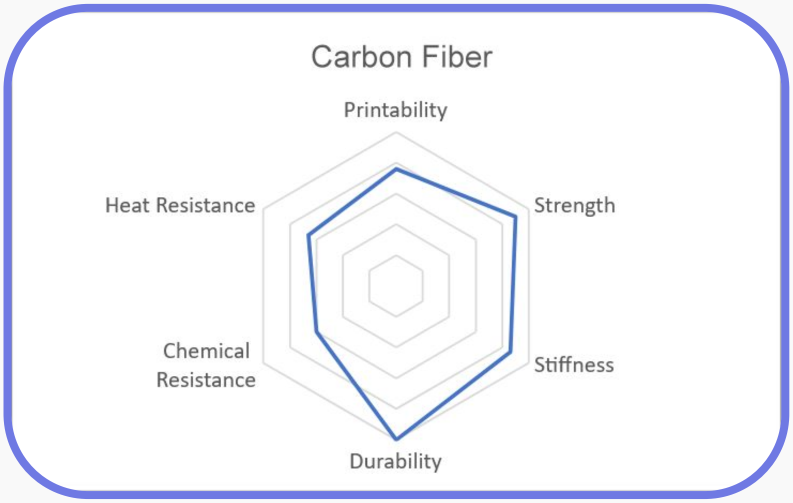
# AVR Landing Gear Design

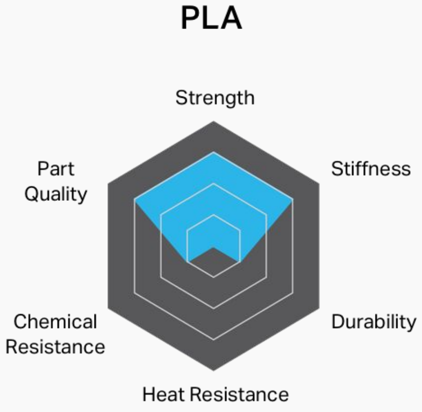
## Material Selection

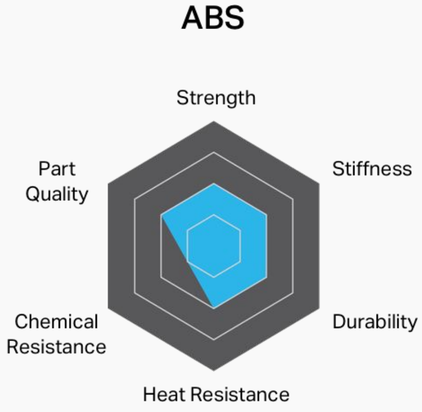
### Filaments Considered

- ➢ PLA
- ➢ ABS
- ➢ PETG
- ➢ Carbon Fiber (Final)

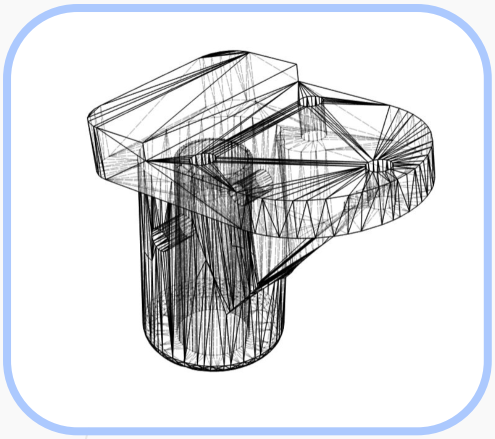
Carbon fiber filament is **strong** and **durable**, which is exactly what we need for the AVR landing gear mounts.



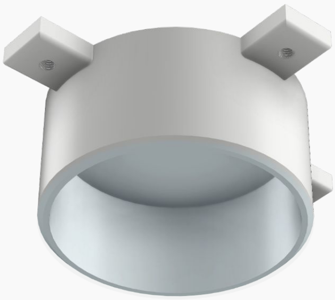





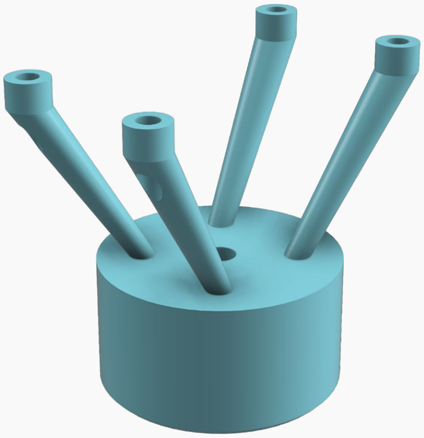


# Electromagnet Mount Design

## Iterations



**Strengths:** Holds Electromagnet
**Drawbacks:** Cannot reach boxes



**Improvement Made:** Can reach boxes
**Strengths:** Easy to grab boxes
**Drawbacks:** Mounting Issues

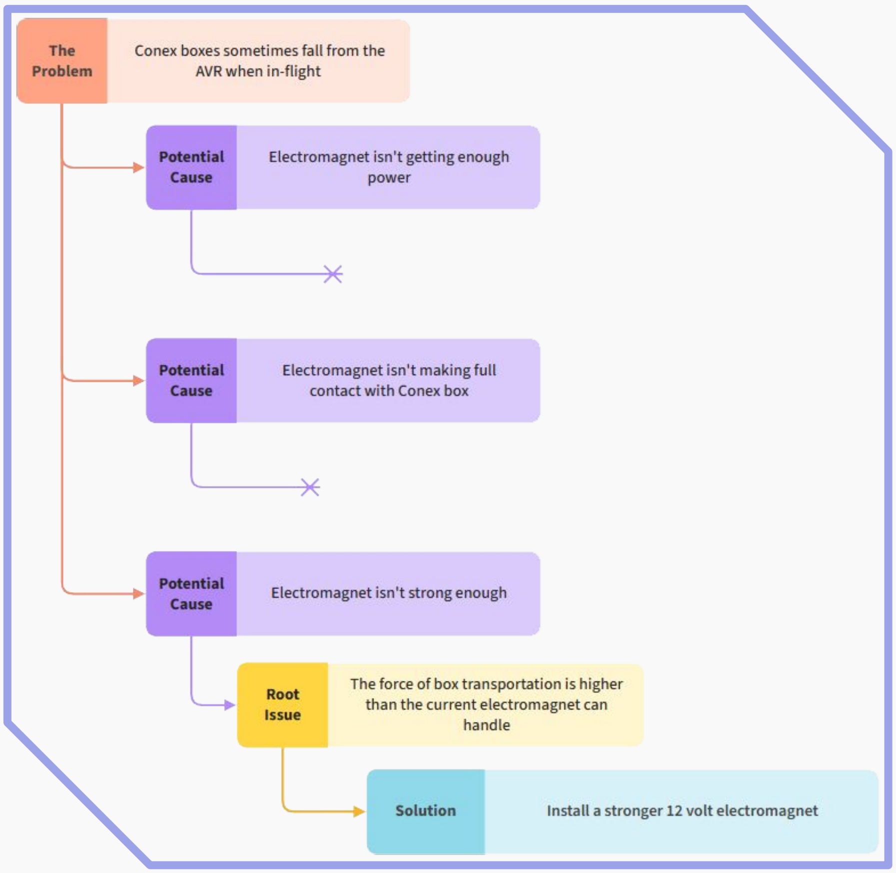
**Improvement Made:** Easier to mount
**Strengths:** Negative space guarantees that boxes are grabbed
**Drawbacks:** Point of failure in arms

**Improvement Made:** No more points of failure, supports 12 volt electromagnet
**Strengths:** Resistant to crashing, same pickup power (legs shortened to allow magnet to reach boxes)
**Drawbacks:** Hard to service

# System Overhaul

## Bigger Is Better

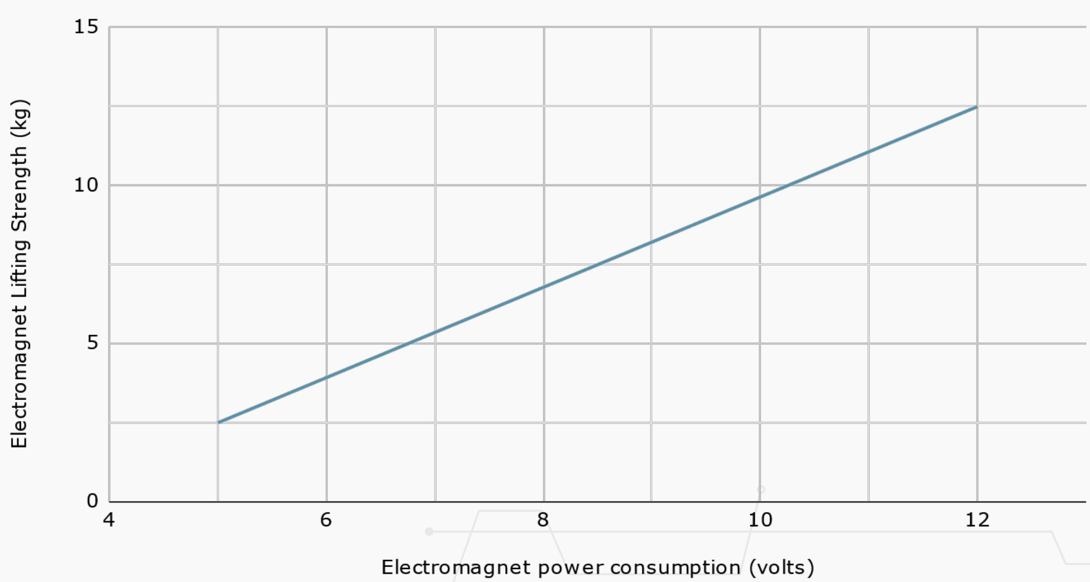
### Upgrade from 5 volt electromagnet to 12 volt electromagnet




Although our 5 volt electromagnet was initially successful, we quickly learned that the strong forces of AVR flight would outweigh the strength of the electromagnet. Our solution was to go bigger, **implementing a 12 volt electromagnet**.

