Matthew **Brady**

M.S.E. Mechanical Engineering | B.S. Mechanical Engineering

The **details** are not the design, they **make** the design

– Charles Eames

Work

Amazon Robotics
North Reading, MA
Intern | Mechanical Engineer

Priority Designs
Columbus, OH
Co-op | Product Design Mechanical Engineer

Education

University of Pennsylvania
M.S.E. Mechanical Engineering
Graduated: May 2017

The Ohio State University
B.S. Mechanical Engineering
Graduated: June 2015

Skills

Digital

SolidWorks
Pro/E (Creo 2)
MATLAB, Python
HTML, CSS, Javascript, JQuery
KeyShot
Adobe Creative Suite

Physical

Mill, lathe, saws, hand and power tools
Haas CNC Lathe
3D Printing
Prototyping
Mechanism design
Plastic part design

Design and Test

Commercial Beverage Dispenser

Role: Electromechanical design and testing

Design & Development

The *Yonanas Classic* home fruit processing machine became a cult sensation because of its ability to turn frozen fruit into a delicious dessert reminiscent of soft serve ice cream. To capitalize on the Yo-craze, a ***commercial version*** of the Classic was developed so restaurants could make and sell Yonanas.

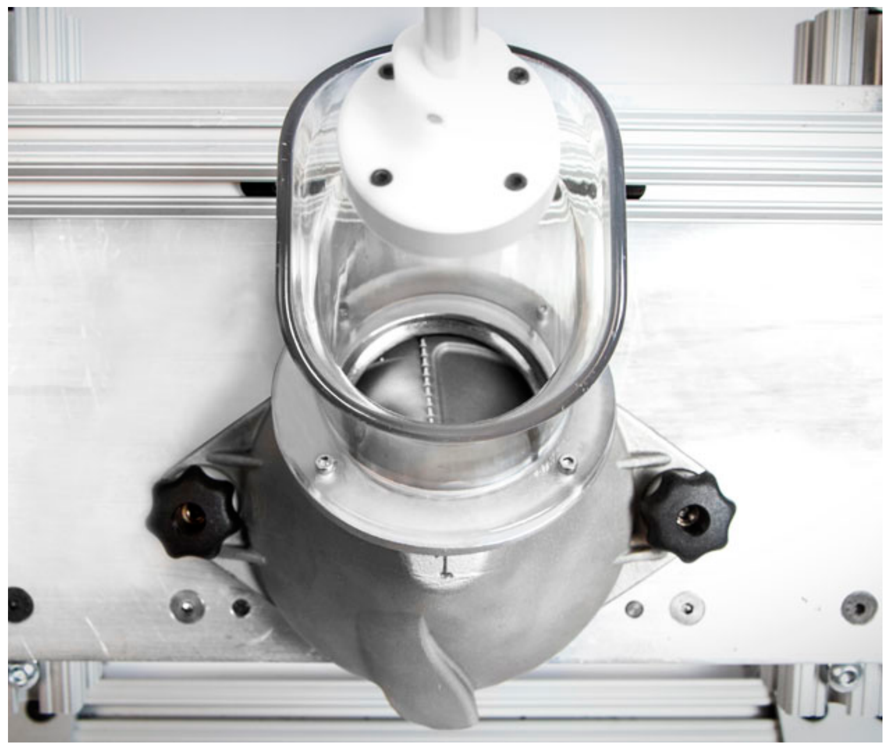
The heart of the Yonanas Classic machine is the ***cutter head***. Tiny teeth on the rotating head puree the frozen fruit to an icy pulp. To ensure consistent quality, the cutter head had to puree the frozen fruit just as finely as the Classic. Therefore, the cutter head was a logical place to start.

The first breadboard model, made of *80/20 extrusion* and *urethane cast parts*, tested a variety of different cutter heads — beginning with a metal plated version of the Classic's cutter head. Another observation from the breadboard prototype was that cleaning the cutter head was quite inconvenient. To solve this issue, a ***rinse station***, to accompany the mix station, was proposed.

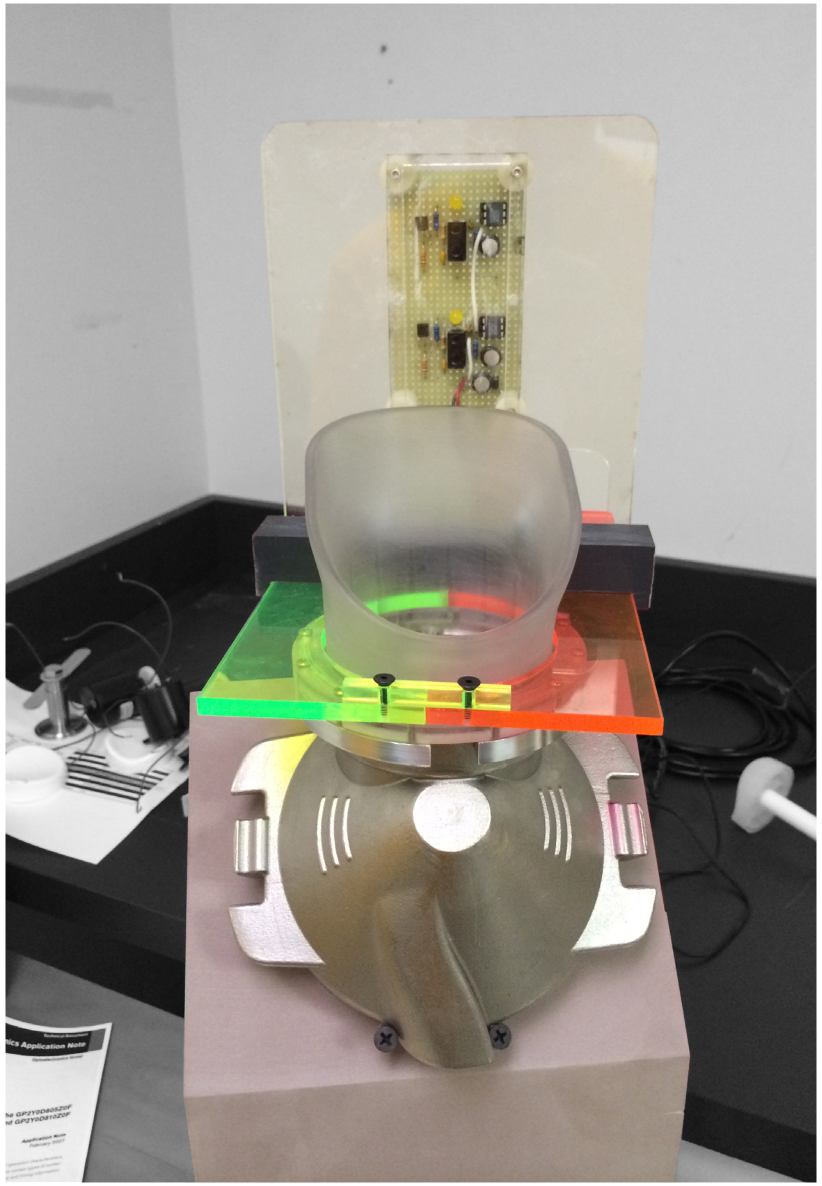
A second generation, full-scale prototype was then constructed using SLA, Objet, machined, and small run urethane cast parts. The second generation prototype was also a test buck for the electromechanical systems that would make it into the production machine.

To ensure longevity, I completed *extensive durability testing* on the P2 prototype. Additionally, the machine had to meet strict ***NSF*** and ***UL*** standards. This involved further development of all food zones so they were easily accessible and cleanable.

The production machine features *sand cast* cutter heads, *injection molded* fascia, and *extruded* aluminum side rails. Throughout the course of this project, I learned what it takes to bring an inkling of an idea to a fully tooled, production device.

