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POLITEKNIK BANTING SELANGOR

MAINTENANCE PROVISION CRIB

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1 2023/2024

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A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A DIPLOMA ENGINEERING IN AIRCRAFT MAINTENANCE

SUPERVISOR:

MOHD AIZUDDIN BIN ELIAS

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REPORT ENDORSEMENT

This report entitled “Maintenance Provision Crib” is being submitted, reviewed, and endorsed to fulfill the conditions and requirements of report writing as specified.

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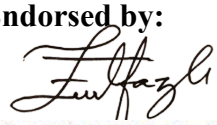
Project Coordinator’s Signature 

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Date : 15/12/2023

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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

MAINTENANCE PROVISION CRIB

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"We hereby declare that this report is the result of our own work, except excerpts that we have outlined its sources and this project will be the ownership of polytechnic.

(ARIG JEREMIAH ALONG)

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DATE: 12 DECEMBER 2023

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ACKNOWLEDGEMENT

We would like to sincerely thank everyone who helped make Maintenance Provision Crib initiative a reality. We genuinely appreciate all the help, advice, and inspiration we have gotten along the way; this project has been a true team effort. Maintenance Provision Crib is proof of the steadfast dedication of the teammates to assisting users in realising their greatest potential. We have worked together to produce a robust and effective solution that puts user convenience and safety first.

Above all, we would want to express our sincere thanks to Mr Mohd Aizuddin Bin Elias, our project supervisor, for his essential mentorship and assistance during this project. His valuable opinions and professional insights have been crucial in guiding the development of the Smart Toolbox and have greatly aided in its success. We sincerely appreciate his steadfast assistance and commitment to our mission.

We would especially want to express our thanks to the faculty and staff of Politeknik Banting Selangor for their tremendous assistance and resources, which were instrumental in the project's creation and its completion. The productive environment that the organisation fostered was essential to the project's success.

We would like to sincerely thank our family for their unwavering support and patience during our endeavour. With their encouragement and belief in our abilities, they provided us with the much-needed motivation to go over the challenges and barriers we encountered. We count it a great blessing that we have in our lives these amazing people who have helped and encouraged us at every step. Their unwavering love, compassion, and support have made this journey feasible and extremely fulfilling. We are eternally grateful for their presence in our lives.

Lastly, we sincerely thank our amazing friends and classmates for their unwavering support throughout the year. Their unwavering support and readiness to engage in thought-provoking discussions have been extremely beneficial to us. We truly have the good fortune to be surrounded by such an amazing group of people who, when we most need them, never fail to offer their best advice and insights. We owe them a great lot since we could not have done what we did with out of their help.

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ABSTRACT

This project presents the Maintenance Provision Crib a Smart Toolbox, a paradigm-shifting improvement in tool storage options within the rapidly developing field of smart technology. Combining intelligent tool identification with semi-autonomous mobility, this creative toolkit blurs the lines between programming and electronics and rethinks storage as we know it. With the integration of an advance motorised system, Maintenance Provision Crib can move about the workplace on its own while the user manually control the direction so that the safety of others in the workplace are still protected. This feature provides unmatched accessibility and convenience by eliminating the drawbacks of conventional, fixed tool storage. Other than that, Maintenance Provision Crib has the capacity to automatically identify the presence or absence of tools in real-time by utilising cutting-edge electromechanics assembly. Through a straightforward interface, users receive quick reminders, guaranteeing that tools are never forgotten or lost. The Maintenance Provision Crib is carefully constructed from exceptional and long-lasting materials. This assures its reliability even under the most adverse circumstances, in addition to ensuring that it withstands the test of time. Maintenance Provision Crib is made to last, whether you work in a maintenance industry or a do-it-yourself enthusiast. You will have the energy to use the toolbox for longer periods of time thanks to the rechargeable battery's steady power delivery construction. This enables you to focus on your job uninterrupted, resulting in increased productivity and effectiveness. Apart from its remarkable robustness and energy economy, Maintenance Provision Crib places safety first as a core component of its design. Maintenance Provision Crib stands out in any workplace because to its eye-catching, highly visible colour paint, which dramatically lowers the possibility of accidents. The vivid colour makes the toolbox stand out whether you're working in low light or in a workshop, helping you avoid accidents and injuries. This safety element is especially important in dangerous environments when it's important to take every care. Maintenance Provision Crib shows its dedication to user safety and well-being by including this visual signal. Well lastly, Maintenance Provision Crib specialised smartphone interface is revolutionary for users. This clever feature makes it really easy to find certain tools inside the toolbox. The days of digging through a jumbled toolbox to find a certain tool are long gone.

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Users may input the name or description of the tool they require using the smartphone interface with the help of Blynk app and an integrated Wi-fi board ESP32, and the toolbox will provide them the precise location of that tools. This improves the user experience overall, removes irritation, and saves time. This feature will completely change the way you operate and increase the productivity of your tasks. Maintenance Provision Crib is the pinnacle of smart tool storage solutions because of its innovative features, safety measures, and smartphone tool-finding capabilities. This project redefines accessibility, security, and user interaction in the tool storage space by embracing user-centric design in addition to meeting efficiency and organisation criteria. With Maintenance Provision Crib, one can embrace the future of tool storage at the intersection of user comfort, safety, and electronics.

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LIST OF SYMBOLS

SYMBOLS	MEANING
“	Inch
A	Ampere
cm	Centimetre
G	Gram
Hz	Hertz
m	Meter
mm	Millimetre
V	Volt
W	Watt

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LIST OF ABBREVIATIONS

MPC	Maintenance Provision Crib
STMS	Smart Tool Management Systems
LED	Light Emitting Diode

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

A toolbox is a versatile and useful tool storage and organisation solution that is popular among professionals and DIY enthusiasts. It is usually made up of a portable box or container with sections, drawers, or trays meant to house various instruments. Toolboxes are utilised in a variety of industries, including construction, car repair, woodworking, and electrical work.

History:

Toolboxes have been around for millennia, progressing from simple wooden chests to increasingly complex designs. The concept of tool storage can be traced back to ancient civilizations when craftsmen carried and protected their tools in boxes or pouches. Toolboxes changed over time to suit various tool sizes, forms, and requirements.

Types:

A toolbox can refer to a variety of tool storage containers. It could refer to a sizable storage system mounted on wheels or a little portable box that can transport a few tools to the site of a job. The majority of modern toolboxes are made of metal or plastic. Beginning in the early 19th century, toolboxes were primarily made of wood. There are 5 types of toolboxes which include plastic, steel, aluminium, waterproof, and cantilever.

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Figure 1.1: Simple wooden toolbox

Figure 1.2: Standard site toolbox

Figure 1.3: Cantilever toolbox

1.2 PROBLEM STATEMENTS

Aviation maintenance technicians require a reliable and organised storage solution for their specialized tools and equipment. The current methods of tool storage and organization can result in disorganization, tool damage, safety hazards, and delays in completing tasks. For example, if tools are left lying around in the aircraft cabin or on the tarmac, they can become a tripping hazard for personnel and passengers. Loose tools can also fall into the engine or other critical areas of the aircraft, which can cause significant damage and even lead to an accident. In addition, the unique requirements and regulations of the aviation industry add a layer of complexity to the storage and organization of tools. Therefore, there is a need for an efficient and effective toolbox solution specifically designed for the aviation industry that can improve organization, protect tools from damage, enhance safety, and ensure compliance with aviation regulations.

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‘If some evil genius were given the job of creating an activity guaranteed to produce an abundance of errors, he or she would probably come up with something that involved the removal and replacement of large numbers of varied components, often carried out in cramped, ill-lit spaces, with less-than-adequate tools, and usually under severe time pressure.’

(Back in the Box: The Importance of Tool Control for Safety- By Robert Wilson, Feb 23, 2022)

Hence, leaving tools or fasteners in the component or system being serviced comprises about 10 per cent of maintenance errors.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

The project aims to:

- To design a user-friendly and ergonomic smart toolbox system that maximises tool accessibility, storage, organisation, and controlled movement of the toolbox for the overall effectiveness and safety of maintenance operations.

- To develop a smart toolbox that combines advanced technologies and IoT to enhance the greatest level of tool reliability and accountability.

- To demonstrate a cost-effective smart toolbox solution that optimises tool usage minimises tool loss or theft, and reduces the need for manual inventory tracking, thereby lowering overall tool management expenses.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure & Design

The project aims to:

- To design a toolbox that contains numerous sections to store additional items which only takes up a small amount of space.

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- To develop a smart toolbox with a well-designed structure that enhances end-user comfort, ease of use and efficient tool organisation.

- To demonstrate a cost-effective solution that reuses an aircraft galley cart as the body of the toolbox with the usage of recycled materials, assuring structural integrity and durability.

1.3.2.2 Mechanical Mechanism & Furnishings

The project aims to:

- To design a mechanical system that includes Cytron TPE 5" tyres with a motor controller for automated forward movement of the toolbox, as well as a switch-controlled lifting mechanism for manual movement utilising castor wheels, providing for various mobility.

- To develop a sturdy butt hinge system for the doors of the recycled aircraft galley cart, ensuring smooth and durable operation when accessing tools stored in the toolbox, as well as a dependable U-shape slider drawer mechanism that allows efficient expansion and retraction for the storage compartments, allowing easy access to tools while maintaining structural integrity.

- To demonstrate the safety aspects and aesthetic look of the toolbox through the application of reflective tape, anti-collision strips, and protective coating.

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1.3.2.3 Electrical Mechanism

The project aims to:

- To design an effective electrical system to control the LED lights, including push buttons that identify whether the tools are placed or not determined by the weight of the tools.

- To develop a reliable wiring system to power the linear actuator DC to provide movement to the toolbox.

- To demonstrate the way the electrical components work flawlessly, highlighting the cooperation between the LED lights, push buttons, linear actuator DC motor and other components.

1.3.2.4 Electronic & Programming

The project aims to:

- To design a user-friendly mobile app that allows for tool location via the control of the LED lights.

- To develop a QR code-based user authorisation (e-logbook) to track tool usage and user accountability.

- To demonstrate an efficient incorporation of the mobile app with the toolbox, emphasising its role in tool locating and improving overall user experience.

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1.4 PURPOSE OF PRODUCT

The Maintenance Provision Crib is an innovative solution for effective and organised tool management in maintenance and repair situations. The concept emphasises sustainability and environmental consciousness by repurposing discarded materials, such as airline galley carts, as the toolbox body. The use of a mobile app, notably the Blynk app, improves accessibility and simplicity of use by allowing users to easily locate tools via LED lights controlled by the program. A linear actuator DC motor allows for forward movement, while manual manoeuvring allows for lateral adjustments, ensuring an ideal location inside the workspace. The use of QR codes for user authentication offers an additional layer of security and accountability, preventing unauthorised tool use.

The LED lights on the toolbox's top, which are operated by a push button, not only help with tool placement but also contribute to a safer and more organised workplace. The weight-sensitive mechanism also ensures that tools are kept correctly, improving overall tool management efficiency. Furthermore, painting the toolbox as furniture gives a sense of professionalism and visual appeal to the product, balancing practicality with a polished appearance for a full and user-friendly maintenance tool solution.

1.5 SCOPE OF PROJECT

1.5.1 General Project Scopes

The MPC proposes an innovative and long-term approach to maintenance tool management. The toolbox body is made from repurposed aircraft galley carts, demonstrating a dedication to environmental responsibility. It contains numerous sections that can store additional items that the technician or mechanic will need for routine maintenance and inspection. Although the toolbox has multiple compartments, it only takes up a small amount of space. The usage of a mobile app, particularly the Blynk app, improves accessibility and user involvement by allowing tool placement via LED lights. The use of a linear actuator DC motor allows for efficient forward movement, while manual manoeuvrability allows for lateral control, guaranteeing adaptability in a variety of operating settings. The QR code authorisation system

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offers an additional layer of protection and accountability by guaranteeing that only authorised users have access to specified tools.

The use of LED lights controlled by a push button indicates tool placement, utilising tool weight as a factor. The visual component of painting the toolbox boosts its attractiveness and smoothly incorporates it into a variety of working contexts. Overall, this project will create a toolbox for technicians, mechanics, and engineers to utilise in maintenance areas such as hangars, workshops, and other industrial areas providing a comprehensive solution that integrates sustainability, technology, and user-friendly features to optimise maintenance tool organisation and usage.

1.5.2 Specific Individual Scopes

1.5.2.1 Product Structure & Design

The product structure and design scope include the selection and reuse of an aircraft galley cart as the toolbox body, taking size, weight, and durability into account. This creates a product structure that maximises storage capacity while taking up as little space as possible, allowing effective use of available space. Include many compartments and sections in the toolbox structure to accommodate various tools and extra things required for routine maintenance and inspections.

1.5.2.2 Mechanical Mechanism & Furnishings

The mechanical system of the Maintenance Provision Crib includes butt hinges for the doors, ensuring sturdy and dependable performance. The toolbox has U-shape slider drawers with an efficient expansion and retraction mechanism allowing for organised tool storage. The final touches include a mix of oil-based paint and spray paint, which improves the toolbox's longevity and appearance. Furthermore, safety measures are integrated by applying anti-collision strips and reflective tape to the toolbox body, ensuring visibility and minimising potential hazards. Cytron TPE 5" Tyres and Castor Wheels help with mobility by providing a varied and smooth movement experience. The combination of these mechanical components and furnishings is consistent with the project's goal of developing a smart toolbox with strong construction, organised tool storage, better safety measures, and efficient mobility possibilities.

`

1.5.2.3 Electrical Mechanism

The electrical mechanism scope comprises LED lights to illuminate them for tool localisation, a linear actuator DC motor for toolbox movement, and a push button for the LED on/off control based on the weight of the tool placed. The electrical system is intended for efficiency and minimal power consumption, ensuring that it contributes to the project's overall sustainability. Aside from that, the wiring and connections will be safe and well-insulated to avoid potential hazards.

1.5.2.4 Electronic & Programming

The electronic and programming scope focuses on integrating the Blynk app with the system, allowing users to locate tools via the mobile app. Developing communication protocols between the app and the toolbox is part of this. The LED light system requires programming to locate tools within the toolbox. The total electronic and programming scope includes developing a user-friendly interface and ensuring that all electronic components work in conjunction with the mechanical and electrical systems.

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CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Toolbox in Aviation Industry

Tool management is an important aspect of aircraft maintenance. Efficient tool organisation and accessibility help to save downtime during maintenance processes. A well-organized toolbox not only speeds the workflow but also guarantees that the appropriate tools are immediately available when needed.

2.1.2 Aviation Toolbox Demands and Trends

- **Smart Toolboxes:** To improve productivity and reduce maintenance times, the aviation sector is rapidly adopting smart and technologically advanced toolboxes.
- **IoT Integration:** Toolboxes with IoT features provide real-time tool tracking, ensuring accountability, and reducing tool loss.
- **Data Analytics**: Analysing maintenance data collected from smart toolboxes aids in predictive maintenance, ultimately enhancing aircraft reliability.

2.1.3 Types of Aviation Toolbox

Standard Toolboxes: These are standard toolboxes designed for general maintenance activities.

Portable Toolboxes: Compact and lightweight toolboxes ideal for on-the-go maintenance operations.

`

Smart Tool Management Systems (STMS): Toolboxes that use smart technology to track, monitor, and optimise tool usage.

2.1.4 Toolbox Evolution in Aviation

Toolboxes in aviation have progressed from simple manual boxes to increasingly sophisticated and technology-driven solutions throughout the years. Automation, smart sensors, and connections have altered tool management, increasing efficiency and decreasing the risk of human error.

2.1.5 Aviation Toolboxes Specifications

Durability: Toolboxes must be durable to endure harsh circumstances and constant use in the demanding aviation environment.

Mobility and technology: Ease of mobility is critical for minimising the amount of energy required to push the toolbox, and advanced features should be included for an improved tool management system.

Compliance with aircraft standards: To ensure their fitness for use in aircraft maintenance, toolboxes should correspond to industry standards and regulations.

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2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure & Design

2.2.1.1 Basic Design of Main Structure

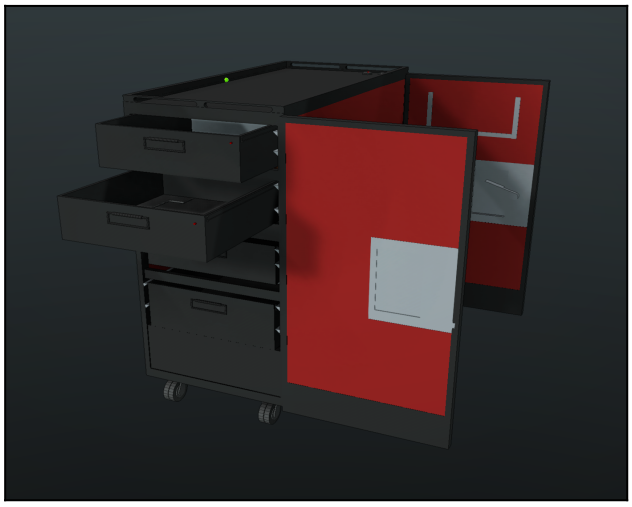

Figure 2.1: Maintenance Provision Crib (MPC)

The Maintenance Provision Crib are built upon the old Malaysia Airline Boeing 737-400 Galley cart and as such, its chassis materials and dimension remain like the galley cart. The wooden wall, solid metal frame and roof, couple with the relatively light yet durable construction make it a perfect fit to be our base for the Maintenance Provision Crib as it allows the motor to propel it at a substantial speed whilst also allowing for implementation of motor, battery and sufficient storage space.

Below are the dimensions of the tool box:

Length: 810mm (Equivalent to 31.89”)
Width: 301mm (Equivalent to 11.85”)
Height: 844mm (Equivalent to 33.23”), 1030mm (Equivalent to 40.55”) (with wheels)

The galley cart are lined with triangle protrusion where the drawer are left to hang. Lengthwise, it is separated by a metal wall (removed) exactly 362mm (14.25”) from

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the galley cart floor with 60mm gap between the two protrusions. Each drawer was made to the related specification: 251mm wide, 376mm long, and 105mm tall.

