

# **Deliverable D**

## **Conceptual Design**

February 9, 2025

### **Thinker Titans**

Benjamin De Vellis

Jennifer Tran

Sana Hosseini

Aaliyah Ansari

## **Abstract**

This document goes through each group member's general concept sketches and the subsystem parts in each. Each concept will be explained with insight into how each of the subsystems would operate for each design. The document then goes through a final prototype sketch which will be composed of the subsystems and features from the group members sketches. We will use the final concept as the model for the final product and will do the same explaining the features.

## **Table of Contents**

Introduction	5
Team member Designs	5
Final solutions	9
Final decided design	11
Conclusion	11
References	12

## **List of Tables and Figures**

Figure 2.1. Sketch - Jennifer	5
Figure 2.2. Sketch - Aaliyah	6
Figure 2.3. Sketch - Benjamin	7
Figure 2.4. Sketch - Sana	7
Table 2.1. Description of subsystems in each concept design.	8
Table 3.1. Three new solutions	9
Figure 3.1. New solution 1	9
Figure 3.2. New solution 2	10
Figure 3.3. New solution 3	10
Table 3.2. Quality of solutions	10
Table 3.3. Weight of the Quality of Solutions	11
Table 4.1. Final decided solution	11
Figure 4.1. Final solution	12

# 1 Introduction

Nuclear utility operators need to confirm that their fuel channels are still in suitable condition to operate by analyzing collected samples in the channel. In order to do this they need a new device, this device will have certain subsystems such as a sampling tool, a feedback system, a fail-safe, removable storage, and a handle.

## 2 Team Member Designs

This section presents the concept sketches done by each member of our team.

### 2.1 Sketch - Jennifer

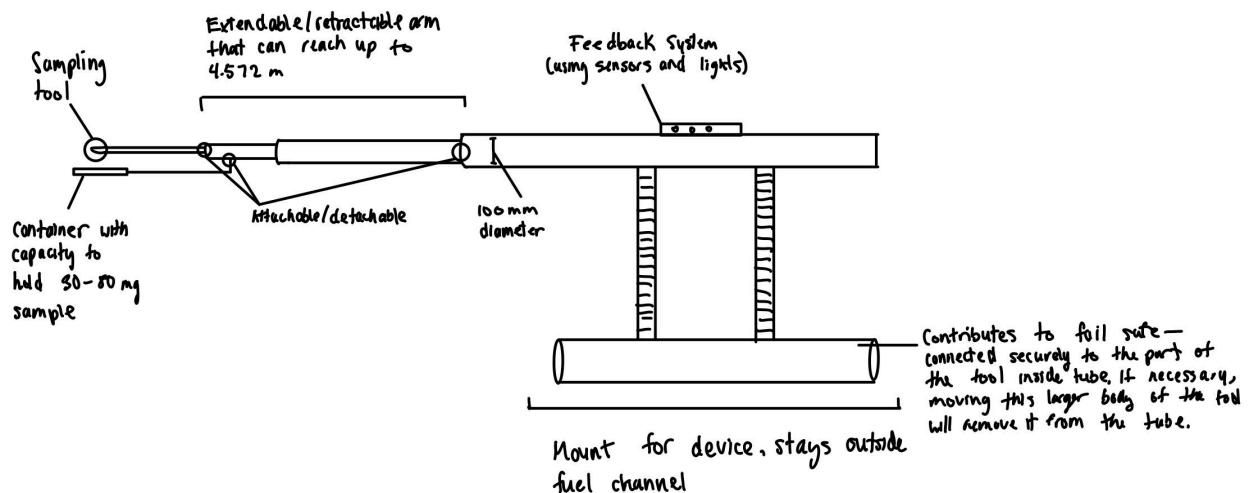


Figure 2.1. Concept sketch for product including subsystems by Jennifer.

The conceptual design in Figure 2.1 implements the five subsystems that we decided on as a group. The sampling tool can be a sharp, metal object capable of scraping a sample from the side of the tube, and depositing the collected sample into the small container that is found under the tool. The feedback system, which can rely on sensors such as force or touch, can tell the user when the tool is scraping. Another sensor could be implemented on the container to detect when a sample has been transferred to it. In the case that the tool fails, it could be removed from the tube by the body of the product that is stationed outside the tube. It would be verified that each component is securely attached to the body of the tool and will not detach in the event of a failure. The container that is located under the scraping tool can be removed to retrieve the sample without it coming into contact with the operator. The section of the device that enters the

tube can be collapsed. This allows for easy transport, and the device can be carried by the two shaded sections at the body.

