To: Dr. David Trevas & Ulises Fuentes

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Subject: Implementation I Memo

The Psyche Sampling Team has been creating a sampling device that is operable on the surface of the Psyche asteroid. This sampling system must be capable of drilling and collecting samples. While in theory the team would be creating a device that is operable in the asteroid's environmental conditions, a restricted budget will not allow the team to create a system that is completely space-proof. The team will be focusing on creating a system that is fully operable on Earth and hypothetically applying the outside conditions to their system. It is important to note that the Psyche surface has not yet been explored, therefore the true composition and topography of this asteroid is still fully unknown. The team thus far has been able to build the tower structure of the main system frame, begin the manufacturing of an operating electromagnetic base, as well as, power and operate the system electronics through Arduino.

1 Implementation

The team has started manufacturing multiple parts to incorporate into the sampling system. These parts are necessary to complete the engineering requirements the team has specified. Manufacturing and design changes were completed to finalize the sampling system.

1.1 Manufacturing

To begin with, one of the first parts that the team started to manufacture the magnetic base used to stabilize the entire sampling system. The magnetic base (MagBase) is manufactured out of steel, and is the shape of doughnut as shown in Figure 1.

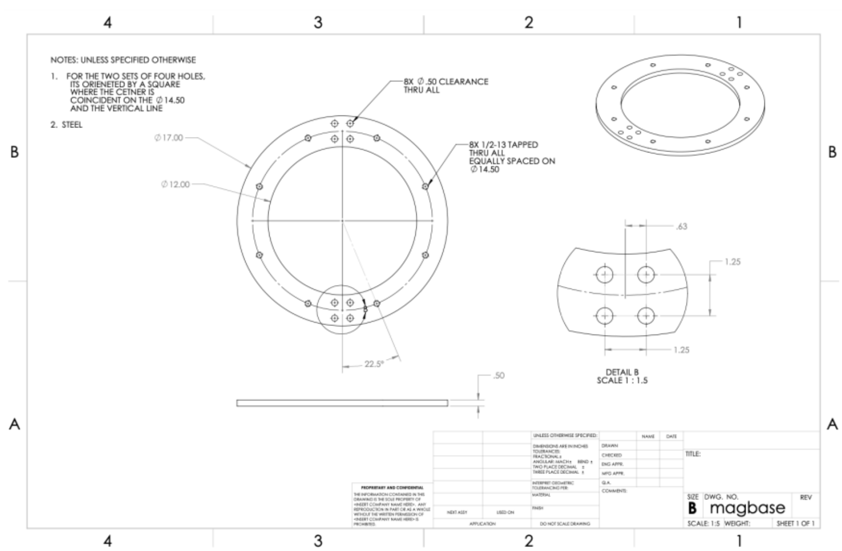

Figure 1: Drawing of the MagBase

The outer diameter will be 17 inches and the inner diameter 12 inches. It will have eight ½-13 tapped holes which will be equally spaced on diameter 14.5 inches. These holes will be used to insert eight iron bolts so that a wire carrying a current may be wrapped around, thus creating the magnetic force. 1000 turns is necessary to create the magnetic force so eight bolts will be sufficient. The MagBase will then have two sets of four clearance holes which are to be used for mounting the aluminum tower the team has built. The team also decided to manufacture a new plate that will be holding the drill and helping it move up and down the tower. Figure 2 demonstrates the new plate.

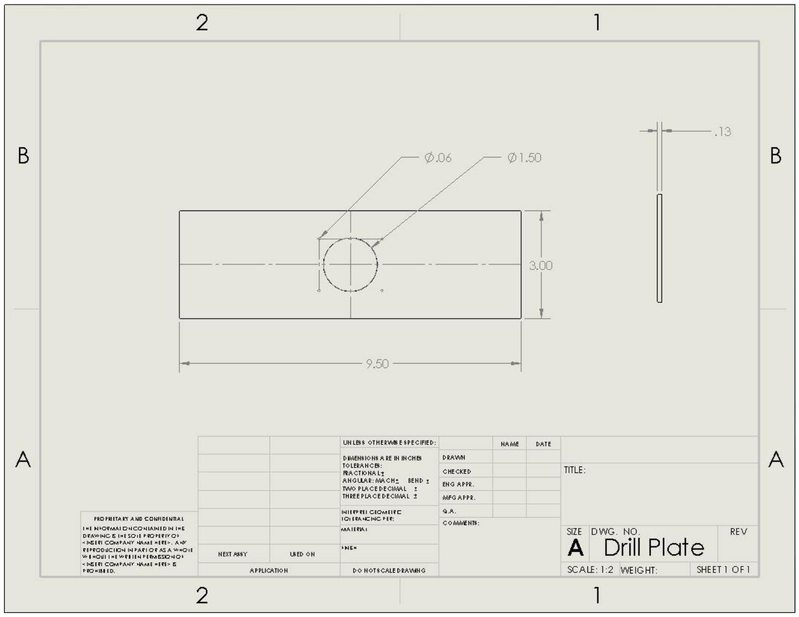

Figure 2: Drawing of the Drill Plate

The plate is made out of aluminum and has a length of 9.5 inches and a width of 3 inches and a thickness of 1/8 of an inch with a 1.5 inch diameter clearance hole in the middle so that the drill goes through.