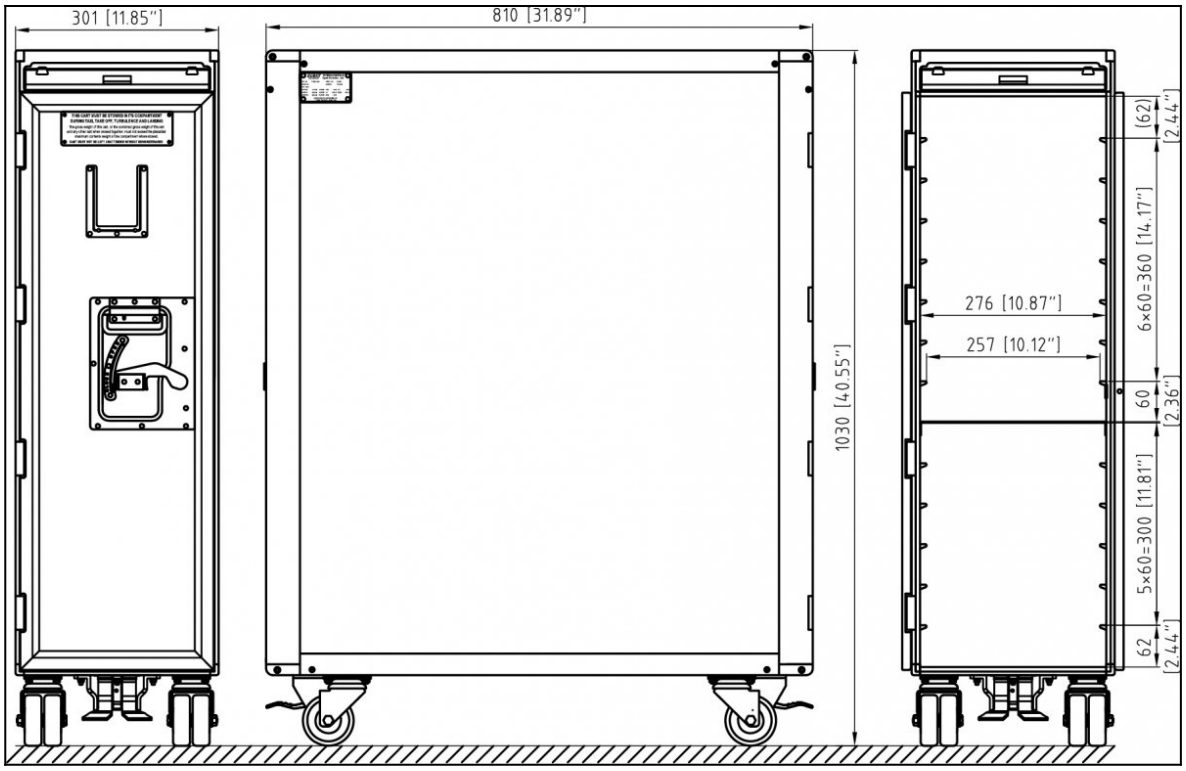

Figure 2.2: Schematic Diagram of Galley Cart

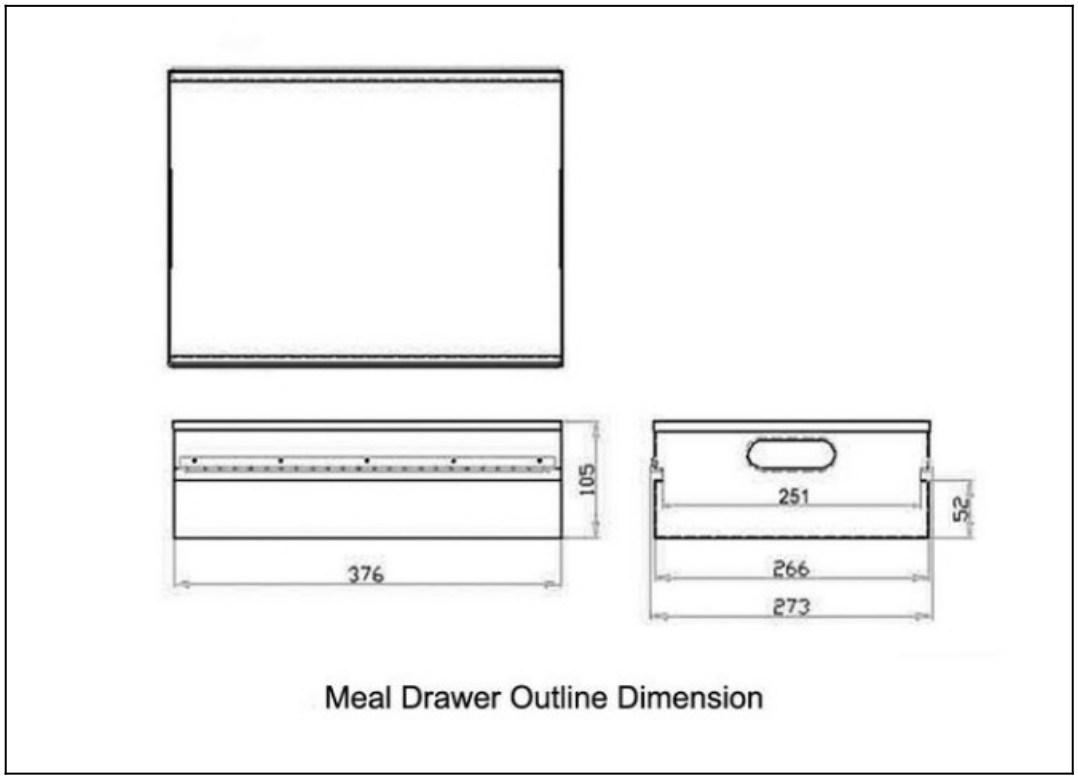

Figure 2.3: Schematic Diagram of the Drawer

Figure 2.4: Storage compartment (left) Engine Compartment (Right)

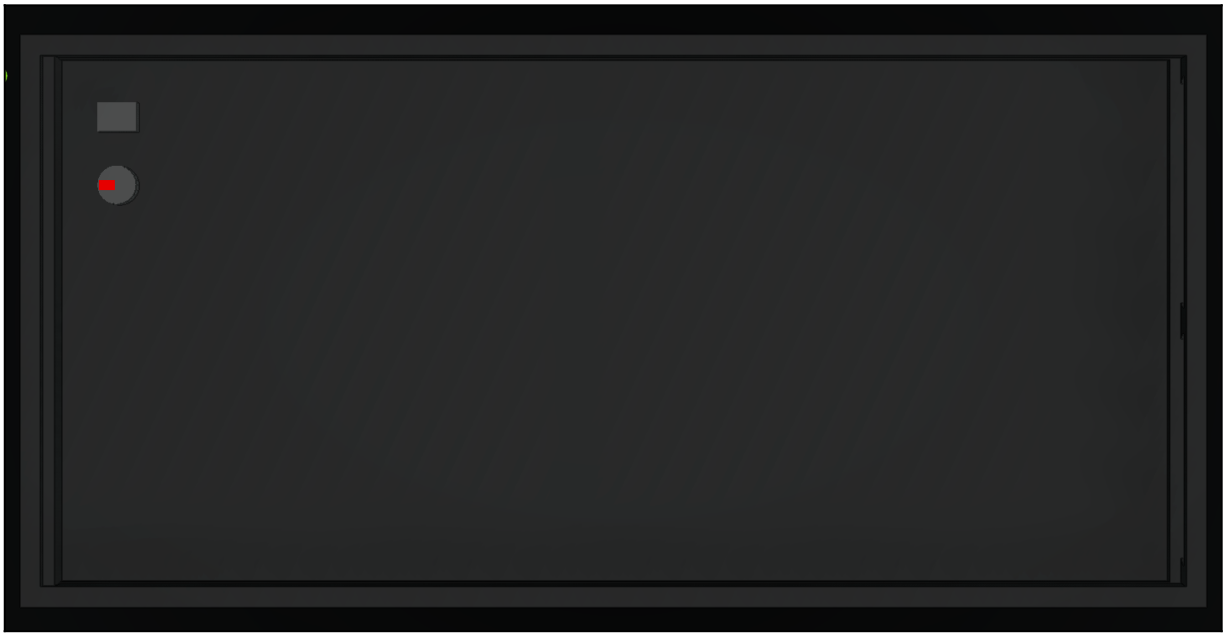

Figure 2.5: Top View of the MPC

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Located at the top are the Linear actuator controller (square button) which will extend or retract the Linear actuator, and Motor Speed Controller (round) which will control the speed of the DC motor.

2.2.1.2 Structural modification

As the galley cart was made quite robust and bare to maximise carrying capacity, significant changes were able to be done on the structure. New supporting structures were constructed on one end of the galley cart to support the linear actuators and DC motor that were to be implemented. A wall was installed right in the middle of the galley cart that separate the storage area with electronics and motor compartment, while the already installed partition that goes lengthwise was deconstructed to make space more available.

Wooden flooring was installed on each drawer to make space for sensory wiring. Aluminium beam installed at every gap between the drawer to act as a support for the drawer movement, allowing it to remain in place even when fully extended. A small part of the galley cart top was drilled to make space for the motor controller system, Linear actuator rocker switch, LED alarm, Toggle switches for forward and backward headlights, and an emergency cut-off switch.

`

2.2.2 Mechanical Mechanism and Furnishings

2.2.2.1 Type of Hinges

2.2.2.1.1 Butt Hinges

Figure 2.6: Butt Hinges (Google n.d)

Butt Hinges are cheap and simple to acquire. Due to the simplistic nature of their design, butt hinges can be surprisingly durable and fixing it are simple which are in-line with the user-friendly objective of our project. The “flap” of the hinges is thin and easily hidden within the structure of the MPC door which are part of the reason on its current sleek and clean design.

`

2.2.2.2 Type of Expansion/Retraction Mechanism

2.2.2.2.1 U-shape Slider Drawers

Figure 2.7: U-Shape Slider

Cabinet slides utilise a U-Shape metal pieces with a singular triangle protrusion attached to the main body of the toolbox. Couple with grease allowing it to be a durable, simple and low friction slider for drawers.

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2.2.2.3 Type of Finishing

2.2.2.3.1 Oil-Based Paint

Figure 2.8: Oil-Based Paint (Google n.d.)

Using a normal water-based paint would not stick well with the wooden wall of the MPC. Instead, Oil-based paint would provide better coverage and better moisture protection to prevent the wooden wall from corroding.

`

2.2.2.3.2 Spray Paint

Figure 2.9: Spray Paint (Google n.d.)

Spray Paints cover the metal and aluminium structure of the MPC from directly contacting the moisture and external element giving them a superb rust prevention and cleaner finish.

2.2.2.3.3 Anti-Collision Strip

Figure 2.10: Anti-Collision Strip (Google n.d.)

To prevent direct collision with other items or walls, the outside of the MPC is lined with an anti-collision polycarbonate rubber strip.

`

2.2.2.3.4 Reflective Tape

Figure 2.11: Reflective Tape (Google n.d.)

To prevent from accident from happening in a low lighting level area, the outside of the MPC is taped with anti-collision strip. This would greatly reflect any light away causing it to stand out more in dim area.

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2.2.2.4 Type of Tyre

2.2.2.4.1 Cytron TPE 5” tyres

Figure 2.12: Cytron TPE 5” Tyres (Google n.d)

Cytron TPE rubber wheel offer a great gripping strength which allow for better control for the motor. Together with its great durability, this wheel can last for a long duration before needing a replacement.

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2.2.2.4.2 Caster Wheel

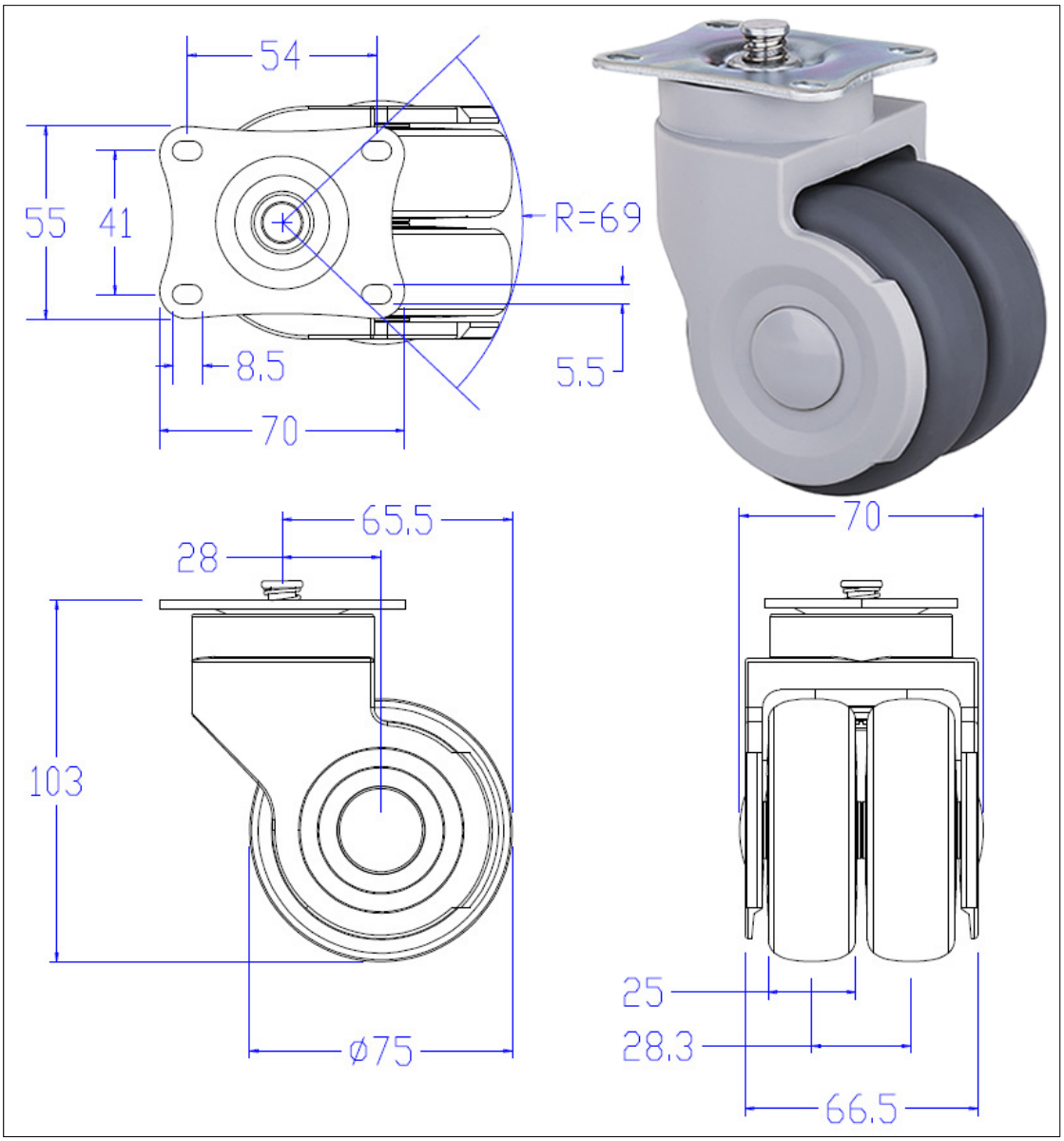

Figure 2.13: Castor Wheel (Google n.d)

The mainstay wheel of the galley cart. Rugged, rigid and smooth. It is a high-quality wheel capable of traversing rough terrain with minimum damage inflicted on the body or the structure of the wheel.

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2.2.3 Electrical Mechanism

2.2.3.1 Electrical Motor

Figure 2.14: DC Motor

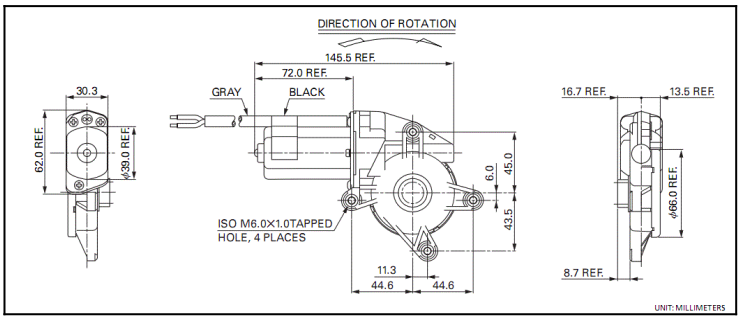

Figure 2.15: Schematic Diagram of the Motor

- **Power requirement: 12VDC**
- **Current handle: <15A**
  Stall Current: <28A
- **Torque: 2.9N.m (30kgf.cm)**
  Stall Torque (locked): 9.8N.m (100kgf.cm)
- **RPM: 51-100 (Rated 60RPM)**

Utilised 12V electrical power to move. Due to its high torque and the lack of requirement for the toolbox to move at high speed, it is a great motor for the Maintenance Provision Crib as it can move heavy load with ease.

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2.2.3.2 Linear Actuator

Figure 2.16: Linear Actuator (Google n.d)

- **Power Requirement: 12VDC – 24VDC (Rated as 24VDC)**
- **Current Rate: <5A**
- **Max Load: 700N**
- **Travel Distance: 200mm**

Use in tandem with the DC motor, controlled using the Rocker Switch. Due to the motor locking in place when not in use, it is necessary to lift it up off the ground if one wants to push the toolbox manually. Using the Linear actuator allow the motor to adjust its height with push of button.

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2.2.3.3 Battery

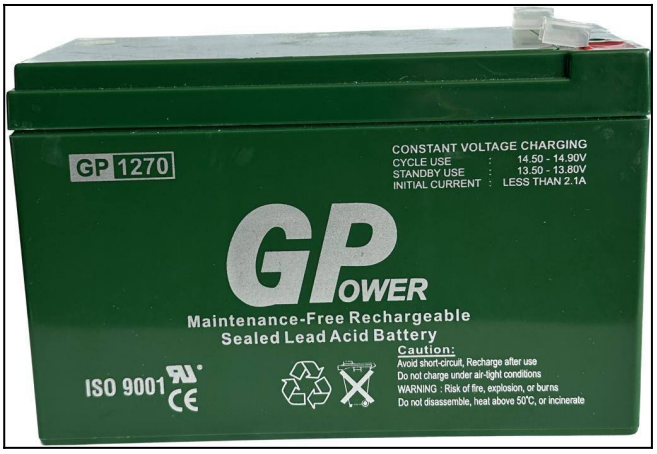

Figure 2.17: Battery (Google n.d)

- **Rated Voltage: 12V**
- **Rated Current: <2.1A**
- **Capacity: 7.0AH**

Battery from GPower utilised 12V with a 7.0AH current is a perfect fit for our low energy intensive MPC. With its rechargeable nature, it allow for multiple uses even after the battery are depleted.

2.2.3.4 Push Button

Figure 2.18: Push Button

Act as a primitive weight sensor by closing the circuit when pressure was applied to the stem. The resulting electricity that pass through the button would light up the LED allowing the tools user to know that there are tool missing.

`

2.2.3.5 Light Emitting Diode

Figure 2.19: Light Emitting Diode (LED) (Google n.d.)

The LED are linked to the Push Button allowing it to light up whenever there is a tools in the cabinet. In the presence of a missing tools, the LED would shut down notifying that there is no tools within the toolbox.

2.2.3.6 LED Strip

Figure 2.20: LED Strip (Google n.d)

LED Strip are used within the toolbox to act as a light source to illuminate the inside of toolbox. This will facilitate the searching for tools by providing lightning in area where there is a poor lightning capability.

`

2.2.3.7 Normally Closed Switch

Figure 2.21: Normally Closed Switch (Google n.d)

Used in tandem with the LED Strip, this switch only allows electricity to pass through when it is not pressed (in normal state) which allow the LED Strip to light up when the drawer was pulled out.

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2.2.3.8 Rocker Switch

Figure 2.22: Rocker Switch (Google n.d)

Allow the electricity polarity to be reverse and thus allow Linear Actuator to extend and retract.

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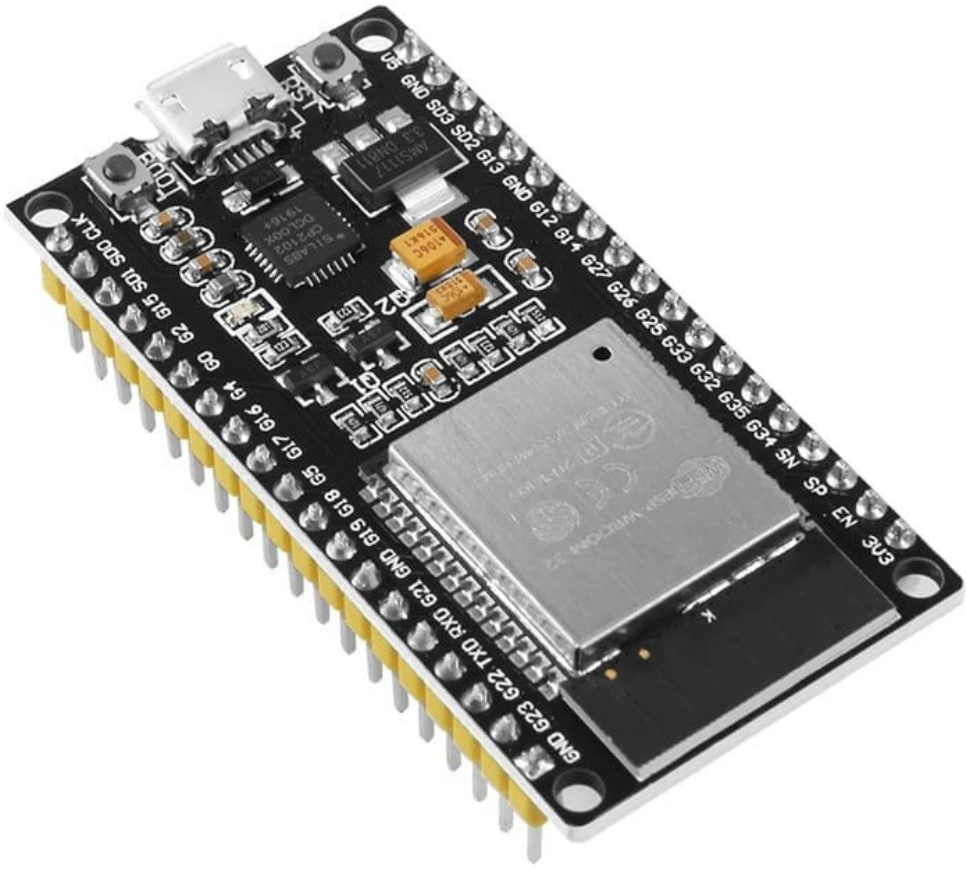
2.2.3 Electronic & Programming

2.2.3.1 Arduino ESP32

Figure 2.23: Arduino ESP32 (Google n.d.)



Arduino ESP32 are a special kind of Arduino board that allow the user to connect to it via Bluetooth or WiFi. This allow the Arduino to be remote control, letting tools user know which drawer have their tools that they needed thus massively increase efficientcy and decrease time wastage.

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2.2.3.2 Blynk

Figure 2.24: Blynk Logo (Google n.d)

Blynk IoT app are a simple and user-friendly apps that was marketed toward beginner with little to no programming knowledge. MPC make use of this app to command our arduino to perform task via smartphone.

