

**POLITEKNIK BANTING SELANGOR**

**SMART PITOT GUARD (SPG)**

<b>NAME</b>	<b>MATRIC NO.</b>
MIRZA FAQIHAH BINTI MUHAMAD NAZERI	24DAM23F1002
WAJDI BE'AUNILLAH BIN MOHD NURI	24DAM23F1008
MUHAMMAD UWEIS QAWI BIN AHMAD FAUDWAZ	24DAM23F1040
MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI	24DAM23F1041

**DEPARTMENT OF AIRCRAFT MAINTENANCE**

**SESSION I 2025/2026**

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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 :**

**MR . MOHAMMAD AZMIN BIN ZAINAL**

## REPORT ENDORSEMENT

This report is being submitted , reviewed , and endorsed to fulfill the conditions and requirements of report writing as specified .

### Checked by :

Supervisor's Signature : 

Supervisor's Stamp : **MOHAMMAD AZMIN BIN ZAINAL**  
~~Ketua Program (PPPT-DH44)~~  
Jabatan Penyelenggaraan Pesawat  
Politeknik Banting Selangor

Date : 19/11/2025

### Endorsed by :

Project Coordinator's  
Signature : 

Project Coordinator's Stamp : **KHAIRUL IZWAN BIN ISMAIL**  
Pensyarah  
Jabatan Penyelenggaraan Pesawat  
Politeknik Banting Selangor

Date : 12th DECEMBER 2025

**CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP**  
**SMART PITOT GUARD**

**SESSION : 1 2025/2026**

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MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI	24DAM23F1041

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

*Mirza*

( MIRZA FAQIHAH )

**SIGNATURE : WRITER 1**



( SUPERVISOR'S SIGNATURE )

*Wajdi*

( WAJDI BE'AUNILLAH )

**SIGNATURE : WRITER 2**

*Uweis*

( MUHAMMAD UWEIS QAWI )

**SIGNATURE : WRITER 3**

MOHAMMAD AZMIN BIN ZAINAL  
Ketua Program (PPPT-DH44)  
Jabatan Penyelenggaraan Pesawat  
Politeknik Banting Selangor

**SUPERVISOR'S STAMP**

*Arif*

( MUHAMMAD ARIF HIFZAN )

**SIGNATURE : WRITER 4**

DATE : 19/11/2025

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## **ABSTRACT**

The pitot tube is a vital aircraft component for airspeed measurement, and its obstruction can lead to critical flight safety risks. Conventional pitot tube covers, while functional, are often overlooked during pre-flight checks or prove inadequate in low-light and high-pressure environments. This project focuses on the design and evaluation of a Smart Pitot Guard (SPG) that integrates advanced materials and smart warning systems to enhance safety and usability.

The methodology involved CAD-based conceptual design, prototype fabrication with polypropylene and vinyl composites, and Microbit programming to operate ultrasonic sensors, LEDs, and buzzers. A self-release mechanism activated by pitot heat was also incorporated to minimize human error. Results from simulations and preliminary testing demonstrate improved durability, visibility, and reliability in alerting ground crew, while the automated disengagement feature ensures operational safety, with 95% of respondents recommending its use. In conclusion, the SPG effectively reduces pitot blockage risks, lowers maintenance costs, and improves ground crew efficiency. Its adoption could set a new standard in commercial aviation safety, preventing foreign object damage and enhancing flight reliability.

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## LIST OF ABBREVIATIONS

SPG	Smart Pitot Guard
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# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND OF STUDY

The pitot-static system is one of the most crucial components in aircraft instrumentation because it provides pilots with essential air-data information as shown in figure 1. Parameters such as airspeed, altitude, and rate of climb or descent all depend on the accurate functioning of this system [1]. At the centre of it is the pitot tube, a small but vital device that measures dynamic pressure as the aircraft moves through the air. Despite its importance, the pitot tube is exposed directly to the environment, making it vulnerable to contamination and obstruction when the aircraft is parked on the ground. Even minor blockages can affect the consistency of air pressure readings, which may influence the accuracy of cockpit displays and flight performance.



**Figure 1: A Standard Pitot Tube Cover**

Because of these risks, aviation authorities and manufacturers strongly recommend or require the use of pitot covers during ground operations. Pitot covers act as a protective barrier, shielding the tube from insects, dirt, moisture, and other

contaminants. They are simple tools, but they play an important role in maintaining the reliability of the pitot-static system. However, the traditional covers commonly used today still depend heavily on human attention and manual inspection [2]. If a cover is not installed correctly, not visible enough, or accidentally left on the probe, it can cause operational difficulties.

Environmental factors also contribute to the challenge. Pitot tubes can be affected by foreign object intrusion, dust accumulation, and exposure to rain or humidity. Insects, especially species that build nests quickly in small cavities, are a known threat in many regions. Ice formation during cold weather or early-morning operations can also pose problems. Although many pitot tubes are equipped with heating systems to combat in-flight icing, these heaters do not prevent contamination during ground time. As a result, an effective ground-safety solution must take into account both physical protection and environmental considerations.

Over the years, various types of pitot covers have been introduced. Most include soft protective sleeves and a bright “Remove Before Flight” (RBF) tag to catch attention during walk-around inspections. While these designs help improve visibility, research and human-factors studies show that small, repetitive tasks—especially those carried out during long shifts or under time pressure—are more susceptible to being overlooked [3]. This means that even traditional high-visibility covers cannot fully eliminate the potential for human error. Another concern is material durability. Some conventional covers can degrade when exposed to heat from the pitot heater if it is accidentally switched on while the cover is still installed. Certain materials may melt, deform, or leave residue on the probe surface, complicating aircraft maintenance. This highlights the need for pitot covers made from stronger, heat-resistant materials and designed to withstand demanding operational conditions. The rise of modern 3D-printing materials such as polypropylene has created new opportunities to develop lightweight, robust, and customizable cover structures suitable for aviation applications [4].

With advancements in technology, researchers have begun exploring enhanced, automated, or sensor-based solutions. Smart maintenance tools that integrate microcontrollers, indicator lights, or proximity sensors have proven effective in reducing reliance on manual checks. The integration of simple electronics into ground equipment such as ultrasonic sensors, LEDs, or buzzers has demonstrated how technology can help remind technicians of equipment status, improving safety during ground handling tasks. In addition, some studies explore methods like acoustic blockage detection to identify obstructions inside the pitot tube without requiring visual inspection.

Regulatory bodies continue to emphasize the importance of pitot protection and consistent inspection procedures. Aviation safety guidelines frequently highlight the risk of obstructions that occur during ground time and stress the need for reliable protective equipment. However, the challenge is not only protecting the tube from contamination but also ensuring that the cover itself does not become a hazard if overlooked [5]. This issue reflects the larger theme of human-factor challenges in aviation tasks that are routine are often the most vulnerable to being missed. Given these considerations, there is a clear need for a new generation of pitot tube covers that go beyond basic physical protection. A modern solution should support technicians through improved visibility, stronger materials, and user-friendly structure [6]. More importantly, it should integrate automated reminders or smart features that reduce dependence on human memory alone. By combining durable design with embedded electronic components, a next-generation pitot cover can significantly enhance ground safety, reduce operational risks, and support maintenance personnel more effectively.

The Smart Pitot Guard (SPG) project is developed based on this gap. It aims to introduce a pitot cover that not only protects the probe from environmental hazards but also integrates sensors, warning systems, and functional mechanisms to prevent it from being forgotten during aircraft operation. Through this project, the goal is to improve the overall reliability of the pitot-static system while addressing real-world

human-factor challenges in aircraft maintenance and ground handling. The SPG represents an innovative step toward safer, smarter, and more efficient aviation ground operations.

## **1.2 PROBLEM STATEMENTS**

The pitot tube plays a vital role in ensuring that an aircraft receives accurate airspeed information. Because it sits outside the aircraft and is exposed to the environment, it must be protected during ground operations using a pitot cover. These covers are meant to prevent insects, dust, moisture, and other contaminants from entering the probe. However, traditional pitot covers rely completely on human attention and manual checks. If the cover is forgotten or not removed before takeoff, it will block the pitot tube and cause unreliable airspeed readings placing the aircraft, crew, and passengers at risk [7].

Although pitot covers seem simple, real-world incidents show that human error continues to be a major concern. On 18 July 2018, a Malaysia Airlines Airbus A330-300 began its takeoff roll in Brisbane with all three pitot covers still attached. The pilots immediately noticed abnormal airspeed indications, causing confusion in the cockpit. Investigations later found that the covers had not been removed due to a breakdown in communication, poor visibility of the warning streamers, and the absence of a proper final walk-around. The ATSB report also noted that the covers used were not as visible as the standard Airbus-approved ones, making them easy to miss during inspections [8].



**Figure 2: Malaysia Airlines Airbus A330-300**

Another example occurred on 27 May 2022, when a Singapore Airlines Airbus A350 in Brisbane was preparing for departure with pitot covers still in place. Fortunately, an engineer spotted the covers just before pushback. The investigation revealed weaknesses in the process for tracking and confirming removal, showing that even experienced personnel can unintentionally overlook something as crucial as a pitot cover. Both cases highlight that despite strict procedures, human factors such as fatigue, assumptions, workload, distractions, and time pressure can lead to dangerous oversights.



**Figure 3: Singapore Airlines Airbus A350**

These repeated incidents show a clear pattern: current pitot covers depend too much on human reliability and offer no built-in way to alert ground crew or pilots if they remain attached. While “Remove Before Flight” tags improve visibility, they still rely on someone noticing them. In busy or dimly lit environments, or during rushed operations, these warnings can easily be missed.

.This problem is even more significant in areas where insects or debris frequently threaten pitot probes. Although covers are necessary to protect the system, the real challenge is ensuring that they are always removed on time. Unfortunately, existing designs fail to address this gap. They protect the probe physically, but they do not provide active reminders, warning signals, or automatic safety features to prevent human error.

Because of this, there is a clear need for a new type of pitot cover one that not only protects the probe from environmental contamination but also helps prevent it from being left on during takeoff. A smarter, more user-friendly design could dramatically reduce risks and support ground crews more effectively.

## **1.3 PROJECT OBJECTIVES**

### **1.3.1 General Project Objectives**

The project objectives are :

- To design an innovative Smart Pitot Tube ( SPG ) that enhances protection and visibility
- To develop a prototype using lightweight , weather resistance and durable materials suitable for aircraft conditions
- To evaluate the effectiveness of the new design in preventing blockages , reduce maintenance costs and to improve overall safety and operational processes .

### **1.3.2 Specific Individual Project Objectives**

#### **1.3.2.1 Product Structure**

- To design a modular pitot tube cover structure that allows for easy installation and removal without compromising the aerodynamic profile of the aircraft.

- To select and integrate appropriate materials for the structural components of the pitot tube cover that can withstand harsh weather, UV exposure, and operational stress.
- To develop a compact internal structure that securely fits standard pitot tube dimensions while preventing contamination from dust, insects, or moisture.
- To enhance the structural ergonomics by including user-friendly grips or locking mechanisms that improve ground handling safety and efficiency.
- To evaluate and optimize the structural strength and durability of the cover through mechanical simulations and material testing.

### **1.3.2.2 Product Mechanisms**

- To ensure visibility by activating an LED light that remains on when the pitot tube cover is not removed.
- To provide an audible warning through a buzzer that continuously sounds if the cover is still attached to the pitot tube.
- To prevent operational oversight by enabling an auto disengage mechanism that allows the cover to detach itself if the previous alerts are ignored

### **1.3.2.2 Software / Programming**

Outlined below are the focused objectives for each area of the project:

- To develop the microcontroller system using Microbit, program with JavaScript in Microsoft MakeCode.
- To integrate sensors such as an ultrasonic sensor to detect whether the pitot tube cover is attached or removed.
- To program the buzzer and LED indicators so they activate when the pitot tube cover is not removed before take off.
- To optimize battery efficiency by ensuring the system consumes minimal power during ground operations and maintenance.

### **1.3.2.3 Accessories & Finishing**

This objectives focuses on enhancing the final design of the Smart Pitot Guard ( SPG ) through the addition of practical accessories and advanced finishing techniques that improves safety , usability , and durability

- To integrate a high visibility “ Remove Before Flight “ streamer that ensures the cover is easily noticed by ground personnel and minimizing the risk of being left on before takeoff
- To use weather resistant to enhances the durability and last longer when the pitot tube cover exposed to extreme environmental conditions
- To ensure the edges and surfaces are smooth and ergonomic which allow safe and easy handling especially when maintenance crews are wearing gloves
- To consider a soft inner lining as part of the finishing process to prevent any potential scratches or damage to the pitot tube itself
- To ensure all accessories and finishes are compliant with aviation standards while contributing to the overall reliability and safety of the design

## **1.4 PURPOSE OF PRODUCT**

The purpose of this project is to improve aircraft safety by developing the Smart Pitot Guard, a new and improved pitot tube cover.

It aims to prevent incidents caused by blocked or forgotten pitot covers by using durable materials, bright warning colors, and a simple alert feature.

This product helps maintenance personnel easily identify and remove the cover before flight, reducing human error and ensuring safe aircraft operation.

## **1.5 SCOPE OF PROJECT**

### **1.5.1 General Project Scopes**

First, this product is intended for use on commercial aircraft only, especially those operating in regions prone to insect-related pitot blockages. Other aircraft types, such as military or private jets, may already have their own advanced protection systems or operate in controlled environments. The smart pitot tube cover will not require major modifications to existing aircraft structures because the design is compact and compatible with standard pitot tube fittings. This product is designed to prevent foreign object blockages such as insect nests or debris, which can compromise flight safety. Furthermore, the smart cover will integrate features like heat-sensitive auto-release or sensor-based alerts to minimize human error. The smart pitot tube cover is specifically developed for large commercial jets or wide-body aircraft, as these aircraft typically face longer ground times and operate in a wider variety of environmental conditions.

### **1.5.2 Specific Individual Scope**

personnel do not notice the presence of the sound and LED light until the plane has already taken off. It will work when the pitot starts to heat up and burns the thread on the pitot cover which allows it to open and detach from the pitot tube

### **1.5.2.1 Product Structure**

This project focuses on the development of a next generation pitot tube cover designed to enhance aircraft safety by preventing common issues such as contamination, moisture ingress, and insect nesting within the pitot-static system. The scope includes conceptual design based on benchmarking existing covers, selection of durable and weather-resistant materials, and detailed structural planning of components such as the protective cap, mounting grip or strap, and high-visibility Remove Before Flight streamer. The product structure will be refined using CAD software to create precise engineering drawings and 3D models, followed by prototype fabrication through 3D printing or rubber molding. Finally, the prototype will undergo structural testing to evaluate fit, weather resistance, and durability under operational conditions, ensuring the design meets both functionality and safety requirements.

