The Sample Snatchers! Sample Subway System

The Sample Subway! A device capable of snatching a precise sample from inside a metal tube in a matter of seconds! It has traction wheels for movement, a powerful scraper for sampling and a precise containment system that keeps the sample protected and isolated from operator contact!
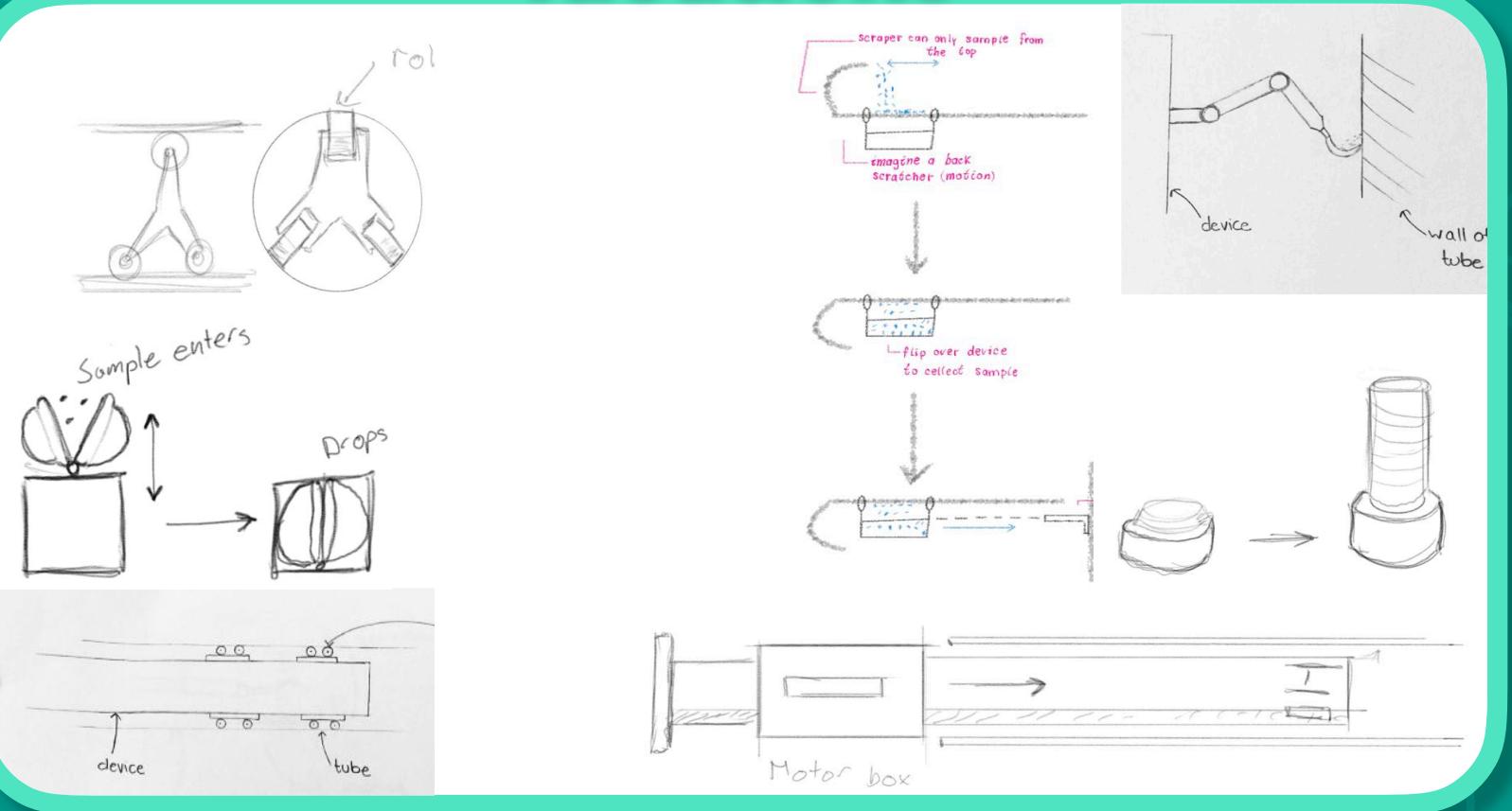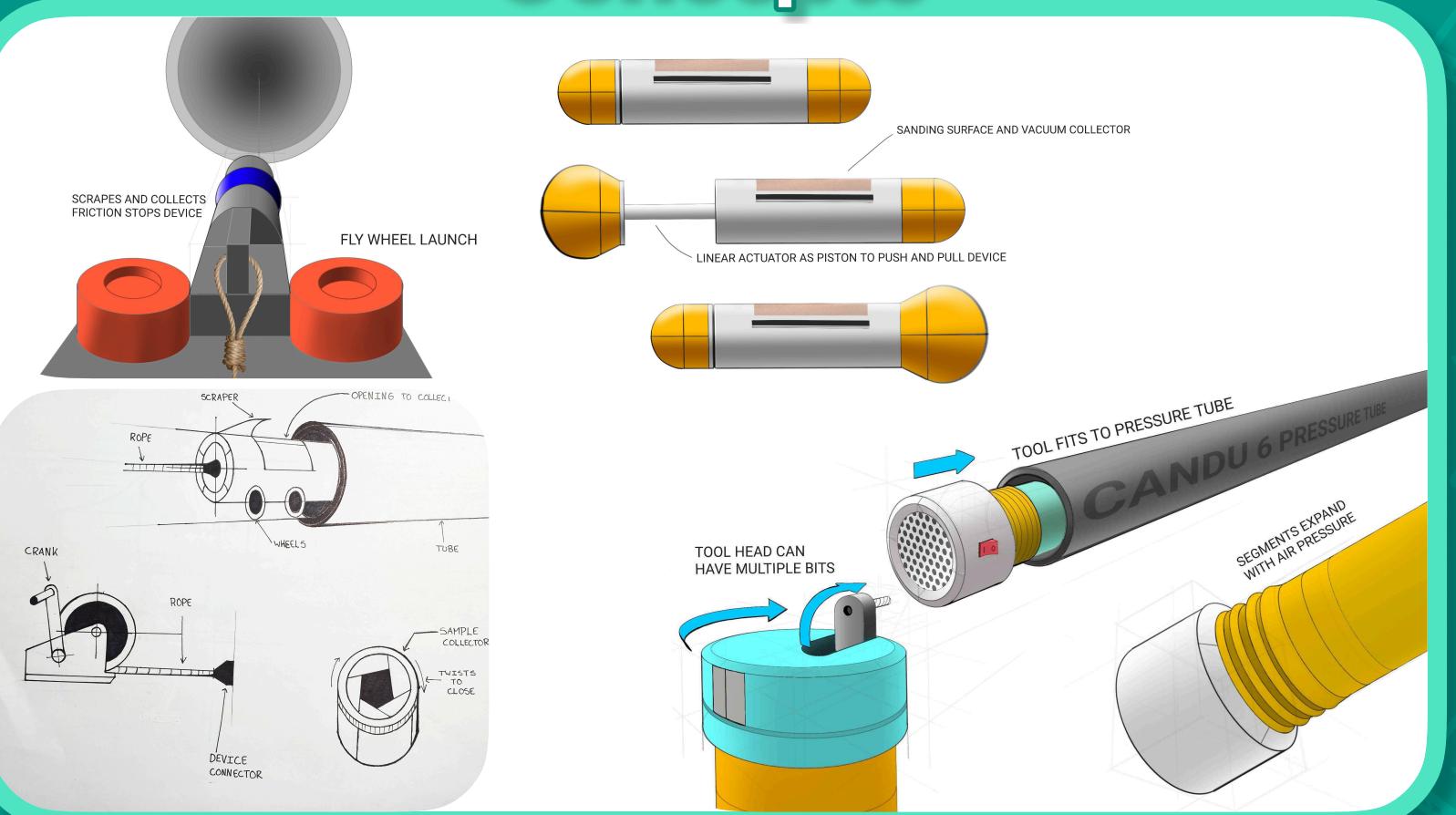
Ideations

Concepts

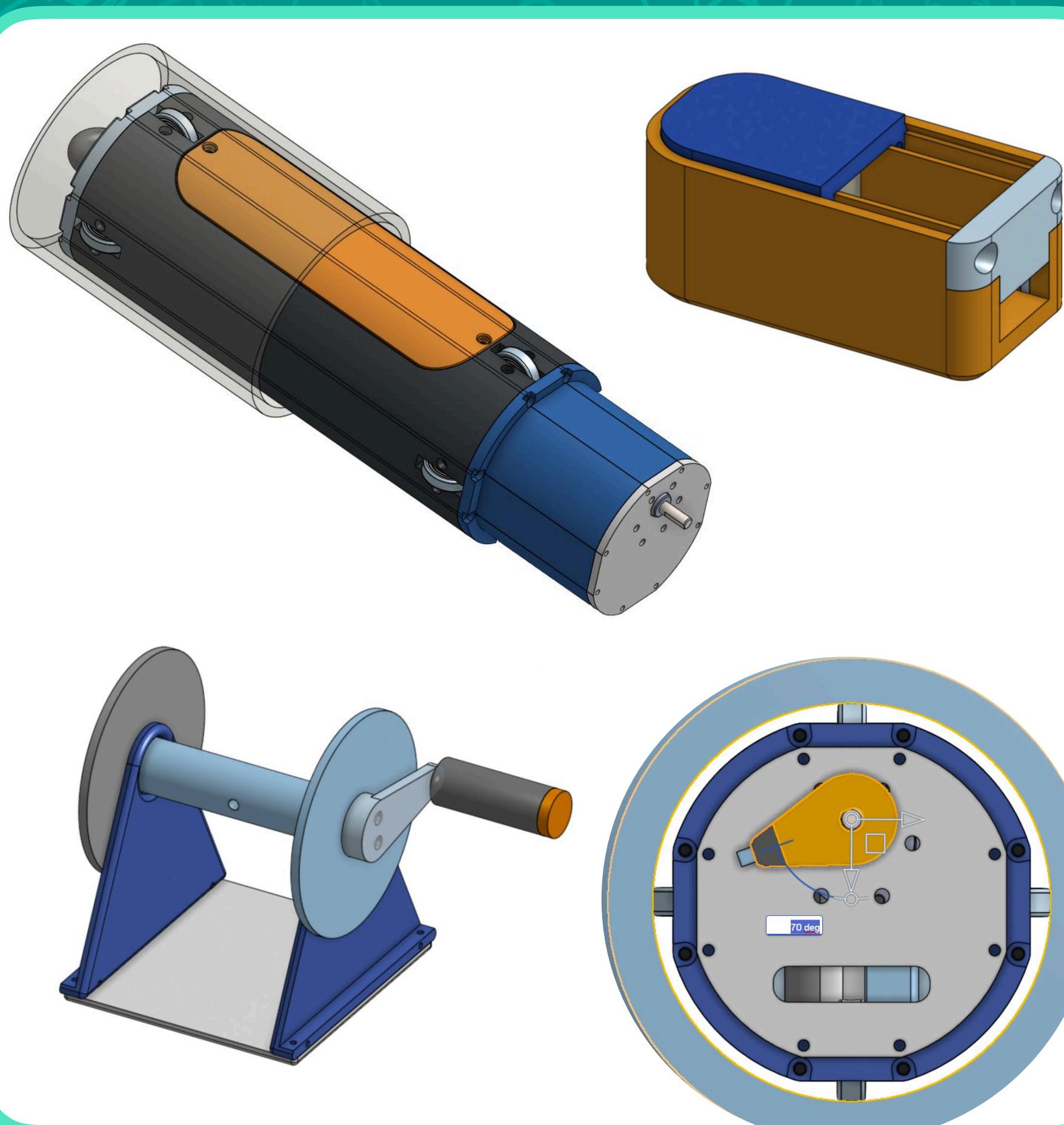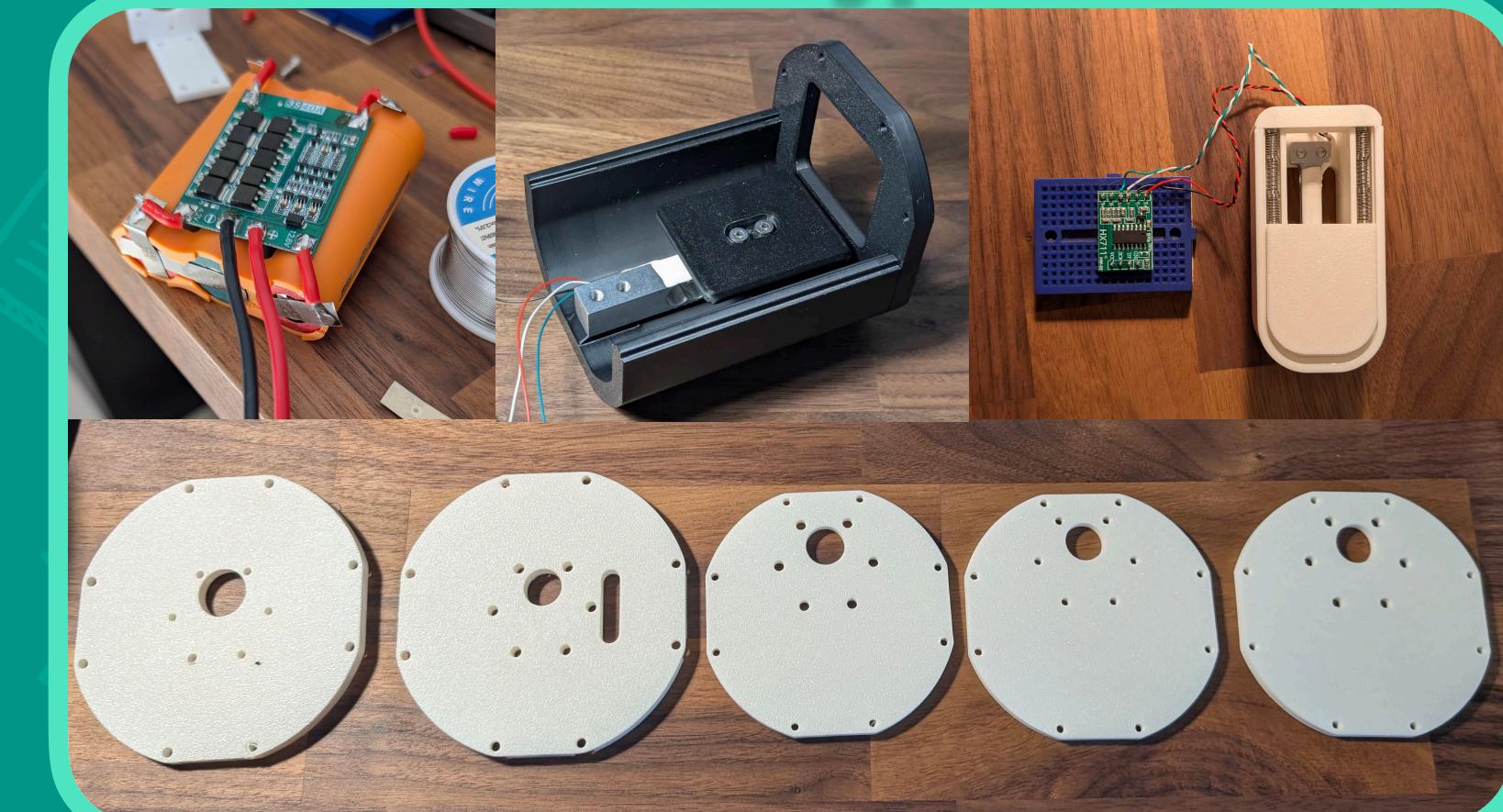## Preliminary CAD

Testing and Analysis Data

