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II. Introduction & Development

The idea for Pulse was originally conceived during 2010-2011 school year. We noticed that many of our students did not possess the knowledge necessary to build complicated vehicles like HICE and Infusion. As a result, many of our more recent projects were copies of past works.

This was especially evident in our Solar Boat program. Many components of the boat were added without any knowledge of their purpose or function. In the 2010-2011 school year, we attempted to correct this problem by building a basic solar boat that was not a copy of a previous design. By doing this, we were able to completely understand the purpose and process of building our project.

During the 2011-2012 school year, our program did not receive funding for the Solar Boat competition. As a result, we decided that we would turn our efforts to building an electric vehicle to compete in an Electrathon competition instead. Like our Solar Boat program, this new vehicle would not be a copy of a previous design. Our team determined that it would be simple in order to develop and further our knowledge in building a vehicle. Originally, we wanted to build a vehicle that ran on lithium ion batteries, and thus we named our new vehicle “LiOn”. However, because of our lack of experience with the batteries and their potential danger, we decided that we would work with sealed lead acid batteries instead. Because of this, our team renamed the new vehicle “Project Pulse.”

The vehicle was designed to compete in an Electrathon race and to travel 30 miles in one hour without damaging the batteries and ensuring the driver’s safety. In order to achieve this goal, we would have to qualify and meet all requirements for the race.

One important factor to consider in building Pulse was whether or not it would travel at our desired speed. We used the Power Calculation (shown below) to determine how much power was required for Pulse to run at 30 miles per hour.

$$P = (W * C_{rr} + ½ p * V^2 * C_d * A) * V.$$

The Power Calculation was given to us by Dr. Michael Sheldon at the California Polytechnic University of Pomona. In the past, the program has used it to determine the power required for other vehicles to run, such as HICE and Infusion. This was the formula that allowed us to monitor and predict our vehicle's ability to run, identify important factors that contributed to efficiency, and set goals for our vehicle's speed.

There are two major components of the Power Calculation: the aerodynamic component and the mechanical component. The mechanical component, $W * C_{rr}$, consists of two variables: weight and the coefficient of rolling resistance. Weight is easily calculated as the weight in pounds of the vehicle, including the driver. Coefficient of rolling resistance is found through a roll down test, which will be explained in the *Mechanical* section of the report.

The aerodynamic component of the Power Calculation consists of $½ p * V^2 * C_d * A$. The first part, ½ p, is half of rho, a coefficient that considers the density of air (0.00238). V^2 is the square of the target velocity in feet per second. The coefficient of drag, or C_d, is a value that considers the shape of the vehicle. Currently, we do not have a C_d for our vehicle; however, we are using the value used for a German vehicle (0.28) that is similar to the shape of our vehicle. This is not a permanent solution, however, and we will calculate a more accurate value that pertains to our vehicle in the near future through the Solid Works design program. The frontal area, or A, is the total area of the vehicle in square feet when viewed in the direction of the vehicle's acceleration.

We realized through the Power Calculation that vital factors such as the coefficient of rolling resistance (C_{rr}), which is the friction between the wheel and the surface, and the coefficient of drag (C_d), which is the resistance to the vehicle caused by air flow, had major roles in determining the vehicle's ability to run. We also realized that at higher speeds, weight did not play as crucial of a role as we had previously predicted, and factors such as frontal area and C_d had a huge impact on the amount of power required to move the vehicle.

After taking all of these factors into account, we felt that we were ready to start building Pulse. Over the course of 2011-2012 school year, we have completed our goal for the school year to complete the chassis and enable Pulse to run under its own power.

III. Design

Concept and Summary

When our team designed Pulse, we wanted it to meet two main objectives. First of all, we wanted our vehicle to meet the rules and specifications of the Electrathon USA race. The other goal for the vehicle was for it to travel 30 miles in one hour without stopping to charge its 12 volt batteries. Like Speed Racer, another LAAE vehicle built for Electrathon USA, Pulse was built using steel tubing welded together. Using steel tubing benefited us because it would be relatively easy to make changes to the chassis design, even after we had begun building. The design team was in charge of designing the chassis and a body concept. In order to meet our goal to travel 30 miles in one hour, our team decided to use the power calculation as a guideline. The power calculation, reproduced below, is a formula that determines approximately how much power in foot pounds is needed for a vehicle with certain dimensions to travel at a certain speed. This is then converted into watts for our electrical team to determine how many watts are required for our vehicle.

$$P = (W * C_{rr} + ½ * C_d * A * p * V^2) * V$$

Using this formula enabled our team to understand which aspects of our vehicle would affect efficiency the most. For example, although keeping our vehicle lightweight was important, the power calculation demonstrated that at higher speeds, weight was not as significant as C_{rr}, coefficient of rolling resistance, C_d, coefficient of drag, or A, frontal area. Another important aspect we focused on in our design was the safety of the driver. We had to ensure our chassis was strong enough to protect our driver from being injured in a race. However, it is important to note that currently, Pulse is not safe enough to compete in an Electrathon USA race.

