# Final Project Presentation

## Team *WACAV*

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# Introduction

# Project Goals

- Complete a thorough design while utilising and following through the design process
- Meet our clients requirements and expectations
- Learn how to utilise the techniques of engineering design and analysis taught in this course

# Problem Statement and Empathizing

The EMED team at Canadian Nuclear Laboratories needs a portable, fail-safe device capable of extracting a metal sample from the interior of a tube in both vertical and horizontal orientations. The device must be capable of passing through potentially warped tubes, store the sample safely without exposing the sample to the operator, provide operator feedback, and collect only between 30 and 80 milligrams of the sample. Additionally, the device must be reusable, and compact enough to be broken down into man-portable sizes.

# Subsystems Identified

- **Movement**
- **Scraping + Collection**
- **Communication**
- **Failsafe**

# Design Criteria

# Movement

- The device must be able to move through a pipe that is 4.572 m long, has a diameter of 101.6 mm, and has a wall thickness of 4.1 mm.
- Must be able to move vertically as well as horizontally.

# Scraping + Collection

- The device must be able to scrape and collect a 30 - 80 mg sample of metal from the tube.
- The sample must be stored in a container that can be sealed in order to prevent the device operator from coming in contact with the sample.

## Communication

- The device must have some method of providing feedback to the user to confirm the distance of the device through the pipe.
- The device must include a method for adjusting the sample retrieval process to ensure that the sample obtained weighs between 30 and 80 grams.

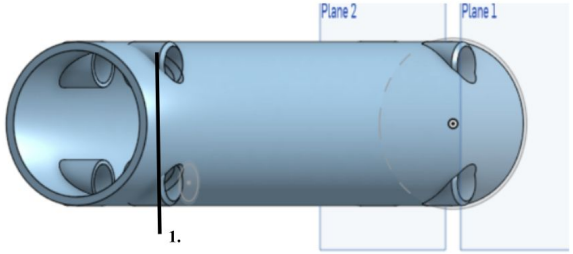
## Failsafe

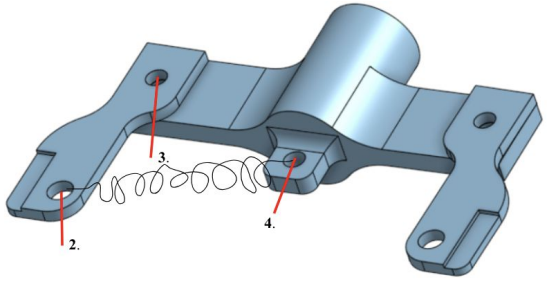
- The device must have a way to be removed from the tube if any of its components fail.

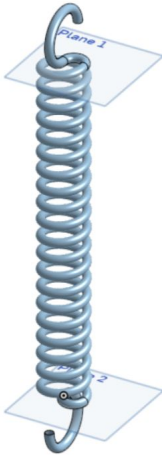
# Design Iterations & Selection

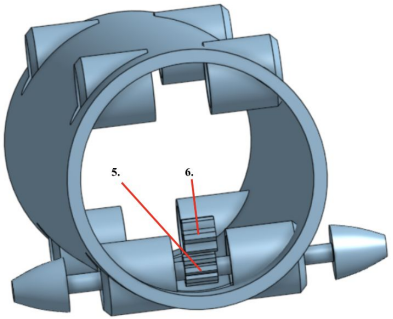
# Idea #1

- This is one of the designs that were developed during the conceptual design stage.