## 2.2 Sketch - Aaliyah

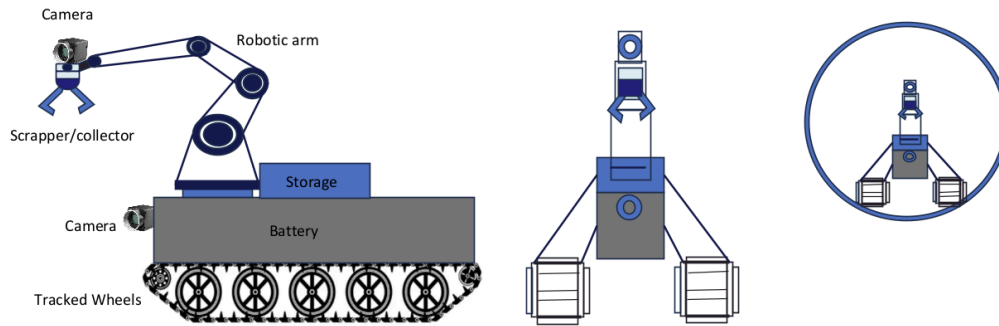


Figure 2.2. Concept sketch for product including subsystems by Aaliyah.

The conceptual design shown includes the five key subsystems we agreed upon. The sampling tool is a robotic arm with a scraper or collector, designed to scrape material and deposit it into a small storage container on the robot. The feedback system is an important part of the design, using cameras and sensors placed around the robot to provide real-time information. The cameras help the robot see its surroundings, while the sensors track its position, movement, and environment. This helps the robot navigate safely, operate the arm accurately, and collect samples efficiently. The fail-safe system is included to keep the robot working even if something goes wrong. It has backup controls and power sources, so the robot can continue operating if one part fails. The fail-safe also includes safety features that stop the robot if there's a problem, preventing further damage. The removable storage system makes it easy to store and transfer collected samples. The container can be detached and replaced quickly, allowing the robot to keep working without long delays. Finally, the handle makes the robot easy to carry or move by hand when needed.

## 2.3 Sketch - Benjamin

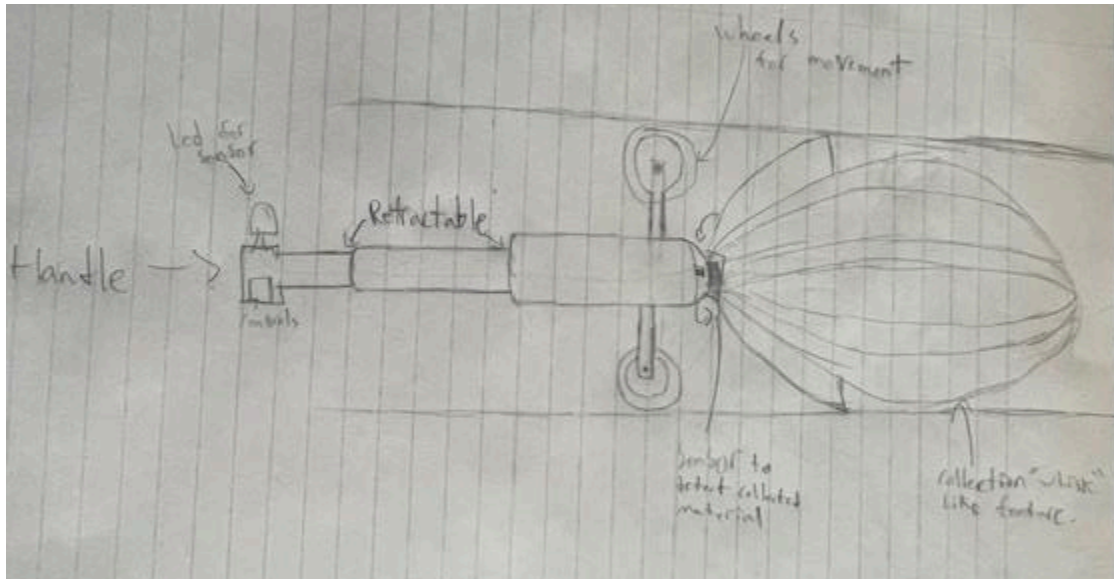


Figure 2.3. Concept sketch for product including subsystems by Benjamin.

