Deliverable E: Project Schedule and Cost

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Abstract

This deliverable is to define the prototyping process for our nuclear pipe sample collector project. It outlines responsibilities, costs, components, project risks, and appropriate tests for determining the success of our prototype. This report will also provide a clear sketch for the chosen concept our group has chosen to base our project off of. This report will also further define our plans for this project as well as whose job each component of this project will be given to.

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Prototype and Testing Plan for Design 2 – Rotating Sandpaper Cylinder

This document details a comprehensive prototyping and testing plan for Design 2, the Rotating Sandpaper Cylinder concept. The plan outlines objectives, costs and components, job responsibilities, testing protocols, group planning and risk management, further work, and final conclusions.

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1. Introduction

Project Context:
Design 2 proposes a remote pipe sampling device that collects fine metal particles from the interior of a 4″ pipe. The concept centers on a rotating cylindrical drum wrapped in abrasive sandpaper. Machined divots on the drum's surface accumulate the loosened material while a low-speed, high-torque DC motor drives the rotation at approximately 30-50 RPM. A fail-safe retrieval mechanism ensures the drum can be withdrawn securely, preserving sample integrity.

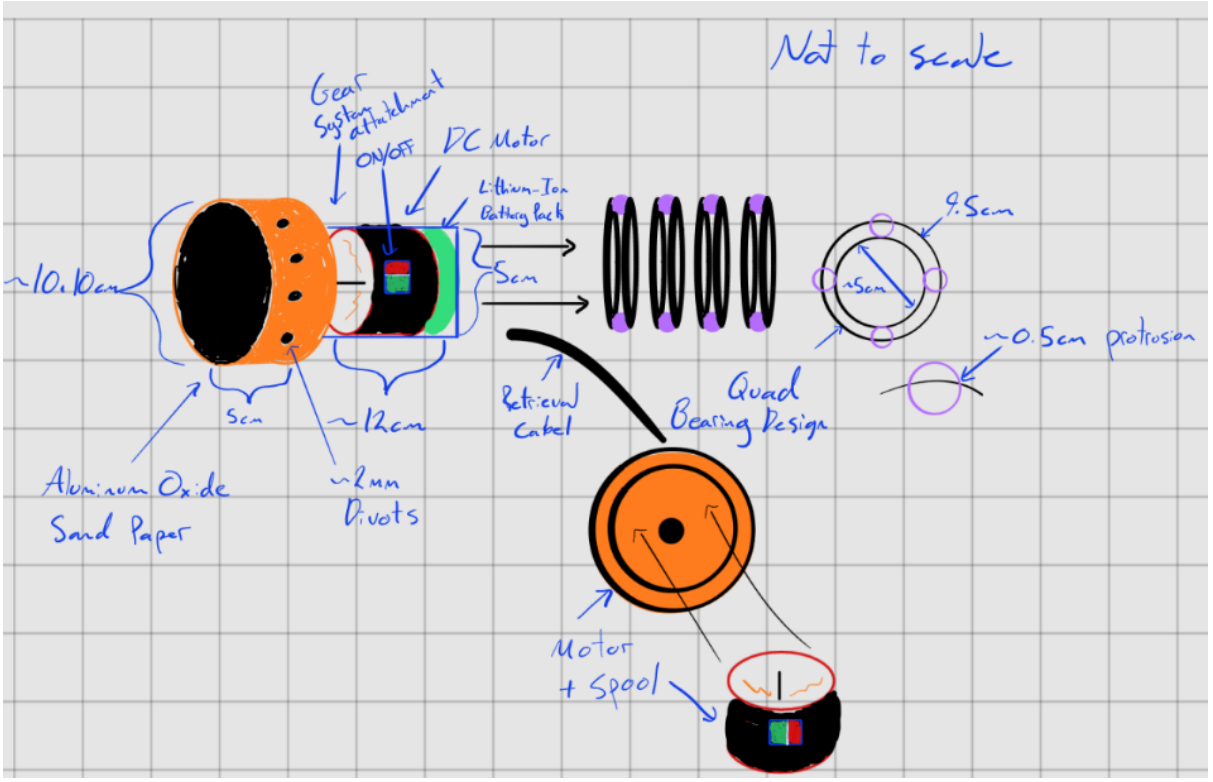

Figure 1: Design Concept

Primary Objectives:

- **Functional Verification:** Demonstrate that the abrasive drum efficiently scrapes and collects metal particles within a target sample weight of 30-80 mg.
- **Operational Consistency:** Validate that the motor and gear/belt drive maintain a steady rotation within the prescribed RPM range under load.
- **Safety & Reliability:** Confirm that the fail-safe retrieval system operates correctly without dislodging or losing the sample.
- **Integration:** Ensure that the overall system (drum, drive, and retrieval) functions cohesively over a full operational cycle (15-30 minutes).

