COMBAT READY PREDICTIVE MAINTENANCE

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

ST Engineering

BACKGROUND

ST Engineering, a global technology and defense company, is exploring new solutions to enhance military vehicle maintenance and ensure operational readiness. By moving beyond traditional scheduled maintenance, the company aims to help military technicians improve productivity, efficiency, and mission readiness.

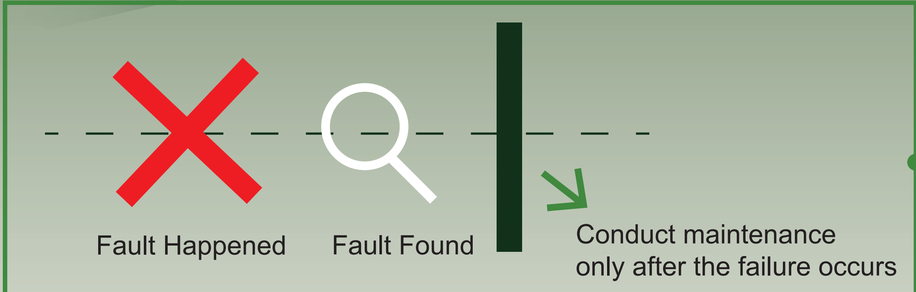
How might we leverage data analytics and machine learning to predict imminent failures in military vehicles, enabling technicians to take proactive actions, reduce downtime, and optimize combat readiness?

Problem Statement

Technician

Current Solution

REACTIVE MAINTENANCE



Reactive maintenance is a "run-to-failure" approach where equipment is repaired or replaced only after it breaks down.

DRAWBACK

- Unplanned Downtime
- Inefficient Resource Allocation
- Safety Risk

CHALLENGES of DATA

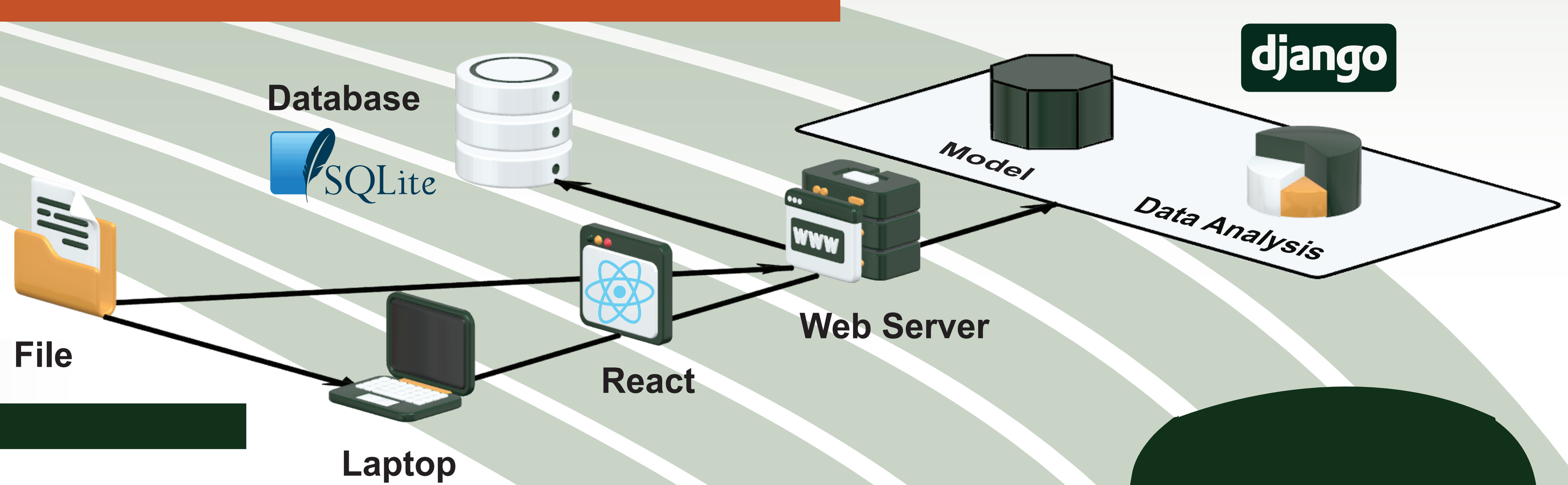
Sparsed Data
Data for all parameters is not collected at each timestamp.