Consideration and Issues

Chassis: Our chassis is currently made of ¾" steel tubing that is welded together. It is a simple box shape that slants slightly downward in the front. We decided along with the mechanical team, that this type of chassis would work well for our needs as it was fairly easy to design and was relatively easy to build. The mechanical team would be able to closely follow our design with precision. Unlike aluminum, which is also lightweight and strong, steel was easier to work with for the mechanical team as they knew how to weld steel. Another reason why steel was chosen was because it is fairly sturdy. This will contribute to the safety of the vehicle, although it is important to note that the shape and design of the chassis will play a much greater role in determining its overall safety. Steel is also easy for the team to obtain and fit the budget constraints, which added to its favorability.

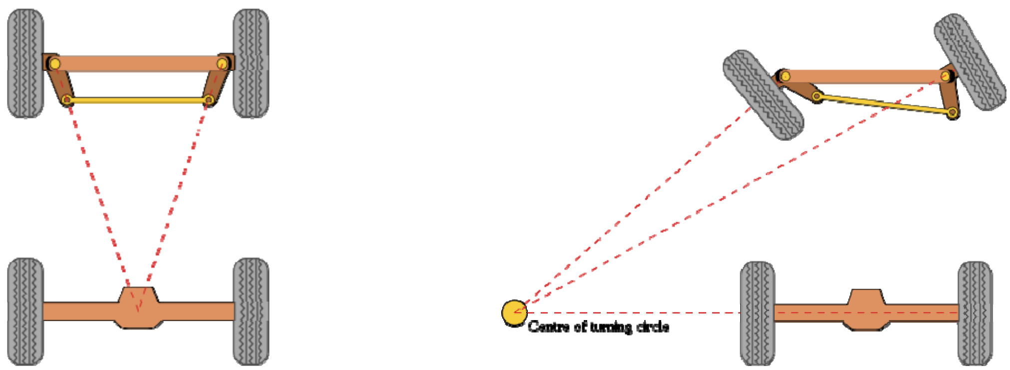
In order to reduce frontal area, we kept the width of the chassis under three feet and kept the car low to the ground, at a little over three feet high with a ground clearance of about two to three inches. A smaller frontal area and lower *Cd* would increase the efficiency. *Cd* is determined by the aerodynamic shape and size of the body, so keeping the chassis compact meant that our composites team would make a smaller body. The design was kept as narrow and short as possible, although we may have been able to reduce the vehicle's height even further if we had decided that the driver would be placed in a prone position. However, we eventually decided to keep the driver in an upright position in order to maintain simplicity. Due to our vehicle's small size, we could not place our batteries inside the chassis, so we had to mount them outside of the chassis. Doing so also allowed for easy access to the batteries and helped stabilize the vehicle by balancing the weight. We minimized weight by reducing the amount of steel we used in the chassis. Only sections of the chassis that were crucial to safety and function were kept, and extra and unnecessary sections were removed from the design. However, we now realize there needs to be more support bars added to vehicle.

In another attempt to increase efficiency, we even considered using 27 inch wheels on Pulse as this would reduce our C_{rr}. However, we eventually decided against this idea because of the complications that would arise in designing and building a vehicle with wheels of this size. Twenty inch wheels were also much easier to obtain than 27 inch wheels.

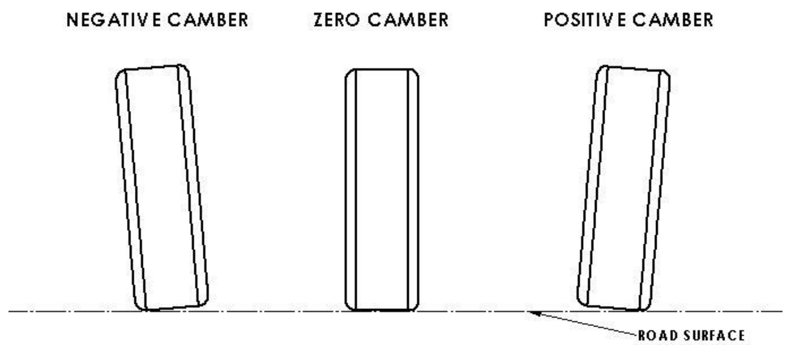
In order to ensure the driver's safety, we designed the chassis to be strong and able to prevent injury in accidents. For example, we added several triangular support bars in potential weak spots throughout the car. We also added support bars on the sides of the driver to protect him/her from lateral collisions. The roll bar height was raised in order to protect the driver's head and to meet a rule that specified that the bar be taller than the driver's sitting height. Because of an Electrathon rule that specified that the driver be able to exit the vehicle unassisted within 20 seconds, the area above the driver was left open to enable him/her to exit easily. In the future, we also plan to add additional triangular support bars to various sections of Pulse that need extra support, such as the front of the vehicle and between the cross member and the main chassis. We also plan to add tubes to connect other sections of Pulse, such as between the pedal mount and the chassis.