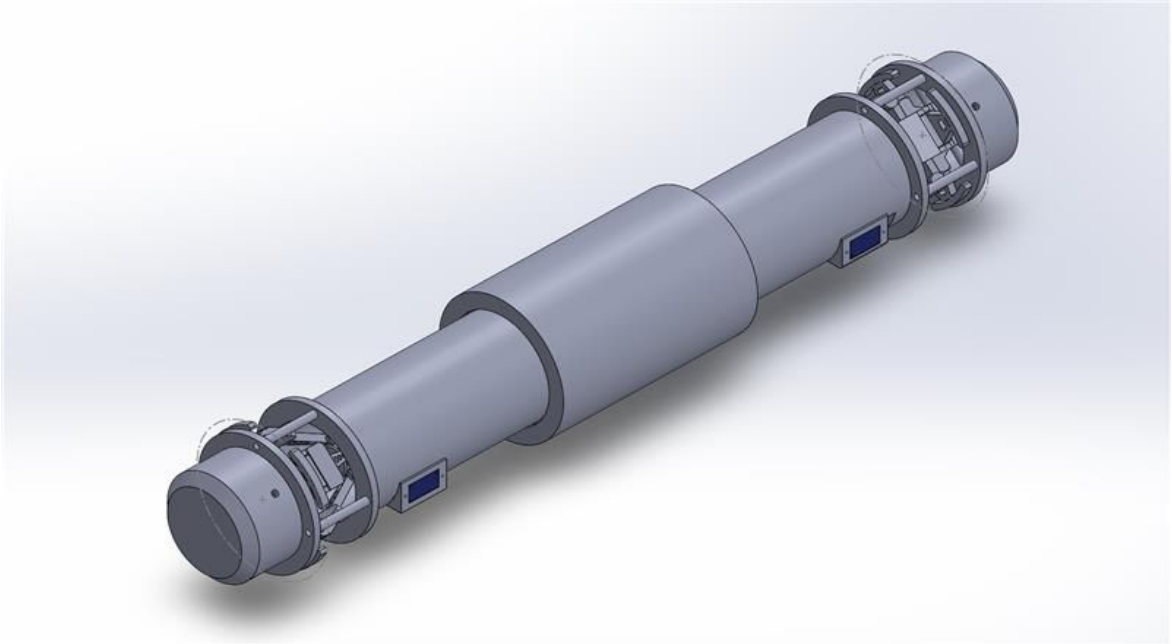


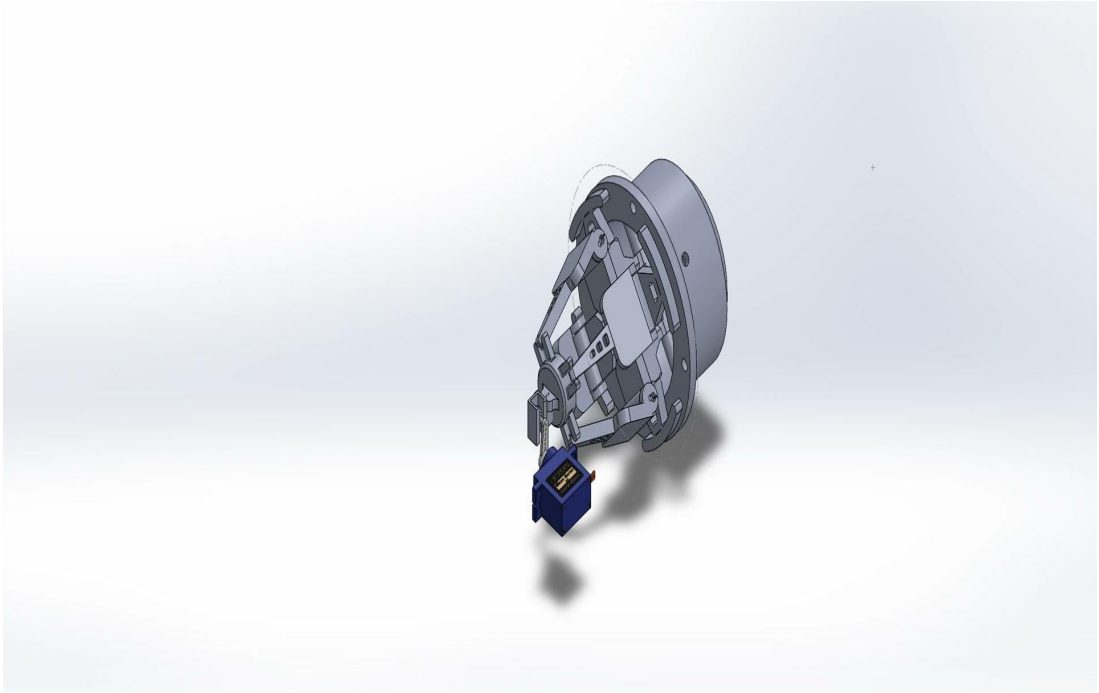



# Idea #2 (Final Design)

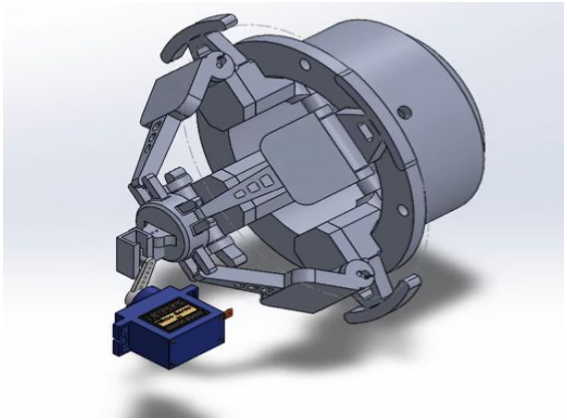


# Prototyping and Testing

# Prototype #1



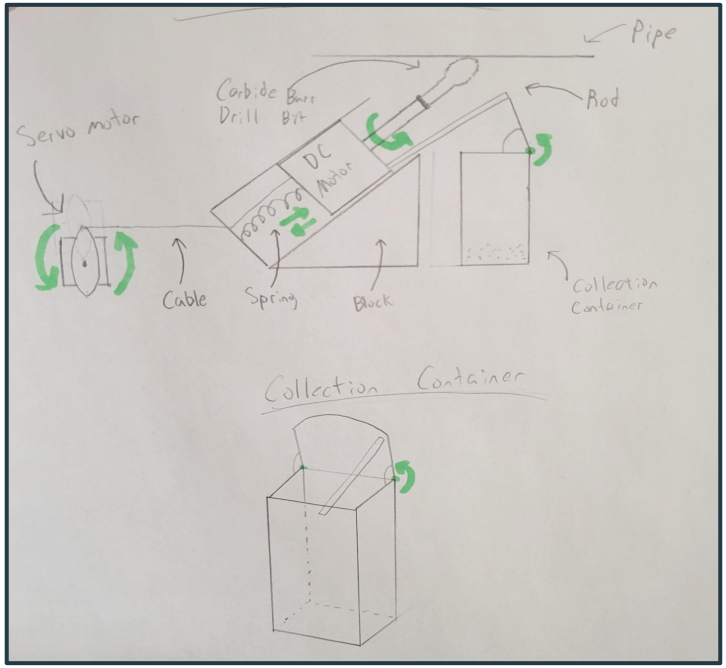
# Movement



- The servo motor is used to operate a mechanism that pushes the clamps outwards, allowing them to grip the surface of the tube.
- The stepper motor drives the rack and pinion system that is mounted inside the middle section.

