

# **Project Deliverable E: Project Schedule and Cost**

Danielle Courtney  
Riana Leveque  
Amanda Lawrence  
Hiba Abdelali  
Amelie Simon

February 19th,2023

## Table of Contents

<b>1. Introduction</b> .....	<b>2</b>
<b>1.1. Chosen Design</b> .....	<b>2</b>
<b>2. Detailed Design</b> .....	<b>3</b>
<b>2.1. Diagrams</b> .....	<b>3</b>
2.1.1. Full Silo View .....	3
2.1.2. Side View and Front View .....	3
<b>2.2. Diagram Explanation</b> .....	<b>4</b>
<b>3. Project Costs and Components</b> .....	<b>5</b>
<b>3.1. Software and Construction</b> .....	<b>5</b>
<b>3.2. Materials</b> .....	<b>5</b>
<b>4. Project Task Plan</b> .....	<b>6</b>
<b>5. Prototype Test Plan</b> .....	<b>6</b>

### 1. Introduction

Following what we have done for the past deliverable, in this deliverable we will make sure to present a clear/detailed concept for the selected design, the cost of materials and components, and include links to each item presented.

Furthermore, we will also include a list of equipment needed to build each prototype and will outline a prototyping test plan to prepare to build the first prototype.

#### 1.1. Chosen Design

In the last deliverable our group agreed on three final designs. Design 1 is the combination of the gliding track, receptor and receiver with infrared frequency measurement method. Design 2 consisted of the fan, beam, and measurement system with a pressure chamber system. Lastly, design 3 was created by combining a hook installation system, dust sensors, and adaptable particle sensors with micro-filtration and wheat sensor system.

In the end, we will only work with one device and the perfect device we could've come up with is a device that includes a DC motor that spins a pulley system. Moreover, attached to this system we find an ultrasonic sensor to tell height of malt and an infrared sensor to tell the place where dust ends, and malt starts.

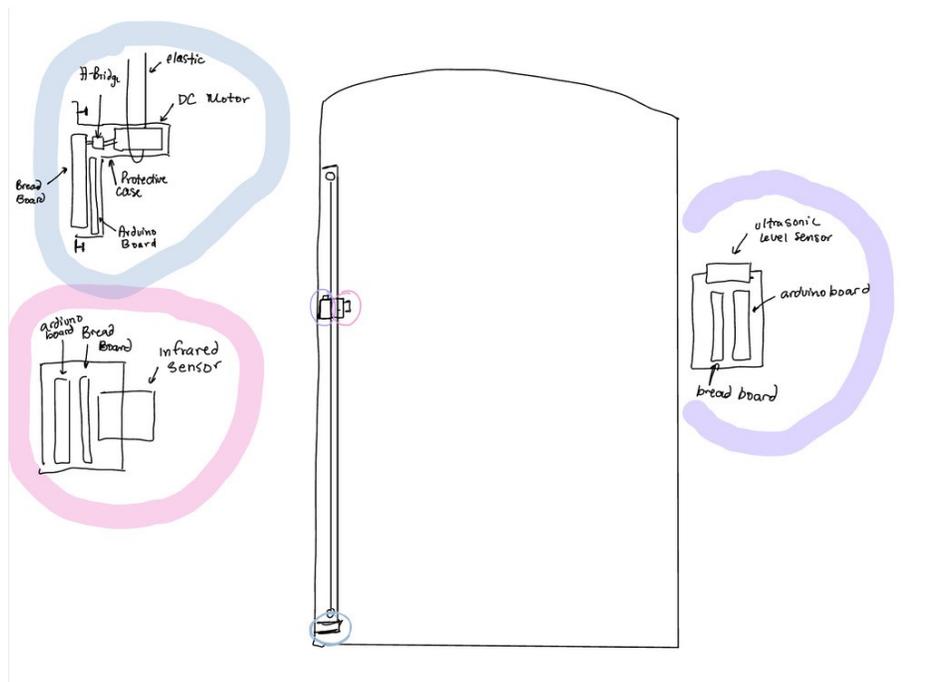
## Deliverable E

Based on this, we had to let go of the designs with the pressure vacuum, fan, beam and microfilter with a wheat tracker, since the previous designs had a lot of elements that would become expensive.

