

Project Deliverable D: Conceptual Design

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February 12th,2023

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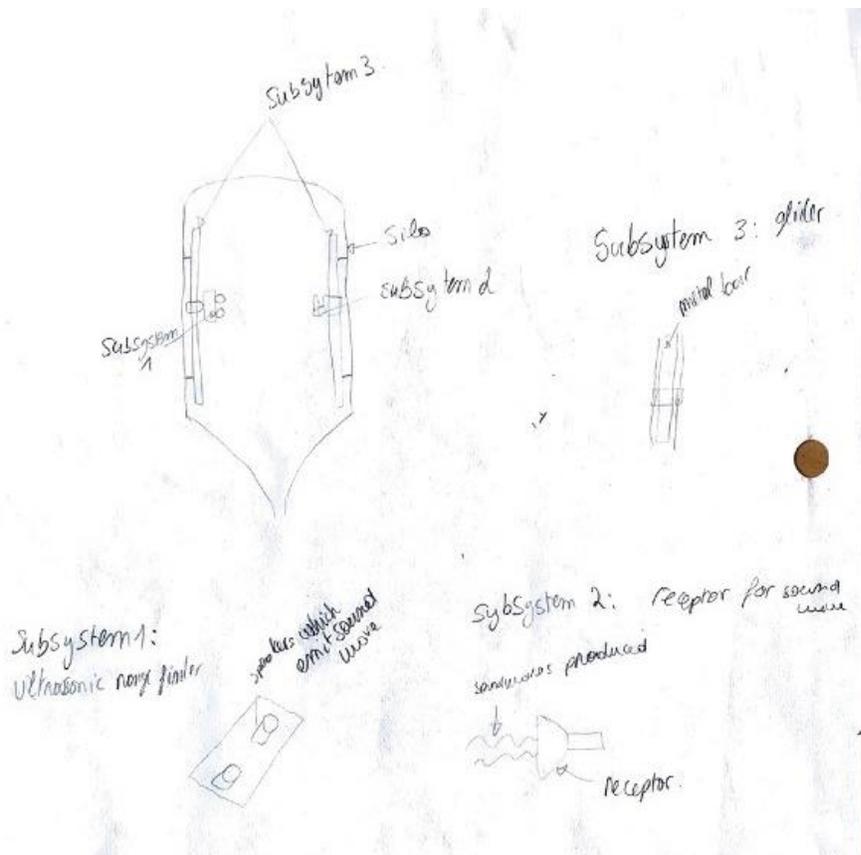
1. Introduction

In this deliverable, we are going to develop a set of conceptual designs for our problem statement. These designs will be based on the previous user benchmarking, technical benchmarking, and the list of prioritized design criteria we have developed. The generated subsystems will permit us to evolve our project as they are ideas that we have created and in which we got inspired in function of the client’s needs during our first meeting with the client. By analyzing and evaluating these concepts we are going to decide on the best subsystems, and create new systems using the combination of the original concepts. Then based on the design criteria one design will be selected and farther developed.

2. Design Concept Generation (Sub-system)

2.1. Design 1: Ultrasonic Dust Sensor (Amelie Simon)

This design consists of two gliders, an ultrasonic range finder and a receptor. The two gliders, placed on opposite sides of the silo, carries the two machines which are leveled. The sound waves are produced at the ultrasonic range finder and are then analysed at the receptor. The pattern of the waves will change whether it is passing through the dust or the malt. This change can be analysed, and the clients can be alerted when dust has been detected. The client will be alerted of the height where the dust was detected.



2.1.1. Subsystem 1: Ultrasonic Range Finder

The ultrasonic range finder uses sound waves, that human cannot hear, to measure distance by listening to the echo wave. In the concept, it will be used as to produce the sound waves only. The waves will be measured using a receptor, they will change pattern when passing through dust compared to malt this change can be noted and alert the client when the waves pass through dust.

However, the speakers of the range finder need to be protected because dust or any particles can hinder the sound wave production. This protection will have to be a material through which the sound waves can pass through with minimal change to the pattern.

2.1.2. Subsystem 2: Receptor

The receptor will be held opposite (on the other side of the silo) the ultrasonic range finder to be able to catch the sound waves and produce graphs of the sound waves produced. Those graphs can be analysed and depending on the pattern, it will detect whether it is dust or malt. Then, the client will be alerted to the distance there is to dust.

As for the range finder, the receptor will have to be protected in order not to be clogged by dust.