The swing arm was placed on two tie rods instead of being welded to the chassis so that it could be easily adjusted if necessary. Currently, suspension needs to be added to the swing arm in order to protect the vehicle from jolts it will encounter during the race.

Steering: We had to take many factors into account when working with the mechanical team to design the steering system. We are currently using a rack and pinion steering system, as we felt that this design would be simple yet able to meet our needs. The team also had to take the Ackerman angle, demonstrated by the diagram below, into account in our design.



The Ackerman angle is the alignment of the spindle to the back wheel, or as in the diagram above, to the center of the back axle line. The Ackerman angle is important because it enables our vehicle to turn with our front wheels by tracing out two different turning radii for the inner and outer wheel. We designed small aluminum forks to attach to each end of the rack and pinion to adjust the steering. One fork was tapped in the regular right-handed direction, while the other was reverse tapped. The forks were tapped differently in order to allow us to adjust how far the tie rods extended from the rack and pinion. In order to allow ourselves to adjust the vehicle’s camber angle (shown below), we needed to be able to adjust the angle of our spindle.



On both wheels, the kingpin is attached to a steel plate connected to the cross member. We needed to drill a slot in the plate in order to adjust the kingpin angle. After discussing this with the mechanical team, we decided that instead of slotting the steel plate, a series of holes would be drilled along a curve instead. This was much easier than slotting the plate.

Future Body: The vehicle currently does not have a composite shell. However, we have a concept drawing of a body completed using Autocad. Our conceptual drawing is focused on reducing Pulse's frontal area and coefficient of drag in order to increase efficiency. After consulting with the composites team and Mr. Bob Franz, a former advisor of the LAAE, we decided that the composite body will have a shell that mimics the Clark Beasley Electrathon vehicle. At the moment, the team has decided to include the wheels into the design of the body. Although this will increase our frontal area for the vehicle, it will reduce drag by removing the air vortex that normally forms from the spinning wheels. However, it is important to note that we are still in the process of determining whether covering the wheels will be worth the extra frontal area that will result from doing so.

Currently, our C_d is the same value (0.28) as the German vehicle mentioned in the introduction. For now, this is a sufficient replacement to determine how much power we need as both this vehicle and Pulse will have a similar body shape. However, this is not a permanent solution. In the near future, we plan to determine a more accurate C_d that pertains to our vehicle through the use of the Solid Works modeling program.

Other issues: Even after the teams began building Pulse, changes were still made to its design because of unforeseen complications and factors. For example, we had to change the width of the rear axle and swing arm in order to accommodate the width of the wheel. Our axle was originally only slightly wider than the wheel itself; however, we did not take into consideration the built-in brakes that came with the wheels we had purchased and had to widen the rear axle. Later, we may need to shorten the swing arm in order to prevent the vehicle from bending downwards. We will also need to add suspension. It is also important to consider that in shortening the swing arm we may alter our Ackerman angle mentioned earlier.

IV. Electrical

System Description

Pulse contains an electrical system based off of the Alltrax Motor Controller schematics. There is the motor controller, motor, switches, batteries, and potentiometers. The new compartments that were added are the multi-meter, two fuses, and shunt.

The motor controller is used for combining the high and low current systems together. Without the motor controller, it will be too difficult to layout the electrical system. The Alltrax AXE 4844 motor controller provided without cost by the Alltrax Company. It is perfect for our use. There are various models so if we were to decide to use more batteries (higher voltage), we will be able to acquire a motor controller to fit our needs. The only complex part of the Alltrax is the need for reprogramming before its first use. Without doing so, the vehicle will not be able to run at its fullest efficiency due to the loss within the motor controller. This can be easily done by opening the black lid on top of the motor controller and connecting it to a computer using appropriate cables. Afterwards, check off the half power reverse.

The Scott Motor is the motor that the program owns, and is the best fit for this Electrathon. This motor is able to rotate up to 3000 revolutions per minute (rpm), even if we will never be going that fast. We are not able to reach such high numbers since voltage (electrical potential difference) and rpm are directly related. Torque, on the other hand, is related with amperage (the flow of electricity within the wire). From the equation: $Power = Voltage * Amperage$, having less amperage for the system is to our benefit. Pulling out more amperage will result to the batteries dropping in voltage faster. When the batteries drop too much in voltage, the amperage will have to increase in order to continually run at 30 miles per hour. Running with a lot of amperage will cause the motor to overheat, and can potentially kill the motor along with the battery from the over drainage.