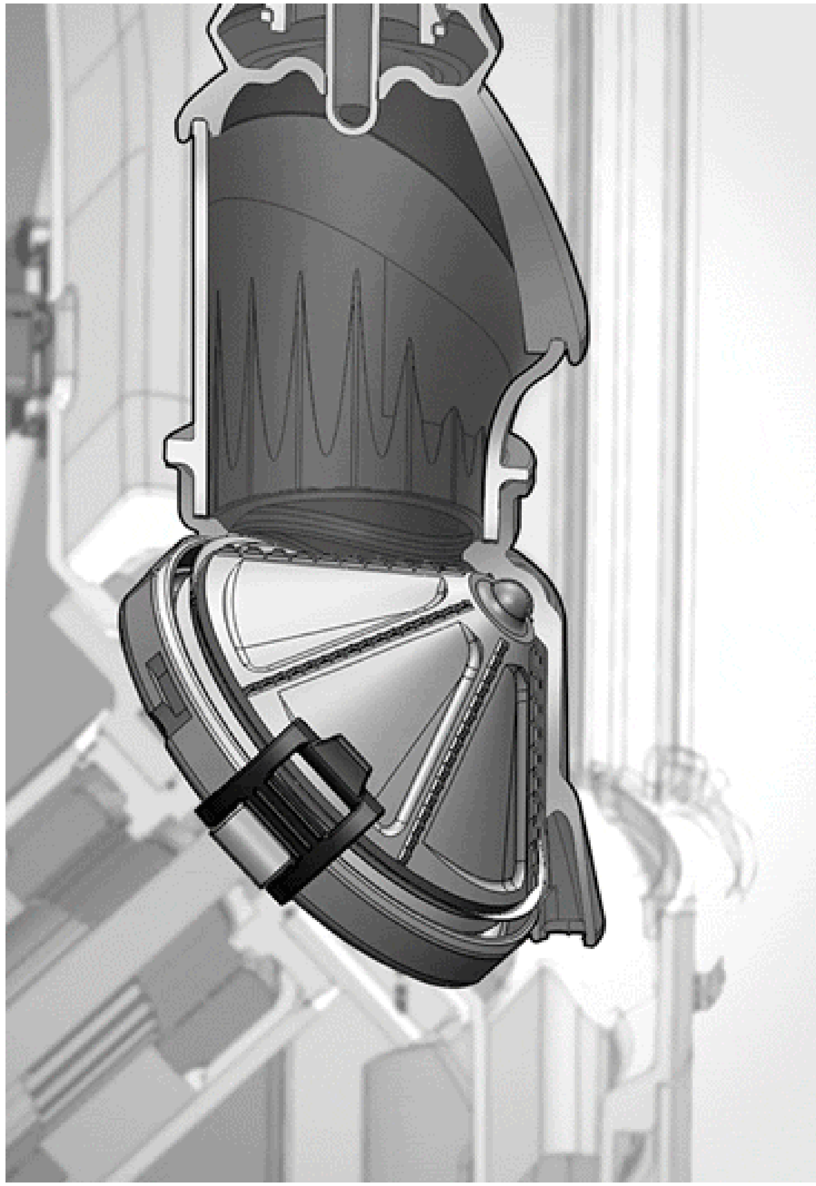


Testing & Verification



Testing and evaluating *IR beam sensors* on a jig I fabricated to determine ideal positioning and orientation to prevent ***fruit cartridge*** loading misalignments

My redesigned ***cutter head seal*** solved all problems related to fruit blowby, while *decreasing the friction* the motor had to overcome to spin the ***cutter head***



A cutaway reveals how water flows through the *rinse station* to clean the ***cutter head***

Hybrid Quadcopter

Gas-Electric Design & Fabrication

Role: Electromechanical design, prototyping, and machining

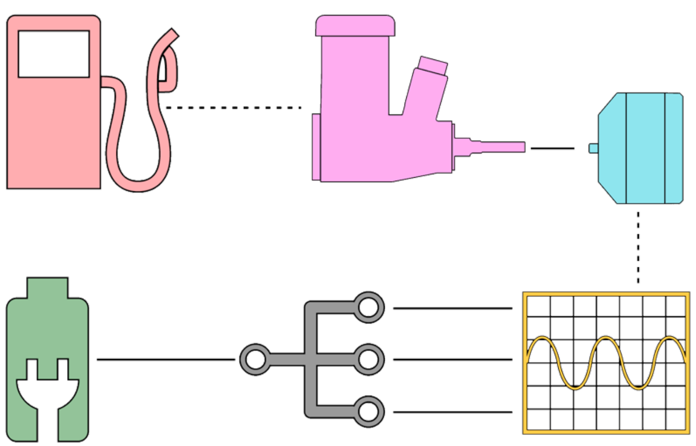
Initial Design

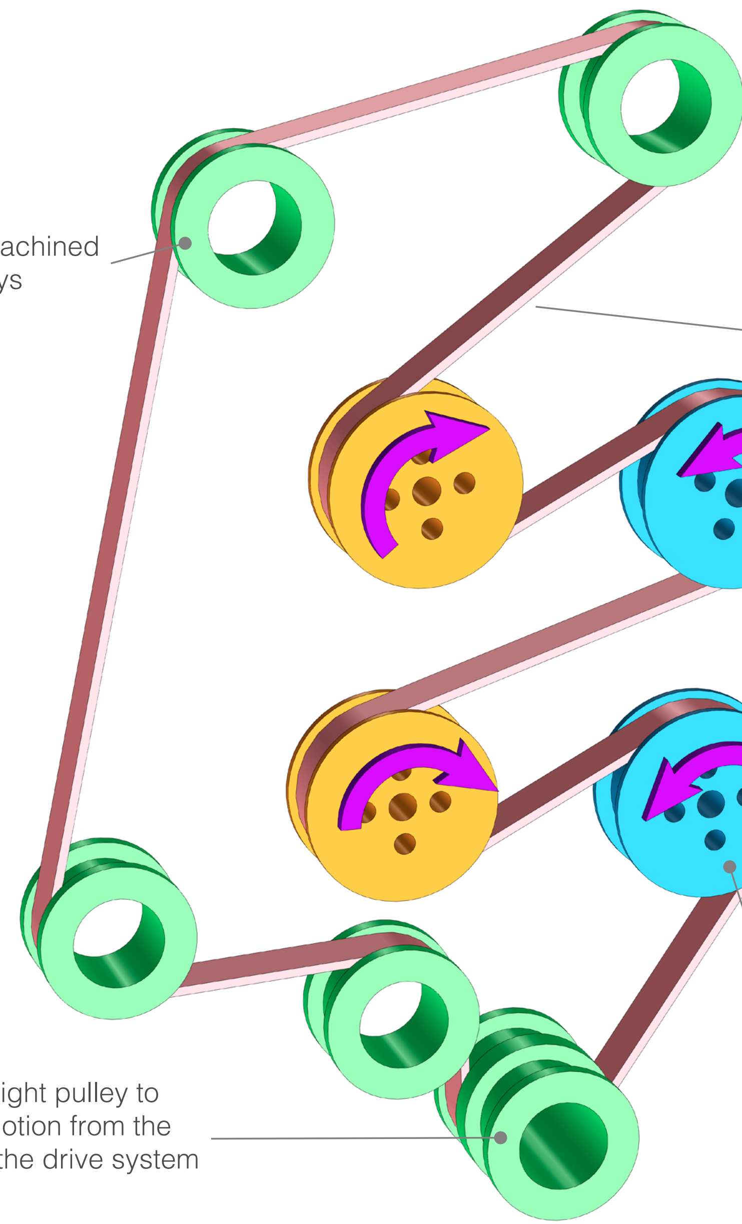
One of the biggest issues plaguing widespread commercialization of drones is that *flight times are often limited to around 30 minutes*. The problem this capstone design project aims to solve is the limited flight time afforded to quadcopters due to current battery technology.

The proposed solution entails using an ***internal combustion engine*** in tandem with a set of ***electric generators***, wherein the electric generators would recharge the battery mid-flight.

During operation, a generator would be spun by an engine. The generator would then be routed to either a ***charging circuit***, to charge the battery; or to a drive circuit, to provide power directly to the quadcopter to sustain power-consuming maneuvers.

A fundamental design constraint is that the hybrid drive system has to be ***modular*** so that it could be mounted on any large, pro-sumer or commercial quadcopter. This meant the unit would need to carry its own fuel, be self-contained, and manage power routing and generation.

