

## User and Product Manual Instructions

This document is a template of a user and product manual. The client may wish to make improvements on the prototype or need to fix it if something goes wrong or another group of students may work to make a more rugged prototype. The document needs to be clear for someone else who is not an engineer **to use, maintain or reproduce the project**. Include as many images and diagrams as possible for a better understanding. Keep it plain, simple, visual and logical.

In general, if you are not sure exactly what to include, imagine that this document was the only thing that you had. Imagine also that your job was to add a new feature or recreate the project that is described in your document. What would you need to know?

Only include details relating to your final prototype.

Template conventions:

- Remove all **red text**, it is only there to guide you
- Remove this page (instructions)
- Replace all instances of <xxx> with the appropriate information for your group, for example you could replace <System Name (Acronym)> by The Amazing Product (TAP)
- Save this document as 'User and Product Manual\_group number' instead of Deliverable X so that others know what it represents when they see it in MakeRepo

GNG<1103/2101>  
**Design Project User and Product Manual**

Submitted by:

<EROSION ACCELERATOR AND GROUP NUMBER 15>

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## **Introduction**

This manual is designed to provide guidance on operating the erosion rate measurement system. It assumes a basic understanding of erosion-related scientific concepts and perhaps some familiarity with Arduino microcontrollers. The structure follows a logical sequence, covering system components, setup procedures, operational instructions, data collection and analysis methods, safety precautions, maintenance guidelines, and additional notes. Intended users include researchers, engineers, students, and quality control personnel, empowering them to effectively utilize the system and gather dependable data on material erosion behavior. However, it primarily addresses user-level operation and basic maintenance, omitting detailed scientific explanations or advanced troubleshooting. While security considerations are not explicitly discussed, safety protocols such as wearing protective gear and securing the container position are emphasized to mitigate risks related to the erosion medium and rotating components. Privacy concerns are minimal as the manual focuses solely on operational instructions and data collection, without involving storage of user information.

## **Overview**

In this project, we created a rapid erosion testing system tailored for CNL. Our main hurdle was devising a tool capable of replicating and magnifying erosion effects on materials within a controlled laboratory environment. A crucial aspect of our strategy involved leveraging data-informed assumptions to ensure the system accurately mimicked accelerated erosion. The system's architecture boasts a straightforward yet efficient design. At its core is a cylindrical plastic chamber serving as the primary erosion space. Positioned atop this chamber is a stepper motor, governed by an Arduino microcontroller to regulate its RPM. This motor precisely manages the rotational speed of the sample holder, with its shaft securely welded to the clamp housing the material undergoing erosion testing. Such a setup enables precise manipulation of a critical erosion factor - the agitation rate. By fine-tuning the motor's RPM, CNL researchers can simulate diverse erosion scenarios in an expedited fashion.

### **1.1 Cautions & Warnings**

As this erosion acceleration system is still in its prototype phase, it may experience some wobbling during operation. To minimize any potential risks, always ensure the container lid is securely fastened before starting a test. This precaution will prevent the erosion medium from spilling out and safeguard the surrounding area.

Select a stable platform that is both level and resistant to vibrations, and ensure it has sufficient load capacity. This will help reduce the chances of tipping or displacement while the system is in operation.



Regarding electrical safety, the prototype operates using an adapter for power supply. It's essential for adults to supervise whenever the system is in use. This ensures a prompt response in case of any electrical issues or unexpected events.

Before each use, carefully inspect the power adapter for any signs of damage such as frayed wires or cracked casings. If any damage is detected, refrain from using the adapter and replace it with a functioning one.

It's strongly advised that users acknowledge the experimental nature of the system by including a written disclaimer.

## **Getting started**

This section guides you through the initial setup and testing of the erosion rate measurement system prototype.