2.2.3.9 Motor Speed Controller

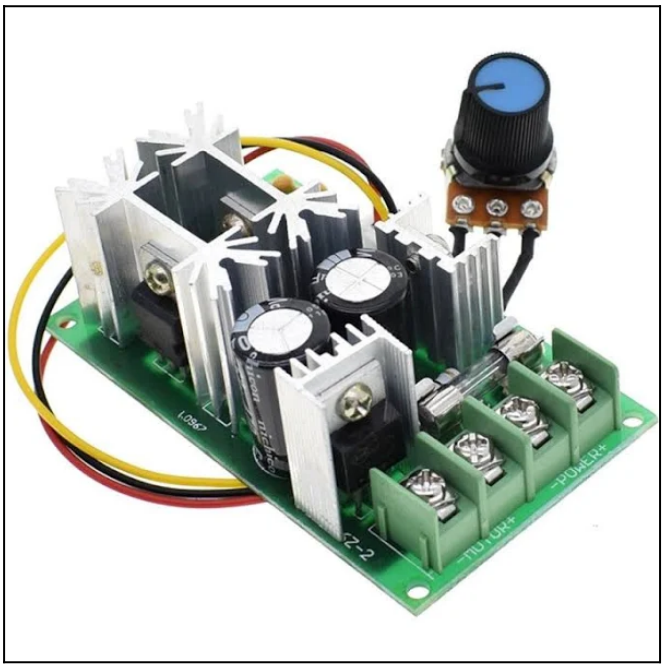

Figure 2.25: Motor Speed Controller (Google n.d.)

Allow the user to control the speed of the DC motor via adjustable resistor. The strength of the current adjusted via the strength of the resistance directly correlated to the speed of the motor.

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2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

2.3.1.1 Intelligent Toolbox GB I l 2465807

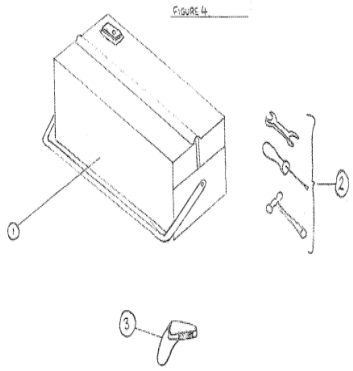
No.	Patented Product	Patent Summary
1.		**Patent Title**: Intelligent Toolbox **Patent No**.: GB I l 2465807 **Published Date:** 02.06.2010 **Patent Office Country:** United Kingdom **Inventor(s):** Robert John Sykes **Abstract:** An intelligent toolbox 1 contains an RFID reader/display unit (see fig 1) in a weatherproof casing (see fig 2) that is attached to a toolbox 1 and can read a set of RFID tags that are fitted to tools 2 contained in the box. The RFID reader is set up to recognise the tags that have been assigned to it. A full signal is displayed when the tools are in the box (fig 1). A 'not full' signal is produced when a tool is withdrawn from the box and out of range of the reader. A mobile phone may get a message including a description of the missing tool or a tool ID code.

Table 2.1: Intelligent Toolbox GB I l 2465807

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2.3.2 Recent Market Products

2.3.2.1 Rousseau R7GKE-30605L3: R-GO Tool Box 60"W X 24"D X 41 1/4"H

No	Marketed Product	Product Summary
1.		**Product Name:** Rousseau R7GKE-30605L3: R-GO Tool Box 60"W X 24"D X 41 1/4"H **Published Date:** N/A **Inventors:** Rousseau Metal inc. trademark **Description:** • A central keyed locking mechanism is included for all drawers in the same cabinet. • Drawer partitions and dividers are included. • Partitioning system with a patent. • The load capacity of the cabinet and its components is 1,500 lbs. • Can climb and descend a 6° slope (1:10 ratio). • Drive wheels that are puncture-resistant and non-marking. • When the control handle returns to its original position, an automatic electromagnetic brake is activated. • There are three speed settings.

Table 2.2: Rousseau R7GKE-30605L3: R-GO Tool Box 60"W X 24"D X 41 1/4"H

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2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

2.4.1 Maintenance Provision Crib vs Rousseau R7GKE-30605L3: R-GO Tool Box vs Intelligent Toolbox GB I l 2465807

	Maintenance Provision Crib	Rousseau R7GKE-30605L3: R-GO Tool Box	GB I l 2465807 Intelligent Toolbox
Self-Propelled capability	Yes	Yes	No
Top Speed	5 KM/h	5.5 KM/h	Not Motorised
Capacity	4 Compartments	7 Compartments	1 Compartment
Maximum Load carrying weight	Est: 300kg	680.39 kg including toolbox weight	N/A
Building Material	Aluminium	Aluminium	N/A
Tools Detection Capability	Yes	N/A	N/A
Battery Capability to support Electric Motor	Est. 10km	20km	N/A

Table 2.3: Maintenance Provision Crib vs Rousseau R7GKE-30605L3: R-GO Tool Box vs Intelligent Toolbox GB I l 2465807

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CHAPTER 3

RESEARCH METHODOLOGY

3.1 Project Briefing And Risk Assessment

3.1.1 Utilisation of Polytechnic Facilities

During the fabrication process of MPC, our team make full use of the Composite Workshop and Workshop 2 in Politechnic Banting where we utilised the large space to do our work in an effective and safe manner.

The wide spaces couple with all the heavy machinery such as shering and bending machine massively cut down time for our fabrication and remodelling time.

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3.2 OVERALL PROJECT GANTT CHART

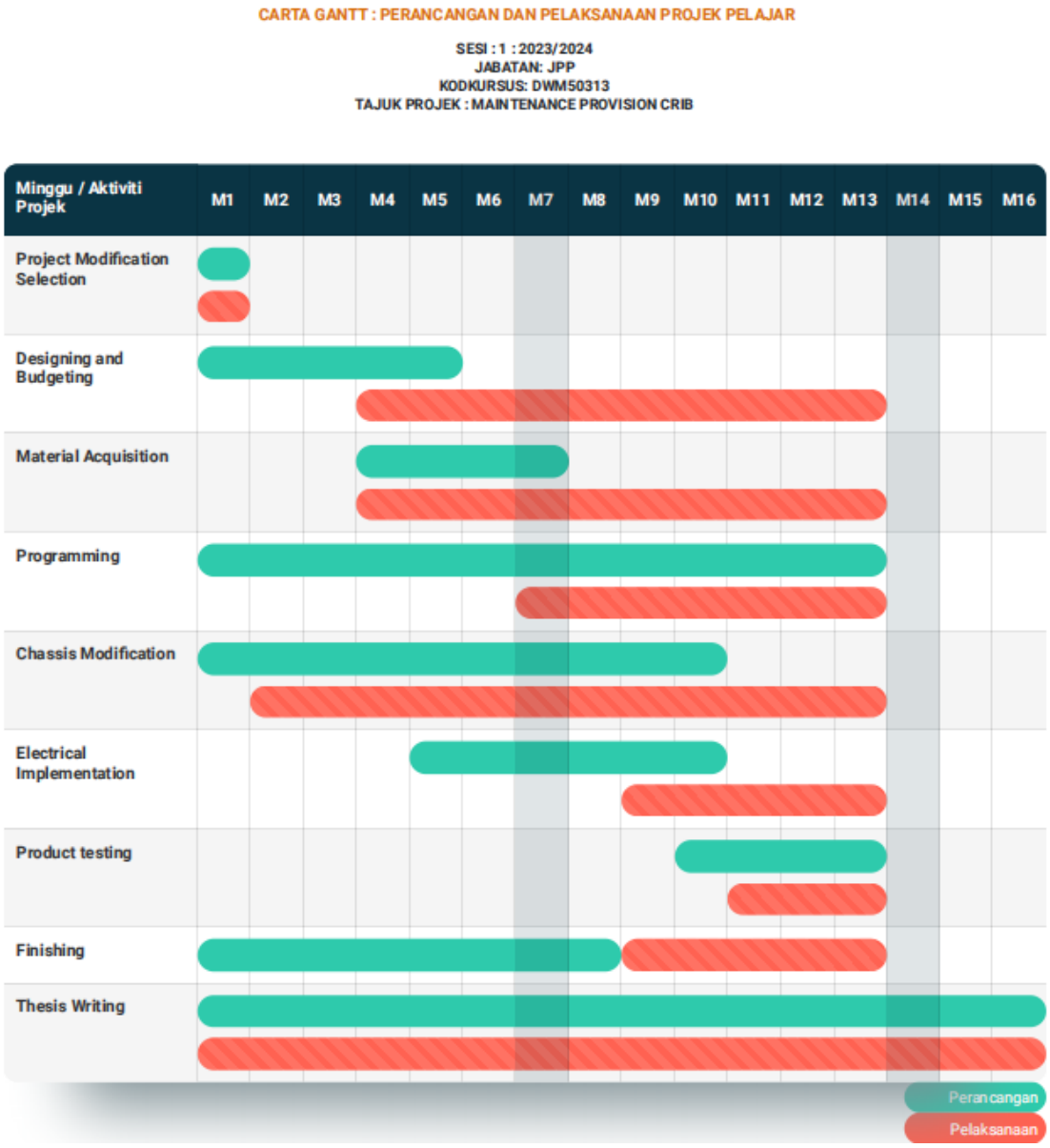

Figure 3.1: Maintenance Provision Crib Overall Gantt Chart

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3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

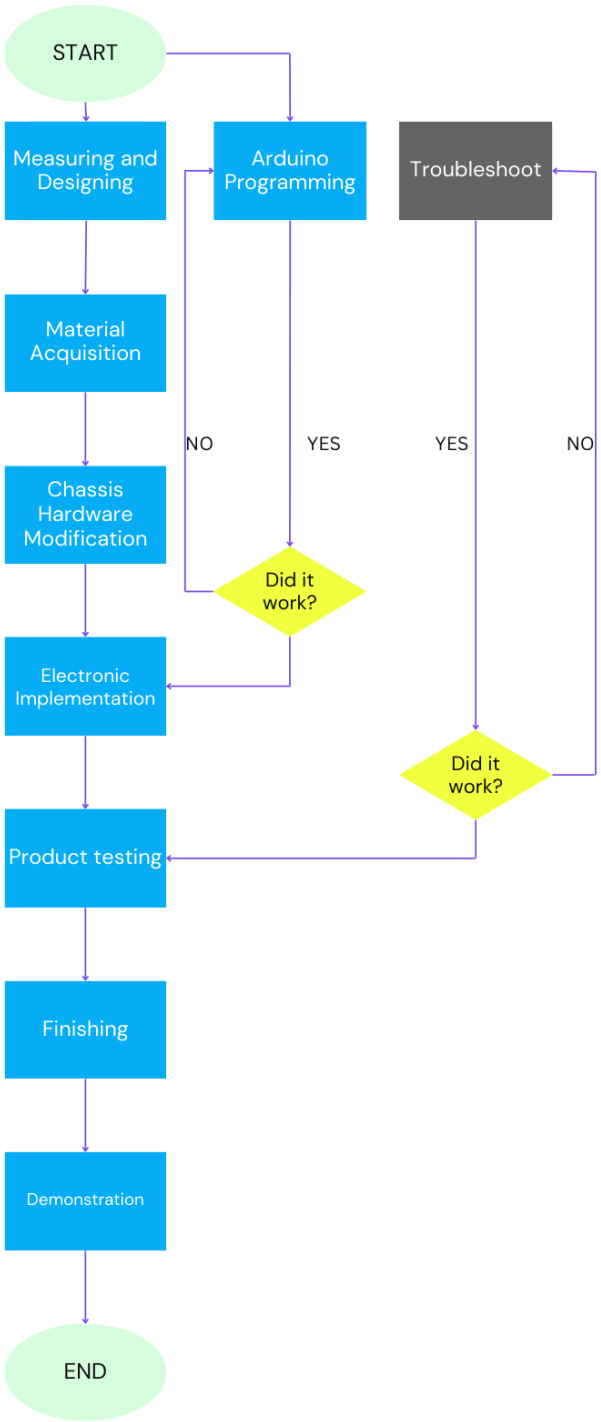

Figure 3.2: Overall Project Flow Chart

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3.3.2 Specific Project Design Flow Chart / Framework

3.3.2.1 Product Structure & Design

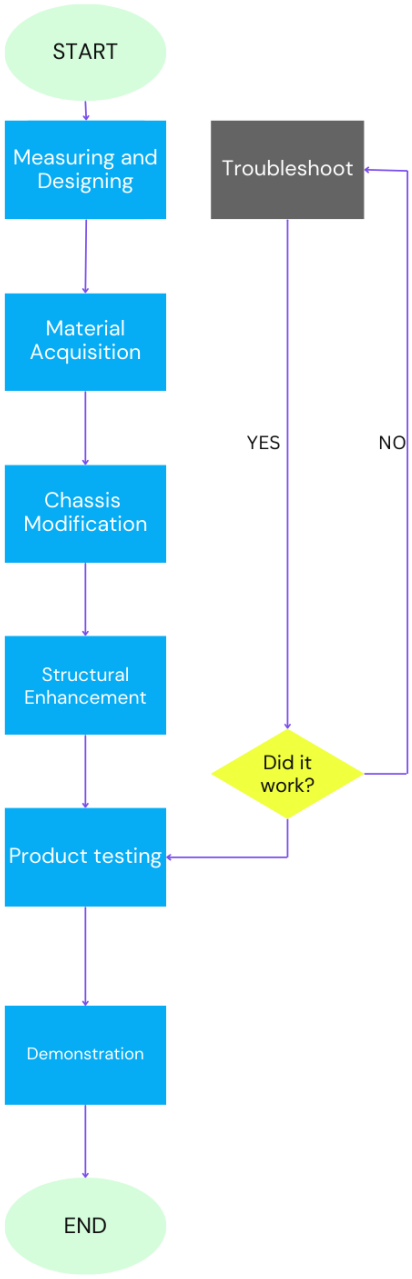

Figure 3.3: Product Structure & Design Flow Chart

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3.3.2.2 Product Mechanical Mechanism & Furnishings

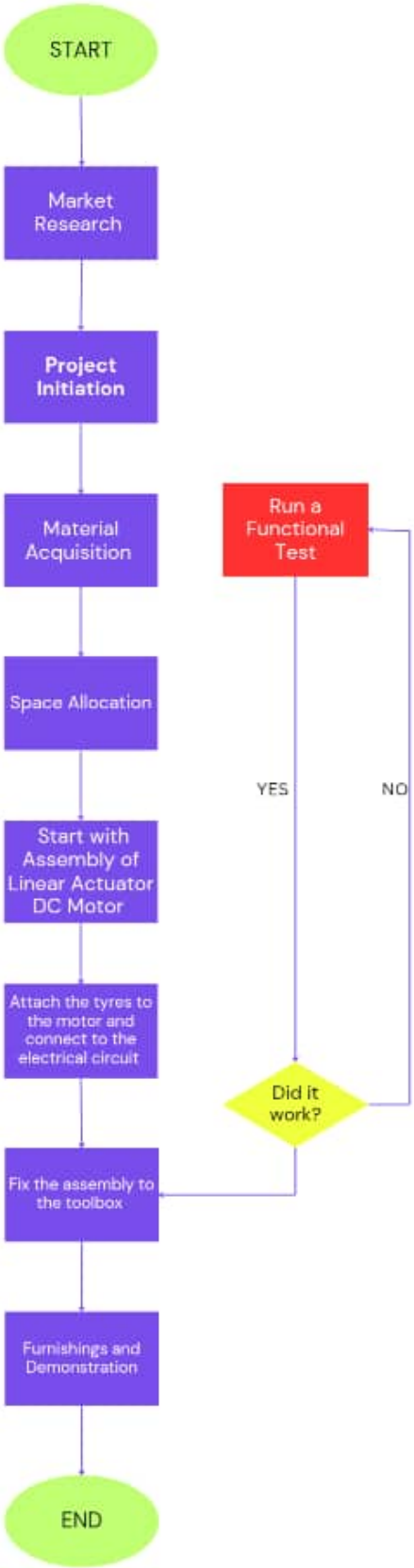

Figure 3.4: Product Mechanical Mechanism & Furnishings Flow Chart

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3.3.2.3 Electrical Mechanism

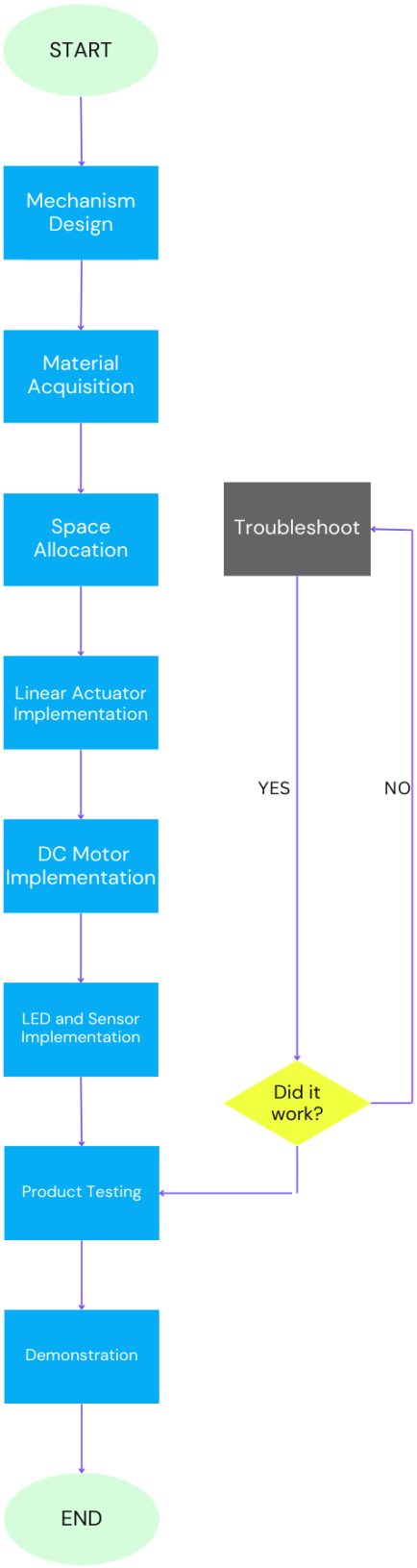

Figure 3.5: Electrical Mechanism Flow Chart

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3.3.2.4 Electronic & Programming

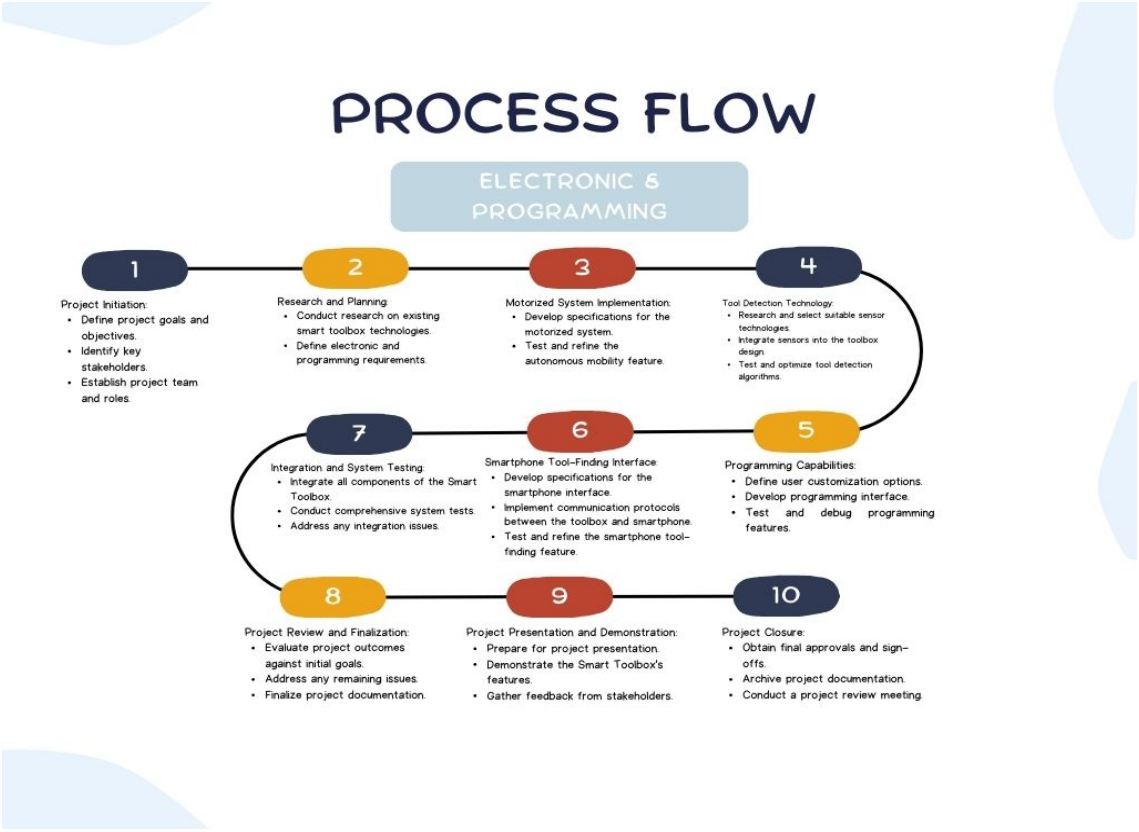

Figure 3.6: Electronic & Programming Flow Chart

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3.4 DESIGN ENGINEERING TOOLS

3.4.1 Design Requirement Analysis

3.4.1.1 Questionnaire Survey

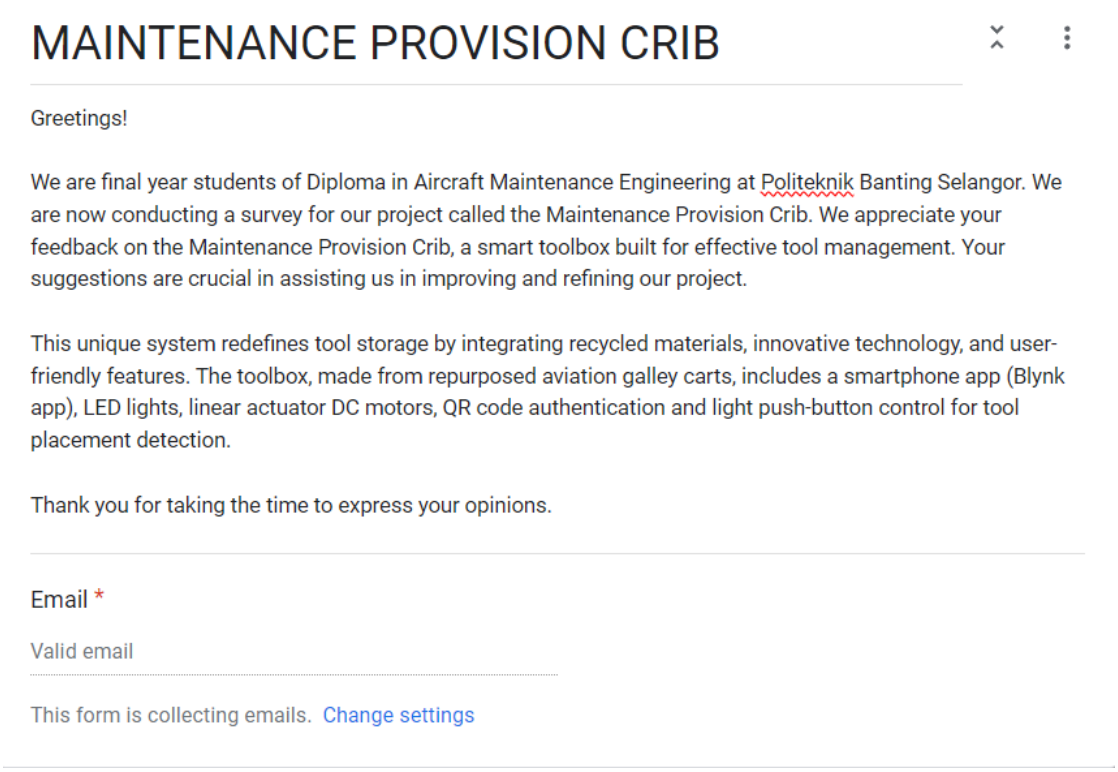

Figure 3.7: survey google form

The survey was conducted through google form, questions were divided into FOUR (4) different part.