This worked flawlessly. The connection between the electromagnet and the box is rock solid, resisting all sorts of in-flight turbulence.

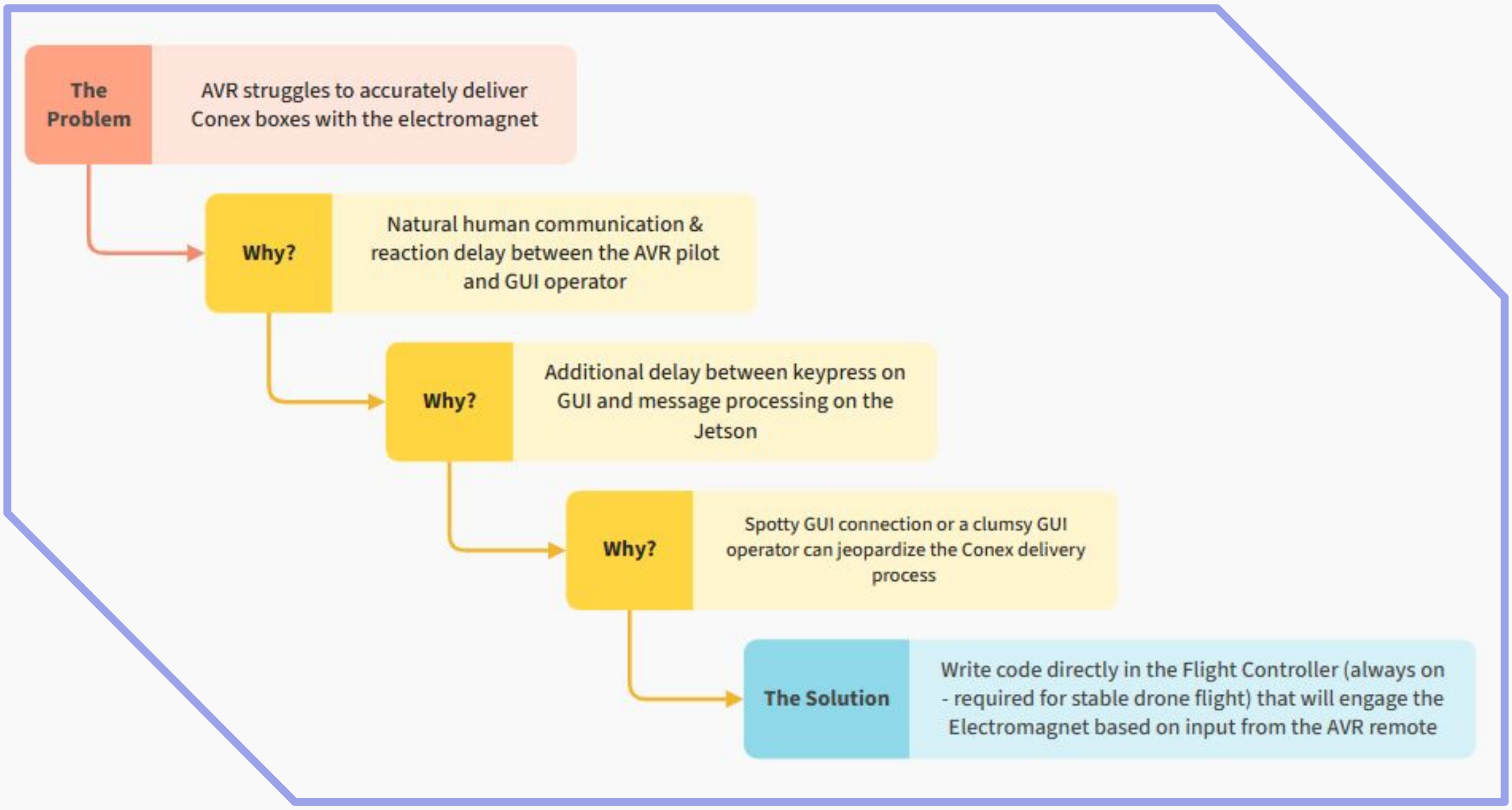
Strength vs power consumption



# System Overhaul

## RC Control

### Controlling the electromagnet via AVR remote

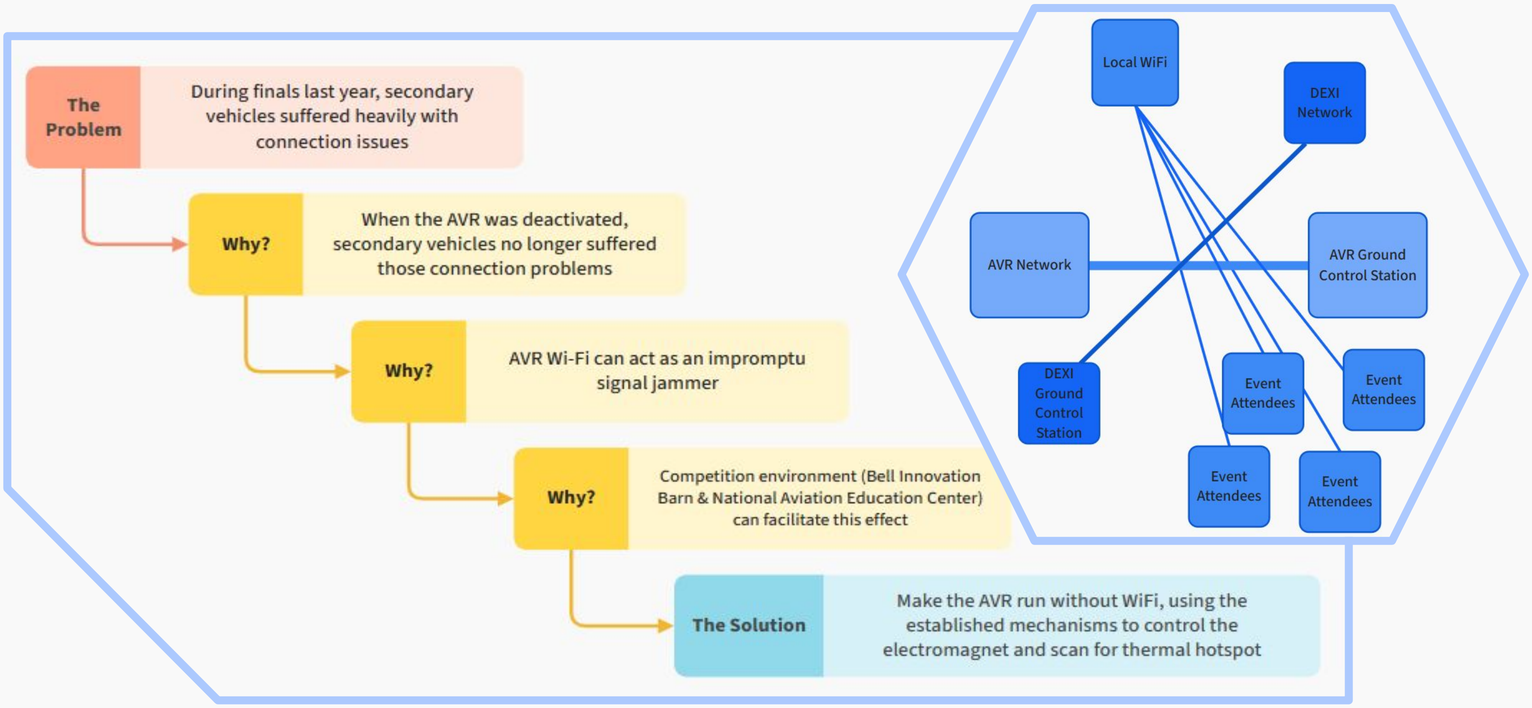



This update to the magnet integration subsystem cuts out **unnecessary delays** and eliminates confusion on the field. The AVR pilot is in **complete control** over the drone and its mechanisms, and quickly delivering Conex boxes has become second nature to our pilot because of this seemingly small change.

# Operation Feature

## The Great Disconnect

### WiFi-Denied Operations




In order to account for the above issues, we **designed our AVR to work completely offline**, independent of a ground controller.