1. **Developing Software for Arduino Microcontroller:** Begin by creating a control program for the Arduino microcontroller. This program will govern the operational behavior of the stepper motor, focusing on adjusting its rotation speed (RPM). Use the Arduino Integrated Development Environment (IDE) to write and upload the program onto the Arduino board. It's essential to ensure compatibility with the specific A4988 stepper motor driver in use.
2. **Connecting Arduino with A4988 Stepper Motor Driver:** Connect the Arduino board meticulously to the A4988 stepper motor driver, following the manufacturer's recommended connection guidelines. This typically involves linking the Arduino's digital output pins to the corresponding step and direction control pins on the A4988 driver.

3. **Verifying A4988 Functionality:** Once the connection between the Arduino and A4988 driver is established, run the uploaded program. Observe the stepper motor's response closely. The program should allow you to control the motor's RPM as needed. This test confirms successful communication between the program, the A4988 driver, and the motor's ability to adjust speed according to the program's instructions.
4. **Assembly of Sample Holder:** Acquire a 5mm diameter metal shaft and cut it to your desired length using a metal cutting tool, ensuring a clean cut. Weld the shaft securely to the clamp designed for holding the material sample undergoing erosion testing. The weld joint should be strong enough to withstand the motor's rotational forces. Use a 5mm socket wrench to attach the motor shaft to the sample holder shaft, establishing the mechanical connection between the motor and the sample clamp.
5. **Testing Integrated System Functionality:** Once all components are assembled, power on the system and run the control program on the Arduino. Observe the system's functionality carefully. The stepper motor should rotate the sample holder shaft at the programmed RPM set within the Arduino software.

## **1.2 Configuration Considerations**

### **Speed Control Integration:**

The halted erosion accelerator system is designed with built-in speed control, removing the need for intricate technical knowledge or manual coding. Its pre-programmed software offers a

user-friendly interface, featuring a straightforward "Run" button to start the erosion test at a preset speed.

#### **Customizable Erosion Rates:**

For users looking to adjust the erosion rate, the software typically includes a control option labeled "Delay" or similar. Reducing the delay value directly increases the rotation speed of the sample holder, thereby accelerating the erosion process. Users can experiment by gradually lowering the delay value until they achieve the desired erosion rate for their specific test.

#### **Streamlined Power Setup:**

The halted erosion accelerator system utilizes a standard power adapter, similar to those commonly used for mobile phone chargers. This familiar design ensures a simple and hassle-free power connection process. Just plug the adapter into a standard wall outlet, and the system is ready to operate.

### **1.3 User Access Considerations**

This device is currently a prototype, so access is limited for safety reasons. Here's a quick guide:

#### **Full Access:**

- CNL Researchers: You can use the accelerator for your research projects because you're familiar with its development and limitations.

#### **Limited Access (May Require Training/Collaboration):**

- External Researchers: We welcome you, but you might need training or collaboration with CNL researchers to ensure safe and effective use.

- Industry Professionals: Similar to external researchers, you might need training or collaboration due to the prototype's unique features.

**No Access:**

General Public: Safety concerns prevent public access at this stage.

## **1.4 Accessing/setting up the System**

Important Note: This guide is intended for authorized users of the Halted Erosion Accelerator prototype, specifically researchers at Canadian Nuclear Laboratories (CNL). Due to the prototype stage, some assembly and configuration steps require a basic understanding of scientific concepts and familiarity with safety protocols.

**Before You Begin:**

- Ensure you have reviewed the safety information provided in the separate safety manual.
- Gather the necessary materials:
  - Halted Erosion Accelerator prototype unit
  - Power adapter
  - Sample material to be tested (ensure appropriate size and shape for the clamp)
  - Safety glasses (recommended)

**System Setup:**

1. **Placement:** Position the Halted Erosion Accelerator on a stable, level surface to prevent tipping or wobbling during operation.
2. **Sample Holder Attachment:**

- Open the lid of the cylindrical container.
- Securely fasten your sample material using the clamp provided. Ensure the sample is centered and balanced.
- Close the container lid firmly.

### **3. Power Connection:**

- Locate the power input on the prototype unit.
- Connect the power adapter to the unit's input and plug the adapter into a standard wall outlet.