Odyssey ER40's are the batteries that we decided to use for this race. Buying one of these 12 volt batteries are costly, however the return for this is just what we needed. The weight of the batteries is 27.5 pounds, so we are able to carry only two to stay within the weight limit. ER40's are 12 volt batteries, lead acid, and sealed (no acid leakage). These batteries are able to run at constant amperage of 21 amps for the full race and still be charged back up to its original condition. If proper care is taken for these batteries, they can be reused multiple times, which can potentially save money after a couple of years.

There are three switches that are placed within the system. The two high current hand isolator switches are located on the side of the driver. The low current switch is on the dashboard of the car. One of the two high current hand isolator switches is located with the handle on the outside of the vehicle so race officials are able to shut off the vehicle without having to reach inside the car. It is stated within the rules that one switch is to be located outside the vehicle for safety precautions. The other high current hand isolator switch is faced inside the vehicle so the driver has immediate access.

There are two fuses within the system in case of system errors. If there were to be too much amperage running through the system, it will be dangerous for the driver and the fuse is a good way to cut off the system independently in case the driver is unaware of the malfunction. One 250 amperage fuse is located between the two batteries since the amperage, flow of electricity, is originating from this point. The second fuse is a 100 amperage fuse, and located between the battery and the switch. This is just for a secondary precaution in case the first one is not working properly.

The shunt, purchased from Glaco Industries, has a 350 amperage to 50 millivolt reading. These shunts are very sturdy and excellent quality. The shunt is necessary so that we are able to place a meter within the vehicle without having to create openings on the wires. The reading on this shunt is a seven-to-one ratio since the one-to-one ratio shunt we originally used caused fluctuations on the readings.

The multi-meter we used is the Fluke Digital Multi-Meter purchased through McMaster Carr. At first, we tried with the Cycle Analysis, a digital multi-meter which was capable of reading amperage, voltage, amperage hours, and miles per hour; however this gave us faulty readings for the amperage. Having a meter in the vehicle is crucial, since this is the only way we are able to figure out how much voltage and amperage the system is running at. Knowing these two will enable us to figure out the amount of power given off, which is related with the speed we are going at. According to power calculations, $P = \left[W * Crr + \frac{1}{2}p * v^2 * Cd * A\right] * v$, we will be needing approximately 434 watts (refer to end notes for detailed calculations), which will result to 18 amps.

There are two potentiometers (able to manually change resistance; pots) working together to control the amperage of the system. The main pot is the hand pot on the dashboard. This sets maximum amperage for Pulse to run on. This has no boundaries. If the driver wanted to, he or she will be able to run with the lowest or highest current possible. The secondary pot is foot pedal at the very front of the vehicle. This pot is only able to move as far as the foot pedal allows it to. Since it cannot be adjusted as easily, this pot requires to be dialed to the correct range before the race unlike the first pot. The first pot is directly connected to the motor controller, and the second pot connected to the first pot, creating a dual pot system. This setup enables the driver to adjust to set amperage and stay at within the range without having to constantly adjust the pot.

$$P = \left[W * Crr + \frac{1}{2} p * v^2 * Cd * A\right] * v$$

$$P = \frac{ft}{lb}$$

$$W = Weight = 560lbs$$

$$Crr = Coefficient\ of\ Rolling\ resistance = 0.0055$$

$$p = air\ density = 0.00238$$

$$V = Velocity = 30\frac{miles}{hr} = 44\frac{ft}{sec}$$

$$Cd = Coefficient\ of\ Drag = 0.28$$

$$A = Front\ Area = 939in^2 = 6.5ft^2$$

$$P = \left[(560lbs) * (0.0055) + \frac{1}{2}(0.00238) * \left(44\frac{ft}{sec}\right)^2 * (0.28) * (6.5ft^2)\right] * \left(44\frac{ft}{sec}\right)$$

$$P = 320.0\frac{ft}{lb} = 434watts$$

V. Mechanical

Summary:

Pulse was first thought of as another electric vehicle. When we started, no one knew much about electric vehicles except for the original we had, Speed Racer. Fortunately we had a helpful tool called Power Calculation. The power calculation calculates the power in foot pounds, which is then converted into watts, in order to estimate the power needed to run at a given velocity. The Power Calc, $P=[W*Crr+(1/2)*p*V^2*Cd*A]*V$, consists of different components. W is weight, C_{rr} is the coefficient of rolling resistance, p is the density of air, V is velocity, Cd is the coefficient of drag, and A is the frontal area of the vehicle. With all this in mind, Pulse could now take shape as we had a baseline to start off of.

The entire chassis is made out of 3/4" hollow steel tubing. We welded all of the connecting parts by fish mouthing the ends of each tube. Most of the welds were created using the TIG welder. This type of welding is better for the vehicle because you can control the amount of heat on the steel. If too much heat is used, it can weaken the steel and make the chassis not as durable against crashes. In order to actually weld the pipes, they need to be fish mouthed to fit properly. Fish mouthing is a process in which a U-shape, or "fish mouth," is created at the end of each pipe. To accomplish this, a person will first find an end mill that is the same measurement as the pipe. After the pipe is secured in the vice the machinist must come down with the end mill into the pipe, almost like drilling. Using an angle finder, make the pipe slanted to make an angled cut to any degree wanted. To the side of the driver are the battery boxes. They were created by cutting an angled piece of steel and welding it together. It would create a stand where the composite battery boxes will sit in.