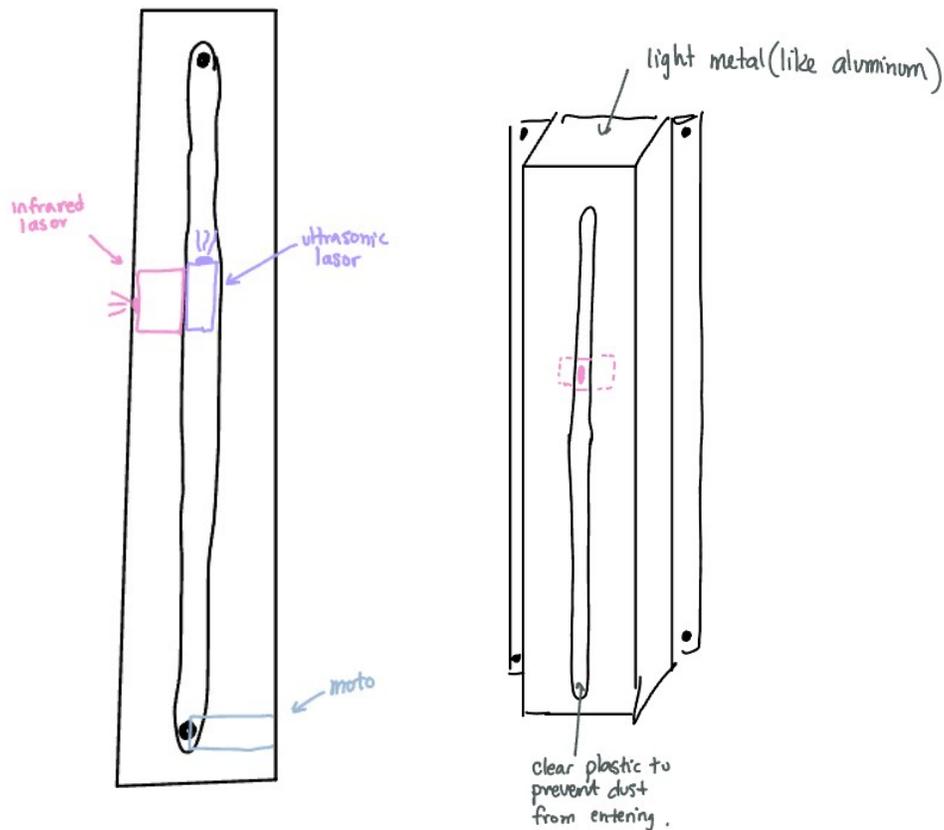
## 2. Detailed Design

### 2.1. Diagrams

#### 2.1.1. Full Silo View



#### 2.1.2. Side View and Front View



## 2.2. Diagram Explanation

This design consists of three major parts, the infrared sensor, ultrasonic sensor, and DC motor. A pulley system will be created using the DC motor to turn a belt. This system will allow the sensors to be lowered until the change from dust to malt is detected. The motor will be located at the bottom of the device and will be programmed using an Arduino Uno. This Arduino Uno will also have a H-Bridge connected to it. The H-Bridge allows the user to control the direction that the motor spins. Therefore, when spinning in one direction it will pull the sensors downward and when in reverse, it will raise the sensors to reset the system. Attached to the motor's belt will be two sensors, an ultrasonic sensor and an infrared sensor. The infrared sensor will start near the top of the silo and be lowered by the DC motor. It will be used to detect when the material within the silo changes from dust to malt. It will be able to detect this because the malt is denser than the dust and will therefore let less light through. This sensor will also be attached to an Arduino Uno to let the user know when this change occurs. Attached to this sensor will be an Ultrasonic level sensor. This sensor will be used to measure the distance from the sensor to the top of the silo. Since both sensors are at the same level, syncing the sensors information will inform the user of the location within the silo where the malt beginnings. Then by subtracting the distance measured by the ultrasonic sensor from the total height of the silo, you are left with the height of malt. Using this height, you can find the volume of malt if you have the radius of the silo. After calculating this volume, the user is aware

## Deliverable E

of how much malt can be pumped out before reaching the layer of dust. This pulley system will be enclosed in an aluminum case. This case will have a clear plastic window which will allow the infrared waves to exit the case, while preventing malt or dust from entering the system. This aluminium case will not be directly attached to the silo, but a metal holder will be attached to the wall of the silo. This way when maintenance is needed, the case can be lifted from the silo using the hatch in the roof and the hook on the top of the case. This way no one needs to enter the silo. This also prevents the risk of explosion since all the maintenance will be done while the device is outside of the silo. Then, once maintenance is completed, the device can be lowered back into the tracks attached to the silo that will hold the device in place.

