TEAM 18 – PENETROMETER

Restated Project Definition and Scope/Project Plan

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Due Friday, January 16th 2015

Mr. Mike Russo and the National Park Service: Project Sponsor
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I. Problem Definition

After working on this project for the Fall 2014 semester, the Team wanted to revisit the objectives and goals of the project.

1.1 Need Statement

There is a need for an easy to use, portable, and wireless penetrometer. As technology evolves, so must modern equipment. It has been established that the sponsor is looking for a more reliable and easier-to-use system than the prototype designed by the previous senior design project. The object of Team 18 is to redesign a penetrometer extending from the 2013-2014 senior design project, which will detect midden levels in the soil present at the Southeast Archaeological Center & National Park Services' field testing site. Team 18 has completed an initial design for the penetrometer. This penetrometer will have portable and wireless capabilities in order to properly distinguish the type of soil present below the ground.

The Team has equipment on order with which products are needed to propel the development of the penetrometer forward, such as the software and Graphical User Interface (GUI) stage. By using modern technology, the team will use the Data Acquisition module (DAQ) and laser range finder to detect the position of the penetrometer within the midden level. The data collected allows a team of non-technical persons to easily read the data through the use of a service such as a software application.

The software application will be separate from the penetrometer physically, allowing said persons to view the necessary data remotely on another device, such as an android powered Nexus Galaxy, to be specific. The software will not be limited to one device. Users will also be able to use the software on all android devices. With the components at hand, Team 18 will implement the design to catapult the penetrometer into the new decade.

"It is difficult to distinguish soil midden levels apart from other organic and mineral soil levels when field testing on site."

1.2 Goal Statement and Objectives

Goal Statement: "Design an instrument that can identify midden and differentiate soil types at various depths."

Objectives:

- Must be able to identify midden levels in remote locations.
- Must weigh less than 50 lbs.
- Must be able to reach depths past 20 feet.
- Should wirelessly display results to a handheld device.
- Device should be very portable.
- Weight should be minimized.

1.3 Constraints

Listed below are the constraints placed on the design. If a design does not meet the listed constraints, the design will not be considered.

- The prototype design must be easy to use.
- The prototype must be able to be used by one person in the field, without assistance.
- The diameter of the prototype must be small enough (less than 1 inch) for the device to penetrate the ground easily.
- The material of the prototype must be strong enough for the device to penetrate the ground without fracturing.
- The prototype design must be able to determine the location of midden and how deep the midden runs.
- The prototype design must be wireless, allowing it to be portable.
- The weight of the prototype must not exceed 50 pounds.
- The data from the device must be reliable.
- The prototype design must allow for wireless data transmission to a handheld device.
- The total cost must not initially exceed $2,000.
    - The sponsor is able to expand the budget if it is deemed necessary by the team and the advisor.

II. Project Revisions

This section will give an overview of the revisions the team has implemented or plans to implement during the Spring 2015 semester.

2.1 Revised Scope

As Team 18 works through obstacles that have occurred throughout the Fall semester, the team has realized many challenges that they will need to overcome in the Spring semester. One major setback from the original plan in the Fall semester is that extension rods will no longer be one of the main focal points of this project. Rather than providing the sponsor with multiple rods to extend further when penetrating into the ground, the team will simply aim for a depth of one meter. It is in their best interest to first worry about this depth before delving into bigger obstacles when penetrating further into the ground.

Another revision that the team has decided to tackle will be the placement and shape of the load cells used on the penetrometer. It is in the team's best interest to place the load cells on the top of the shaft's design so that it will not become damaged when forced into the testing site's soil. The team will use a donut-like shaped load cell for the bottom load that will fit along the inner shaft and will read only the force felt on the inner shaft. The load cell that will be placed on the top will read the outer shaft's force. These two load cells will read each shaft independently.