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2.1.3. Subsystem 3: Glider

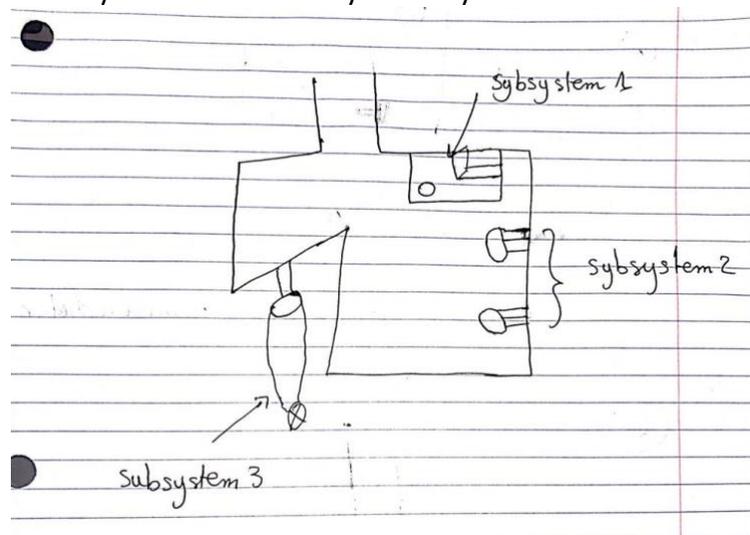
The glider will be a system of two metallic bars placed on opposite sides of the silo with a box attached to it to place the range finder and the receptor. One bar will hold the range finder, the other will hold the receptor. The two devices will have to be, at all times, directly opposite of each other, on the same axis for the best measurement to be measured.

The boxes are allowed to move on the bars to get measurements at different heights to not miss the dust.

This system will be hard to install in the silo.

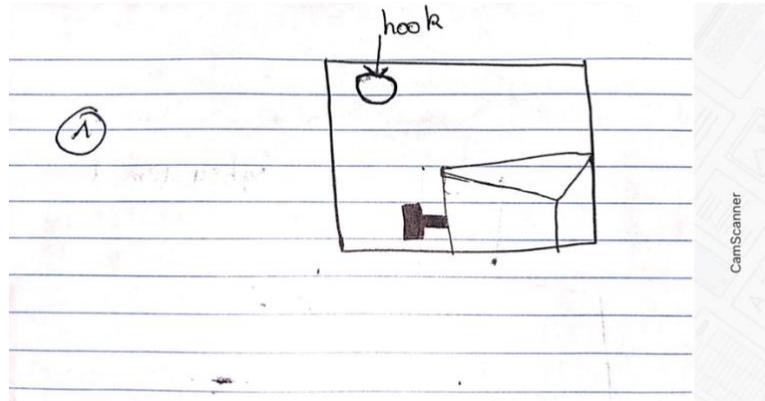
2.2. Design 2: Dust Sensor and Collector (Hiba Abdelali)

This module integrates mature dust detection technology, it has high sensitivity to detect the dust particles in air and malt with good consistency and stability. It is also easy to use and can be used with ventilation systems and brewery industry.



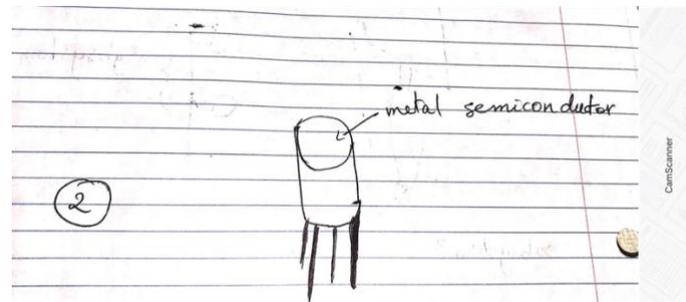
2.2.1. Subsystem 1: Zh08 Dust Sensor

The attachment of this subsystem with a vertical hook on the roof has so many advantages but most importantly the installation becomes very flexible. It has a real time response accurate data and low power consumption and it adopts particle counting principal to detect the particles. The dust sensor uses an optical sensing method to detect dust. A photosensor and an infrared light-emitting diode which is known as an IR LED are optically arranged in the dust sensor module. The photo-sensor (PT) detects the reflected IR LED rays which are bounced off the dust particles in the air.



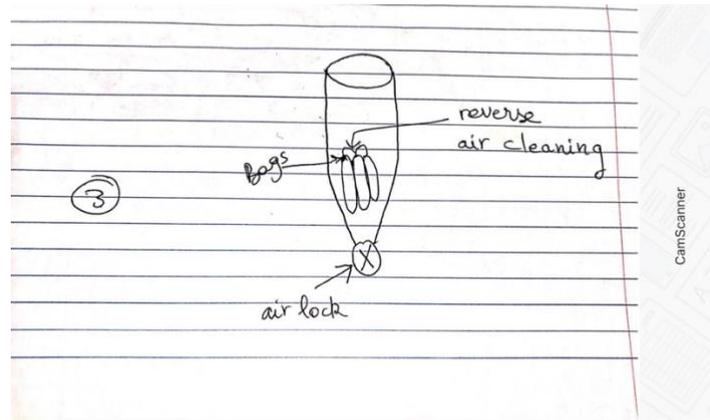
2.2.2. Subsystem 2: Wsp 2110 Gas Sensor

This sensor adopts multilayer thick film manufacturing technology. The heater and the metal oxide semiconductor material on the ceramic substrate of subminiature are fetched out by electrode down lead, encapsulated in metal socket and cap, it is used in automatic exhaust device, and it has also high sensitivity to organic gases such as benzene.