Figure 2.3 is a concept sketch which includes each of the 5 subsystems in a model of the device. The sampling tool and collector is a rotating whisk-like shape which passively scrapes the sides of the tube, collecting the scraped substance at its base. The scraping and collection system is attached to the rotating motor however is completely removable making it an easily removable storage system. The fail safe is a feature which makes it easily collapsible using a leveled cylindrical “telescope” like body which allows it to compress quickly and easily. The feedback system is a sensor at the bottom of the collection chamber which sends a signal to an LED at the base of the device when it senses sufficient material has been collected letting the user know it has properly retrieved its sample. Finally, the handle is at the base of the device and can be used to collapse the device as well as having the controls for the rotation and wheels, and LED attached.

## 2.4 Sketch - Sana

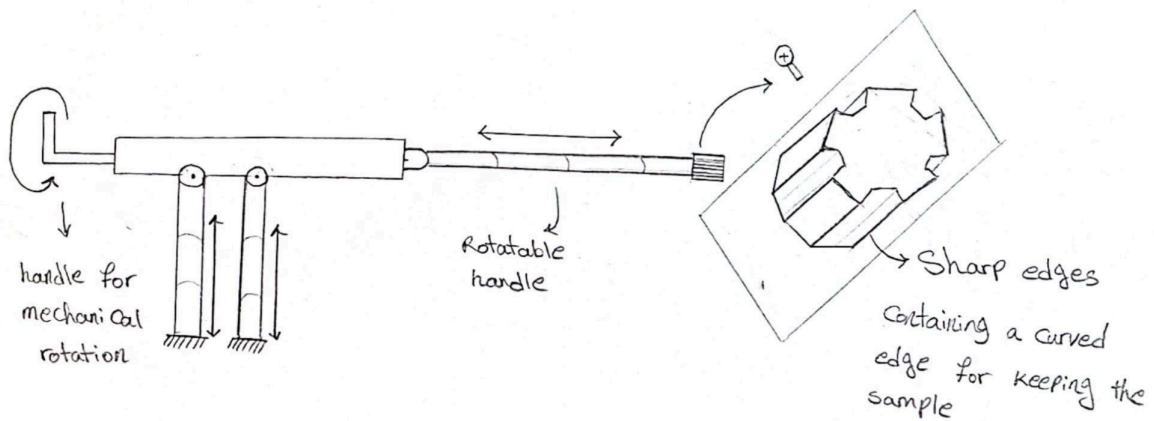


Figure 2.4. Concept sketch for product including subsystems by Sana.

The sketch above shows the design of the sampling tool containing all the 5 subsystems that we came up with as a group. There is a suitable long handle to go through the tube to the maximum length of 4.5 meters, which is coming in a foldable mechanism that folds and goes inside the empty cylinder beside it so that the tool will be easy to carry to different parts of the company and proper in the size. This handle is rotatable by another handle attached to it which makes it easy to do so by hand and without an armature. On the right end of the handle, there is a scraper which has the shape that is shown above and has sharp edges on the side to scrape from the tube, moreover there will be a sensor on this part to measure the mass of the sample and make sure it is between 30-80 mg. The scraper has an arc in one of the edges that will act as a container for the collected sample. There are also two base columns attached to the lower part of the tool to make it stable and fail-free. Also all the parts are removable, so in case of any problem a new one can be attached.

**Table 2.1: Description of subsystems in each concept design.**

<b>Subsystem</b>	<b>Benjamin</b>	<b>Jennifer</b>	<b>Sana</b>	<b>Aaliyah</b>
<b>Sampling system</b>	Whisk like scraper	Metal scraping tool	Sharp edge (scraper)	Scraper with adjustable angles for effective collection.
<b>Fail safe</b>	Contractible body and removable from scraper	Securely connected parts that can be removed as one by the body	Removable/ detachable parts	Emergency stop and retractable robotic arm.
<b>Removable Storage</b>	Removable scraper and collection system	Removable container for sample	Storage being a part of scraper itself and removable	Easily detachable and replaceable storage container.
<b>Feedback system</b>	Sensor to light	Sensors/lights (arduino)	Sensor	Sensors and cameras for real-time monitoring.
<b>Handle</b>	Bottom of base	Body of product	Left end mechanical handle	Centralized lightweight handle for easy transport.



### 3 Final solutions

This section combines ideas for subsystems from the previous section to create three new possible solutions. Then, these solutions will be ranked in order to decide the final solution.

