Design Assignment

Team Name: sd-may22-42

Team Members: Robert Wedan, Chimzim Ogbondah, Jason Grunklee, Tzu-Chien Liu, Freedom Clark, and Animesh Shrouti

3.1 Design Context

3.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	**Description**	**Examples**
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities) This project could impact other researchers in the agricultural field who could benefit from the data we are receiving. A project like ours does not impose any impedances on the public. Our project also could benefit farmers who are interested in the CO_2 levels in their soil.	Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities Our project does not increase or reduce exposure to pollutants or harmful substances but can accurately measure these potentially harmful substances to help stakeholder groups better assess their test beds/fields. The safety risks associated with our project are minimal but the drill on our design is a potentially dangerous aspect. The drill will be generally low power but can be dangerous if used improperly.

		Like most automation projects, the goal is to replace the need to physically go out and take the measurements by hand. This may reduce job opportunities if a lab worker has the responsibility of completing this measurement. In general, our robot will just save the lab time and allow them to complete their work more efficiently which can generate revenue for the lab. This in turn can help the lab afford to hire more people creating jobs.
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures. Our project is not directly affecting various communities, nations, or ethnic cultures. While other global and cultural places may adopt our technology, we are mostly developing this for use by the agricultural department at Iowa State. While a later revision of our work may involve other cultural considerations, this project does not. Our group believes that this project accurately reflects the values, practices, and aims of the profession we are attempting to aide.	Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices Development or operation of our robot does not violate a profession's code of ethics or create an undesired change in the community and its practices.

Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement. The acquisition of the materials for our product will have an environmental impact that is beyond our knowledge. We have little information regarding the sustainability of the products we purchase but our group is committed to building a sustainable product to the best of our ability under our budget constraints. Our product will require a power source that will most likely be a battery. While batteries are not always a sustainable solution, our group intends to use a rechargeable battery to save on waste. A better understanding of ground soil may create an environmental impact on the earth that is unintended by our product. Stakeholder groups may intend to change the soil composition based on the data provided by our sensing unit.	Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials Our project will require the use of energy from nonrenewable sources as well as materials that are non-recyclable. However, we are going to make an environmentally conscious effort to reduce the use of these materials within our budget.
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups. Our product is receiving grant funding provided by our faculty client that is dedicated to the research completed by	Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization This project is not being created for consumers but instead is being created for a specific target user. The high development cost exists because this product is not commercially available

	undergraduates at Iowa State. The allotted project total is $3000. The outside economic impacts of our project remain widely unknown. Depending on how successful our project is there may be a created demand for our product. In this case we would need to worry about the cost to consumers, the effects on community markets, and the products financial viability for production.	and is being created on this small scale for specific use. While risks are encountered, the money that will be used for development is dedicated to undergraduate research and does not propose a high risk for the organization.

3.1.2 User Needs

List each of your user groups. For each user group, list a needs statement in the form of:

User group needs (a way to) do something (i.e., a task to accomplish, a practice to implement, a way to be) because some insight or detail about the user group.

The user of our product needs to be able to set a path using GPS and receive soil data from the robot at each destination along the path because the user of our product is likely interested in the results of those findings for research purposes.

The client that we pass our work on to after completion needs to be able to read and understand our documentation on how the robot works and the code we have written because they likely intend to expand on our working design for further implementation.

3.1.3 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Robotic sensing systems for greenhouse gas emissions presented in the problem statement currently exist in the world but most are large and very expensive. Our goal is to create a functional copy on a smaller scale and a much stricter budget. Our client has detailed some of the solutions that already exist at Iowa State. Many of those solutions are very large in comparison to the system we are trying to build. These solutions are commercially available for tens of thousands to hundreds of thousands of dollars.

The advantage of using a small system like ours is that it will be much less expensive and will be easier to repair. While our product lacks the accuracy and precision that a state-of-the-art system has, it will not have as high of maintenance costs and will be easier to deliver to the field.

3.1.4 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

This project has sufficient technical complexity shown by the three main design aspects and our products ability to compete with current solutions on the basis of cost effectiveness.

Our product demonstrates sufficient technical complexity by having three main design aspects that utilize distinct scientific, mathematical, and engineering principles. It can be broken up into the robotics of the system, the sensor apparatus, and the data collection and user interface. Each section requires expertise in that part of the system and no system is complete without all three of these sections working in perfect harmony.

Another way our product demonstrates technical complexity is by challenging industry standards with a small and inexpensive version of the commercially available robotic gas emission sensing system.

3.2 Design Exploration

3.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc.

There are many key design decisions that need to be made for this project to work as intended. These include selecting the right commercially available robot, selecting the right commercially available NDIR sensor, what drilling mechanism will we use to push the sensor into the ground, how will we attach the sensor to the drilling mechanism, how will we attach the drilling mechanism to the robot, how do we account for the torque of the drill, how will we send data from the robot to the user, how will we design the user interface to be accessible by the user, and many more.

3.2.2 Ideation

For one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). List at least five options that you considered.

When selecting the right commercially available robot there are many things our group must consider. These include but are not limited to the price, programmability, dimensions, weight, payload, speed, and battery life of the robot. For all of these options we looked online for relevant solutions and have five options to consider.