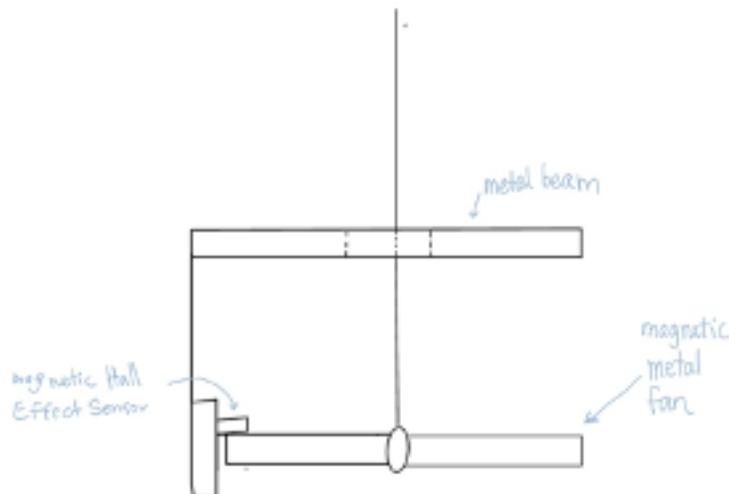
2.2.3. Subsystem 3: Dust Collector

This subsystem has so many advantages such as small size, light weight and it is easy to install and use, simple maintenance. It has also a good stability for a long period of time. Dust collector system work by drawing dust and particulates from the air through a filter that first captures and separates the matter and then discharges purified air back into the workplace or environment.



2.3. Design 3: Fan Dust Sensor (Amanda Lawrence)

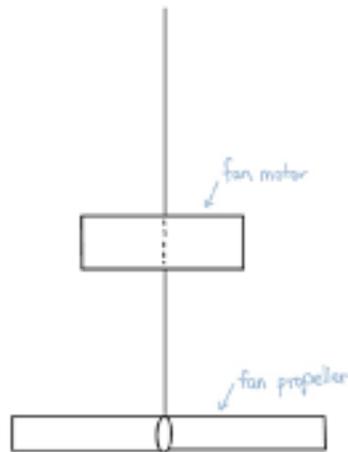
This design is for a fan system which would be installed in the silo. This system uses the difference in density between the dust and the malt to detect when the layer of dust reaches the level of the fan. It will then send an alert the user which informs them of how much malt is remaining in the silo. The volume of malt remaining in the silo will be calculated using the height of the fan above the ground and the diameter of the silo. The sensor will let the user know when to stop pumping the malt to remove the left-over dust.



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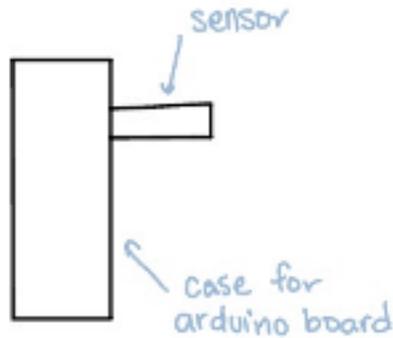
2.3.1. Subsystem 1: Fan

The first subsystem consists of a fan and its motor. The fan will hang from the roof of the silo, with a distance of three meters from the floor. This distance allows easy access for repairs and maintenance, since a six-foot ladder allows the average person to reach over 3 meters high. Easy access for maintenance was very important to the client. This distance also keeps the blades of the fan well above anyone's head for safety purposes. Also, technical benchmarking shows that industrial fans, that are approximately 3.5 feet in diameter, range between \$700 and \$1100, which is very affordable. A negative aspect of this subsystem is the large size and weight of the design. To reduce this issue, light weight metals like aluminum which has a density of 2710kg/m^3 can be used.