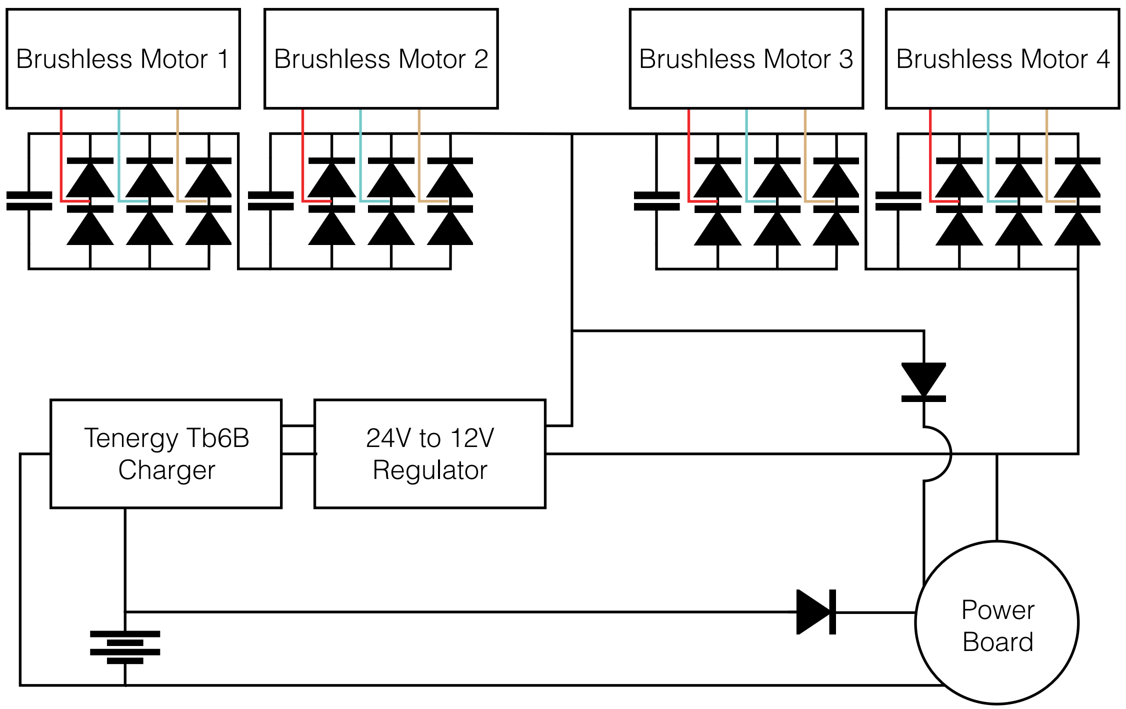


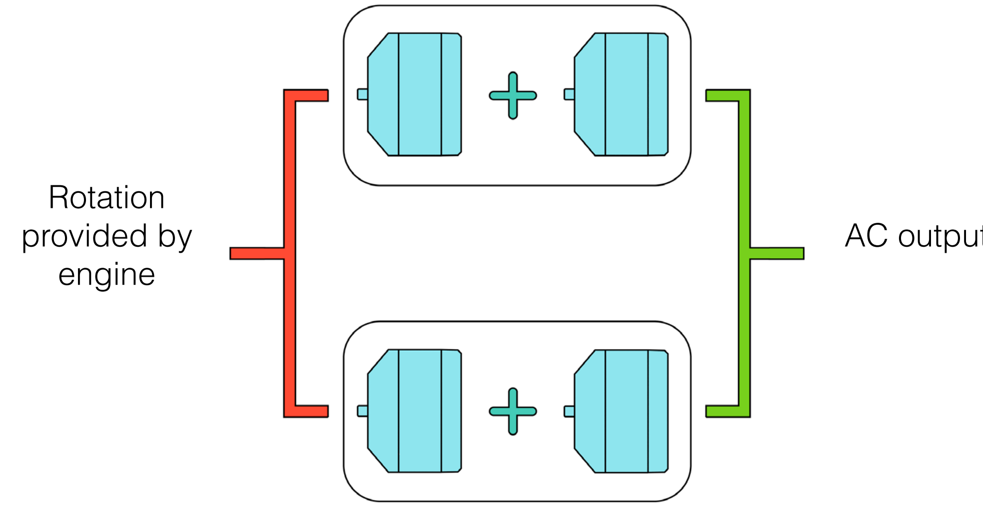


Electrical Design

Power management was the most challenging aspect of this project from an electrical standpoint. The battery was capable of outputting *8.5A at 24V* at any one moment. In order to deal with this, large *power diodes* were used in conjunction with transistor protective circuitry.

When the engine spun the generators, the power coming out of the brushless DC motors (3 phase AC) first needed to be transformed into usable DC. This was accomplished using four, ***custom three-phase rectifier circuits*** — one per generator. The resulting DC power was then used to both *power the quadcopter* and *recharge the batteries* during flight.