- PART A: Respondent's Demographic
- PART B: User's Experience
- PART C: Problem Faced By Users
- PART D: Product Improvement

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3.4.1.2 **Pareto Diagram**

Pareto Diagram: MAINTENANCE PROVISION CRIB

User Experience	Frequency	Cummulative Frequency	Cummulative Percentage
Not important	6	6	6%
Slightly important	6	12	12%
Important	20	32	32%
Fairly important	29	61	62%
Very important	38	99	100%
GRAND TOTAL	99		

Table 3.1: pareto data from the survey respondent

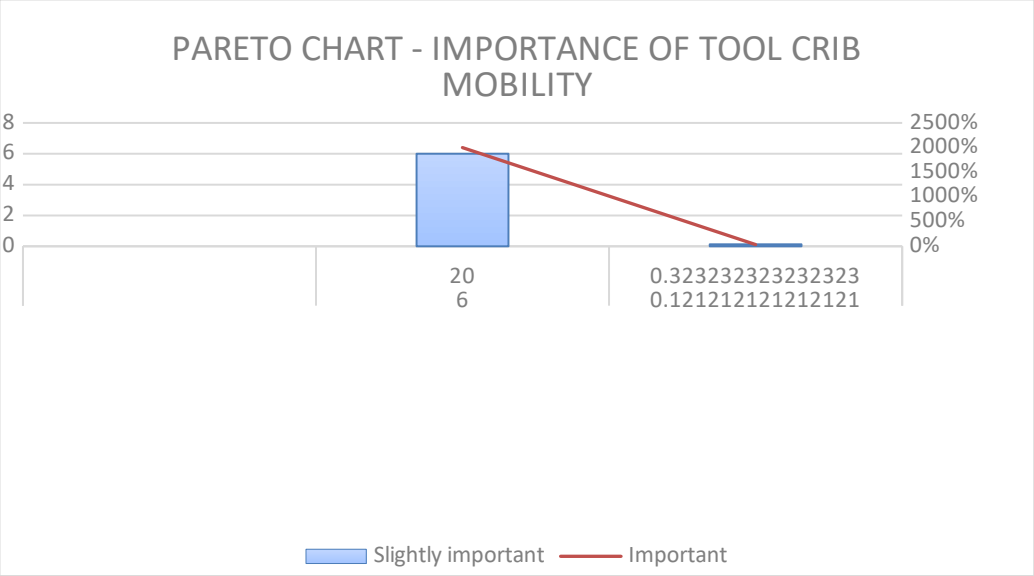

Figure 3.8: pareto diagram for Maintenance Provision crib

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3.4.2 Design Concept Generation

3.4.2.1 Function Tree

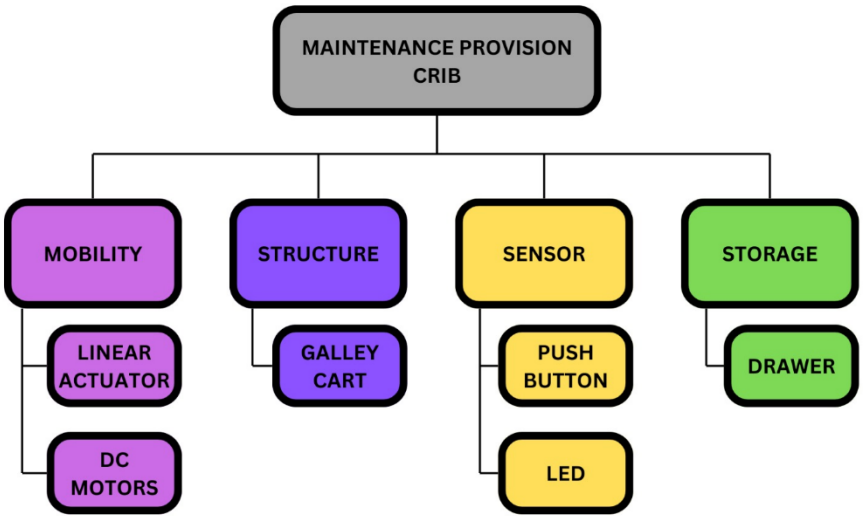


Figure 3.9 : Function Tree For MPC

3.4.2.2 Morphological Matrix

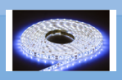
Function	Idea 1	Idea 2	Idea 3	Idea 4
Material	Aluminium 	Stainless Steel 	Steel 	Polyproplene 
Design (shape)	Square 	Rectangle 	Trapezium 	
Size	Small	Medium	Large and Short	Large and Tall
Finishing	Paint 	Spray 	Epoxy 	Lithium Grease 
Component (sensor)	Pressure sensor 	Laser Sensor 	Proximity sensor 	
Component (Alarm)	Buzzer 	LED light 		
Accessories	LED strip 	Neon strip 		

Table 3.2: Morphological Matrix For Maintenance Provision Crib

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3.4.2.3 Proposed Design Concept 1

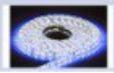
Function	Concept 1	Justification
Material	Stainless Steel 	Easily available, cheap, great corrosion resistant, easy to handle.
Design (shape)	Rectangle 	Easy to make and maximized volume.
Size	Medium	Easy to store, have large amount of space and cheap to produce.
Finishing	Lithium Grease 	Protect steel from rusting.
Component (Sensor)	Laser Sensor 	Detect tools in the toolbox.
Component (Alarm)	1. Buzzer 2. LED Light 	Remind user that a tool(s) is missing via aural and visual reminder.
Accessories	LED Strip 	Cheap and energy saving.

Table 3.3: Proposed Design Concept 1

3.4.2.4 Proposed Design Concept 2

Function	Concept 2	Justification
Material	Aluminium 	Lightweight, relatively durable, good corrosion resistance
Design (shape)	Square 	Easy to make and the shape support greater load perpendicular due to its shorter length.
Size	Small	Compact and easily manoeuver
Finishing	Spray 	Prevent aluminium from direct contact with air and moisture thereby lowering risk of rusting
Component (Sensor)	Proximity sensor 	Able to reliably sense tools nearby
Component (Alarm)	1. LED light 2. Buzzer 	Remind user that a tool(s) is missing via aural and visual reminder.
Accessories	LED Strip 	Cheap and energy saving.

Table 3.4: Proposed Design Concept 2

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3.4.2.5 Proposed Design Concept 3

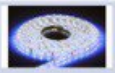
Function	Concept 3	Justification
Material	Stainless steel 	Lightweight, relatively durable, good corrosion resistance
Design (shape)	Square 	Easy to make and the shape support greater load perpendicular due to its shorter length.
Size	Medium	Larger space to fit additional storage area
Finishing	Spray 	Prevent aluminium from direct contact with air and moisture thereby lowering risk of rusting
Component (Sensor)	Proximity sensor 	Able to reliably sense tools nearby
Component (Alarm)	1. LED light 2. Buzzer  	Remind user that a tool(s) is missing via aural and visual reminder.
Accessories	LED Strip 	Cheap and energy saving.

Table 3.5: Proposed Design Concept 3

3.4.2.6 Accepted Vs Discarded Solution

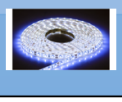
Function	Idea 1	Idea 2	Idea 3	Idea 4
Material	Aluminium 	Stainless Steel 	Steel 	Polyproplene 
Design (shape)	Square 	Rectangle 	Trapezium 	
Size	Small	Medium	Large and Short	Large and Tall
Finishing	Paint 	Spray 	Epoxy 	Lithium Grease 
Component (sensor)	Pressure sensor 	Laser Sensor 	Proximity sensor 	
Component (Alarm)	Buzzer 	LED light 		
Accessories	LED strip 	Neon strip 		

Table 3.6: Accepted Vs Discarded Solution

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After careful evaluation, Concept 3 has been selected as the preferred solution for the project. This concept offers several advantages that make it a compelling choice. Firstly, it provides a more cost-effective option compared to the other concepts considered, allowing for efficient utilization of resources.

Concept 3 emphasizes simplicity while retaining the majority of the desired functions. By focusing on essential features, it ensures practicality and ease of use for technicians and engineers in the aviation industry. The streamlined design optimizes functionality, making it intuitive and straightforward to operate, ultimately enhancing productivity and reducing potential complexities.

Concept 3's small design is one noteworthy feature. The toolbox's efficient use of space enables it to effortlessly integrate into a variety of work contexts, including the constrained or tight areas frequently encountered in aircraft maintenance operations. Its small size helps make greater use of the area that is available while making sure that the necessary tools and equipment are close at hand.The Concept 3's outstanding mobility is yet another salient characteristic. The toolbox has been given manoeuvrability features that make moving it about the aviation facility simple. The toolbox is easily portable, making it possible to move between workplaces, hangars, or other airport locations while always keeping equipment close at hand. This improved mobility increases workflow effectiveness and reduces needless travel.

In summary, Concept 3 presents a comprehensive solution that meets the project requirements effectively. Its cost-effectiveness, simplicity, compactness, and excellent mobility make it a compelling choice for the intended application in the aviation industry. By implementing this concept, the project aims to enhance operational efficiency, facilitate better organization, and contribute to a safer and more productive working environment for technicians and engineers involved in aircraft maintenance.

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3.4.3 Evaluation & Selection Of Conceptual Design

3.4.3.1 Pugh Matrix

Criterion	Factor	Concept 1	Concept 2	Concept 3
Cost	0.2	D	1	2
Storage Space	0.2	A	2	1
Manoeuverbility	0.2	T	1	2
Durability	0.2	U	1	2
Longevity	0.2	M	1	2
Total Score	1.0		6	9
Ranking	-	-	2	1

Table 3.7: Pugh Matrix

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3.5 General Product Drawing

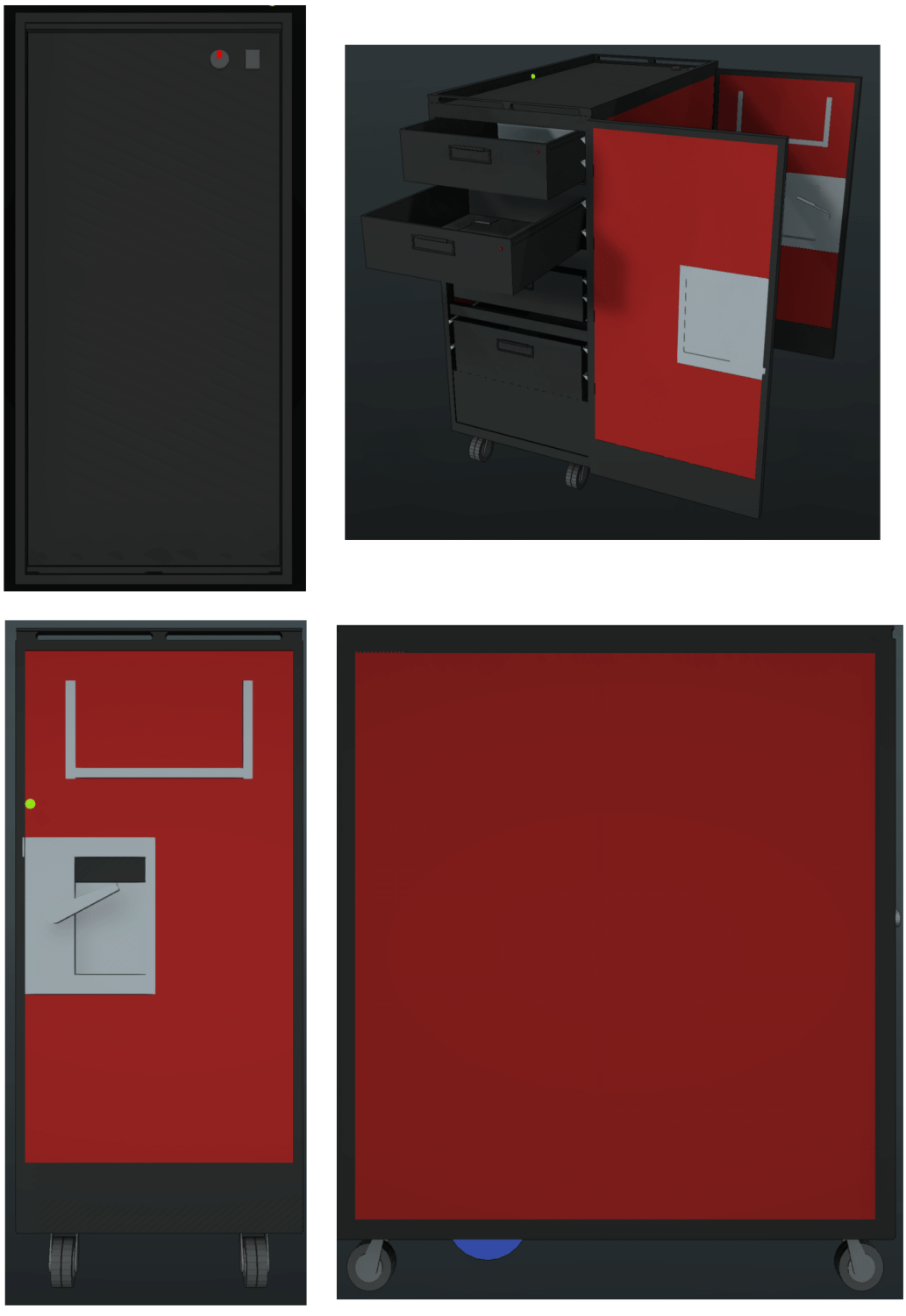

Figure 3.10: Schematic diagram of MPC

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3.5.2 Specific Part Drawing / Diagram

3.5.2.1 Product Structure & Design

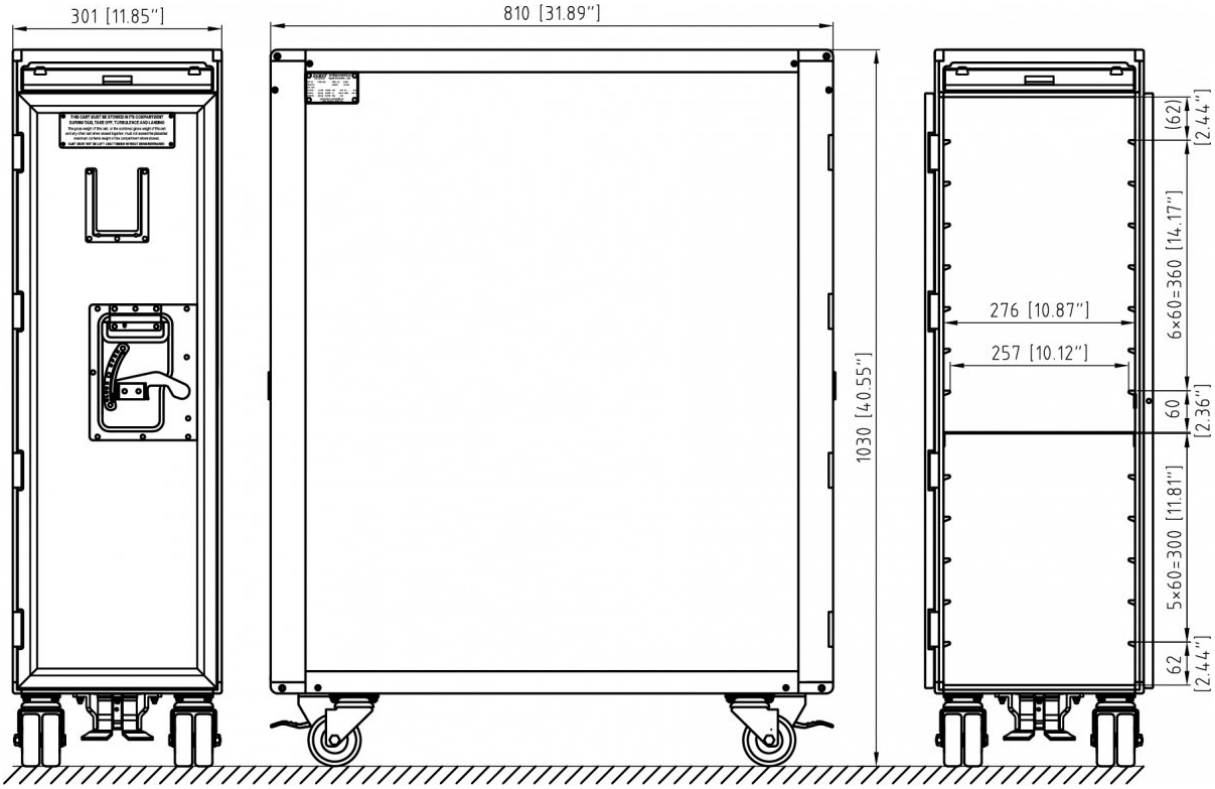

Figure 3.11: Schematic Diagram of the Galley Cart

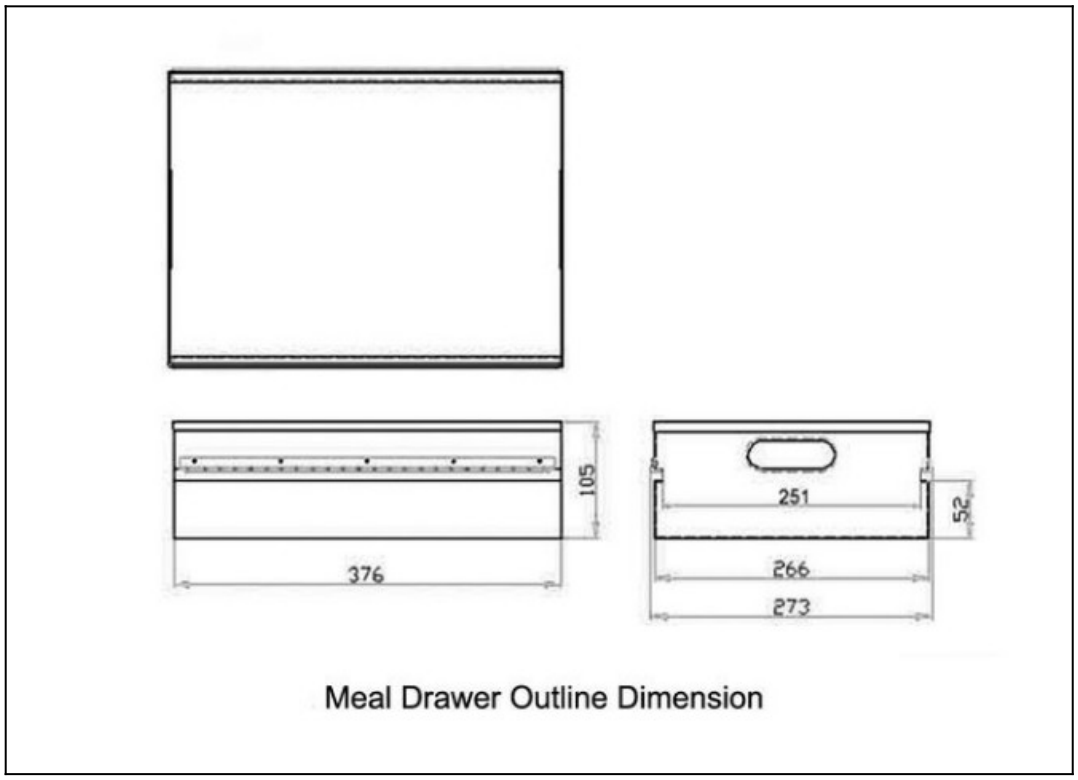

Figure 3.12: Schematic Diagram of Drawer

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3.5.2.2 Product Mechanical Mechanisms & Furnishings