### **4. Software Control :**

- The prototype requires control software to be uploaded and run on a computer.
- Detailed instructions for software download and upload are provided in a separate user manual.
- Once the software is running, you can initiate the erosion test and adjust settings as needed.

### **Adjusting Erosion Rate:**

The software interface typically provides a control element labeled "Delay" or a similar term.

- Decreasing the delay value directly translates to an increased rotation speed of the sample holder, accelerating the erosion process.
- Increasing the delay value will slow down the rotation speed, resulting in a slower erosion rate.

- Experiment by incrementally adjusting the delay value to achieve the desired erosion rate for your specific test. The user manual provides detailed information on interpreting the delay value and its impact on the erosion process.

### **Important Reminders:**

- Never operate the system without a sample material secured in the clamp.
- Always wear safety glasses when operating the system, especially during sample placement and removal.

## **1.5 System Organization & Navigation**

### **1.5.1 Arduino Circuit**

In our circuit we used 5 male-female jumper wires, an arduino UNO board, an A4988 driver expansion board, an A4988 Driver, a 12V DC 1.5A power supply, and an NEMA 17 motor. To complete the circuit we used our jumper cables to connect our UNO to the expansion board, on the expansion board we directly attached our driver, the power supply cables, and the motor cable (the cable connected to the motor) to the required places.

### **1.5.2 Arduino Software**

For our Arduino software we had a short 20 line section of code that ran a loop that ended after a certain number of steps or substeps (depending on what the subset was set to), we used this to set the motor to stop after x (depending on how long we wanted to run the trial) amount of rotations for each trial. In this loop we had the steps alternating in a high and low state with a delay in

between, the smaller the delay the faster the motor will go, if you want the delay to be very low (you want the motor to spin very fast), you will need to program some acceleration (start with a larger delay to get to a smaller delay) or the motor will miss step and not function as it should.

### 1.5.3 Container and Clamp

On the other end of our physical prototype, we had a clear plastic container filled with salt water, a NEMA 17 stepper motor, a clamp, and a metal shaft. Our motor is mounted on top of the lid of our container with the shaft on the motor in the container, the shaft is connected to the motor via an adapter that is welded on the shaft. The adapter has a 1.5cm opening (the welded side) and a 4.94 mm opening, the 4.94mm opening is pressed onto the 5mm motor shaft and is held by friction. On the other end of the shaft we have our clamp, our clamp is welded to the shaft with the part that grabs onto the sample pointed away from the shaft (toward the bottom of the container).

## 1.6 Exiting the System

To exit the system you must first do one of three things: first you can just unplug or turn off the power supply to stop the motor (the code on your computer will still be running but no power is getting to the motor), or you can comment out the program and re-upload it, lastly you can just close arduino. If you didn't unplug the power supply in the previous step you must do so now, after this you can disassemble as necessary.

## Using the System

- 1.7 **Input:** From the main software interface, you can change the speed or direction of the rotation.
- 1.8 **Output:** This menu allows selection of pre-programmed erosion test profiles. Each profile may have specific settings for rotation speed (indirectly controlled through delay value) and test duration. CNL researchers familiar with the prototype will have developed and uploaded these profiles for various testing scenarios.

**Figure 1: an image of the arduino code.**

```
1 // defines pins
2 #define enablePin 6
3 #define stepPin 5
4 #define dirPin 4
5
6 void setup() {
7   // Sets the two pins as Outputs
8   pinMode(enablePin, OUTPUT);
9   pinMode(stepPin,OUTPUT);
10  pinMode(dirPin,OUTPUT);
11  digitalWrite(enablePin,LOW);
12 }
13 void loop() {
14  digitalWrite(dirPin,HIGH); // Enables the motor to move in a particular direction
15  int y = 800; // This value changes how many rotations are made before the motor stops: 800 is one rotation, 1600 is two rotations, 2400 is three rotat
16  for(int x = 0; x < 800; x++) {
17    digitalWrite(stepPin,HIGH);
18    delayMicroseconds(500); // by changing this time delay between the steps we can change the rotation speed
19    digitalWrite(stepPin,LOW);
20    delayMicroseconds(500);
21  }
22 }
```

### 1.9 Delay Value Adjustment

- **Input:** A slider bar or numerical input field is labeled "**Delay**".
- **Output:** This control element allows adjusting the delay value between the software program and the motor driver. Decreasing the delay value increases the motor's rotation speed, accelerating the erosion process. Increasing the delay value slows down the motor's rotation, resulting in a slower erosion rate. The specific range and impact of delay value adjustments will be detailed in the user manual for the current software version.