After the chassis was completed, we focused on the spindles. The spindles are the necessary components that make the vehicle roll and turn. The spindles connected to the chassis. We laid down a steel bar connecting across the chassis. This would end up being the cross member for our vehicle. Then we welded two other steel bars angled to fit the turning radius or Ackerman Angle. The Ackerman angle is the angle the vehicle needs in an order to make a complete turn left or right. Two steel plates had a series of drilled holes at the end to fit the tie rods through. The holes were done for us to adjust the caster angle. The caster angle allows having more leverage with the wheels to the vehicle. We drilled holes through the axles to put the kingpin through. We put tie rods so we would be able to adjust our camber any way we thought would be more efficient. The steering is a rack and pinion mechanism. We raised it with an aluminum plate to reach the wheels, with two forks on each side with a left hand or reverse bolt connecting the two pieces. The steering rod is connected to a tie rod allowing us to adjust the length from the wheel to the steering. Lastly, we bolted the spindle to the axle in order to complete the steering. An aluminum piece was made to hold the drum brake stationary and keep it from rotating with the wheel. The rack and pinion is connected to a universal joint with a splined end where the steering shaft will connect. The steering wheel reaches out closely to the driver that will make it uncomfortable to drive. To pull the steering wheel off, press the button on the side of the steering wheel and it should be unattached.

We used 20” inch wheels with Michelin tires because earlier in the year, we conducted roll down tests and found that our Michelin tires had the least C_{rr} (Coefficient of Rolling resistance). The swing arm is attached to the chassis because in case the back part of the vehicle is misaligned we could correct it with the swing arm. To correct it, there are tie rods that could be adjusted by aligning back into place. The back axle is just a solid 10.5” steel bar dyed on both ends.

On the front of the vehicle we welded together three square pipes as a base to attach the pedals. The accelerator is directly connected to the potentiometer, while the brake pedal is connected to the brake lines that are connected to drum brakes. We used drum brakes because of their efficiency. They will not cause any friction against the wheel, which will make the vehicle slow down. There are no brakes on the back wheel because the rules only require brakes on two wheels. With disk brakes there would be more friction with the brake calipers. This will cause the vehicle to slow down. The drum brakes are inside of the hub of the wheel and will expand when the pedal is pushed. When not being used, the brakes will remain inside of the hub and will not interfere with the spinning wheel.

The original idea was that the suspension would keep the swing arm from hitting the ground. Unfortunately, the suspension did not work. To compensate for the loss, we added a steel pipe connecting the chassis to the swing arm. The disadvantage of doing this is that we lose our suspension, and we would have to run on a flat surface, not bumpy, because all the energy from a bump would transfer to the welded part of the steel pipe. We used a five-point seat belt system because it is required by the electrathon. There are two chest straps, one lap strap, and one that goes in between the legs.

Considerations & Issues:

We considered a variety of factors involving the vehicle. We considered using 27” wheels, but we found out that they were too big to work with. Also the availability of the wheels did not allow us to purchase these wheels and would’ve caused many more problems. We ran into a problem with the steering, as the steering rods were too short to reach the wheel. The steering rods are the aluminum rods that connect to the wheel to make a turn.

A big problem we ran into was the suspension. The original suspension we installed connected to the swing arm and the chassis itself. The suspension would not work on our vehicle. So to fix the problem we decided to weld a steel pipe from the middle of the swing arm to the chassis. The consideration for next year is the geometry and placement of the suspension. The choices that we have to fix the problem are shortening the swing arm to allow the suspension for more control and less leverage to the swing arm. Also the angle of where the suspension could be placed onto the actual chassis. The greater the angle, the more the suspension has control onto the road.

Another issue we ran into was the chain. Deciding whether to use either a bike chain or a poly-urethane belt was a difficult decision. We originally used with a polyurethane belt, but later into the building of Pulse, the belt is only made for a set distance between the motor and wheel. Also, the wheel gear used a different type of teeth from the motor gear. We switched to the bike chain because it was more universal and was easier to lengthen or shorten to fit our needs. A big problem is the gear ratio. The gear ratio we have on the vehicle is a 44:15. There are 44 teeth on the wheel gear and 15 teeth on the motor gear. The wheel gear does not have enough teeth to travel the speed we want and it drained too much power from the batteries and not enough of it went to the car itself. We also want to consider that we cannot let Pulse draw out too many amps and volts during the race. This will allow for a comfortable constant speed without killing the batteries. The solution is to change the wheel gear to a much larger number to get more speed instead of torque.

