DEPARTMENT OF MECHANICAL ENGINEERING

Team B1: Soil Samplers
Automated Soil Sampling System for Farm Use

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Motivation, Goal, Impact

Goal
Provide a soil collection system capable of…
- Sampling various types of farmland dirt
- Storing the samples
- Being placed onto an existing robotic transversal platform

Impact
We aim to assist large-scale farms by saving time and labor.
- Reduced risk of injuries from prolonged sample work
  - Usually a multi-day procedure
  - Saving 30 hours of manual labor
- Only 1 soil collection system is needed to “get the job done”
  - Save $450 per run (assuming $15 minimum wage)
  - Worker can focus on other tasks

Requirements

Customer Requirements
- Sample depth of 4-6”
- Collect soil in wet and dry conditions
- Collect 4-6 samples per acre (50-acre maximum)
- Penetrate clay, but also sandy and silty soil
- Store collected samples
- Extractor system must fit on a robot platform
- Entire assembly (including robot platform) able to store in a trailer (20ft x 8.5 ft)

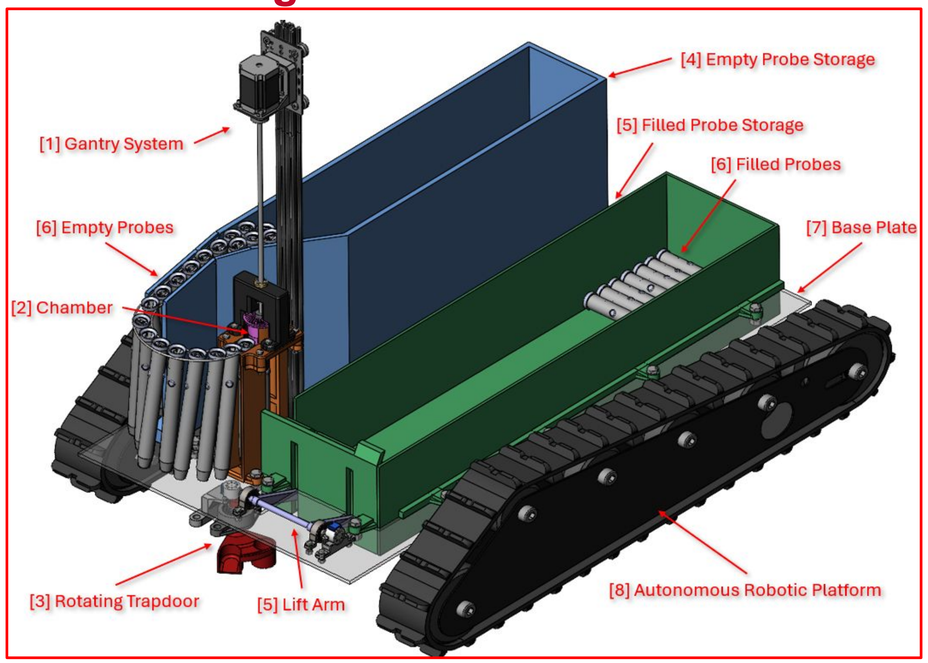
Engineering Characteristics
- Safe to use (no presence of hazardous features, i.e, sharp, toxic, etc.)
- Easy repairability
- Maximize soil sample storage density/capability
- Maximizes the number of successful collected samples

Overview
Our final design automates the driving of a soil *extractor probe* into the ground with a NEMA23 stepper motor. The *extractor probe* serves as both the extraction & storage method.

1. Each empty probe starts in the *empty probe storage*, where it feeds into the *extraction chamber*.
2. The *lead screw* drives the *extractor probe* into the ground to attain a sample.
3. Once the sample is obtained, the probe is lifted out of the ground and deposited in the *filled probe storage bin*.

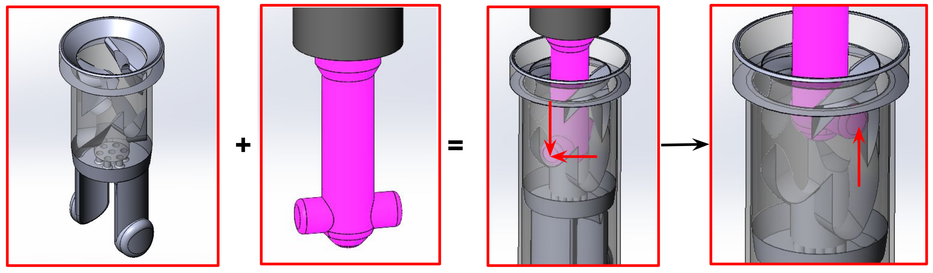
Subsystems
- [1] Gantry & lead screw system
- [2] Extraction chamber
- [3] Rotating trapdoor (exploded down)
- [4] Empty probe storage w/ rail connection
- [5] Filled probe storage w/ lift arm
- [6] Extractor probes (empty/filled)
- [7] Base plate
- [8] Autonomous robotic platform (not in scope)

Final Design

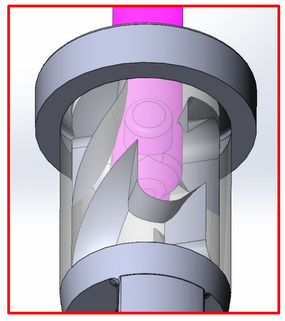


Design Calculations & Decisions

Probe End Cap & Pin
The *probe end cap* & *pin* are designed to withstand up to 200 pounds of axial driving force.



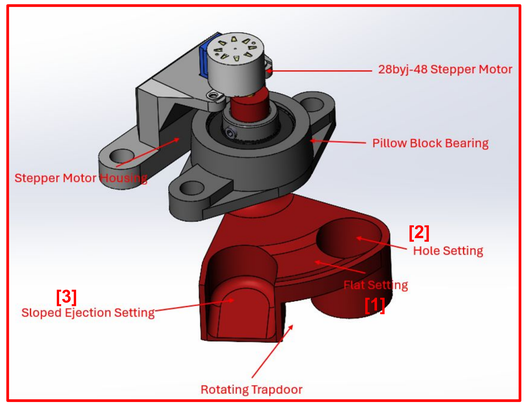
Probe End Cap *Pin* Driving into soil Upwards extraction



Innovative coupling system using only pin rotation & translation

Rotating Trapdoor
The *rotating trapdoor* (located below the chamber) serves multiple purposes,

1. A resting surface for the probe to stand on for pin insertion **[1] Flat Setting**
2. A guide for the probe during soil penetration **[2] Hole Setting**
3. An ejection method for a filled probe to be removed from the extraction chamber **[3] Sloped Ejection Setting**



Prototype & Test Results

Prototype
For our prototype, we decided to mainly focus on the following subsystems:

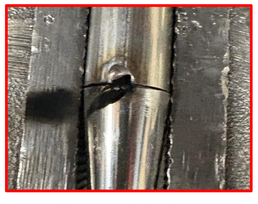
- [1] Lead screw/gantry system
- [2] Extraction chamber
- [3] Rotating trapdoor System
- [4] Extractor Probe

Testing
Two primary manufacturing methods were tested for the probe cutting edge:

1. Create a taper by welding a stainless steel cone and tube together
   a. A hole was burned through the cone and tube due to the stock being too thin
   b. The epoxy used to create the thicker cone also burned at the contact point
2. Create a taper from the tube body directly and welding the gaps together
   a. This succeeded and could be post processed to include teeth designs

[4] Extractor Probe(s)

Method 1 on Left
Method 2 on Right



Method 1 Failure