### **1.5.2.2 Product Mechanisms**

Product mechanisms for our project which is Next Generation Pitot Tube Cover is not too complicated. First the LED light, the way it works is to keep flashing when it is installed on the aircraft, this is one of the important mechanisms for maintenance workers who work while maintaining the aircraft. Because after the aircraft is finished being maintained and ready to be released, the maintenance workers can notice if they have not removed the pitot tube cover by the flashing light on the aircraft.

Also, the buzzer that keeps buzzing, it was one of the mechanisms that we made as an additional precaution so that our workers don't notice the light. It will be the same as the light method where it will still sound if it is not removed from the plane's pitot. The presence of this sound will increase the sensitivity of the workers involved in maintaining the ship, if they don't notice the LED light, there is a sound that they can hear.

Finally, our sewing method and the type of thread we use. Our sewing method is Lockstitch which makes the pitot tube cover difficult to open unless the thread burns. We added this method for emergency situations if maintenance

### **1.5.2.3 Software/Programming**

Software and Programming is a part of SPG , the system commonly use a microcontroller automation and safety functions during aircraft on ground operations. There is many various of Microcontroller as a brain for our system, but we only have 2 options either Arduino UNO or Micro bit depending what project needs. Ultrasonic sensor we use as for sensor integration to detect whether the pitot tube cover is attached or removed. Besides, warning system where the microcontroller will control buzzer and LED lights to alert if the cover is still on during on ground and programming the logic to ensure the system responds correctly to inputs and works automatically. The important things in software is testing and troubleshooting to make sure the code works in real conditions and making changes if needed. When the pitot tube cover in not use, operations of warning system will be off and this will be save battery power

### **1.5.2.4 Accessories & Finishing**

This project focuses on the development of SPG that enhances safety , durability , and usability for ground operations .

This project also covers the accessories and finishing aspects of the next generation pitot tube cover, focusing on enhancing both functionality and visual safety. Accessories include a brightly colored Remove Before Flight streamer made from weather resistant fabric for high visibility during walk around inspections, and optional features such as a breather hole or drainage slit to prevent pressure buildup or moisture accumulation. The finishing

process will ensure smooth surface texture and edge treatment to avoid scratching or damaging the pitot probe, while also incorporating anti slip or textured grip areas for easier handling during installation and removal. Attention will be given to color coating using UV stable paint or molded-in pigment to maintain visibility and durability over time. These finishing elements are crucial to ensuring the cover is practical, durable, and easily identifiable during ground operations.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 GENERAL LITERATURE REVIEW

#### 2.1.1 Aviation Industry in Malaysia

The aviation industry in Malaysia is growing rapidly and plays an important role in the country's economy. It includes commercial airlines, maintenance organizations, aviation training centres, and regulatory bodies such as the Civil Aviation Authority of Malaysia (CAAM). As the industry continues to expand, the demand for high safety standards and skilled maintenance personnel also increases. Safety in aviation depends greatly on the accuracy and reliability of aircraft instruments, including the pitot-static system which measures airspeed [12]. In recent years, several aviation incidents worldwide were caused by pitot tube blockages due to insects, debris, or covers that were not removed before flight. Even though Malaysia has strong safety regulations, human error can still occur during maintenance or pre-flight checks. These mistakes can happen due to fatigue, poor visibility, or distractions during ground operations. This issue highlights the need for better equipment and safety awareness in the Malaysian aviation industry.

The Smart Pitot Guard was developed to support these safety improvements. It is designed to reduce the risk of pitot-related incidents by using durable materials, high-visibility colours, and a simple alert feature to remind ground crews to remove the cover before flight [13]. This product not only helps prevent accidents but also supports Malaysia's goal to strengthen its aviation safety culture and reduce maintenance errors [14]. By improving small but critical tools like pitot covers, Malaysia's aviation industry can enhance both safety and efficiency. The Smart Pitot Guard can be applied in training

institutions, airlines, and maintenance organizations, making it a valuable innovation that fits the needs of modern aviation practices in Malaysia.

### **2.1.2 Trend or Demand for Low Cost Carrier**

The trend and demand for pitot tube covers in aviation are clearly growing. This is because of factors like more global air traffic higher awareness of the risks from foreign object damage, and a stronger focus on aircraft maintenance and safety. Recommendations from regulatory bodies such as the FAA and EASA, along with aircraft manufacturers like Airbus, highlight the importance of these protective devices to keep flight instruments accurate [15].

Pitot tube covers are essential in preventing accidents caused by blocked pitot tubes. Their simple design protects the pitot static system from insects, debris, dust, and moisture, ensuring reliable airspeed readings. The market for pitot tubes and their covers is growing, with many manufacturers offering a variety of products to meet the needs of the aviation industry.

New technology is also changing pitot tube cover design. Innovations like smart warning systems that alert pilots when the cover is still on, and self-releasing designs that come off when the pitot heat is activated, are gaining popularity and will likely continue to grow in use. These improvements help reduce human error and make aviation safer.

Regular maintenance including cleaning and replacing pitot tube covers, is key to their effectiveness. Covers made from durable materials like kevlar last longer and offer better protection. Looking forward, the demand for pitot tube covers is expected to keep rising as the aviation industry expands and safety remains a priority. Future research could lead to smarter covers with real-time monitoring or more standardized rules for pitot tube cover use across aviation authorities. The focus on preventing pitot tube blockages will continue driving the need for effective and innovative protection solutions.

### 2.1.3 Type of Pitot Tube Cover in Aviation

The pitot tube is a vital component of an aircraft instrumentation system and it is mainly responsible for measuring airspeed. Its proper function is critical for safe flight operation, so protecting it from environmental factors and foreign object debris also known as FOD is very important when the aircraft is on the ground. There are several types of covers designed to protect this sensitive instrument. This report will identify three different types of pitot tube covers and the companies that manufacture them based on the provided research material.

1. **The blade style pitot tube cover** as shown in figure 4, is made by ASA, also known as Aviation Supplies & Academics Inc. This is clearly shown on their product page, which names the item as Aircraft Pitot Tube Cover Blade Style. The copyright info on the page also confirms this. Other aviation shops also sell the ASA Pitot Tube Cover Blade Style, which shows that ASA is a known supplier of this cover. ASA gives a full description of the cover, including the venting feature, the material used, and the remove before flight banner. This shows they focus on both function and safety for this important aircraft part.



**Figure 4: Blade Style Pitot Tube Cover**

2. Another type of pitot tube cover is called the Pitot Booty as shown in figure 5. This name is mainly used by Aircraft Spruce & Specialty Co. for their own pitot cover product. These covers are made from soft, bright red vinyl that resists mildew and follows the military spec Mil C 20696. Just like the blade style cover, the Pitot Booty also has a Remove Before Flight streamer to help with pre-flight safety. It has a tough, leather like design made to fit tightly over L shaped pitot tubes with a diameter of 5/8 or 11/16 inch. It uses a Velcro strap to keep it in place and protect it from weather and insects. Since Aircraft Spruce calls these covers Spruce's own, it shows they are the maker of this style. Other companies might sell similar covers, but the name Pitot Booty is mostly linked with Aircraft Spruce. Customer reviews also give useful info about how well it fits different aircraft and the overall quality of the product.



**Figure 5: Pitot Booty**

3. A third type of pitot tube cover is the universal pitot tube cover. This type is made to fit a wide range of aircraft and pitot tube sizes. One example is the cover from Brown Aircraft Supply Inc. It is built to be strong and weather-resistant, with bright orange and yellow reflective colors to make it easy to see in different lighting conditions. This helps pilots avoid missing it during pre-flight checks. The cover is designed to fit pitot tubes from as small as 1/4 inch, like those on home-built aircraft, to as large as 1 inch, used on corporate jets. It uses a Velcro strap with a sewn-in rubber edge that makes it fast and secure to attach. This design is useful for people or maintenance teams working with different aircraft types or when the pitot size is not exactly known. Brown Aircraft Supply Inc.

makes this universal pitot tube cover, as shown on their product page. Other companies like Plane Sights and Nelson also offer universal covers, showing that there is a strong need for these flexible designs.

#### **2.1.4 Research of Previous Study**

Pitot tubes measure airspeed and are vulnerable to foreign-object blockages such as insects, debris, and dust when the aircraft is parked. Traditional pitot covers, like bright remove-before-flight sleeves or plugs, physically protect the pitot inlet on the ground. They must be installed manually and removed before flight. In contrast, smart pitot covers use sensors or mechanisms to warn or automatically release if left on. Recent research and safety reports show clear differences in how each approach prevents blockages and human error, with important effects on flight safety and reliability. Overall, traditional covers effectively block insects but rely on human attention. Smart covers add automation and alerts to reduce human error. Studies show that smart covers can be highly reliable in detecting whether they are still in place, with some prototypes achieving 100% accuracy in tests. Although formal field trials are still limited, features like automatic ejection and preflight warnings can significantly lower the risk of taking off with a cover on. However, smart covers also bring new factors to consider, such as timing with pitot heat, higher cost, and the need for electronic maintenance, so operators must use them thoughtfully.

## 2.4 Comparison of Previous and Current Study

**Table 1 : Comparison With Other Products**

Type		
Feature	Traditional Pitot Tube Cover	Smart Pitot Tube Cover
Operation	Manual installation and removal.	Install like traditional; uses sensors/actuators to aid removal.
Blockage Protection	Physical barrier stops insects/debris.	Same physical protection once fitted.
Human Error Mitigation	Relies on checklists and visual cues (bright streamers). Accidents occur if forgotten	Features (e.g. LEDs, alarms) alert pilots/crew; auto-release if activated by pitot heat
Failure Mode	If left on, pitot is blocked in flight (as seen in Brisbane 2018) If not used at all, pitot vulnerable to insects (Bergenia 1996).	If mechanism fails or pitot heat not applied, cover acts like traditional (must still remove manually)
Implementation Status	Widely used and required by many operators (per FAA, airlines, OEMs).  Low cost, simple (fabric, rubber). Inexpensive.	New technology: PitotShield V2 is available; research prototypes exist
Cost & Complexity	Low cost, simple (fabric, rubber). Inexpensive.	Higher cost; contains polymers, electronics or mechanisms. May need maintenance.
Regulatory Guidance	Industry urges universal use, especially in high-risk areas (Brisbane, Heathrow)	Emerging focus; not yet widely regulated, but aligns with recommendations to “protect probes even short-term”

## 2.1.6 Smart Pitot Guard Ideal Concept and Specifications

### 1. Material

- Polypropylene
- Resistant to corrosion, chemicals, and light impacts
- Operating temperature: -20°C to 130°C

### 2. Design Features

- Snug fit based on pitot tube type (custom-molded)
- Integrated “Remove Before Flight” streamer, high-tensile fabric
- Auto-disengage mechanism (spring-loaded or servo-assisted) triggered by flight readiness or external input
- Lightweight, ergonomic design for quick installation/removal

### 3. Warning System

- micro bit programmed alert module
  - LED indicator flashes when aircraft systems power on or checklist is initiated
  - Buzzer sound to alert if the cover is not removed
- Can be triggered via:
  - Simple onboard tilt or motion detection
  - Countdown or pre-flight sequence activation
- Code written in Make Code or C++, easy for maintainers to understand and update

### 4. Power Source

- Battery-powered Micro bit standard AAA or lithium cell
- Estimated lifespan: 3 to 6 months per battery set

- Accessible battery housing with waterproof sealing

## **5. Color & Visibility**

- red/orange
- Reflective strips for visibility in low light
- Large “REMOVE BEFORE FLIGHT” text

## **2.2 SPECIFIC LITERATURE REVIEW**

### **2.2.1 Product Structure**

#### **2.2.1.1 Basic Design of Pitot Cover**

While the function of a pitot tube cover may appear simple, its design plays a crucial role in maintaining the safety and airworthiness of an aircraft. One of the most important design requirements is dimensional accuracy. It must fit securely to the specific pitot tube model. A loose cover can fall off due to vibration or wind, while an overly tight cover can damage the pitot surface. Our cover is designed to meet the exact measurements of the pitot tube to ensure compatibility, safety, and durability.

#### **2.2.1.2 OEM Standards (Original Equipment Manufacturer)**

To ensure safe and standardized use of pitot tube covers, several aviation regulatory and manufacturing standards are followed. These standards are typically defined by aircraft manufacturers (OEMs) issued by the aircraft or pitot tube manufacturer. These standards include the exact dimensions and geometry of the pitot tube to guarantee a secure and accurate fit. Additionally, OEMs provide detailed instructions for the correct installation and removal of the covers to minimize human error. They also specify approved part numbers and vendor sources to ensure quality and consistency. A vital safety feature included in these standards is the requirement for visibility labeling such as “REMOVE BEFORE FLIGHT” tags, which serve as critical reminders to ground crews and flight personnel during pre-flight inspections.

## **2.2.2 PRODUCT MECHANISMS**

Filament- lightweight and durable thermoplastic material often used for 3D printing and prototyping. In the Smart Pitot Guard, it is suitable for the outer casing because it resists heat, moisture, and impact. Its flexibility, smooth finish, and low weight make it ideal for aerodynamic and protective component

### **Type of LED Lights**

#### **Surface Mounted Device (SMDLEDs)**

There are a few kinds of LED Light that are small and suitable for this project such as Surface Mounted Device LED (SMD LED), where they have a various small size, but it still capable to make an emitting bright light. This SMD LEDs can also be programmed to blink using a control circuit.

#### **High Power LEDs**

Other than that, there is also High-Power LEDs, but it was slightly larger than SMD LEDs but still compact and it also extremely bright, suitable for applications requiring maximum illumination. connect to a control module to enable blinking.

#### **Integrated Flashing LEDs**

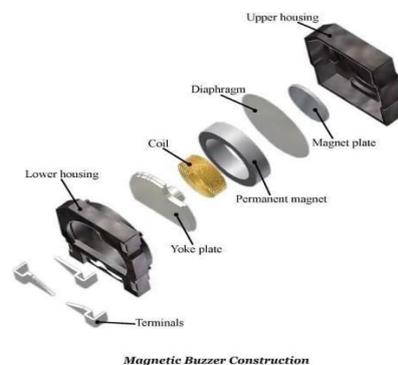
And the last one is Integrated Flashing LED, where it available in small sizes like 3mm or 5mm. These LEDs have built-in circuits that enable blinking without additional modules. And this type of LED is easy to use, and it was space saving because of the small sizes. A buzzer is a small electronic device that produces sound and usually used in an alert or signal in alarms, timers, or electronic systems. It converts electrical energy into sound waves and is commonly found in devices like fire alarms, microwaves and doorbells.

