Project Deliverable H: **Prototype III and Customer Feedback**
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Why are we doing this test?

Our ideation process was a long and changing phase in the lifetime of the project. To create a system that applies force on the wheels in a way that creates enough friction to stop and slow down the robot, many diverse ideas came up. Most of them involved mechanical parts with different convoluted systems.

The above ideas had many problems that were associated with them. Most of those problems were related to the placement on the robot, and the feasibility of the proposed systems. With those dilemmas in mind, a brand new design was formulated. Instead of using a mechanical system, based on a motor to activate the brake, a purely electrical system controlled by arduino was created. This system involves a rubber brush attached to a solenoid that would be used to oscillate or apply a constant force on the wheel to slow down or stop Bowie. This system will be more reliable, and be much easier to equip to Bowie due to the smaller size of the solenoid in comparison to most mechanical systems ideated. However, there are a few potential problems with this solution that could only be verified through thorough testing. The amount of force that can be applied through a given amount of voltage is an important aspect to observe. Since there are only 5 available volts for the entire system, it is important to verify that the given voltage will be sufficient to brake Bowie's wheels in the required time. Moreover, the complexity of programming required to attain our desired objective might arise some problems which could force us to change the plan of our system. Similarity, the structural integrity of the system under a perpendicular force also has to be analyzed. The general objective of the third prototype is to build off of the flaws we encountered in prototype I and II and to create a realistic version of how our subsystem would work on Bowie. Higher speeds can also be tested to give some space for error, and make the system usable for possible future variations of Bowie.

Additionally, the prototype can be use to get more required feedback from Erin, to find the best way, if any, to place the system on Bowie.

Test Objectives Description

What are the specific test objectives?

-ability to stop the wheels with the solenoid attached to a brush.
-3D print all the parts same parts from Bowie used for the attachment of the wheel.
-Develop an app which allows us to control the solenoid by bluetooth.

What exactly is being learned or communicated with the prototype?

-Ability to stop a replica of Bowie's wheel
-To develop our programming skills and knowledge to create an app
-improvements to be made to the design
-mechanism
-Usage of a 3D printer
-Further develop our solid work skills and circuit knowledge

What are the possible types of result?

If our prototype goes as planned hopefully our program will activate the solenoid and, efficiently stop the wheel using gradient breaking or immediate breaking. Another outcome is failure, our prototype could easily malfunction or not be capable of stopping the wheel gradiently and will instead bring the wheel to a full stop each time, or our programming knowledge might not be sufficient for the development of the app and the achievement of our objectives. Another potential failure is overestimating our ability to create the 3D printed objects.

How will these results be used to make decisions or select concepts?

With these results in mind we will be more cautious with our materials, use the most efficient method, and we will prepare for the worst. Our

concept may still change, we will use our scientific and mathematical knowledge to make our decisions and select any new concepts required.

What are the criteria for test success or failure?

The main criteria for the test of success or failure is if our programming skills are efficient enough to accomplish our desired goals. Another factor is if our new braking system design which is attached to the solenoid will be capable of stopping the wheel effectively in both a manual mode, and a gradient mode. If the different gradient modes are capable of decelerating Bowie's wheels at different rates, and the manual mode is capable of stopping Bowie in the fastest possible way that will also be sufficiently fast, then the design is successful.

What is going on and how is it being done?

Describe the prototype type (e.g. focused or comprehensive) and the reason for the selection of this type of prototype.

This prototype was based off prototype I, II, the feedback we received from our client and our initial vision of our goal. We gathered all the flaws and successes in prototype I and II then recreated a more reliable and efficient way to stop Bowie the robots wheel. For prototype III we came up with the solution of using Bowie's exact design of his wheel and surrounding attachments, which we 3D printed from the design our client sent us. Furthermore, one of our initial goals was to be able to remotely control the braking system. For this prototype we will hopefully create an app which connects to the solenoid via bluetooth. Essentially this idea was the most reasonable and efficient. To make this prototype as realistic as possible we created an identical wheel and surrounding components of that of Bowie. To create an identical drive system of Bowie we need to improve our 3D printing and solid work skills. In conclusion, a lot of the parts which allowed our system to function were created in prototype II. Therefor, this

prototype was mainly focused on creating a realistic version of Bowie's drive system and to improve the overall subsystem (such as the bluetooth app).

Describe the testing process in enough detail to allow someone else to build and test the prototype instead of you.

Our final prototype improves upon the designs of first two prototypes and was thought of by adjusting the flaws of prototype I and implementing the programed arduino from prototype 2, with an accompanying bluetooth app.

For this prototype we took the circuit from prototype 2, and created a finalized PCB based off our breadboard layout. We then fixed up our program, and created a bluetooth app for it.

We drew up a basic sketch of our ideal circuit, and how the whole prototype will be mounted, so we had something to work from. Then we gathered our materials and started working on the function of the wheel. Our plan was to rotate the wheel on command from a remote bluetooth app from our phones. We connected our arduino to a motor by using connecting wires and the finalized PCB.