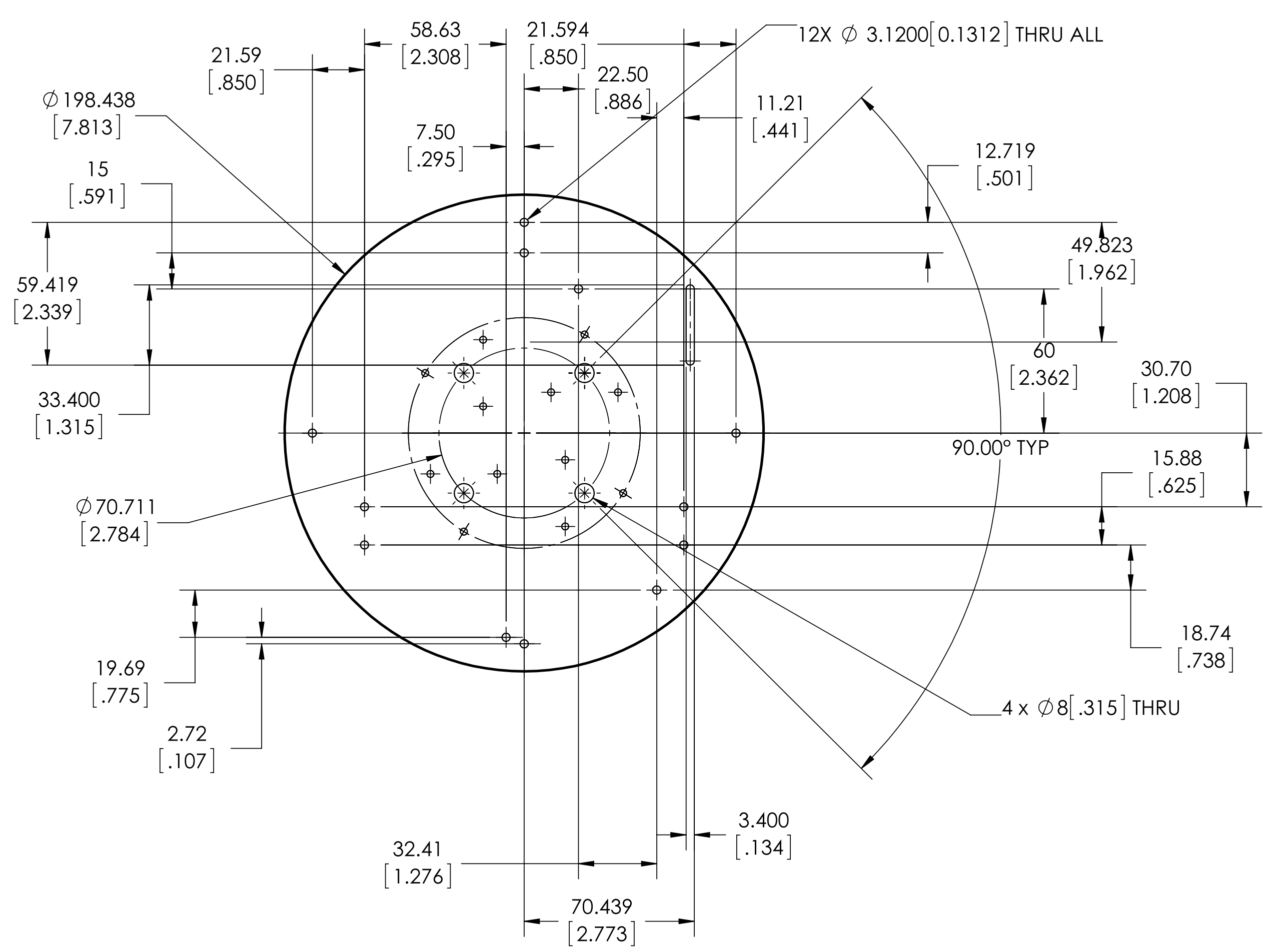


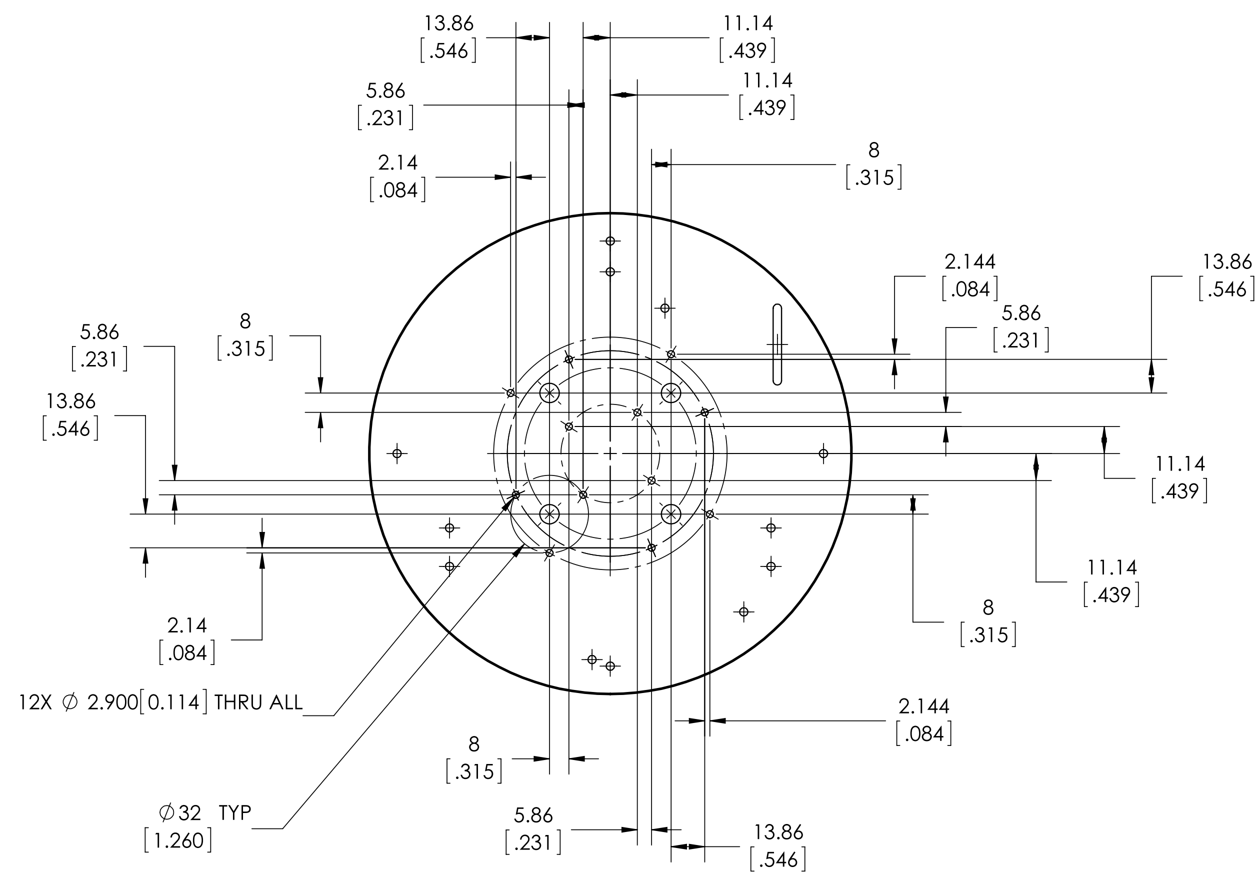
Determining the output signal from the generators was one of the first steps in designing the electrical aspects of the hybrid drive system. Spinning at approximately *2800 RPM*, a single generator produced a *no load voltage of 14.2*V_{pp}. Being ***brushless DC motors***, the output was an ***AC*** sine wave, which was then *rectified*. In order to guarantee at least 24V was being produced by the generators under hovering conditions (i.e. low current draw), ***two sets of generators***, in series, were placed in parallel, as shown above.

A *Teensy 3.1 microcontroller* was used to determine when and where power was directed. An *algorithm* was developed to determine the outgoing voltage from the battery and the requested voltage from the propeller-driving motors, through the electronic speed controller (ESC). The Teensy then directed the generated power as necessary. A ***solderable breadboard*** was constructed to allow the inputs to be connected or disconnected, mechanically, and tuned as necessary with potentiometers.

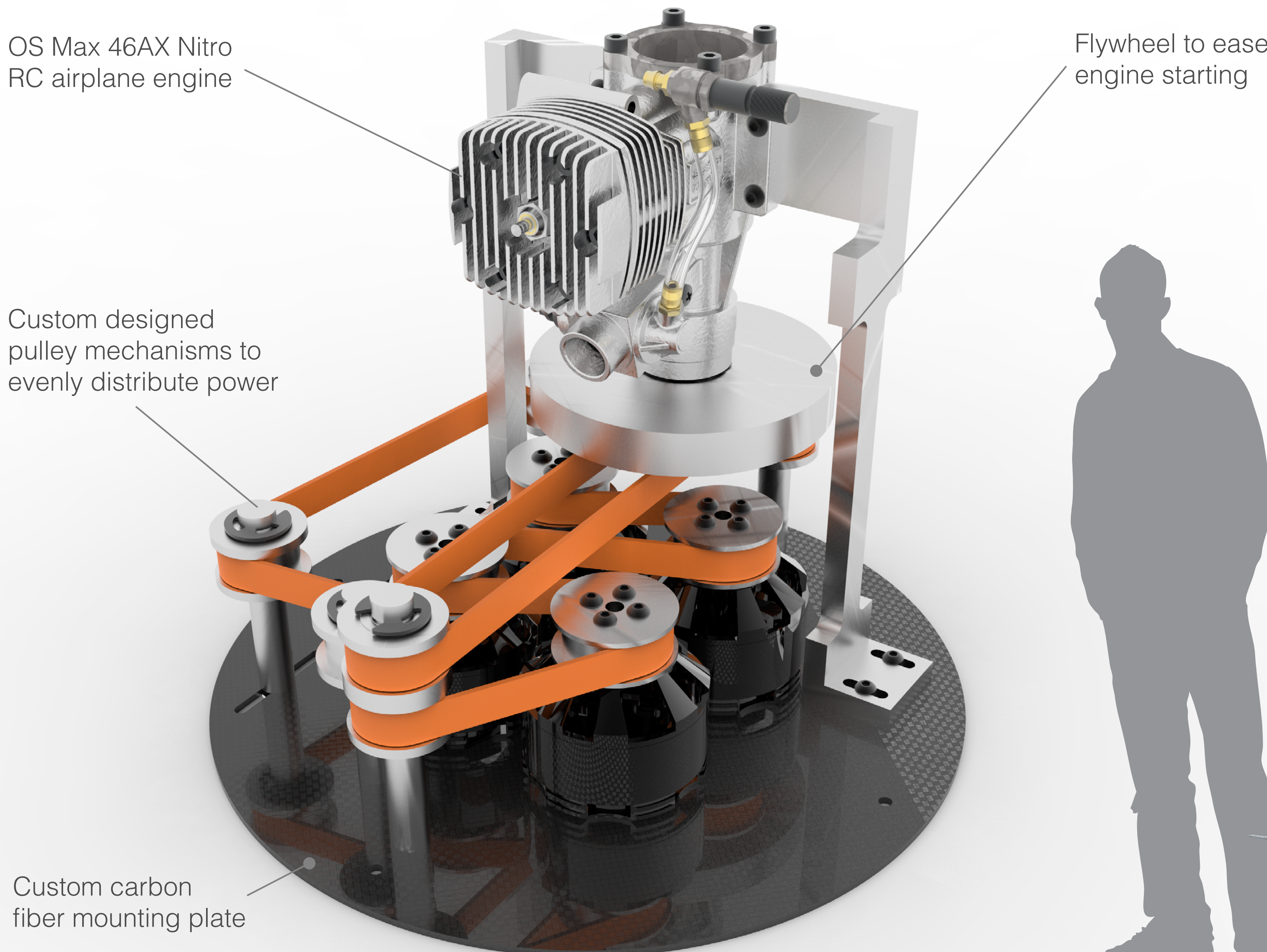
Drawings

One of the most complex components of the hybrid drive system was the ***main mounting plate***. To ensure proper pulley alignment, all holes and slots needed to be precisely placed and tolerances tightly controlled. To ensure the final result matched the design intent, the mounting plate was ***CNC machined*** out of a *carbon fiber* blank.