Unlabelled Data
Lack of ground truth

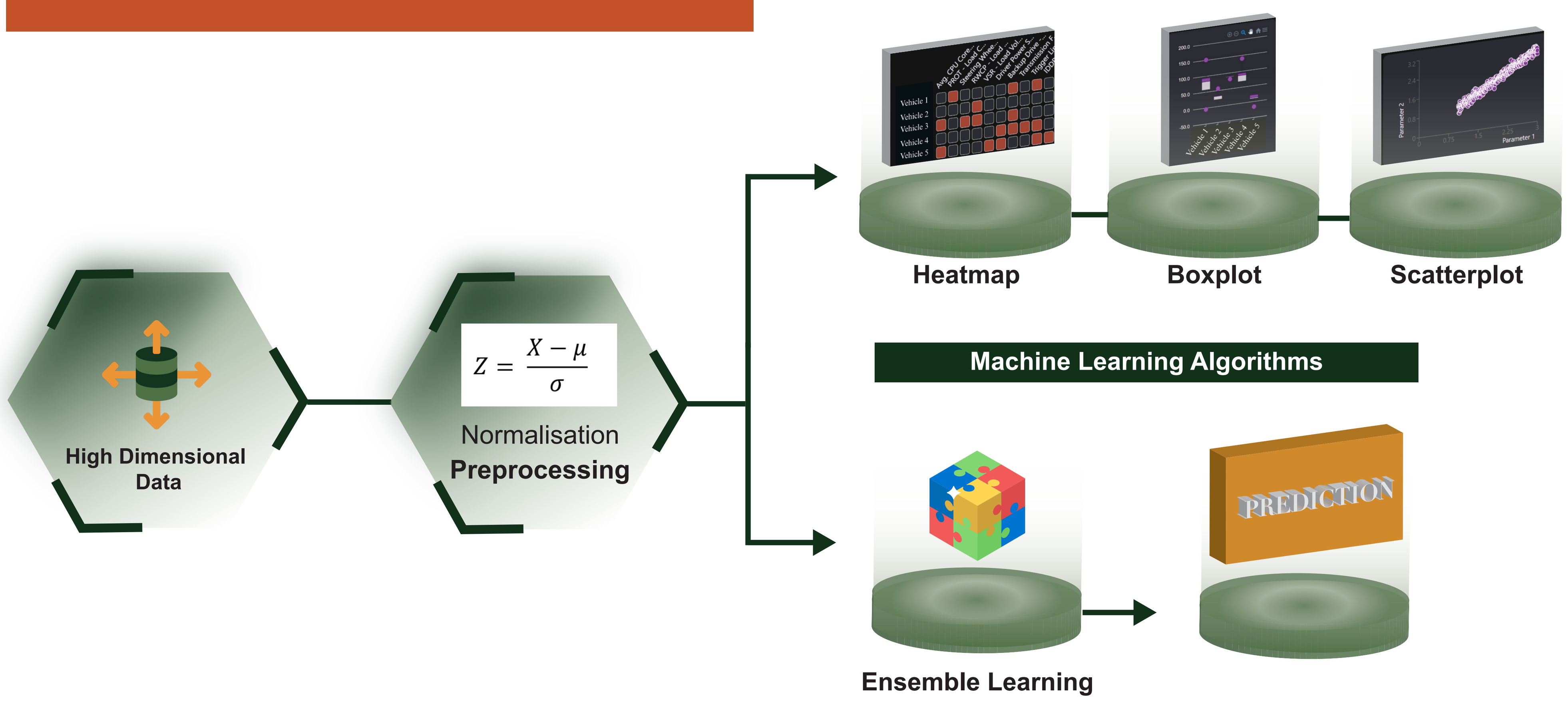
Proposed Solution

A predictive maintenance platform that utilise data analysis and machine learning to provide smart diagnostics to detect anomalies in military vehicles for tomorrow.