- By **cutting out the problematic WiFi network,** we ensure that the AVR is always **operating efficiently** and **does not disrupt the wireless operations** of other competition vehicles

- All of our system implementations have led to this, creating one fluid and **independent operations mechanism.** The only connection that the AVR requires is between the pilot and the drone, allowing the pilot to dedicate 100% of their attention to flying and fostering unparalleled focus & performance on the field.

**Other teams rely** on the **AVR network** to score **thermal points** and activate their **Conex pickup** mechanisms.

**We do not.** No WiFI is **one less critical failure point** for the AVR that can make the difference between a failed and successful mission.

# Dexi System Architecture

## DEXI Drone

Flight Control System

- Accelerometer
- GPS

GPIO Pins

- Laser
- IR Beam Detector

Camera Serial Interface (CSI)

- AprilTag Camera

Communication System

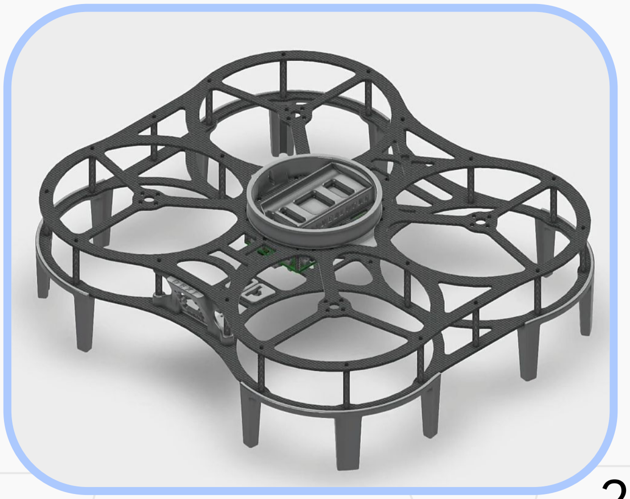
- 2.4 Ghz Remote Control Protocol
- 5.2 Ghz WiFi Network

Propulsion System

- ESC
- Motors
- Propellers

DEXI Structure

- Chassis
- Landing Feet
- Prop Guards



# DEXI Operations

## Operation Programming

Our DEXI programming provides an optimized and intuitive suite for completing operational tasks in the field

### Scoring Synergy Subsystem

**Subsystem Purpose**
Facilitate communication between the AprilTag and IR beam detection, minimizing confusion for team members and preventing sequence-breaks in the competition.

**Behind-the-scenes**
AprilTags will not be recognized unless an IR beam has been scanned beforehand, unless phase three has been entered.

**Components:**

➢ IR Beam Handling Codeblock (Tested by exposing the IR receiver to an IR emitter and monitoring results)

➢ AprilTag Handling Codeblock (Tested by exposing the Pi Camera to an AprilTag and monitoring the results)

# DEXI Operations

## Operation Programming (cont.)

### Game Tracking & Reaction Subsystem

**Subsystem Purpose**
Track the progress of the match and react to certain events, primarily the changing of the phases.

**Behind-the-scenes**
We constantly check the vertical velocity of the DEXI, once it passes a certain threshold we determine that the drone has taken off and consider the match started.

**Components:**

➢ Vertical Velocity Handling Codeblock (Tested by reporting vertical velocity data and comparing it to stated data from established telemetry sources)

➢ Match tracking Codeblock (Tested by starting different timers that trigger respective phase actions)

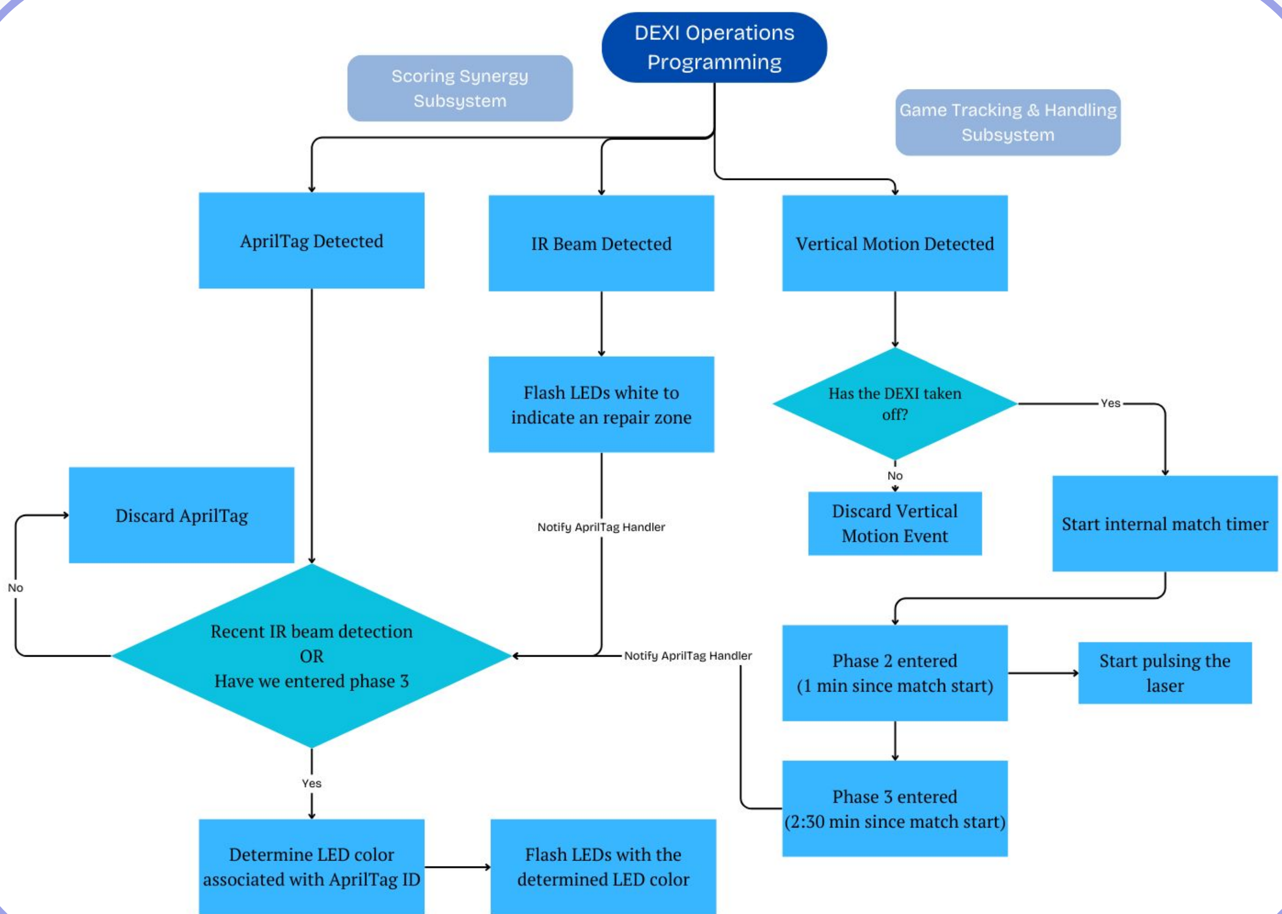
➢ Onboard accelerometer (Tested by calibrating sensors and verifying that sensor output matches expected values)

| Phase One | Phase Two | Phase Three |
|---|---|---|
| Use laser to help with scanning IR beams and AprilTags | Activate laser pulsing | Deactivate IR beam requirement for AprilTags |

# Operation Feature

## Leaving The Nest

### Self-reliant DEXI software, with minimal Ground Station input

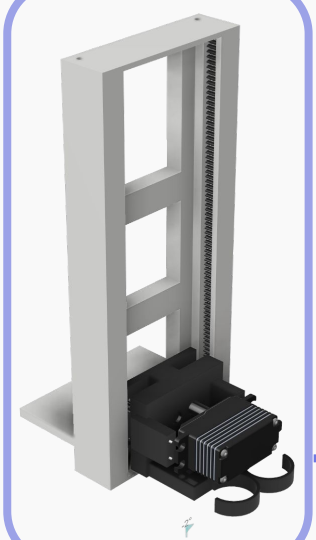



Our DEXI is capable of **tracking and progressing** through the match as more phases open up. This enables the Ground Station operator to take a backseat role when it comes to direct DEXI control, instead **acting as a spotter and communicator** for the DEXI pilot. The only times where the Ground Station operator must engage with the DEXI, is to **help the pilot target laser welds using the camera feed** or **overriding problematic code** (often caused by glitches during startup)

# RVR

## Previous Iterations

**Gear-driven lift**



- \+ Allows for easy stacking of boxes for bonus points
- ➢ Used dual electromagnets to attach to Conex boxes
- ➢ Prototypes and testing revealed promising results

Ultimately failed due to reliability issues - gear lift was too unstable to handle heavy stress of box lifting and movement

**Lead Screw lifter**

- \+ Dual lead screws raised the boxes to stacking height
- \- Lead screws proved to be temperamental and hard to repair