### 3. Project Costs and Components

#### 3.1. Software and Construction

Tool	What it does	Cost
Arduino IDE	This IDE allows us to write code which can control the input and output of the system that is controlled by Arduino Unos.	\$0
3D Printing	We will need to 3D print components of motor and a case for the sensors to be held together.	Cost of materials
Welding	The metal case for the entire system will be needed to be welding together.	Cost of materials
Soldering	The wires will be soldered together so that a breadboard is not needed. This is because when transporting the device, the wires could come loose in the breadboard.	Cost of materials
DC_Motor.h	This is the library for the DC Motor which allows us to control the speed, and direction of the motor.	\$0
Wire.h	This library is for I2C communication and will allow the multiple devices to communicate with each other.	\$0
NewPing.h	This library allows us to control the ultrasonic sensor.	\$0
SharpIR.h	This library allows us to control the infrared sensor.	\$0

#### 3.2. Materials

[https://docs.google.com/spreadsheets/d/1\\_6eDXblhRYOx4zYgXHt28yj-Eaj8WlcSOY6wxMTWIOM/edit?usp=sharing](https://docs.google.com/spreadsheets/d/1_6eDXblhRYOx4zYgXHt28yj-Eaj8WlcSOY6wxMTWIOM/edit?usp=sharing)

## 4. Project Task Plan

<https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=W0i6TQepbeJ6ZhzyYW2wj0PJPBqUQxZb%7CIE2DSNZVHA2DELSTGIYA>

## 5. Prototype Test Plan

Test ID	Test Objective (Why?)	Description of prototype used and of Basic Test Method (What?)	Description of Results to be recorded and how these results will be used (How?)	Estimated test duration and planned start date
1	Tested to ensure that these boards send the right information to the right place and are connected in the correct manner. By triggering the Arduino uno board we will be able to see which device setups work and don't	<p>Arduino Uno and H boards</p> <p>The LED test light on an Arduino uno board signals about every two seconds and the communication should be almost instant between the base computer and the devices</p>	Recording the set-up, any changes that were made, and any coding that needed to be adjusted. These results will be used so that we can benchmark and choose the most efficient method	So, the overall time should take <b>5 minutes per board</b> , if not less.
2	Tested to ensure that the method of infrared is effective for the desired outcome	<p>Infrared sensor</p> <p>It will be used to detect when the material within the silo changes from dust to malt. It will be able to detect this because the malt is denser than the dust and will therefore let less light through.</p> <p>To test we can build a mini version of the silo environment and measure the infrared as it moves through the lighter material ("dust")</p>	<p>Infrared sensors and the ultrasonic and the ultrasonic sensors go together, the time it takes to notice a change in infrared throughout the dust vs malt will trigger the sonar waves which will then give a distance</p> <p>All measurements will be recorded as well as changes that are made to once</p>	To test both the emitter and receiver using an Abati multimeter takes about <b>3-5 minutes each</b>

Deliverable E

		to the heavier material (“barley wheat”).	again ensure that we are using the best set up as possible	
3	Tested to ensure that the sonar waves act effectively with the infrared ensuring successful device	<p>Ultrasonic sonar: This sensor will be used to measure the distance from the sensor to the top of the silo. Ultrasonic sonars work because they have two ports on sends an upward ultrasonic wave and as soon as the wave hits an obstacle (being the roof of the silo in this situation) it rebounds. The other port receives the rebounded wave and measures the distance between the sensor and the roof based on how long it took for the wave to return.</p> <p>We can test these sensors with an Arduino uno board, the sensors, female/male jumper cables and some type of obstacle, then by triggering the sensors once the wave returns a distance measurement will be sent to the base computer.</p>	^^^	Testing should take in total 7-10 minutes
4	This needs to be tested to ensure it glides smoothly over the bearings and is strong enough to carry the weight of the sensors.	<p>DC motor and pulley system: A pulley system will be created using the DC motor to move a belt. This system will allow the sensors to be lowered</p>	Notes of how well the bearings rotate with the motor and belt, any changes, tweaks or adjustments to be made to any	10 minutes to make sure things are moving smoothly

Deliverable E

		<p>until the change from dust to malt is detected</p> <p>This will be tested by setting up the system with two opposing vertical attachments, running the motor and taking note of how the system moves</p>	<p>parts of the system including the motor, code, belt material, attachments, etc.</p>	
5	To make sure device is completely successful	<p>Simultaneous testing of all parts</p>	<p>Any rejigging of how pieces are attached and connected, as well as the longevity of cohesive movement</p>	<p>15-minute test duration to be able to test all parts and devices simultaneously ensuring everything runs cohesively</p>
6	To make sure the entirety of the device can be completely enclosed and no risk of exposure to harsh environments	<p>The device casing</p> <p>This can be tested by closing the casing completely and exposing it to potential environmental changes i.e., water, dirt, dust, etc.</p>	<p>Whether or not casing is properly secured</p>	<p>10 minutes, max</p>