SYSTEM ARCHITECTURE DESIGN



MACHINE LEARNING APPROACH



Optimized Maintenance Scheduling

Enhanced Fault Detection & Proactive Response

Ensured Operational Readiness & Mission Assurance

Maintenance Log Webpage:

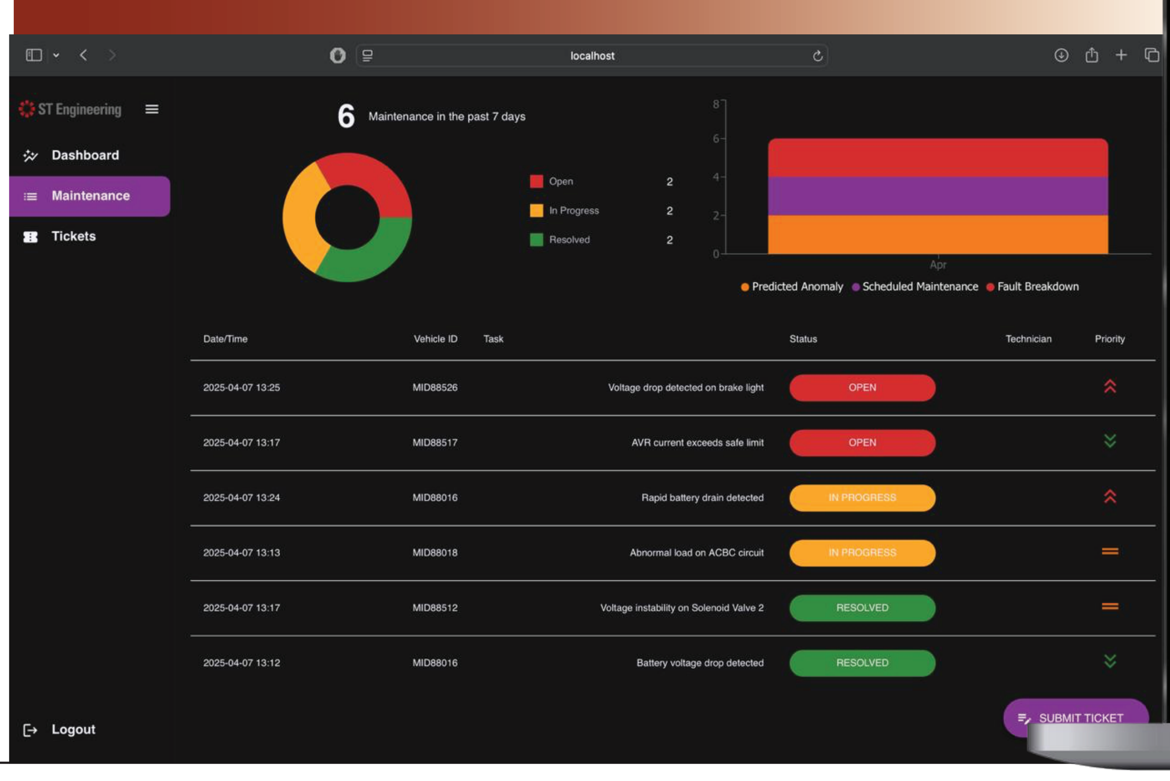
- Tracks maintenance history
- Identifies critical issues
- Prioritises tasks for optimized operations

Dashboard Webpage:

- Detects and flags high-risk faults automatically
- Customises alerts and thresholds
- Monitors maintenance trends and logs historical data

Report Ticket Submission Webpage:

- Simplifies issue reporting with guided inputs
- Auto-assigns tickets based on priority and expertise
- Integrated with maintenance logs