Used passive rare-earth magnets to grab boxes

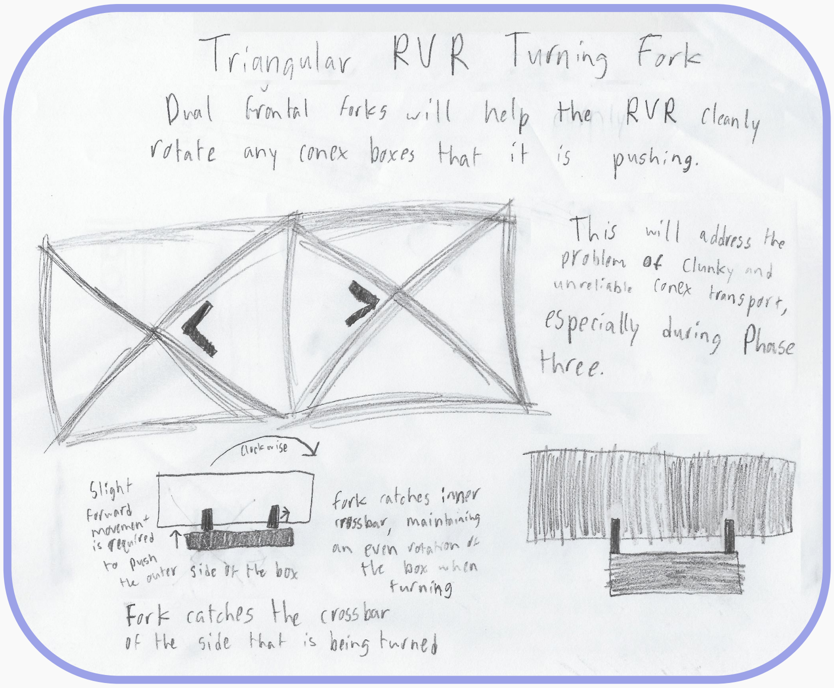
**Simple push**


- \+ No more unreliable lifting gimmick
- \+ Synergize with our skilled RVR pilot
- \- Issues with turning

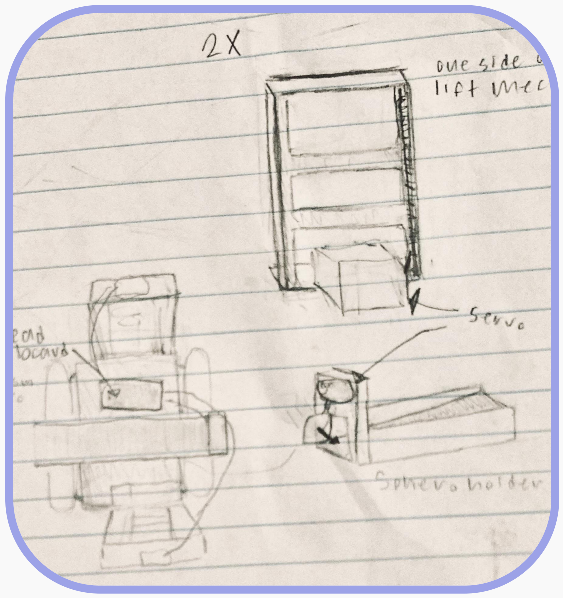
For how primitive it was, it performed well (mostly due to a highly proficient RVR driver)

# RVR

## Down Selection




Two-pronged fork mechanism interlocks with the new Conex boxes in order to help when pushing the boxes around corners

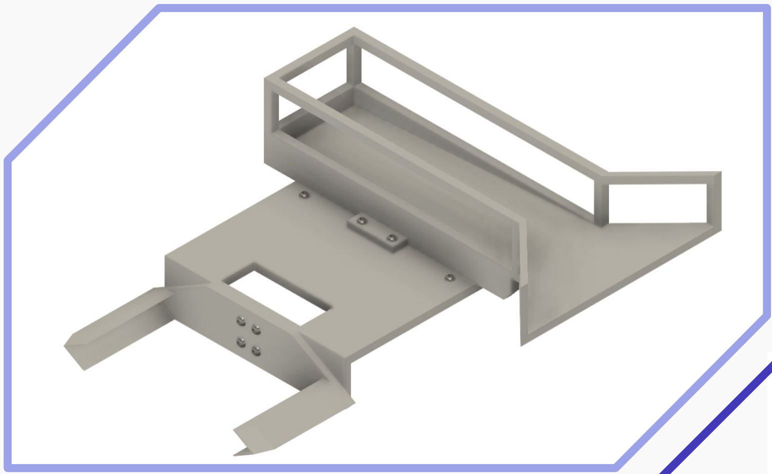


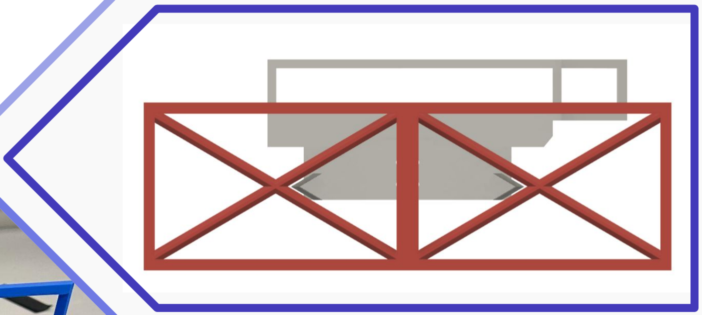

Gear-driven box lift mechanism using 2 electromagnets, gears, and a servo to attach to and lift boxes

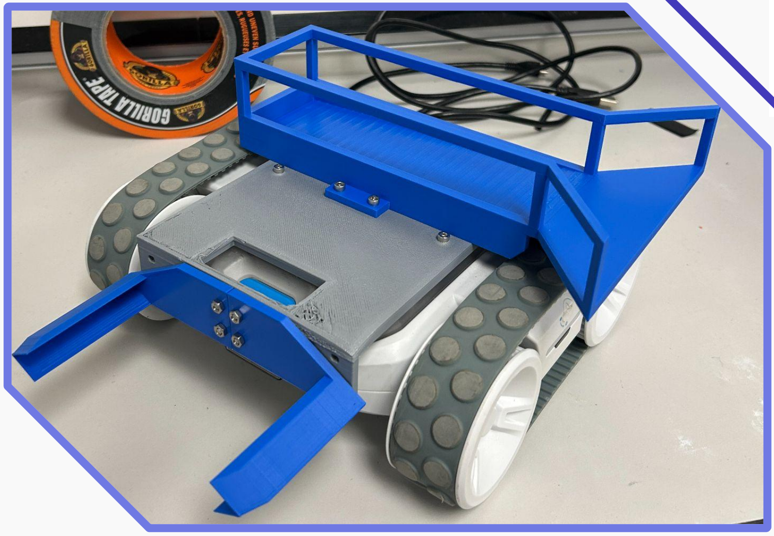

Tested out a widened Sphero holder; makes loading all spheros into the RVR during phase one much easier and will be implemented

# RVR

## Final Implementation



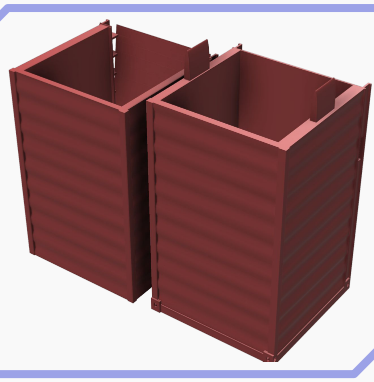





The implementation of our final RVR design was a leap ahead of our past mechanisms. The **turning forks were highly effective**, making Conex transport drastically easier, especially during phase three when the RVR must travel around the bridge. **The updated Sphero holder increased the margin of error** when picking Spheros up from the tech station, meaning we could shave some time off of phase one that was often spent correcting the RVR’s parking job.

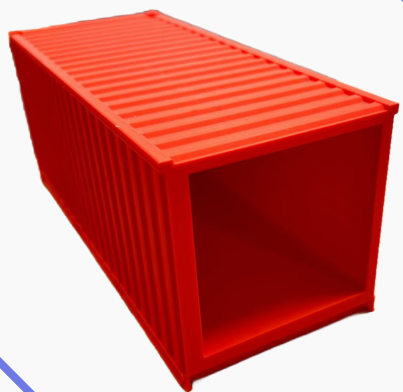
# Conex Boxes

## Early Iterations



1st iteration
(with ramp)

2nd iteration



1st iteration
(without ramp)

Initially we designed and printed life like containers to focus on looks and added a simple ramp.

**Pros:**

- Aesthetic design

**Cons:**

- Spheros struggled to board and disembark
- Difficult for Spheros to remain in the box during flight

We then redesigned the box with a lattice structure, but kept lightweight PLA sides to maintain the aesthetic. A channel was also added to allow for spheros.