## Piezoelectric Buzzer

Piezoelectric buzzers are compact audio signalling devices that produce sound using the Piezoelectric Effect. The way it works is when an alternating voltage is applied to the piezoelectric element, it deforms and vibrates rapidly, these vibrations generate sound waves, which are amplified by the resonator. The frequency of the sound can be controlled by adjusting the input voltage, allowing for different tones. This buzzer can produce sound between 1 kHz to 7 kHz. An it was typically ranges from 3V to 24V DC.

## Magnetic Buzzer

Magnetic buzzers as shown in figure 6, are audio signaling devices that operate using electromagnetic principles. When an electric current passes through the coil, it creates a magnetic field, this magnetic field interacts with the metal diaphragm, causing it to vibrate, the vibrations produce sound waves, which are amplified by the housing. This buzzer typically ranges from 3V to 24V DC, and it can produce sound between 1kHz to 7kHz



*Magnetic Buzzer Construction*

**Figure 6 : Parts Of Magnetic Buzzer**

### **2.2.3 Software / Programming**

#### **Micro Bit**

In the development of pitot tube cover warning systems, both Arduino and micro bit platforms have been widely explored, each offering different strengths depending on the project requirements. A study by researchers used Arduino combined with ultrasonic sensors and AI based programming to create a warning system that could detect the presence of a pitot tube cover and alert the operator before flight, aiming to reduce the risk of airspeed indicator failures. Arduino is known for its flexibility, wide range of compatible sensors, and an enormous support community, making it suitable for more complex and customized systems. However, micro bit presents a strong advantage especially for projects that require fast development, built in sensors, and easy to use programming interfaces. According to comparison studies, micro bit comes pre equipped with a range of features like an accelerometer, magnetometer, temperature sensor, LED matrix, and Bluetooth communication which minimizes the need for adding external modules therefore simplifying the entire system architecture.

Choosing micro bit for your pitot tube cover warning system is the best decision considering the nature of your project. Micro bit offers a compact all in one solution where many of the necessary sensors are already built in, reducing overall wiring complexity and saving development time. Additionally, its support for both block based and Python programming allows for easier modifications and upgrades if needed in the future. Although Arduino can handle more extensive and industrial level tasks, for a warning system that primarily focuses on detecting the pitot tube cover and sending alerts effectively, microbit is more than sufficient. It also promotes better integration with visual indicators like LED patterns or simple audio alarms without requiring extra coding libraries. Therefore, based on the balance between ease of use, integration and the project scale, micro bit is strongly recommended for your warning system design.

## **2.2.4 Accessories & Finishing**

### **Typical Accessories on Pitot Tube Cover**

Pitot tube covers usually come with several common accessories to improve their function and safety. The most popular one is the REMOVE BEFORE FLIGHT streamer or banner. This bright red tag is attached to the cover to make it easy to see, reminding pilots and ground crew to take it off before the aircraft takes off. Some covers also come with fasteners like velcro straps to secure them properly. For smaller or DIY versions, elastic bands are sometimes used for a tight fit. On larger aircraft, some advanced covers include installation aids like orange kevlar loops to make putting them on or taking them off easier sometimes even using a pole. Certain blade style covers are built with vents to prevent pressure buildup while the cover is still on the probe. Others use reflective materials or bright colors like orange and yellow so they can be seen clearly in low light areas.

There are also smart pitot tube covers that include warning systems. These use microcontrollers, wireless modules, or LED to alert the crew if the cover is still on when the aircraft powers up. Some systems even use ultrasonic sensors and AI to detect the situation. For turbine aircraft, there are self releasing covers that automatically fall off if the pitot heat is turned on. Some high end covers also come with silicone tip protection inside to avoid damaging the probe.

All these extra features and accessories are meant to protect the pitot tube better, make the cover easier to use, and most importantly, help improve flight safety by reducing the chances of blocked or forgotten pitot tubes.

## **Type of material used in Pitot Tube Cover**

Pitot tube is very important in aircraft because it helps measure airspeed. If the tube is blocked by things like insects, dust, or water, it can give wrong readings, which is dangerous for the flight. That's why using a pitot tube cover is important when the aircraft is parked. It helps protect the tube and keeps the readings accurate .

Vinyl is one common material for covers because it's cheap and water-resistant. Marine vinyl is stronger and can handle sunlight and cold weather. Some covers have fiber backing to make them more durable. They usually come with a red "Remove Before Flight" tag made from strong material so it won't tear easily.

Kevlar is another good material. It's very strong, can handle high heat, doesn't melt, and is fireproof. Some Kevlar covers also protect the probe tip and are used on military or commercial planes. If the pitot heat is turned on by mistake, Kevlar won't melt and block the tube.

Plastic covers are also used. They are cheaper and still protect well, especially for small aircraft. Some even have holes to release pressure. Fabric like canvas or Taslan is used in DIY or smart covers with warning systems.

Good pitot covers must be strong, heat-resistant, and able to survive any weather. Some covers follow safety standards like fire resistance and strong streamer design. All this shows that pitot covers are small but very important to keep flights safe.

## 2. 3 Review of Recent Search / Related Products

### 2.3.1 Related Patented Products

#### 2.3.1.1 Patent A

Table 2: Review Of Patent A

Bil.	Product	Description
1.		<p>NAME: ASA REMOVE BEFORE FLIGHT Pilot Tube Cover  MANUFACTURER: ASA</p> <p>MATERIAL USED: Heavy-Duty Plastic Material</p> <p>DIMENSION BODY: 5/8" Pitot 2 x 17"</p> <p>Abstract: This pitot tube cover is designed to fit securely over 5/8" pitot systems commonly found on Cessna 300 and 400 series aircraft, Citation and Conquest models; Beechcraft single- and twin-engine aircraft; Piper Navajo, Cheyenne, and most G1000-equipped Mirage, Matrix, and Meridian models; as well as Mooney, Mitsubishi, Learjet, and Cirrus aircraft.</p> <p>Essential for ensuring flight safety, the cover protects the pitot tube from dirt, debris, and insect contamination. It features a highly visible red "Remove Before Flight" streamer, serving as a clear and critical preflight safety reminder for flight crews. Constructed from durable, heavy-duty plastic, the attached 2" x 17" banner is screen-printed in white on a bright red background to maximize visibility.</p>

### 2.3.1.2 Patent B

**Table 3: Review Of Patent B**

Bil	Product	Description
1.		<p>NAME: KPC4 SERIES</p> <p>MANUFACTURER: Sesame Technologies, Inc</p> <p>MATERIAL USES: Triple-layered Kevlar</p>

### 2.3.1.3 Patent C

**Table 4: Review Of Patent C**

Bil.	Product	Description
1.		<p>NAME: Pitot Shield V2 Smart cover Model: Pitot Shield version 2 standard size</p> <p>MANUFACTURER: DeGroff Aviation Technologies</p> <p>MATERIAL USED: Polypropylene</p> <p>DIMENSION BODY: Length 5.2in Diameter 2.25in Weight 120g</p> <p>Abstract: This standard size pitot shield v2 smart cover fits nearly all turbine aircraft round pitot tubes. If the tip of the pitot tube is less than 3in/76mm from the mast or the diameter at 3in/76mm from the tip is less than 0.47in/12mm, or the pilot tube diameter within three inches from the tip is greater than 13/16in (21mm), the standard pitot shield v2 smart cover will not fit</p>

### 2.3.1.4 Patent D

**Table 5 : Review Of Patent D**

No.	Product	Description
1.		<p>Name : KPC6 Series Pitot Tube Covers</p> <p>Manufacturer : SESAME Technologies</p> <p>Material Used : Kevlar</p> <p>Abstract : The design boasts tough as nails kevlar construction that provides a strong barrier against slashes , cuts , punctures and delivers durability , stiffness , fire protection thus providing exceptional protection of the pitot probe .</p>

### 2.3.2 Recent Market Products

#### 2.3.2.1 Product A



**Figure 7 : Aviation Supplies & Academics, Inc.**

Aviation Supplies & Academics, Inc. (ASA) as shown in figure 7, began in 1940 as Merrell Aviation Ground School, primarily focused on training post-war military pilots for civilian aviation roles. Initially producing plotters, regulations, and training manuals, the company expanded its offerings in the 1960s to include a broader range of pilot supplies and educational materials.

In 1969, the organization became the Northwest School of Aviation, aiming to franchise under the name Aviation Seminars of America (ASA). The name changed to

Aviation Supplies and Academics in 1976, aligning more closely with its expanded focus on publishing and training. ASA was incorporated in 1977 and shifted its mission to manufacturing and publishing aviation education products.

The company sold its ground school and retail store in the 1980s to concentrate entirely on educational publishing and pilot supplies. It relocated to larger facilities in 1985 and again in 1990 to support its growing operations.

ASA has published the FAR/AIM since 1945 and has produced test preparation materials for over 60 years. Today, its extensive product line includes textbooks, software, online courses, videos, instructor tools, maintenance materials, flight computers (such as the E6-B and CX- 3®), and drone training resources.

ASA products are distributed globally and used across a wide range of training environments, including ICAO, CAA, FAA Part 61/107/141/147 programs, universities, aviation schools, and by individual aviators. With over 85 years of experience, ASA is a trusted provider of aviation training solutions, known for its commitment to quality, consistency, and customer service.

### 2.3.2.2 Product B



**Figure 8 : Sesame Technologies, Inc.**

Sesame Technologies, Inc. as shown in figure 8, is a U.S.-based company specializing in high-temperature aviation ground support equipment (GSE). Since its founding in 1990, the company has built a reputation for innovation, quality craftsmanship, and safety-driven solutions.

Their offerings include protective equipment for sensitive aircraft components, such as pitot tube covers, static port covers, ice detector covers, and engine shields. These products are designed to withstand harsh environments and ensure safety during ground operations. The company operates under a rigorous quality management system certified to ISO 9001:2015 and compliant with AS9100D standards. They are also a 10-time recipient of the Boeing Performance Excellence Award.

Sesame Technologies, Inc. is a Licensee of The Boeing Company and has license rights to use Boeing proprietary data for the sale of high-temperature GSE products in support of Boeing aircraft

### 2.3.2.3 Product C



**Figure 9 : DeGross Aviation Technologies**

DeGross Aviation Technologies as shown in figure 9, is a company based in the United States that has been operating since 1985. They focus on developing and manufacturing aviation safety products for corporate, commercial, and general aviation. The company is known for its innovation in pitot tube covers, especially the Pitot Shield and Pitot Shield V2. These pitot tube covers are designed to automatically detach when pitot heat is activated, helping to prevent human error during aircraft operation. The Pitot Shield V2 is made to fall off within 2 to 5 minutes after pitot heat activation, ensuring the pitot tube is clear before take off.

DeGross Aviation Technologies manufactures products that can fit a wide range of aircraft, including Airbus, Boeing, Gulfstream, and Cessna models. Their products are used by pilots and maintenance crews to improve operational safety and reduce the

chance of critical mistakes. Besides pitot tube covers, they also design and sell other aviation safety equipment such as lightweight wheel chocks, high visibility streamers, EZ Lock tie downs, navigation light reflectors, and various cockpit accessories.

All their products are proudly designed and manufactured in the United States. DeGroff Aviation Technologies emphasizes quality, durability, and user friendliness in every product they offer. Their solutions are built to meet the demands of modern aviation, where reliability and safety are top priorities. Through years of experience, the company continues to contribute to the aviation industry by providing smart, effective, and simple to use safety tools for pilots and aircraft technicians around the world.

#### 2.3.2.4 Product D



**Figure 10 : Sesame Technologies**

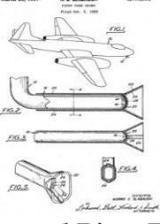
The company serves executive, commercial, and military aviation sectors worldwide. At the heart of Sesame Technologist's success lies its commitment to quality, safety, and precision. The company offers to main product lines which is the signature series and the executive series GSE. The signature series is a longstanding line in the company's catalog includes pitot tube covers, total air temperature sensors cover, static wick covers and ice detector covers. These products are specifically engineered to endure extreme temperatures and harsh operational environments and also utilizing advanced materials such as DuPont Kevlar and Nomex. This ensures maximum protection for critical aircraft sensors and systems during ground operations.

Other than that, Sesame Technologies as shown in figure 10, is not only dedicated to producing high performance equipment but also to maintaining the highest standards of quality management. The company's processes are ISO 9001:2015 certified and AS9100D compliant and ensuring rigorous control over every step of production. Each component undergoes 100% inspection from raw material selection to final assembly and reinforcing the company's reputation for consistency and reliability.

In recognition of its outstanding performance, Sesame Technologies has received the Boeing Performance Excellence Award on multiple occasions and is officially licensed to use Boeing Propriety data for the production and sale of high temperature ground support equipment.

## 2.4 Comparison Between Recent Research And Current Project

**Table 6 : Comparison Of Other Pitot Tube Covers**

Feature	 <p>Patented Pitot Tube Cover</p>	 <p>Pitot Tube Cover Blade Style</p>	 <p>Next Gen Pitot Tube Cover</p>
Material	High-grade plastic or metal with frangible sections for self-removal.	Rubber, silicone, or plastic.	Polypropylene.
Temperature resistance	Up to 1100°F (593°C) with ceramic or heat-resistant materials.	Typically up to 100°C.	-20°C to 130°C.
Warning system	Some designs include pressure sensors or frangible features that activate upon airflow.	Usually no warning system.	Yes – Micro:bit- based alert system.
Disengagement function	Auto-disengage via airflow- induced breakaway mechanisms.	Manual removal only.	Auto-disengage system integrated.
Durability	Designed for long-term use and harsh conditions.	Moderate to high.	High – suitable for operational conditions.
Cost	High due to advanced features and patented design.	Low to moderate.	Moderate – balances cost and innovation.
Market Availability	Limited to specific aviation suppliers.	Widely available.	Not yet on market (prototype stage).

# CHAPTER 3

## RESEARCH METHODOLOGY

### 3.1 PROJECT BRIEFING AND RISK ASSESSMENT

#### 3.1.1 Utilization Of Polytechnic's Facilities

The facilities provided by the Polytechnic, including the laboratory spaces, Wi-Fi network, Microcontroller Lab, and aircraft training equipment, played a crucial role in supporting the development of the Smart Pitot Guard. These facilities enabled us to perform prototype fabrication, coding and testing of the Micro:bit warning system, and validation of the auto-disengage mechanism on actual training aircraft pitot tube structures.