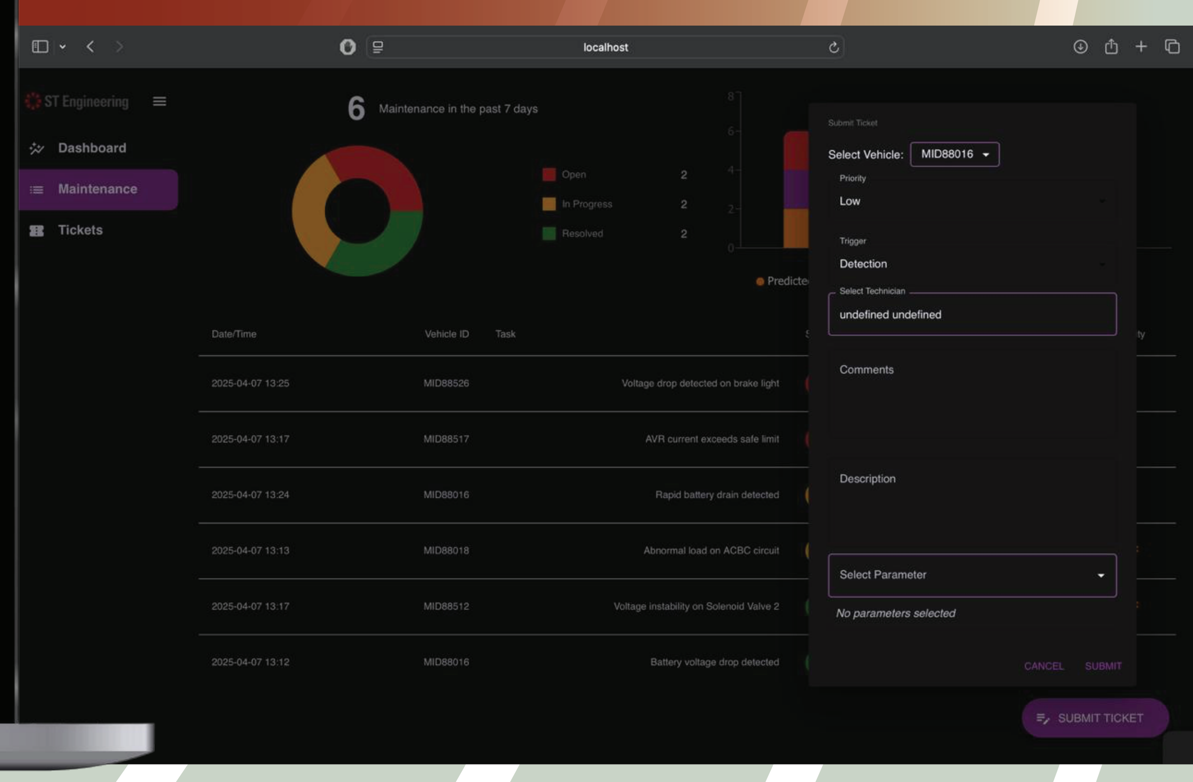


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image: Flaticon.com

PROBLEM STATEMENT

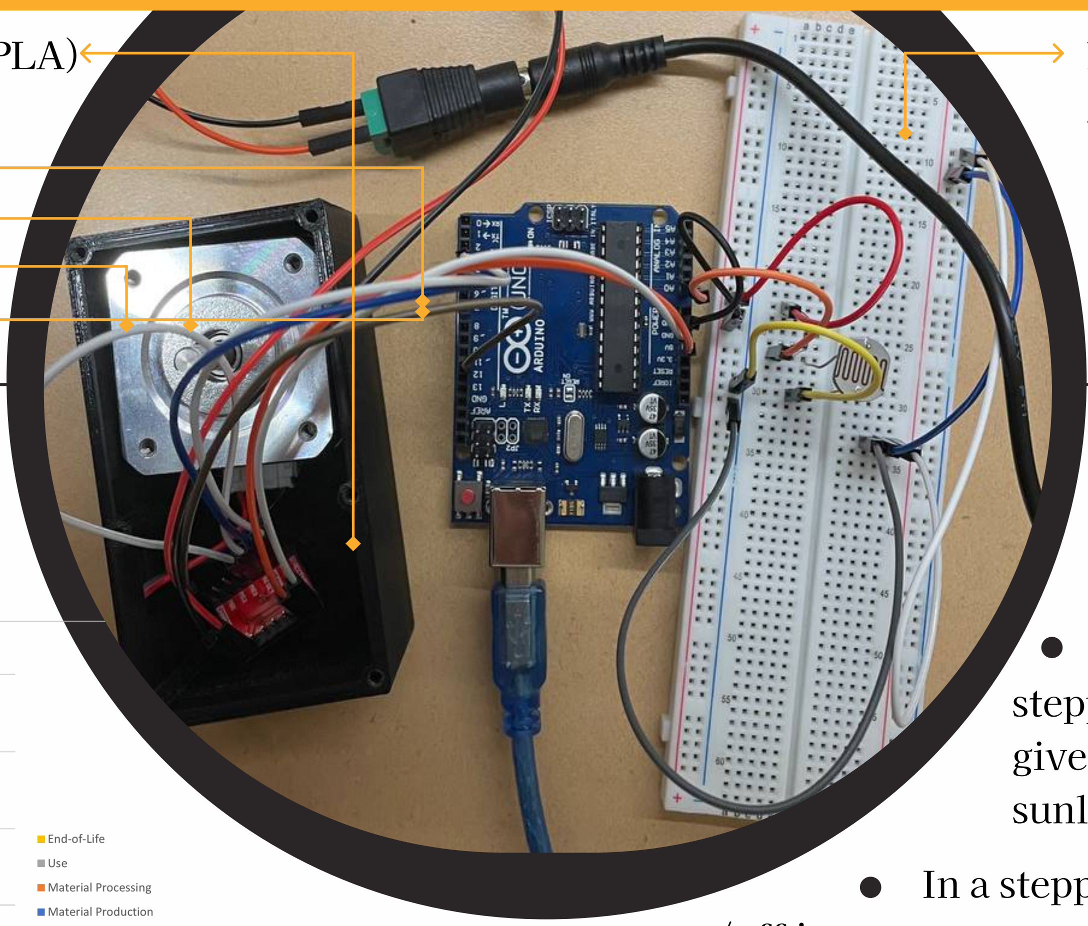
Our focus is on SUTD Hostel residents, at night, other residents can peer into each other's rooms. This becomes an invasion of privacy as it forces residence to shut their blinds if they want their privacy back, which puts the responsibility on residents to open or close their blinds at certain times. Furthermore, waking up to the blinds open leads to positive mental and physical health benefits such as increased energy levels, a happier mood throughout the day (sets tone), an increase in vitamin D levels, and encourages a healthier sleep schedule due to the biological clock. Hence, the residents should not be made to pick between privacy and these benefits. Our solution would automate this process, allowing them more control over their privacy and health.

Housing: Polylactic Acid (PLA)

Body:

- Natural Rubber
- Cast Iron
- Stainless Steel
- Copper

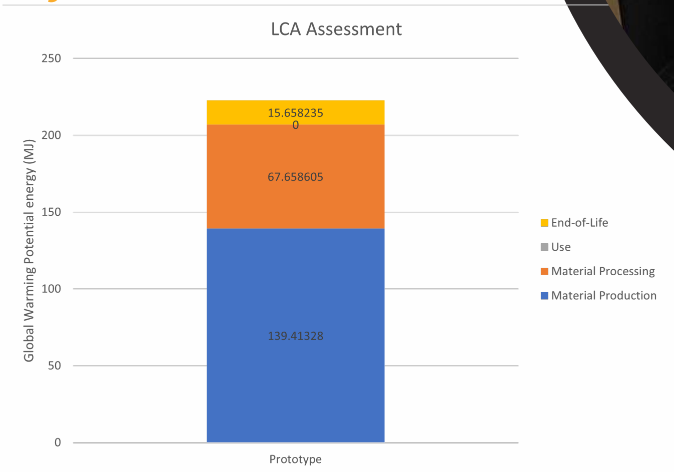
Inside

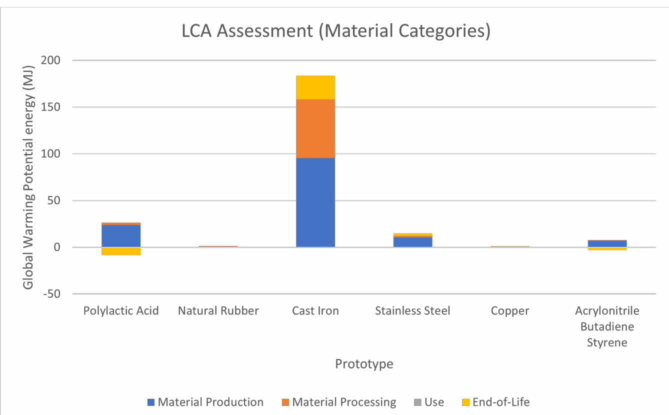


External Component: Acrylonitrile Butadiene Styrene

SSW

Product Life Cycle Assessment





Environmental Consideration

The prototype will not have much environmental impact as it is used indoor, it is harmful to environmental only when disposing.

Assumptions

- Assume the plastic part of prototype is combusted for energy recovery and the rest is recycled.
- Assume the electronic part (Arduino and motor driver) is ignored as it is essential to the prototype.
- Assume the material processing of PLA, natural rubber, cast iron and copper is industrial practices.

Future Improvement

- The size of the prototype can be reduced to decrease the energy used for the material production.
- Replace the materials of the prototype with recyclable materials for decreasing the energy comsumption in the End-of-Life stage.
- Replace the motor inside the prototype with higher efficiency one in order to reduce the environment impact.

Video Link: https://youtu.be/CzZWXcssXMQ

TW

Physics Concept Applied

- We connected a LDR and a stepper motor, which rotates given the incident intensity of sunlight.
- In a stepper motor coils are turned on/off in sequence, a rotating magnetic field is created that interacts with the fields of the magnets in the stator to create torque and mechanical energy through the rotating movement

Data Collection and Analysis

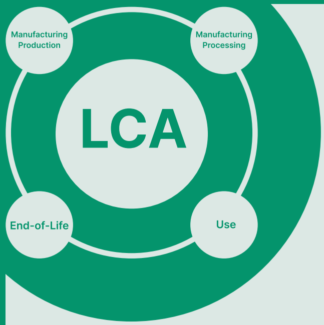
- A mass of m=750g was required to pull the beaded chain of the blind, F=m*9.81=73.6N. The rotating wheel has a radius, r=2.5cm. Where torque is the product of force and perpendicular distance from pivot point to force, t=F*r=1.84Nm.
- Tthe current across the stepper motor was measured to be I=3.5A, with a P.D. across of V=9.0V. thus a power input of Pin=31.5W
- The shaft rotates at 48rpm. Hence power output Pout=rpm*t/5252=16.8W. Efficiency Pout/Pin=53.4%

Limitation

- This prototype either fully rolls up or down the blinds and it is not designed to adjust the length of the blinds
- This prototype is unique to the blind bead chain, for it to fit into the gear and rotate.

Future Improvement

- This prototype can be further improved with remote control system as a second function to make users have the control over the blinds.
- The prototype can be improved to be more adapility to fit different types of curtains.



3.007 Science for a Sustainable World 2D Component

Environmental Impact

MAGNETIC IRON

Manufacturing Production

- Fossil fuel consumption affects the habitat conversion.
- Greenhouses gas emissions leads to climate change (global warming) which disrupts local habitats.
- Wastewater contaminants directly harm fish and amphibians.

Manufacturing Processing

- Greenhouses gas emissions leads to climate change (global warming) which disrupts local habitats.

Use

- High energy consumption during use stage leads to global warming causing habitat loss to wildlife.

End-of-Life

- High energy and heat are required to recycle which will lead to global warming causing disruption on local habitats.
- Landfill disposal causes habitat loss to wildlife and it may cause toxic chemicals leaking which will poison the wildlife.