**Pros:**

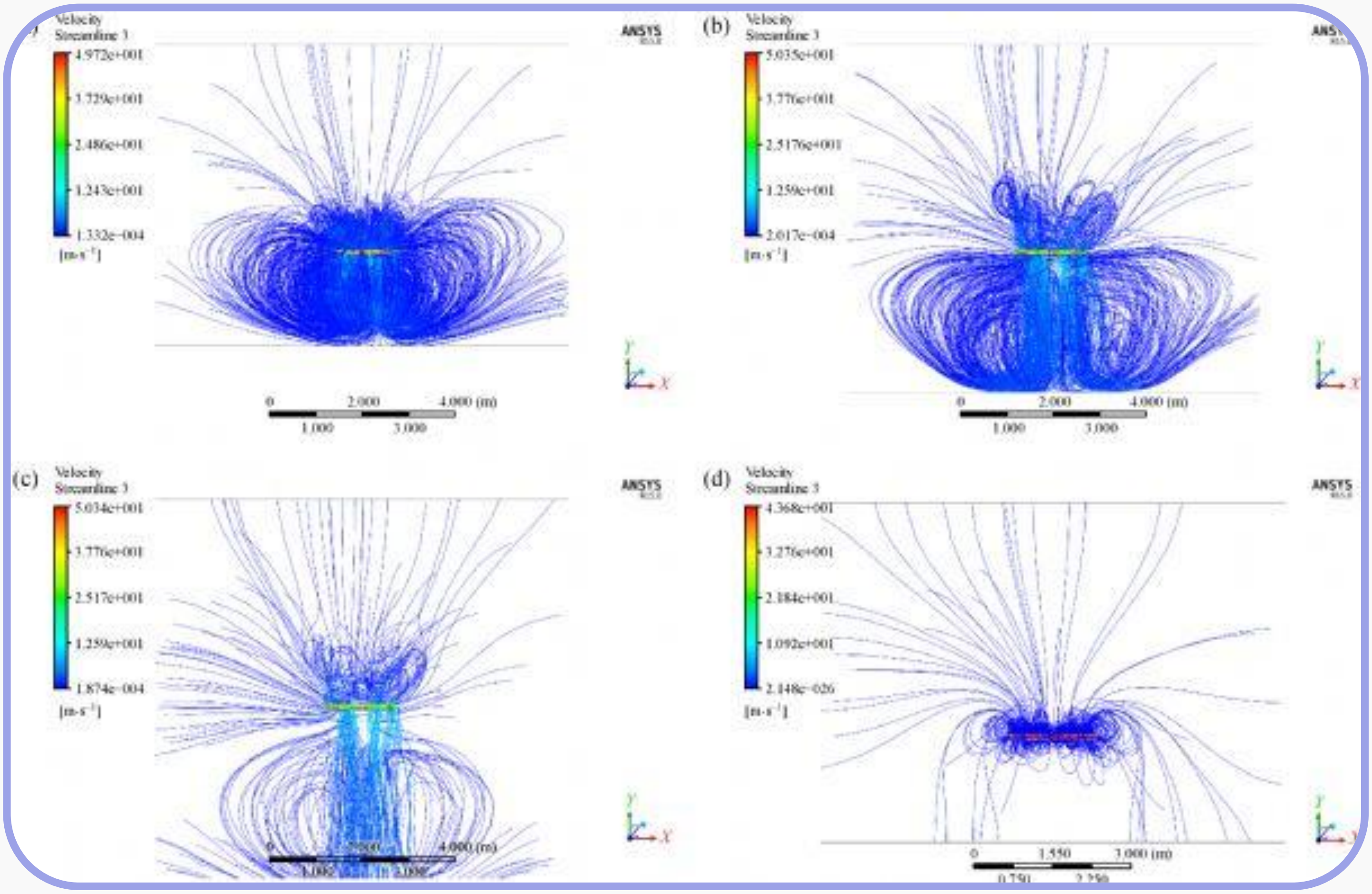
- Lighter weight than original
- Easier for Spheros to board
- Maintained aesthetics
- Rare earth magnets on bottom for faster stacking, if time permits

**Cons:**

- Large surface area on sides meant AVR propeller wash could send boxes sliding
- Magnetic plates were too small to easily connect to AVR

# Conex Boxes

## Rotor Downwash Research

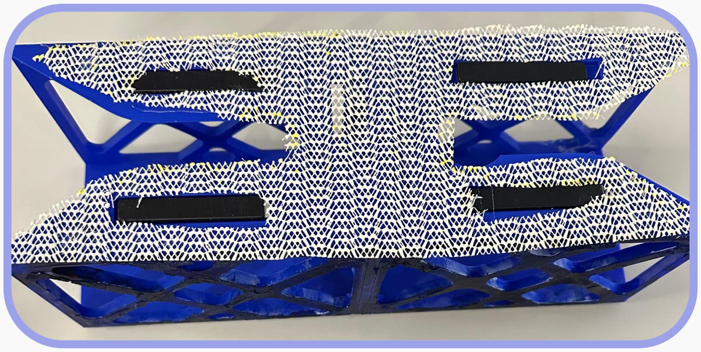


- Rotor **downwash intensity increases** with proximity to ground
- Disruptions oriented in horizontal vector at ground-level, **increasing need for pass-through holes** in Conex boxes
- Research and test results **influenced design** for high pass-through Conex boxes.

Image Source: The computational fluid dynamic modeling of downwash flow field for a six-rotor UAV (Zheng, Liang, Liu)

# Conex Boxes

## Post-Competition Improvements



During the first competition we found the boxes to be very unreliable when it came to AVR pickup. They would slide around the field, pushed by the down force from the AVR's propellers.

**Changes:**

- Side panels removed to prevent boxes from being pushed around by the AVR
- Implemented rubber netting on the bottom (Further reduced shifting during AVR approach)

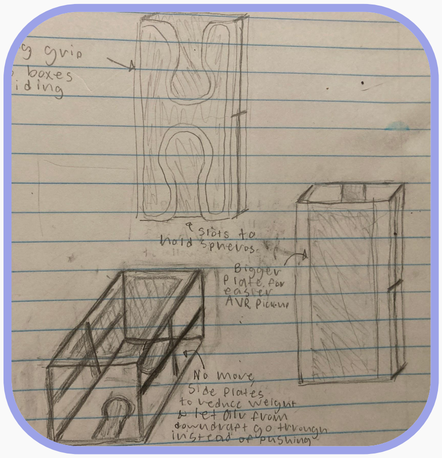
**Issues:**

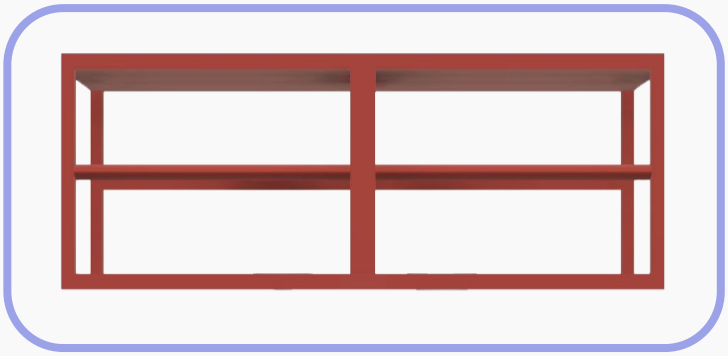
- Small metal top plates made it hard to grab accurately and quickly
- Suboptimal aerodynamics still led to sliding boxes in certain scenarios
- Netting made it difficult for spheros to disembark from the boxes in certain scenarios

# Conex Boxes

## Final Design - Concept

After we qualified, we went back to the drawing board and redesigned the boxes to maximize airflow and magnetic contact area.

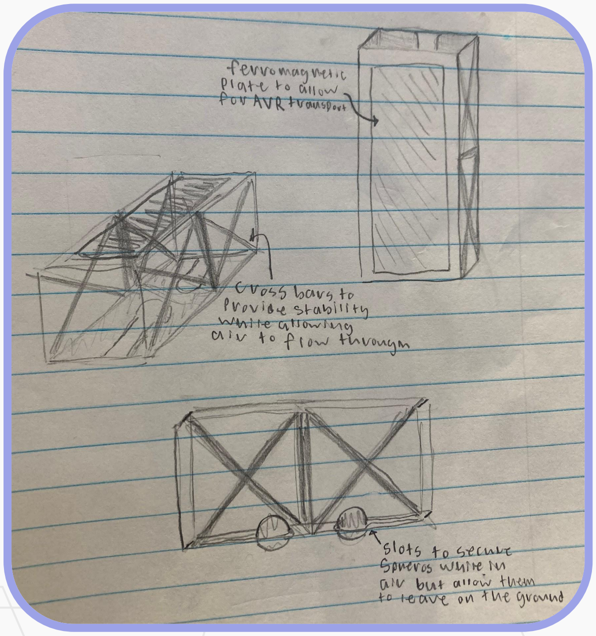


**Maximum Airflow Conceptual Design (Never Produced)**

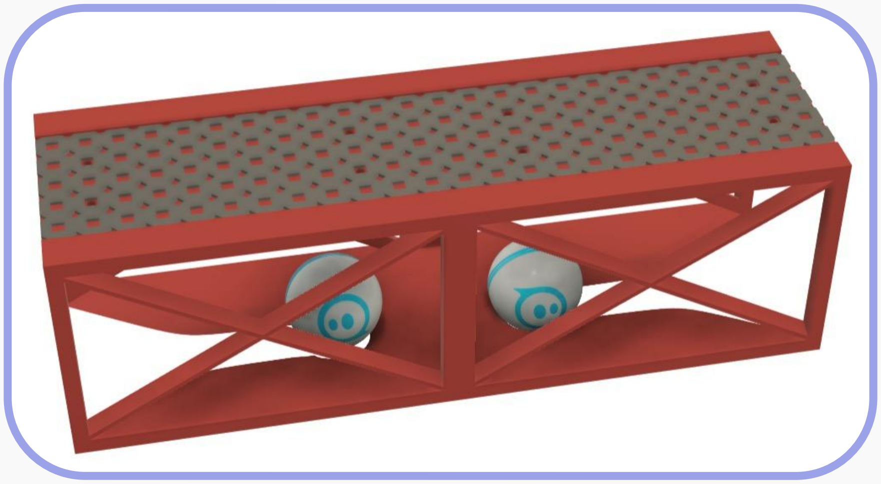
Unfortunately, this concept did not hold up to simulated strength testing. We determined that it needed more supports to be viable, as well as removing the netting due to it affecting the ability of the Spheros to enter