By fully utilising these institutional resources, we were able to improve our project efficiency, enhance testing accuracy, and ensure the reliability of the Smart Pitot Guard under realistic conditions. This experience demonstrates the importance of proper facility utilisation in strengthening innovation, improving productivity, and supporting successful engineering project outcomes.

#### 3.1.2 Project Collaboration & Transfer Of Technology

The development of the Smart Pitot Guard was further improved through collaboration with two key partners: Asia Digital Engineering (also known as ADE) and Cytron Technologies. Their contributions provided valuable industrial and technological support that greatly shaped the product's overall performance and practicality.

Asia Digital Engineering, a recognised organisation in aircraft maintenance and engineering, shared essential insights into pitot tube contamination risks, ground-handling procedures, and

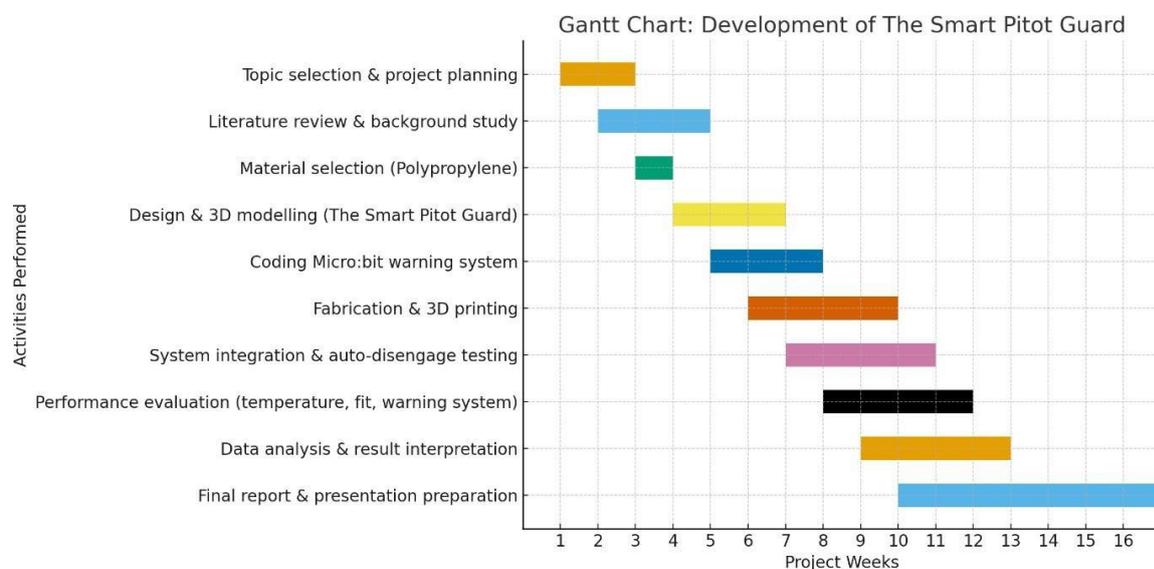
operational safety requirements. Their feedback helped us refine the auto-disengage mechanism to ensure that the Smart Pitot Guard does not interfere with line maintenance activities and remains fully compatible with aviation industry practices.

Cytron Technologies, a leading provider of microcontroller and electronic development tools, offered technical guidance in improving the Micro:bit-based warning system. Their support helped enhance coding structure, circuit safety, and system responsiveness—while maintaining the project’s design requirement of avoiding advanced technologies such as NFC, QR, pressure sensors, Bluetooth, or solar power. Their involvement ensured that the system remains simple, cost-effective, and reliable for aviation training environments.

The collaboration with ADE and Cytron Technologies has significantly enhanced the innovation and technical strength of the Smart Pitot Guard, resulting in a product that is practical, efficient, and aligned with real-world aviation standards. This partnership successfully integrates engineering knowledge, technological development, and industry experience to create a safer and more effective pitot tube protection system.

### 3.2 OVERALL PROJECT GANTT CHART

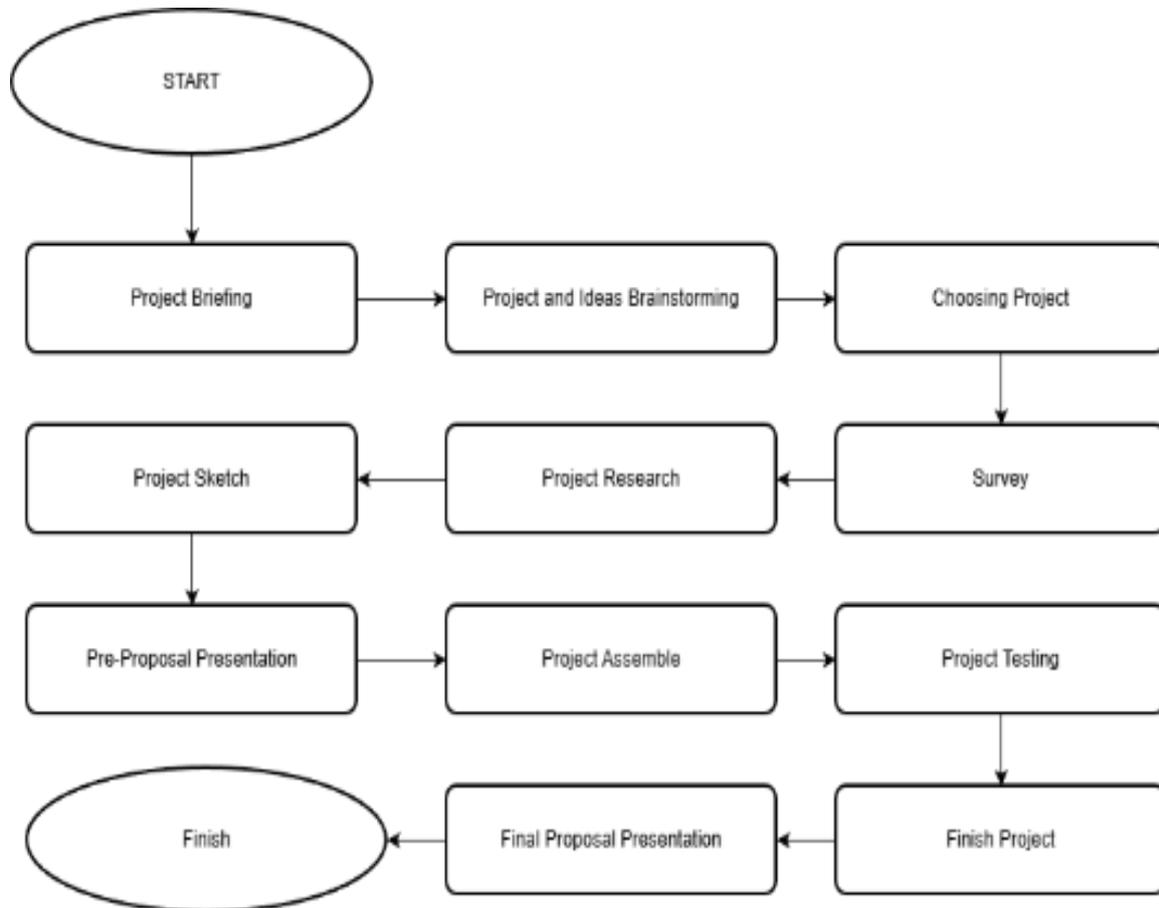
**Table 7: Overall Smart Pitot Guard**



### 3.3 PROJECT FLOW CHART

#### 3.3.1 Overall Project Flow Chart

Table 8 : Overall Project Flow Chart



## **3.3.2 Specific Project Design Flow / Framework**

### **3.3.2.1 Product Structure**

The design process for the Smart Pitot Guard focuses on developing the physical structure and supporting electronic framework required to protect the pitot tube during aircraft parking.

The product structure consists of the following stages:

#### **1. Hardware Structure**

The hardware structure involves the development of the mechanical and electronic assembly of the SPG. This includes:

- Polypropylene cover body designed to fit securely onto the pitot tube
- Mechanical auto-disengage system for removal during engine start vibration
- Microbit board as the main controller
- Power supply module, PCB wiring, and onboard warning indicator

The design priorities durability, weather resistance, and ease of installation during aircraft ground operation.

#### **2. System Layout Design**

A planned arrangement of internal components is developed, including:

- Microcontroller positioning
- Magnetic latch placement
- Sensor location (if used)
- Routing of wiring to the LED warning system
- The layout ensures ease of assembly, accessibility, structural rigidity and weight efficiency.

### **3.3.2.2 Product Mechanism**

The product mechanism describes how Smart Pitot Guard operates and performs its protective and warning functions.

#### **1. Protection Mechanism**

- The polypropylene cover is installed onto the pitot tube to prevent dust, insects, and debris intrusion.
- Mechanical locking design ensures firm attachment during ground conditions.
- Auto disengage system allows the cover to drop safely when vibration is detected.

#### **2. Warning System Mechanism**

- Microbit provides visual blinking warning as external alert.
- LED indicator warns the ground crew that the cover is still attached.
- Timing code controls LED flashing cycles for energy efficiency.

#### **3. Workflow Mechanism**

- Cover installed manually by crew → LED activates automatically
- Before aircraft departure → LED continues warning
- Aircraft vibration → auto-disengage is triggered
- Cover safely detached

### **3.3.2.3 Software / Programming**

The software design focuses on Microbit programming for the external warning function.

#### **Platform Selection**

1. Microsoft Make Code environment Microbit firmware environment

#### **Programming Logic**

2. LED blinking cycle coded to always maintain high visibility
3. Auto-run script when power supplied
4. Emergency blinking pattern for increased visibility

## **System Integration**

- Programming linked to power module and external wiring
- LED brightness calibrated for outdoor visibility

## **Testing and debugging**

- Testing LED visibility during daylight and night
- Debugging power consumption and stability
- Testing proper functioning during prolonged operation

### **3.3.2.4 Accessories / Finishing**

This stage focuses on achieving usability and proper product presentation.

#### **1. Accessories**

- Nylon rope attachment to prevent losing the cover on ground
- Protective foam insert to avoid pitot surface scratches
- Storage pouch when not installed

#### **2. Finishing**

- Smoothing and rounding of edges for safety handling
- Ensuring color remains standard for airport ground visibility
- Surface finishing for wear resistance

#### **3. Packaging and Presentation**

- Instruction manual and installation guide
- Usage and safety label
- Proper storage method for maintenance crew

## 3.4 Product Description

### 3.4.1 Design Requirement Analysis

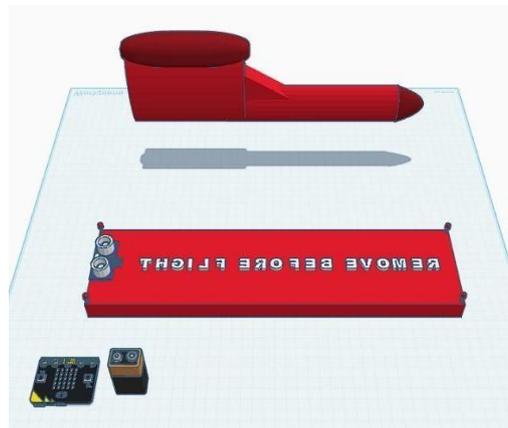


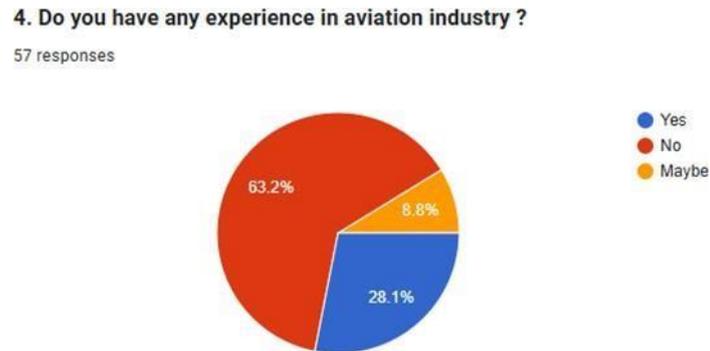
Figure 11 : 3D Design Of SPG

The Smart Pitot Guard as shown in figure 12, is an innovative aircraft ground safety device designed to provide superior protection for pitot tubes against environmental contamination, such as dust, insects, moisture, and debris. Engineered with durable, UV resistant materials, the cover ensures reliable performance across extreme weather conditions while maintaining a lightweight structure for ease of handling. It features an integrated high visibility remove before flight warning flag to enhance pre-flight safety procedures and minimize the risk of oversight. Designed to fit standard commercial aircraft pitot tubes, the cover offers exceptional durability, chemical resistance, and user friendly installation, meeting both operational requirements and regulatory standard for aviation ground equipment.

#### 3.4.1.1 Questionnaire Survey

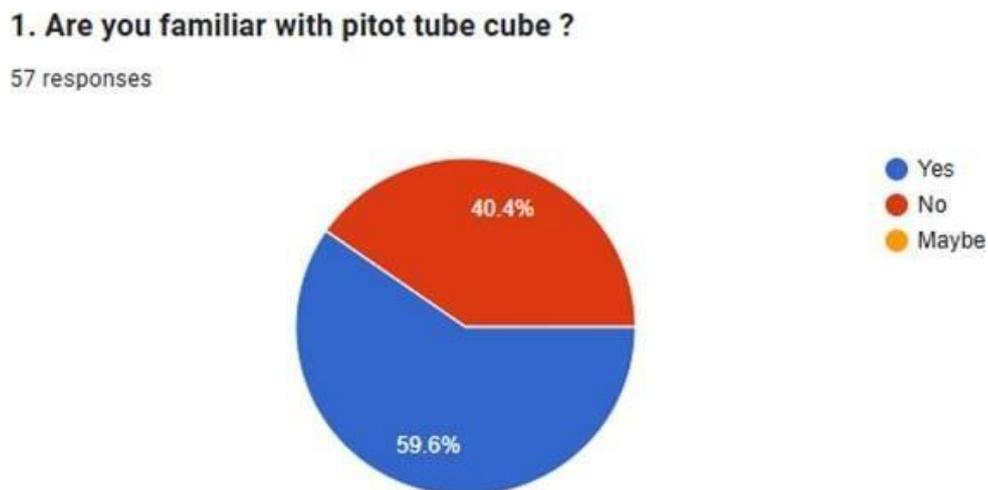
Surveys provide structured and quantifiable data making them useful for analysis and decision making. It also helps to understand public or target audiences opinion on a topic . Surveys also are the simplest and time efficient method as it can be distributed to a broad demographic and allow quick responses. We examined the questionnaire

data and created charts and graphs for better understanding. The following are some of the essential questions that helps us analyse the topic from the overall questionnaire which was completed by 57 respondents as shown in figure 13, from varied background.