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2. Project Costs/Components

Bill of Materials (BOM):
A detailed BOM is essential for both cost management and design verification. Key components include:

Component	Description	Estimated Cost (USD)	Comments/Notes
Rotating Drum	Aluminum alloy drum wrapped in abrasive sandpaper; includes machined divots (~2 mm deep) for sample retention.	$5 - $15	Key for efficient scraping and particle collection.
Motorized Drive System	Brushed DC motor (6V–12V, 10–20W) with gear/belt assembly; powered by a compact battery pack.	$15 - $30	Ensures controlled rotation (30-50 RPM) under load.
Retrieval Mechanism	Fail-safe cable or loop system with a clutch/manual override for safe extraction of the drum post-sampling.	$20 - $50	Critical for preventing sample loss during retrieval.

Supplementary Components	Fasteners, wiring, control switches, connectors, and any other necessary hardware.	$10 - $20	Supports integration and overall system assembly.
Total Estimated Project Cost	*Sum of all components*	**$55 - $125**	Costs must be validated with vendor quotes and approved through the BOM.

This table summarizes the main components, their descriptions, estimated costs, and additional notes for clarity.

Total Estimated Project Cost:
Approximately $55-$125. All component costs must be confirmed and approved via the project cost spreadsheet linked with vendor quotes and reimbursement guidelines.

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3. Job Responsibilities

Team Task Breakdown and Role Assignment:
To ensure efficient progress, each task is assigned to specific team members with clearly defined responsibilities and estimated durations:

- **Task 1: Detailed Design Drawing & BOM Finalization**
  Caleb Gilbert
  - **Role:** CAD Designer
  - **Duration:** 2 days
  - **Output:** Updated design drawings detailing drum dimensions, drive system integration, and fastener placement.
- **Task 2: Materials Procurement & Component Sourcing**
  Ian Kahuro
  - **Role:** Procurement Lead
  - **Duration:** 3 days
  - **Output:** Approved BOM with cost estimates, vendor links, and purchase orders.
- **Task 3: Fabrication of Subsystems:**
  Berke Dai/Quin Ramos
  - **(a) Drum Assembly & Sandpaper Application:**
    - **Role:** Fabrication Specialist

        - **Duration:** 4 days
    - **(b) Motorized Drive Assembly:**
        - **Role:** Mechanical/Electronics Engineer
        - **Duration:** 3 days
    - **(c) Fail-Safe Retrieval Setup:**
        - **Role:** Mechanical Assembly Lead
        - **Duration:** 2 days
- **Task 4: Prototype Integration & Initial Bench Testing**
  Quin Ramos/Berke Dai
    - **Role:** System Integrator
    - **Duration:** 3 days
    - **Output:** Fully assembled prototype ready for preliminary tests.
- **Task 5: Iterative Testing & Data Collection**
  Visisht Kaushik/Ian Kahuro
    - **Role:** Testing Engineer (collaborative effort)
    - **Duration:** 5 days (iterative cycles)
    - **Output:** Comprehensive test logs, data analysis, and recommendations for modifications.
- **Task 6: Final Prototype Adjustment & Documentation**
  Visisht Kaushik
    - **Role:** Project Manager
    - **Duration:** 2 days
    - **Output:** Final design documentation, revised drawings, and test reports.

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4. Appropriate Testing

Testing is structured to address critical performance criteria and to verify that the prototype meets the design objectives. Tests will be documented using our standardized test plan template.

Test 1: Drum Rotation & RPM Verification

- **Objective:** Confirm the drum rotates steadily within 30–50 RPM.
- **Metric:** RPM (measured with a tachometer).
- **Method:** Operate the motor first without load and then with simulated pipe contact; monitor RPM over a 15-minute cycle.
- **Pass Criteria:** RPM remains within ±5 RPM of the target range.

