Project Deliverable G: Prototype II and Customer Feedback

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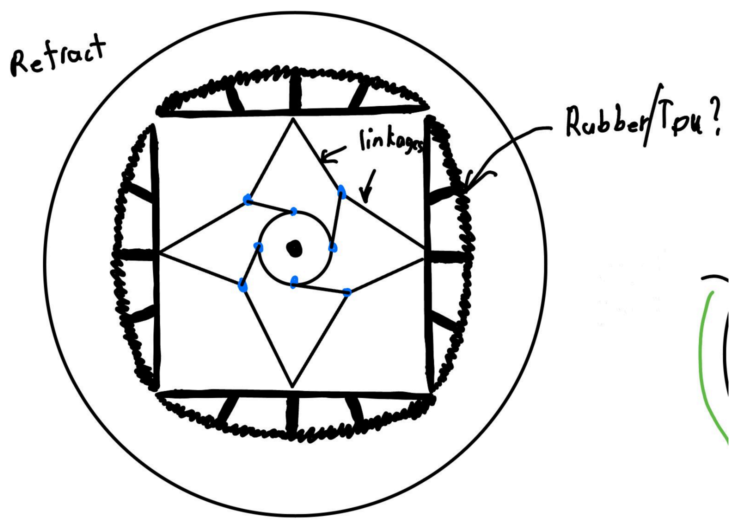
1. Feedback Received on Design

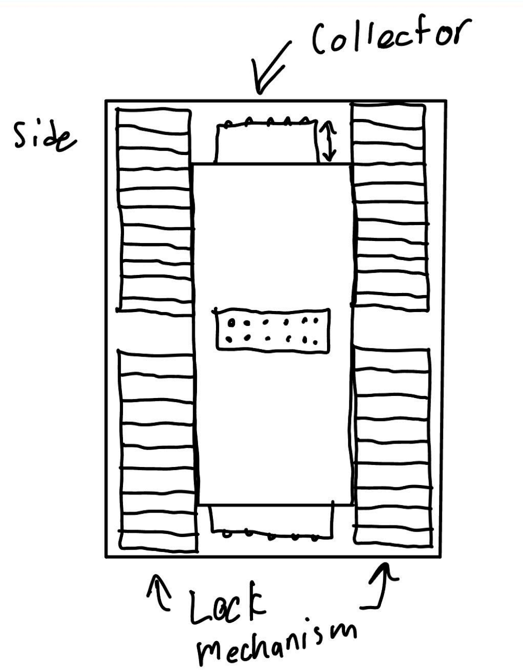
The feedback that we received on our design is mainly that our simple design is very desirable for our client and that we should pursue testing to ensure that all components will be able to withhold their tasks. During the meeting, the client emphasized the importance of using simple and effective methods for sample containment. They highlighted gravity as a potential method of sample collection, which ensures that the design is simple and efficient. Following our in class presentation of our design to the client we received feedback on our scraping mechanism having enough torque and power to scrape a sample seeing as though our design has to be light to allow for the rigidity of the measuring to move the design.