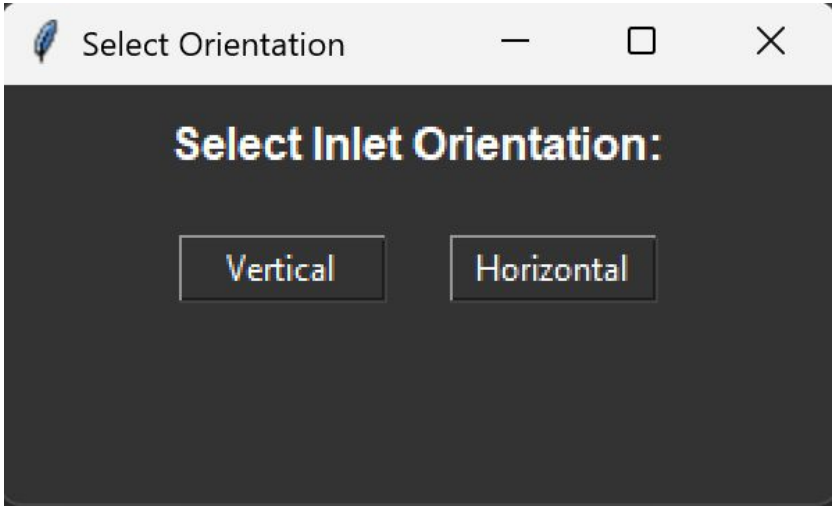
# Scraping and Collection

- The servo motor releases a spring, letting the drill bit contact the pipe while the DC motor spins it to scrape the pipe's surface.
- The rod connected to the motor opens the lid of the collection system as the drill bit extends and closes it when the drill bit is retracted.

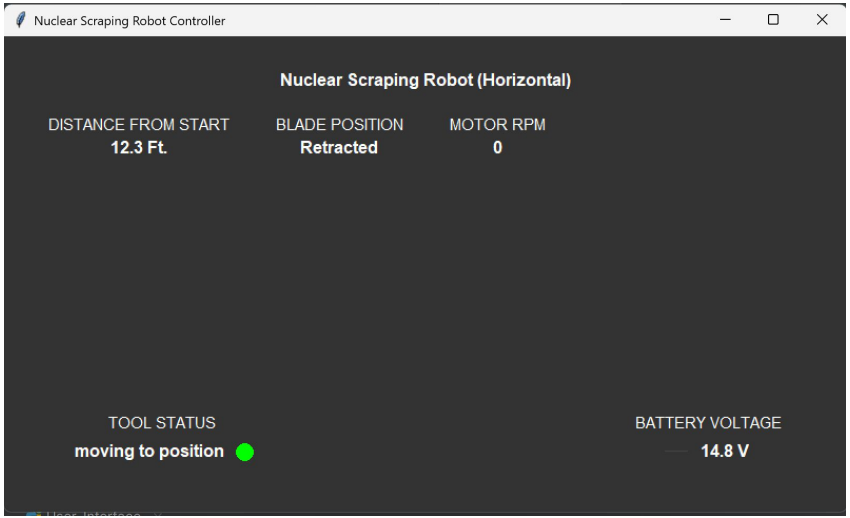



**GREEN indicates movement**

# User Interface



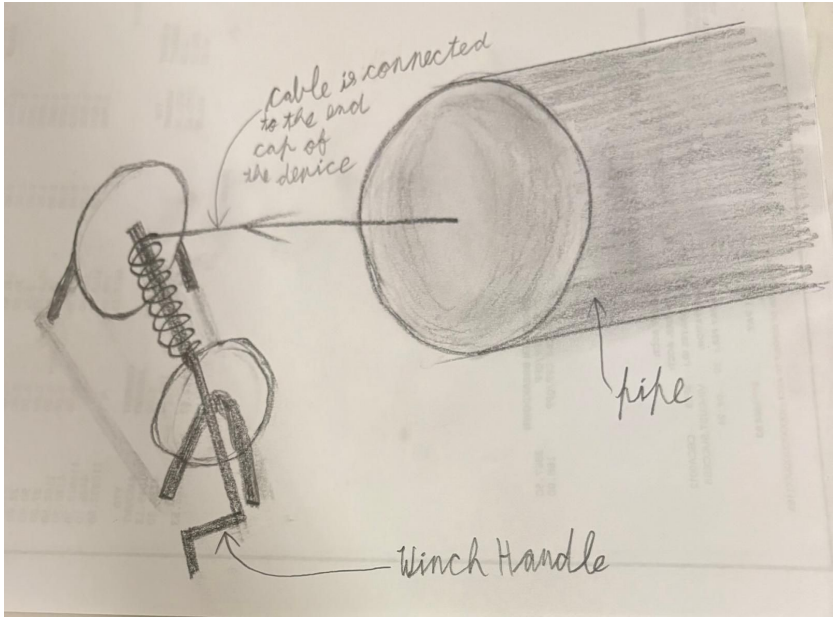

Tube Orientation



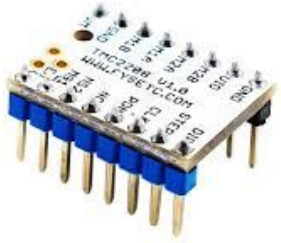

Status

# Failsafe

- The winch cable is attached to one of the end caps of the device.
- The handle is rotated anticlockwise to pull the device out of the tube.