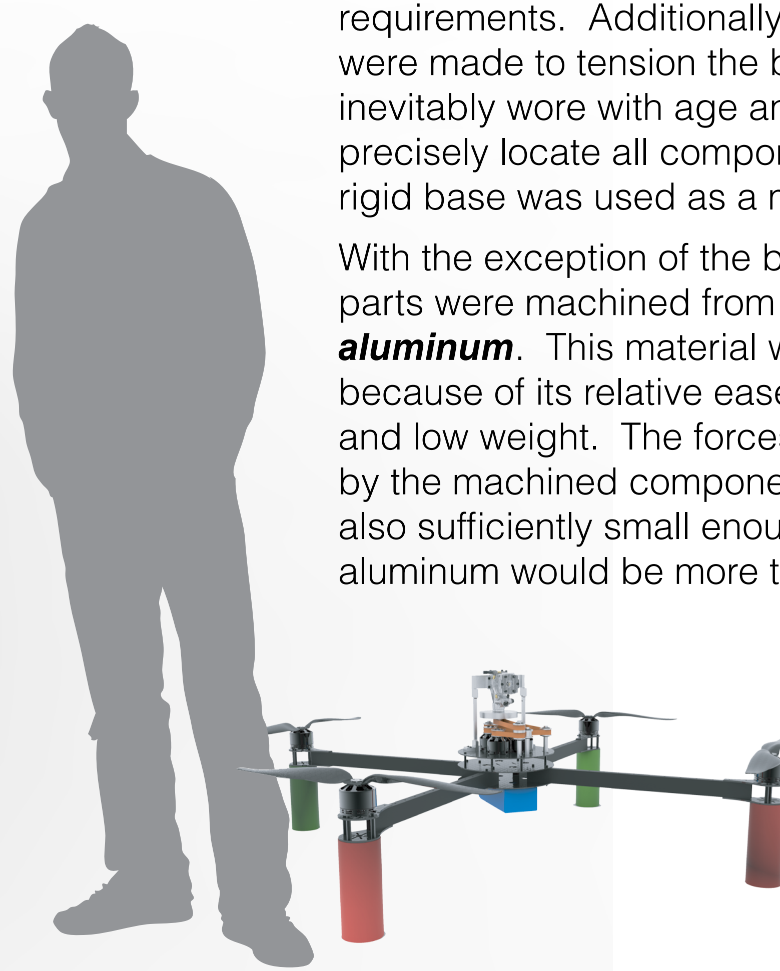


Hybrid Drive System

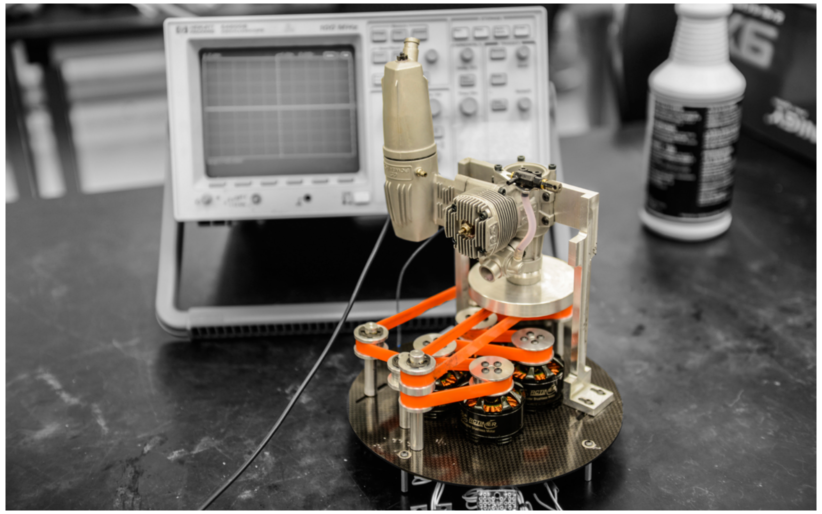


The final design utilized a custom designed ***belt drive system*** that transmitted the power from the engine to the *four generators*. The design took into account minimum belt wrap angles, belt slip, and torque transmission requirements. Additionally, affordances were made to tension the belt as it inevitably wore with age and use. To precisely locate all components, a single, rigid base was used as a mounting plate.

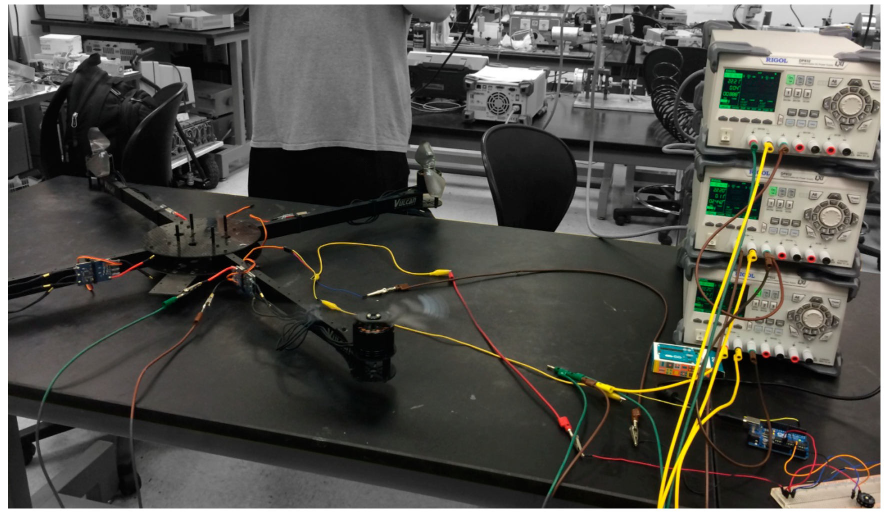
With the exception of the base, all custom parts were machined from billets of ***6061 aluminum***. This material was chosen because of its relative ease to machine and low weight. The forces experienced by the machined components were also sufficiently small enough that 6061 aluminum would be more than adequate



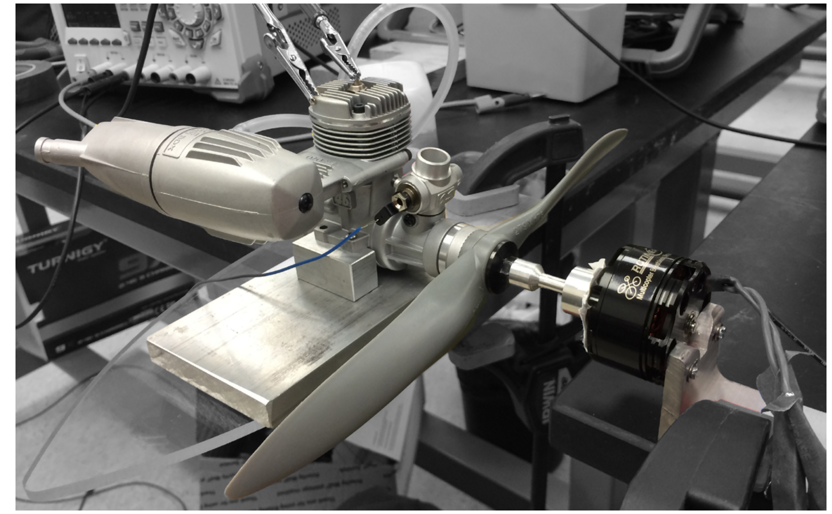
Prototype



The ***hybrid system*** features a *nitro engine* and four *brushless DC* motors acting as generators