The electrical design from the Fall semester sent the data from the distance sensor to a separate Android device running a separate app. All of the data would have to be saved and exported to a computer to combine the results to determine if midden was present at that sampled location. This was because it was unsure if it was possible to gather data with a host device (the Android tablet) to two Bluetooth devices. It has been researched and it is possible to do, thus resulting in a better design. However, this may require much more coding and testing of the developed app.

2.2 Revised Major Goals and Objectives

As previously stated, the major goal of this project is to develop and construct a device that is able to identify midden and detect changes in the soil type while probing the ground. Based on the Fall 2014 semester design, there were a few changes that needed to be made in order for the device to fulfil its purpose.

First, the forces from the load cells had to be decoupled. To accomplish this, both load cells have been moved to the top of the penetrometer. One load cell is attached to a solid rod that extends down to the cone tip, and the other is attached to a hollow rod that runs the length of the penetrometer and connects to the outer walls at the bottom of the device. The lower load cell that reads the outer walls has a through hole so that the solid rod connected to the cone tip can run through it without disturbing it. This design will eliminate interference between the two load cells. Second, the overall diameter of the penetrometer needed to be reduced. By moving the load cells to the top, the diameter of the shaft can be smaller than the previous design. The cone tip diameter can also be lessened. The smaller shaft and cone tip diameter will allow for easier penetration of the device when used. Third, to make the device portable and semi-wireless, the device will be connected to a wireless data acquisition system that will receive the findings using

Bluetooth capabilities. This DAQ along with the battery pack will be placed in a secure housing that will either be placed on top of the penetrometer or in a separate housing that can rest on the ground, allowing for more portability when the user is in the field.

The previous electrical design from the Fall 2014 semester varies slightly with the new revised design. A 14V rechargeable battery will be the voltage source for the load cells in the penetrometer. To ensure the load cells receive the required constant 10V, a 10V voltage regulator will be used. A wireless DAQ with Bluetooth capabilities will be sampling and recording the output voltage of the load cells. The data will be sent to a tablet running an Android app to be developed by the team. A Leica Disto D330i laser distance sensor will be used to measure the distance that the penetrometer travels into the ground. The distance sensor also has Bluetooth capabilities, and the data will be sent to the tablet running the Android app. Code will be implemented to use the data gathered from the load cells and the distance sensor to display a graphical representation of the combined results, and to be saved for further analysis if needed.

III. Project Concerns

Throughout the Fall 2014 semester many design problems arose. In this section, the future project concerns are discussed.

3.1 Challenges Found in Fall

In the fall, much progress was made on the overall design. After starting with the bottom loaded design, the load cells were found to be too large and the design was changed to being top loaded. This caused a lot of problems in finding a design that could translate the forces read to the top of the shaft. At first, our design lacked a good way of reading the friction. When a friction sleeve was added, it was determined it was way too long and did not separate the cone force from the friction force enough to get a good reading. This resulted in our current design that entails two transmitting rods to move the force up through the shaft.

Other problems encountered include trying to find the correct material to choose for the shafts. It has to be strong under a compressive load and it has to be strong when it is very thin. The rods we are using are very thin and must be adequately strong.

Reliable data acquisition from the load cells is one of the main concerns of the electrical aspect of the design. The load cells output a very small range of voltage and the different soil types may yield a slight difference in voltage. Thus, it is very likely the load cell signals will have to be amplified in order to yield a better resolution. While amplifying the signals likely solves the problem of low resolution, it also introduces the problem of supplying constant amplification. The supply voltage to the amplifier will also have to be regulated to ensure a constant amplification. The second major concern for the electrical design is creating an app on an android device that will display the data for the user. It will take much research and time to develop code so that the app can properly receive "real-time" data from the DAQ and range finder through Bluetooth simultaneously.

3.2 Newly Developed Concerns

After much debate, the team selected a design that had the load cells located on the upper portion of the shaft. Although this made the design more complicated, it allowed the lower shaft to be smaller which was worth the trade-off. Challenges arose when it came to transmitting the cone force and the friction force to the top of the penetrometer to be read by the load cells. The current design involves two rods to translate the force upwards but the size of the rods must be very small. If the rods bend at all there will be error, so bearings must be used. The real problem is fitting two transmission rods inside the external shell as well as having bearings in between each rod.