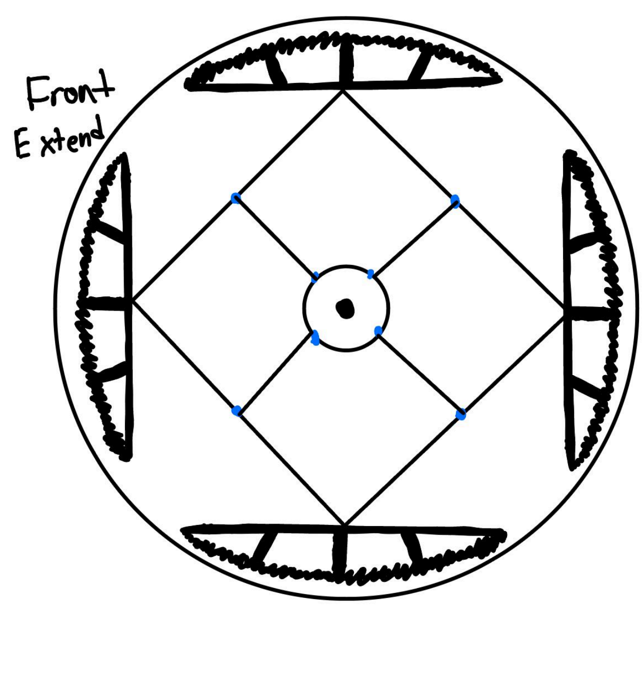
2. New Prototype

a. Updated “Rough” Design Drawings

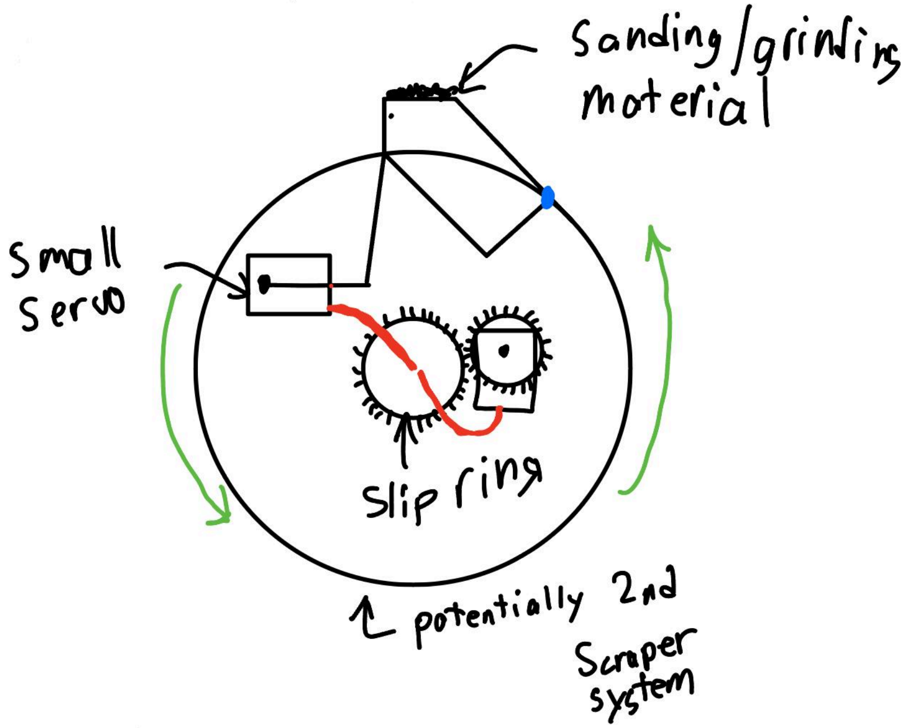
Locking Mechanism:



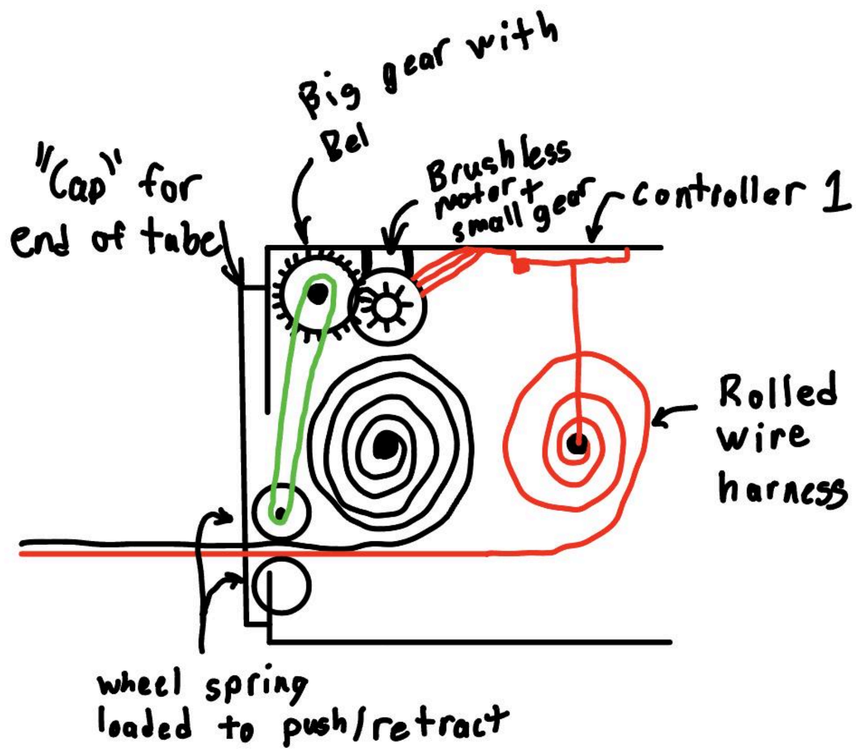




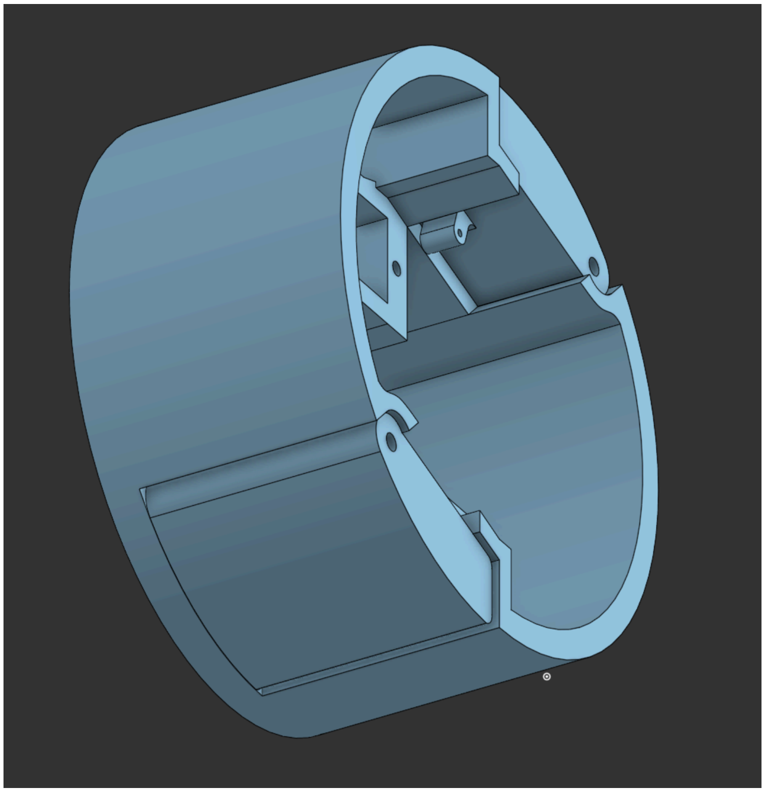
Scraping Mechanism:

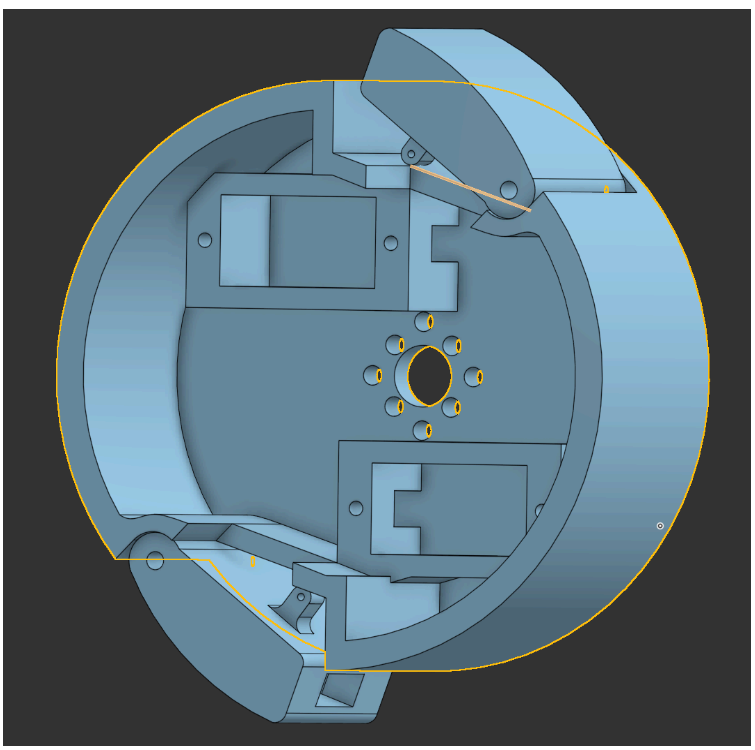


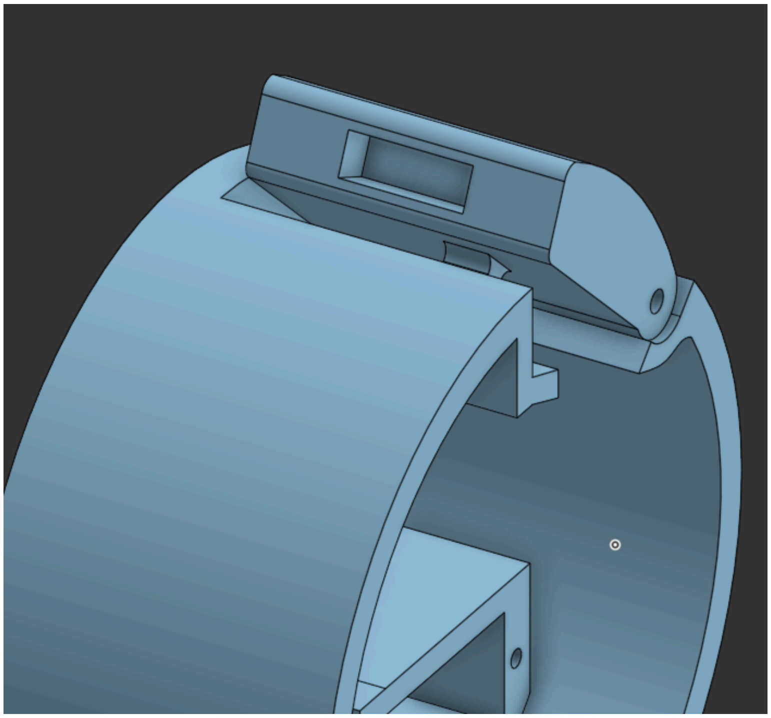
Movement Mechanism:

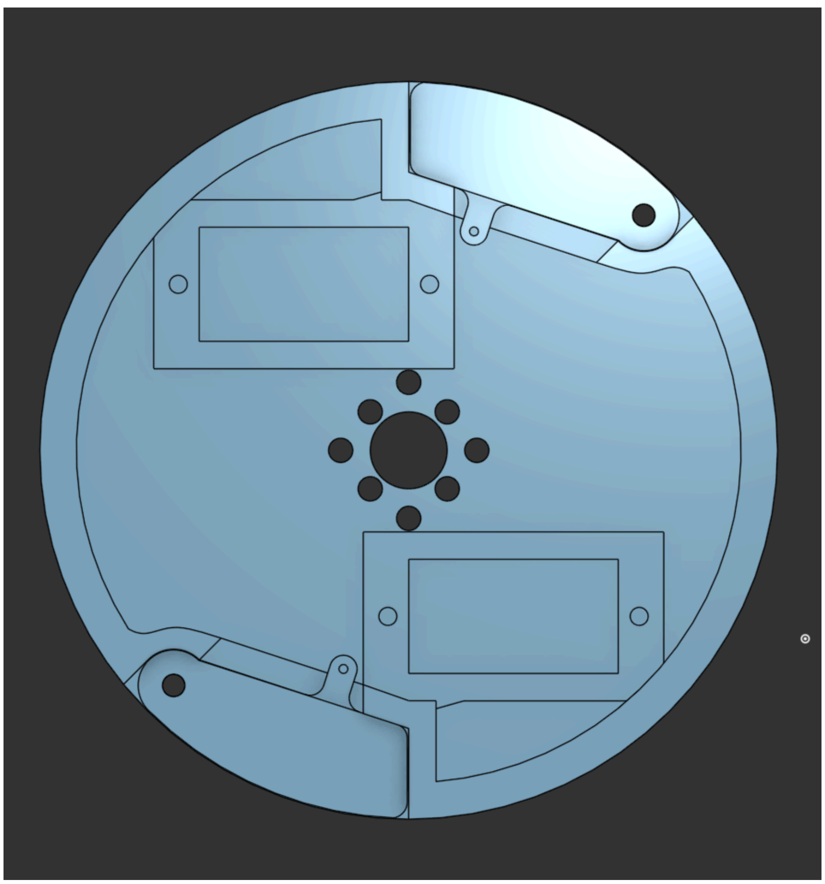


3. CAD Model









Sample Code

```
#include <Servo.h>
#include <Wire.h>
#include <MT6701.h>

#define MOTOR1_PIN  12  // pin for measuring tape motor
#define MOTOR2_PIN  13  // pin for wire motor
#define MOTOR3_PIN  14  // pin for collection system motor
#define SERVO1_PIN  22
#define SERVO2_PIN  23  // pin for servos for locking mechanism
#define ENCODER_PIN 21  // pin for encoder

Servo motor1;
Servo motor2;
Servo motor3;
Servo servo1;
Servo servo2;
MT6701 encoder;

const int lockRotationAngle = 45;  // Placeholder for actual angle
const int unlockRotationAngle = 0;

volatile int pulseCount = 0;  // Variable to count encoder pulses
unsigned long lastTime = 0;
float velocity = 0.0;  // Motor velocity in pulses per second
float angle = 0.0;     // Motor angle in degrees

void setup() {
    motor1.attach(MOTOR1_PIN);
    motor2.attach(MOTOR2_PIN);
    motor3.attach(MOTOR3_PIN);
    servo1.attach(SERVO1_PIN);
    servo2.attach(SERVO2_PIN);

    Serial.begin(9600);
    Wire.begin(); // Initialize I2C
    encoder.begin(); // Initialize MT6701 encoder

    pinMode(ENCODER_PIN, INPUT);  // Set encoder pin as input
```

```
    attachInterrupt(digitalPinToInterrupt(ENCODER_PIN), countPulse, RISING);

    unlockMechanism(); // Unlocks system before extension
    delay(1000);

    unravelToDepth(1600); // Extends collection section to 15 feet
    delay(2000);

    stopMotors(); // Stops motors
    delay(3000);

    lockMechanism();  // Locks after reaching desired depth
    delay(3000);

    rotateCollectionSystem(1600); // Collects sample
    delay(3000);

    stopMotors(); // Stops motors
    delay(5000);

    unlockMechanism();  // Unlocks before retraction
    delay(1000);
}

void loop() {

    // Gets current angle and angular velocity
    float angle = encoder.getAngle();
    float velocity = encoder.getVelocity();

    float angleDegrees = angle * (180.0 / PI);

    // Prints data
    Serial.print("Angle: ");
    Serial.print(angleDegrees);
    Serial.print(" degrees, Velocity: ");
    Serial.print(velocity);
    Serial.println(" rad/s");

    delay(1000);
}

// Unravels to desired depth
void unravelToDepth(int speed) {
    motor1.writeMicroseconds(speed);
```

```
    motor2.writeMicroseconds(speed);
    delay(5000);  // Placeholder for actual unraveling time
    stopMotors();
}

// Collects sample
void rotateCollectionSystem(int speed) {
    motor3.writeMicroseconds(speed);
}

// Stopping motors
void stopMotors() {
    motor1.writeMicroseconds(1000);
    motor2.writeMicroseconds(1000);
    motor3.writeMicroseconds(1000);
}

// Extending locking mechanisms
void lockMechanism() {
    servo2.write(lockRotationAngle);
    delay(500);
}

// Retracting locking mechanisms
void unlockMechanism() {
    servo2.write(unlockRotationAngle);
    delay(500);
}
```

Extension Component

The extension component will have a rigid measuring tape type design that is able to push the device into the tube and also retract it back if or when needed. The rolling and unrolling of the tape will be done by a sort of mechanism that will have enough force and strength to both be able to hold the mechanism up vertically and also push it 15 feet deep into the tube.

Scraping/Collection Mechanism

The scraping mechanism will go hand in hand with the locking mechanism as the inner part of our design will revolve around the center of itself. While the machine is turning, an extendable arm will come out with both the scraper and the collection bin where it will scrape the pipe on each turn and collect it at the same time.

Locking Mechanism

The locking mechanism includes 4 curved wheel type designs that will press against the tube walls when the entire machine is in the correct place, allowing for easy collection of samples. These wheels will be retracted and will only extend when 15 feet inside the tube and scraping is required.

4. Prototyping Test Plan

Test Number	Reason for Prototype	Evaluation Criteria/Determine Measurables	Level of Prototype	Kind of Prototype	Metrics	Test Description	Analysis Method
1	Performance Measurement	Depth test	HiFi Comprehensive	Physical	Distance: feet	Depth test: Testing the maximum depth attainable by the tool	Measure using measuring tape or through other means of analysis
2	Performance Measurement	Portability test	HiFi Comprehensive	Physical	Portability: dimensions of shape (in) and weight (kg)	Portability test: Testing the portability of the device	Weigh using scale and measure using measuring tape
3	Performance Measurement	Reusability test	HiFi Comprehensive	Physical	Reusability: number of samples	Reusability test: Testing the number of samples that can be taken in a certain length of time	Let device run in repeated trials and determine the maximum number of samples possible within x amount of minutes
4	Performance	Durability test	HiFi	Physical	Durabilit	Durability test:	Continuously run