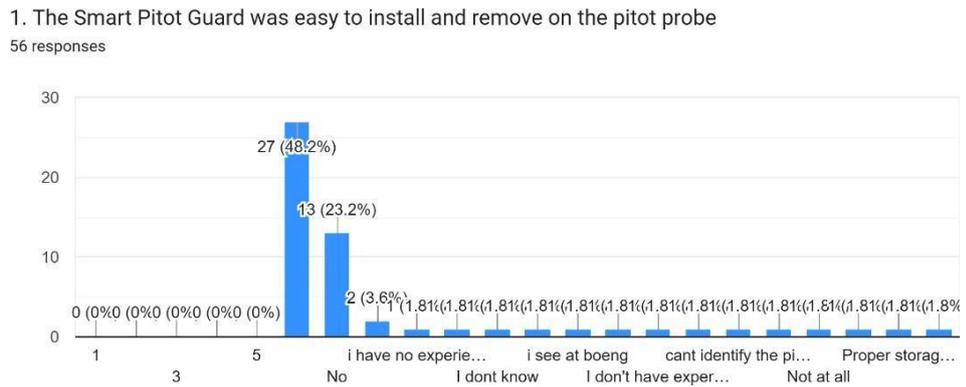
**Figure 12 : Survey Question 1**

We start the data analysis by asking them if they were familiar with the pitot tube cover in the aviation industry and the majority of the user (59.6%) responded yes as shown in figure 14. The percentage of no answer is approximately (40.4%)



**Figure 13 : Survey Question 2**

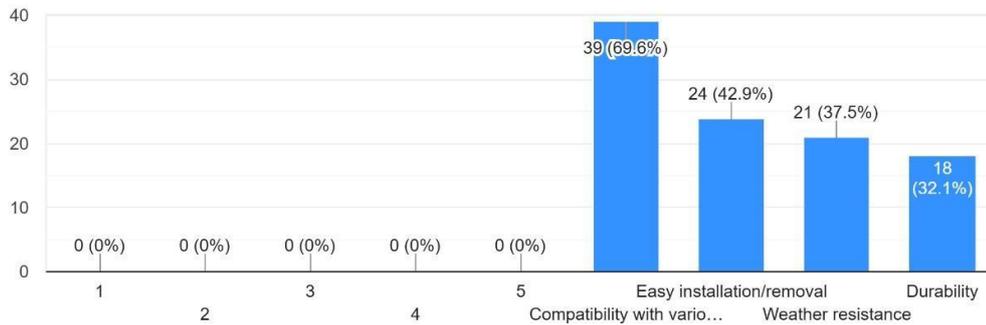
One of the questions asked was the important factors to consider when designing aircraft pitot tube cover as shown in figure 15. Based on the results, cost effectiveness was the most highly rated factor, indicating that respondents prioritize affordability. Other than that, over half of the respondents highlighted the importance of preventing from contamination which plays a critical role to maintain accurate airspeed readings and flight safety.



**Figure 14 : Survey Question 3**

Another question that was asked is about the trial evaluation of the Smart Pitot Guard received positive feedback from the respondents as shown in figure 16. Most participants agreed that the product was easy to install and remove on the pitot probe and showing its user friendly and ergonomic design.

2. The polypropylene material felt durable and suitable for ramp environment.  
56 responses



**Figure 15 : Survey Question 4**

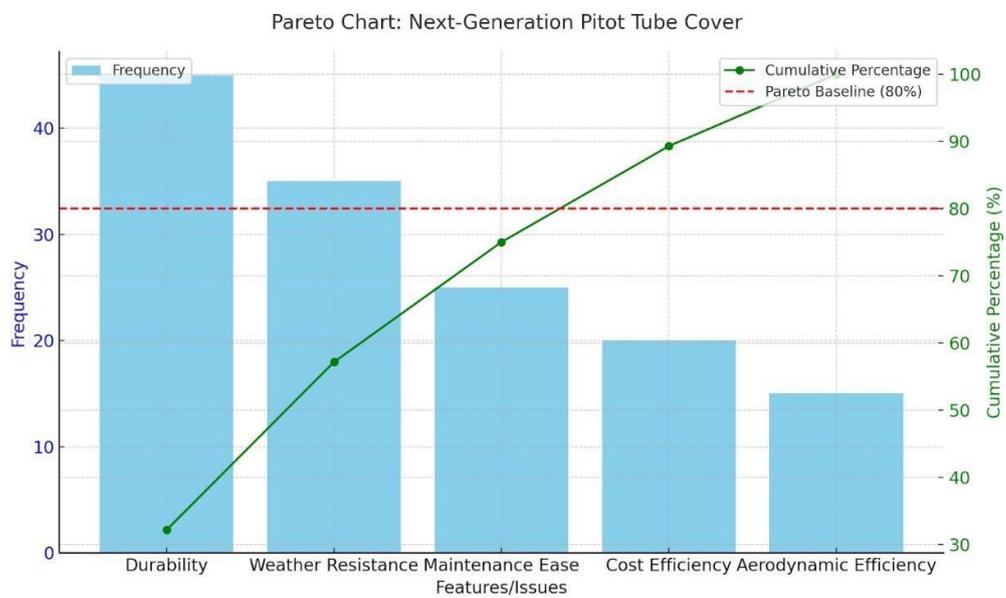
Respondents also commented that the polypropylene material felt durable and suitable for the ramp environment. The material provided a solid and reliable feel also suggesting that it can endure harsh weather conditions, heat exposure and routine handling on the flight line. To analyse how important it is to incorporate advanced materials into aircraft pitot tube covers, we can approach data analysis. Most of them agreed that the advanced materials are very important

### 3.4.1.2 PARETO DIAGRAM

#### RANKING THE PROBLEM USING ARETO CHART DIAGRAM

**Table 9: Pareto Chart**

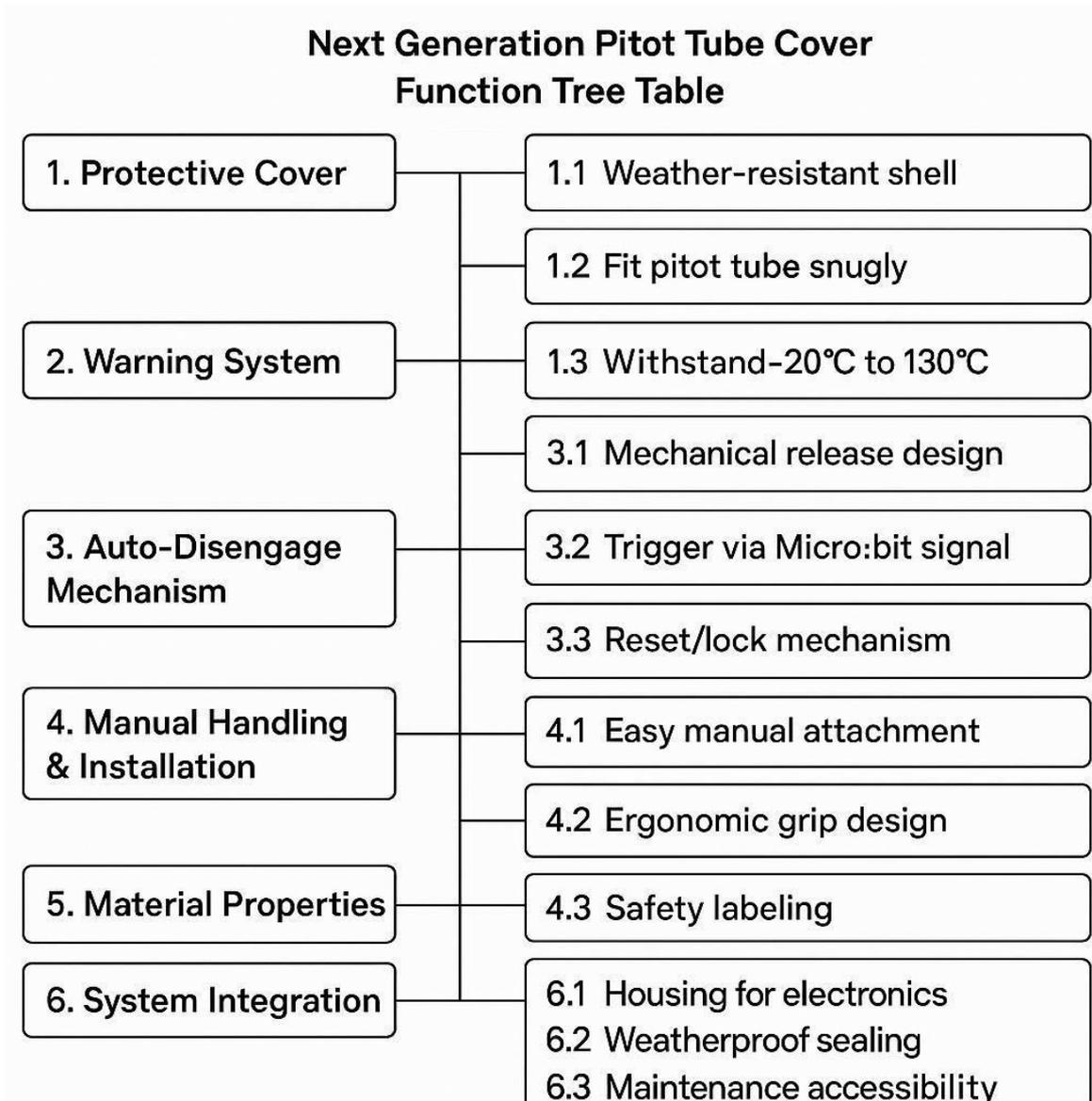
Features/Issues	Frequency	Cumulative Frequency	Cumulative Percentage (%)
Durability	45	45	28.48
Weather Resistance	35	80	50.63
Maintenance Ease	25	105	66.46
Cost Efficiency	20	125	79.75
Aerodynamic Efficiency	15	140	100.00
<b>Total</b>	<b>140</b>		



## 3.4.2 Design Concept Generation

### 3.4.2.1 Function Tree

Table 10 : Function Tree



### 3.4.2.2 Morphological Matrix

**Table 11 : Morphological Matrix**

<b><u>ASSIGNMENT 2 : MORPHOLOGICAL MATRIX</u></b>				
	MIRZA FAQIHAH	WAJDI BE'AUNILLAH	UWEIS QAWI	ARIF HIFZAN
<b>FUNCTION (SUB-FUNCTION)</b>	<b>IDEA 1</b>	<b>IDEA 2</b>	<b>IDEA 3</b>	<b>IDEA 4</b>
<b>MATERIAL</b>	Hybrid Materials	Vinyl	High density polyethylene	Fiberglass
<b>DESIGN</b>	Ergonomic Grip	Sleeve type	Round cover	Valcro
<b>HARDWARE</b>	Flexible Inner Lining	Pitot tube cover	Flashing lights	
<b>COLOUR</b>	Fluorescent Green	Orange and yellow	Bright red	Yellow
<b>SEWING TECHNIQUE</b>	Lockstitch	-	Chain stitch	Backstitch
<b>Software</b>		Arduino		

### 3.4.2.3 Proposed Design Concept 1

**Table 12 : Proposed Design Concept 1**

<b>FUNCTION</b>	<b>IDEA 1</b>	<b>JUSTIFICATION</b>
<b>MATERIAL</b>	Hybrid Material	The selection of hybrid materials for the next generation pitot tube cover is based on a combination of performance , durability , weight reduction , and environmental resistance . It also improved their durability and strength .
<b>DESIGN</b>	Ergonomic Grip	Easy to remove and install
<b>HARDWARE</b>	Flexible Inner Lining	Ensure tight seal around the pitot tube while preventing scratches
<b>COLOUR</b>	Fluorescent Green	High visibility in various lighting conditions . Whether in daylight , low-light environments , or adverse weather conditions , fluorescent green stands out more effectively than traditional red or black covers . This ensures that maintenance personnel can quickly locate and remove before flight , reducing the risk of takeoff incidents caused by an obstructed pitot tube .

### 3.4.2.4 Proposed Design Concept 2

Table 13 : Proposed Design Concept 2

<b>FUNCTION</b>	<b>IDEA 1</b>	<b>JUSTIFICATION</b>
<b>MATERIAL</b>	vinyl	A common choice due to its affordability, weather resistance, and ability to be easily sewn or molded to fit the pitot tube shape.
<b>DESIGN</b>	Sleeve type	A simple longer cover just like a tube that slides on over pitot tube probe to provide extra protection pitot tube from insect or any debris and also fabric cover with “REMOVE BEFORE FLIGHT” tag
<b>HARDWARE</b>	Pitot tube cover	Serves as a component placement and cover for the pitot tube.
<b>COLOUR</b>	Orange and yellow	Orange and Yellow is bright colour and making it easy to spot in various lighting conditions to ensure high visibility during pre flight checks.
<b>SOFTWARE</b>	Arduino	As a processor and runs the role of a pitot tube cover based on Artificial Intelligence. Where Arduino contains several programming languages that are inputted as a database.

### 3.4.2.5 Proposed Design Concept 3

**Table 14 : Proposed Design Concept 3**

<b>FUNCTION</b>	<b>IDEA 1</b>	<b>JUSTIFICATION</b>
<b>MATERIAL</b>	High density polyethylene	HDPE (High Density Polyethylene) is a type of heavy duty plastic. HDPE is known for its weatherproof, such as resistant to water and temperature variations, making it suitable for outdoor use.
<b>DESIGN</b>	Round cover	When making a pitot tube cover, the important aspect is to make it easy to install and remove. By using round cover, the cover can be slipped on off with ease.
<b>HARDWARE</b>	Flashing lights	Flashing lights indication can be useful as it can attract technicians attention showing that the pitot tube cover is still attached.
<b>COLOUR</b>	Bright red	It is crucial to make the pitot tube cover using bright colours so it can stand out. Most aircraft surfaces are neutral-coloured such as grey, white and metallic. This may enhances the visibility of the technician to remove them before flight.