Also, the back wheel is crooked. If someone were to look at the vehicle from the back, the rear wheel is slanted to the left side. To fix this problem, we have to realign the swing arm because the placement of the axle on the two plates is misplaced. One is higher than the other, making it rise up. A major problem with Pulse is the placement of the motor to the rear wheel. The motor should sit perfectly aligned with the wheel; it should not be out of place, and if it is, the vehicle will lose efficiency. The way it is right now, is that the motor is a little too much to the left of the wheel gear. To fix it, we need a new motor mount.

Frame & Chassis:

The chassis is constructed with 3/4" hollow steel tubing all welded together. The places where the tubing had to be welded at two ends, we fish mouthed the sides to make it stronger and easier to weld so there would be no gaps. The goal was to make Pulse small and compact to reduce drag and cut down our frontal area. This is a way of making the Power Calculation a smaller number for our use. Another goal was trying to make it as light as possible. The roll bar was bent by the tube bender and welded into place. The back part of the vehicle is the swing arm and is held by two tie rods and a cross member welded from the center of the chassis to the swing arm. This was to compensate the problem of suspension until we fix it. The swing arm at the end has two pipes compressed and welded to steel plates on both sides. The reason for it being compressed was because the pipes were now square instead of circular, making it easier to weld. These plates have a cut out of an L shape to put the rear axle through. Another issue our vehicle has is its lack of strength. The front end of the vehicle is too weak to withstand a collision. Because of this, we need to create something that will reinforce the front of the vehicle in order to protect our driver.

Steering:

The steering is a rack and pinion mechanism. We chose rack and pinion because it seemed to be the easiest form of steering. The rack and pinion is raised by an aluminum plate to reach where the steel plate comes out of the axle. With two tie rods attached at the end of the rack and pinion, the forks are connected with a bolt. The forks have a hole drilled through the middle; this hole is reverse tapped with a reverse (or left hand) screw. Then the opposite side is tapped again with a tie rod attached to it. This is to adjust the steering. Placing the steering directly in the middle allows you to adjust by spinning the tie rod to the exact place where a bolt could fit through the tie rod and axle. Coming out of the rack and pinion is a U-Joint. This universal joint allows the steering wheel to move in almost every direction because of the 2-axis ball joints. Connected to the U-Joint is a splined steering rod connecting to the steering wheel. There is a hex placing where the steering wheel connects with just a push of a button.

Brakes & Safety:

We decided to go with drum brakes rather than disk brakes. We went with drum brakes because there is no friction between the wheel and the actual brakes, unlike disk brakes, which constantly touch the wheel causing it to slow down from friction. There is an aluminum-machined part that is bolted to the steering rod. The steering rod controls the steering which allows the wheels to turn. The purpose of the aluminum piece is to hold the drum brake in place without rotating with the wheel. We only have brakes on the two front wheels because that is what the rules require. Also, adding another brake to the back wheel would have been too complicated. The front end of the vehicle is very weak. We need to reinforce and support it in order to allow more safety for the driver. To ensure safety, we have installed a five-point seat belt system. The seat belt has two chest straps, one lap strap, and a strap that goes in between the driver's legs. Not only is this safer, but the rules also require it.

Tires & Wheels:

A big question, and most common, is why we use three wheels instead of four? To answer that question we use three wheels because there is more drag added to an extra wheel. Without an extra wheel it is easier to reduce our drag on the ground. We have three 20" wheels on our vehicle. We have figured out that the larger the wheel is, the farther it will roll. According to the equation $C=2(\pi)r$ the longer the radius, the bigger the circumference will be. With considering that, larger wheels will roll farther than small wheels when being rotated. We bought our tires from a manufacturer with a hub in order to use drum brakes. The only problem with these wheels is the fact they are made out of strong steel which makes them heavier than what we wanted. We took out the stock bearings and added ceramic bearings for more efficiency. This would improve efficiency because ceramic bearings are a lot smoother when spun and less friction is caused when compared to metal bearings.

The type of tire we will use or are going to use all depends on the C_{rr} (Coefficient of Rolling Resistance). C_{rr} is very important to the vehicle because it is a part of Power Calc. C_{rr} is the rolling resistance of a tire, which means how much does the tire form or molds into the road it's running on. We test this by something called a Roll Down Test. There are three wooden blocks that are exactly one inch high. The blocks are angled to 45˚ degrees at the end. The vehicle is then placed with each wheel on one block. A driver must be put inside the vehicle for better accuracy. So now that it is barely hanging off the edge, the vehicle is released and gravity takes it as far as possible. The driver then presses on the brakes to stop the vehicle. The measurement is taken in inches and then divided by one. The lower the number, the better the C_{rr} because that means the wheels sticks less to the road. Although we tested many wheels we wanted the one that had the best C_{rr}. The ones we have chosen are Michelins.

