Los Altos Academy of Engineering

Energy Invitational Design Brief

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1. Introduction

The Los Altos Academy of Engineering (LAAE) is excited to participate in its second Energy Invitational Competition. Previous competitions we have partaken in include the Metropolitan Water District's Solar Cup and UCI Energy Invitational. Our objective with this competition is to gain experience that allows us to grow as a team and present a new project that represents our academy.

With our program returning from quarantine, most of the students had little to no experience with the equipment our academy offered. We had to be rebuilt, going back to the foundation with learning how to use basic engineering tools. In our second year back, LAAE decided to take another step by participating in a new competition. This would help the students learn how to create a project that meets certain requirements and deadlines. As the first semester progressed, our team bounced between different races until we finally committed to the Energy Invitational at the beginning of December.

In the process of designing and building our vehicle Spectre, the team faced many challenges. Students were not familiar with working on the machines and lacked the experience to work as an efficient team. In addition, our only licensed driver has a large stature, forcing us to cut valuable weight off our vehicle. However, the teams developed effective communication with one another as they began to understand the roles they played in this project.

Despite our inexperience and struggles, the academy has learned to persevere and find new innovative ways to overcome each challenge. United by a common mission, we want to dedicate all our efforts and hard work in hopes to present a vehicle that we are proud of, and ultimately, offer our incoming members the same opportunity.

2. Faculty and College Mentor Advisor(s)

Our faculty advisor for the Energy Invitational Competition is Edward Richter. Mr. Richter has been the instructor for LAAE since 2008. He has a bachelor degree in Literature at American University, Washington D.C. and teaching credentials from California State University, Los Angeles. Richter also has a master's degree in Curriculum and Instruction with an emphasis in STEAM from Concordia University, in Portland, Oregon.

Throughout Mr. Richter's role as an advisor, he has led multiple teams through different robotics challenges and electric competitions. During his years as the academy's instructor, some of his former students work for companies such as SpaceX, Boeing, and Raytheon. Last semester, Mr. Richter encouraged our Information Technology (I.T.) team to participate in the Congressional App Challenge in 2022. One of the teams who competed in the competition won the "Best Team App Award" out of 192 applicants in the 39th Congressional District.

3. Industry Advisor

Our industry advisor is Erik Muñoz. He is an alumni that was a member of the Los Altos Academy of Engineering. He is currently working as a Union HVAC technician supervisor. Once a month, Muñoz visits our program during his free time to give the mechanical team tips to efficiently build Spectre. As an important individual to our academy, Muñoz helps the teams make sure that all safety inspections are met and explains the process of building and using a welding TIG. With his help, our mechanical team was also able to construct the roll bar in a short amount of time. Muñoz's advice has improved the teams' ability to productively complete projects on time, granting valuable information that greatly benefited the mechanical team.

4. Schedule of Meetings With Advisors and Mentors

Due to our late application into the competition, we did not have a dedicated industry advisor that we could schedule meetings with. Our industry advisor for the competition, Erik Muñoz, came into the engineering shop whenever he had free time. His busy schedule and our limited days of staying late after school negatively affected our ability to schedule advisory meetings. Fortunately, we were able to have Muñoz visit once a month to help us resolve certain mechanical problems that we had and assist in using new equipment.