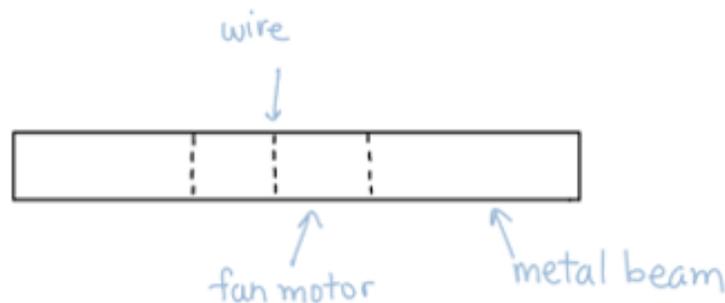
2.3.2. Subsystem 2: Magnetic Hall Effect Sensor

The hall effect sensor will be used to detect when highly magnetic metal crosses its path. Therefore, the ends of the blades could be coated in iron which is denser than aluminum but is more magnetic. This sensor will then be connected to an Arduino board which will measure the rpm of the fan's blades. If the rpm is high, this means the blades are rotating faster with less resistance indicating a lower density of material, like dust, but if the rpm is low, more resistance is being applied to the fan indicating it is pushing malt. Therefore, the sensor will let the user know if they can continue pumping the malt out of the silo. This sensor is very affordable, the version for the Arduino board is priced around five dollars and can go to around twenty dollars for more elaborate versions. Also, since the location of the sensor being at the same level as the fan, it is only 3 meters above the ground so there is easy access for maintenance.



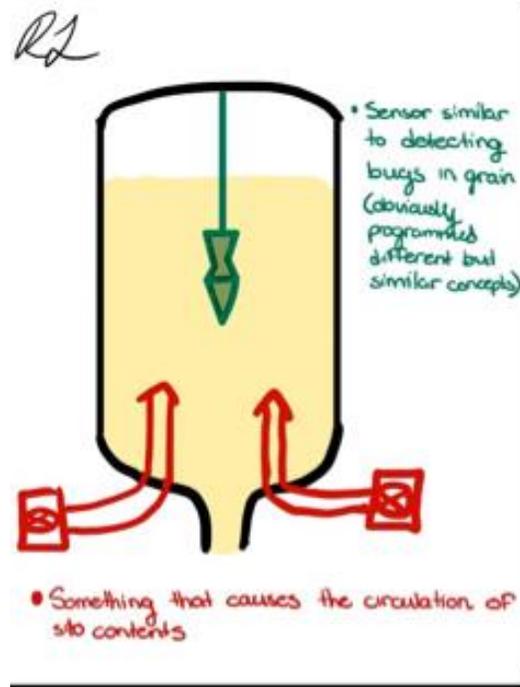
2.3.3. Subsystem 3: Beam

This beam will be used to keep the volume of material being spun by the fan constant. Without the beam, more force would be applied to the fan if the silo was completely full then if it was half full. Therefore, the sensor would not be able to give an accurate reading of the material at that level. The beam will support the load of the material directly above the fan and create a pocket of constant volume where the fan is being spun. Therefore, the detection of dust will be able to take place. Also, the beam will prevent damage to the motor since the fan's motor will be stored inside the beam. This way, less maintenance will be needed on the fan. A negative aspect of this subsystem is the material for this beam would need to be very strong as it is supporting a large mass, which means it would be heavy and difficult to install. A positive is that due to its simplicity and height above the ground it would be easier to do maintenance on the device.



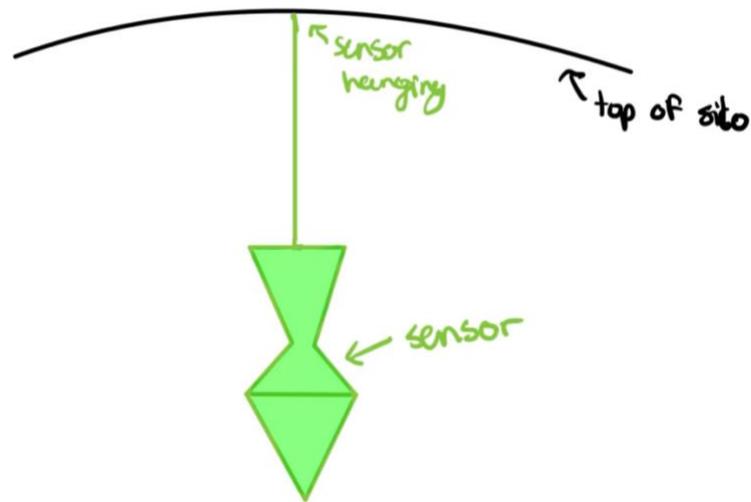
2.4. Design 4: Sensor & Circulations (Riana Leveque)

This design utilizes a sensor, and a fan to promote circulation within the silo. It is modeled with the idea of sensing bugs/insects in grain in mind, with obvious programming differences in the sensor. This would need power, to generate the fans, causing an additional cost and it would also take up more space around the sensor than other designs. Another flaw that was pointed out upon presenting the idea, is this model would mix together the wheat and malt.