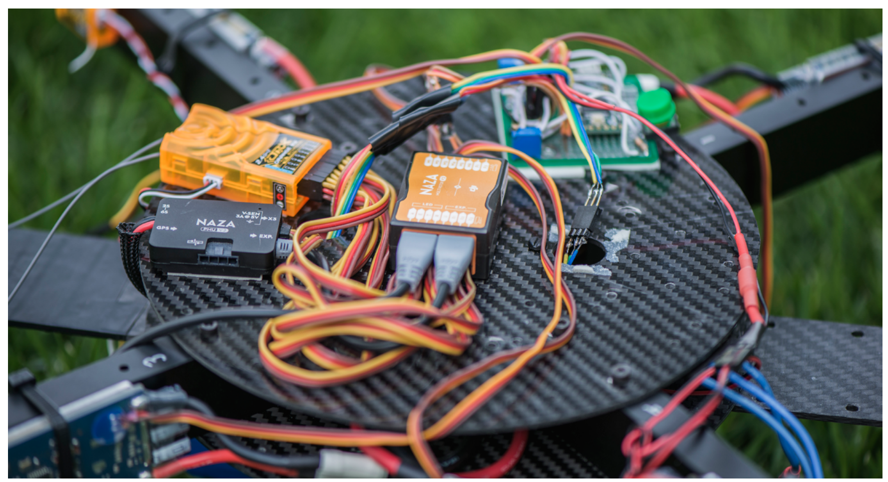


Bench testing the ***quadcopter*** to determine minimal current requirements



Testing and verification to determine maximum output voltage from a single generator, as spun by the ***engine*** directly

The *18" carbon fiber propellers*, capable of providing enough lift to carry the entire ***hybrid system***, with ease



Testing the ***quadcopter's*** electronics and evaluating the pro-totyped power management circuit

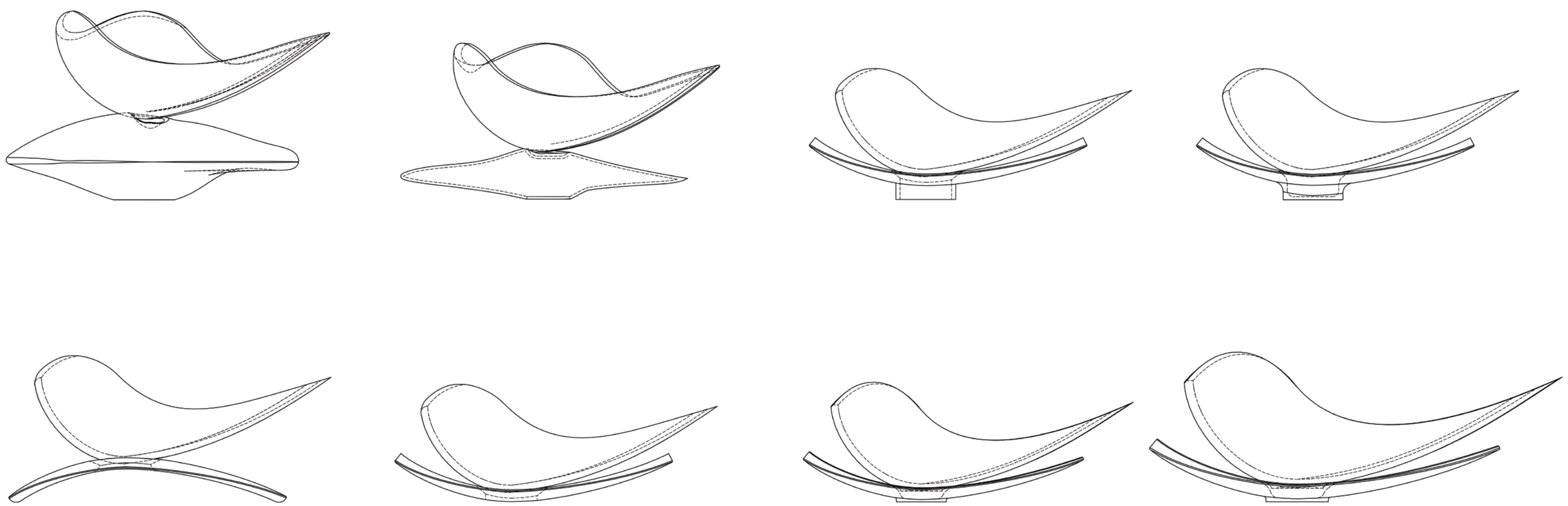
All systems go — testing the quadcopter in the mechanical engineering courtyard at *Ohio State*

Drop of Tea

Rethinking the Cup and Saucer

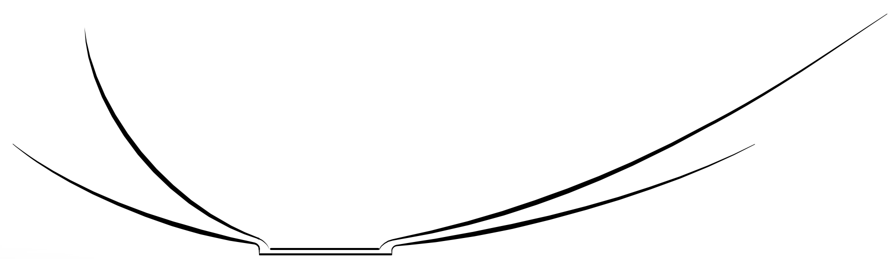
Role: Designer, prototyper

Process



Line drawings of the Drop of Tea cup upon various iterations of the saucer, leading to the final saucer design and scaling. The need to scale the cup and saucer came to light after ***3D printing*** a completed cup and saucer using a ***MakerBot Replicator***

Rendering of the final cup and saucer



Gestural drawing of the most significant lines that define the Drop of Tea ***cup*** and ***saucer***

The ***drop of tea cup*** draws inspiration from man's primal need to drink using his own two hands. The shape of the cup resembles the *hands being clasped* together, as if about to draw water from a natural source. A *vein* runs from the spout of the cup to its base - reminiscent of the seam generated between the hands. From a functional perspective, this feature creates a track where the user may place the string or chain of the tea bag or loose tea infuser.

The ***saucer*** is intended to venerate the cup. By using curves that taper to very fine edges, the saucer appears to fade away into the background, its profile distilled to nearly the *thinnest of lines*.

Both the cup and saucer meet the table in an equally delicate manner. Raised only *2mm from the surface*, the saucer's minute pedestal suggests instability. However, when the cup is filled with liquid and placed upon the saucer, the *center of mass is axially aligned* with the saucer's foot, the complete ensemble an almost ***serene balancing act***.

Interactive Blocks

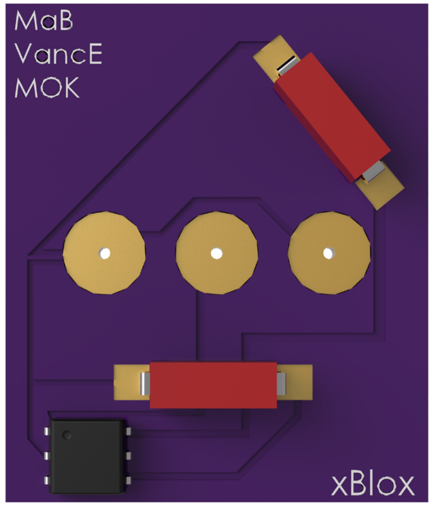
Electromechanical Toy Design

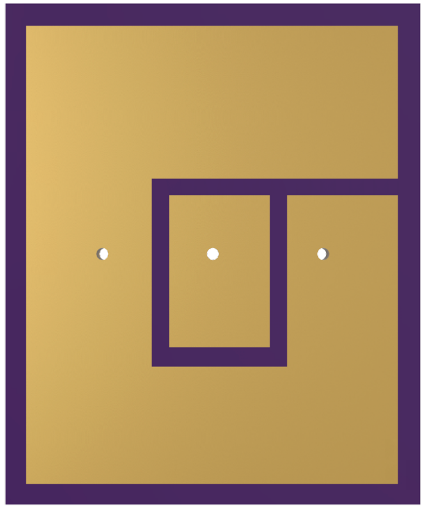
Role: Electromechanical design, engineering, and prototyping