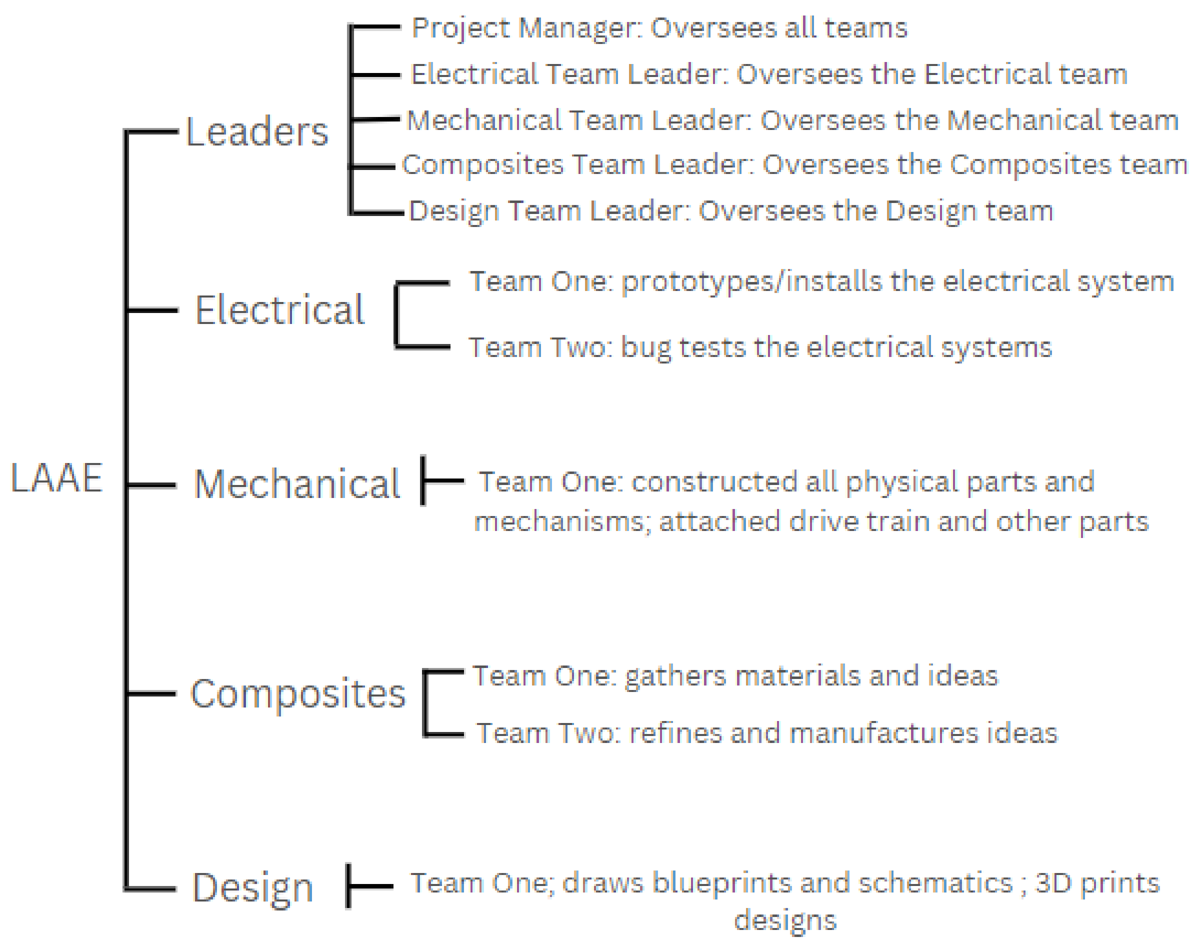
5. Team Members/ Titles/ Assignments

Members	**Titles**	**Assignments**
Regina Azcorra	Electrical Member	Assembled high current wires
Owen Beals	Driver/ Electrical Member	Oversaw the car brake light and car horn system
Presley Campbell	Electrical Member	Made the mount for the horn switch
Alejandro Chico	Electrical Team Leader	Oversaw electrical projects and filmed video segments for the design video
Alejandro Contreras	Electrical Member	Researched new batteries used in the car
Elias Cuevas	Writer/ Electrical Member	Assisted in writing the electrical segment of the design brief.
Anastasia Mechekoff	Electrical Member	Reprogrammed Alltrax and built car wire
Alejandro Mejia	Electrical Team Leader	Oversaw electrical projects and research
Andrew Ore	Writer/ Electrical Member	Assisted in writing the electrical segment of the design brief

Gavin Sandoval	Electrical Member	Helped create wires for the car and edited the design video
Alison Guan	Writer/ I.T. Team Leader	Wrote about our advisors, the design process, and refined the report
Francisco Flores	Writer/ Mechanical Team Leader	Helped assemble the car and wrote the mechanical segment of the design brief
Samantha Sandovol	Project Manager	Made sure everyone was on track
Kevin Guan	Mechanical Member	Assisted in welding the roll bar to the seat
Ruben Seawright	Mechanical Member	Worked on all aspects of the car
Alyna Huerta	Mechanical Member	Worked on mechanisms and welding involved for the car
Julie Loiacano	Composites Team Leader	Made a battery box
Itzak Diaz	Composites Member	Cut the body of the car
Nathan Rodriguez	Composites Member	Relocated switch box and assisted in composite aspects
Jose Portillo	Writer/ Composites Member	Made the switch box and wrote the composite segment of the design brief
Bryan Medina	Writer/ Design Member	Made the design presentation, provided the design blueprints, and 3D printed designs
Jordan Loiacano	Design Team Leader	Worked on the design presentation, provided the design blueprints and 3D printed designs
Chloe Yoon	Writer/ I.T. Member	Refined sections in design brief
Fionina Tung	Video editor/ I.T. Member	Created the script for the design video
Ahmed Al-Ansari	Mechanical Member	Replaced seat belt bar and assisted in welding the roll bar to the seat

Giana Diaz	Mechanical Member	Attached the wheels to the car and drilled hole for the motor control
Anthony Garcia	Mechanical Member	Made the placement for the motor
Henry Millan	Mechanical Member	Worked on mechanical aspects of the car

6. Organization Chart & Subsystem Team Responsibilities



7. Basic Vehicle Configuration & Description

Our team has decided to enter the Energy Invitational with a three-wheeled Blue Sky kit vehicle named Spectre (Blue Sky Design 2023 pg.1). Upon entering the competition, the program had 3 available vehicles to enter with: a built vehicle, a nearly finished vehicle, or buying an F24 kit car (Green Power 2023 pg.1). Our original plan was to enter the competition with two vehicles, the F24 and our completed electric vehicle. Unfortunately the completed vehicle, Volt, had crashed during a test run, the front end being damaged beyond simple repair. When looking to place an order for the F24, we realized that the kit would not be shipped and arrived on time for the competition. This meant our only option was to finish and modify the unfinished vehicle, Spectre.

The chassis of Spectre consists of a hollow steel frame and a teardrop shaped fiberglass body (Blue Sky Design 2023 pg.1). At the rear of the vehicle we have a model 4BC2770 Scott DC motor powered by 2 ExpertPower EXP12200 batteries located behind the driver. The motor is mounted at the back of the vehicle on a newly machined aluminum plate. Our previous motor plate had to be replaced since it was damaged and a risk to the security of the motor.