1.2 Design Changes

Currently there are three major design changes. The changes include the base, electronic, and the tower. The previous base was made of wood and had no method of attaching to the asteroid surface. The new base is currently in the process of being made and will be constructed of ferrous iron with a magnetic component to attach to the surface. The initial electronic assembly consists of a series of switches that efficiently controlled the drill and linear actuators. As explained below, the new assembly will require less user input and control more parameters of the apparatus. Lastly, the tower which contains the drill and linear actuator was originally made of wood, yet the new tower is made from Tetrix building materials and will bolt to the new base.

1.2.1 Design Iteration 1: Change in Base Subsystem Discussion

Initially, the MagBase was going to have the wire wrapping around itself. While this was the initial thought, after analysis, the magnetic force the product would create would not be sufficient enough to stabilize the system. Since the wires would be wrapped around, the magnetic force that is emitted would be all around, wasting energy. The design change was to incorporate iron bolts that would be used to coil around instead of the base. By doing so, the magnetic force would face directly down. This design change utilizes the full potential the electromagnetic provides. This change can be seen in Figure 3, a CAD rendering of the MagBase with the bolts.

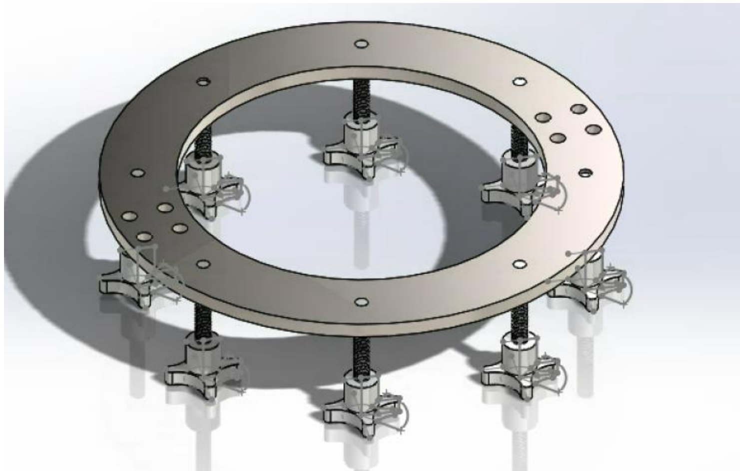

Figure 3: MagBase Design Change

1.2.2 Design Iteration 2: Change in Power Source and Operation Discussion

For the original idea the team was set on using batteries with seperate circuits to run the drill. This would require the team to manually switch on and off the system. The drawback to this operation in the manual power required to switch the device on and off. This could lead to irregularities in the motors as well as making the system impractical for space. For the power source, the team realised simple batteries did not provide enough voltage to run the motors and drill at the necessary speeds and torques. From troubleshooting these issues the team decided to use an Arduino system to create an autonomous drill, which is more practical of a drill that is required to run without any supervision. For the power source the team has chosen to power the system using one large battery, such as a car or lawn mower battery. This will provide the motors enough power to run the motors at top efficiency and have a maximum life span. These changes can be seen in Figure 4. The left picture represents the original design for power and operation while the right picture shows the iterated power and operation design.