Drive System:

Our drive system is fairly simple as it composes of a chain, two gears, and a motor. We are using a simple bike chain to make any corrections easier i.e. making the chain longer or shorter. The motor is Scott Motor that is supposed to reach max RPM of 3000. RPM stands for revolutions per minute meaning how many times it will make a complete rotation in one minute. The motor mount is positioned poorly because the motor does not line up with the rear wheel. This will cause the chain to curve or bend causing great stress and tension to the chain in places where it is not supposed to be happening. Also the gears are off because are gear ratio does not let us go faster. The current ratio we are using is a 44:15. We need to experiment with different types of gears that will allow the vehicle to run more efficiently. If we had correct alignment and a better gear ratio it is possible to reach our goal of 30 miles in one hour.

VI. Composites

Summary

Summary of Concept

Project Pulse was designed to be an electric vehicle with a steel chassis and composite body. The composites team, being inexperienced, spent the majority of the year learning about composites fabrication. The composites team also plans to create a body that will increase the efficiency and performance of the vehicle. This body will ultimately improve the aerodynamics of the vehicle and provide a body without adding too much weight.

Seat

The seat of the driver was composed of two parts, the backrest and the actual seat. The backrest was constructed from one layer of Coremat material sandwiched between two layers of two-ply fiberglass. The Coremat material is a very strong structural material and allows the finished product more rigidity and retention of shape. The material was constructed via a wet lay-up with epoxy resin and slow hardener. A wet lay-up is the process in which we mix the epoxy solution (hardener and resin) in a mixing cup, which causes a chemical reaction. We then apply it to a material, fiberglass in this case, before the chemical reaction finishes, or cures, allowing the material to absorb the epoxy, binding it to another layer of material. This process is used because it is not only quick, but also easily performed while still getting the job done.

As for the base of the chassis, we used aluminum honeycomb due to the durability of the material from its hex-core pattern and its resistance to flexing. These properties were suitable for the base of the vehicle because it also served as a base to the seat. Its resistance to flexing allowed our driver to safely sit in her seat.

Motor Control Cover/Battery Boxes

The motor control cover and battery boxes are made by performing a wet lay-up off of a mold. The mold is composed of cardboard that was cut up to the specified shape. Cardboard was used because it was malleable and inexpensive. It was filled with expanding foam to prevent the mold from caving in during the curing process. The mold was made so the battery boxes and motor control cover would come out as one whole piece. This process resulted in a much stronger piece, making it better for Project Pulse overall. It consists of two layers of fiberglass so it is light and flexible, but still has the right amount of resilience to withstand the weight of the battery.

Future Plans

Cerritos College

Due to our lack of knowledge in composites technology, we enrolled in a class at Cerritos College for Composites and Fiberglass Fabrication under Mr. Terry Price. Throughout the class, we have been able to correct major flaws in our vacuum bagging process, such as the placement of the probe, the application of sealant tape to the surface, and the failure to vacuum bagging on clean, even surfaces, which resulted in a series of leaks. We also learned various methods to increase the efficiency and perfect the products of our work. Some examples of this would be the usage of ears in vacuum bagging to prevent bridging, creases formed by crevices when vacuum bagging. We also learned how to adequately apply and use some of the materials we were unfamiliar with. In addition to enrolling the incoming sophomores into the Composites Fabrication classes, we plan to continue working with him throughout the progression of Project Pulse.

Body Design

Plans for the body design of Project Pulse have been decided. Since our program has designed and built many vehicles, our body design will be largely influenced by these vehicles. The shapes of the variety of these vehicles include: teardrop, box, as well as the classic Electrathon body shape introduced by Clark Beasley, as seen on Speed Racer. The weight, frontal area, and aerodynamic efficiency of the body will all be considered as we select the most suitable design. Due to the short timeframe in which we have to construct the body, we have decided to splash the body of our vehicle. The process to create a splash of a vehicle is much quicker than creating a mold, but it also causes the surface of the completed product to be slightly rough. After completing a sketch and outline of the body on AutoCAD, our design software, we will create a plug, or a fake copy of the vehicle, using plywood as material for the frame and expanding foam as filler. After gelcoating the completed plug, we will then create a splash of the plug; then, we will even out the surface and apply coats of paint and finish.

Material Possibilities

There are many possibilities for the material used in the making of the body. Through composites, we can use fiberglass, carbon fiber, Kevlar, or even a combination of inter-woven materials. The properties of these materials, such as the rigidity, malleability, and resistance to compression and stretching create many options as to what we use and where we use it. Due to the availability of these materials, we will most likely use fiberglass as the main component, reinforcing it with strips of carbon fiber where needed.

VII. Public Relations

The Public Relations and Project Management Office has been working on the plan needed to take Project Pulse out to race. Although we still have a long list to tasks to do, the LAAE have already taken several measures to succeed in the process. One measure is the announcement of Project Pulse.