We have experience working with this format from past electric vehicles (EVs) that the program produced. The team originally planned to use a set of batteries that we already had. These batteries are the PowerSonic PG-12V55-FR; however, each of these batteries weighed 39.5 lbs, totaling a weight of 79 lbs. We had to cut the weight of the batteries due to the ultra light weight requirement of 330 lbs. The batteries were swapped out for our current lighter ones, only weighing 13.3 lbs each.

The vehicle will be sitting on 2 Maxxis 16x1.95 inch wheels in the front and a Maxxis 20x1.95 tire for the rear wheel (MAXXIS 2023). Inner tubing for the two front tires are Maxxis Welterweight 16x1.95-2.125 Schrader tubings and the rear tire has 16x1.90-2.125 Schrader tubing (MAXXIS 2023). Steering for the vehicle will be done through hollow steel lever tubes. Our throttle, brakes, and horn are mounted onto the levers.

Figure 1

Image of Spectre

Note. This is an image of our current vehicle Spectre, taken by electrical team leader, Alejandro Chico.

Initially, the vehicle design was meant to resemble our past Aerocoupe, Volt, consisting of a tear drop body design made from fiberglass material. However, due to competition requirements and driver safety, necessary modifications had to be applied to comply with regulations.

The rulebook requiring a licensed driver pushed us to look for a suitable candidate. However, our only potential driver is of a taller stature, limiting our weight and forcing us to increase the height of our roll bar. Therefore, modifications were made to extend our roll bar to 2” past the driver’s helmet to meet safety requirements. These limitations required us to remove the canopy of our vehicle. This will negatively impact performance in air flow because the removed canopy now leaves a huge dip on the top of the car. Although Spectre's coefficient of drag increases—affecting performance in speed—it was a necessary change. (Toyota Canada, 2017, p. 1).

In addition, a five point harness is included as a safety procedure for our driver. The front of the vehicle has a steel bar guard used to prevent potential leg/foot injury incase of impact, as well as pink insulation foam to serve as our impact cushion (Amazon Pink insulation foam 2023).This cushion is 330 square inches and is placed outside the body of our vehicle. To communicate to other drivers on the road, rear brake lights have been added along with our new horn which the button for will be mounted onto the steering levers.

Axle adjusters have been added to the rear of our vehicle because of a past incident where time had been wasted in attempts to change out the rear wheel and placing it back into its original position. The axle adjuster is two nuts on a bolt, threaded through a piece of hex shaped steel that is welded onto the same frame piece as where the wheel sits. These parts let us retain the same position of the wheel when removed and placed back. This allows us to be more time efficient if we deem it necessary to pull out the rear tire and replace it.

8. Powertrain Configuration

The running gear uses a fixed gear chain and sprocket system with a gear ratio of 5:1. The gear and sprocket system is a chain system that connects the motor to the rear wheel which causes the rotation (Deziel, 2018, p. 1). The smaller driving sprocket with 12 teeth is attached to the shaft of the motor while the larger 60 teeth gear is the driven gear attached to the rear wheel. As the driving gear rotates five times, the driven gear rotates once. This is how the 5:1 ratio is derived, affecting the rpm of the rear wheel, leading to the amount of torque in the system of rotation. By using Newton's law of sum of torques equation, $\sum\tau = rFsin\theta$, it is proven that the increased radius of the larger gear attached to the wheel will increase the torque of the vehicle. With increased torque, the speed of the car also increases (Saini, 2021, p. 1).

Figure 1

Image of a Chain and Sprocket system

Note. This Image is not to scale (Taken from Thomas)

The ratio of the running system was left unchanged because of our situation where our goal was to simply be able to enter a competition after a long absence from competitive projects. Due to time shortage, inexperience, and lack of knowledge after COVID-19, we decided to continue using the 5:1 gear ratio.

This system is turned by our model 4BC2770 Scott DC motor mounted to the back of the car. It is a 24 Volt DC motor rated for 2800 rpm with a power of 1.6 hp at a continuous current of 400 amps (LAAE, 1999 pg.1). The rear of the car had already been set up with a system for that specific motor. Switching out our motor was not an option due to the time needed to re-design and create new parts that connect to the motor. Relating back to our lack of time before the competition date, we could not look into alternative motors.

Figure 2

Image of the Scott DC Motor

Note. This is a reference image. (Taken from Aerial Equipment Parts).

The rear wheel pushing the vehicle forward will be on a Maxxis 20x1.95 inch tire. The wheel is a freewheel meaning that the axle gear can rotate the wheel but the wheel's own rotation will not cause the axle gear to rotate with it (Kalkhoff-Bikes 2023 pg.1). This is important because if the wheel's rotation were to turn the motor's shaft in reverse, the motor will act as a generator and electricity will be pushed back into the electrical system causing an electrical malfunction.

Figure 3

Image of the Maxxis HookWorm tires

Note. This image is not scaled. (Taken from MAXXIS)

9. Brake System

The braking system used for Spectre is a bicycle caliper disc hand brake. We are familiar with using this set of brakes the most since we have experience with using them for past vehicles. For example, during our modification process it was noticed that there was an issue with the brake cable not fully retracting. Our understanding of how these brakes operate allowed us to address and quickly solve the issue.