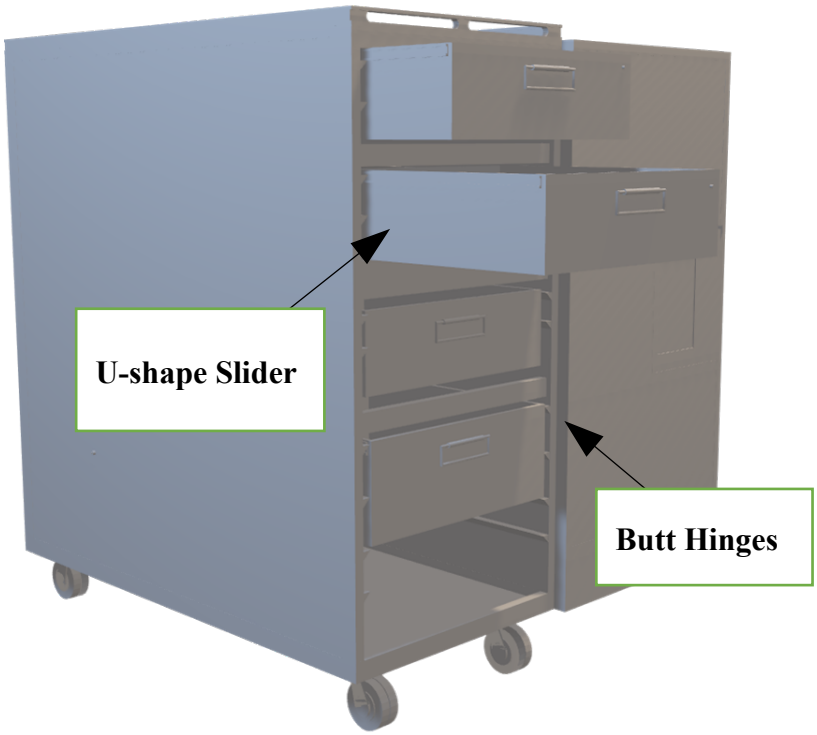

Figure 3.13: U-shape Slider and Butt Hinges

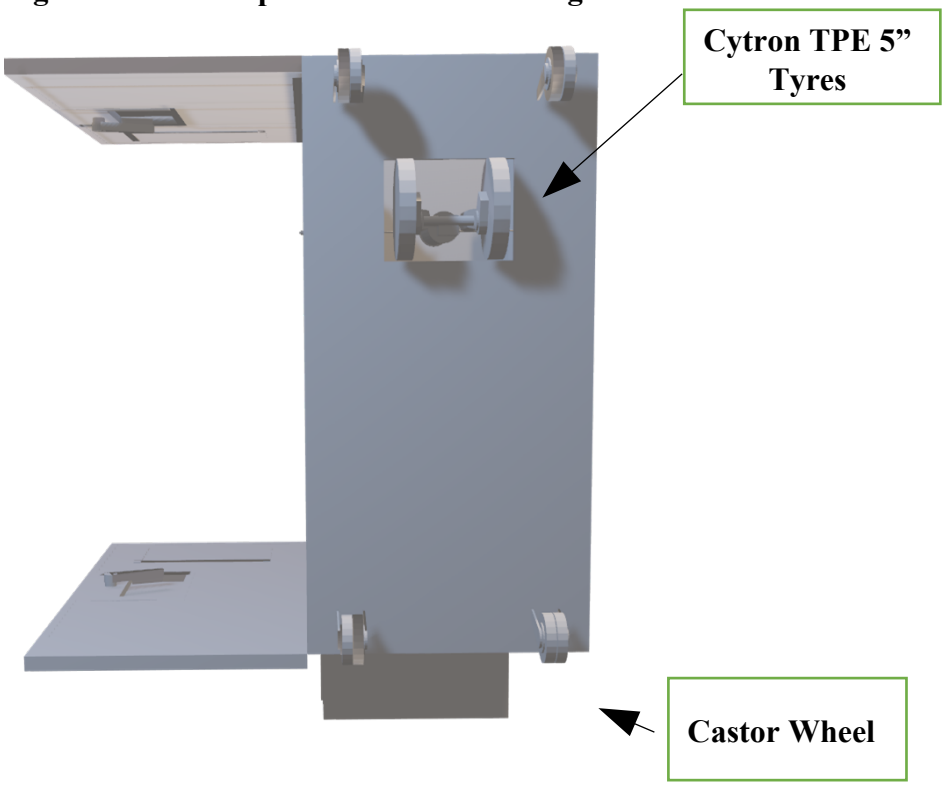

Figure 3.14: Cytron TPE 5” Tyres and Castor Wheels

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3.5.2.3 Electrical Mechanism

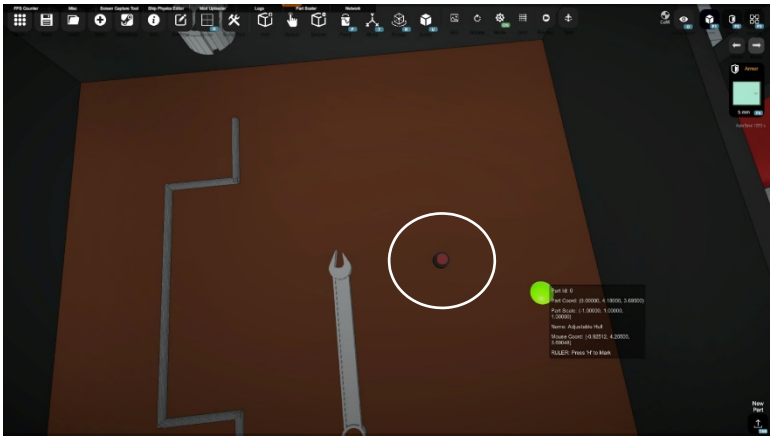

Figure 3.15: Push button sensor

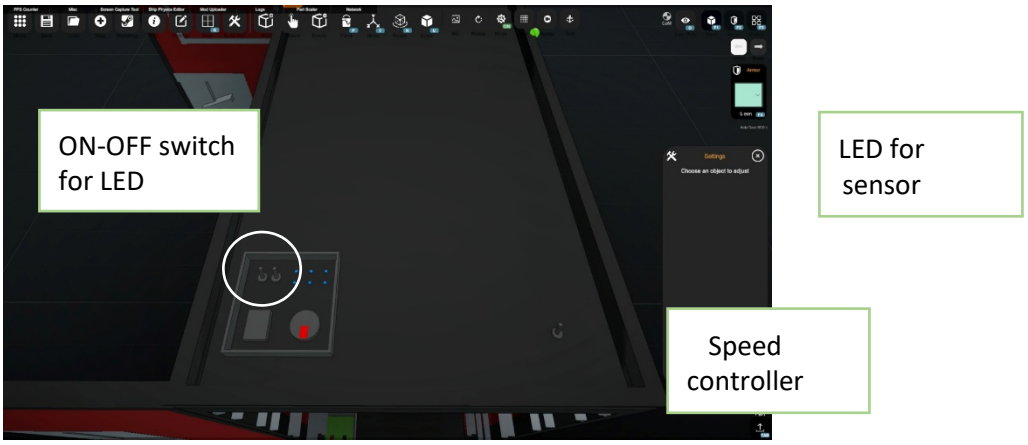

Figure 3.16: Control panel

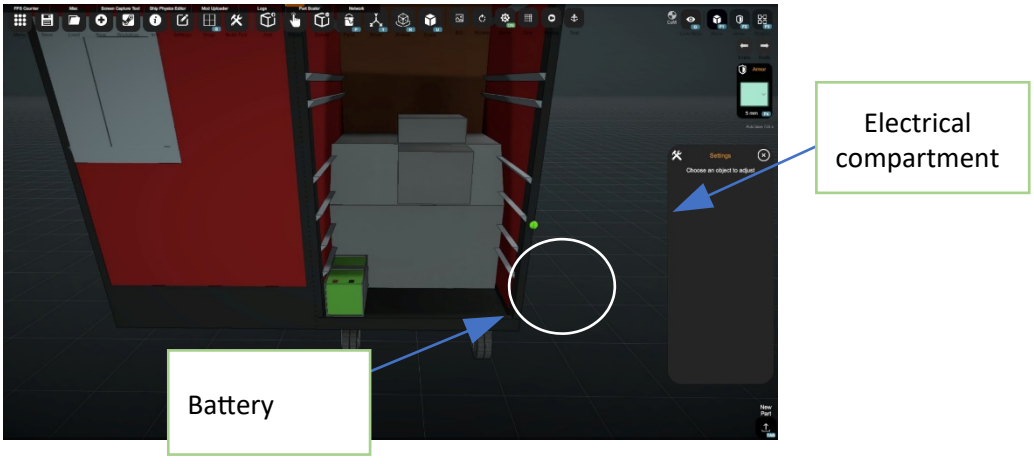

Figure 3.17: Electrical compartment & battery

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3.5.2.4 Electronic & Programming

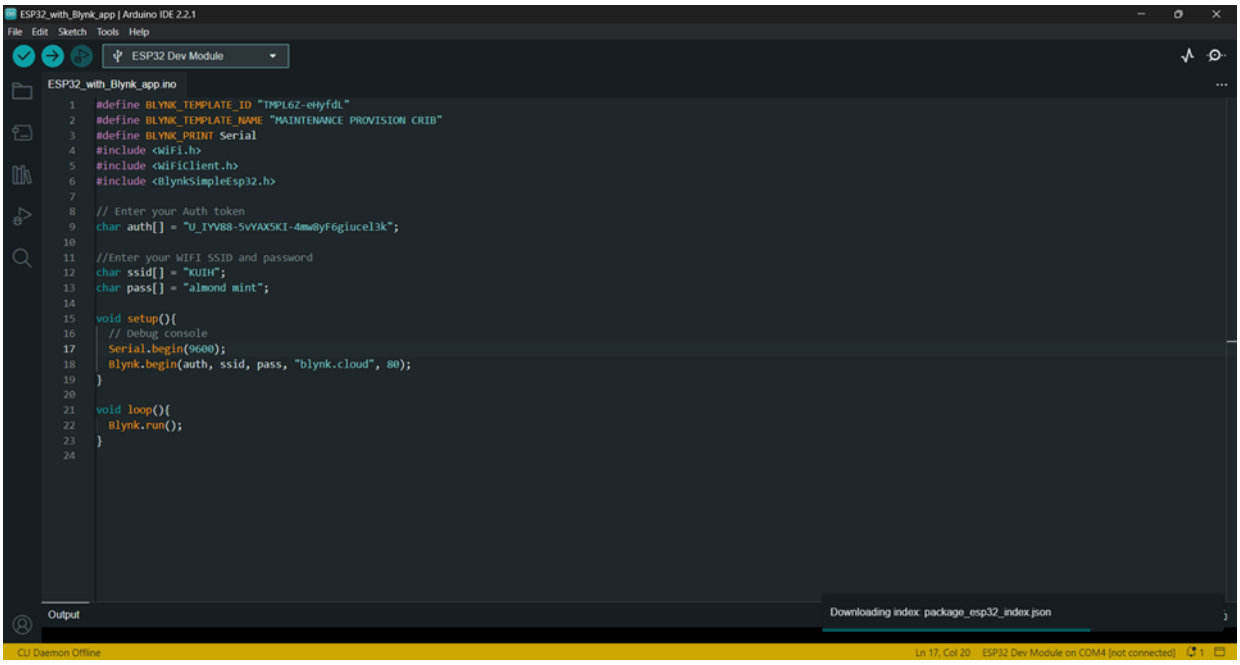

Figure 3.18: programming for Arduino ESP 32

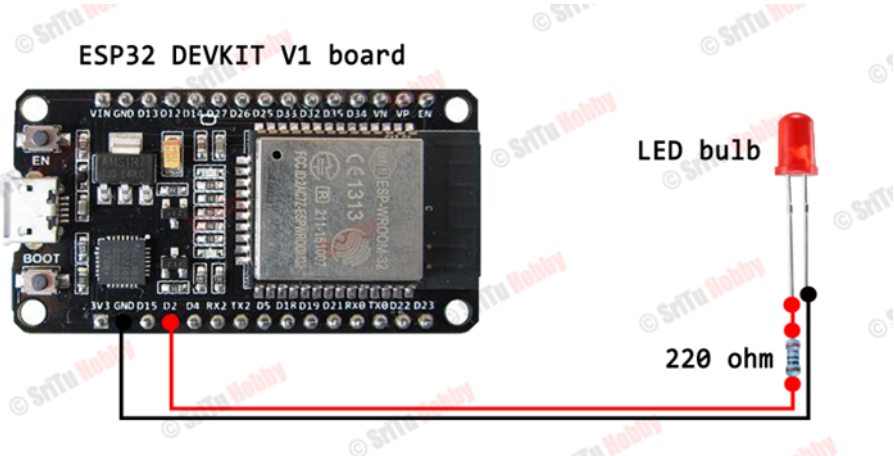

Figure 3.19: circuit for LED

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3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

No.	Materials	Description
1.	 **Power Window DC Electrical Motor**	Utilised 12V electrical power to move. Due to its high torque and the lack of requirement for the toolbox to move at high speed, it is a great motor for the Maintenance Provision Crib as it can move heavy load with ease.
2.	 **Cytron TPE 5" Tyres**	Cytron TPE rubber wheel offer a great gripping strength which allow for better control for the motor. Together with its great durability, this wheel can last for a long duration before needing a replacement
3.	 **Linear Actuator**	. Due to the motor locking in place when not in use, it is necessary to lift it up off the ground if one want to push the toolbox manually. Using the Linear actuator allow the motor to adjust it's height with push of button.
4.	 **Battery**	Battery from GPower utilised 12V with a 7.0AH current is a perfect fit for our low energy intensive MPC. With its rechargeable nature, it allow for multiple uses even after the battery are depleted.
5.	 **Push Button**	Act as a primitive weight sensor by closing the circuit when pressure was applied to the stem. The resulting electricity that pass through the button would light up the LED allowing the

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		tools user to know that there are tool missing
6.	 **Light Emitting Diode (LED)**	The LED are linked to the Push Button allowing it to light up whenever there is a tools in the cabinet. In the presence of a missing tools, the LED would shut down notifying that there is no tools within the toolbox.
7.	 **LED Strip**	LED Strip are used within the toolbox to act as a light sources to illuminate the inside of toolbox. This will facilitate the searching for tools by providing lightning in area where there is a poor lightning capability.
8.	 **Normally Closed Switch**	Used in tandem with the LED Strip, this switch only allow electricity to pass through when it is not pressed (in normal state) which allow the LED Strip to light up when the drawer was pulled out.
9.	 **Rocker Switch**	Allow the electricity polarity to be reverse and thus allow Linear Actuator to extend and retract

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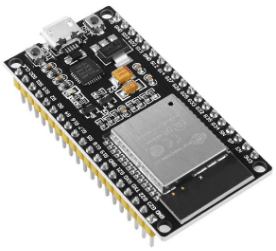
10.	 **Arduino ESP 32**	Arduino ESP32 are a special kind of Arduino board that allow the user to connect to it via Bluetooth or Wi-Fi. This allow the Arduino to be remote control, letting tools user know which drawer have their tools that they needed thus massively increase efficiency and decrease time wastage.
11.	 **Motor Speed Controller**	Allow the user to control the speed of the DC motor via adjustable resistor. The strength of the current adjusted via the strength of the resistance directly correlated to the speed of the motor.
12.	 **Reflective Tape**	To prevent from accident from happening in a low lighting level area, the outside of the MPC are lined with anti collision strip. This would greatly reflect any light away causing it to stand out more in dim area.
13.		To prevent direct collision with other items or wall, the outside of the MPC are lined with anti collision polycarbonate rubber strip.

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	Anti-Collision Strip	
14.	 **Spray Paint**	Spray Paint cover the metal and aluminium structure of the MPC from directly contacting the moisture and external element giving them a superb rust prevention and cleaner finish.
15.	 **Oil Base paint**	Oil base paint would provide better coverage and better moisture protection to prevent the wooden wall from corroding.

Table 3.8: Material Acquisition Listing

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3.7.2Machines and Tools

3.6.2.1 Machines For Mpc Fabrication

No	Machines	Description
1.	 Squaring shear	To cut sheet metal to desired size
2.	 Portable Electric Drill	To drill holes in a material, and to insert screw and other threaded fasteners into a material
3.	 Rivet Gun	To fasten two or more pieces of metal sheet together
4.	 Hand Grinder	To achieve fine finishes or light cuts on metals and other materials
5.	 soldering machine	Melts the solder to fuse two materials using heat applied through a concentrated point

Table 3.9: Machine used for MPC Fabrication

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3.6.2.2 Tools For Mpc Fabrication

No.	Tools	Description
1.	 screwdriver set	To drive or to turn screws into and out of threaded holes
2.	 steel ruler	To measure the length of an object
3.	 wire stripper	To strip the wire cover exposing the copper wire inside
4.	 pliers	To hold object firmly
5.	 saw	To cut solid object such as wood to a prescribe length or size
6.	files 	To smooth out the edge of material like material

Table 3.10: Tools for MPC Fabrication

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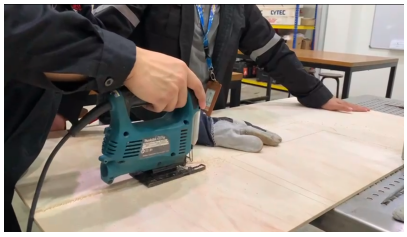
3.6.3 Specific Project Fabrication

3.6.3.1 Base structure

NO	Process	Description
1.	 Dismantling Transverse Bulkhead	As the transverse bulkhead are unnecessary and intruding on potential storage area, It is removed.
2.	 Cutting Wooden Board to be place inside the drawer	Wooden floorboard was cut according to drawer size.
3.	 Marking Place to put supporting structure for wooden flooring	Place where supporting structure for the floor board was marked, drilled and installed.
4.	 Installing the wooden floor board	Wooden floorboard were installed. The area below the wooden floorboard is where the sensory wires will be placed.
5.	 Cutting Steel Square to be use as supporting structure	Square metal beam were cut according to specific size.

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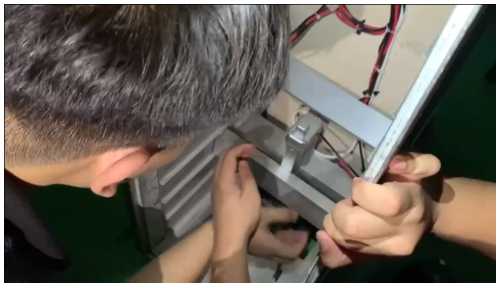
6.	 Installing Supporting Structure	Supporting beams are installed around the motors and linear actuator to increase the rigidity and prevent them from moving.