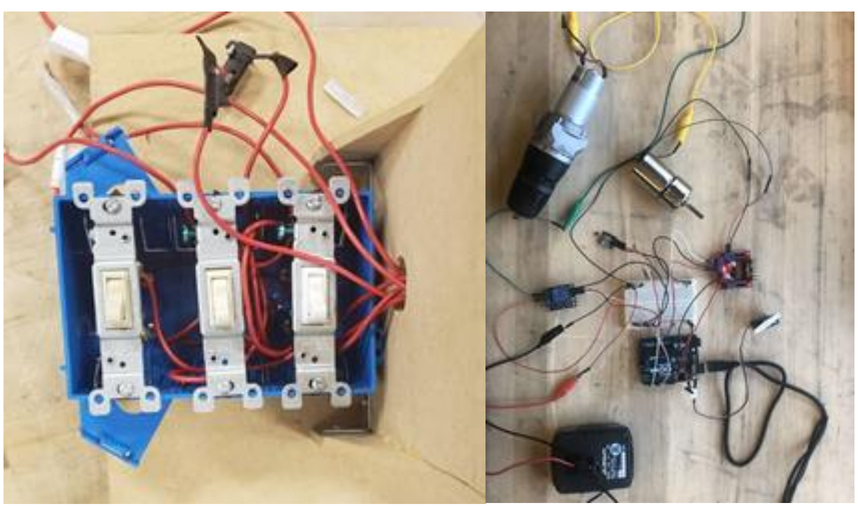

Figure 4: Power Source and Operation Iteration

1.2.3 Design Iteration 3: Change in Tower Structure Discussion

The original dower system was manufactured using wood in order to keep cost low. Utilizing a bent-over design, the tower was remarkably unstable and prone to tipping. As well, the design failed to accommodate space for the linear actuators. The new design is already constructed using Tetrix building supplies seen in Figure 5.

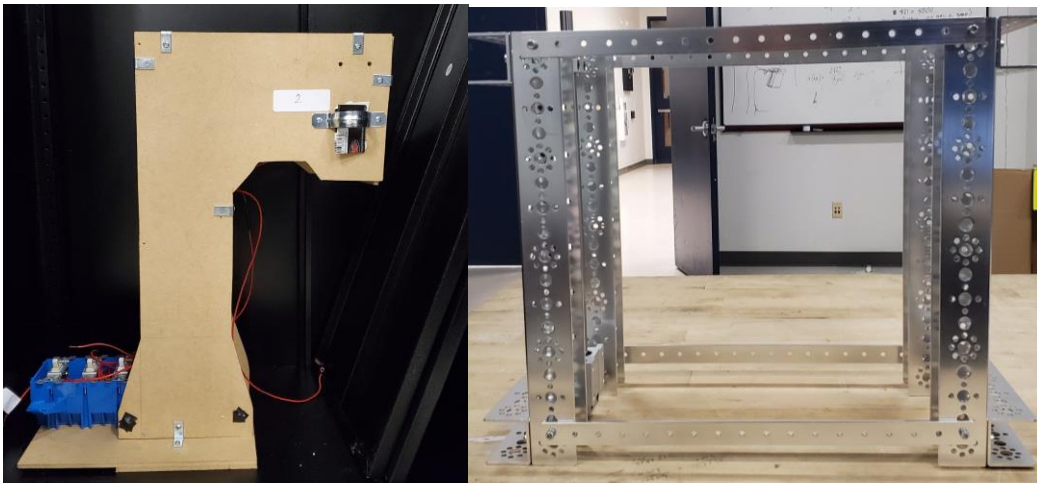

Figure 5: Design Change of the Tower

The Tetrix allows for a somewhat modular assembly capable of being easily redesigned and rebuilt. As well, the assembly method allows for a stronger yet non-permanent construction. The new tower also has been built to accommodate the ball screw and linear rail inside the assembly. Tetrix uses an interlocking system consisting of small bolts and nuts that can be placed into pre-placed holes along the length of the scaffold pieces. The old tower was connected to the base using L-brackets and screws, the new base will be bolted to the base, making for a stronger and more stable design. The tower is also much shorter than the old design, reducing the chance of tipping. The tower will act as “base” for the addition of the caching system and drill assembly. This will be what the team builds off of for the rest of the semester.

2 Future Implementation

For future implementation the team plans to create a caching system, a system to remove the sample from the core drill, and a solid electronic circuit. The caching system is planned to be an arm that, when activated, swings under the drill assembly and catches the sample. The sample remover will be constructed using a servo motor and a 3d-printed assembly and mount. The Electronic circuit is currently connected through a breadboard; however, the team plans to solder the leads together to make cleaner and stronger connections. In order to accomplish this the team will continue using the current schedule for team and staff meetings. In the event the team is behind what is planned according to the Gantt chart, meetings on Wednesdays can be arranged. Currently, the budget has not been depleted as the team makes purchases, and at the moment there is a buffer set to allow last minute purchases. Currently the future planned 3d-printed parts are the only purchases yet to be made, and there are currently no other parts to be sourced.

2.1 Further Manufacturing and Design

In the future, the team plans on manufacturing the arm that sways in and out of the tower. This arm will most likely have to be designed and manufactured because of the complexity. This will require two or more servo motors to bring the arm in, and rotate the caching system so the samples may be stored. The caching system will be the last product in designing. The team will also need to complete the coding and programming for the Arduino operating system. This includes finalizing the full code into one single code that fully operates the entire system and incorporating a bluetooth controlling element to the code. Once this code is finalized, the team will need to solder wires together so that the electrical wiring can be implemented into the final product.