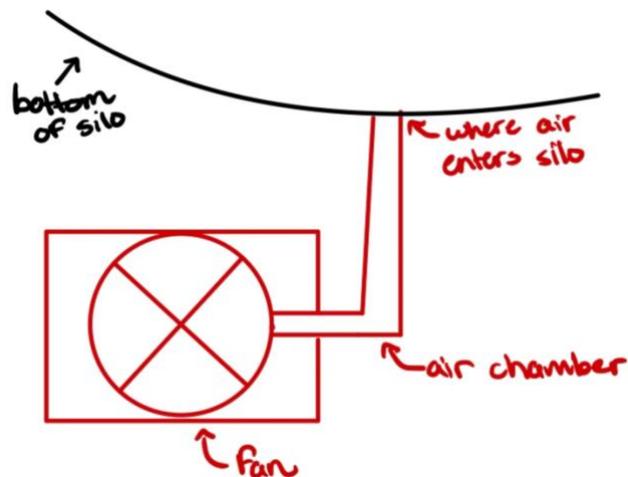
2.4.1. Subsystem 1: Dust Sensor

The sensor would be hanging from the roof of the silo, allowing for easy access as most are removable for maintenance. The dust sensor would be programmed to determine how much dust is in the malt, information that the client has asked us to secure for them. This sensor would be a modified version of one that determines if there are insects, and how many, in grain.



2.4.2. Subsystem 2: Fan/ Circulation System

The fan would provide the energy needed to circulate the malt/dust, though there is a flaw as it would cause the malt and dust to combine. The fans would be connected to the bottom of the silo, on the outside, forcing air up. Having the fans on the outside will allow for easy access, but will also take up valuable floor space.



2.5. Design 5: Pressurized Filtration (Riana Leveque)

This system utilises a pressurized-vacuum system to stop movement within the silo, meaning the malt and wheat are unable to combine. In the bottom, there is a micro-filter that stops the wheat from exiting the silo, only allowing malt to pass through to the next part of the brewing process. Within the micro-filter, a tracking device would measure how much wheat the filter is stopping from passing through.



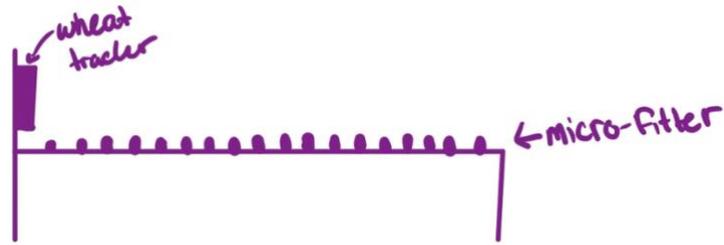
2.5.1. Subsystem 1: Pressure Chamber

The pressurized system, utilizing vacuum like components, ensures the contents of the silo are unable to move except for exiting through the micro-filter.



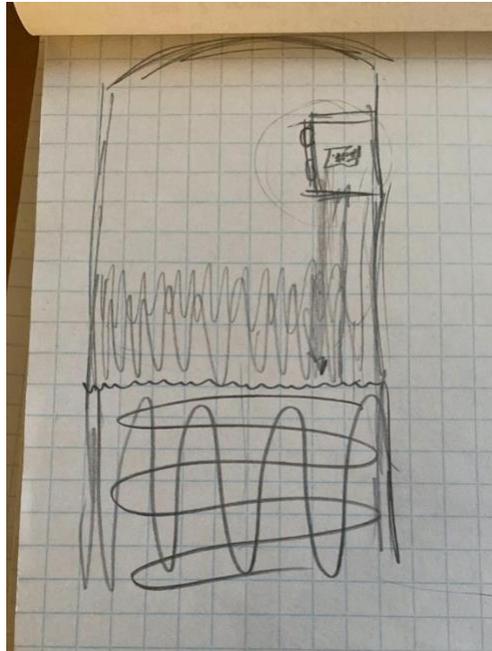
2.5.2. Subsystem 2/3: Micro-filter With Wheat Tracker

The micro-filter stops the small (sometimes microscopic) wheat particles from leaving the silo, while allowing the liquid malt to pass through. In order to determine how much wheat is being stopped, a tracker is installed directly on top of the filter, which measured how much wheat is remaining in the silo after all the malt has passed through.



2.6. Design 6: Infrared Dust Sensor (Danielle Courtney)

This design is for an infrared measurement system to be installed near the top of the silo. This system uses infrared frequencies to differentiate between the dust and wheat in the silo and sends a distance measurement back to its base. This measurement is then sent to the operations system which then tells the operator what point to offload the wheat till, leaving just the dust behind.