The handbrake is located on the steering levers of the vehicle for easy and quick access to the driver. The brakes are attached to an electrical system including the brake light and brake horn. The electric input comes from the 24 V batteries which will go through a DC-DC converter. This will make the 24 V into a 12 V setup wired around the car.

Figure 4

Image of the caliper disc brakes

Note. This is an image used for reference. (Taken from Walmart)

10. Body

The body of Spectre is made from fiberglass material. The composites team determined that we would have to use fiberglass over carbon fiber. Fiberglass was chosen for its lightweight property which helped us in achieving the weight limit of 330lbs for the competition. In addition, the material has significant chemical resistance and abrasion resistance (Hristo 5). Since our past vehicles were all made from fiberglass, our team trusted the same designs. The cars have all proven to work efficiently with that material so we did not doubt that the performance of the car would be damaged by the fiberglass.

Based on the safety requirements of the competition, we needed a body that would provide protection for our driver. The body of the car not only covers the entire vehicle but seals off openings that could harm the driver. The cover prevents rocks and track debris from entering the vehicle, meeting the requirements to maintain safety (Vital Link 14).

The battery boxes are made of fiberglass with carbon fiber surrounding the box to fit the batteries compactly because the material is durable. Fiberglass prevents the batteries from being prone to damage due to its great resistance to collision and good stability (Hristo 8). The material is also non-conductive which is the best material to use when containing batteries. The electrically non-conductive component increases safety and it has low thermal conductivity to improve the rate of heat transfer (Fibergrate 10). This safety measure protects our driver from an overheating car and provides an easier escape from the vehicle if a fire occurs.

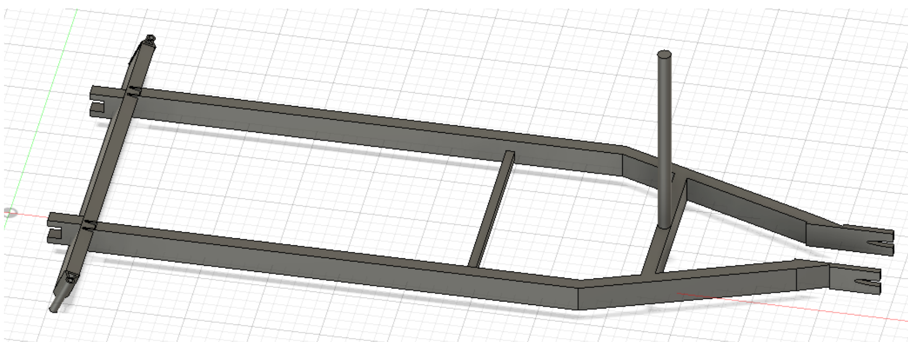
The teardrop shaped frame covering the vehicle is our fiberglass shell. Our team decided on the shape of a teardrop due to the shape being found in nature, allowing the vehicle to pass through air resistance meeting opposition from the air around it (University of Bolton 1). With a vehicle that counteracts air resistance, our drag coefficient for the speed of the car will also decrease. In other words, the car will be able to travel a further distance with less drag causing a loss of speed (Toyota Canada 1). Recently, we have decided to remove the canopy that is placed on the top of the car due to our tall driver. The driver is the only student in our program who has a Driver's License which is why the canopy needs to be removed. This affects most of our aerodynamics because there is a gap at the top of the car where the driver sits. The gap allows air flow into the car increasing the amount of drag which will affect our speed.

In order to meet the safety requirement of having no sharp edges or protrusions, the composites team decided to create covers using spray foam insulation (Vital Link 14). The insulation foam is used as stability holders for our two switches that connect our motor to the motor controller. When using the chemical, the foam flows and forms into the shape of the cavity. Use of the material is also efficient because it can be easily shaped and cut (RHH 3). This results in an easy method of molding the foam around our switches. The spray foam is also used to create our cover for the motor controller that is located in front of our driver. The cover prevents the driver from hitting the control during the race.

Cracks on the car are patched by epoxy resin. Through research for strong durable adhesives, we found that epoxy resin was the best option. The chemical is heat resistant, has mechanical strength, and adhesion to metals (Epoxy Resin Committee). We have been able to work efficiently with epoxy and it has been proven to be effective so far.