## **Figure 2: where to use the delay in the code**

```
delayMicroseconds(500); // by changing this time delay between the steps we can change the rotation speed
digitalWrite(stepPin,LOW);
delayMicroseconds(500);
```

### **1.10 Run Test**

- **Input:** A clearly labeled button "->" (Upload) on the software interface.
- **Output:** Pressing this button initiates the erosion test according to the selected program or adjusted delay value. The sample holder will begin rotating within the container, simulating the erosion process. The software may display elapsed test time or other relevant data during the test run.

**Image:** A screenshot of the software interface showcasing the "Run Test" button would be placed here.

### **4.5 Stop Test**

- **Input:** A clearly labeled button "End Erosion Test" on the software interface.
- **Output:** Pressing this button prematurely halts the ongoing erosion test. The sample holder rotation will cease, and the software may record any collected data up to that point.

**Image:** A screenshot of the software interface showcasing the "Stop Test" button would be placed here.

## Troubleshooting & Support

### 1.11 Common Issues:

#### 1.11.1 No irregular smell no smoke no sound not running:

##### 1.11.1.1 CODE:

1.11.1.1.1 You must ensure that the enable pin (Labeled “EN” on the board) is set to HIGH as shown in figure 1.

1.11.1.1.2 You must ensure that the step pin alternates between HIGH and LOW with an appropriate delay in between

1.11.1.1.3 You must ensure that your delay does not start too small

1.11.1.1.4 You must ensure that the Jumper wires are connected to the pins shown in the code

#### 1.11.2 Smoke and Smell:

1.11.2.1 The driver is oriented backward, you must ensure that the screw on the A4988 driver is closer to the Motor cable.

#### 1.11.3 Sound but not spinning:

1.11.3.1 You must ensure that you start with a smaller delay value

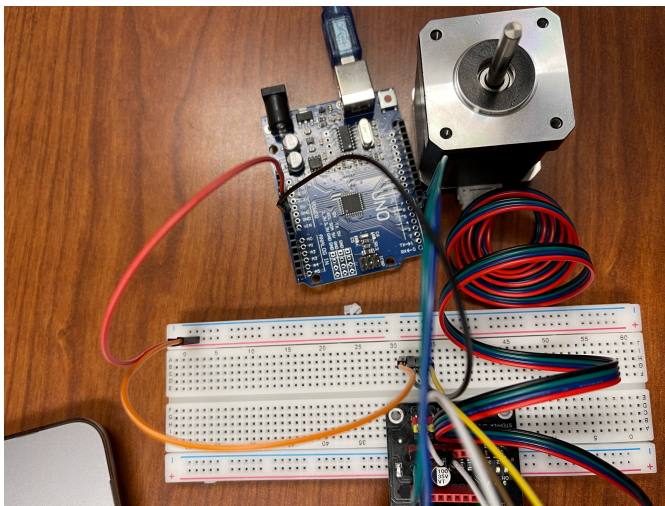
### 1.12 Maintenance

The tank should be emptied daily and refilled with new water and salt, this will remove any debris that has eroded to ensure it doesn't damage any components. It also provides the opportunity to weigh the core sample to have more accurate results.

## Product Documentation

We had a few different prototypes that taught us valuable lessons during our testing that we implemented into our final solution. These lessons include how much salt is required as a useful abrasive, that we needed a larger container and the effects of an increased rpm.