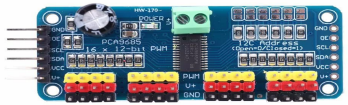


# Electronics

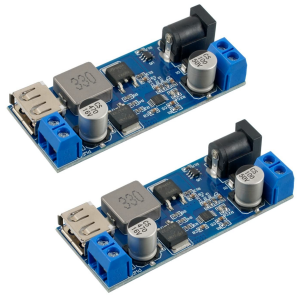


**Stepper Motor Driver**

**DC Motor Driver**



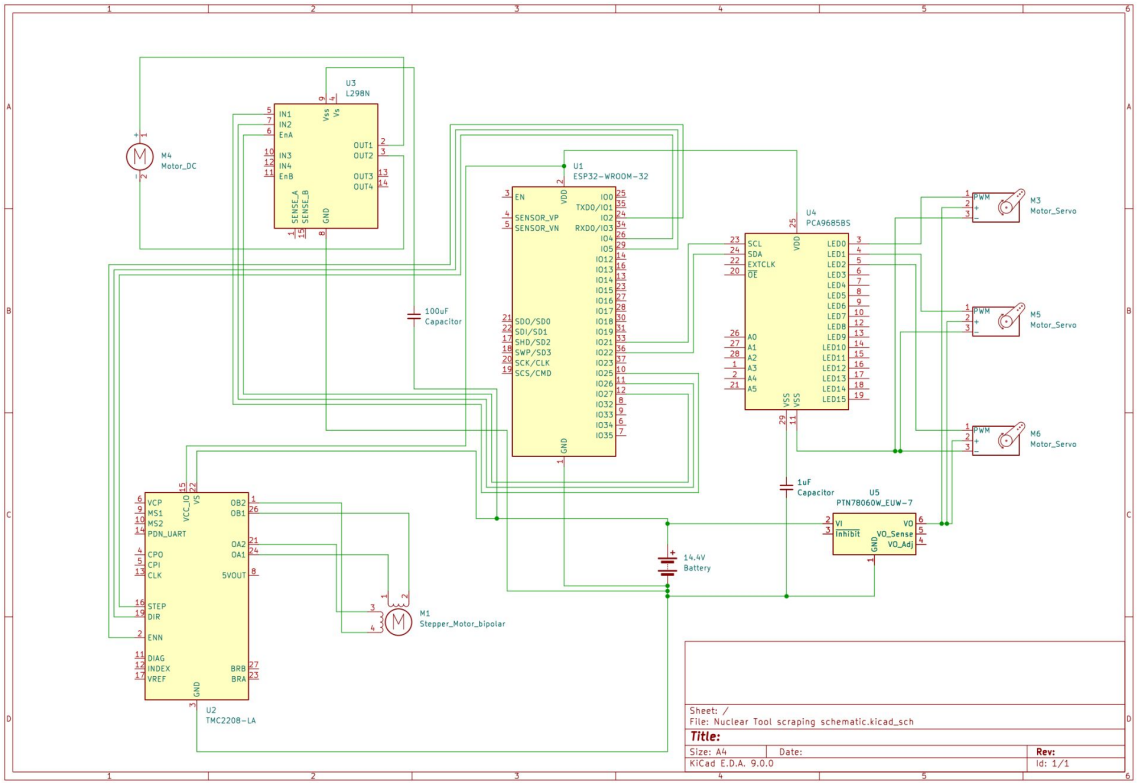
**Servo Motor Driver**



**Voltage Step Down Converters**

- The motor drivers control the motors based on the sequenced signals given by the microcontroller.
- The buck converter is used to step down (reduce) the voltage for components that require a lower voltage to function properly.