2.6.1. Subsystem 1: Infrared Receiver

The first sub-system in this design is the infrared receiver. This is where the release and return of the infrared frequency occur. Infrared waves are longer wavelengths that can sense what may not be as easy with other devices, being dust in this situation. With other sensors particles of dust may be left behind but infrared can detect beyond what the human eye can see. Because dust and wheat give different heat signatures the moment the wavelengths pass through the dust and detect the wheat, that distance will be recorded by the receiver.

The base of the system will be located near the top of the silo on the wall, with easy exterior access to the necessary parts. A system to be able to reach the device would have to be already in place for the design to be feasible.

A complication with this system is a silo is not immune to outside temperatures without help. There needs to be a way to maintain a core temperature to ensure accuracy with the infrared measurements.

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2.6.2. Subsystem 2: Internal Computer

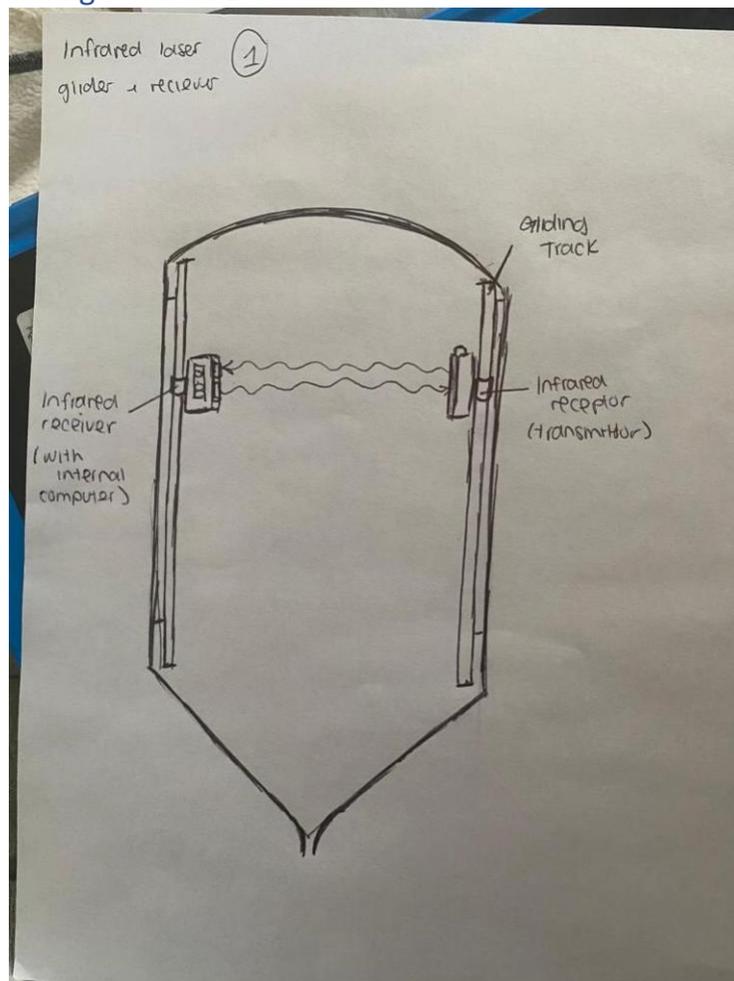
The computer on the inside of the base is responsible for the record keeping and transmitting of measurements recorded by the infrared receiver. The operator needs to be able to send requests for the desired measurement and receive the number quickly to ensure operations don't slow. Correct coding and reliable features are vital for this to be successful

2.6.3. Subsystem 3: The Base

The base is where everything is held. It protects all technology and operations from internal and external interference. It has a casing that keeps all parts clean and clear of materials while still maintaining those organic ideologies of which are so important to the company.