### 3.4.2.6 Proposed Design Concept 4

**Table 15: Proposed Design Concept 4**

<b>FUNCTION</b>	<b>IDEA 1</b>	<b>JUSTIFICATION</b>
<b>MATERIAL</b>	Silicone-coated fabric	Heat-resistant and durable
<b>DESIGN</b>	Valcro	The loop and the hook make it strong when press
<b>HARDWARE</b>	-	-
<b>COLOUR</b>	Yellow	It was a bright colour so it was highly visible

### **3.4.2.7 Accepted vs Discarded Solution**

According to all the concepts that we researched, we decided to come out with another concept, which is Concept 5, as our final project. This is because Concept 5 uses advanced material technology to enhance the pitot tube cover. Vinyl is selected as the main material due to its affordability, weather resistance, and ease of molding. The design chosen is a round cover, ensuring easy installation and removal while providing maximum protection.

For hardware, the pitot tube cover itself acts as the primary component, offering durability and functionality. The color selected is bright red, ensuring high visibility against aircraft surfaces to alert maintenance personnel before flight. The sewing technique used is a lockstitch, which is strong and secure, preventing unraveling and ensuring the covers longevity.

Additionally, this concept incorporates software integration using microbit. The micro bit as a small computer that controls and interacts with electronic components. It can senses change in the environment using built in sensors, process the data through programmed instruction and respond by showing outputs such as lights, sound, or movements. In short , the micro bit acts as a controller, sensor and communicator in various projects.

### 3.4.3 Related Patented Product

#### 3.4.3.1 Pugh Matrix

Table 16 : Pugh Matrix

<b>CRITERIA</b>	<b>CONCEPT 1</b>	<b>CONCEPT 2</b>	<b>CONCEPT 3</b>	<b>CONCEPT 4</b>	<b>CONCEPT 5</b>
<b>Material</b>	2	3	1	D	3
<b>Design</b>	1	1	3	A	3
<b>Hardware</b>	3	3	3	T	3
<b>Colour</b>	3	2	3	U	3
<b>Sewing Technique</b>	1	3	3	M	3
<b>Software</b>	1	3	1	-	3
<b>Total Score</b>	11	15	14	-	18
<b>Ranking</b>	4	2	3	-	1

### 3.4.3.2 Conceptual Design of the Proposed Product

**Table 17 : Final Proposed Product Design**

<b>FUNCTION</b>	<b>IDEA 1</b>	<b>JUSTIFICATION</b>
MATERIAL	Vinly	A common choice due to its affordability, weather resistance and ability to be easily sen or molded to fit the pitot tube shape
DESIGN	Round Cover	When making a pitot tube cover, the important aspect is to make it easy to install and remove. By using round cover, the cover can be slipped on off with ease.
HARDWARE	Pitot Tube Cover	Serves as a component placement and cover for the pitot tube
COLOUR	Bright Red	It is crucial to make the pitot tube cover using bright colours so it can stand out. Most aircraft surfaces are neutral coloured such as grey,white and metallic. This may enchances the visibility of the technician to remove them before flight.
SOFTWARE	Micro bit	Acts as a small computer that controls and interacts with electronic components. It can sense changes in the environment using its built in sensors.

### 3.5 PRODUCT SKETCHES / WIRING DIAGRAM / \*INTERFACE LAYOUTS

#### 3.5.1 General Product Drawing General Interface Layout

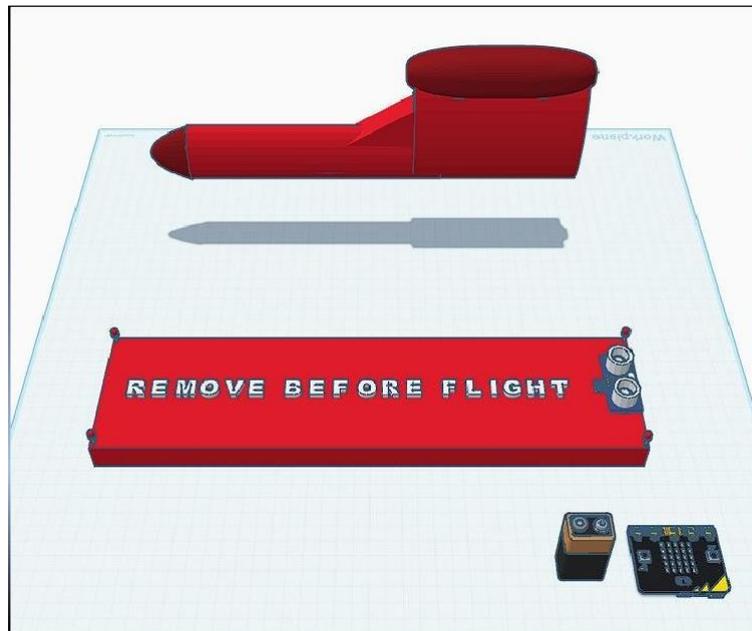


Figure 16 : Full Design Of SPG

Figure 16 shows the full design of our next generation pitot tube cover system made in Tinkercad. On top is the pitot tube model, shaped like the real one used on aircraft. In the center is the red cover part with the words “REMOVE BEFORE FLIGHT” to act as a warning tag. On the right side of the cover, I added two ultrasonic sensors to detect if the pitot tube is still covered. At the bottom right, there is a Micro: bit and a 9V battery which are used to power the warning system. This design combines the usual safety method with a digital system that can alert the user if the cover is not removed before flight.

### **3.5.2 Specific Part Drawing Specific Interface Layout**

- Pitot Tube Model (Top of the Workspace)

A 3D representation of an aircraft pitot tube, shaped accurately to match the real part used for measuring airspeed. It is placed at the top of the Tinkercad workspace.

- Protective Cover with Warning Label (Center)

A rectangular red cover designed to fit over the pitot tube.

The words “REMOVE BEFORE FLIGHT” are clearly written on top in raised white letters to act as a visual warning. This part serves both as a physical barrier and a standard safety reminder for ground crews.

- Ultrasonic Sensors (Right Side of the Cover)

Two ultrasonic distance sensors are attached to the right end of the red cover.

Their function is to detect whether the cover is still on the pitot tube, enabling automatic detection.

- micro: bit Microcontroller (Bottom Right Corner)

Positioned separately at the bottom-right area of the workspace.

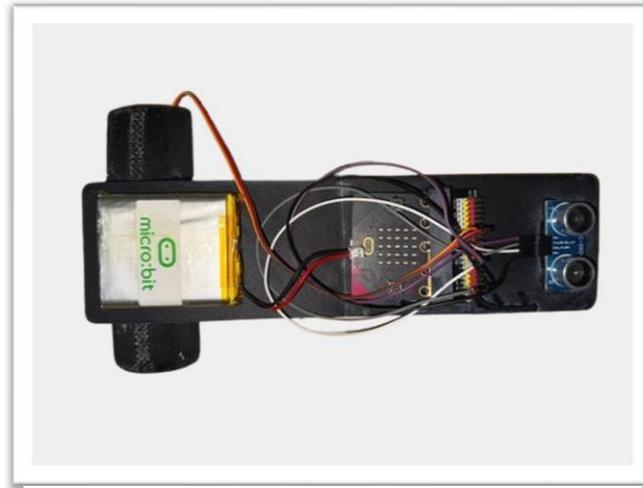
It acts as the brain of the system, receiving signals from the sensors and triggering the warning system if needed.

- 9V Battery (Next to the micro: bit)

Also placed in the bottom-right section.

Provides power to the micro: bit and the sensors, making the system operational.

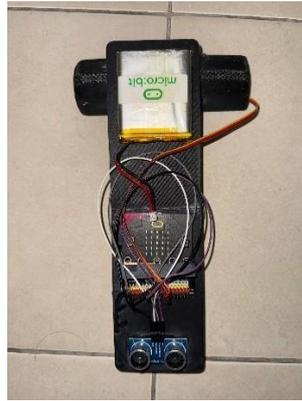
### 3.5.2.1 Product Structure



**Figure 17: Components Of SPG**

Our pitot tube cover consists of two primary components as shown in figure 17. The main cover and a strap with a “REMOVE BEFORE FLIGHT” tag. The main cover is designed to fit snugly over the aircraft’s pitot probe, providing protection against environmental elements such as dust, insects, and moisture while the aircraft is parked. It is made from a durable, heat-resistant material such as heavy duty plastics, ensuring it can withstand harsh weather conditions and temperature variations. The second component is a highly visible strap made from strong nylon or polyester fabric, attached firmly to the main cover. This strap includes a clearly marked “REMOVE BEFORE FLIGHT” tag in white lettering on a bright red background, in line with industry safety standards. The bright red color of both components enhances visibility during ground inspections.

### 3.5.2.2 Product Mechanisms



**Figure 18 : Mechanism Of SPG**

A smart pitot tube cover is a critical safety device designed to protect an aircraft's pitot tube from contaminants and obstructions while it is on the ground. This advanced cover integrates several key features to ensure it is noticed and removed before flight, including a continuous buzzer alarm, flickering LED lights, and a self-opening system as shown in figure 18, like the Pitot Shield V2™ Smart Cover™.

This pitot tube cover is equipped with a high-decibel buzzer, that activates when the aircraft's systems detect startup procedures. Once triggered, the buzzer emits a loud, continuous alarm that will not stop until the cover is manually removed or powered off. This ensures that ground personnel are alerted immediately if the cover is still in place, preventing potential safety hazards caused by an obstructed pitot tube during flight. In addition to the buzzer, the cover features flickering LED lights designed to provide a clear visual signal. The LED lights begin flashing when it was manually on and continue until the cover is removed. The high intensity flickering pattern ensures visibility in both daylight and nighttime conditions, making it easy for ground crews to recognize that the cover is still attached. This redundancy in warning systems helps minimize human error in aircraft operations. To further enhance safety, this smart pitot tube cover incorporates a self-opening system like the Pitot Shield V2™ Smart Cover™. The cover is designed with a thermal actuator, which responds to heat from the aircraft's pitot heat system. When the pitot heat is powered on, the actuator triggers an automatic release mechanism, causing the cover to detach without requiring manual intervention. This

process typically occurs within 2-5 minutes of startup, ensuring the pitot tube is unobstructed before take-off.

This combination of audible, visual, and automated safety features makes the smart pitot tube cover an essential tool for preventing airspeed measurement errors and ensuring safe aircraft operations.

### 3.5.2.3 Software/Programming

```
1 basic.forever(function () {
2   // Measure distance using the ultrasonic sensor
3   distance = sonar.ping(
4     DigitalPin.P1,
5     DigitalPin.P2,
6     PingUnit.Centimeters
7   )
8   // Check if the distance is within the warning range (0-100 cm)
9   if (distance > 0 && distance <= 100) {
10    // Trigger warning sound
11    // Play a tone
12    music.playTone(262, music.beat(BeatFraction.Whole))
13    // Display warning message
14    basic.showString("REMOVE COVER!")
15  } else {
16    // Clear the display if no warning
17    basic.clearScreen()
18  }
19  // Wait for 1 second before the next check
20  basic.pause(1000)
21 }
22 })
23
```

Figure 19 : Make Code

The software and programming features of the pitot tube cover warning system using Micro bit focus on safety using sensor detection and automated response. The system is programmed using Make Code as shown in figure 19, with a simple loop that runs forever to monitor real-time conditions. In this setup, an ultrasonic sensor is connected to pin P1 and pin P2 to measure distance between the sensor and any nearby object. If the measured distance is more than 0 and less than or equal to 100 centimeters, the system will activate the warning. This includes playing a tone using the Micro bit's sound module and displaying a warning message that says REMOVE COVER using the LED display. If the area is clear or the distance is more than 100 centimeters, the display will turn off and no sound will be played.

This logic makes the system smart enough to detect if the pitot tube is still covered or if there is an object in front of it. The code waits for 1 second between each check using

pause command to prevent false alerts and to save power. Compared to using a static switch, this version allows the system to detect based on real distance, which can also help identify foreign object presence. The program uses simple condition checking and clear outputs, which makes it easy to understand and effective for real applications. This proves that even basic programming on Micro bit can support aircraft safety in a reliable and practical way.

#### 3.5.2.4 Accessories & Finishing



**Figure 20 : Accessories Of SPG**

The accessories and finishing components as shown in figure 20, of the next generation pitot tube cover are designed to support both functionality and safety. One of the most prominent accessories included is the “ REMOVE BEFORE FLIGHT “ tag , a mandatory safety feature widely used in aviation . This tag is brightly colored is typically red with white lettering and made from high strength , weather resistant nylon or PVC . It is attached to the cover using a reinforced grommet and lanyard and making it highly visible to both ground crew and flight crew during walk around inspections . In addition to the remove before flight tag , reflective strips are integrated onto the surface of the cover . These strips are essential for operations during night time or low visibility condition to ensure the cover is easily spotted under hangar lighting or flashlights . High visibility finishing helps prevent incidents where the cover is unintentionally left on during takeoff preparations .

The finishing of the cover itself is a critical aspect of its design . The outer layer is coated with UV resistant , anti corrosive paint or polymer to withstand exposure to harsh environments including rain , sun , jet fuel vapors , and extreme temperatures . Smooth rounded edges prevent scratches or abrasions on aircraft surfaces . The interior of the cover may include a soft lining or silicone padding to avoid direct contact with the metal pitot tube to ensuring no damage occurs during installation or removal .

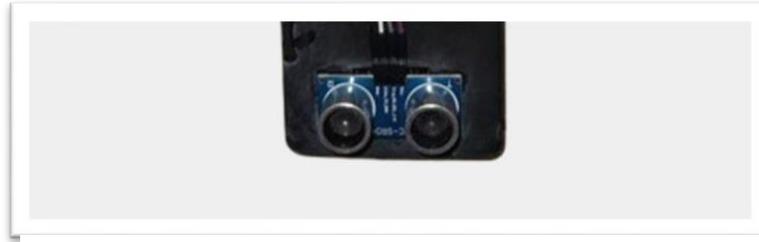
### **3.6 Prototype / Product Modelling**

#### **3.6.1 Prototype / Product Modelling**



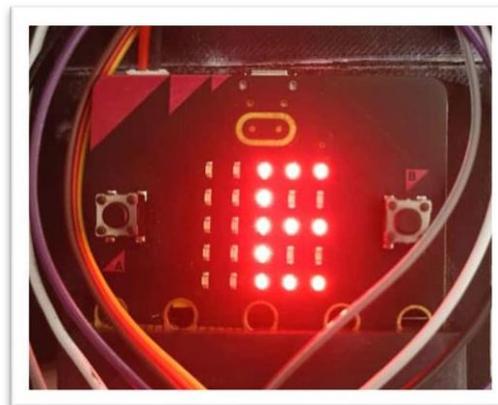
**Figure 21 : Polypropylene Filament**

The Smart Pitot Guard is an innovative 3D printed polypropylene as shown in figure 21, cover that provides strong protection and smart functionality for aircraft systems. It is lightweight, durable, and heat resistant, effectively protecting the pitot tube from dust, insects, and debris.