Another concern deals with how to mount the load cells. The design has to have a mount for both the top and bottom load cells that connects to the external housing. This is still in the works, as the size for the housing has to be selected based off of what electrical equipment has to fit into the upper housing. The mounts have to be securely fit into the housing without blocking access to the inner equipment.

It is of the most importance that the DAQ, android device, batteries, and other electrical devices be ordered as quickly as possible so that testing can be performed. It is possible to perform all the analysis and design without the load cells since all that is needed is a voltage signal that mimics that of the load cells. While analysis and testing of the electrical design is being done, the team will continuously think of ways that the mechanical and electrical designs can be effectively integrated together.

IV. Procurement

The procurement process is extremely vital to the project. The following will explain the progress made and future plans for the procurement of the necessary equipment and materials.

4.1 Procurement Progress

The electrical components that will be used in the penetrometer have been finalized. The procurement forms for this equipment are in the process of getting approved. The total estimated cost of the electrical portion is $364. The mechanical portion is still in progress, as the equipment for the mechanical design is still being finalized. The final design, product selection, and procurement forms will be completed within the next two weeks.

4.2 Budget

The budget allotted to the friction cone penetrometer team is in the amount of $2,000.00. Based on the sponsor's criteria and constraints, this penetrometer will be made of high class materials that are able to withstand the environment and repeatability. To accomplish this goal, the sponsor has stated that a larger budget can be used for the project to complete the product, if necessary. Due to requirements from the university, the team will be aiming to stay below the budget first given for the project until otherwise stated. Figures 1 and 2 on the next page show the procurement breakdown of the electrical and mechanical components to be purchased for the project.

Due to re-evaluation of the mechanical design, specifics such as model numbers and part numbers have not been added to the breakdown of prices, but a general range of the electrical components and mechanical components have been shown in the graphs of the budgets. The total budget allocated to the electrical components is estimated to be $364 while the mechanical design is estimated to be $1,027. Another graph, Figure 3, can be shown to represent the mechanical, electrical, and remaining budget totals as a percentage of the entire budget. The upcoming weeks will allow the team to finalize all purchases with Dr. Shih and have a more accurate value for parts for both the mechanical and electrical components.