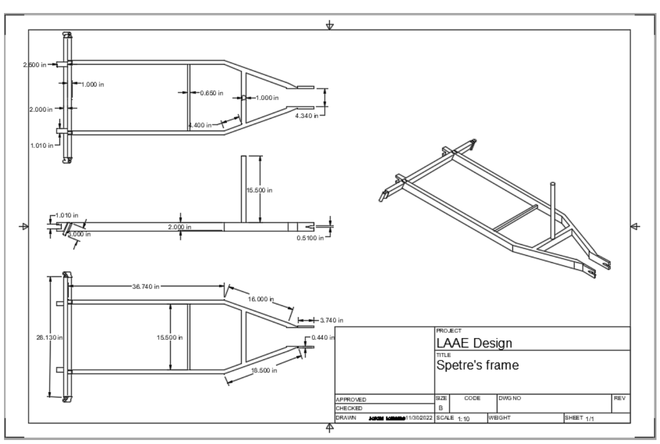
11. Design Drawing & Parts List

Figure 1



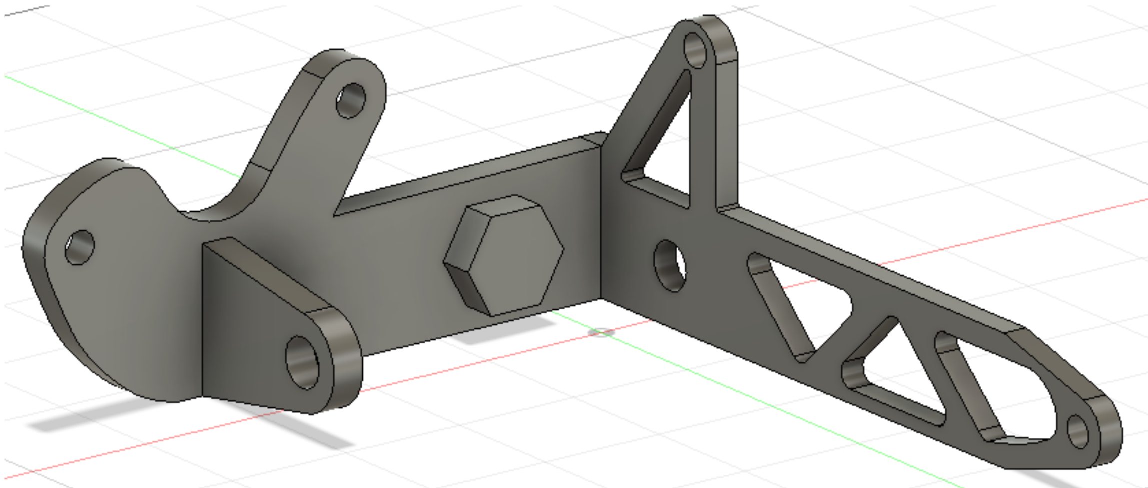
Note. This is the 3D model for Spectre's frame, drawn by our design team.

Figure 2



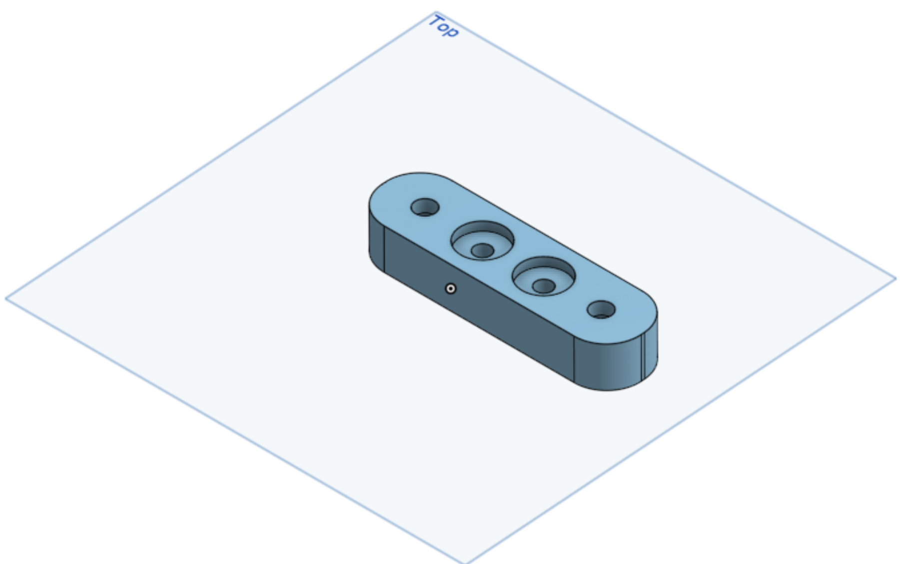
Note. This is the schematic for Spectre's frame, drawn by our design team.

Figure 3



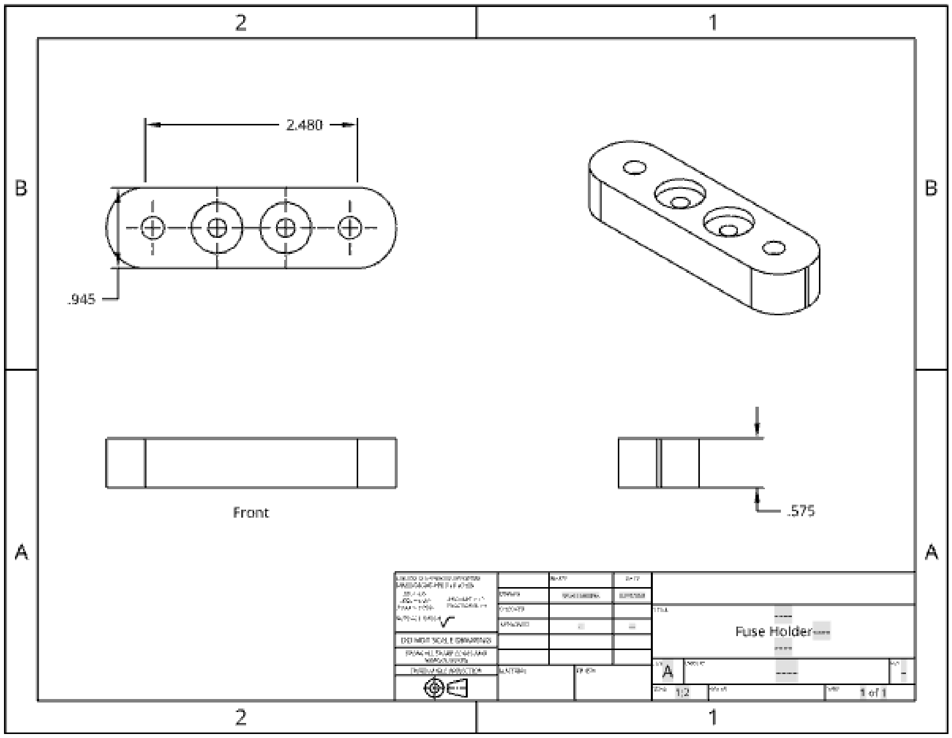
Note. This is a 3D model of the spindle used for Spectre that was drawn by our design team.