3. Concept Generation (Full Solution)

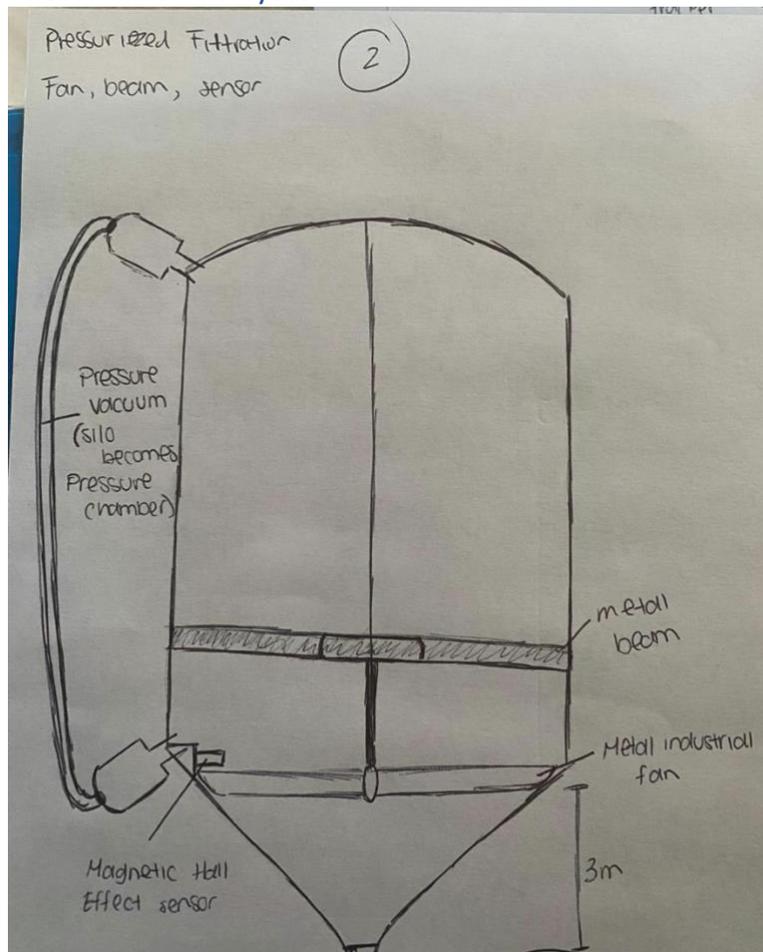
3.1. Design 1: Gliding Infrared Dust Sensor



This design is a combination of design 1 using a gliding track and the receptor and receiver used in that design with design 6's infrared frequency measurement method.

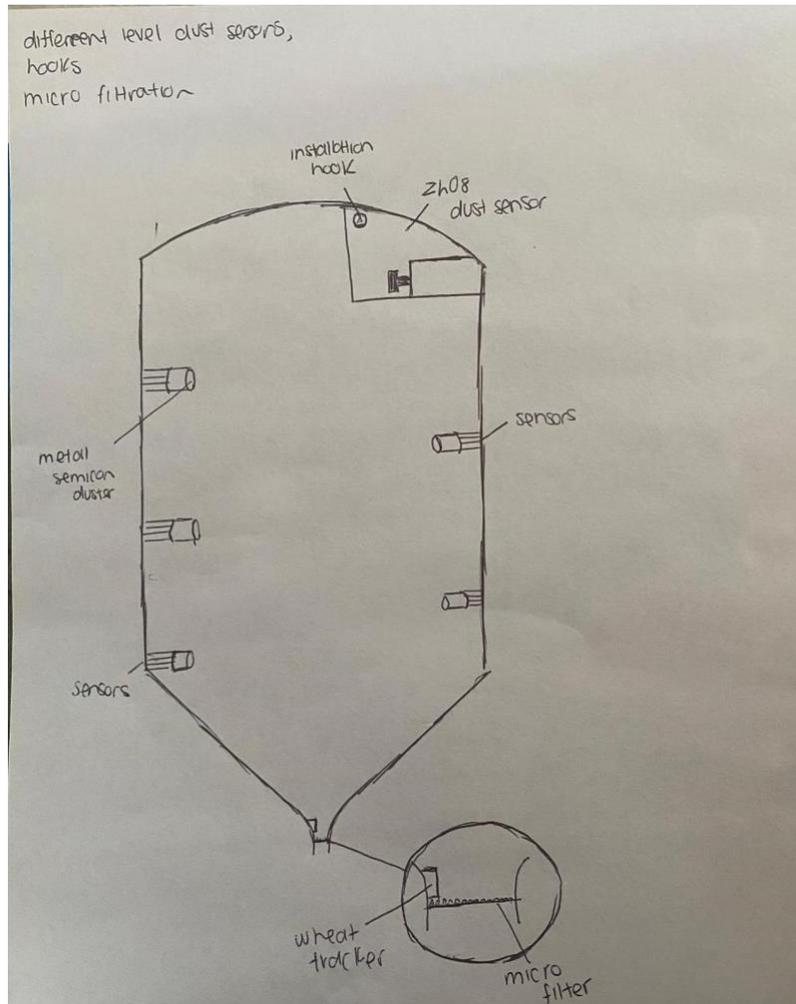
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3.2. Design 2: Pressurized Fan System



This design is a combination of design 3's fan, beam, and measurement system with design 5's pressure chamber system.

3.3. Design 3: Multi- Sensor Dust Collector



This design is a combination of design 2's hook installation, dust sensors, and adaptable particle sensors with design 5's micro filtration and wheat sensor system.

4. Analysis and Evaluation

4.1. Positive and Negatives of Designs

4.1.1. Design 1: Infrared Dust Sensor

4.1.1.1. Subsystem 1: Glider (Design 1)

A positive aspect of this subsystem is that it allows easier access to the sensor and receptor for installation and repairs because you can lower them to ground level. A negative about

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this subsystem is due to the length of the glider it will be difficult to initially install. This could be made easier using light and affordable materials such as aluminum.