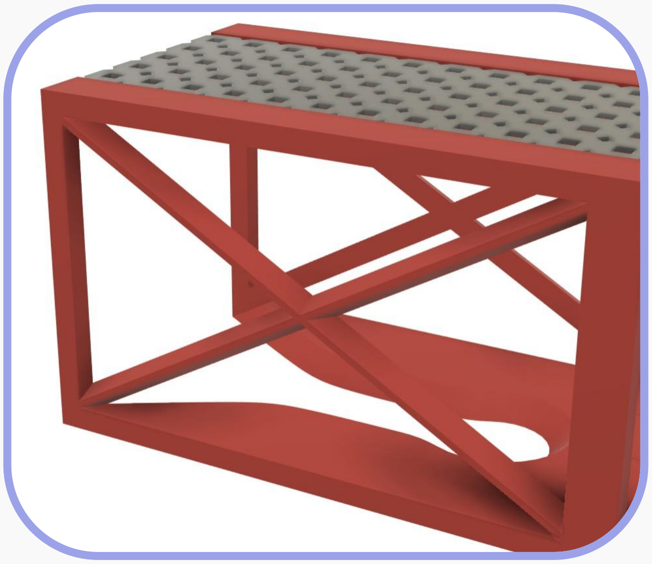
So we drew up a rough sketch of an overhauled model that could withstand whatever we could throw at it...



# Conex Boxes

## Final Design - Implementation





**And that takes us to our final Conex implementation...**

Our current Conex boxes have been a massive success. The optimized siding prevents the AVR from pushing the boxes around on the field, and the increased magnetic plate coverage makes picking up the boxes a breeze for the AVR. The RVR also synergizes with the upgraded Conex boxes, fixing edge cases related to ground transport.

# Mission Planning and Key Advantages Identified

# Predicted Score

**Our predicted score is:**
**121-129**

**Best points in terms of risk** (time loss) **vs reward are Conex deliveries, Vehicle and Conex return to starting area, and AVR thermal hot spot scanning**

**Least rewarding points are train yard switches and transformer paddle switches** (time-consuming and takes away from other objectives)

**Scanning:**

- Scan all thermal hot spots (2) - Can be done quickly and rewards 10 points for each hot spot
- Scan all AprilTags and IR beams (10) - Time efficient, 3 points per scan

**Positioning:**

- Immediately fly AVR to loading area in phase one
- Lineup with transformers before phase three
- RVR brings Conex boxes to the bridge ramp before phase three
- Spheros positioned by container yard and launch pad at all times

**Numbering:**

- We created a numbering system for all points on tracks, weld locations, and hotspots which were later implemented into the competition
- We all call out the numbers and colors as well as having a scribe write them down

# Key Advantages Identified

- **Proactively solve issues in the field**
- **Prioritize high-value points at low time-cost**
- **Utilize pilot's skill to complete challenges, as well as technical maneuvers to save the game**
- **Changed our mission plan based on new game times**
- **Prioritize phases two and three because of high point values but if time permits collect missed phase one points**
- **Able to work around technological failures and still be successful**
  - **Jetson failure** for an entire qualifying competition after a slight crash – **we maximized all other possible points**
  - **Dexi Failure** to run code in the middle of several competition rounds – **targeted any bugs in code and found an issue with DEXI firmware - solution devised if the problem should arise again**
  - **RVR** mechanism completely broke down in the field - **used AVR to take mechanism off the RVR, and utilized the natural pushing mechanism for the rest of the day**

# Future Improvement Plans & Lessons Learned

## In-Depth Mission Planning Can Help Reduce Problems Down The Line

- The issue with the weak electromagnet could have been entirely prevented if we had precisely calculated the maximum force that the Conex box would be under earlier
- In the future, we should be careful of recklessly buying components and precisely devise the specs that we need

## Be Mindful Of How Different Mechanisms Interact On The Field

- We failed to consider was how much the propwash of the AVR affected the Conex
- In the future, it's important to have multiple members consider how systems will interact on the field

## Do Not Over-Complicate Systems

- Our RVR suffered from over-complication, and it resulted in a lot of struggles when it came to troubleshooting and fixing errors
- In the future, we should approach simple problems with simple solutions in mind
- This is reflected in the RVR final design, but would have been a massive time saver if originally implemented

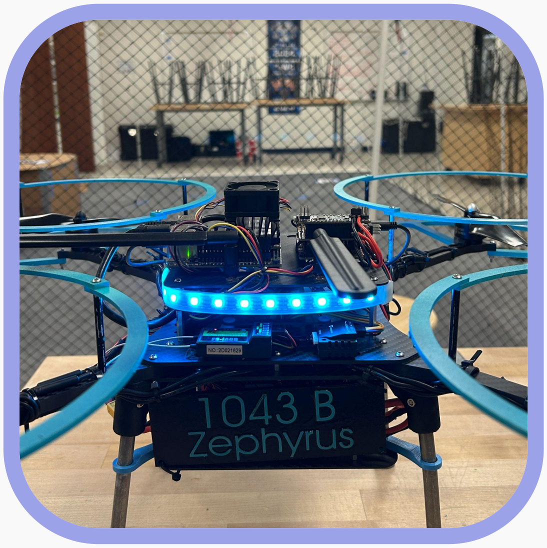
# Appendix

# Artistic Design Choices

## Sphero Construction Worker

The Sphero design was painted to imitate a construction worker. We felt that this fit the theme of "Infrastructure recovery" and the Spheros being called technicians added to how well the construction worker design fit.

## AVR Color Scheme




Our AVR has a jet black body with cyan accents, reflecting a windy & dark night sky. This color scheme is inspired by our team name, Zephyrus, the Greek God of West Wind.

# Artistic Design Choices

## T-Shirt Design

Highland Park Robotics logo on the front, so that both school teams match.


Our personal team logo of a hawk (that represents Zephyrus) is on the back of the shirt to separate us from other teams.

# Workshop Safety Processes

**General Meeting Safety Measures:**

- An adult coach was present during all meetings
- Sign-in sheets were used for attendance and making sure everyone is accounted for in case of emergency
- Fire extinguishers were readily available
- Students that were ill were encouraged to stay home, preventing the spread of sickness

**Lab Safety Protocols:**

- All team members follow lab safety guidelines, especially while using hand or power tools
- Safety glasses are mandatory while working with tools to prevent injuries