Table 3.11: Structural Process for MPC

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3.6.3.2 Electrical mechanism

	 Installing Linear Actuator and Motor	

Table 3.12: Electrical Mechanism process For MPC

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3.6.3.3 Electronic & Programming

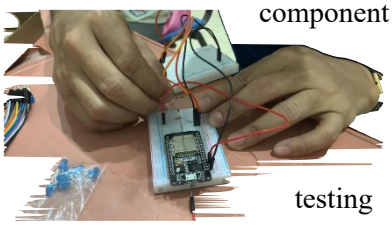
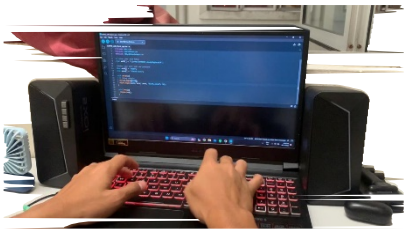
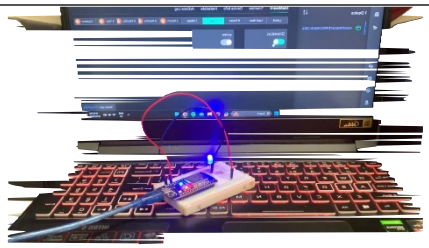
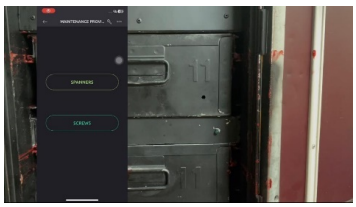
No.	Fabrication process	Description
1.	component  testing	Testing the component through circuit construction on a breadboard
2.	 programming	Writing a code for the ESP 32 by using Arduino IDE application
3.	 programming test run	Testing the programming after some trials and errors until it is working as intended
4.	 electronic implementation	Implementing the electronics onto the structure

Table 3.13: Electronic Process for MPC

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3.6.3.4 Finishing

No.	Fabrication Process	Description
1.	 Paint application on toolbox body	The toolbox body is painted with oil-based paint in the appropriate colour. Multiple layers of paint are used to improve the texture and consistency of the finish.
2.	 Paint application on the panels	The panels are spray painted to give an aesthetic look.
3.	 Taping of reflective tape at the toolbox edges	The toolbox body edges are taped with reflective tape to create awareness to the users or surrounding people.
4.	 Application of anti-collision strip at the edges of toolbox	The anti-collision strip is applied at the edges of the toolbox body to prevent collision impact.

Table 3.14: Finishing Process for MPC

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3.7 Product Testing / Functionality Tests

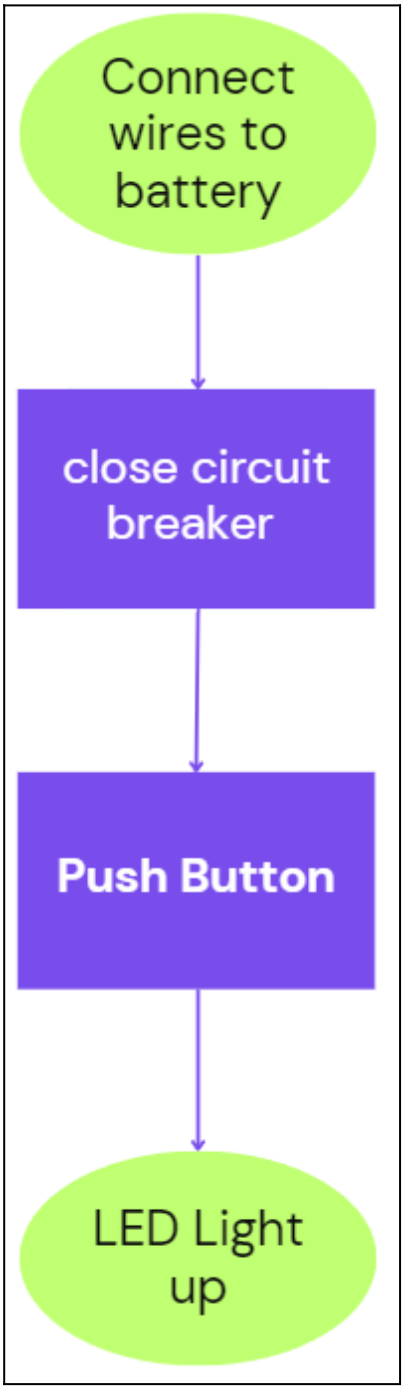

Figure 3.20: Functionality Test for Sensor

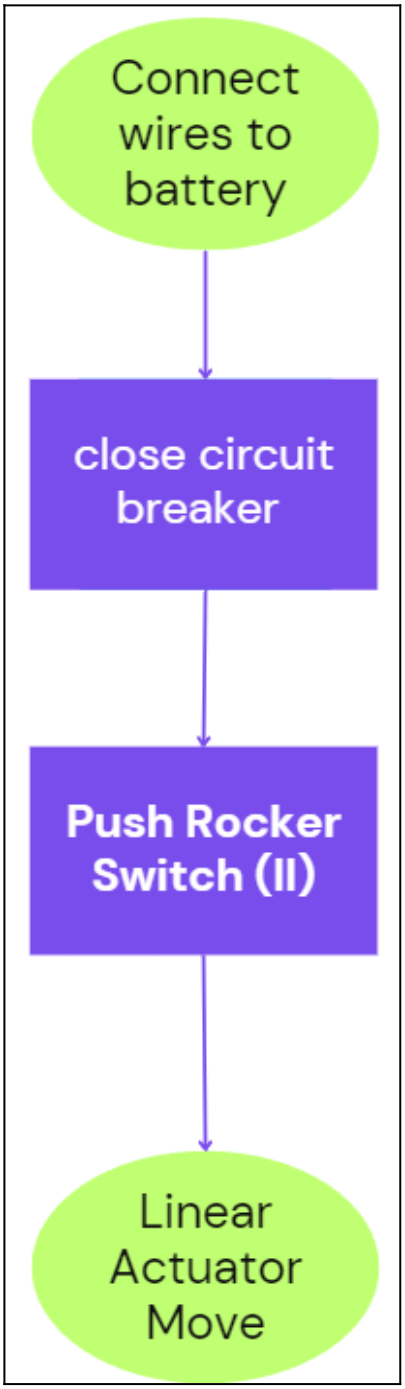

Figure 3.21: Functionality Test for Linear actuator

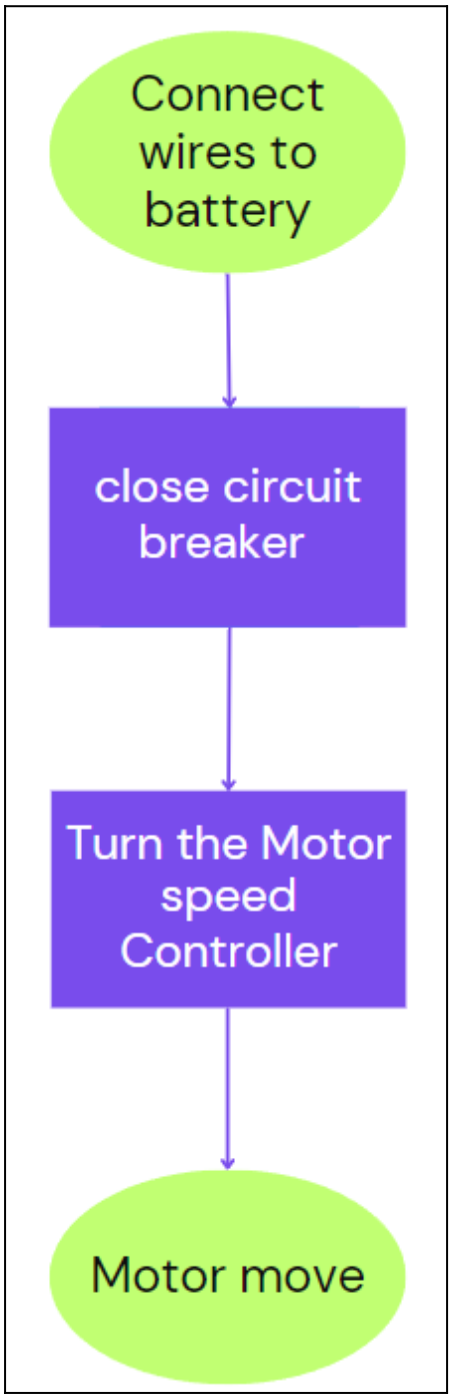

Figure 3.22: Functionality Test for Motor

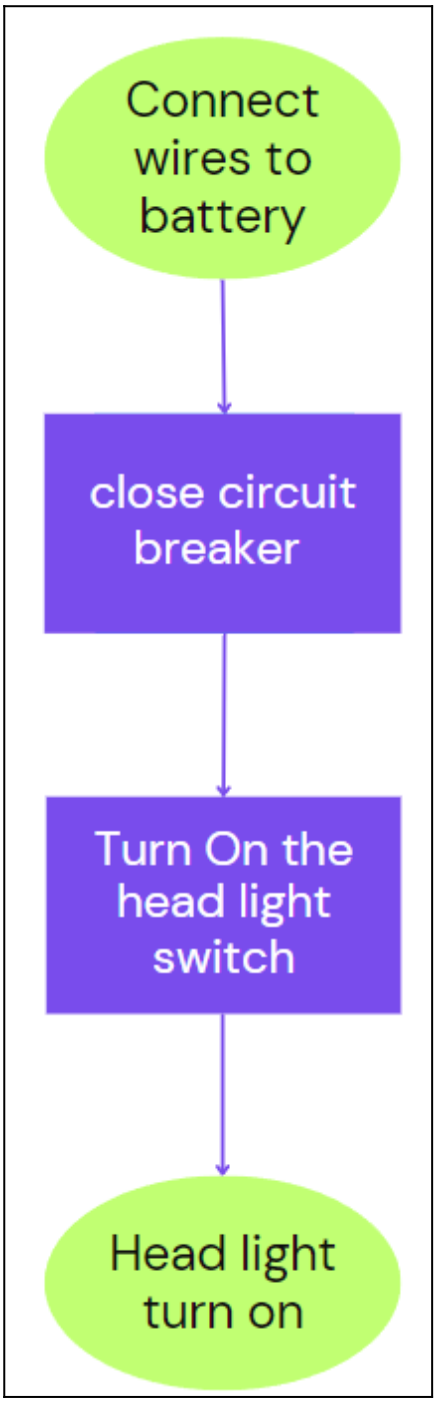

Figure 3.23: Functionality Test for Head Light

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3.9 LIST OF MATERIALS AND EXPENDITURES

Product structure				
NO.	**Item Details**	**Unit**	**Price/Unit**	**Total(RM)**
1	door latch L 006-L	1	5.90	5.90
2	hot glue stick 1.1 x 20cm 10pcs	1	8.50	8.50
3	L bracket	10	0.60	6.00
4	plywood 9mm x 2' x 4'	2	20.00	40.00
5	aluminium rect hollow 1'' x 2'' (m)	3	16.50	49.50
6	Clear epoxy 4 mins 2x17 ml	1	6.90	6.90
7	sunlife steel bands 12mm	1	7.40	7.40
8	PVC-LINK weatherproof protective cover	1	8.50	8.50
9	WIREMAN weatherproof enclosure box	2	8.00	16.00
10	(AGS1) Hot glue gun stick	1	6.00	6.00
Product machanism				
1	10pcs 3/16'' (M5) flat washer	1	0.60	0.60
2	1/4'/ flat washer	1	0.50	0.50
3	dry wall screw 6 x 3/4'' (pkt)	3	0.70	2.10
4	dry wall screw 6 x 1'' (pkt)	3	0.80	2.40
5	ACE galvaniseo roofing bolt&nut 1/4''x1/2''	10	0.20	2.00
6	ACE galvaniseo roofing bolt&nut 1/4''x3/4''	10	0.30	3.00
7	ACE galvaniseo roofing bolt&nut 1/4''x4''	6	0.80	4.80
8	ACE galvaniseo roofing bolt&nut 3/16''x3/4''	4	0.20	0.80
9	Washer	20	0.30	20.00
10	m3 screw 6mm/10mm	20	0.10	2.00

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electrical mechanism				
1	**1.5mm single cable- red (m)**	**13**	**0.90**	**11.70**
2	**1.5mm single cable- black (m)**	**8**	**0.90**	**7.20**
3	**2.5mm single cable-red (m)**	**10**	**1.50**	**15.00**
4	**2.5mm single cable-black (m)**	**10**	**1.50**	**15.00**
5	**4mm single cable- black (m)**	**3**	**2.00**	**6.00**
6	**4mm single cable- red (m)**	**3**	**2.00**	**6.00**
7	**10m 23/0.15x2 coil fajar pin cable**	**2**	**10.00**	**20.00**
8	**1m 23/014 B/W flat wire**	**15**	**0.80**	**12.00**
9	**twin cable R/B-m**	**4**	**2.50**	**10.00**
10	**1m 7/0.2m single core multi standard wire red**	**2**	**1.00**	**1.00**
11	**1m 7/0.2m single core multi standard wire black**	**2**	**1.00**	**1.00**
12	**5A/6A connector-pc**	**4**	**1.00**	**4.00**
13	**10A connector ops-pc**	**1**	**1.50**	**1.50**
14	**15A connector-pc**	**1**	**2.40**	**2.40**
15	**connector 20A**	**2**	**3.00**	**6.00**
16	**110m/f connector**	**4**	**2.40**	**9.40**
17	**KNX-1 toggle switch**	**3**	**1.50**	**4.50**
18	**KNX3-1 2P on off switch**	**4**	**2.50**	**10.00**
19	**2 pin on off black rocket switch**	**1**	**3.00**	**3.00**
20	**3way toggle switch**	**3**	**1.50**	**4.50**
21	**Switch on off (HS)**	**5**	**2.00**	**10.00**
22	**refrigerator light suis**	**8**	**3.30**	**26.40**
23	**INDIA 60A 8 way terminal link**	**2**	**5.00**	**10.00**
24	**wire tape**	**6**	**0.80**	**4.80**
25	**heat shrink tube**	**2**	**1.50**	**3.00**

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26	**10pcs 2.4 blue insulated ring**	**3**	**1.60**	**4.80**
27	**wire clip**	**18**	**0.40**	**7.20**
28	**fork insulated terminal wire crimp**	**2**	**1.00**	**2.00**
29	**USB RGB LED 5V 3m**	**1**	**23.90**	**23.90**
30	**LED strip 12v**	**1**	**30.00**	**30.00**
31	**12v DC pilot indicator lamp**	**2**	**1.90**	**3.80**
32	**7v-30v step down high ampere voltage regulator 5v**	**1**	**9.90**	**9.90**
33	**12v-40v 10A DC motor speed controller**	**1**	**14.90**	**14.90**
34	**5v LCH Relay**	**1**	**3.50**	**3.50**
35	**solenoid JF-0837B**	**1**	**25.00**	**25.00**
36	**GP Back Up battery 12V 7AH battery**	**1**	**29.00**	**29.00**
37	**12v 7.2AH alarm GP battery**	**1**	**55.00**	**55.00**
38	**5pcs 10A 2mm glass fuse**	**1**	**2.00**	**2.00**
39	**crocodile clip set**	**1**	**7.50**	**7.50**
Electronic and programming				
1	**LED diode**	**10**	**1.00**	**10.00**
2	**solderless beadboard**	**1**	**3.90**	**3.90**
3	**Arduino 40p breadboard dupont jumper wire male to male**	**1**	**3.70**	**3.70**
4	**Arduino 40p breadboard dupont jumper wire female to male**	**1**	**3.70**	**3.70**
5	**resistor 0.25w 5% (220R) 10pcs**	**1**	**1.00**	**1.00**
6	**10pcs LED 3mm 5mm Light**	**1**	**1.20**	**1.20**
7	**NodeMCU V2/Lolin V3/Arduino ESP-32**	**1**	**32.90**	**34.67**
8	**IC 7404**	**2**	**1.50**	**3.00**
9	**IC 7408**	**2**	**1.50**	**3.00**

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10	**IC 7432**	**2**	**1.50**	**3.00**
11	**LM 2596 step down 3A**	**1**	**6.50**	**6.50**
12	**PCB board**	**1**	**2.50**	**2.50**
13	**Everyday 6A battery**	**1**	**17.60**	**17.60**
14	**3xAA battery holder**	**1**	**3.50**	**3.50**
15	**crocodile clip**	**4**	**2.00**	**8.00**
Accessories and furnishing				
1	**145mm M10 low volt tester**	**1**	**5.50**	**5.50**
2	**soldering iron 60w**	**1**	**15.50**	**15.50**
3	**Spray paint red**	**3**	**6.50**	**19.50**
4	**Spray paint silver**	**1**	**6.50**	**6.50**
5	**Spray paint black**	**4**	**6.50**	**26.00**
6	**polycarbonate rubber-feet**	**51**	**0.60**	**15.60**
7	**16mmx1.17mm trans hose-m**	**1**	**1.80**	**1.80**
8	**High quality big sponge**	**1**	**6.00**	**12.00**
9	**16'' roller handle**	**1**	**3.00**	**3.00**
10	**4'' nippon roller refill**	**1**	**2.00**	**2.00**
11	**melux 77 gloss ML 6613 Red**	**2**	**20.00**	**40.00**
12	**nylon paint brush**	**1**	**2.50**	**2.50**
13	**0.5kg grease**	**1**	**10.00**	**10.00**
14	**101 pure minyak tanah**	**1**	**4.50**	**4.50**
15	**10pcs 3M glue self adhesive wire clip**	**1**	**12.00**	**12.00**
16	**double colour reflective tape 300cm x 5cm**	**4**	**3.64**	**9.56**
17	**8'' OK-IN cable tie-10pc**	**1**	**0.70**	**0.70**
18	**4'' OK-IN cable tie-1H**	**1**	**1.50**	**1.50**
	Total		**RM**	**909.2**

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Table 3.15: List of expenditure

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CHAPTER 4

RESULT AND DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

This Maintenance Provision Crib contains various innovative functions to improve tool management and accessibility. The toolbox body is made of recycled aviation galley carts, which not only encourages sustainability but also assures a strong and long-lasting construction. The integration of a mobile app, particularly the Blynk app, enables users to communicate with the toolbox in real-time. Users can utilise the app to efficiently locate tools within the toolbox using LED lights, resulting in a more organised and efficient workstation. A linear actuator DC motor allows the toolbox to move forward autonomously, while manual manoeuvring allows for lateral movement, giving users full control over the toolbox's direction. QR codes are used to enable secure tool usage by allowing users to authorise access to certain tools. This feature enhances the tool management system's security and accountability. A push button on the toolbox also controls the LED lights, which act as a visual indicator of tool placement. The lights are engaged or deactivated depending on the weight of the tools, making it easier to determine whether items have been properly stored in the toolbox. Overall, the Maintenance Provision Crib provides a full solution for efficient tool management by integrating sustainability, technology, and user-friendly features to improve workflow in maintenance and repair conditions.

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4.1.2 Specific Part Features

4.1.2.1 Product Design & Structure

The MPC repurposes the aircraft galley cart as its primary body. The aircraft galley cart structure is an excellent basis, due to its durability and modularity. The galley cart is usually made of Aluminium, which provide a strong and lightweight foundation for the toolbox. The drawers and compartments that were initially intended to store in-flight meal service items have been modified to accommodate various tools and equipment. The proportions and arrangement of the galley cart provide an organised and effective storage option for tools, improving accessibility for maintenance operations.

Component	Material Used	Purpose or Function
Frame Structure	Aluminium, Stainless Steel	➢ Offers structural support and integrity. ➢ Prevents rusting caused by the environment (e.g., saltwater).
Drawers	Aluminium	➢ Store tools, equipment, and materials.
Security Features	Locks and Latches	➢ Ensure the safety and security of stored items.
Lighting	LED Lights	➢ Provide sufficient illumination for tasks. ➢ Illuminates to show the tools availability.

Table 4.1: Product structural

Further modifications were made in order to strengthen the load bearing capacity of the galley cart. Supporting structures, pillars and wall were added to facilitate the implementation of the new electrical motors and linear actuators, sensory suite, circuit breaker, transformer, etc.

With the newly reinforced body, the galley cart was successfully reborn as the Maintenance Provision Crib. The strengthen body can now support the heavy equipment and tools with ease and still perform as a great tools carrier. While the outside of the galley cart remains the same, the modification make the galley cart much more rigid and stronger compare to before.

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4.1.2.2 Mechanical Mechanism & Furnishings

The Maintenance Provision Crib combines specific mechanical mechanisms and furnishings to improve functionality and user experience. Butt hinges are used for the doors, ensuring a long-lasting and dependable pivot point for smooth opening and shutting. The U-shape slider drawers function as the expansion/retraction mechanism, allowing for convenient and organised tool storage. The Cytron TPE 5" Tyres and Castor Wheels address mobility by providing a blend of stability and manoeuvrability.

The use of oil-based paint and spray paint for finishing not only improves the appearance of the toolbox but also increases its durability, preserving it from wear and tear in a variety of environmental situations. As a safety element, anti-collision strips and reflective tape are strategically attached to the toolbox body. The anti-collision strips operate as a protective barrier, lowering the danger of impact damage, while the reflective tape improves visibility, especially in low-light settings. Hence, these characteristics work together to improve the overall effectiveness of the Maintenance Provision Crib by assuring a strong, safe, and user-friendly smart toolbox for efficient tool storage and access.

Figure 4.1: Finishings

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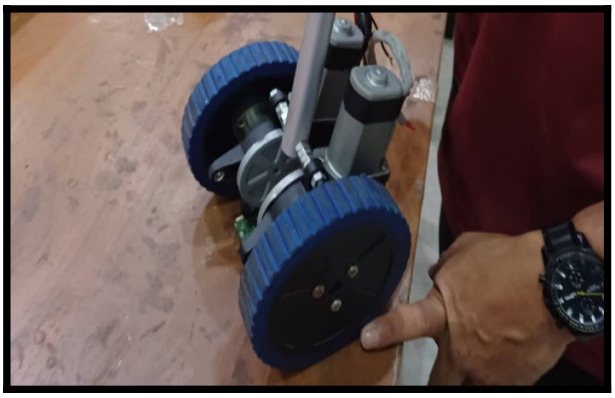

Figure 4.2: Cytron TPE 5” Tyres

4.1.2.3 Electrical Mechanism

The Maintenance Provision Crib are equipped with the capability to sense tools within the drawer by means of pressure sensor. Together with the LED located at the top of the MPC, MPC can communicate to the user whether there is a missing tool or not quite effectively.