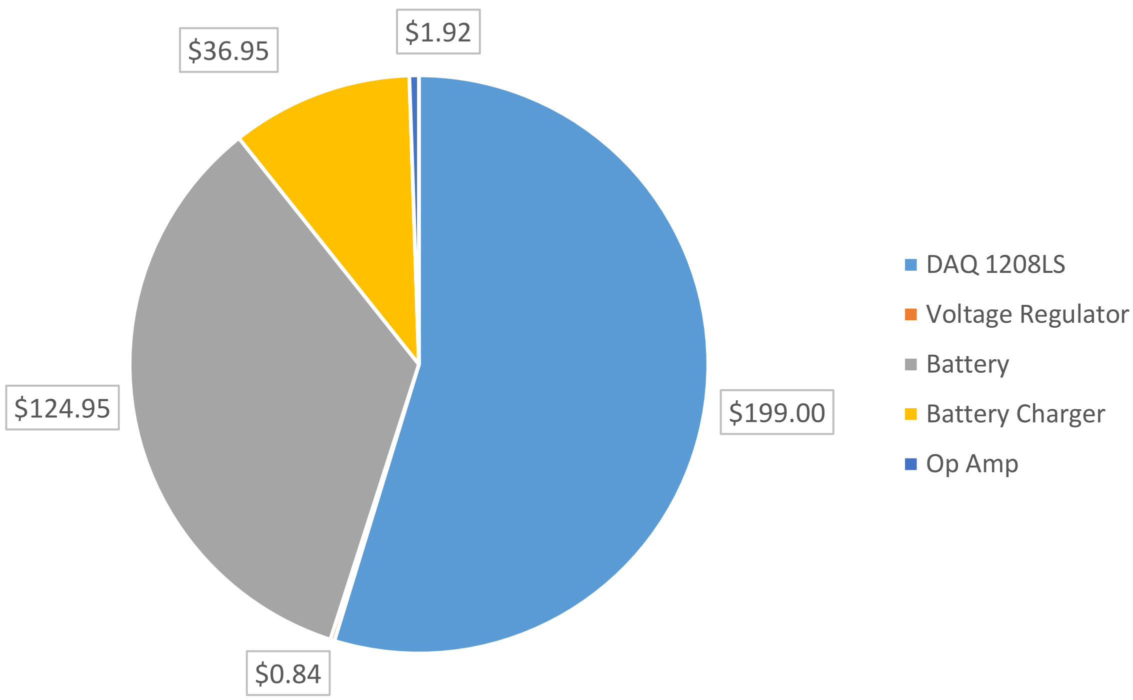


Figure 1. Estimated Cost of Electrical Design

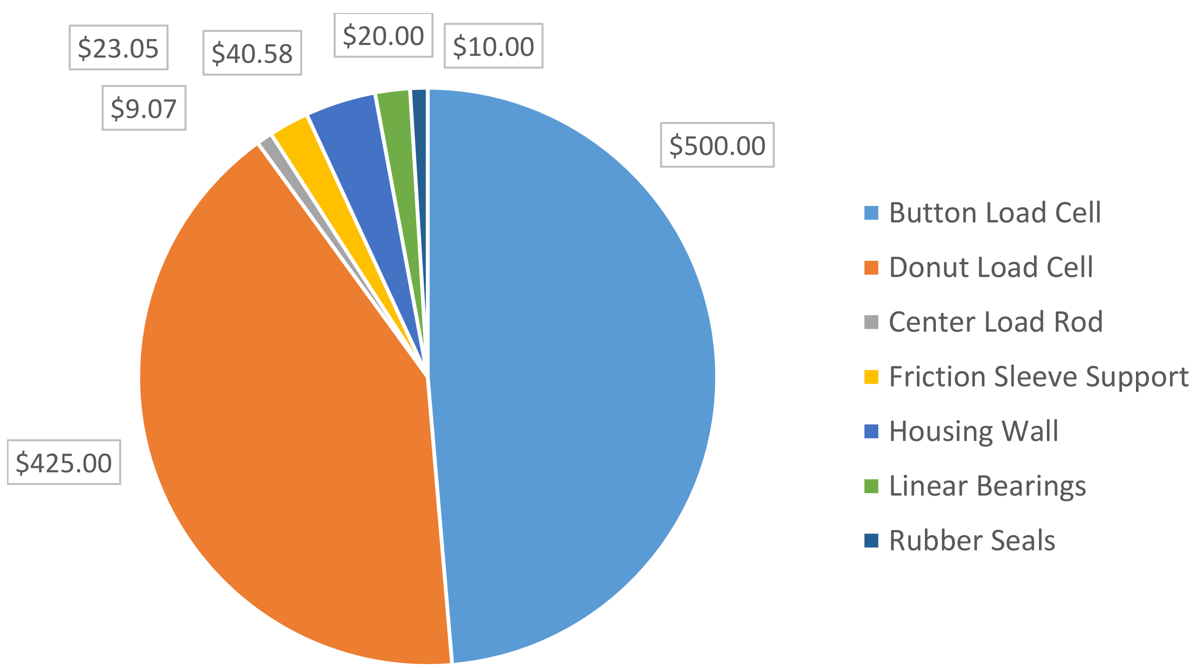


