# Prototype 2

**Design Team 6**
**05/11/18**

Objectives: The objectives of our second prototype is to combine a comprehensive physical prototype of our sand filtering system and to create a focused physical prototype for the break beam laser. For the sand filtering system, our main goal is to make verify the feasibility of the filter, so that the sand is able to filter out of the hopper. For the break beam lasers, our main goal is to wire and implement the code to the lasers, so that they can be easily implemented in the next prototype. Ultimately, these 2 prototypes give us the majority of our third and final comprehensive prototype.

**Prototype test plan:**

Filter:
Our goal for this test was to test the filter as well as our assembly's structural weaknesses. Because our prototype was comprehensive, we used it to gain knowledge on the performance of the filter when it was assembled with the other components.
Our test involved observations on the overall performance of the system as well as the ability of the filter to evacuate sand.

Laser sensors:
In order for the sensors to be successful, their break points and range had to be tested.
For the lasers to be implemented an understanding of their abilities had to gained.
This test involved developing code for the sensors and then testing the effects of different code in the output. We tested this by setting the lasers to be in alignment then obstructing the beam and analyzing what data was returned on the control monitor.

**Analysing critical subsystems:**

The results of our test yielded information on the nature of our project. Two major points of data collected were in regards to our sensors and filter. During testing we learned what coding tweaks needed to be made to have the lasers function properly. Our testing of the filter proved positive of its design and only slight design modifications would need to be made. The modifications revolved around polishing the assembly of the product and the cohesiveness of the different subsystems.

Physical design

The critical subsystem of the design of the hopper is the filter. This is the main focus of our design, as it is paramount to filter the sand from the hopper in order to maximize the space in

the hopper. After we built the hopper, we tested the filter to make sure that the sand and wet sand was exiting the filter, while maintaining the trash inside. Through our testing, we determined that 90% of dry sand was filtering through the filter. In addition, we determined that 80% of wet sand was filtering through the wet sand. The sand that didn't get filtered out was blocked by trash at the bottom of the hopper and could not leave. The reason less wet sand was able to filter out was because wet sand often got stuck to the trash, whereas dry did not. During this testing, no small or large trash items fell out of the hopper. This is well within our target specifications, as we had made our ideal and acceptable target specifications at 75% and 50%, respectively. We did not implement the ramps in this design as we already verified they work in prototype 1.
In order to improve this prototype from the last one, we changed the filter in the hopper based on our testing and benchmarking that we discovered in the last prototype. Whereas previously we had a rectangular filter with cut-out circles, our new and improved filter was a grid of continuous cut-out squares(see pictures). This change in the filter greatly impacted the removal of wet sand compared to the circle filter, as it was less likely to get stuck between the holes.

Setting up the lasers to be implemented in prototype 3

A key design concept our hopper is the implementation of lasers sensors that are able to determine when the hopper is full and must be emptied. After receiving the break beam laser sensors ordered online (see: deliverable E), we programmed them using Arduino so that the lasers are able to tell Bowie's operator when there is room in the hopper. It says “empty space”, when the laser sensors are not blocked and “Blocked” when the hopper is full. When an object passes through the lasers without blocking the sensors, the message appears as “Blocked” then “empty space” to signify that the item cleared the laser and there is still room . These messages are all printed to the serial monitor of Arduino. Obviously though, when the hopper is integrated with Bowie, there is a need to integrate these messages into the system of Bowie. However, this could not be done at the current phase of our production. In order for the lasers to be properly integrated, it needs a little power from Bowie’s battery. This would also have to be integrated with Bowie, and can not be done right now. Currently, the lasers are connected through the Arduino in order to monitor the messages being printed to the serial monitor. The connection through the computer is the current power supply for the laser sensors.

**Steps of Laser Implementation**

1) Order and receive lasers from https://www.adafruit.com/product/2167
2) Using the arduino instructions on adafruit.com, set up the wires on a breadboard in order to implement the code
3) Implement the code from adafruit.com
4) Edit the code so that it prints “Blocked” and “Empty space” to the serial monitor. Create a nested loop so that when an item blocks the sensor, only after 10 seconds it prints blocked in order to allow items to past by

5) Upload the code using arduino, and test the code by viewing the messages printed to the serial monitor
6) Buy a PCB board from the maker lab and switch the wires from the breadboard to the PCB board
7) Solder the wires together on the PCB board
8) Plug the lasers into the keyboard and test to make sure it is working properly.

**Steps of Physical Design**

1) Create vector pdf of the Hopper design using Inkscape
2) Purchase acrylic sheet and laser cut the hopper design out of the sheet using the vector pdf file
3) Design Brackets to hold the Hopper walls and filter together
4) 3D Print Brackets
5) Acquire sample filter from store
6) Cut filter to proper dimensions
7) Construct complete Hopper using hot glue to cement the pieces together
8) Use leftover sand acquired for prototype 1 to test the new filtration design's efficiency at filtering out both wet and dry sand.

**Stopping Criteria**

Sensors:
There are 2 main situations that have to be resolved in order to stop testing the sensors. The first is when an object passes through the sensors. This stopping criteria occurs when an object passes through the sensors, registers as "blocked" on the serial monitor, and then immediately prints "empty space". This is a necessary stopping criteria since it shows that an object was deposited in the hopper, yet there is still more space. The second situation would be when an object is deposited in the hopper and the hopper is full. The stopping criteria would be that the sensor would print "Blocked" to the serial monitor, and stays as "Blocked" rather than switch back to "empty space" like in the previous situation. This is a necessary stopping criteria because it shows that the hopper is full and trash needs to be removed.

Physical design of the hopper and filter:
In order to stop testing the physical design of the hopper, 2 things must occur. The first stopping criteria is that sand, including wet sand, exits the hopper through the filter. This is the main goal of the design. The second stopping criteria is that after the sand is removed, the items and garbage in the hopper stays in the hopper, as it does not pass through the filter. This is important because it would be useless if the filter holes were big enough that the trash and sand passed through the filter and back onto the beach. So, only once it has been explicitly shown that sand is being removed from the hopper, and the trash is staying in, can the testing be finished.

**Conclusion**

In this prototype, we combined a comprehensive physical prototype of the hopper with a focused prototype of the laser beam sensors. We verified the feasibility of both the filter, in order to ensure that it was filtering the sand as we had originally hoped. For the lasers, we coded, wired and solder all the wires together. This will allow us to implement the lasers easily in prototype 3.