**Project Deliverable D: Conceptual Design**

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**Abstract**

*This document defines three key subsystems for the final product and presents some conceptual designs that have been developed for one. These concepts will be analyzed and compared to obtain the most effective solutions. Three functional design combinations will be created from these designs, and a single global concept will be selected from the three combinations. The chosen concept will then be further developed in future stages of the design process.*

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# Introduction

This document showcases our conceptual designs, sketches, evaluations and justifications for how we selected the best solution for our design for the design challenge. Each team member had a role to play as we all showcased one idea for each of the three subsystems, and after talking it over and careful consideration we landed on what we believe the best design is.

# Sub-systems

We have selected three sub-systems for our design: the movement mechanism, the scraping mechanism, and the collection mechanism. The movement mechanism will control how the device will traverse through the pipe. The scraping mechanism will obtain the metal sample from the inner surface of the pipe. The collection mechanism is how the sample will be stored to prevent direct contact between the operator and the sample.

## Movement

| Design # | Team Member | Design | Description |
| --- | --- | --- | --- |
| 1 | Ethan |  | 4 wheels are attached to the device by expanding and contracting “arms” that can adjust their length based on the size of the tube |
| 2 | Jacob |  | A motorized crawler which incorporates magnetic wheels to keep the crawler alined in the tube properly. Crawler is tethered and can be pulled out safely at any time, and is wireless and the locomotive system is run on battery power. |
| 3 | Wade |  | This design features a tracked robotic crawler that moves inside the pressure tube, a mechanical scraping arm will extend from the machine to remove material from the inside wall. |
| 4 | Ramya |  | This sketch illustrates a tracked robotic system designed for scraping and material collection. The movement system includes tracked wheels for stability, enabling forward motion, turning, and an extendable platform for increased reach. A camera-mounted arm provides visual feedback, and the scraping mechanism collects material efficiently through an adjustable blade. |
| 5 |  |  |  |

| Design # | Benefits | Drawbacks |
| --- | --- | --- |
| 1 | * Works in both vertical and horizontal orientations * Can adjust to slight elevation changes(e.g. pipe sagging) | * Requires some time to align with pipe before using |
| 2 | -proper alignment  -can combat for sagging in pipes  -capable of working in the horizontal direction | -doesn't work in the vertical direction, which after undergoing modification this could change |
| 3 | * easy movement within the tube * allows for easy access to samples in different positions | * cannot access vertical pipes |
| 4 | * Supports forward motion and turning, allowing precise maneuverability. * Extendable platform enhances reach and flexibility. | * Turning in tight spaces may be challenging due to the track design. |
| 5 |  |  |

## Sample Collection System

| Design # | Team Member | Design | Description |
| --- | --- | --- | --- |
| 1 | Ethan |  | Small arm that rotates 360 degrees along the inner perimeter of the pipe, collecting sample inside a small chamber |
| 2 | Jacob |  | A tri prong scraper that is razor sharp and as the crawler moves it scrapes the pipe loosening shavings to be collected. |
| 3 | Wade |  | An extendable arm coming from the body that scrapes the bottom of the pipe and retracts the metal back towards the body. |
| 4 | Ramya |  | The Scraping Blade Mechanism uses an adjustable blade to scrape a thin metal layer, ensuring a 30-80 mg sample. A compartment behind the blade temporarily stores the sample before transfer. This setup allows for precise and consistent extraction. |
| 5 |  |  |  |

| Design # | Benefits | Drawbacks |
| --- | --- | --- |
| 1 | * Consistent sample size | * Would require sampling substance to be found at a distance from the perimeter from the pipe * May be a difficult to implement |
| 2 | -easy to use requires no adjustments | -blades can dull and me need to be frequently replaced or sharpened |
| 3 | * easily able to scrape the bottom of pipes * consistent sample sizes | * constant use could wear down device |
| 4 | * Adjustable blade allows control over sample thickness. * Simple mechanical design with minimal moving parts | * Potential for minor tube surface damage over repeated use. |
| 5 |  |  |

## Collection mechanism

| Design # | Team Member | Design | Description |
| --- | --- | --- | --- |
| 1 | Ethan |  |  |
| 2 | Jacob |  | A vacuum head that trails behind the robot suckign up shaving residue into the container. Container has a maximum of 80mg capacity, and alerts the user when filled to 30 grams. |
| 3 | Wade |  | Cylindrical vacuum chamber to collect metal samples from within the body. Maximum capacity of the tank is 80 mg. |
| 4 |  |  |  |
| 5 |  |  |  |

| Design # | Benefits | Drawbacks |
| --- | --- | --- |
| 1 | * Isolated sample * Easy to implement | * Requires way of transferring sample from collecting system into storage chamber |
| 2 | -keeps sample isolated in closed top container | -vacuum may suck other unwanted debris |
| 3 | * Minimizes sample contamination and allows better retrieval. | * Requires power supply. * Storage and filters would need cleaning. |
| 4 |  |  |
| 5 |  |  |

# Global Concepts

| Design # | Design |
| --- | --- |
| 1 | (Design 4 for Sample Collection and Movement) |
| 2 | (Design 2 for collection mechanism) |
| 3 | (Design 2 for collection mechanism) |

# Analysis

Through the evaluation of the design’s efficiency and limitations we determined the best solution as shown in our design 1. This combination allows for precise sample extraction while minimizing errors and contamination. Despite some complex ideas, the benefits of the final design outweigh the challenges, making it the best and most effective solution for the design challenge.

# Conclusion

After exploring multiple designs for each subsystem, and looking at their strengths and weaknesses as a team, we came to the optimal solution for our design challenge. Our final design has the most effective features from our initial sketches while keeping in mind the key constraints. By combining our individual work and team decision-making, we developed a solution that best meets the requirements of the project. This process improved our abilities to work as a team and make solid group decisions.