	Measurement		Comprehensive		y: number of uses before failure or errors	Testing the "life" of the device	device and determine how many uses before failure
5	Performance Measurement	Failsafe test	HiFi Comprehensive	Physical	Failsafe test	Failsafe test: Determining if the device can be retrieved in an emergency scenario	Run device and then attempt to retrieve the device while it is conducting the trial
6	Performance Measurement	Movement Mechanism Reliability Test	HiFi Comprehensive	Physical	% of attempts that reach the desired depth	Movement Reliability test: Testing the reliability of the movement system of the device	Conduct a large number of trials and note down how many failed to reach desired depth and calculate % of reliability of mechanism
7	Performance Measurement	Storage test	HiFi Comprehensive	Physical	Volume (mg) and % of attempts that succeed in sample storage	Storage test: Testing to see if the device can successfully storage appropriate amounts of sample consistently	Load the container and measure volume, then run trials and note down number of trials that failed to store desired amounts of sample
8	Performance Measurement	Scraping Mechanism Reliability Test	HiFi Comprehensive	Physical	Amount of sample removed per trial	Scraping Reliability Test: Testing to determine the consistency of the sample collection device	Run device multiple times and determine the average sample size, as well as how often the device collects a sample around the average size
9	Performance Measurement	Locking test	HiFi Comprehensive	Physical	Seal Integrity: maximum weight supporte	Locking test: Testing the maximum amount of weight that can be supported by the locking	Gradually add weight to the device when in vertical orientation until locking system fails

					d by the locking mechanism	mechanism and ensuring that the mechanism can support the rest of the device	
10	Usability Measurement	UX test	HiFi Comprehensive	Analytical	UX Satisfaction: Time taken for a user to operate device (minutes) and user satisfaction levels	UX test: Observing users interacting with the device and determining the amount of time needed for the user to learn to operate the device and how satisfied they are with how it is controlled	Conduct trials with different users and recording both task completion time and user satisfaction levels
11	Usability Measurement	UI test	HiFi Comprehensive	Analytical	UI Satisfaction: User opinions on UI design	UI test: Observing users interacting with device and getting their opinions on how satisfied they are with the overall appearance of the device	Asking different users about how they feel about the design of the device, and noting down their opinions

5. Updated BOM

Item Number	Material/ Component	Unit Cost	Quantity	Total Cost
1	Servo motors: used to roll up and unroll measuring tape, and used for the clamping mechanism	$5	3	$15
2	Camera module: used to monitor and capture real-time visuals while the project is working	$10	1	$10
3	Tajima GS-16BW GS Lock Standard Scale Steel Blade, 16'X1": this is a possible tape measurer we will use as it is very thick and strong, and is 16ft in length meaning it meets the requirements	$40	1	$40
4	30-Pack 3/8" x 13" Zirconia Sanding Belts, 30 Grit Nylon Material, Metal Grinding SandPaper for Polishing and Grinding: this will be used to grind and sand metal shavings off of the inner pipe to be collected	$15	1	$15
5	Small Screws,	$9	1	$9

	600pcs 12 Kinds of Small Screws Nuts Assortment Kit M1 M1.2 M1.4 M1.6			
6	Magnetic Encoder MT6701 Magnetic Induction Angle Measurement Sensor Module 14bit High Precision Can Perfectly Replace AS5600	$2.47	1	$2.47
7	ABS	$0.13 per gram	TBD	TBD

6. Testing and Procedures for Prototype 2

a. Design specifications

Design specification	Units	Value	Verification method
Movement mechanism reliability	Percentage	95%	95% reliability of system without fail
Movement distance	Feet	50	see if the prototype can travel 50 feet
Container storage	Mg	30-80	Test scrape in pipe
Scraping mechanism reliability	Percentage	95%	95% reliability of scraping the appropriate amount

b. Validation plan

Design specifications	Test method and materials needed	Methods of recording results	Estimated time duration
Movement mechanism reliability	Shorter length of 4 inch diameter tube. Testing by running the prototype through the tube at least 20 times	How many successful attempts are achieved	20/20
Movement distance	Test the prototype through the tube up to 15 feet 20 times	How many successful attempts are achieved	20/20
Container storage	Prototype container and prototype pipe	If the container can successfully gather an appropriate sample of size from the prototype pipe	10/20
Scraping mechanism	Prototype scraper and prototype pipe	If the scraper is reliable and scrapes the valid amount of pipe.	15/20
Locking Mechanism	Force	If pipe can easily scrape	15/20