1. **Design Criteria Based on Interpreted Needs:**

Needs:	**Design Criteria Based On Each Need:**
The solution needs to be able to measure the amount of dust in the grain silo	The solution can measure dust
The solution needs to be able to tell if the silo has too much dust for the filtration system to handle	The solution can measure dust
The solution needs to be able to detect if abnormal amounts of dust are incoming	The solution can detect incoming dust in advance
The solution needs to be able to recommend changing silos if the dust levels are too high	The solution can make recommendations based on information gathered The solution can communicate with the HMI system
The solution needs to be accurate to limit potential false alarms/missed alarms	The solution can measure dust accurately
The solution needs to be able to communicate with the existing HMI system at the facility	The solution can communicate with the HMI system
The solution needs to be accessible	The solution is easy to access
The solution needs to be easy to install	The solution is easy to install
The solution needs to fit within the existing infrastructure in the brewery	The solution fits where it's meant to be installed
The solution needs to meet return on investment criteria	The solution is cheap to construct The solution is cheap to operate and maintain
The solution needs to be easy and cheap to operate and maintain	The solution is cheap to construct The solution is cheap to maintain and operate
The solution needs to operate all year round	The solution can operate under different temperature conditions

Summary of Design Criteria: The solution can measure dust accurately, the solution can detect incoming dust in advance, the solution can make recommendations based on information gathered, the solution can communicate with the HMI system, the solution is easy to access, the

solution is easy to install, the solution fits where it's meant to be installed, and the solution is cheap to construct, maintain, and operate.

2. Benchmarking

Aretas:

- Accuracy: optical dust measurement system, "highly sensitive detectors".
- Cost: "save time and money", no price listed on site, company provides a quote for each situation. "
- Size: not listed.
- Communication: audible alarms, sends alerts via app and text, can provide scheduled dust level readings.
- Installation/accessibility: can be powered by AC, DC, or USB.

LCDM:

- Accuracy: "will detect materials as low in density as five pounds per cubic foot and as high as 100 pounds per cubic foot" using a rotary paddle system.
- Cost: "cost-effective choice" and "an affordable price", no price listed on site, contact company for a quote.
- Size: "a single 4 3/4-inch hole in the center of the roof will accommodate the body of the sensor".
- Communication: sends information via the AgriMesh app.
- Installation/accessibility: mounted at the top or side of the silo, adjustable height. Only have to drill a hole and screw the sensor in, download the app, and it's ready to go.

LvLogics:

- Accuracy: uses a laser that has +/- 5% accuracy
- Cost: "affordable", no price listed on site.
- Size: 1016 mm diameter, 2540 mm length, made of plastic and polyethylene.
- Communication: records levels over intervals of 1 minute to 100 hours, sends info to an app and can alert via email.
- Installation/accessibility: can be mounted on the sides or roof with screws or magnets, can be retrofitted to any silo.

Terabee:

- Accuracy: can measure in silos up to 60 m tall using "optical technology".
- Cost: "reduced cost", price not listed on site, can contact company for a quote.
- Size: not listed on site.
- Communication: data transmitted via radio frequency to an external system.

- Installation/accessibility: powered by a battery that lasts “years”, and can replace it when it dies.

CMC:

- Accuracy: Sensitivity of 0.5 pF.
- Cost: “affordable solution”.
- Size: 9.5 mm diameter probes; standard probe length is 406 mm.
- Communication: not listed on site.
- Installation/accessibility: “Provides easy installation and easy removal”.

Monitor:

- Accuracy: can detect energy changes as small as 0.5 pF, has “self-validating algorithms” that ensure accuracy.
- Cost: not listed on site.
- Size: not listed on site.
- Communication: connectable to an HMI system, can send alerts via an app as well.
- Installation/accessibility: “able to be installed by plant personnel”.

Harvest:

- Accuracy: not listed on site.
- Cost: $1950 + GST + ($25/month).
- Size: not listed on site.
- Communication: has “automated alerts available for re-order levels”; data viewable via website or app.
- Installation/accessibility: not listed on site.

Vega:

- Accuracy: +/- 1 mm accuracy using radar.
- Cost: “economical solution”.
- Size: not listed on site.
- Communication: not listed on site.
- Installation/accessibility: “maintenance-free operation in all applications”.

PulsarGuard:

- Accuracy: “sensor listens to noise caused by impacts, and friction within structures, on a wide frequency bandwidth of 100 to 600 kHz, making it sensitive to the slightest changes in process conditions”
- Cost: no cost listed, but the company can provide a quote upon request; the claim it is “low cost”

- Size: 125x31x65 mm; 1.41 lbs.
- Communication: not listed on site.
- Installation/accessibility: ”there is no need to shut down the process for installation”; “installation takes minutes”.

3. Target Specifications:

Design Criteria: (In descending priority)	**Target Specification:**
The solution can measure dust accurately	Can detect dust as dense as 5 lb/ft^3 and has +/- 5% accuracy
The solution can communicate with the HMI system	Able to send predictions to HMI system and sound the alarm if it predicts an imminent arrival of malt with more than 3% dust
The solution is cheap to construct, maintain, and operate	$2000 or less including installation and future maintenance costs per silo
The solution fits where it’s meant to be installed	30 cm x 30 cm x 30 cm or less in size
The solution can make recommendations based on information gathered	Able to interpret data collected and determine likelihood of clogging dust filter
The solution can detect incoming amounts of dust in advance	Be able to sensor dust from the incoming grain pipe
The solution is easy to access	Brewery employees can access it with standard equipment
The solution is easy to install	Able to be installed by brewery employees, the installation process can be done as quickly as possible.
The solution can operate under different temperature conditions	-20 to 80° C

Wrike snapshot:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=DZTjlvlriK6no5A4QXl9M06nQPgflXCp%7CIE2DSNZVHA2DELSTGIYA