E-Bike Conversion Kit
Progress Report

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Since the presentation of the project proposal, there has been significant progress on the project, along with substantial changes to the project design. The first significant change is regarding the electrical components and this major change was for the electrical motor and the motor controller. The electrical motor needed to be changed to a 250W brushed DC motor, and because of this, the controller needed to change too. The reason for this change was since there was no availability of brushless electric motors given the short time frame of the project. Luckily, a motor where the electronic controller was included with the purchase of the motor was abe to be found.

Since the project proposal, most of the significant components of the project have been ordered. The first was the 18, 3.7v 2500mAh LG HE4 lithium-ion batteries. These batteries were chosen because to build the smallest size battery pack, and we only need seven batteries in series. These batteries in series add up to approximately 24V. Then with putting the batteries in series in parallel with another set of series batteries, there will be a total capacity of 5000mAh. The motor will be operating at 10A continuous, therefore providing approximately 30 min of runtime for the electric bike. Another component that was ordered was a battery management system (BMS) and this will control the charging of the batteries to endure all battery cells are balanced while charging to prevent cell damage. This will also protect the batteries under short circuit conditions while providing undervoltage and overvoltage protection. A battery charger was also purchased, which will be used to charge the batteries. There were also modular connectors purchased that will be used to construct the lithium-ion battery pack. The team has also gone to talk to Craig Seaboyer, who is a Senior Electronics Technologist who works for St. Francis Xavier University (StFX). The group discussed the electrical aspects of the project with Mr. Seaboyer, and he informed the group that we can come by anytime when we need help or access to tools.

The next step for the electrical aspects of the project is going to be building the electrical diagrams using AutoCAD. These diagrams will show the interconnection between the BMS, the controller, the motor, and all the external sensors. Then, following the AutoCAD drawings being completed, the final wiring of components will start on the bike. Following this, the assembly of the battery pack, with the plan being to use seven batteries in series with two cells in parallel (7s2p). The final configuration of this is still needing to be determined.

Regarding the mechanical components of this project, there were no significant changes to the design. However, the size and type of motor had to be changed mainly due to availability. Based on the research that was done in the proposal of the project, this 250W brushed DC motor will meet all the requirements of the project. The plan is still to design an enclosure that will contain the motor, motor controller, batteries, and BMS. The supports for the enclosure and their attachment methods still need to be finalized.

The team met up with Steve MacDonald who is a machinist working in StFX's machine shop to discuss design requirements and make plans for the upcoming weeks. Steve was presented with a rough sketch of the enclosure and its contents. Steve requested that our next drawings be done in AutoCAD or Inventor, and that they are done in inches. After the arrival of all the parts, each part was measured and created as a part file in Inventor. By combining the part files for the motor, motor controller, batteries (including their connector pieces), and the battery management chip, the minimum dimensions for the enclosure were determined. After combining all the part files in inventor and leaving some extra room on each side for easy accessibility, the outer dimensions were determined as follows: 7.75'' x 12.75'' x

5’’. The bottom and the four walls of the enclosure will be made of 1/8” stainless steel, while the top of the enclosure will be made from 1/8” PVC. The group first decided on aluminum, when the plan was to bolt the sides onto the base. After discussing options with Steve, and discovering he could weld the pieces together, the group decided to switch to stainless steel. Stainless steel is the ideal option for material as it has a high corrosion resistance, high heat resistance, and the ability to be welded onto. The reason for using PVC as the cover material is because it is lightweight and was recommended by Steve. The PVC will be attached to the enclosure using hinges that will be welded on to the side of the enclosure. The thickness of 1/8” was determined by viewing the different sheets of stainless steel in the machine shop, discussing the different options with Steve, and taking into consideration that this enclosure is only needed to hold approximately 15-20 pounds, and will be supported both horizontally and vertically. Shown below (Figure 1) is the first stage of the enclosure that includes the base and the sides that will all be made out of 1/8” stainless steel as they will be required to be welded. The hinges, the lid, along with the horizontal and vertical supports are still in need of being calculated and designed.