Figure 2. Estimated Cost of Mechanical Design

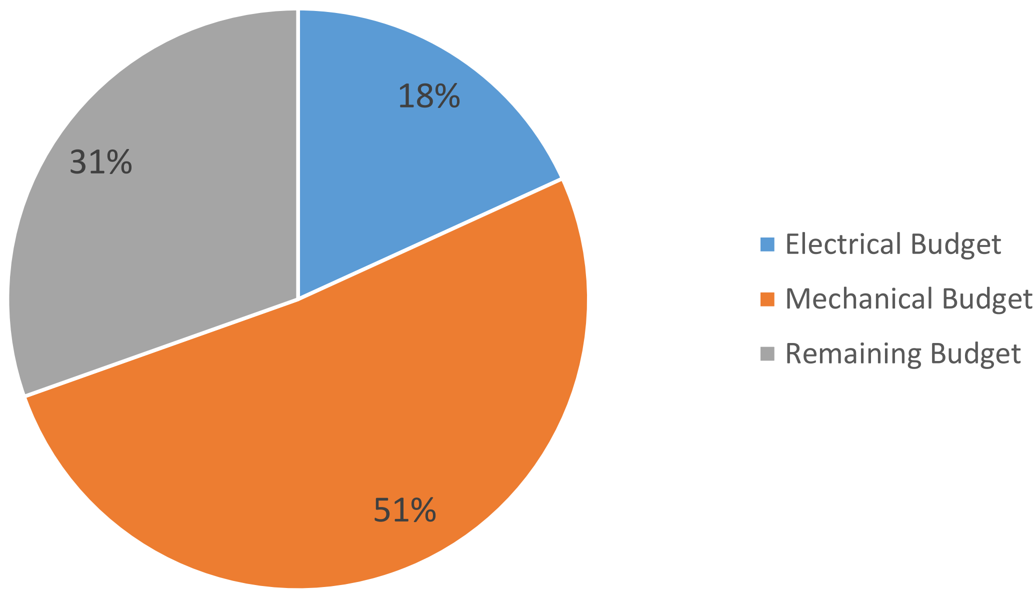
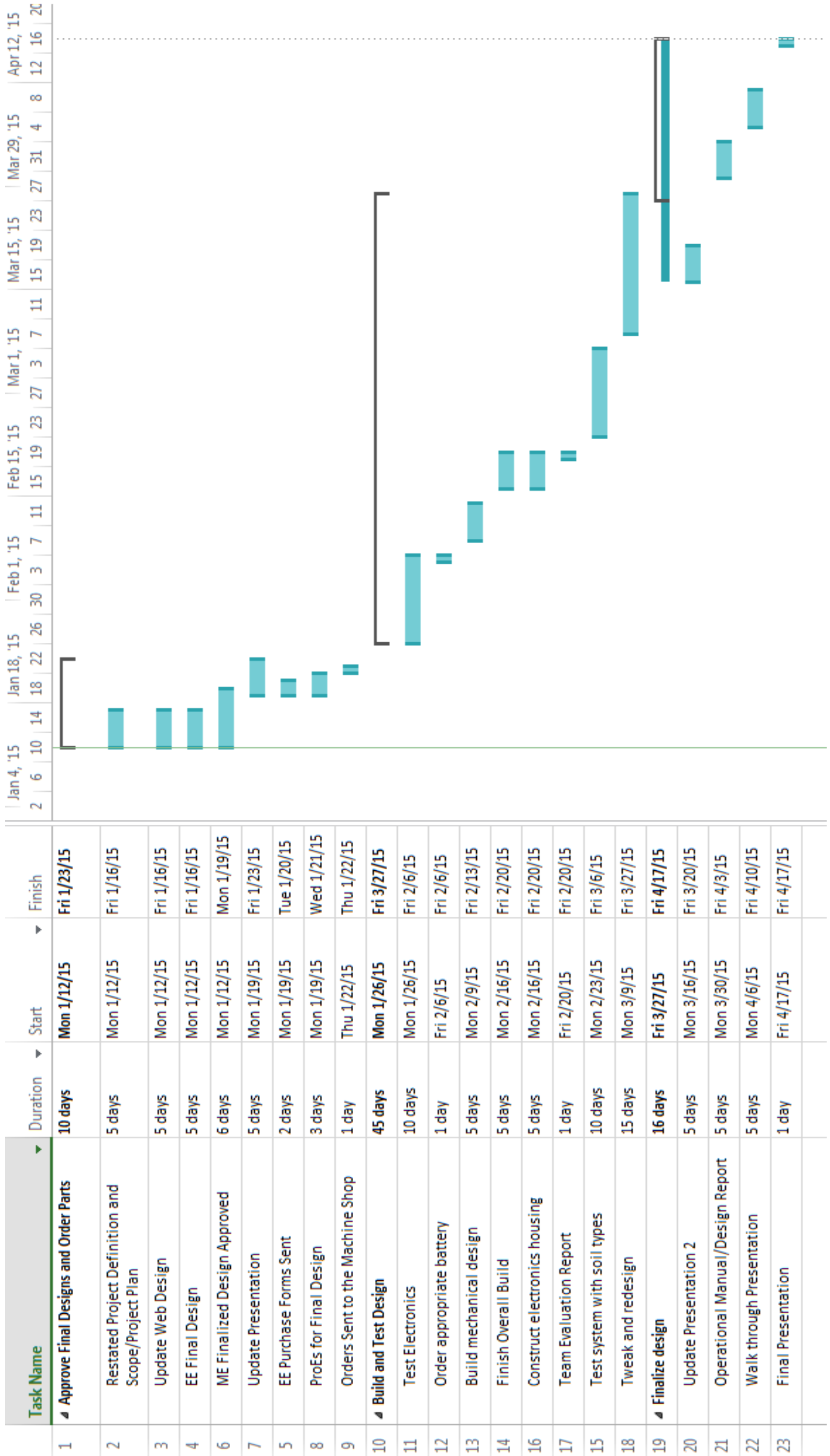