Test 2: Abrasion Efficiency & Sample Accumulation

- **Objective:** Verify that the drum scrapes the pipe effectively, allowing metal particles to collect in the divots.

- **Metric:** Weight of the collected sample (target 30–80 mg).
- **Method:** Run the prototype on a standardized test pipe section under controlled conditions; measure sample weight after each cycle.
- **Pass Criteria:** Consistent sample weights within the target range across multiple tests.

Test 3: Fail-Safe Retrieval Functionality

- **Objective:** Ensure the retrieval system pulls the drum back without sample loss.
- **Metric:** Visual and weight inspection of the sample post-retrieval.
- **Method:** Complete a full sampling cycle and perform retrieval at different angles and conditions.
- **Pass Criteria:** No dislodgement of the sample or mechanical jamming; sample weight remains consistent.

Test 4: Overall System Integration & Endurance

- **Objective:** Assess system performance over an entire operational cycle (15–30 minutes).
- **Metric:** Stability of motor performance, voltage/current consistency, and absence of mechanical failures.
- **Method:** Continuous operation under load; real-time monitoring of system parameters.
- **Pass Criteria:** System functions without interruption or failure for the full duration.

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5. Group Plan and Project Risks

Group Plan:

- Utilize a collaborative task board (e.g., Trello or MS Project) to monitor progress, set deadlines, and track responsibilities.
- Conduct daily stand-up meetings for status updates and issue resolution.
- Maintain a shared document repository for design revisions, test data, and progress reports.

Project Risks & Contingency Plans:

- **Risk 1: Inconsistent Drum RPM**
    - *Mitigation:* Adjust motor control parameters or incorporate a gear reduction system.
- **Risk 2: Insufficient Sample Accumulation**
    - *Mitigation:* Test and optimize abrasive grit selection and divot dimensions; iterate based on sample weight data.

- **Risk 3: Failure of the Retrieval Mechanism**
    - *Mitigation:* Implement redundant cable attachments and test alternative retrieval methods (manual override if needed).
- **Risk 4: Component Delays or Cost Overruns**
    - *Mitigation:* Maintain a buffer in the schedule and budget; obtain pre-approval for any changes to the BOM.

Stopping Criteria:

- If three consecutive test cycles fail to meet critical metrics (RPM control, sample weight, or retrieval integrity), halt further testing to re-evaluate and modify the design.

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6. Further Work

Post-testing iterations will focus on:

- Refining the abrasive material and divot geometry based on test feedback.
- Integrating sensor feedback for real-time monitoring of sample collection and motor performance.
- Enhancing the retrieval mechanism for better user ergonomics and reliability.
- Preparing a comprehensive cost analysis report and final design documentation for the subsequent deliverable.

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7. Conclusion

This comprehensive plan for the Rotating Sandpaper Cylinder prototype establishes clear objectives, a detailed breakdown of components and costs, specific job responsibilities, and rigorous testing protocols. Through iterative testing and proactive risk management, the team will refine the design to meet all functional, performance, and safety criteria before advancing to the final prototype stage. This structured approach ensures that the design not only meets the client's needs but also adheres to the engineering best practices outlined in our project deliverables.

8. References

Design for Manufacturing Guidelines:
https://wiki.makerepo.com/wiki/Design_for_manufacturing
(Provided detailed strategies for building cost-effective, reliable prototypes.)

Purchasing Guide:
https://wiki.makerepo.com/wiki/Purchasing_Guide
(Helped in defining the Bill of Materials and ensuring vendor-approved component sourcing.)
Canadian Nuclear Laboratories (CNL):
https://www.cnl.ca/
(Background on client requirements and safety considerations for handling hazardous samples.)
MatWeb – Material Properties Database:
https://www.matweb.com/
(Used to obtain technical data on Aluminum 6061, including density and mechanical properties.)
Engineering Toolbox – Friction and Mechanical Calculations:
https://www.engineeringtoolbox.com/
(Served as a reference for friction coefficients and slope calculations relevant to braking force analysis.)
Component Vendors (e.g., Digi-Key, McMaster-Carr):

- Digi-Key: https://www.digikey.com/
- McMaster-Carr: https://www.mcmaster.com/
  (These sites were referenced for motor specifications, battery pack details, and fastener selection.)

Prototyping and Testing Methodologies:

- MIT OpenCourseWare – Prototyping Resources: https://ocw.mit.edu/