Figure 4



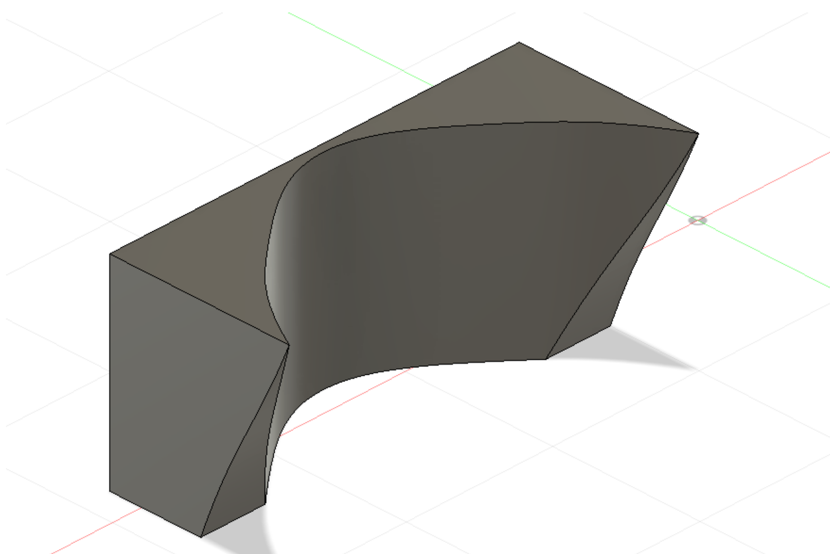
Note. This is the 3D model for the fuse holder, drawn by our design team.

Figure 5



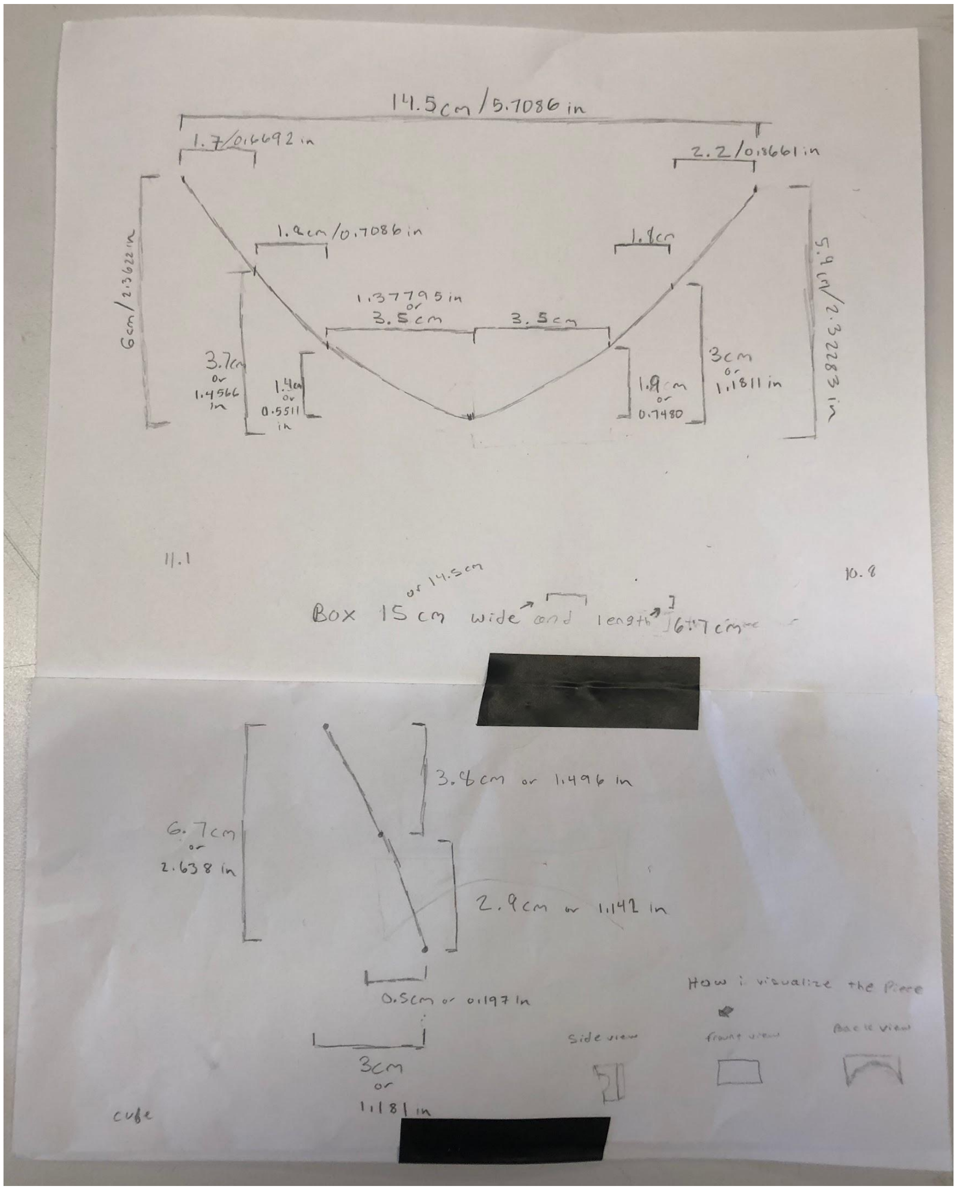
Note. This is the schematic for the fuse holder, drawn by our design team.