# Circuit Diagram



# Bill Of Materials

| Item No. | Component | Description | Qty. | Cost (CAD) |
|---|---|---|---|---|
| 1 | ESP32 Dev Board | Main Microcontroller (Wi-Fi, Bluetooth) | 2 | $23.95 |
| 2 | TMC2208 Stepper Motor Driver | Stepper driver (for rack and pinion movement control) | 1 | $10.19 |
| 3 | L298N DC motor Driver | Motor driver for scraper rotation movement | 1 | $2.51 |
| 4 | PCA9685 Servo Driver | 16 channel PWM servo driver | 1 | $8.33 |
| 5 | 6V Buck converter | Step down module for servo motors | 1 | $2.89 |
| 6 | NEMA 17 Stepper motor | Rack and Pinion Movement | 1 | $14.07 |
| 7 | DC Motor | Scraping rotation | 1 | $8.99 |
| 8 | MG995 Servo Motor | High torque servo | 3 | $15.36 |
| 9 | 3S 11.1V LiPo Battery | Power Source | 1 | $16.20 |
| 10 | Wires and Connectors | Set of 40 | | $2.95 |
| 11 | 1 uF Capacitor | | 1 | $1.33 |
| 11 | 100 uF Capacitor | | 1 | $0.12 |
| 14 | Pinion Gear | Carbon Fiber Mix Filament (3d printed) | 1 | $0.77 |
| 15 | Rack | Carbon Fiber Mix Filament (3D printed) | 1 | $1.34 |
| 16 | Carriage support | Polycarbonate Filament (3d printed) | 1 | $0.52 |
| 17 | Clamp Carriage | Polycarbonate Filament (3d printed) | 4 | $5.40 |
| 18 | Central Arm | Polycarbonate Filament (3d printed) | 4 | $1.80 |
| 19 | Central Arm Connector | Polycarbonate Filament (3d printed) | 1 | $0.38 |
| 20 | Servo Guide | PLA (1 roll) | 1 | $30.00 |
| 21 | Servo Guide Rail | PLA | 1 | \| |
| 22 | End Caps | PLA | 1 | \| |
| 23 | Back Section | PLA | 1 | \| |
| 24 | Front Section | PLA | 1 | \| |
| 25 | Middle Section | PLA | 1 | \| |
| 26 | SG-5 Carbide Bur | Scraping Tool | 1 | $18.23 |
| 27 | M5x0.8mm Screws | Fastener | 8 | $15.00 |
| 28 | #12-28 Screws | Fastener | 8 | $5.18 |
| | | | | |
| | | | | **Total Cost: $185.53** |

# Testing

- **Movement**
- **Scraping and Collection**
- **Failsafe**

# Movement

## Type Of Test

The device will be tested within the pipe given in the lab, and the distance traveled per movement sequence will be measured. Through multiple trials, the range of movement per cycle will be determined.

## Fidelity - High

The outer shell of the device will be constructed, containing only the necessary components required for this evaluation.

## Why?

To ensure proper operation, fluidity over multiple trials, and ensure accurate distance in meters.

# Scraping

## Type Of Test

The device will be tested within the pipe given in the lab. The test will involve timing the duration required to remove 30-80 mg of material. This trial will be repeated multiple times, and the results will be noted.

## Fidelity - Medium

Just the scraping tool will be setup on own stand to test efficacy against tube.

## Why?

To ensure the tool efficiently scrapes the metal while leaving the surface undamaged, along with measuring time to collect a sample in the acceptable range in milligrams.

# Failsafe

## Type Of Test

The machine will be tested within the pipe given in the lab. Once the tool is placed down the tube and the holding system is active, we will activate the winch.

## Fidelity - Medium/High

The outer shell of the device will be constructed, containing only the necessary components required for this evaluation.

## Why?

To ensure the winch effectively retrieves the tool while not damaging the tube.

# Future Plans

# To Be Completed

- Finish completing code
- Wire circuits and components
- Complete further testing with prototypes II and III
- Complete our final prototype for design day

# Thank you for listening!

**Any Questions?**