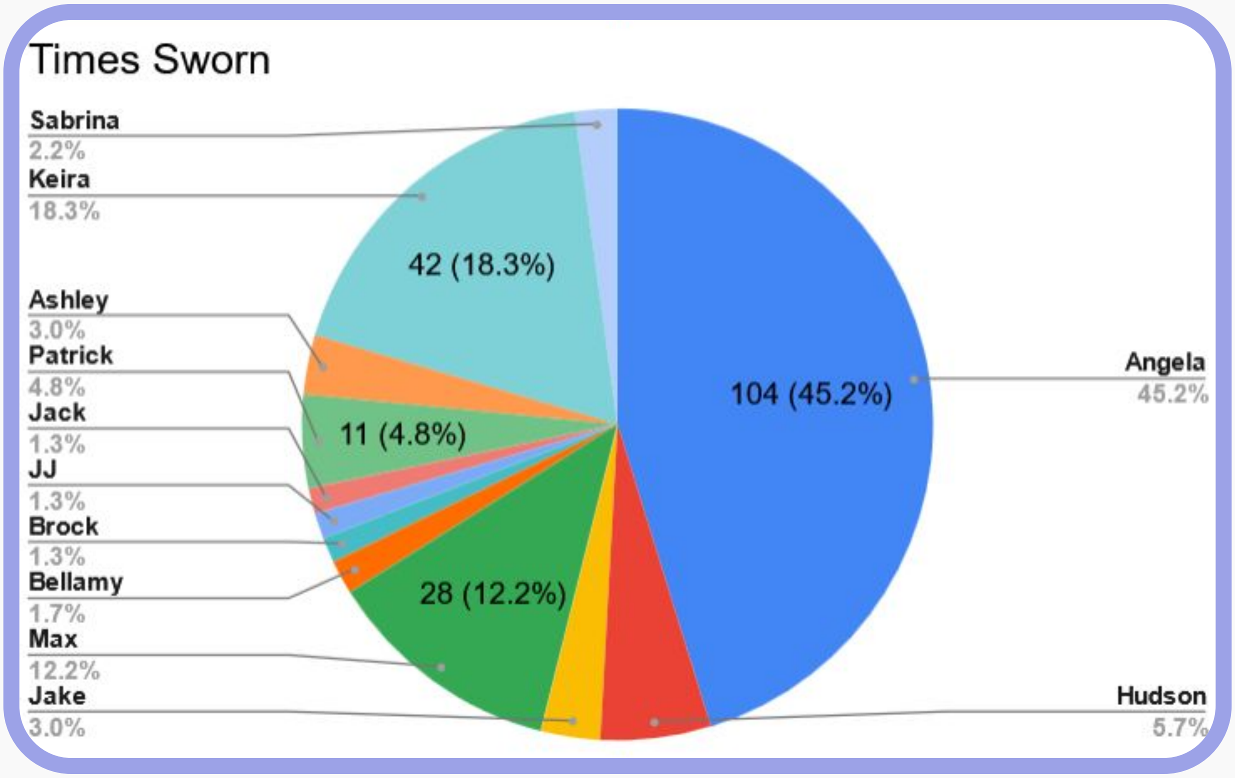
**Flight Safety Measures:**

- The drone is equipped with propeller guards to prevent accidents such as entanglement with the net or other obstacles on the practice field
- All pilots must train consistently to fly the drone
- Pilots must clear the flying zone and alert others of takeoff if needed before any drone controls are engaged

# Swear Jar

| Name | Times Sworn | Money Owed |
|---|---|---|
| Angela | 104 | $26.00 |
| Hudson | 13 | $3.25 |
| Jake | 7 | $1.75 |
| Max | 28 | $7.00 |
| Bellamy | 4 | $1.00 |
| Brock | 3 | $0.75 |
| JJ | 3 | $0.75 |
| Jack | 3 | $0.75 |
| Matt | 0 | $0.00 |
| Patrick | 11 | $2.75 |
| Ashley | 7 | $1.75 |
| Keira | 42 | $10.50 |
| Sabrina | 5 | $1.25 |
| Total | 230 | $57.50 |

- 25 cents per swear
- Created to encourage more conscious, thoughtful word choice & to build sportsmanship
- Will be used for an ice cream party at the end of the season
- Has helped with team bonding and synergy



# Journal Entries

**Week of 4/7/24**

- First meeting to discuss the new season
- We went over team roles and our individual strengths
- Discussed team name and planned future practice times
- Max ran the sandbox image as a container and connected his computers to the AVR GUI to the sandbox container

**Week of 5/12/24**

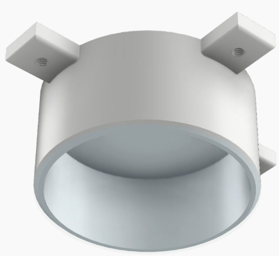
- Our AVR Drone can detect AprilTags successfully and flash the LED ring upon detection
- AVR: repaired props, removed last years equipment, replaced a few wires, is now fully assembled
- Big code changes have been made to auton
- Max added functions in the sandbox to assist with auton

**Week of 5/19/24**

- Rudimentary Auton achieved

**Week of 8/18/24**

- First electromagnet mount was designed
- Improved Auton by adding a objscanner model



**Week of 8/25/24**

- Started RVR Code
- Experimented with Sphero ramp on Conex boxes
- Started presentation
- Started assembling DEXI

**Week of 9/1/24**

- DEXI fully assembled
- Started developing first RVR mechanism (gear driven)
- Started working on team logo
- Organized internal drone wiring

# Journal Entries

**Week of 9/8/24**

- Brainstormed electromagnet power method by using a MOSFET

**Week of 9/15/24**

- Tested our electromagnet
- Tested autonomous flight
- Finalized RVR lifting mechanism
- Fixed issues with DEXI parts

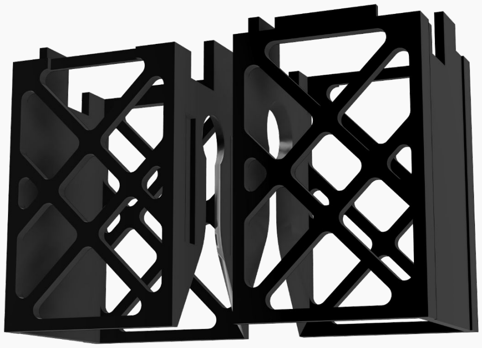
**Week of 9/22/24**

- More DEXI part fixes
- Improved Conex boxes, they are lighter and more easily secure spheros
- Installed our 5 volt electromagnet

Our five volt electromagnet

- Began designing stronger landing mounts
- Began DEXI program

New lightweight Conex boxes with slot to hold Spheros secure



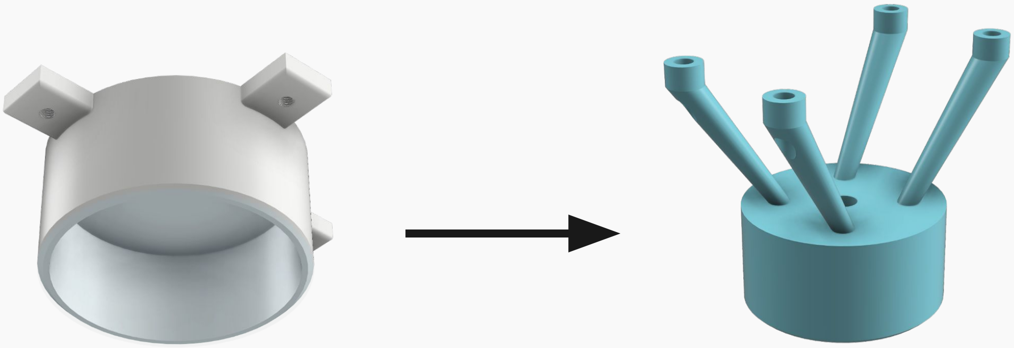
# Journal Entries

**Week of 9/29/24**

- Started designing artistic elements

Our original Sphero concept drawings

- Redesigned Magnet Mount



Old magnet Mount

New Magnet Mount

- Wrote code to scan hotspots in phase three
- Mounted FPV and Thermal Camera on DEXI

**Week of 10/6/24**

- Continued Auton Testing
- Installed new landing mounts

**Week of 10/13/24**

- Designed stronger mounts and landing gear to reduce breaking
- RVR auton is taking shape

# Journal Entries

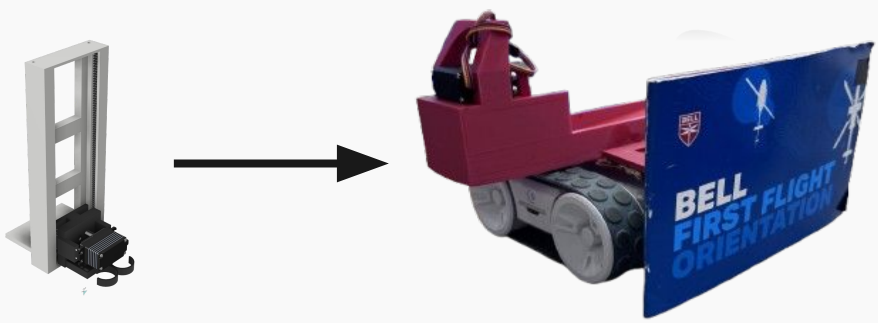
**Week of 10/20/24**

- DEXI will flash lights when IR beams are detected now
- Installed new carbon fiber leg mounts
- Began developing a way to wirelessly control RVR mount
- Found issues in our PI CM4 chip
- Achieved wireless control of electromagnet

New landing leg mounts

**Week of 10/27/24**

- Finalized presentation and notebook for first comp
- Began redesigning RVR mechanism due to mobility issues




- Improved CONEX boxes with magnets on bottom and metal plates on top

Conex boxes with metal plates and magnets for stacking and graffiti for enhanced aesthetics

# Journal Entries

**Week of 11/3/24**

- Auton has been deemed too unreliable for the competition
- Redesigned the magnet mount to make grabbing Conex boxes easier

Electromagnet mount redesign

**Week of 11/10/24**

- Due to inconsistency we have redesigned the RVR once again
- Finalising presentation and notebook
- New 12 volt magnet arrived, we installed and tested it

New 12 volt electromagnet

- Designed new magnet mount to use with the new magnet

Optimized magnet mount for 12 volt magnet

# Journal Entries

**Week of 11/17/24**

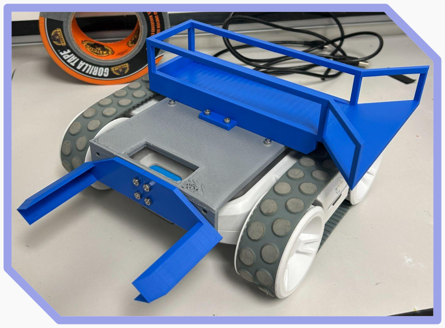
- Made our drones non-WiFi dependent
- DEXI debugging