PLA

Manufacturing Production

- More environmentally friendly than plastics made from finite fossil resources. The carbon emissions producing PLA is 80% lower than that of the productions of traditional plastics.

Manufacturing Processing

- Requires a high-pressure injection to give it the shape that is desired.

Use

- Water consumption for maintenance of the product.

End-of-Life

- Biodegradable under commercial composting conditions and will breakdown within twelve weeks.
- Broken down into smaller pieces, then into micro-plastics.
- These micro-plastics might end up in the ocean, harming the marine life and possibly disrupting and harming the food chain.

Acrylic

Manufacturing Production

- The production process emits carbon dioxide, carbon monoxide, formaldehyde and other compounds that are harmful to the environment.

Manufacturing Processing

- Bulk polymerization, the monomer and catalyst are poured into a mold, which is sealed and heated to produce the reaction that forms acrylic plastic polymer.

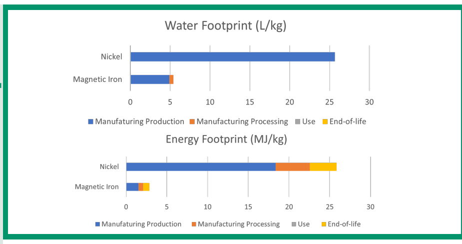
Use

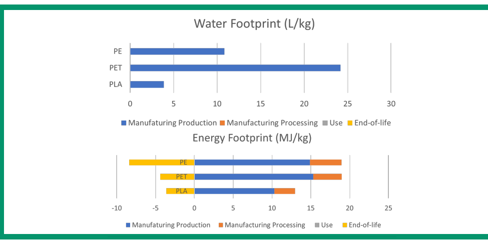
- Water consumption for maintenance of the product.

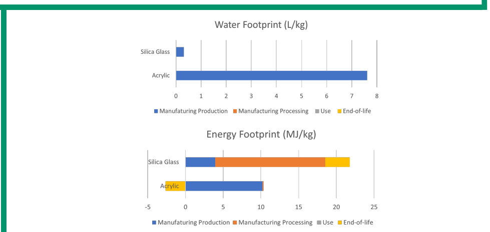
End-of-Life

- It is non-biodegradable and not renewable.
- Recycling process:
  Involves decomposition of acrylic at high temperatures, by melting lead and bringing it into contact with the plastic, causing it to depolymerize. This recycling process releases a lot of toxic gases.

Resource Footprint







End-of-Life Analysis

Recycle:

- Most ferrous metal is recycle. (Recycling rate ~99% in 2021)
- Metal can be recycled without losing its properties.The recycled metal will be used to produce new metal.

Recovery:

- Smelting is performed on the product to liberate iron.

Repurpose:

- Able to melt under very high temperature and can be cut into granules. Afterwards, it is ready to be remolded into a new product.

Recycle:

- Handed over to a recycling plant grinds the PLA and extrude it into new filament.

Reuse:

- Life span of acrylic is approximately 10 years.
- It can withstand exposure to high levels of UV light.

Repurpose:

- Acrylic paint can be formed by grinding acrylic and suspending it in water, then adding pigment.

Material Choice

- Magnectic iron has lesser water and energy footprint than Nickel.
- It can be easily recycled, the recycling rate is the highest in Singapore. (Recycling rate ~99% in 2021, (NEA, 2021))
- Iron is low in cost and has tensile high strength.
- Iron can greatly increase the power of electromagnet in motor.

- PLA has the least water and energy footprint than PE and PET.
- Durable, high tensile strength, water resistant and affordable.
- Environmentally friendly, does not generate greenhouse gases like conventional plastics.
- Made from materials like corn, which might consume precious edible crops and also take up large land space to grow them.

- Acrylic has a lower energy footprint than glass.
- Although acrylic has a higher energy footprint than glass, it is:
- Highly resistant to variations in temperature.
- Up to 17 times the impact resistance of silica glass.
- Has half the weight of silica glass and ideal for precision machining.

References

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- GRANTA Edupack Database
  Nickel, magnetic iron, PLA, PET, PE, acrylic, silica glass