## BOM (Bill of Materials)

Item Name	Description	Quantity	Cost	Links
Arduino Uno		1	\$9.00	<a href="https://makerstore.ca/shop/ols/products/arduino-uno-r3-clone">https://makerstore.ca/shop/ols/products/arduino-uno-r3-clone</a>
Breadboard		1	\$2.50	<a href="https://makerstore.ca/shop/ols/products/breadboard">https://makerstore.ca/shop/ols/products/breadboard</a>
Jumper Wires		20	\$2.00	<a href="https://makerstore.ca/shop/ols/products/jumper-cables-pack-of-10">https://makerstore.ca/shop/ols/products/jumper-cables-pack-of-10</a>
Stepper Motor		1	\$22.14	<a href="https://www.amazon.ca/dp/B0B93HTR87?ref=ppx_yo2ov_dt_b_product_details&amp;th=1">https://www.amazon.ca/dp/B0B93HTR87?ref=ppx_yo2ov_dt_b_product_details&amp;th=1</a>
Stepper Motor driver		1	\$17.49	<a href="https://www.amazon.ca/Bolsen-Reprap-Stepper-Aluminum-Printer/dp/B07G15Z31B?pd_rd_w=dUQHv&amp;content-id=amzn1.sym.8498c5a8-80f5-4771-a949-ea2afb45d3ad&amp;pf_rd_p=8498c5a8-80f5-4771-a949-ea2afb45d3ad&amp;pf_rd_r=9VR0K76423R4M61B0X79&amp;pd_rd_wg=IPyuk&amp;pd_rd_r=83e1f5f2-4af8-4a80-8903-d9d58daddff4&amp;psc=1&amp;ref=ppx_yo2ov_dt_b_sim_0_t">https://www.amazon.ca/Bolsen-Reprap-Stepper-Aluminum-Printer/dp/B07G15Z31B?pd_rd_w=dUQHv&amp;content-id=amzn1.sym.8498c5a8-80f5-4771-a949-ea2afb45d3ad&amp;pf_rd_p=8498c5a8-80f5-4771-a949-ea2afb45d3ad&amp;pf_rd_r=9VR0K76423R4M61B0X79&amp;pd_rd_wg=IPyuk&amp;pd_rd_r=83e1f5f2-4af8-4a80-8903-d9d58daddff4&amp;psc=1&amp;ref=ppx_yo2ov_dt_b_sim_0_t</a>

Clear Container			\$4.50	<a href="https://www.dollarama.com/en-ca/p-clear-container-with-lid/3033716">https://www.dollarama.com/en-ca/p-clear-container-with-lid/3033716</a>
4ft of rebar		1	\$7.99	<a href="https://www.princessauto.com/en/10-mm-x-4-ft-steel-rebar/product/PA0009097965">https://www.princessauto.com/en/10-mm-x-4-ft-steel-rebar/product/PA0009097965</a>
AC TO DC CONVERTER		1	\$12.99	<a href="https://www.amazon.ca/gp/product/B09TKMSJNL/ref=ox_sc_act_title_1?smid=A3I3X0RGZILGMT&amp;psc=1">https://www.amazon.ca/gp/product/B09TKMSJNL/ref=ox_sc_act_title_1?smid=A3I3X0RGZILGMT&amp;psc=1</a>
Socket 5mm		1	\$5.99	<a href="https://www.homedepot.com/p/Husky-1-4-in-Drive-5-mm-6-Point-Metric-Standard-Socket-H4D6P5MM/202911894">https://www.homedepot.com/p/Husky-1-4-in-Drive-5-mm-6-Point-Metric-Standard-Socket-H4D6P5MM/202911894</a>

## Testing & Validation

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Increased Batteries, Increased RPM: Adding more batteries increased the voltage supplied to the motor, resulting in higher rotation speeds (RPM).

Higher RPM, Increased Erosion: This confirms a common trend in erosion testing - faster erosion rates at higher speeds. The increased speed exposes the sample to more erosive forces per unit time.

Mass Addition for Torque Evaluation: Adding mass to the rotating element helped assess the motor's torque capability. The motor maintains a desired RPM with the additional mass, it suggests sufficient torque for the erosion testing application.