Figure 6



Note. This is the 3D model of the brake light holder, drawn by our design team.

Figure 7



Note. This is the schematic for the brake light holder, drawn by the design team.

Table of Parts List

Vehicles Sections	Vehicle Parts
Frame	Steel tubing
Batteries	ExpertPower Model: EXP 12200
Brakes	Bicycle caliper disc hand brake
Roll Bar	1 inch diameter steel tubing
Motor	Scott DC Power Products Model: 4BC2770
Tires	2 Maxxis 16x1.95 inch tires Maxxis 20x1.95 inch tire
	Maxxis hookworm tires
Inner Tubing of Tires	Maxxis Welterweight 16x1.95-2.125 Schrader inner tubing
Throttle	Alvey Tech 3-Wire Thumb Throttle 22mm grip
Wires	22 AWG Standard Wire Silicone Tinned Copper Wire Spool 25ft
	GearlT 8 Gauge 25 ft
Wheels	Skyway wheels

12. Performance Evaluation Weight, center of gravity, acceleration time, skid pad time, energy usage

Due to the car not being completed at the time of writing this report and the lack of materials to collect data, we were unable to test the car. This performance evaluation is hypothetical.

The maximum weight of the car and driver had to be 330 lbs, and our weight exceeded that due to the heavy metal on the car and our driver weighing 170 lbs. To lessen the load, we opted to get new batteries that would weigh less. Our options were the Powersonic PG-12V55-FR (39.5 lbs), Odyssey PC1100 (27.5 lbs), Optima D35 (37.5 lbs), and Expert Power EXP12200 (13.3 lbs) batteries. We had the Powersonic, Odyssey, and Optima batteries at our disposal. However, the batteries weighed far too much and were above 45 AH. These batteries were more powerful than what we needed for fifteen minute races. So, we bought 20 AH Expert Power batteries that weighed 26.2 lbs in total. This weight difference allowed us to take one more step in our goal of getting under 330 lbs.

Figure 1

Image of a Expert Power EXP12200 battery

Note. This is a general image of a Expert Power EXP12200 battery (Taken from Expert Power)

We chose to use 20 AH batteries because the amp-hours are enough to get us above 15 mph. We know this because of our 2013 electric vehicle race where we aimed to draw around 21 amps to drive 30 mph (LAAE 2013). In that race, we had ER-35 Odyssey batteries which ran with 28 AH (LAAE 2013). Since this race has four 15-minute heats, we need to draw amperage for a total of an hour. These batteries can draw 20 amps every hour. That's only one amp under the amperage that the bigger batteries were drawing in the past. It is more than enough to get us above the 15 mph mark that the race insists we drive.

Figure 2

Image of a ER-35 Odyssey battery

Note. This is a general image of a ER-35 Odyssey battery (Taken from Raceparts)

The center of mass has not been considered by our team. Due to our car frame coming from a kit, there were already specific spots for electrical and mechanical equipment. For instance, the motor has a sizable gap in the back of the car without any other place to comfortably put it in. Above it lays a perfect gap for our Expert Power batteries. The only other place to put the batteries is the front of the car, which is already full with shunts, wires, and an Alltrax. Any more would discomfort our large driver who barely fits the vehicle.

The acceleration time will be measured using the Cycle Analyst V3 CA-DP which will measure velocity in real time. We may also use a stopwatch to track the velocity at a certain time. Using the equation $A=\triangle V/\triangle T$ (where A=acceleration, $\triangle V$=change of velocity, $\triangle T$=change of time), we can determine the acceleration of the vehicle (Milliman 2021).

Although we do not have a set path to finding the amount of energy the car will use, we do have a method to increase the effectiveness of the batteries. Our program uses a process called discharging. We discharge our batteries by creating a circuit similar to our vehicle and run it through a specific amperage for a certain amount of time. To improve our batteries for this competition, we set our system up for an hour while drawing 25 amps and checking the voltage every five minutes. We decided to draw exactly 25 amps because that's a bit over the 21 amps that our 2013 vehicle drew while racing. We don't know the exact amount of amperage the car will draw since at the time of writing this design brief, we have yet to test our car on a track and measure its electrical outputs. However, this process will still be beneficial to the efficiency of our car.

