Conceptual Design

Vidvath Tanjore

Wesley Savage

Andrew Bettin

Connor Rennie

Andrew Walisser

University of Ottawa

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Mr. David A. Knox

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Drive subsystem ideas:

1. **Cascading lift (inchworm)**

How does it work ?

The tool consists of front and rear clamping legs that expand radially to grip the ends of the tube. It also features a servo-driven linear extension system that moves the tool forward.

To move through the tube, the rear clamping legs first grip the ends of the tube, while the front legs remain free. The linear extension system then moves the tool forward. Once the tool has advanced, the front clamping legs grip the tube, and the rear legs release their hold, allowing the rear part of the linear system to move forward.

This process continues in a cyclic manner until the tool reaches the desired position in the tube, where the sample collection can be performed.

Pros:

- Unlikely to get stuck
- Does not need manual steering

Cons:

- Slow
- It needs more motors so there is a higher likelihood of malfunction.
- Cannot be operated without motors, and as a result, it cannot be retrieved from the tube in the event of motor failure

2. **Tank tracks**

How does it work?

The device uses tracks (rubber belt-like structures) that grip the surface of the tube, allowing it to be driven into and out of the tube using a motor.

Pros:

- Extra friction force for climbing vertical tubes

- Springs hold it securely in the tube

Cons:

- Susceptible to jams from build up in the tube
- Tracks could damage the delicate surface of the tube
- Is not fail-safe as it has to be driven by a motor

3. **Wheel driven**

How does it work?

The device uses wheels to move in and out of the tube.

Pros:

- Simple
- Reliable
- Lower chances of damage to the surface of the tube

Cons:

- Less grip as compared to tracks or the inchworm method
- Difficult to implement without using motors.

4. **Telescopic system (selfie stick)**

Pros:

- The entire machine does not have to enter the pipe
- Does not have to be built super compact
- Very unlikely to get stuck in the pipe

Cons:

- Will be very big and heavy to accommodate 15 feet of extending pipe
- Difficult to maneuver
- Needs a lot of power

Sample collection ideas:

1. **Circumferential drilling**

Pros:

- Leaves little change in structure of the tube

- Reliable rate of sample

Cons:

- Difficult to implement efficiently

2. **Scraper**

Pros:

- Pre (programmed) can lead to very accurate amounts of sample taken per scrape of the hook

Cons:

- Leaves behind an uneven surface in the pipe

3. **Spot Drilling**

Pros:

- Quick and easy

Cons:

- Leaves little holes in the pipe, which would render it useless, as it would lead to fuel leaks.

4. **Chipping/chisling**

Pros:

- Simple to implement

Cons:

- May lead to weakening of structural integrity of the tube
- May give sporadic amount of sample per chisel causing excess samples

- **Vacuum**

Pros:

- Easily able to collect the whole sample

Cons:

- Part of sample may be sucked into vacuum motor leading to mis-calculation of sample size

- Chances of clogging the tube, making it difficult to clean, and unreliable.

- **Catching tray**

Pros:

- Simple to implement

Cons:

- Some sample could miss the tray and get left in the pipe
- Some sample may lay in the tray with no path

- **Funnel**

Pros:

- None of the sample will miss and get left in the pipe

Cons:

- Some of the sample could get stuck to the funnel leading to inaccurate sample

- **Wet cloth/swab**

Pros:

- Simple to implement

Cons:

- Likely will contaminant the sample
- Inconsistent collection amounts

<u>Failsafe ideas:</u>

- **Safety cord attached to a winch**

Pros:

- Super failsafe and reliable
- Can be relied on if hardware and software encounter an issue

Cons:

- Could scratch the inside on the pipe when the machine gets dragged out

- **Encoded emergency system**

Pros:

- Last line of defense if the system completely shuts down, it would default to retracting out no matter the stage of process

Cons:

- Code could break or the issue could be something that can't be fixed by code (hardware malfunction)

Power sources:

- **Battery**

Pros:

- Compact and means the machine can be more modular
- Can work without external power

Cons:

- If the battery is not charged then the machine may cease working during sampling requiring the failsafe

- **Direct power**

Pros:

- Ensures that the machine never loses power and is not limited by a power supply

Cons:

- Becomes difficult for operator to set-up in a high radiation environment

Operator feedback:

- **Scale**

Pros:

- Verifies an accurate sample every time the machine is run

Cons:

- Very difficult to implement at the milligram level of sample we are using
- High cost

- **Depth sensor**

Pros:

- Ensures to the operator that the machine is the required distance down the tube

Cons:

- Signals may be interfered by the environment

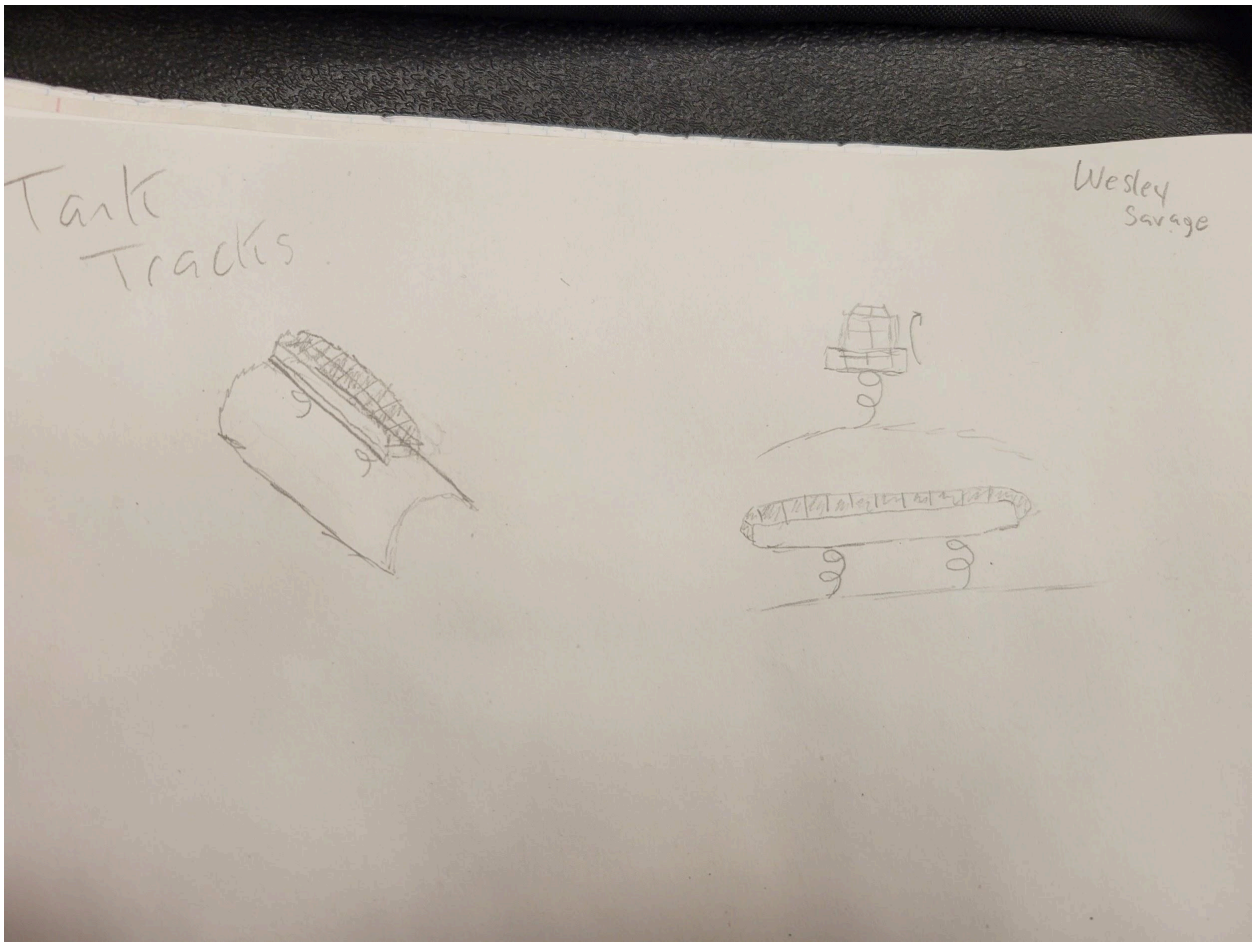
- **Signal given to say the % of drilling done (pre-programmed for weight)**