Once we got a fully functioning circuit we could add a wheel to the motor. To attach the wheel to the motor, we 3D printed a rim for wheel with a hole in the center to attach the motor with a screw. We wanted our prototype to be more realistic than the last so we decided to 3D print an exact replica of Bowie’s wheel and the attachment arms for the wheel.

With the part of the wheel out of the way, it allowed us to start working on the actual braking system. To start we got a larger solenoid that is an improvement to the stopping force of the last, and attached the solenoid to the same PCB as the wheel and began securing all connecting wires. For the action of the solenoid we decided to have it activate in both a oscillating motion, to gradually slow it down, and an emergency break which would activate then hold its position. Moreover, we learned enough

programming language to follow through with this plan as hoped. By using the arduino we could activate the solenoid whenever and however we wanted. Furthermore, we laser cut and put together a box, and attached the entire wheel assembly and solenoid system. The box had a hollowed interior to allow the PCB and arduino to fit. We cleaned up our circuit and Bluetooth app to make sure everything was functioning correctly. We finally created a 3D printed braking pad attachment to the solenoid.

What information is being measured?

During our testing of prototype III we measured the time required to stop the wheel using the Solenoid with a brush, and the rate of which the solenoid would pulsate to decrease the speed of the wheel by using the bluetooth app.

What is being observed and how is it being recorded?

Our progress throughout the development of prototype III is being observed with pictures and notes. We had to modify specific parts of the prototype by problem solving the obstacles we encountered in prototype I and II.

What materials are required and what is the approximate estimated cost?

1st Prototype

Materials	**Cost ($)**
Rubber Tape	4.32 + tax = 4.88
Cardboard boxes	Free (From CBY)
Solenoid (12V 5N)	Free (From CBY)
Breadboard	4.00
Electrical Wires	Free (From CBY)
4 AA batteries	Free (From CBY)
Battery holder	Free (From CBY)
Button	Free (From CBY)
Switch	Free (From CBY)
Fan	Free (From CBY)
3D printed wheel and cylinder	Free (From CBY)

2nd Prototype

Materials	**Cost ($)**
4 Relay Module	Free (From CBY)
Arduino Uno board	Pre-owned
Breadboard	Pre-owned
Wires	Pre-owned & Free (From CBY)
3D printed casing	Free (From CBY)
Tactile buttons x 3	Pre-owned

Solenoid (4.5V)	6.08 + tax = 6.87
Diode	Free (From CBY)

3rd Prototype

Materials	**Cost ($)**
4 Relay Module	Free (From CBY)
Arduino Uno board	Pre-owned
SPP-C Bluetooth Module	Pre-owned
Wires	Pre-owned & Free (From CBY)
3D printed casings	Free (From CBY)
Resistors (1kΩ & 2kΩ)	Pre-owned, Free (From CBY)
Solenoid (12V)	30.32
Diode	Free (From CBY)
Joint 5V & 12V power bank	Free (From CBY)
MDF board (3/32”)	3.00
PCB board	Pre-owned
Screws	Free (From CBY)
5.5 x 2.1 mm Male DC Power Connector Cable	Pre-owned
5.5 x 2.1 mm DC Power Y-Splitter Cable	Pre-owned
Toggle Switch	Pre-owned
Electrical tape	Free (From CBY)
Painter’s tape	Free (From CBY)

What work (e.g. test software or construction or modeling work or research) needs to be done?

We are still in the process of testing the force of our new solenoid. Since prototype II was more focused on the electrical circuit of our project it didn't allow for much time to test our new solenoid. Moreover, we must test a suitable brush which would provide enough friction to stop the wheel. We had to model a CAD box for the solenoid using solidworks and 3D print both the box, attachment clips and other components required for Bowies drive system. Furthermore, we have to test the reliability of the app and what functions we are able to implement.

When is it happening?

How long will the test take and what are the dependencies (i.e. what needs to happen before the testing can occur)?

We set the time frame to complete prototype III and presentation for design day on March 27th . Before the testing can occur we must gather all the materials and improve the outline of our plan. We depend on an efficient and effective team in order to finish our prototype in the desired timeframe. This prototype relies on a lot of 3D printing, it will be difficult to finish this prototype quickly considering 3D printing takes a while. Another dependency is our ability to learn a suitable amount of coding to be able to control and adjust both the motor and the braking system by using an app.

A separate test planning Gantt chart can be created to help making sure that the testing fits with the overall project schedule or it can be defined as part of that schedule (i.e. as a sub-task).

Since we created a fairly reasonable Gantt chart to follow it has made it easy to stay on schedule so far. Therefore, to this point the testing fits with the overall project schedule.

When are the results required (i.e. what depends on the results of this test in the project plan)?

For prototype III our results are required to be completed by March 27th according to our project plan. In order to meet this requirement we scheduled to find all the compulsory materials to create a visual representation of our enhanced idea. Furthermore, we had to make an outline of prototype III so we had a general plan we could follow, from there we used the time given to use during our lab to create the second prototype of our braking system.

Pictures of Prototype 3