**Figure 22 : Ultrasonic Sensor**

The ultrasonic sensor as shown in figure 22, in the Smart Pitot Guard works together with the built-in warning buzzer to improve safety during ground operations. When the sensor detects a person or movement within 100 cm, it triggers the buzzer to beep five times, reminding the ground crew that the Smart Pitot Guard is still attached to the pitot tube. This feature provides extra safety in case the LED warning is not noticed, ensuring clear awareness before flight.



**Figure 23 : LED Lights**

The LED light as shown in figure 23, feature on the Smart Pitot Guard acts as the main visual warning system to ensure flight safety. It displays a bright “Remove Before Flight” message that can be seen clearly by both the ground crew and the pilot, reminding them that the Smart Pitot Guard is still attached to the pitot tube. This LED serves as the main visual alert, preventing any oversight before the aircraft begins operation.



**Figure 24 : Thermal Actuator**

The auto disengage feature as shown in figure 24, it works as a safety system to prevent flight incidents. When the pitot tube's anti-ice system heats up to around 100°C, the temperature sensor activates the servo motor to open the cover, allowing the SPG to release itself. This feature helps protect the aircraft if the ground crew forgets to remove the cover before flight.

### 3.7 Development of Product

#### 3.7.1 Material Acquisition

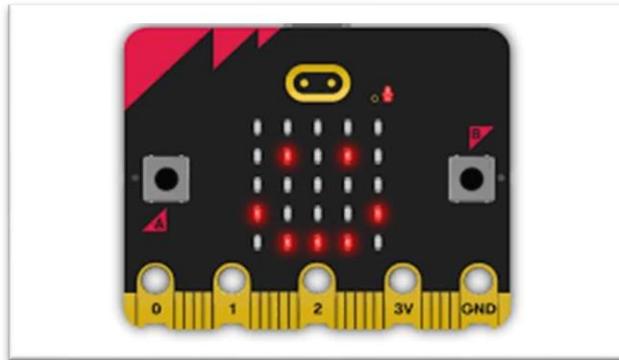
Table 18 : Material For Software

Item / Software	Description
<p data-bbox="97 589 316 622"><b>Microsoft Word</b></p> 	<p data-bbox="711 712 1493 801">Used to write, format, and organize the final year project report professionally according to institutional guidelines.</p>
<p data-bbox="97 1010 197 1043"><b>CIDOS</b></p>  <p data-bbox="97 1227 699 1279"><b>KEMENTERIAN PENDIDIKAN TINGGI</b> <b>JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI</b></p>	<p data-bbox="711 1104 1485 1193">Used to access reference materials, coursework guidelines, and institutional learning resources for the project.</p>
<p data-bbox="97 1361 248 1395"><b>MakeCode</b></p>  <p data-bbox="196 1686 616 1727"><b>Microsoft MakeCode</b></p>	<p data-bbox="711 1480 1501 1570">Programming software used to code and simulate the Micro: bit system, including the warning and auto-disengage features.</p>

### 3.7.2 Material and Tools

**Table 19 : Materials For Software**

<p><b>Shapr3D</b></p> 	<p>3D modeling software used to design the Smart Pitot Guard structure and components with precise dimensions before 3D printing.</p>
<p><b>Canva</b></p> 	<p>Used to create posters, infographics, and visual presentations for clear and attractive project displays.</p>
<p><b>ChatGPT</b></p> 	<p>Utilized as a virtual assistant to generate ideas, improve technical writing, and enhance report clarity throughout the project process.</p>
<p><b>Google Form</b></p> 	<p>Used to collect data, feedback, and responses from participants or evaluators for project validation and analysis.</p>



**Figure 25 : Micro;Bit Sensor**

A pocket-sized, programmable computer with a built-in buzzer, microphone, LED lights, gyro motion, temperature sensor, and Bluetooth.



**Figure 26 : Electrical Wiring**

Short electrical wires with connectors on each end used for temporary, solderless connections between electronic components and circuits.



**Figure 27 : Motion Sensor**

A device that uses high-frequency sound waves to measure distance or detect objects without physical contact.



**Figure 28 : Micro Servo Motor**

A low-cost, lightweight micro servo motor with a 180-degree rotation angle and 9g weight



**Figure 29 : Battery**

A thin, lightweight, and rechargeable battery known for its high energy density.



**Figure 30 : 3D Print Fillament**

strong, lightweight, and chemical-resistant thermoplastic materials used for 3D printing.

### **3.7.3 Project Fabrication**

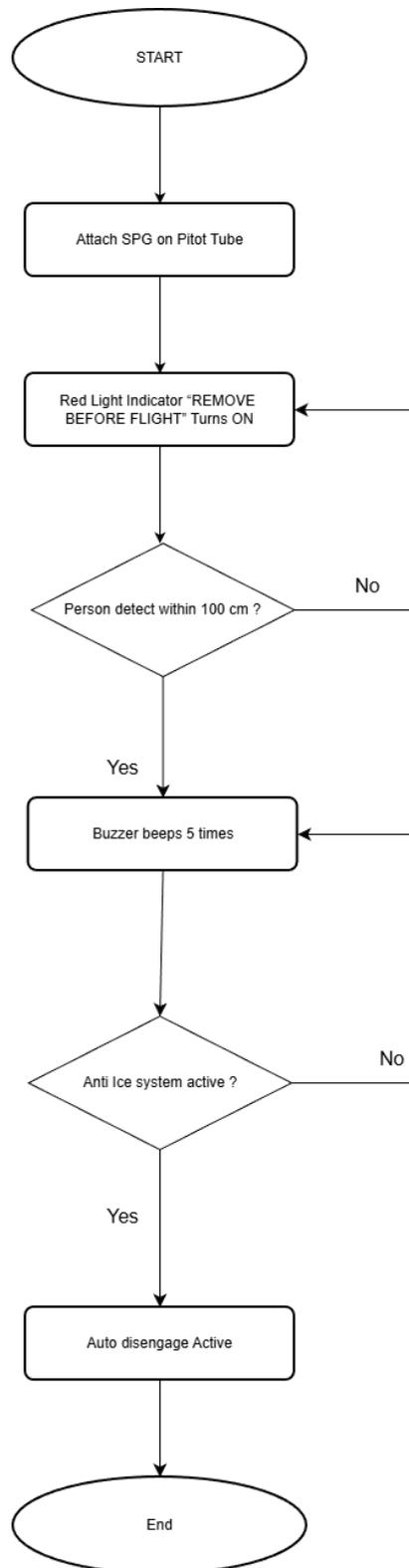
The project fabrication process began with selecting polypropylene as the main material due to its light weight, durability and suitability for 3D printing. The prototype was designed around a micro:bit controller and an actuator, which formed the core of the system's electronic and mechanical functions. The first stage involved creating a complete 3D model, where the dimensions, tolerances and component placements were planned to ensure proper fit and smooth assembly. After the design was finalised, all parts were produced using a 3D printer with settings adjusted specifically for polypropylene to prevent warping and ensure structural strength. Each printed component was inspected and corrected where necessary before moving on to the assembly stage.

Post-processing included trimming support structures and sanding contact areas to achieve a clean fit. The housing sections were then assembled, followed by the installation of the actuator and the placement of the micro:bit within its compartment. Wiring was arranged neatly to avoid interference with the actuator's movement. Once assembled, the prototype was tested to verify that the micro:bit could control the actuator effectively. The tests checked movement, responsiveness and overall structural stability. Any minor alignment or wiring issues were adjusted to improve performance.

Overall, the fabrication process combined careful 3D design, proper material handling and precise assembly, resulting in a functional polypropylene-based prototype that successfully integrates both mechanical and electronic components.

### 3.8 Product Testing / Functionality Tests

Table 20 : Product Testing Of SPG



### 3.9 List of Material & Expenditures

Table 21 : List Of Materials For SPG

No.	Items	Unit	Price (RM)
1	Polypropylene Filament	1 Roll	73.50
2	Micro: bit V2	1 Unit	85.00
3	Ultrasonic Sensor (HC-SR04)	1 Unit	4.90
4	Servo Motor (SG90)	1 Unit	6.50
5	Li-Po Battery	1 Unit	24.90
6	Jumper Wires	1 Set	2.50
7	Temperature Sensor	1 Unit	15.50
10	Buck Converter	1 Unit	20.10
11	Charger Module	1 Unit	5.00
	Total	11	203.30

# CHAPTER 4

## RESULT AND DISCUSSION

### 4.1 PRODUCT DISCRIPTION

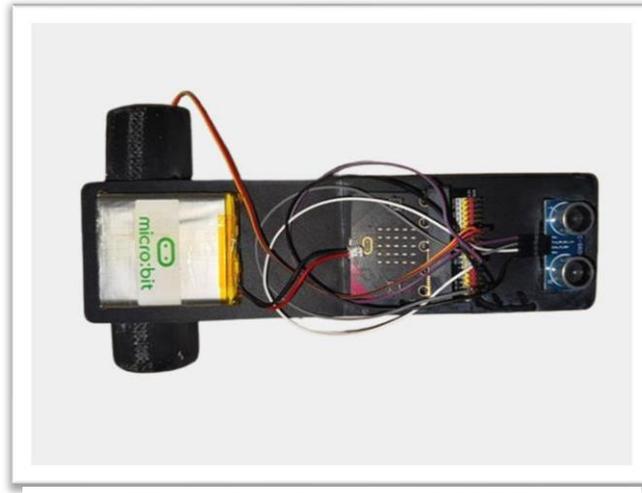
#### 4.1.1 General Product Features and Functionalities

The Smart Pitot Guard is designed to automatically protect the pitot tube from environmental contamination such as dust, insects, and moisture when the aircraft is parked. This system combines a mechanical cover with a Microbit controlled mechanism that opens or closes automatically based on sensor input. It enhances ground safety by minimizing the risk of foreign object damage also known as FOD and reduces the need for manual handling, while also improving inspection awareness through an integrated LED ground and cabin indicator that alerts both external crew and cockpit personnel.

The design emphasizes safety, reliability, and efficiency in line with modern aviation maintenance practices. Constructed from filament polypropylene, the product is lightweight yet durable, capable of withstanding high temperatures, ultraviolet exposure, and outdoor conditions without deformation. To overcome existing issues, the Smart Pitot Guard introduces an automated protection system combining a mechanical cover mechanism with a Microbit based control unit. The system uses programmed logic to detect when the aircraft is inactive and automatically closes the pitot cover, and when the aircraft is preparing for flight, it retracts the cover to ensure the pitot tube is clear before takeoff. In addition to these functions, the system features a warning buzzer that activates if the pitot cover is not removed during pre flight and an auto disengage mechanism that allows the cover to detach automatically if all warnings are ignored, ensuring maximum safety even under rushed or high pressure ground operations.

## 4.1.2 Specific Part Features

### 4.1.2.1 Product Structure



**Figure 31 : Structure Of SPG**

The Smart Pitot Guard features a carefully engineered structure designed to provide durability, functionality, and aerodynamic efficiency. The main body is constructed using filament polypropylene, a high-quality thermoplastic material chosen for its excellent strength, flexibility, and lightweight characteristics. This material is highly resistant to heat, moisture, and corrosion, making it ideal for use in outdoor aviation environments where exposure to high temperatures and humidity is common. The polypropylene casing ensures that the product remains stable and reliable even under continuous sunlight or vibration during aircraft movement on the ground.

The structure of the Smart Pitot Guard consists of three main sections: the base ring, the movable cover, and the electronics housing. The base ring securely attaches to the pitot tube, ensuring a tight fit without affecting the tube's accuracy or alignment. The movable cover acts as the main protective component that automatically opens and closes based on the system's programmed operation. Its curved and aerodynamic design prevents drag when retracted and shields the pitot opening from dust, debris, and insects when closed. Inside the housing, the electronic components such as the BBC micro:bit controller, servo motor, and wiring are neatly arranged to maintain weight balance and mechanical stability.

To enhance reliability, the design incorporates modular and ergonomic principles, allowing easy assembly, maintenance, and replacement of parts. The surface of the casing is coated with a UV-resistant and weatherproof finish to prevent fading, cracking, and damage due to prolonged exposure to sunlight or rain. This smooth surface also reduces friction and prevents foreign particles from sticking to the cover. Overall, the structural design of the Smart Pitot Guard provides a strong, lightweight, and durable protection system that meets aviation safety requirements while maintaining a professional and modern appearance.

#### 4.1.2.2. Product Mechanisms

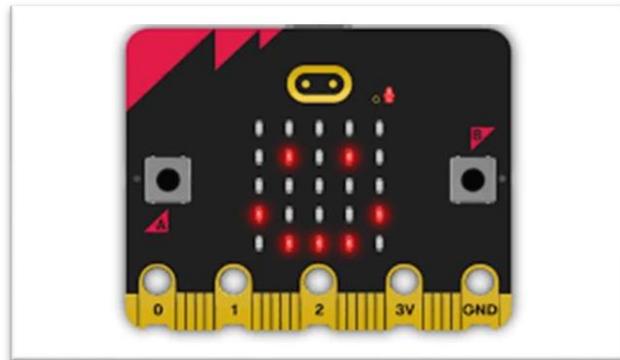


**Figure 32 : Auto Disengage Mechanism**

The auto-disengage system consists of several integrated components that enable the pitot cover to react to temperature conditions. It includes a temperature-sensing module positioned internally to monitor heat, a compact heating element to support temperature detection accuracy, and a micro-control unit that governs the release logic. In addition, the mechanism houses a physical release structure, which is using thermal actuator, designed to separate the cover when triggered. These elements are embedded within reinforced housing to protect the internal electronics from external conditions such as weather, dust, and aircraft-ground handling activities.

The visual status indicator feature comprises a high-visibility LED light mounted on the exterior surface of the pitot cover, along with a transparent protective lens to ensure clarity under different lighting conditions. The indicator is supported by a compact power supply and control circuit that manages its illumination status. To reinforce awareness, a bold “REMOVE BEFORE FLIGHT” label is also incorporated into the design, providing direct visual attention to personnel. The placement of the indicator and label is structured to remain noticeable from multiple viewing angles, enhancing ground crew situational visibility. The warning buzzer mechanism consists of an audible alert module paired with an integrated proximity sensor capable of detecting objects or personnel within approximately 100 cm of the pitot cover. The buzzer is driven by an electronic control unit that regulates its activation, allowing it to generate predefined beep sequences. This unit is housed within a compact enclosure to ensure durability against ground-handling environments, while the sensor is positioned externally to maximise detection coverage. The system also shares the same powering and control circuitry that supports the visual indicator and temperature-based release functions, ensuring reliable synchronisation between components.