Moving to other points, with the two DC motors and two linear actuators, the MPC are able to travel semi-autonomously. Propel by the motor, the MPC can travel in a straight line for a fair amount of time at a slightly slower than walking speed., It can be guided only by slight nudge.

Finally, it’s interior are fully lighted with LED strip that light up when the drawer are pulled. Two LED at forward and aft of the MPC can be light up to illuminate the surroundings or act as a beacon.

4.1.2.4 Electronic and Programming Mechanism

The Maintenance Provision Crib are made up of a number of electronics and added with a touch of IoT components that are crucial to make the process of Maintenance Provision Crib smooth and easier.

By using Blynk app we can receive data, send data and give commands through the Blynk cloud. For that, we need to create a dashboard using our smartphone, tablet, or computer. Once done with the app we link the app using ESP 32 board which it is capable to transfer data using wi-fi, and for that we need to write a code in Arduino to run the ESP32.

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Then, In the Maintenance Provision Crib we added two dc motor combined with a linear actuator to move the crib around effortlessly. The movements are controlled by using a 10A PWM DC Motor speed controller to control the speed of the motor and a momentary switch to control the height of the linear actuator. For the tools detection we used momentary push button connected with a LED**.**

4.1.3 General Operation of the Product

The general operation of MPC is when the QR code scanning (e-logbook) is done for users' authentication, the power supply will be turned on. The MPC will move in the forward direction, manual manoeuvring, on the other hand, allows for lateral adjustments for accurate positioning. Next, the mobile app Blynk will allow the users to track and identify tools within the MPC by indicating the LED lights on each drawer. Additionally, the push buttons on the MPC will indicate the tool placement using LED lights. The lights are turned on or off based on the weight of the tools.

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4.1.4 Operation of the Specific Part of the Product

4.1.4.1 Product Structure & Design

The Maintenance Provision Crib utilised a very robust galley cart that can singlehandedly hold tons of weight while having a small form factor and a considerably light weight. This, together with its high storage capacity, allow for a significant amount of redesigning that allow it to be self-propelled and become what known as the Maintenance Provision Crib.

4.1.4.2 Mechanical Mechanism & Furnishings

The MPC operates to provide a smooth and user-friendly operation. Butt hinges for the doors enable strong and smooth opening and shutting, allowing simple access to the tool storage compartments. The U-shape slider drawers function as an efficient expansion and retraction mechanism, allowing for more organised tool storage. The Cytron TPE 5" Tyres and Castor Wheels address mobility by allowing for stable movement with the option of manual manoeuvring and automated forward motion. The dual finishing with oil-based paint and spray paint not only improves the appearance but also adds longevity by protecting the toolbox from the weather. Anti-collision strips and reflective tape, for example, give an extra layer of protection by reducing the danger of impact-related damage and enhancing visibility, especially in low-light settings.

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4.1.4.3 Electrical Mechanism

The Maintenance Provision Crib are equipped with arrays of electrical mechanism. Its greatest feat are its self-propel capability via the twin DC Motor that allow it to travel at 2km/h even on rough terrain and on a gentle slope. The linear actuator that are mated together with the motors allow for a seamless transition from a semi-auto to a fully manual control at a touch of a button.

The arrays of weight sensors located within the heart of the toolbox are also what make the MPC a prominent contender for the future of toolbox development. Calibrated to sense weight on it, the MPC can identify missing tools and notify the user of its missing tools. Together with the E-logbook, the administration steps needed for borrowing and lending of the toolbox and tools are reduced significantly, allowing for greater efficiency, cut down on administration time and lower the usage of paper in the aim for a greener future.

Last but not the least, LED strips finalised the concept of MPC illustrious future. The interior are lined with LED strips that provide a bright viewing experience in otherwise dark environment. This lowers the risk of injuries and significantly speed up the tools locating steps as user can see the entirety of the toolbox.

Finally, building upon the aforementioned point, two strips of LED decorate each end of the MPC. With a flick of switch, this LED strip become a headlight that will act as a alerting factor to surrounding personnel and as a guide for the user to see.

4.1.4.4 Electronic & Programming

Maintenance Provision Crib have 3 main functions for electronics and programming. For tool detection, a push button was placed under the tool compartment to detect and trigger the LED to light up notify the user if the tools are present or absent. Next, motor is connected to a linear actuator making it possible to push it fully manually or even semi-auto. The movements can be controlled using a momentary switch and a speed controller switch. Lastly, Blynk app and ESP 32 board made it possible to locate certain tools by using a phone where the phone and the board are linked by using a wi-fi. The function of the ESP 32 board is to receive command and execute the command that has been program to the board.

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4.2 Product Output Analysis

NO.	Parameter	Result	Remark	Analysis
1.0	General Parameter			
1.1	Maximum Loading Capacity (KG)	78KG	While the MPC can handle 78KG, it is not adviceable for a prolonged use under maximum load.	-
2.0	Speed Limit			
2.1	Speed Limit (Unloaded)	3.6 KM/H	Speed Limit was calculated at the top speed the MPC can travel within a straight line in controlled flat track.	Speed massively drop by 61.1% in full load compare to unloaded.
2.2	Speed Limit (partially Loaded)	2.2 KM/H		
2.3	Speed Limit (Fully Loaded)	1.4 KM/H		
3.0	Times Of Operation			
3.1	Time of Operation (Unloaded)	1000 Hours	Time of Hours are calculated from fully charge battery (12V 7.0AH)	Duration decrease non-linearly with each usage. Possible degradation of battery was not taken into account but may be a factor in the calculation.
3.2	Time of Operation (partially Loaded)	900 Hours		
3.3	Time of Operation (Fully Loaded)	790 Hours		
3.4	Time of Operation (Head light turned on)	500 Houra		

Table 4.2: Project Output Analysis

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4.3 PROJECT IMPACTS / PURPOSE OF PRODUCT

The purpose of MPC is to provide a solution to the issues of tool organisation and tracking in maintenance areas. This project supports environmental sustainability by repurposing discarded materials, such as an aeroplane galley cart, as the toolbox body. The integration of the Blynk mobile app and LED lights addresses the issue of tool location within the toolbox, improving efficiency in tool access. The linear actuator DC motor provides for forward movement, while manual manoeuvring allows for lateral adjustments, ensuring appropriate toolbox positioning and reducing the manpower. The integration of push buttons to regulate the LED lights based on tool weight offers a visible indication of tool placement, assisting in quick visual inspections. Furthermore, the use of QR codes as an e-logbook for user authorization offers an additional degree of protection and accountability, allowing only authorised individuals to use specified tools and hence minimising the loss of tools.

In the context of impacts, this project helps to sustainability efforts by encouraging material reuse and keeping to eco-friendly practises. The use of smart features, made possible by the Blynk app and QR code authentication, improves overall tool management efficiency while minimising downtime in maintenance operations. The motorised and manual movements allow for flexibility to various working environments, boosting the toolbox's versatility. The ability to track tools in real-time and provide visible indications via LED lights not only improves organisation but also contributes to a safer and more optimised working atmosphere. As a whole, the Maintenance Provision Crib desires to revolutionise standard toolbox operations by providing maintenance personnel with a smart, sustainable, and efficient alternative.

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4.4 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.4.1 Product Structure & Design

Initial problem encountered while modifying the toolbox was the outrageously strong transverse bulkhead that separate the top and bottom part of the galley cart in two. With no fasteners holding it up, we were stumped on how to dismantle it but with time, it slowly give away.

Next, come to separating the toolbox into two parts. One hosting the electrical and electronic components, the other would be the storage zone. The problem here was taht the metal sheet was too thin to have a rigidity to hold its own shape so we could not build a wall with it. We soon attach a thick wood in the middle and sandwich it with said sheet of metal.

The final point would be the supporting structure of the linear actuator. As the actuator needed to push the MPC up slightly, it si important for the supporting structure to be strong and rigid, yet at the same time, no standard fastener can be used too frequently as it will make the outside appearance of the MPC worse. Instead, we glued it together and insert a small metal piece that lodge itself into the gap of the outside wooden wall and the metal surface within the toolbox.

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4.4.2 Mechanical Mechanism & Furnishings

The mechanical mechanism and furnishings' objectives were met with success. The linear actuator DC motor works properly, and the body of the toolbox is painted to look nice, and the edges are covered with safety tape to raise awareness. However, significant issues showed up during the development of the Maintenance Provision Crib.

Problems Encountered	Solutions
Problems with Hinge Alignment	Precise calibration and adjustment mechanisms were implemented to maintain proper alignment, allowing for the doors to open and close smoothly.
Slider Drawer Jamming	The use of grease for lubrication fixed the problem, allowing for consistent and smooth drawer operation.
Paint Durability Issues	Experimented with various paints and application methods. For long-lasting aesthetics, we chose strong paint and assured diligent cleaning of the surface.
Durability of the Anti-Collision Strip	The use of an improved material of the anti-collision strips, such as rubberized compounds, offered efficient protection against collisions and extended the lifespan of the strips.

Table 4.3 List of Problems Encountered & Solutions

`

4.4.3 Electrical Mechanism

The challenges faced while assembling the electrical mechanism is the installation of the motor. The motor cannot fix onto the supporting structure, and it will detach when it run. This problem is solved by tie and fix the motor using the steel band and add bolt to support two of the motor.

Besides, the second problem is the sensor for detect the missing tools. The LED bulb that connects the sensor didn't light up after place the tools. This problem has been checked and rectified and this cause by the LED burn out due to the high ampere and voltage. This problem solved by replace a higher voltage LED bulb and lower the voltage flow.

Lastly, the problem uncounted is the speed controller cannot install on the surface of the tool crib. Finally, this problem solved by detach the speed controller and resolder after install onto the control surface of the tool crib.

4.4.4 Electronic & Programming

The challenges faced while assembling the electronics and programming primarily arise during the programming phase.

In the initial coding attempt, the board were not detected by the Arduino IDE application. Upon investigation, it was discovered that the issue was from the improper installation of the libraries for these components. Once this was rectified, the problem was successfully resolved.

The second problem was to connect two LED to the ESP32 board. Once we've successfully uploaded the code into the ESP32 board we test the functionality by using only one LED and once we've done that we tried to connect another LED to the board but the Led didn't light up. After couples of trials and error, we tried to sketch a new wiring diagram and follow it with in details and remake the data stream from the Blynk app.

`

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM AND OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

The notable achievement of the project is its environmental impact, which contributes to sustainability by recycling materials. The incorporation of smart technology, such as the Blynk app and LED lighting, improves operational efficiency by assisting users in quickly locating tools within the toolbox. The combination of a linear actuator DC motor and manual manoeuvring provides a versatile and user-friendly mobility solution, allowing the toolbox to be readily positioned as needed. The use of QR codes for tool authorisation improves security by guaranteeing that only authorised users have access to certain tools.

`

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure & Design

With increase structural support, new coating and enhance mobility system, the grand objective of laying down the foundation for mechanism implementation has completed with a great success. The chassis can now support the various mechanical and electrical function as well as a smoother travelling experience. This accomplishment, while minor in a grand scale of all thing, allow for smoother and more complete technology implementation into the chassis.

5.1.2.2 Mechanical Mechanisms & Furnishings

The Maintenance Provision Crib, a Smart Toolbox, has made significant achievements towards meeting its design goals. The combination of Cytron TPE 5" Tyres and a motor controller for automatic forward movement, as well as a switch-controlled lifting mechanism for manual mobility utilising castor wheels, has resulted in a versatile and efficient mechanical system. The toolbox's doors include a strong butt hinge system that ensures smooth and long-lasting operation, and the U-shape slider drawer mechanism allows for organised tool storage with seamless extension and retraction. The addition of safety measures such as reflective tape and anti-collision strips not only improves the toolbox's visual appeal but also emphasises the company's dedication to user safety. The use of protective oil-based and spray paint finishes adds to the toolbox's durability and resilience. Overall, the Maintenance Provision Crib accomplished its goals by offering a durable, safe, and aesthetically beautiful smart toolbox for efficient maintenance provision.

5.1.2.3 Electrical Mechanisms

The Maintenance Provision Crib provide a safety for the tools to prevent lost. The detect sensor in the toolbox will detect the missing tools and give alert to the user. Besides, the DC motor that drive the tool crib reduce energy for user and the design of this product provide two ways that manual or semi-auto to move the tool crib to the working area. In addition, the LED light on the tool crib provide a good vision for the user during night or in a dark area and it also function as an alert during night. Lastly, the speed controller aids to control the speed of the tool crib move so that it can be the suitable moving speed for the user to control it.

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5.1.2.4 Electronic & Programming

Throughout the construction of the electronics and compiling the codes for the Maintenance Provision Crib the objective to Implementation of semi-Autonomous Mobility has been successfully implemented a motorized system that allow the maintenance provision crib to move by using a motor while the directions are manually controlled by the user, enhancing the accessibility and efficiency in tool storage. We also has been successful integrating a push button switch that can trigger and identify the presence or absence of tools in real-time, ensuring the risk of the tools misplaced to be minimized and kept organized. Lastly, by using BlynkApp and ESP 32 board it has been a big help to provide users with a smartphone tool finding interface that enable users to locate specific tools efficiently.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The contribution or impact of this project is to provide an eco-friendly solution by reusing the aircraft galley cart. Next, it improves operating efficiency with the use of technological advancement such as Blynk app to identify the location of the tools within the MPC. Other than that, it also develops a secure and intelligent tool management system via QR code scanning (e-logbook) user authorisation. In addition, the MPC boosts the toolbox's functionality by adding a dynamic and adaptive dimension with the aid of linear actuator DC motor. In summary, this project makes a significant contribution to the field of maintenance and tool supply.

`

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure & Design

While the Maintenance Provision Crib have been a resounding success, it is important for continued progression to be made in order for the product to stay relevent and following the latest technological advancement.

Following list are the recommended improvement and suggestion for further models:

1. **Structural Enhancement:** While the current chassis and structural modification allow for a great Weight-to-Strength ratio, further structural enhancement are required if more powerful and heavier motors are to be installed.
2. **Lightening body:** Current weight of the galley cart remain to be excessive and will eat up the displacement for carrying capacity. By using lighter materials, more loads can be put on the MPC safely as well as increasing the speed of the MPC.
3. **Suspension system instalment:** Current mobility structure are bare and all the vibration are soaked up by the main structure itself. Implementing suspension system allow for increase durability and lower noise during travel.

`

5.3.2 Mechanical Mechanism & Furnishings

We hope that with continued effort and commitment in the future. This project has the potential to be upgraded or improved into a superior product. Here are some potential enhancements and future research directions for the Maintenance Provision Crib (Smart toolbox) project:

Improvements:

- **Improved Mobility:** Consider including a more modern mobility system that enables for 360° movement, which will make manoeuvring the toolbox in tight places or around obstacles easier.
- **Functional design:** Incorporate ergonomic concepts to ensure that the toolbox is intended for ease of maintenance, such as giving proper clearance for maintenance personnel, suitable room for tools, and taking the technician's position into account during repairs.
- **Safety Features:** Consider incorporating extra safety features beyond the safety tape, such as proximity sensors, emergency stop mechanisms, or collision avoidance systems, to improve the toolbox's overall safety.

Suggestions for Future Research:

- **Smart Toolbox Automation:** Look into the possibility of automating the toolbox's mobility, such as including sensors for obstacle detection and autonomous navigation to boost efficiency and eliminate the need for manual manoeuvring.
- **Human Factors in Maintenance:** Analyse the impact of human factors and ergonomics on maintenance jobs in order to improve the design of the toolbox for ease of use and efficiency.
- **Materials and Finishes:** Investigate the use of sophisticated materials and finishes to improve the toolbox's longevity, corrosion resistance, and overall attractiveness.

`

5.3.3 Electrical Mechanism

We hope that the Maintenance Provision Crib can be widely use in all industries. This project has potential to be upgrade into more advance function and provide convenient to user and increase the working efficiency for the workers.

Improvement:

- **Add DC motor:** Install more DC motor to provide a greater force and movement for the Maintenance Provision Crib. It will also provide a greater force during carrying the tools and carry more load.
- **Upgrade sensor**: Use more advance sensor such as photo sensor. It can provide the more accuracy to detect the missing tools and can prevent the tool stole by placing weight object on the sensor.
- **Add solenoid lock**: Solenoid lock in the too crib can prevent the unapproved personal to use the tool crib. This can also prevent user didn't register by scanning the QR code on the tool crib.

Suggestion for future research:

- **Detect sensor**: Investigate more suitable sensor that can install in the tool crib that save space, more accurate and more efficiency.
- **New motor:** searching for new motor that power saving, high torque, and high efficiency to provide a greater movement and carry more load in the tool crib.
- **Upgrade alerting system**: research for the more advance alert system such as alert by phone to replace the LED and provide more accurate information for the missing tools.

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5.3.4 Electronic & Programming

For future research regarding the electronics and programming of the Maintenance Provision crib, we would like to improve on the mobility of the tool crib by making it able to move using a remote, with this ability, the user can effortlessly control the tool crib from afar.

Furthermore, it would be more desirable to be able to create a standalone application specifically catered to be used with the Maintenance Provision Crib instead of using BlynkApp as the main app to find the tools.

Lastly, instead of having to scan the QR code to register the user before using the crib, it would be great to use an NFC (near-field communication) card that can automatically register the user in the system by a single touch.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
MUHAMMAD HAIKAL BIN SHAH KAMARUZZAMAN	
1.3.1.2	Specific Individual Project Objective: Product Structure and Design
1.4.2.1	Specific Individual Project Scope: Product Structure and Design
2.2.1	Specific Individual Literature Review: Product Structure and Design
3.1.2.1	Function Tree
3.2.1	Project Briefing And Risk Assessment
3.2	Gantt Chart
3.4.1	Overall Project Flowchart
3.4.2.1	Specific Project Design Flow Chart / Framework: Product Structure and Design
3.6	General Product Drawing and Schematic Diagram
3.6.1	Product Drawing and Schematic Diagram: Product Structure and Design
3.7	Product Testing / Functionality Tests
3.7.3.1	Specific Project Fabrication Process: Product Structure and Design
4.1.2.1	Specific Parts Feature: Product Structure and Design
4.1.4.1	Operation of the Specific Part of the Product: Product Structure and Design
4.2	Product Output Analysis
4.3.1	ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS: Product Structure & Design
5.1.2.1	Specific Achievement of Project Objectives: Product Structures and Design
5.3.1	IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH: Product Structures and Design

`

SUB-CHAPTERS	DESCRIPTION
SHIVATAARANI D/O MOHAN	
1.1	Background of Study
1.2	Problem Statements
1.3.1	General Project Objectives
1.3.2.2	Specific Individual Project Objectives: Mechanical Mechanism & Furnishings
1.4	Purpose of Product
1.5.1	General Project Scopes
1.5.2.2	Specific Individual Scopes: Mechanical Mechanism & Furnishings
2.1	General Literature Review
2.2.2	Specific Literature Review: Mechanical Mechanism & Furnishings
2.3.1.2	Related Patented Products: Intelligent Toolbox GB I l 2465807
2.3.2.2	Recent Market Products: Rousseau R7GKE-30605L3: R-GO Tool Box 60”W X 24”D X 41 ¼”H
2.4.2	Maintenance Provision Crib vs Rousseau R7GKE-30605L3: R-GO Too Box 60”W X 24”D X 41 ¼”H vs Intelligent Toolbox GB I l 2465807
3.3.2.2	Specific Project Design Flow/Framework: Mechanical Mechanism & Furnishings
3.5.2.2	Specific Part Drawing / Diagram: Mechanical Mechanism & Furnishing
3.7.3.4	Specific Project Fabrication: Finishing
4.1.1	General Product Features & Functionalities
4.1.2.2	Specific Part Features: Mechanical Mechanism & Furnishings
4.1.3	General Operation of Product

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4.1.4.2	Operation of the Specific Part of the Product: Mechanical Mechanism & Furnishings
4.2	Project Impacts/Purpose of Product
4.3.2	Analysis of Problem Encountered & Solutions: Mechanical Mechanism Furnishings
5.1.1	General Achievements of the Project
5.1.2.2	Specific Achievement of Project Objectives: Mechanical Mechanism & Furnishings
5.2	Contribution or Impact of the Project
5.3.2	Improvement & Suggestions for Future Research: Mechanical Mechanis & Furnishings