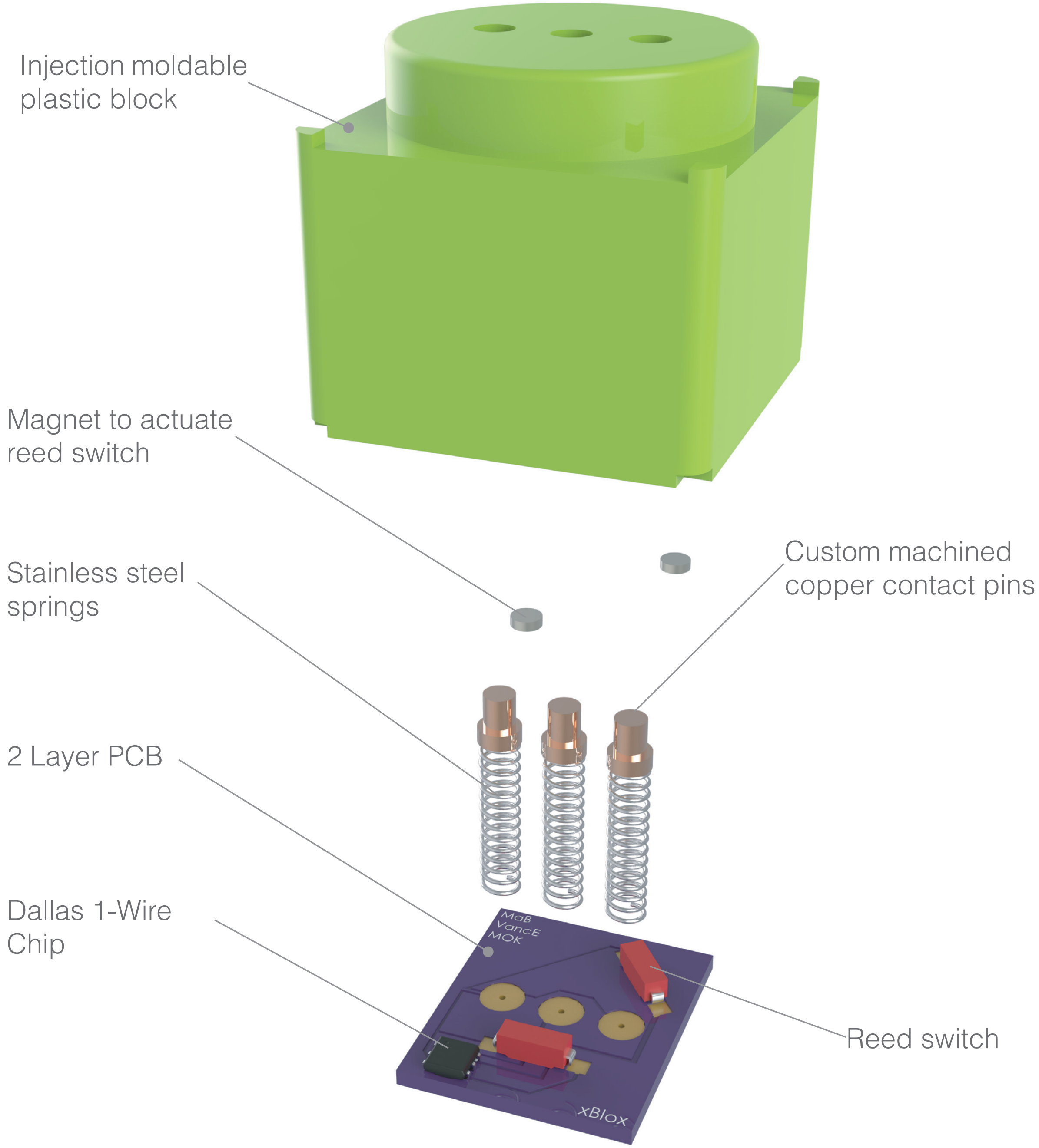
Details

During a child's formative years, developing motor skills is essential. It is also something that is disregarded when children become immersed in a virtual environment. However, what if the ***virtual environment came alive***, requiring physical interaction? Such is the goal this project aims to solve. By creating ***interactive building blocks***, children can interact with on-screen content and create physical realizations of virtual constructs.

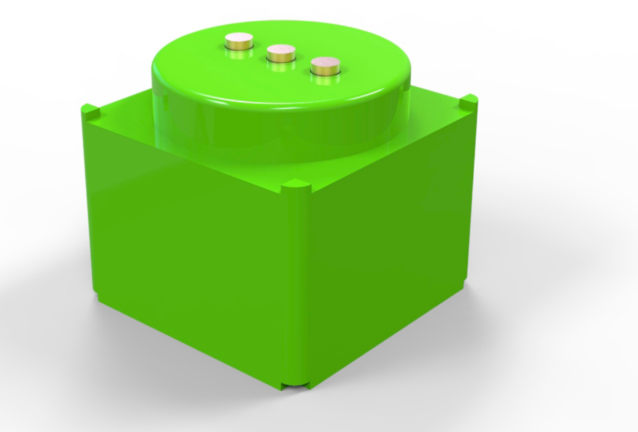
The foundational unit is the block itself. The base block consists of *five primary components* — a plastic housing, a set of copper pins, springs, and a PCB for control and data transmission. Leveraging the power of the *Dallas 1-Wire* chip, the blocks minimize component cost while maximizing versatility. As blocks are stacked upon each other, the chip recognizes that another block has been stacked and sends the new block's MAC address to the main control board (an ***Arduino Mega***). This data is then interpreted, via Serial, by the *Bluetooth* connected computer. Virtual blocks are placed on screen in the corresponding positions that the child has placed the physical blocks. The experience is not only engaging for the user, but a novel application of how a virtual world can be created using real, physical objects.



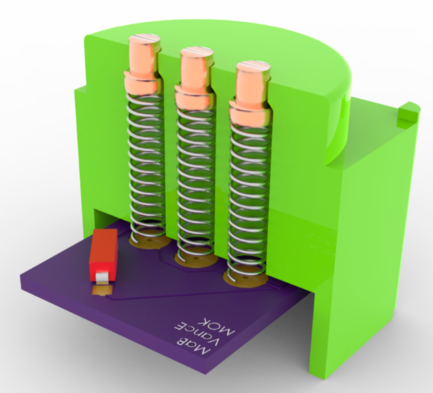




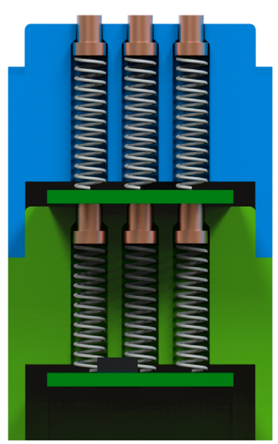
Prototype



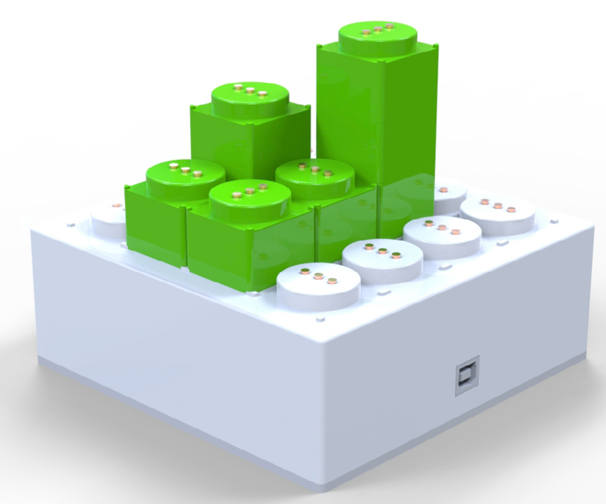
Cross section of a single block, showing how each pin functions as an *independent* unit



Single block, featuring three *independently sprung* pins



Double stacked blocks, showing the *interaction* between the *sprung pins* and the *conductive* base boards