Figure 3. Total Budget Estimation

V. Appendix

5.1 Gantt Chart



	Task Name	Duration	Start	Finish
1	Approve Final Designs and Order Parts	10 days	Mon 1/12/15	Fri 1/23/15
2	Restated Project Definition and Scope/Project Plan	5 days	Mon 1/12/15	Fri 1/16/15
3	Update Web Design	5 days	Mon 1/12/15	Fri 1/16/15
4	EE Final Design	5 days	Mon 1/12/15	Fri 1/16/15
6	ME Finalized Design Approved	6 days	Mon 1/12/15	Mon 1/19/15
7	Update Presentation	5 days	Mon 1/19/15	Fri 1/23/15
5	EE Purchase Forms Sent	2 days	Mon 1/19/15	Tue 1/20/15
8	ProEs for Final Design	3 days	Mon 1/19/15	Wed 1/21/15
9	Orders Sent to the Machine Shop	1 day	Thu 1/22/15	Thu 1/22/15
10	Build and Test Design	45 days	Mon 1/26/15	Fri 3/27/15
11	Test Electronics	10 days	Mon 1/26/15	Fri 2/6/15
12	Order appropriate battery	1 day	Fri 2/6/15	Fri 2/6/15
13	Build mechanical design	5 days	Mon 2/9/15	Fri 2/13/15
14	Finish Overall Build	5 days	Mon 2/16/15	Fri 2/20/15
16	Construct electronics housing	5 days	Mon 2/16/15	Fri 2/20/15
17	Team Evaluation Report	1 day	Fri 2/20/15	Fri 2/20/15
15	Test system with soil types	10 days	Mon 2/23/15	Fri 3/6/15
18	Tweak and redesign	15 days	Mon 3/9/15	Fri 3/27/15
19	Finalize design	16 days	Fri 3/27/15	Fri 4/17/15
20	Update Presentation 2	5 days	Mon 3/16/15	Fri 3/20/15
21	Operational Manual/Design Report	5 days	Mon 3/30/15	Fri 4/3/15
22	Walk through Presentation	5 days	Mon 4/6/15	Fri 4/10/15
23	Final Presentation	1 day	Fri 4/17/15	Fri 4/17/15

Figure 4. Gantt Chart