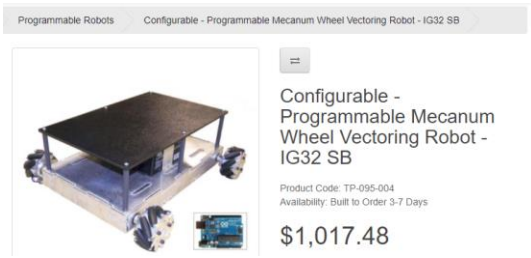
	A	B	C	D	E	F	G	H
1	URL	Price	Programmability?	Dimentions	Weight	Payload	Speed	Battery life
2	https://www.supe	$1,500	Yes	21.6" x 17.8" x 6.0"	40 lb	90 lb	130 ft/min	2 - 5 hr
3	https://www.supe	$716	Yes	15.5" x 13.5" x 4.0"	13 lb	15 lb	110 ft/min	1 - 4 hr
4	https://www.supe	$1,030	Yes	19.3" x 18.4" x 4.0"	30 lb	50 lb	200 ft/min	2 - 4 hr
5	https://www.supe	$1,674	Yes	28.0" x 22.0" x 11.0"	70 lb	45 lb (up to 160lb)	319 ft/min	1 - 3 hr
6	https://www.supe	$2,168	Yes	24.2" x 19.7" x 8.0"	60 lb	200lb	200 ft/min	2 - 5 hr
7								

(prices on the pictures below are not accurate)

Number 1:

Number 2:

Number 3:



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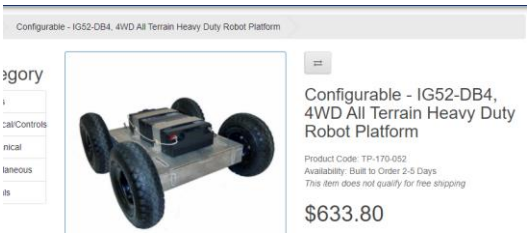


Number 5:

3.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

While we have not made our decision yet, our decision will be based on finding the robot that is programmable, has enough weight to withstand the torque from the drill, can carry the weight of the drilling mechanism, can move relatively quickly through the terrain, has a long battery life, and is the most inexpensive while meeting all the previous criteria.

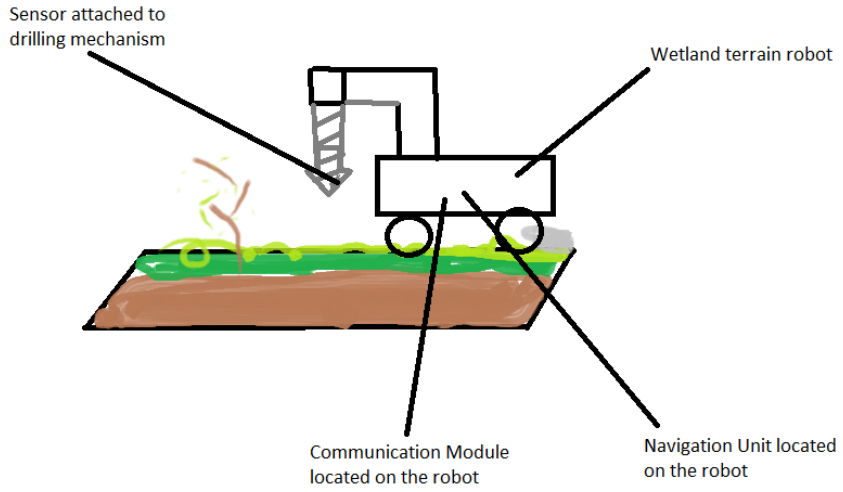
3.3 Proposed Design

Discuss what you have done so far – what have you tried/implemented/tested?

3.3.1 Design Visual and Description

Include a visual depiction of your current design. Different visual types may be relevant to different types of projects. You may include: a block diagram of individual components or subsystems and their interconnections, a circuit diagram, a sketch of physical components and their operation, etc.

Describe your current design, referencing the visual. This design description should be in sufficient detail that another team of engineers can look through it and implement it.



Our current design will look something like this. A land roaming vehicle with a drilling mechanism that has a sensor attached to receive data. It will move from point to point using a navigation unit that will use GPS. The data collected from the robot will then be sent to the user using the established communication module. The robot and sensor will be a commercially available and purchased using the allotted budget. The drilling apparatus will also be commercially available and will be held using an attached arm.

3.3.2 Functionality

Describe how your design is intended to operate in its user and/or real-world context. This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

How well does the current design satisfy functional and non-functional requirements?

At the start, the robot will be placed in a controlled test bed. A predetermined route will be programmed and followed by the robot using GPS. At each test site within the controlled environment, the robot will stop, drill into the ground, and record the sensor data received. After sending the data to the user, the robot will then take the sensor out of the ground and move to the next test site along the path and repeat the process until complete.

This current design completely satisfies all functional and non-functional requirements of our project as determined by our client. The process described above is a perfect implementation of the project prompt.

3.3.3 Areas of Concern and Development

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

A lot of the concerns regarding the current design stem from the many key decisions that go into this project. All of these decisions must be made before we can reach the final product and they are not very straightforward. Our team has very little experience with the mechanical aspects of this project including the torque of the drill and how that needs to be offset by the weight of the robot.

Our immediate plan for developing solutions for these concerns is to get together as a team a decide how to proceed on this project. We have a few ideas on how to implement our design, but we must narrow our range and focus on completing the project. We also will seek approval from our faculty advisor on all key decisions we make throughout the semester to ensure we are on the right path.

NOTE: The following sections will be included in your final design document but do not need to be completed for the current assignment. They are included for your reference. If you have ideas for these sections, they can also be discussed with your TA and/or faculty adviser.

3.4 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

3.5 Design Analysis

- Did your proposed design from 3.3 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate over the design?

3.6 Design Plan

Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.