**Table 3.1: Three new solutions.**

Subsystem	Solution 1	Solution 2	Solution 3
<b>Sampling system</b>	Whisk-like scraper	Rotating-collecting Scraper	Claw Arm
<b>Fail safe</b>	Contractible body and removable from scraper	Completely removable storage/collection system	Emergency stop and retractable robotic arm.
<b>Removable Storage</b>	Removable container for sample	Storage is included in the scraper and are both removable	Easily detachable and replaceable storage
<b>Feedback system</b>	Sensors	Sensors	Camera
<b>Handle</b>	Left end mechanical handle	Bottom of base	Body of Product

Solution #1

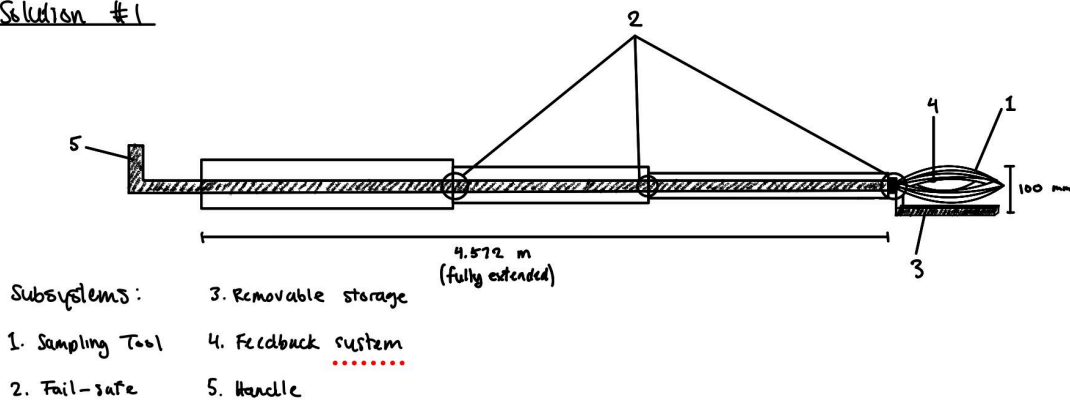


Figure 3.1. New solution 1.

### Solution #2

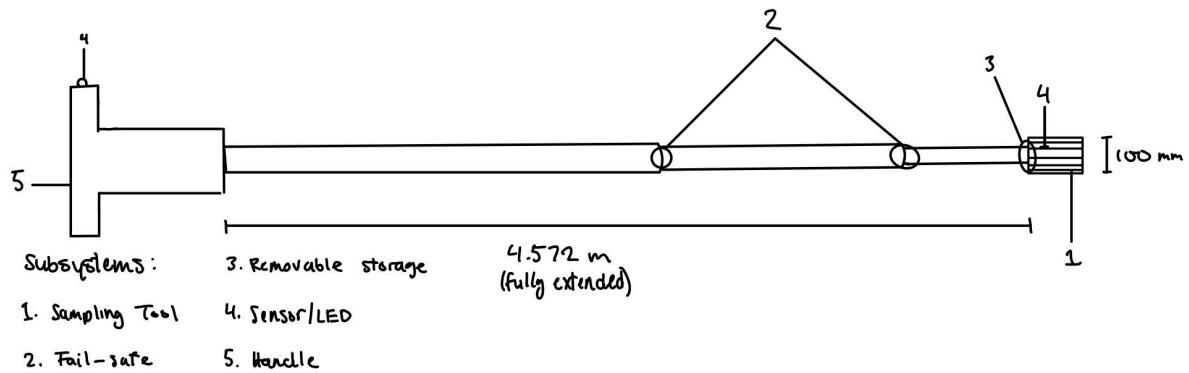


Figure 3.2. New solution 2.