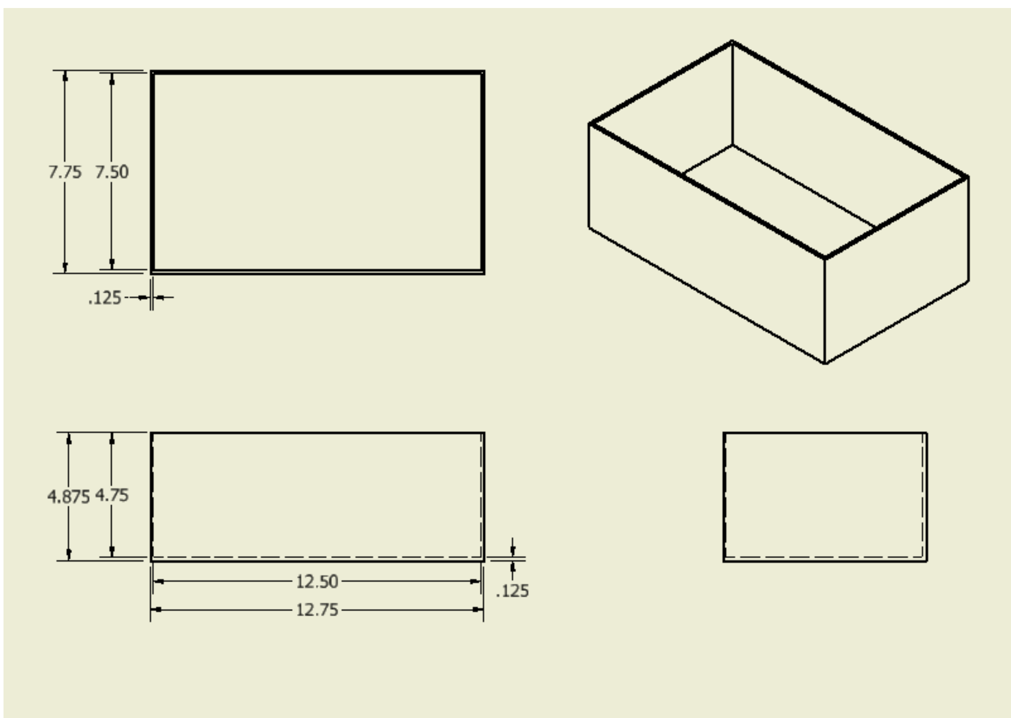


Figure 1 - E-Bike Case Views

After the latest meeting with Steve, the group provided him with the inventor file of the enclosure (Figure 1) as a starting point and Steve was able to produce a slab of wood with the same dimensions as our base piece of the enclosure. With this, we can physically lay the parts onto the slab, and mark exactly where they will sit, and where they will be secured to. This bottom slab also will allow us to get the exact measurement of how long the horizontal support will need to be. The gear of the motor will need to be directly above the center of the wheel, so the chain can run down. With this, we can place the slab where it will be, and measure the distance from the start of the enclosure to under the seat giving us the distance of our horizontal support. From this, we can also measure vertically down to determine the length of our two vertical supports. With this information, the next step will be to complete the inventor drawings of the supports, and how they will be attached. The options for how the supports will be attached to the bike are still being explored. Currently, we plan to use split rings for the attachment mechanisms to the bike frame. After finalizing all these designs, it will be time to get started with machine shop production.

The 250W DC motor was chosen because according to the motor specification sheet, it has a full load output torque of 22N/m which is more than enough to power the e-bike. The torque requirement of the bike was 1.7817Nm at 0° and 0.5056Nm at 5° angles of elevation, this was calculated by multiplying the friction force by the radius of the wheels and the cosine angle of elevation (theta). The friction force was calculated by multiplying the normal force acting on the bike by the rolling coefficient of friction that was researched to be 0.004 [1] between the wheels(rubber) and the road(asphalt). For the normal forces acting on the bike the group derived a total mass of (73Kg) by adding the mass of the bike(5Kg) and the estimated average mass of the person riding the bike(68Kg), then multiplied it to the acceleration due to gravity(9.81m/s^2).