Table 1

Table of our Battery Discharge Process with 25 amps being drawn

Battery Identifiers (letter identifier and year)	B2023	C2023

Minutes discharged	Voltage of battery B2023	Voltage of battery C2023
Before discharge	13.19	12.94
0 (Start)	12.29	12.19
5	12.29	12.19
10	12.33	12.12
15	12.25	12.13
20	12.15	12.01

25	12.14	12.00
30	12.02	11.95
35	11.95	11.88
40	11.80	11.81
45	11.79	11.73
50	11.78	11.68
55	11.67	11.62
60	11.62	11.51

13. Timeline, To Do List, Assembly & Finish Plan

November 2022	Our team gets word of the Vital Link Energy Invitational from our research group.
December 2022	We begin the process of registering for the Vital Link Energy Invitational and start looking into how we need to modify our existing Aerocoupe electric car “Spectre”.
December 2022	Beginning the process to finish basic components of our new EV Spectre such as seat belt security, fixing brakes, creating alignment bar, and battery fixtures.
January 2023	We officially register for the Energy Invitational and begin ordering parts to meet the car qualifications.
January 6, 2023	We chose our driver, Owen Beals, who met the qualifications required by the competition. This included his age, driver’s license, and insurance provider.
January 9, 2023	Bar to hold batteries in place is replaced with

	a change in material from aluminum to steel.
January 2023	Mechanical alters seat belt arrangement to ensure security in placement for driver safety.
January 2023	Electrical team looks into new batteries to replace the 12V 56 Ah Power Sonic PG-12V55-FR to minimize weight, and settles on the ExpertPower 12200 12V 20 Ah.
January 2023	New, smaller alignment bar is made to address the size issue which limits steering.
February 6, 2023	We weighed the car with and without the driver and realized we needed to cut some weight.
February 9 2023	The Electrical team begins working on the brake light system with micro switches as well as the car horn.
February 14, 2023	Cycle Analyst arrives and we begin testing it out.
February 2023	Axle Adjusters are brought to the Mechanical team's attention and begin the process of machining them.
February 2023	Mechanical team creates a new motor plate to replace the used and damaged one.
February 15, 2023	Electrical replaces all 2 gauge wires with thinner 8 gauge wires to minimize weight.
March 5, 2023	The design brief is submitted.
March 2023	Cycle Analyst and car horn and brake light system is installed and is test driven.
April 2023	Our team begins to prepare for competition.
May 6, 2023	Race day

14. Safety Features & Procedures

Prior to the preparation of the competitions, Spectre only had a few safety features. To begin with, Spectre has two master electrical system switches. These switches interrupt all power and are easily accessible to both the driver and the team (Vital Link 14). Few adjustments were necessary for our already installed five-point safety harness, padded headrest, solid body and floor panels to ensure the stability of these components (Vital Link 14).

The safety guidelines required our team to adjust the height of our roll bar to better accommodate our tall driver. The roll bar was previously 20.25 inches tall because we had smaller drivers, however, our current licensed driver was far taller than the roll bar and so it needed to be expanded for two inches of clearance above the driver's helmet. A new roll bar is in production with a larger volume of metal tubing.

We also created smaller battery boxes to keep the Expert Power 12200s in place. Our battery boxes are made of fiberglass instead of carbon fiber to minimize conductivity (Gardiner 2020). The battery boxes will be prevented from moving around in the larger pre-cut hole with expanding foam. The foam will also add an extra layer of insulation separating the batteries from the driver (Gardiner 2020).

The driver has to follow a number of safety guidelines. This includes a race suit, a helmet (Less than 7 years of age), a head sock, arm restraints, neck restraints, and safety shoes. The race suit is a quilted 2-layer Proban 1 piece suit from Crow Safety Gear which is SFI 5 approved. The helmet is a HJC i10 helmet from RevZilla which is made out of a polycarbonate shell (Things That Fold, 2020). Furthermore, the neck and arm restraint as well as the head sock come from Crow Safety Gear. Lastly, the driver requires a driver's license with no exceptions. Due to this rule, we only had one driver who could race for us.

Figure 1

Image of a Quilted 2-layer Proban 1-piece suit

Note: This is a general image of a Quilted 2-layer Proban 1-piece suit (from Part123)

There are some issues that our program has stumbled across at the time of writing. For instance, the electrical team is finding a way for the battery pack terminals to be isolated with zero exposed cable wires. One way they have thought to solve this issue is by using a composite cover over the battery boxes. Moreover, the newly brought in cycle analyst has proven difficult to install for our team. They are currently working on wiring and placing it on the car. Lastly, the team has been working on wiring a DC to DC converter from 24V to 12V for the smaller car horn and brake light system.

Figure 2

Image of a DC 24V to DC 12V 10A 120W Step Down Buck Converter

Note. This is a general image of a DC 24V to DC 12V 10A 120W Step Down Buck Converter (Taken from Amazon)

15. Conclusion

In the beginning of this competition, our team had little experience in the workshop, and no experience in competitions, the entirety of our group had to start from the ground up. Through weeks of studying the rulebook and discussing solutions, our group furthered our progress and ultimately finished a car.

However, this car did not come without faults. Little data has been collected due to minimal tests being run, because of the lack of equipment needed to get data such as velocity and amperage drawn. Yet, this setback did not stop our group from finishing a car within the limitations of the rulebook.

Furthermore, the weight and height of our driver forced us to accommodate our vehicle and transform it into an eligible contender. Through trial and error, our team has shown grit and motivation to succeed in this competition.

16. References

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