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SUB-CHAPTERS	DESCRIPTION
LEW KIM WENG	
1.3.2.3	Specific project mechanism: Electrical mechanism
1.5.2.3	Specific project scope: Electrical mechanism
2.2.3	Specific project review: Electrical mechanism
2.2.3.1	Electrical motor
2.2.3.2	Linear actuator
2.2.3.3	Battery
2.2.3.4	Push button
2.2.3.5	Light Emitting Diode
2.2.3.6	LED strip
2.2.3.7	Normally ON switch
2.2.3.8	Rocker switch
3.9	List of material and expenditure
4.1.2.3	Specific part features: electrical mechanism
4.1.4.3	Operation of specific part of the product: Electrical mechanism
4.3.3	Analysis of problem uncounted & solution Electrical mechanism
5.1.2.3	Specific achievement of project objective: Electrical mechanism
5.3.3	Improvement & suggestion for future research: Electrical mechanism

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SUB-CHAPTERS	DESCRIPTION
ARIG JEREMIAH ALONG ANAK MICHAEL	
1.3.2.4	Specific project objective: electronic & programming
1.5.2.4	Specific individual scope: electrical & programming
2.2.4	Specific literature review: electronic & programming
2.2.4.1	Arduino ESP 32
2.2.4.2	Blynk App
2.2.4.3	Motor speed controller
3.1	Design engineering tools
3.1.1.1	Questionnaire Survey
3.1.1.2	Pareto Diagram
3.1.2	Design Concept Generation
3.1.2.2	Morphological Matrix
3.1.2.3	Proposed Design Concept 1
3.1.2.4	Proposed Design Concept 2
3.1.2.5	Proposed Design Concept 3
3.1.2.6	Accepted vs Discarded Solution
3.1.3	Evaluation & Selection of Conceptual Design
3.1.3.1	Pugh Matrix
3.4.2.4	Specific project design flow/framework: electronic & programming
3.6.3.3	Specific part drawing/diagram: electronic & programming
3.7.1	Development of product: material acquisition
3.7.2	Development of product: machines and tools

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3.7.3.3	Specific project fabrication: electronic & programming
4.1.2.4	Specific part features: electronic & programming
4.1.4.4	Operation of specific part of the product: electronic & programming
4.3.4	Analysis of problem encountered & solution: electronic & programming
5.1.2.4	Specific achievement of project objectives: electronic & programming
5.3.4	Improvement & suggestion for future research: electronic & programming

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APPENDIX B: TURNITIN SIMILARITY REPORT

MAINTENANCE PROVISION CRIB

by arig jeremiah along michael

Submission date: 04-Dec-2023 01:54AM (UTC+0800)
Submission ID: 2246107052
File name: MAINTENANCE_PROVISION_CRIB_TURNITIN.pdf (3.78M)
Word count: 12542
Character count: 63394

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MAINTENANCE PROVISION CRIB

ORIGINALITY REPORT

8%	4%	1%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Jabatan Pendidikan Politeknik Dan Kolej Komuniti Student Paper	5%
2	www.casa.gov.au Internet Source	<1%
3	www.dot.mn.gov Internet Source	<1%
4	www.coursehero.com Internet Source	<1%
5	www.flightsafetyaustralia.com Internet Source	<1%
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11	Submitted to Universiti Teknologi Malaysia Student Paper	<1%
	Submitted to New England Institute of	1

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21	www.bosdrain.nl Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
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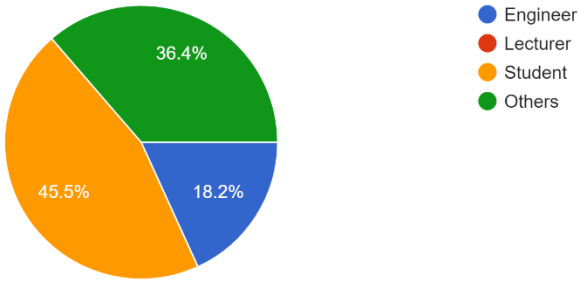
APPENDIX C: PRE-SURVEY FORM

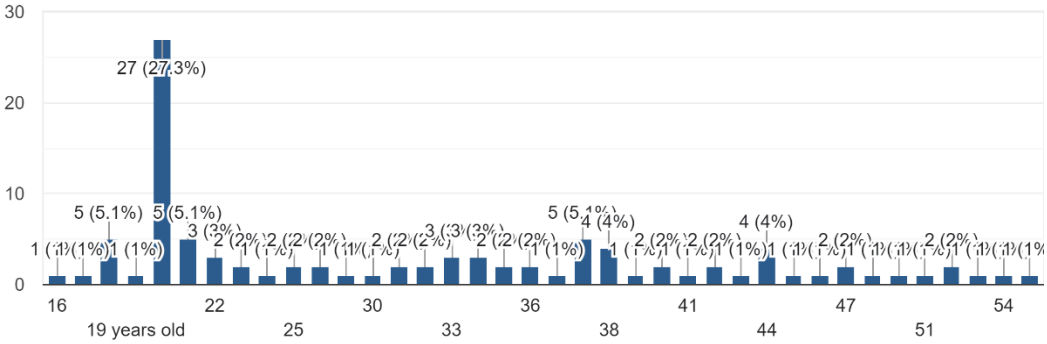
Occupation

99 responses



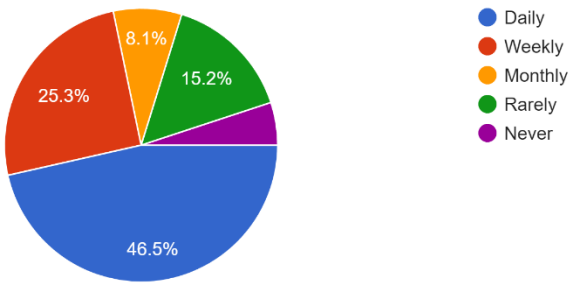
Age

99 responses



1. How often do you use tools in your studies/work?

99 responses



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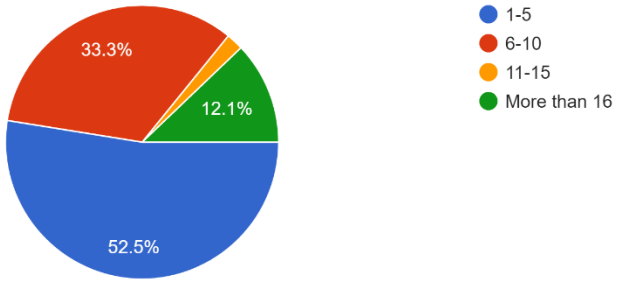
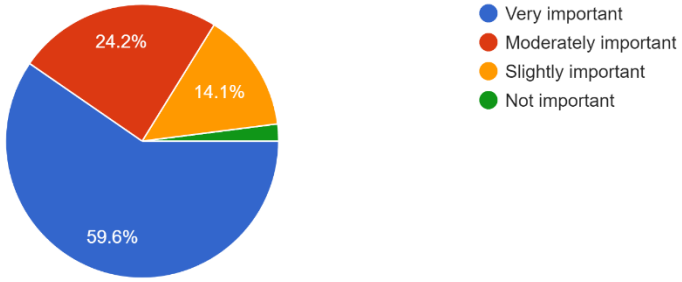
2. How many different types of tools do you typically use in your studies/work?

99 responses



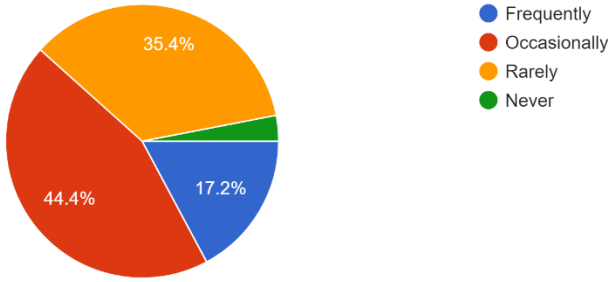
3. How important is having access to a wide variety of tools for your studies/work?

99 responses



4. How often do you encounter situations where you need a tool but do not have it?

99 responses



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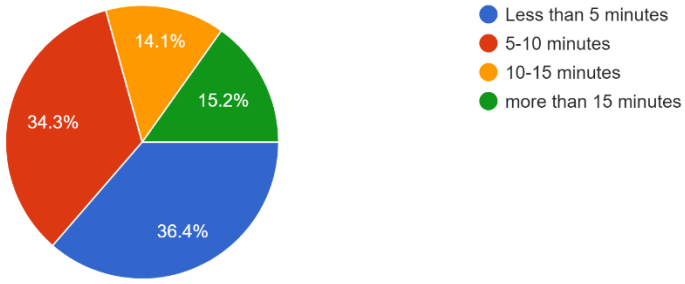
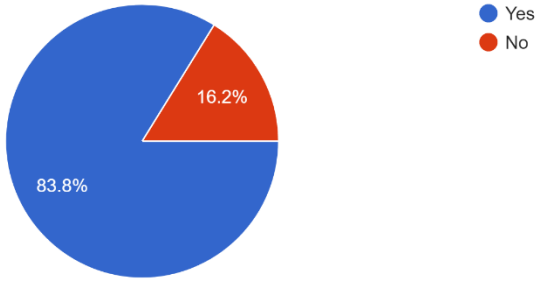
5. How much time do you typically spend looking for the right tool when you need it?

99 responses



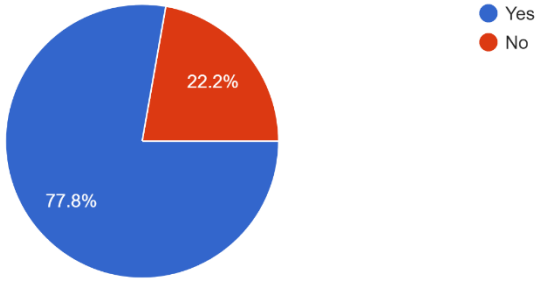
6. Have you ever encountered a situation where a tool was not available when you need it?

99 responses



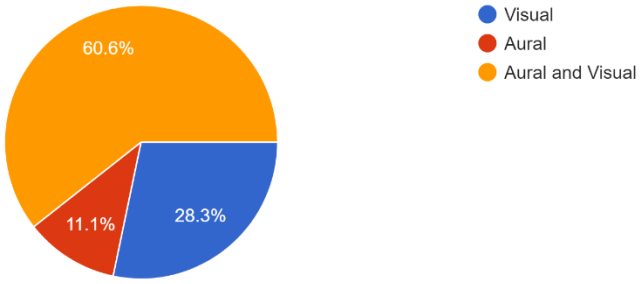
7. Would you prefer an alarm system in a maintenance provision crib?

99 responses



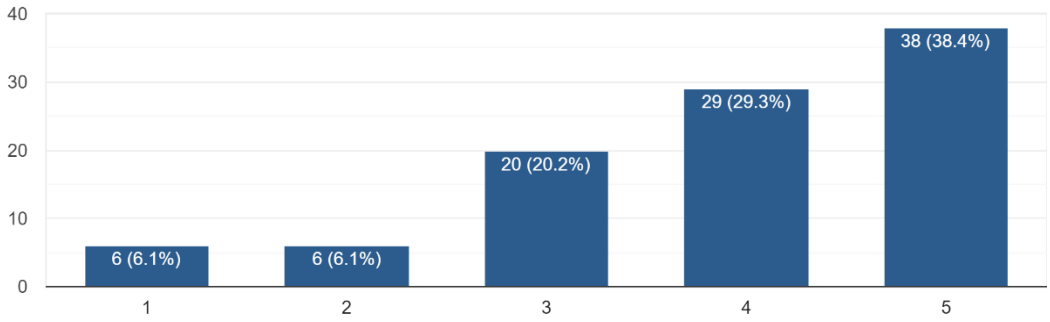
8. If yes, what type of alarm system do you prefer?

99 responses



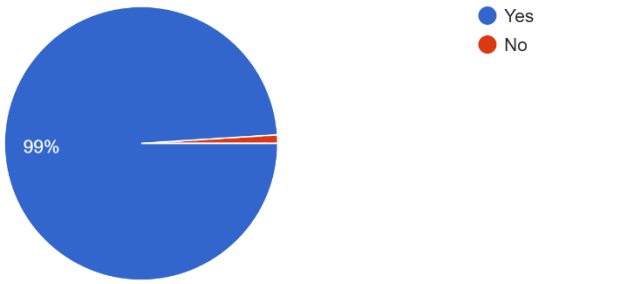
9. How important is the tool crib mobility to you?

99 responses



10. By providing lighting inside the drawer, do you think it can help you to search for tools in poor lightning area?

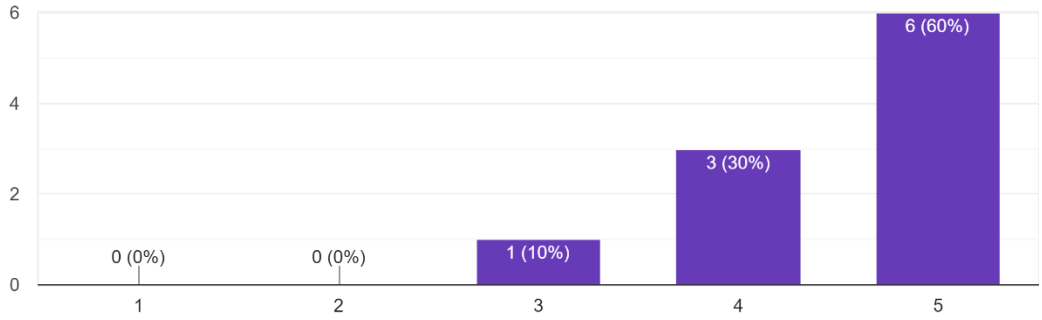
99 responses



APPENDIX D: POST-SURVEY FORM

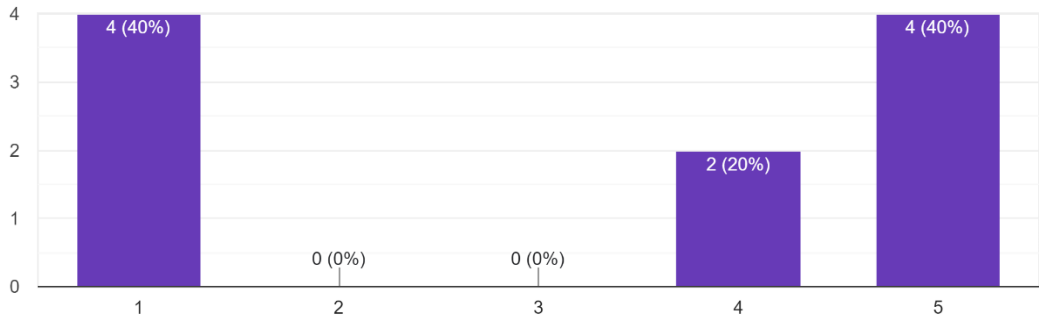
How satisfied are you with the Maintenance Provision Crib's operation and performance?

10 responses



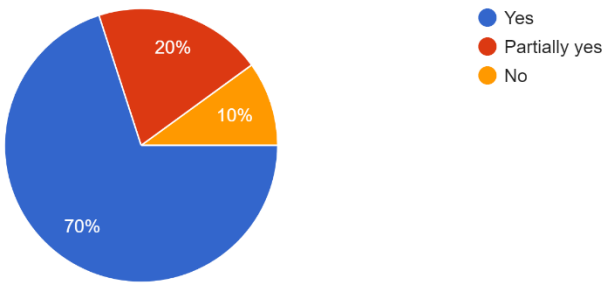
How easy was it to find and retrieve the tools using the Blynk app and LED lights?

10 responses



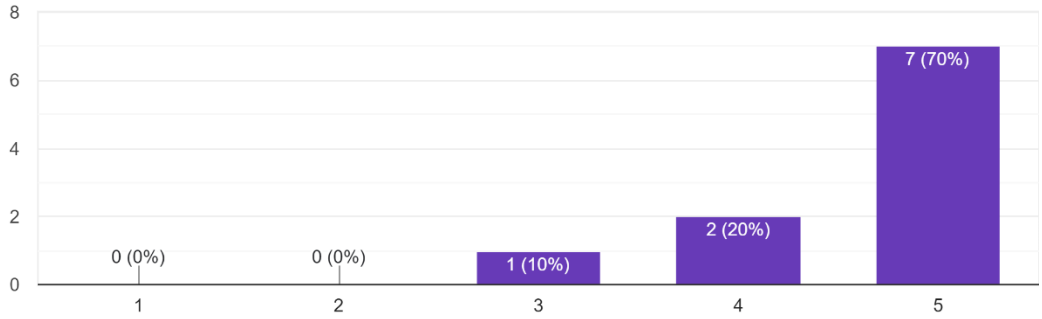
Did you find the utilisation of repurposed aircraft galley cart as the toolbox body to be innovative and environmentally friendly?

10 responses



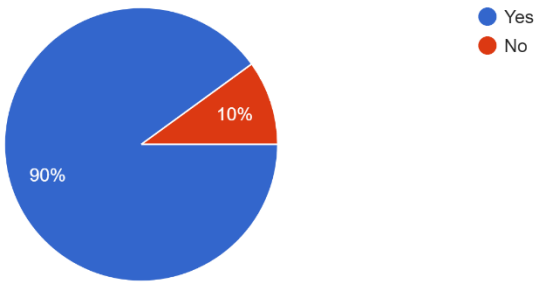
Rate the linear actuator DC motor's efficiency in facilitating the forward movement of the toolbox during repair operations.

10 responses



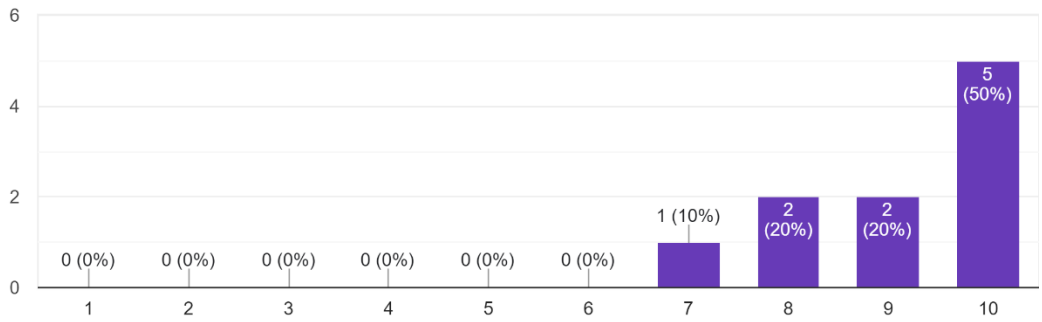
Do you think the QR code authorisation system works well for guaranteeing that only authorised users have access to certain tools?

10 responses



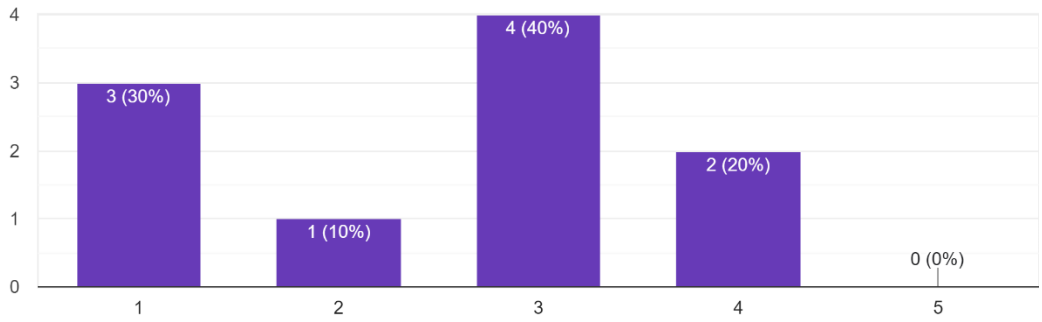
On a scale of 1 to 10, how reliable is the weight-based tool identification system in checking whether or not tools are placed in the toolbox?

10 responses



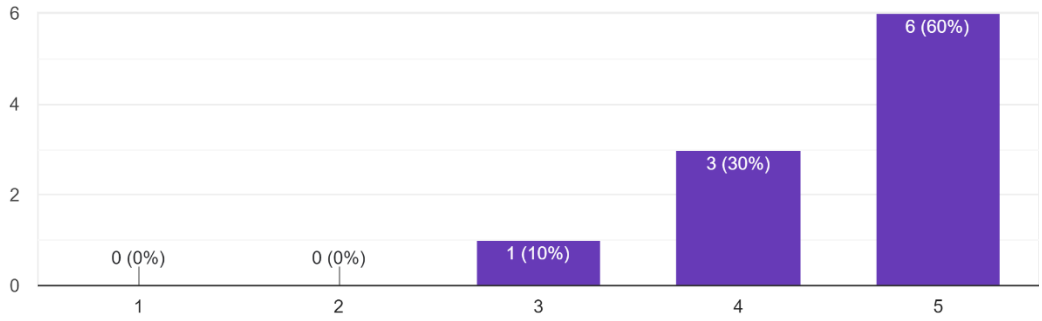
How appealing did you find the painted toolbox and safety tape furnishings?

10 responses



Based on your experience, how likely are you to suggest the Maintenance Provision Crib to others for similar purposes?

10 responses



Do you have any more thoughts or suggestions for improving the functionality, design, or user experience of the Maintenance Provision Crib?

10 responses