There are currently two newsletters already published and one more coming along. The November 2011 newsletter describes how the Los Altos Academy of Engineering came up with the newest project. Looking for competitions to race in, the LAAE discovered the Emerald Coast Electrathon from the former advisor, Mr. Robert Franz. In the February 2012 newsletter, the Public Relations team explained where the vehicle would race and the progress on the vehicle's construction. The third newsletter of this year, which is going to be published in September, describes the completion of the Project Pulse chassis. In addition, LAAE has sent several members to Cerritos College to learn composites in order to make the Project Pulse body.

The 2012 Open House, was also the first event in which Project Pulse was showcased to the general public. This is important to the team because it displays a working vehicle to the programs supporters and sponsors. The showcase was successful as LAAE presented the new, working vehicle and drove it around for all to see.

Another part of the plan to send Project Pulse to Florida is fundraising. This trip requires large amounts of money to send the vehicle to Florida and back. In order to get the money to do this, the program has conducted fundraisers. Some of the ways the Los Altos Academy of Engineering has fundraised is through the Fireworks stand, the Pizza Company fundraiser, and the McDonald's fundraiser.

The third step is to determine how to get the vehicle to Florida and back. Several options that have been discussed include driving a van with the vehicle inside or trusting and asking a shipping company to ship the vehicle. Although shipping Pulse is probably very expensive, it is still a possibility. The two companies whom Public Relations and Project Management Office has spoken to UPS and FedEx. The cost, according to the information we have received would be approximately $1200 and $1700, respectively. Thus the cost will be an average of $1500. Both of these companies said that they would ship by land. There is much more needed information to consider before the decision is made as to which company we should use. Such information includes the speed and the cost of the shipping.

Some of the tasks that the Public Relations and Project Management Office still needs to complete are the publication of three more newsletters, fundraising to send the vehicle to Florida, talking to many other shipping companies, by land or sea. Shipping will be considered although not likely. Brochures of the new vehicle are to be completed and printed several months from now, preferably around the middle of February of 2013. LAAE plan to pass out the brochures at the competition so it is necessary to complete these brochures before the competition in Pensacola, Florida. The new newsletters of the 2012- 2013 school year should probably be published in November and February. These dates are subject to change. The trip plan should be completed in November. It may not be finalized, but it should be completed.

Fundraisers are a major part to the plan. More fundraisers are needed, but are not yet planned. These fundraisers are what will be needed to takes the team to compete in Florida.

VII. Future Considerations

Currently, Pulse is a functioning vehicle. It can travel on its own power at about fifteen miles per hour for a few minutes at a time. However, it is not ready yet for Electrathon USA, and we still have much to address and work on next year.

First of all, we have a completed chassis. However, it is still not finished and is not safe enough to race. Next year, the mechanical team plans to add structural support to the front and sides of the chassis. Currently, the front end of the chassis is not sufficient to fully protect the driver from collisions. We plan to fix this by welding steel tubes to Pulse to create structural triangles to improve the sturdiness of the car.

Another problem that we plan to address next year is the motor-wheel gear ratio. As of now, Pulse does not meet the thirty mile per hour goal set in the beginning of the year. Instead, it travels at about half of that speed. Ideally, Pulse should use about ten to fifteen amperes to run at thirty miles per hour. However, it uses about 22 amperes to travel at 15 miles per hour. In order to fix this problem, it was recommended to us that we change our gear ratio; as it is currently inefficient and is not maximizing the potential of our motor. Next year, we plan to make a series of gears at various teeth amounts and test them on Pulse in order to determine which gear ratio would be the most efficient on flat terrain similar to what we may encounter at the Electrathon.

We also need to address the problem of our vehicle’s suspension. Currently, with the addition of our shocks, our vehicle bends under its own weight at the swing arm. Our team has discussed several possible solutions to this issue, although there may be more. The first solution discussed was to reduce the length of the swing arm. Doing so would reduce the leverage and force the weight of the car is able to exert on the swing arm. The second solution discussed was to use longer and larger shocks, as these would be able to handle the weight of the vehicle. The last solution discussed was to change the angle of the swing arm in order to maximize its leverage and potential.

Furthermore, we plan to adjust the alignment of the rear wheel. Currently, it is crooked at a slight angle, which will reduce the efficiency of our vehicle. This will require fine tuning and precision on the part of our mechanical team to fix this issue.

Pulse currently does not have a composite body. Our composites team will need to work with our mechanical and design team to build a composite body for Pulse. Our team plans to create an aerodynamic body that will increase our vehicle’s efficiency.

Finally, next year, our team will need to run tests on Pulse. We need to run these tests in order to determine whether or not Pulse will be able to be efficient, fast, and last long enough in order to race in Electrathon USA.

Although these are all of our major considerations for Pulse for next year, there may be unforeseen considerations or problems that may arise. Although we cannot plan for these situations now, we can be ready to face them in the future.