Blocks attached to the *base block*

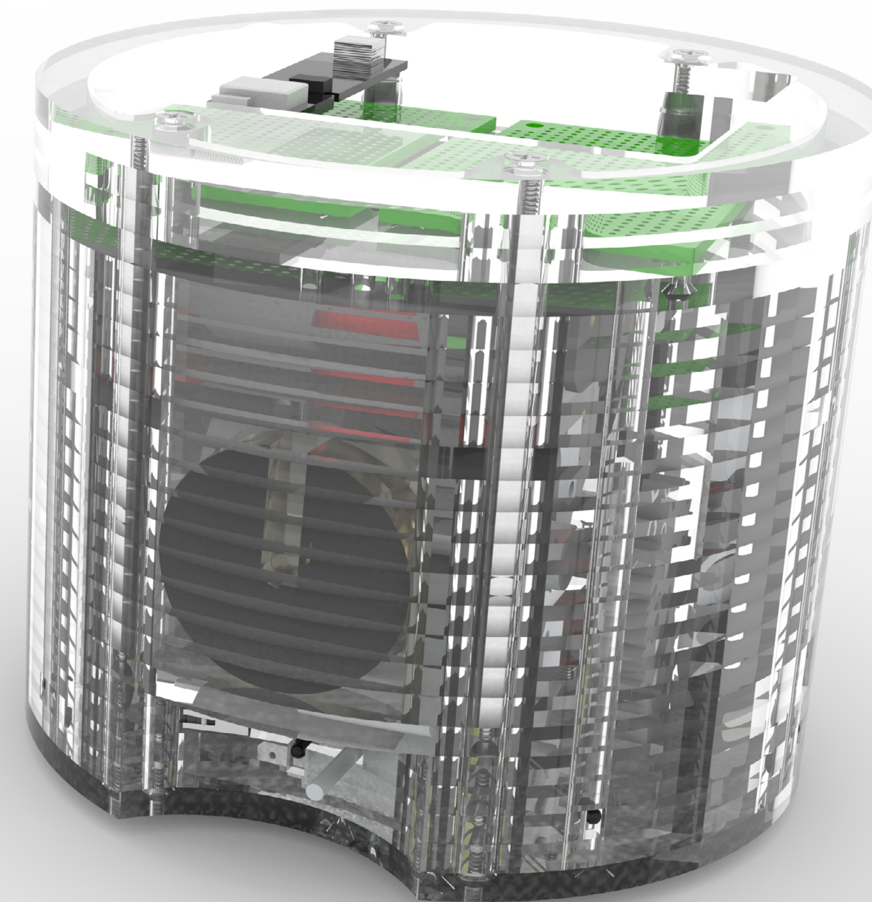
One of the biggest, and most important, components of the inter-block connections are the contact points. To ensure consistent contact is being made, and to eliminate manufacturing tolerance issues, each contact needed to be independently sprung.

To do this, I designed a ***custom copper pin*** and added tubes to the ***injection molded plastic housing***. Individual springs are then soldered to each copper pin to create a *spring-pin unit*.

The spring-pin unit is then soldered to pads on the PCB I created, solidifying the connection between the pin contacts and the contacts on the board itself.

Three pins were used to *balance forces* on the block placed on top. This eliminates the issues related to blocks separating from each other, or becoming tilted, as would occur if only two springs were used. Additionally, I raised the height of the outside cylinder by 50%, further increasing the *frictional engagement* between stacked blocks, which is the primary holding force.

Through a series of 3D printed ***MakerBot*** and ***Objet*** prototypes, the final design was realized. Not only is the final product *fully manufacturable*, but it is robust and consistent, all key metrics when designing a mass-market product such as this.



Robockey

Autonomous Robots Playing Hockey

Role: Mechanical design, programming, fabrication, and machining

The Challenge

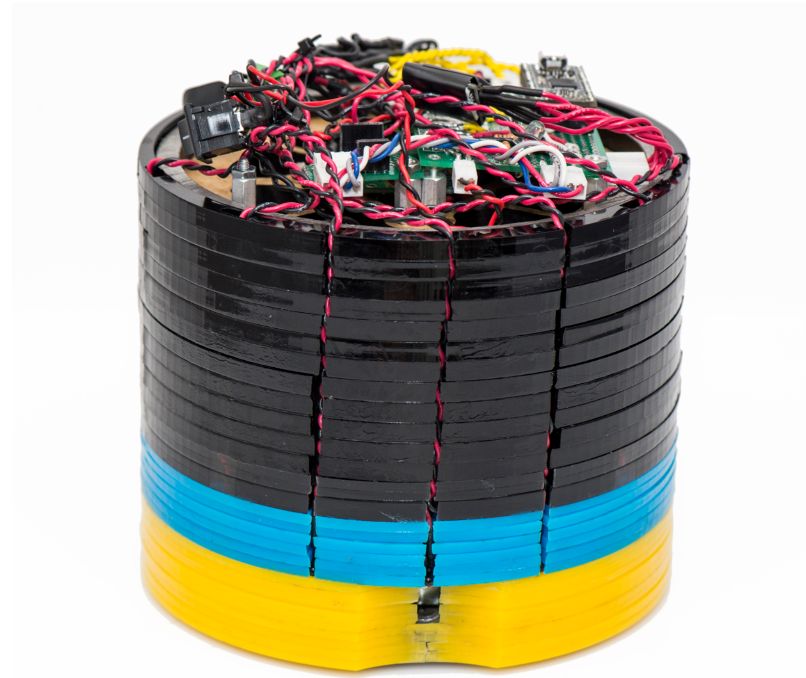
The Robockey tournament is the culminating project in the semester long *mechatronics* class. Consisting of 33 teams of three to four people, each team is tasked with building three **fully autonomous** robots that play hockey. Each robot is driven with the Maevarm M2 microcontroller and localized using a Wii-mote camera. Additionally, *WiFi* is used to communicate between robots, and with the game-master.

Strategy is developed very on in the design process. My team chose to build *three unique robots*, each with a specifically designed capability. One robot would be tasked with traversing the rink at blazing fast speed, another would be strong enough to withstand enemy collisions, and the final bot would be capable of lateral movement at the defensive goal.

Additionally, in doing research into previous competitions, it became apparent that **stronger**, **better built** robots would be able to better withstand the perils of the tournament. In years past, many teams would have plastic robots with wires hanging off of their robots and components not fastened down. This appeared to lead to some teams' downfall.

Rules and research in hand, the design and engineering began. All engineering choices were made to best suit each robot's intended application, while keeping durability paramount.

The Team



Attacker

The **attacker**, the offensive player on the Robockey team, is made primarily of acrylic and is designed to be *quick and nimble*. It features two puck slots, making it capable of firing the puck from two sides and reducing the amount of time spent turning around to face the puck. Each puck slot has a ***solenoid*** embedded in it. The solenoid is used to fire the puck towards the goal. Goals scored through shooting are worth two points, so the ability to shoot the puck would be an immense advantage over most of the competition. To "see" the puck, the attacker has ***eight infrared phototransistors*** positioned around its base. The puck is then tracked according to which phototransistor is conducting most. Finally, four 18650 *lithium ion* batteries are used to power the *12V DC motors* driving each wheel

Goalie

To protect the goal, every successful Robockey team needs a net minder. The **goalie** is designed to be flat on the back side with wheels that go left to right, as opposed to front to back. This allows the goalie to sit directly against the flat front of the goal and *drive side to side*, minimizing the chance that it could get out of position. The goalie also has ***three phototransistors***, helping it to see the puck at a very wide angle and slide side to side in front of the goal as necessary. The goalie is also *weighed down* with 24 50g weights, making it a force to be reckoned with when other teams attempt to stuff the puck into the goal. In order to make quick changes to the form of the goalie, ***laser cut MDF*** is used for its body. MDF is used because it is much less brittle than acrylic, making it better at absorbing the rough contact that is characteristic of Robockey matches.

Enforcer

The **enforcer** is designed to push opponents out of the way and clear the puck from the defensive zone — both important traits in any Robockey match. Built around a solid, 1/4 inch thick, 5-1/2 inch diameter, ***steel cylinder,*** this bot is the muscle on the team. A 3/8 inch thick steel plate is *machined* and *welded* to the base of the cylinder, to ensure components are *precisely* aligned and accurately placed.
In addition to its solid construction, the enforcer has ***seven phototransistors*** around its base and a ***solenoid*** to fire the puck. To disguise the steel tube from the competition, ***laser cut acrylic*** rings are press fit around the outside of the cylinder. These rings also act as a housing for the phototransistors.

Thank You

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