SENIOR CAPSTONE/
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# Autonomous Soil Sampling Machine

**Cale Robertson[1], Eion Stephens[2], Emma Nobbe[3], Gavin Dyson[4]**

*[1]Agricultural Systems Management; [2]Agricultural Systems Management;*
*[3] Agricultural Systems Management; [4]Environmental and Natural Resource Engineering*

PURDUE UNIVERSITY
Agricultural and Biological Engineering

## Executive Summary

The autonomous soil sampling machine was designed to increase productivity of soil sampling. The goals of the project were to create the bagging system and probing system for the machine. Several solutions were considered for each system, but the shielded soil probe and CNC bagging system were the best solutions for the projects constraints. These systems were then created and tested to see how they would work together and how accurate and efficient the systems would be. The impact of this project is to improve the efficiency of soil sampling by decreasing cost and increasing accuracy.

## Research & Context

**Key Factors of Research:**

- Current soil sampling machine designs
- Soil Sampling Techniques
  - 6–8-inch soil cores
  - 5-8 cores as sub-samples to create one composite sample for 2.5 acres
  - Cross-contamination of soil

## Value Proposition

The machine is designed to assist our sponsor with decreasing the cost and increasing the accuracy of soil sampling. Which in turn, will allow more growers to frequently soil sample and therefore use prescription rate application to help the environment.

## Characteristics & Limits

**Constraints:**

- Store minimum 32 samples
- Maximum size of system is 30" by 40"
- Operate on battery power
- Soil core needs to be taken within 85.3 seconds
- Probe strength greater than force to push the probe into the soil

**Criteria:**

- Cost
- Sampling Time
- Reliability
- Energy Consumption

**Codes, Standards, and Societal Impacts:**

- Code – ASTM D1587/D1587M-15
- Code – ASTM D6282/D6282M-14
- Soil Cross Contamination Standard
- Environmental Impact: Less environmentally taxing compared to existing machines due to electric powered system

**Project Deliverables:**

- Complete set of design drawings and parts list
- Operational Probe Prototype
- Operational Bagging Prototype
- Data from testing process

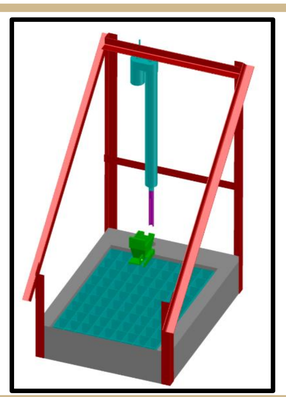

*Figure 1: AutoCAD design of the final probing and bagging solution system together.*

## Solution Ideas & Selection

The project has two parts, the probing system and the bagging system. The possible solutions for the probing system were:

- Closed probe
- Open probe
- Shielded probe

The possible solutions for the bagging system were:

- Plastic bagging system
- CNC machine system

To evaluate the solution best for the project a decision matrix was made for both systems. The criteria considered in the decision matrix were power consumption, speed, cost, potential soil loss, reliability, and, additional for the bagging system, labor input. After scoring each solution idea based on the criteria, the highest scorers were the shielded probe and the CNC machine bagging system. The final created systems can be seen in Figure 2 and 3.

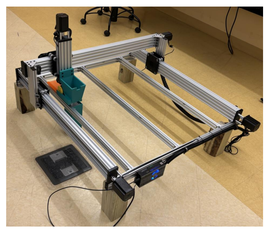

*Figure 2 (above): Shielded probe without linear actuator.*

*Figure 3: CNC machine with funnel attached*

## Design & Development

The final design for the probing system is a hand-crafted shielded probe with a linear actuator attached. The final design for the bagging system is a CNC machine with a custom designed soil funnel. Figure 1 to the left, shows the design for the final solution. The testing completed was to calculate the efficiency of the CNC machine and accuracy of the probing system.

## Testing & Feedback

Some of the tests completed for the prototype, shown below in Figure 4 and 5, were speed of the CNC machine and soil loss of the probing system. Based on the results of these tests, the prototype meets those constraints and criteria.

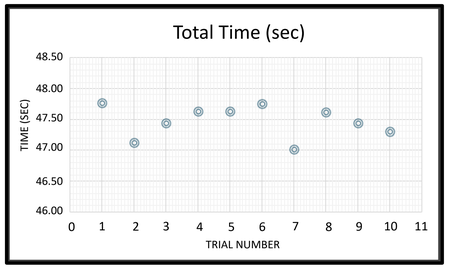


*Figure 4: Graph representing the time taken to reach the bag fill location and back to home position on CNC machine.*

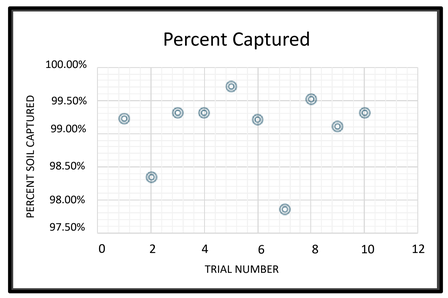


*Figure 5: Graph representing the percent of soil transferred from the probe to the funnel.*

## Project Impact

Moving forward, the project will be handed over to the sponsor, they will do the programming for the rest of the machine and combine our prototypes with the robotic platform. To provide maximum impact, all the materials, design drawings, parts list, operational prototypes, and data testing will be given to the sponsor as well.

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