4.1.1.2. Subsystem 2: Sensor Receptor (Design 1)

A positive is that it is easy to access for maintenance and installation. A negative is that there might have to be additional maintenance to make sure that the receptor and sensor are calibrated and at the same height at all times.

4.1.1.3. Subsystem 3: Infrared Sensor (Design 6)

A positive aspect of this subsystem is that it is relatively inexpensive and it is easy to access for maintenance due to the glider. A negative is that maintenance might need to occur more regularly to make sure nothing is obstructing the sensor.

4.1.2. Design 2: Pressurized Fan System

4.1.2.1. Subsystem 1: Fan (Design 3)

A positive of this subsystem is that it is at 3 meters above the ground level and is therefore easy to access. A negative is that it needs to be magnetic to trigger the sensor and therefore will need to be a heavier metal. This could make installation more difficult.

4.1.2.2. Subsystem 2: Magnetic Hall Effect Sensor (Design 3)

A positive of this subsystem is that it is inexpensive. A negative is the maintenance that would need to be done to make sure that there is no malt getting caught in the fan preventing the sensor from getting accurate readings.

4.1.2.3. Subsystem 3: Pressure Chamber (Design 5)

A positive of this system is that there would be easy access and ability to make repairs. A negative is that it would be very expensive to instal and would mean altering the silo.

4.1.2.4. Subsystem 4: Beam (Design 3)

The positive is that due to its simplicity there would be little to no maintenance. It would also protect the fan's motor which means less maintenance would need to be done on the fan. A negative is that it would have to be a very strong metal to support the load of the malt. Therefore, making it difficult to install.

4.1.3. Design 3: Multi-Sensor Dust Collector

4.1.3.1. Subsystem 1: Zh08 Dust Sensor (Design 2)

A positive is that the sensor takes up minimal space in the silo and due to its small size, it would be easy to install. A negative is that due to the design of having multiple sensors, it would become very expensive.

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4.1.3.2. Subsystem 2: Dust Collector (Design 2)

A positive of the dust collector is that since it is on the ground level it is easy to access and will require little to no maintenance. A negative is that it is very expensive to isolate the dust from the malt.

4.1.3.3. Subsystem 3: Micro-Filter (Design 5)

A positive with the micro-filter is it is inexpensive and easy to replace due to it being at the bottom of the silo. A negative about the micro-filter is that it may need to be replaced often depending on the amount of force being applied to it by the malt being removed.

4.2. Benchmarking Charts

Specifications	Infrared Laser, Glider & Receiver	Pressurized, Fan, Beam & Sensor	Hiba's Dust Sensor, Hooks & Microfilter
Cost	Unknown	\$700-\$1100 +	Unknown (But cost of multiple sensors)
Material of device	Multi.	Enforced Plastic, Aluminum and Iron	Metal + Sensor Materials
Sensitivity and range	Infrared is very sensitive	Pressurized chambers are inherently sensitive	Sensors could easily miss dust that is not within on of their ranges
Easy & Time Effective Installation	Once glider pieces are installed, should be minimal maintenance and installation	Lots of working sub-systems, meaning more time for installation and more room for malfunctions	Lots of different sensors & hooks to install.
Size & Weight	No external (out of silo) pieces, gliding track and glider take up room on the inside of the silo	Fan & pressure vacuum take up external space, beam and sensor take up internal space	All parts take up minimal additional internal space.
Method of Calculating Level	Infrared laser on a glider that sends information to a receiver	Beam moves silo contents so that sensor can determine how much wheat is in a pressurized silo	Multiple sensors to determine wheat on the sides of the silo, with a micro-filter that allows only malt through at the bottom of the silo.

Specifications	Importance (Weight)	Infrared Laser, Glider & Receiver	Pressurized, Fan, Beam & Sensor	Hiba's Dust Sensor, Hooks & Microfilter
Cost	2	2	3	1

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Material of device	1	3	2	1
Sensitivity and range	3	2	3	1
Easy & Time Effective Installation	3	3	1	2
Size & Weight	2	2	1	3
Method of Calculating Level	2	2	2	1
Total		30	26	20

From the table above, the infrared laser, glider and receiver is the best concept and is the one that will be considered for further improvement.

5. Conclusion

In conclusion, the designs made by each member of the team were combined into three different concepts. These designs were made based on the information collected during the first meeting with the client. From those three concepts, the “Infrared Laser, Glider & Receiver” was chosen because from the decision matrix it scored the greatest number of points.

However, the three concepts will still be presented to the clients. From their feedback, we will refine and get a better sense of their needs.

6. Project Planning and Task Assignment

<https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=Qsnr30ztBs0VHfkhdmiL0g5bDcKN5Bfa%7CIE2DSNZVHA2DELSTGIYA>