Cross sectional model for cutting path to achieve 65 mg sample

Weight averaging and filtering for mechanical strain and electromagnetic interference Achieved +/- 9.5 mg

```
18:49:56.868 -> Weight: 3090 mg
18:50:06.717 -> Weight: 3104 mg
18:50:16.474 -> Weight: 3108 mg
18:50:26.320 -> Weight: 3109 mg
18:50:36.105 -> Weight: 3108 mg
18:50:45.891 -> Weight: 3103 mg
18:50:55.706 -> Weight: 3105 mg
18:51:05.503 -> Weight: 3091 mg
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Prototypes

Technical Specifications

Load Cell Accuracy:	+/- 9.5 mg
Containment:	Isolated Spring Loaded Mechanism
Power System:	Custom 12.6V 40A Removable Battery Pack
Scraping Motor:	1 x JGB37-520 12V 12RPM 35kg.cm
Movement Motor:	2 x N20 12V 200RPM
Fail-safe:	Custom Winch Mechanism
Control System:	ESP32 w/ HX711 ADC, ITB2 + L293D Motor Drivers
Chassis Materials:	PETG Body, PLA Motor Mounting Plates, 608 Bearings, M3 Screws
Scraping Bit:	NC3030 Lathe Bit

About the Project

Client: Canadian Nuclear Laboratories (CNL)

Project Goal:
Develop a device to retrieve a metal sample that weighs 30-80 mg from inside a 15-foot long tube with a 4-inch internal diameter. The tube may be oriented vertically or horizontally.

Background:
CNL operates in environments with high radiation and limited access. Sampling metal from deep within infrastructure is essential for monitoring structural integrity, but poses unique challenges.

Our Solution:
The Sample Subway is a device that scrapes and collects a sample from a nuclear reactors pressure tube wall to be analyzed for hydrogen embrittlement. It is able to do so remotely, minimizing operator contact. The container is self sealing and measures the mass so that the operator never has to touch the material collected.