**Week of 11/24/24**

- Continued to debug DEXI

**Week of 12/1/24**

- Finalized RVR mount and pusher



Final RVR design

- Finalized CONEX boxes

Final CONEX box design

- Added new features to DEXI like automatic laser firing, integrated new timing, timer from infrared scan replaced with one AprilTag scan opportunity

# Engineering Notebook

ZEPHYRUS

1043B

**Cover Slide: Prioritize professional looks over "fun" looks.**

**Teamwork** (This section should be called **"Project and Engineering Management")**
☐ Did you identify team captains and subsystem leads? e.g., Team Captain, AVR lead, RVR lead, Sphero Lead, etc., and possibly hardware / software lead or chiefs.
☐ Did you assign responsibilities based on skillsets?
☐ Did you show a tier-based organization chart? Show a hierarchy.
☐ Did you show a task-based project management system? Even something as simple as a whiteboard / Kanban / Notion / Trello, etc.
☐ Did you identify major milestone dates (e.g., begin / complete brainstorming, begin / complete preliminary design, begin / complete critical design, complete production, begin testing)
☐ Did you use a Gantt chart?
☐ What were your communication channels? Slack? Discord?
☐ **Did you show evidence of all of these steps above using charts / tables / graphics / images?**
☐ **Are you using / saying the key words: "project management", "task management", "schedule management"**
Do not waste too much time introducing each other. 15 seconds to identify all members
**1-2 minutes**

**The next 3 sections should be your "System Design" section, and should be blended together**
**{**

**Design approach process**
☐ Did you use an Engineering Development Process? (e.g., Agile / Systems Engineering V/ basic engineering development process, PLTW process).
☐ Did you show evolution from research > brainstorming > concepts > down selection > preliminary design > final design > testing > revision / iterations?
☐ For your down selection, did you use a guided methodology? (e.g., decision matrix, scored rubric, etc.)
☐ Are you discussing that you went from hand sketches, and rapid prototypes (but low fidelity, such as cardboard) before going straight into 3D printing?
*It's a **bad thing** if judges see you jump straight into CAD and 3D printing without basic prototyping.*
☐ **Did you show evidence of all of these steps above using charts / tables / graphics / images?**
☐ **Are you using / saying the key words: "iteration", "conceptual design", "prototype design", "final design", "decision making"**

**Demonstrated engineering skills** (IGNORE BARE MINIMUM SKILLS: 3D printing, block coding, soldering, assembly, basic tool use)
☐ Are you show casing any unique engineering skills, besides the minimum skills listed above?
Examples below:
☐ Weight and balance / Center of Gravity analysis & optimization

- [ ] Rewriting basic code to improve performance / reliability
- [ ] Aerodynamics evaluation (AVR down wash, maximizing Conex “flow-through”)
- [ ] Specialized 3D printing / infill modification / unique features
- [ ] Methods to improve reliability (e.g., passive systems, reduction of reliance on 2.4 GHz Wi-Fi, fail safe, self-actuated systems)
- [ ] Materials analysis to support: crash resistance, ductility, etc. Use material science terms.
- [ ] Vibration attenuation (NOT the same as vibration compensation)
- [ ] Design for manufacturing (e.g., making parts printable)
- [ ] **Did you show evidence of all of these steps above using charts / tables / graphics / images?**
- [ ] **Are you using / saying the key words: "optimization", "improvement"**

**Demonstrated research and effort**

- [ ] What research did you perform? How did your research **influence** the design of your system?
- [ ] Consider: magnetic systems research, radio-frequency research, autonomy, material properties, flight dynamics / properties, 2 vs 3 bladed props
- [ ] Did you perform any engineering analysis? How did that **influence** your design?
- [ ] What future areas of research are you interested in to improve the performance of your team?
- [ ] What extra effort did you put in? (e.g., Max's autonomy code, extreme focus on weight reduction, passive systems, reduction of reliance on the 2.4 GHz frequency)
- [ ] What were the biggest challenges you wanted to mitigate the impacts of? (e.g., downwash, Wi-Fi un-reliability, small, netted area)
- [ ] **Are you using / saying the key words: "design influence", "research" , "analysis"**
- [ ] Do not just say you studied the game manual.

**4-5 minutes**

}

**Game winning strategy** (DO NOT regurgitate the game manual objectives). Recommend calling it "**Mission Planning & Strategy"** or something similar

- [ ] What is your predicted score?
- [ ] Discuss points optimization: which points have most reward with low risk? Which points have high risk low reward?
- [ ] Discuss flight plan / path plan for AVR, RVR and Sphero. Consider pre-positioning.
- [ ] Communication strategies? Are you implementing concise comms?
- [ ] How are you playing to your system’s strengths?
- [ ] Discuss changes to game strategy based on practice runs and competition runs.
- [ ] Did you analyze your own competition video? What were the top 3 failures?
- [ ] Optional: Any mitigation / plan B strategies? What do you do if your AVR fails? What to do if ___ fails? (Don’t spend too much time on this, but good for bonus points)
- [ ] **Did you show evidence of all of these steps above using charts / tables / graphics / images?**
- [ ] **Are you using / saying the key words: "flight plan", "mission plan", "de-briefing", "execution strategy", "strategy optimization", "feedback loop"**

**1-2 minutes**

**Lessons Learned** consider this your **"Future Improvement Plans & Lessons Learned"**

☐ (DO NOT discuss basic lessons learned (e.g., learned how to code / solder / 3D print, communicate, teamwork, management… everyone does this)
☐ What critical issues did you encounter with your drones? What was the issue, and *quickly* walk through a root cause analysis (Strongly recommend using: 5-WHYs, fishbone diagram, FMCEA, etc.)
☐ What repeated issues did you team continue to encounter? How will your team be ***proactive*** and not ***reactive*** in preventing these issues next year? Consider structural changes / checklists / management changes, inspection processes, better training, etc.
☐ Discuss areas for future optimization to drone.
☐ Do not use generic failure terms: "___ failed" or "___ broke" or "___ didn't work", "____ fried". Use detailed engineering language.
☐ Do not say your solution was to just "read the manual" or "check the forum". Use detailed engineering language
☐ **Did you show evidence of all of these steps above using charts / tables / graphics / images?**
☐ **Are you using / saying the key words: "proactive improvements", "structural improvement", "documented for future use", "root cause", "failure analysis"**

**Quality of presentation**

☐ Are we using a CLEAN presentation template that is not too busy, and looks professional.
- I recommend using a white background with color accents, rather than colored backgrounds.

☐ Do you have at least one meaningful graphic / chart / image / table per slide?
☐ Where possible, are you using GIFs / automatic videos in place of images? Picture worth a thousand words, video is worth a million.
☐ Are we handing props / vehicle components to the judges during the presentation for closer inspection?
☐ Are you well-rehearsed and well spoken?
☐ Are you hitting the 9-minute mark exactly?
☐ Are you responses to questions concise (**e.g., less than 1 minute**)?

**HINT:** If judges think you are missing in one area of your presentation, we are asking you questions to help YOU gain back points. If you can answer questions more concisely, and allow more time for MORE questions, than you are getting more points.

It's a good sign if the judges ask challenging questions - it means you hit all topics well, and are now farming for extra points.

☐ Are you using smooth / non-distracting / non-gimmicky slide transitions?
☐ Is your presentation downloaded in case Wi-Fi fails?
☐ Are you doing your best to cover as much meaningful content in a short amount of time?
☐ Are you removing things from your presentation that is considered average / what everyone else is doing?
☐ Are my bullet points concise? Are we avoiding paragraphs?
☐ Is your color scheme consistent?
☐ Using GPT to spell check and improve quality of bullet points?
☐ Are you prepared to defend your claims? Judges may call you out if you claim to do something but provided minimal evidence.

**Things Worth Ignoring / Spending minimal time on (allocate more time towards the important stuff)**

☐ Safety procedures
☐ Artistic design (besides T shirts)
☐ Community outreach (judges will look through books for this)
☐ Thank the judges after your presentation, not during (wasted time)

k Advice

1. Follow the same advice as the presentation, but a little more detail. Still **focus on graphics over text**. Judges cannot read every word, and rely on information graphics to convey story
    a. Notebook should be able to be skimmed through in 5 minutes, with key focus on engineering design.
2. Order it in the same order as your presentation. Don't follow Appendix C too closely. It's not that good
3. Add page dividers with tabs. Make sure judges can easily locate the engineering section, and that it is one spot, and not spread out.
4. Use GPT to help you write. It is an aid, not a crutch
5. Notebook scoring is ranked. Points that you earn denies points from other teams.
6. **Things that WILL earn you points:** everything in the presentation
7. **Things that honestly will not earn you points.**
    a. Safety section. Just provide the basics
    b. Meeting Minutes / Logs. Just provide the basics. Highlight takeaways at top of page, in **bold**. Put logs and meeting notes in the back.
    c. Artistic Elements. Put in the back of book.
    d. Team bios: Just provide the basics and team organization. Front of book with project management section.