## **Conclusions and Recommendations for Future Work**

There were many important lessons learned during this project, including how important rigorous testing is. We had our system working as intended on the morning of design day until it suddenly started vibrating and randomly changing directions. Even after all of our preparations our system quit functioning properly when we had no more time to fix it. Perhaps if we had more in depth testing that occurred over a longer period of time we could have prevented this error. Another lesson we learned is having proper time management, tasks always take longer than expected so we learned to allocate more time to certain tasks. The most productive paths to continue would be to keep testing for longer this way any system errors would be identified. If we had a few more months to work on this project we would first fix the problem we encountered on design day and then start recording erosion testing from our system. We would gather precise data about just how well our system works and how long it takes to see results. An idea we abandoned was a different clamp design, we were unable to purchase what we were looking for and the process of design and manufacturing our own clamp would take too long.

# APPENDICES

## APPENDIX I: Design Files

<https://makerepo.com/abdulahad10/2013>

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Deliverable E	<a href="https://uottawa-makerspace.s3.us-west-2.amazonaws.com/bu08602s100f5ta057kslij0k9jt?response-content-disposition=inline%3B%20filename%3D%22Deliveable%20E%202020.pdf%22%3B%20filename%2A%3DUTF-8%27%27Deliveable%2520E%2520.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033522Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=68f603073a53eefc1b00e631fb6f7eb2b8683f1ca911b56fcb65128373d6447f">https://uottawa-makerspace.s3.us-west-2.amazonaws.com/bu08602s100f5ta057kslij0k9jt?response-content-disposition=inline%3B%20filename%3D%22Deliveable%20E%202020.pdf%22%3B%20filename%2A%3DUTF-8%27%27Deliveable%2520E%2520.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033522Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=68f603073a53eefc1b00e631fb6f7eb2b8683f1ca911b56fcb65128373d6447f</a>	
Deliverable D	<a href="https://uottawa-makerspace.s3.us-west-2.amazonaws.com/fbfq91lr9mi6dyd0pzuaxeno8pdd?response-content-disposition=inline%3B%20filename%3D%22DELIVERABLE%20D.pdf%22%3B%20filename%2A%3DUTF-8%27%27DELIVERABLE%2520D.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033647Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=97949507a557f8adcece508126b05e71a05d24449860567e6870dc61d621d78">https://uottawa-makerspace.s3.us-west-2.amazonaws.com/fbfq91lr9mi6dyd0pzuaxeno8pdd?response-content-disposition=inline%3B%20filename%3D%22DELIVERABLE%20D.pdf%22%3B%20filename%2A%3DUTF-8%27%27DELIVERABLE%2520D.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033647Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=97949507a557f8adcece508126b05e71a05d24449860567e6870dc61d621d78</a>	
Deliverable I	<a href="https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b">https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b</a>	
Deliverable G	<a href="https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b">https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b</a>	
Deliverable C	<a href="https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b">https://uottawa-makerspace.s3.us-west-2.amazonaws.com/pehezrqbsoe786fa9r1m4waau?response-content-disposition=inlin%3B%20filename%3D%22Project%20Deliverable%20F_%20Prototype%20%20and%20Customer%20Feedback%20GNG%201103.pdf%22%3B%20filename%2A%3DUTF-8%27%27Project%2520Deliverable%2520F_%2520Prototype%2520%2520and%2520Customer%2520Feedback%2520GNG%25201103.pdf&amp;response-content-type=application%2Fpdf&amp;X-Amz-Algorithm=AWS4-HMAC-SHA256&amp;X-Amz-Credential=AKIA34PB766H365OOAG6%2F20240411%2Fus-west-2%2Faws4_request&amp;X-Amz-Date=20240411T033726Z&amp;X-Amz-Expires=300&amp;X-Amz-SignedHeaders=host&amp;X-Amz-Signature=049111f1cced0d5477bde4362d7f3761552664515db689e2802016911e8d66b</a>	