2.2 Schedule Breakdown

As of the beginning of Week 7, the team is on schedule to complete the final product development stages by the March 23rd deadline. The team is about halfway through this development process and has been working diligently each week to finalize the product before spring break. Originally, the team set the deadline to be the Sunday before the final due date, however the deadline has moved up to the Friday before spring break starts (March 13th). This change was due to how much the team has accomplished already and the availability of the team during the week of spring break. A new team general schedule breakdown for the rest of the semester is outlined in Appendix A.

2.3 Budget breakdown

As of the beginning of the spring 2020 semester the team started ordering parts and building the sampling system. Appendix B shows the bill of materials and how much money the team has spent up to date. The starting budget for the team was $1000, after spending $750.62 on parts for the sampling system. The team has $249.38 left for the project and will use it for manufacturing the drill plate and to buy a new battery.

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4 3 Conclusion

Overall the team has been successful in the final product building process. The team thus far has been able to stay on schedule, create subsystems for the product and stay under budget with the purchases that they have made to create this system. Although there have been changes to the designs created in the first semester of Capstone, the team has been able to implement changes that benefit the success of the final sampling system product.

5 4 Appendix

5.1 4.1 Appendix A: Updated Team Schedule

Week Number	Date Range	Team Project Goal	Team Assignment Due
Week 7	Feb. 24 - Mar. 1	Have electromagnetic base manufacturing finished and Arduino code mostly finalized.	Implementation Memo
Week 8	Mar. 2 - Mar. 8	Have an electromagnetic base connected to the main frame, connect sample caching system, and make Arduino bluetooth operated.	Midpoint Presentation Hardware Review
Week 9	Mar. 9 - Mar. 15	Solder electrical wires from Arduino, have all subsystems in place (and operating!!). Overall, have the final product built.	Draft of Poster Individual Analysis
Spring Break			
Week 10	Mar. 23 - Mar. 29	Upload up-to-date documents on website and implement any final changes to our final product. Make adjustments and edits to the final draft of the poster and submit it to the printer shop. Begin testing!	Final Product Website Check 2
Week 11	Mar. 30 - Apr. 5	Have the final poster printed by the beginning of the week and work on implementation memo. Implement changes to product based on testing. Re-test product where the testing failed.	Final Poster Implementation Memo II
Week 12	Apr. 6 - Apr. 12	Complete testing that needs to be completed, per client request. Write testing report.	Testing Proof Report
Week 13	Apr. 13 - Apr. 19	Practice U-grads presentations and prepare for client presentation next week. Make sure the poster is PERFECT for the presentation.	

Week 14	Apr. 20 - Apr. 26	Begin Final report and operation/Assembly manual. Practice some more.	U-Grads Presentation!!
Week 15	Apr. 27 - May 3	Finish final deliverables.	Final Report Operation/Assembly Manual
Week 16 (Finals Week)	May 4 - May 8	Upload up-to-date documents and finalize the website.	Final Website Check Client Hand-Off

5.2 4.2 Appendix B: Updated Bill of materials

Bill of Materials			
Part Name	Part Quantity	Part Price	Part Description
Tetrix box	1	Provided by Dr. Trevas	Used the Tetrix box to create the tower
Drill motor	1	Used from old drill	The main that would be the main component and drills through the materials
Arduino kit	1	$71.80	The Arduino kit will help in controlling all the electronic parts in the sampling system
Easy-Access Base-Mounted Shaft Support	3	$13.38	The supports keep the ends of the rods from wandering and create a more accurate motion.
External-Thread Ball Nut	1	$63.46	The balls screw nut uses ball bearings to thread onto the ball screw, reducing friction.
Mounted Linear Sleeve Bearing	1	$53.31	The linear bearing moves frictionlessly along the steel shaft .
Ball Screw	1	$44.31	The ball screw translates the rotational motion of the motor to vertical motion to raise and lower the drill assembly.
Linear Motion Shaft	1	$16.95	The linear motion shaft provides support to the drill assembly, removing the need for a second ball screw.
Iron Four Arm Knob	8	$11.67	These are the screws that will be attached to

			the base and wrapped with magnet wire.
Servo Motor	1	$31.99	The servos motors will be used to actuate the caching arm, and the sample remover.
Clamping Beam Coupling	1	$8.36	This coupler will connect the motor to the ball-screw.
Base	1	$398.74	The base will support the tower and magnetic feet.
Total Price		$750.62	

5.3

5.4 4.3 Appendix C: Project Disclaimer

This work was created in partial fulfillment of Northern Arizona University's Capstone Course "ME 486C". The work is a result of the Psyche Student Collaborations component of NASA's Psyche Mission (https://psyche.asu.edu). "Psyche: A Journey to a Metal World" [Contract number NNM16AA09C] is part of the NASA Discovery Program mission to solar system targets. Trade names and trademarks of ASU and NASA are used in this work for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by Arizona State University or National Aeronautics and Space Administration. The content is solely the responsibility of the authors and does not necessarily represent the official views of ASU or NASA.