### Solution #3

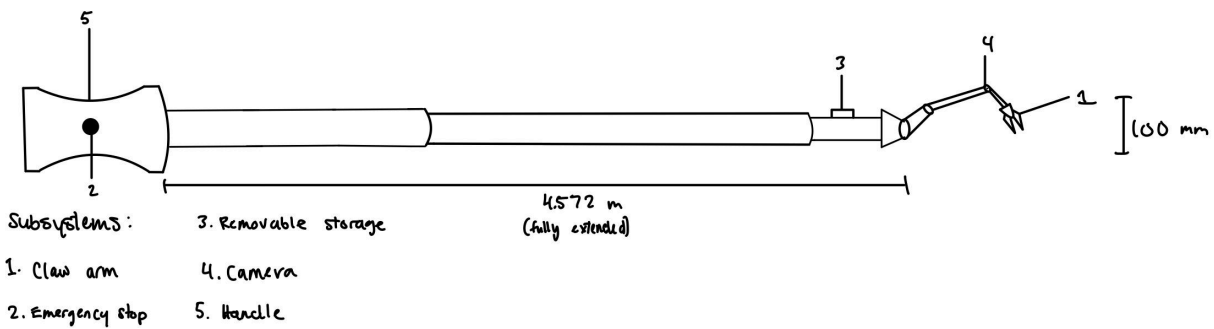


Figure 3.3. New solution 3.

Table 3.2: Quality of Solutions **Great** **Ok** **Bad**

Subsystem	Solution 1	Solution 2	Solution 3
Sampling system	Whisk-like scraper	Rotating-collecting Scraper	Claw Arm
Fail safe	Contractible body and removable from scraper	Completely removable storage/collection system	Emergency stop and retractable robotic arm.
Removable Storage	Removable container for sample	Storage is included in the scraper and are both removable	Easily detachable and replaceable storage
Feedback system	Sensors	Sensors	Camera

<b>Handle</b>	Left end mechanical handle	Bottom of base	Body of Product
---------------	----------------------------	----------------	-----------------

**Table 3.3: Weight of the Quality of Solutions** 3 2 1

Subsystem	Solution 1	Solution 2	Solution 3
<b>Sampling system</b>	2	3	1
<b>Fail safe</b>	2	3	1
<b>Removable Storage</b>	3	2	3
<b>Feedback system</b>	3	3	1
<b>Handle</b>	3	2	2
<b>Total</b>	13	13	8

## 4 Final decided design

After ranking, solutions 1 and 2 both ended up with a score of 13. Therefore, we decided to further combine these two to create a final solution where all subsystems meet the criteria with a ranking of 3.

**Table 4.1. Final decided solution**

Subsystem	Final Solution
<b>Sampling system</b>	Rotating-collecting Scraper
<b>Fail safe</b>	Completely removable storage/collection system
<b>Removable Storage</b>	Removable scraper (containing sample)
<b>Feedback system</b>	Sensors
<b>Handle</b>	Left end mechanical handle
<b>Total</b>	15

## Final solution

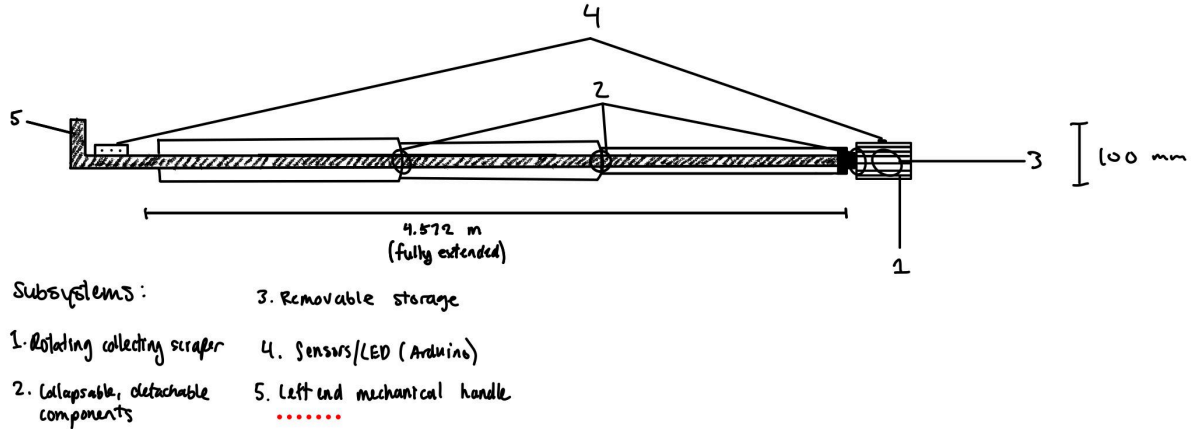


Figure 4.1. Final solution.

## 5 Conclusion

After consulting our previous research and benchmarking, we have come up with our own designs following the design criteria and implementing needed subsystems. We then took these designs and subsystems, and combined them to create 3 potential final solutions. Finally, after comparing each feature of the solutions we can take the best of the three and we have our final solution. This solution meets all design requirements and has all needed subsystems.