Pros:

- Keeps the operator updated on percentage of sampling completed

Cons:

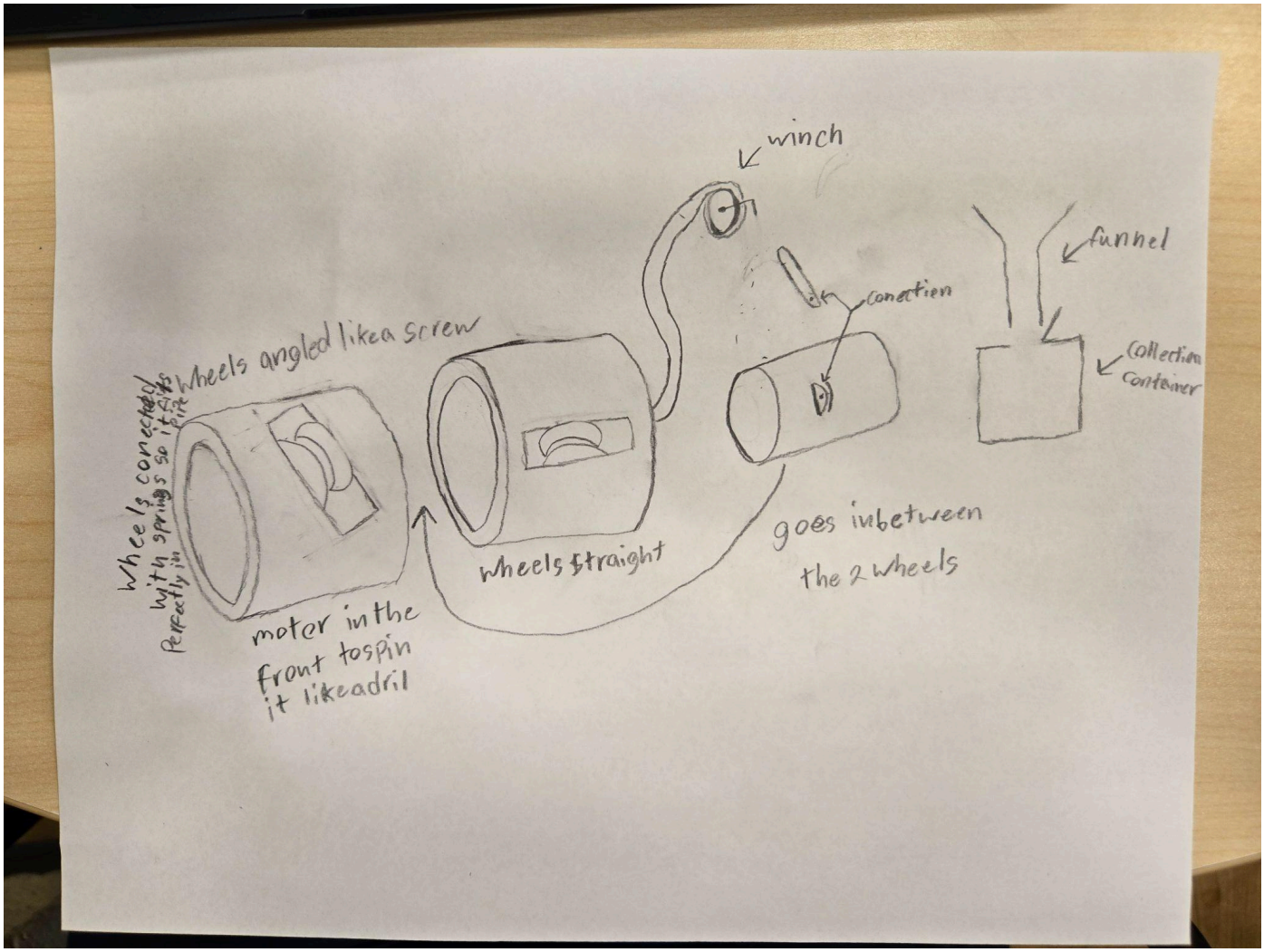
- Signals may be interfered by the environment