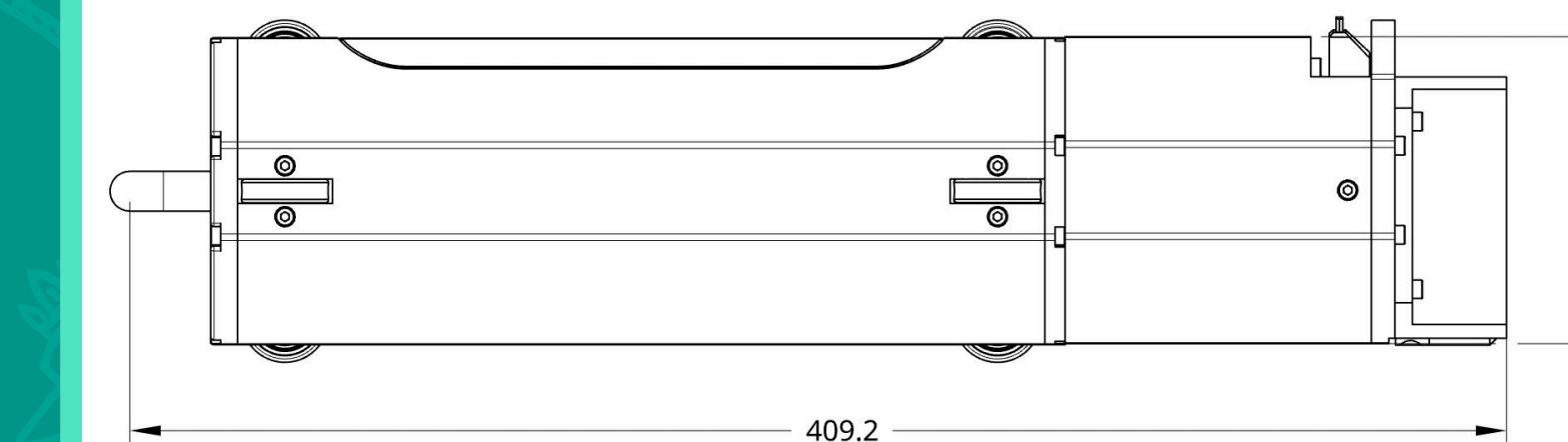
Key Features:
- Safe Handling: Sample is automatically stored in a sealed container
- Sampling: Mechanism scrapes for a sample between 30–80mg
- Operator Feedback: Real-time tool and process status
- Fail-Safe Design: Tool can be fully retrieved in case of failure using a winch
- Lightweight: A single operator can carry and deploy the device
- Self-Contained Power: Integrated power sources included

Problem Statement:
"Operators who service nuclear reactors need a device to collect metal samples from pressure tubes while minimizing exposure to contaminated material. The solution should be compact and completely removable from the pressure tube, and it should also be able to report the stage of operation within a limited time."

Bill of Materials

Item #	Part	Vendor	Description	Qty	Cost
Battery and Power Delivery (PDXX)					
PD01	22 awg Wire	Amazon	Wires for connecting components to circuit	1	CA$0.80
PD02	XT60 Connectors	Aliexpress	Connectors for battery pack	1	CA$1.60
PD03	16 awg Wire	Amazon	Wires for 12v components	1	CA$0.80
PD04	P42A Molicel Battery 21700	18650	For battery pack assembly	3	CA$15.00
PD05	3S Battery Management System	Aliexpress	For safety	1	CA$2.94
PD07	LM2596	Aliexpress	Step down buck converter, 36V/24V/12V/5V/3V	1	CA$0.45
Control and Logic (CLXX)					
CL01	ESP32-WROOM-C3	Elegoo	Controller w/ Wifi + BT	1	CA$9.99
CL02	H-Bridge Motor Driver BTS7960	Aliexpress	Driving 12V motor for scraping	1	CA$7.41
CL03	HX711 Sensor	Aliexpress	Strain gauge for mass analysis	1	CA$1.80
Measurement (MXX)					
M01	100g Load Cell	Aliexpress	Strain gauge to measure mass	1	CA$4.93
Structural Components (SCXX)					
SC01	PLA ~0.70 KG	Bambu	Filament for chassis	1	CA$16.99
SC02	M3 Female Threaded Insert	Aliexpress	Heat set threaded inserts for chassis	1	CA$0.80
SC03	M3/M4 Machine Screws	Aliexpress	Various length M3 Machine Screws	24	CA$1.00
Sampling Tooling Components (STXX)					
ST01	Lathe Bit	Aliexpress	Lathe Bit and armature	1	CA$3.25
ST02	GB37-520 7rpm 12v Motor	Aliexpress	For moving the armature with lathe bit	1	CA$11.28
Movement (MVXX)					
MV01	Bearings	Aliexpress	For reducing friction and precise movement	8	CA$4.69
MV02	N20 12V 200RPM	Aliexpress	Moves the device through the pipe	2	CA$10.78
MV03	Rubber Bands	Amazon	Increases Friction of wheels, prevents slippage	8	CA$1.68
				Total:	**CA$96.19**