<u>Values:</u>

Mass(m)= 68Kg + 5Kg

= 73Kg

Acceleration(a)= 9.81m/s^2

Rolling coefficient of friction (μ)= 0.004

Radius (r)= 0.6221m

Air resistance ignored!

<u>Solution:</u>

Normal Force (Fn)= (mass)*(acceleration)

Fn= (73Kg) *(9.81m/s^2)

Fn= 716.13N

Friction Force (Fr)= (Fn)*(μ)

Fr= (716.13N) *(0.004)

Fr= 2.8645N

At 0° angle of elevation:

Torque (T)= (Fr)*(Radius)*cos(theta)

T= (2.8654) *(0.6221)*cos(0)

T= 1.7817Nm

At 5° angle of elevation:

T= (2.8654) *(0.6221)*cos(5)

T= 0.5056Nm

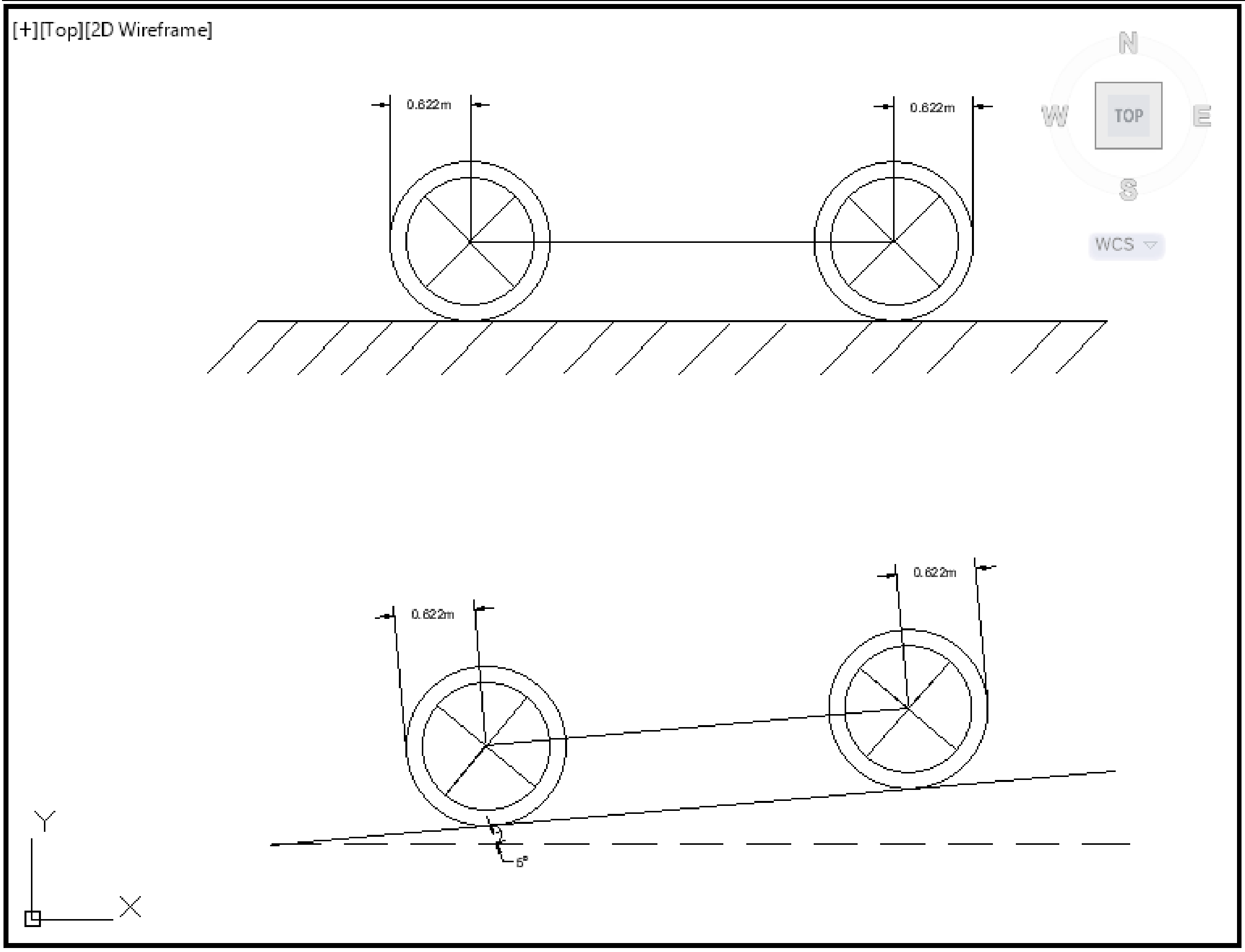
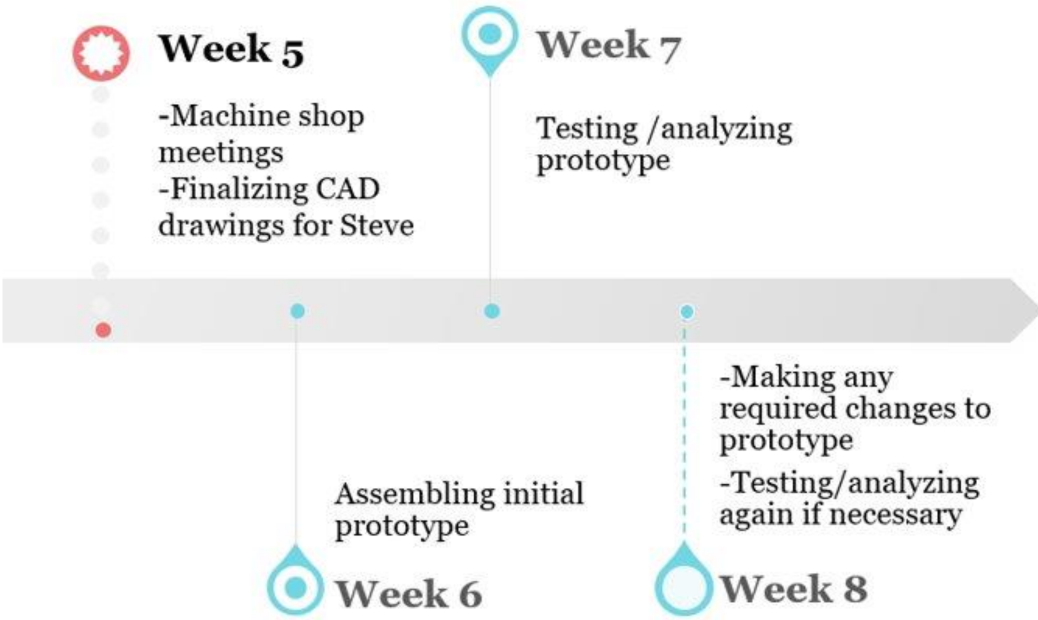


Figure2 – Free Body Diagrams

Currently we are in week five of the project and are progressing well. The timeline had to be slightly readjusted to compensate for the delay in the shipment of the parts which was out of our control. Looking forward, the goal is to have the parts enclosure and the supports produced in a timely manner. Then, the assembly of the product can begin which will be followed by the testing phase to ensure performance of the product.



The E-bike conversion kit project is progressing well from the both an electrical and mechanical aspect. A key to the progress and success that has been achieved so far has been the communication with the various technical experts in their respective fields, Craig Seaboyer and Steve MacDonald, to gain insight and expertise on certain aspects that are unfamiliar. This support, along with a learning curve that has come with the development of Inventor and anaylsis skills is becoming an asset for the progression and development of this project.

References

[1] The Engineering ToolBox, "Rolling Resistance," [Online]. Available: https://www.engineeringtoolbox.com/rolling-friction-resistance-d_1303.html. [Accessed 5 March 2020].