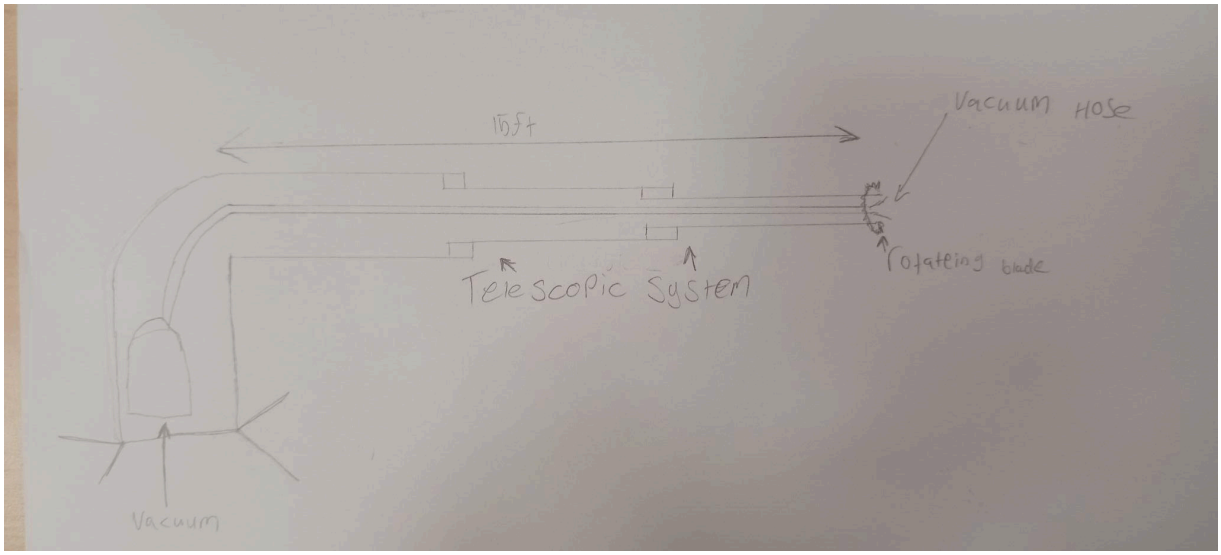
Sketch of tank tracks - Wesley Savage

Prototype Ideas:

1: Wheel driven, Scraper, Funnel, Safety Cord, Battery, Signal



2: Telescopic, Circumferential Drilling, Vacuum, Emergency retractacting system, Direct Power, Scale



3: Cascading lift, Drilling, Catch tray, Safety Cord, Battery, Depth sensor

Comparison Matrix

Bad=1 **Poor=2** **Okay=3** **Good=4**

	Prototype #1	Prototype #2	Prototype #3
Reliability of sample weight	Okay	Good	Poor
Modularity	Okay	Poor	Poor
Efficacy of fail-safe	Okay	Poor	Okay
Power source	Okay	Poor	Okay
Speed of travel	Good	Okay	Poor
Speed of sample	Okay	Poor	Good

collection			
Effect of drilling on tube	Okay	Good	Bad
Operator feedback	Okay	Good	Poor

	Criteria Weight	Prototype #1	Prototype #2	Prototype #3
Reliability of sample weight	5	3	4	2
Modularity	3	3	2	2
Efficacy of fail-safe	4	3	2	3
Power source	2	3	2	3
Speed of travel	2	4	3	2
Speed of sample collection	2	3	2	4
Effect of drilling on tube	4	3	4	1
Operator feedback	3	3	4	2
	Totals:	77	76	60

Overall Choice

As can be seen in the matrix table, prototype #1 has the best result along with being the most feasible option for the resources available to us as first year students. It also has the most well rounded performance servicing a wider variety of the design criteria in this project. As well, prototype #2 have aspects that would be very difficult to implement on our small budget as they include aspects like a small sensitive scale, and cascading lifts.`