### 4.1.2.3 Software/Programming



**Figure 33 : SPG Programmed System**

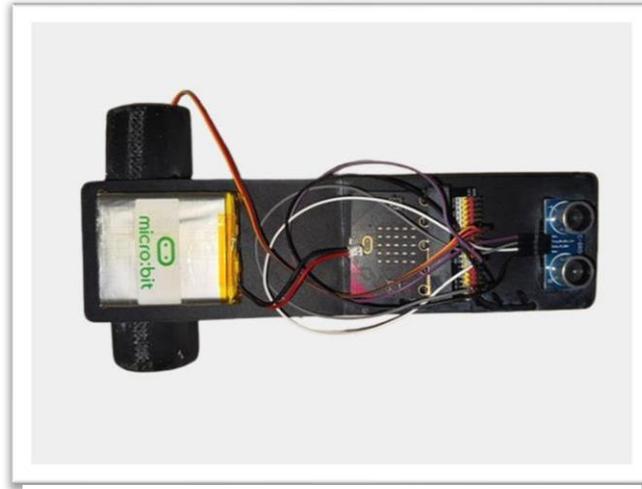
The Smart Pitot Guard uses a programmed warning system that runs on the BBC Micro:bit. This microcontroller is chosen because it is simple, reliable, and suitable for small electronic applications related to aircraft safety systems.

The system is programmed to alert the user when the pitot guard is still attached while the aircraft is powered on. It uses both LED light and buzzer as indicators. When the system detects vibration or electrical activity, it will automatically activate the warning to remind the user to remove the guard before flight. This helps to avoid wrong airspeed indication that may happen if the pitot tube is blocked.

The code is written in Micro Python using the Make Code editor. The program has three main parts which are initialization, input detection, and output response. The auto-disengage function is also included, where the system will release the locking mechanism once the aircraft is ready for operation, ensuring the pitot tube is clear.

The software can be easily updated in the future for improvement such as changing the alert pattern or sensitivity level. The connection between the sensors and programmed logic gives fast and accurate response, making the Smart Pitot Guard more reliable and efficient to use during ground operation.

#### 4.1.2.4 Accessories & Finishing



**Figure 34 : SPG Accessories**

SPG is equipped with several accessories and finishing elements that enhance both functionality and compliance with aviation ground-safety standards. It uses a lithium-polymer (Li-Po) battery that serves as the primary power source for the system's LED indicators, buzzer, and Micro:bit microcontroller, ensuring continuous operation and reliability during ground-handling procedures.

The external surface of the SPG features a permanent label marking with the phrase "REMOVE BEFORE FLIGHT." This marking is applied using durable, heat-resistant 3D printing that complies with the Civil Aviation Authority of Malaysia (CAAM) safety requirements for aircraft ground-handling and maintenance visibility. The specification aligns with the guidelines outlined in Safety Information 8/2022, Pitot Probes Obstruction on Ground & Pitot-Cover Hazard, which emphasizes the importance of clear identification and high-visibility markings on pitot protection devices to prevent obstruction-related incidents during aircraft operations (Civil Aviation Authority of Malaysia, 2022).

Overall, these accessories and finishing details ensure that the SPG is not only operationally efficient but also complies to aviation safety and ergonomic requirements.

### **4.1.3 General Operation of the Product**

The Smart Pitot Guard operates through a fully automated control system that functions without requiring manual installation or removal each time the aircraft is parked or prepared for flight. Once the device is powered on, the embedded BBC micro:bit controller begins to monitor signals from its programmed sensors, which serve as input to determine the aircraft's operational status. These signals can include movement, vibration, or power input detection, indicating whether the aircraft is in standby or active condition. When the system identifies that the aircraft is idle or parked, it automatically commands the servo motor to rotate and close the pitot cover, forming a tight seal over the pitot opening to prevent the entry of dust, insects, and other contaminants.

When the aircraft transitions from ground standby to an operational or takeoff state, the micro:bit receives a corresponding signal or sensor trigger. This activates the servo motor to retract the cover automatically, ensuring that the pitot tube is completely unobstructed before flight. The entire opening process occurs smoothly within seconds, demonstrating reliable synchronization between the sensor input and motor output. Throughout the operation, the LED matrix display on the micro:bit provides real-time feedback, a red indicator confirms that the cover is closed, while a green indicator shows that the system is open and ready for flight. This simple yet effective visual cue allows maintenance personnel to verify the system status at a glance, even from a short distance.

## **4.1.4 Operation of The Specific Parts of the Product**

### **4.1.4.1 Product Structure**

The Smart Pitot Guard is designed with a simple yet durable structure that ensures both reliability and efficiency in protecting the pitot tube. Its main body is made from filament polypropylene, a lightweight and heat-resistant material known for its flexibility and strength. This material allows the product to withstand outdoor conditions such as sunlight, rain, and high temperatures, which are common on the aircraft ramp. The use of polypropylene not only provides strong protection but also keeps the device light enough to avoid adding unnecessary weight to the aircraft.

The structure consists of three main parts which is the base ring, the movable cover, and the electronics housing. The base ring is fitted securely around the pitot tube to hold the system in place without affecting the function of the tube. The movable cover acts as a protective shield that opens and closes automatically depending on the aircraft's status. Inside the body, the micro:bit controller, servo motor, and wiring are neatly arranged within the housing compartment to maintain proper balance and ensure smooth operation. Each component is positioned carefully to prevent damage and to make the system easy to assemble or service.

To enhance the overall durability, the product's surface is coated with a UV- and weather-resistant finish that protects it from corrosion and fading. The smooth outer layer also helps reduce dirt buildup and makes cleaning easier. The structure of the Smart Pitot Guard shows a balance between practicality and innovation, it is strong enough to handle outdoor exposure, yet simple enough to be maintained and improved in the future. This thoughtful design ensures the product remains efficient, user-friendly, and suitable for long-term use in aircraft maintenance environments.

#### **4.1.4.2 Product Mechanisms**

The auto-disengage system operates by continuously monitoring the temperature generated by the pitot tube once the aircraft is powered. As the electrical heating element within the pitot tube increases its temperature, the temperature-sensing module embedded inside the cover detects this rise. When the temperature approaches a calibrated threshold of approximately 100°C, the signal is processed by the onboard micro-controller, which interprets the condition as an indication that the pitot cover has not been removed. In response, the controller activates the mechanical release mechanism, which is using thermal actuator, allowing the pitot cover to disengage automatically and separate from the tube. Once released, the cover drops away, ensuring that the pitot is unobstructed and able to measure airflow normally. This operation provides a final safety override to prevent flight with a blocked pitot tube.

The visual status indicator functions by delivering a clear and immediate visual reference regarding the installation status of the pitot cover. When the pitot cover is installed and its internal electronics are active, the LED indicator illuminates to signal its presence. The control circuit regulates the lighting pattern, allowing the indicator to either display a steady beam or produce a REMOVE BEFORE FLIGHT visual. This illumination ensures that ground crew can easily identify whether the pitot tube is still covered, even from a distance or in low-visibility environments. By providing immediate visual confirmation, the system supports correct removal procedures during pre-flight inspection. The warning buzzer operates as an active proximity-based alert system. When the pitot cover is switched on, the buzzer module enters standby mode while continuously receiving input from an integrated proximity sensor. If a person or object is detected within an approximate distance of 100 cm, the controller triggers the buzzer to emit a sequence of five beeping tones. This short burst of audible signals serves as an immediate awareness cue to personnel working near the pitot area, reminding them of the cover's presence and prompting safe removal before further aircraft preparation. The system resets automatically after the five-beep cycle and will re-activate if motion is detected again within the sensing range, ensuring repeated warning capability whenever necessary.

#### **4.1.4.3 Software/Programming**

The software system for the Smart Pitot Guard is programmed using the BBC Micro: bit platform with Micro Python as the main coding language. The program is written to control the warning and auto-disengage functions, ensuring the device works smoothly during aircraft ground operations.

The code detects vibration or movement from the aircraft and activates the LED light and buzzer when the pitot guard is still attached while power or motion is detected. This helps to alert the ground crew immediately and prevent the aircraft from taking off with the pitot tube covered.

Each function in the program responds in real-time, so every input from the sensors gives a direct output without delay. The auto-disengage feature is also programmed in the same system, allowing the pitot guard to release automatically once the aircraft is ready for flight.

To make sure the software runs efficiently, the code is kept lightweight and optimized to avoid unnecessary delays. The system can also be updated easily to improve response time or modify alert settings. Overall, the software ensures that the Smart Pitot Guard operates reliably and gives a fast, accurate warning before flight.

#### **4.1.4.4 Accessories & Finishing**

During operation, the accessories and finishing elements of SPG play an essential role in ensuring proper functionality, durability, and safety awareness throughout ground-handling and pre-flight processes. The lithium-polymer (Li-Po) battery continuously powers the LED indicators, buzzer, and Micro:bit microcontroller during active use, allowing the system to operate independently without aid of external power sources. This self-sustaining feature ensures uninterrupted alert functions during long maintenance or turnaround periods.

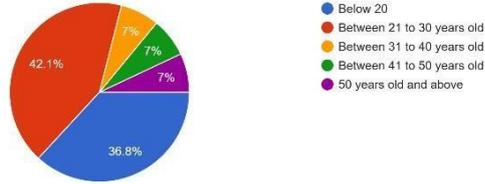
The LED indicators remain illuminated while the cover is attached, providing a constant visual warning to ground crew. When motion is detected within close range, the buzzer activates automatically, producing an audible alert. These functions operate in coordination with the Micro:bit program, which manages timing, signal input, and sensor response.

The heat-resistant 3D-printed body shields the internal components from environmental stress, including engine heat, precipitation, and mechanical wear during installation and removal. Meanwhile, the “REMOVE BEFORE FLIGHT” marking serves as a direct visual reminder to prevent omission errors, even under low-light conditions. Collectively, these features ensure safe, efficient, and CAAM-compliant operation of the SPG under real-world aircraft maintenance conditions.

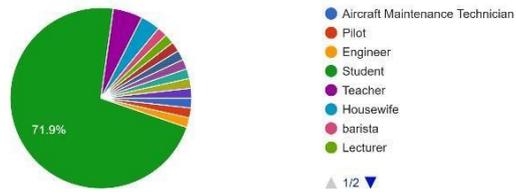
## 4.2 Product Output Analysis

### 4.2.1 Survey Questions

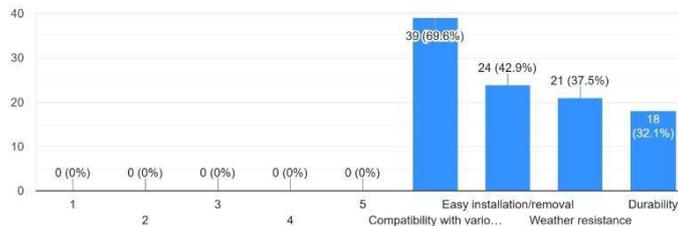
2. Age  
57 responses



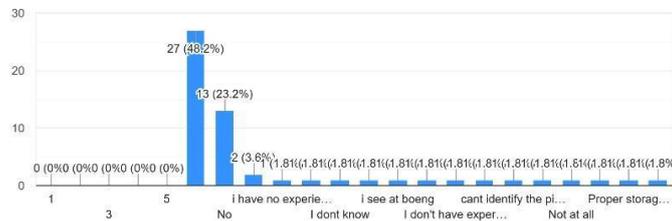
3. What is current occupation ?  
57 responses



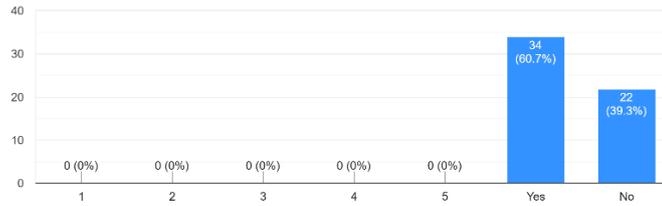
2. The polypropylene material felt durable and suitable for ramp environment.  
56 responses



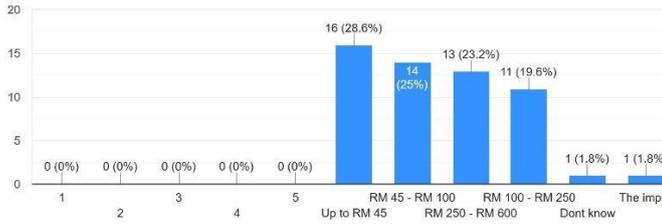
1. The Smart Pitot Guard was easy to install and remove on the pitot probe  
56 responses



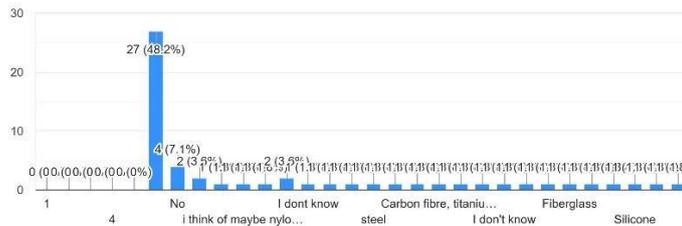
2. The cover maintained a secure fit without slipping or loosening.  
56 responses



4. The auto disengage system via heat detection + solenoid worked reliably.  
56 responses



5. The LED indicator was visible in daylight and low light conditions.  
56 responses



#### 4.2.2 Pre-Test Survey Mean

Before the Smart Pitot Guard was introduced, respondents were asked about their experience and understanding of existing pitot protection methods. The majority indicated that traditional manual covers, while simple, often led to human errors, such as forgetting to remove the cover before flight or failing to reinstall it after landing. Many also agreed that manual handling could be time-consuming, especially during aircraft turnaround. On a five-point scale, only 45% of participants rated the existing method as “effective,” and 60% expressed concern about possible safety risks associated with human oversight. This pre-survey result highlighted the need for an improved, automated solution that could increase consistency and safety in protecting pitot tubes.

### **4.2.3 Post-Test Survey Mean**

After testing the Smart Pitot Guard prototype, participants completed a post-survey to evaluate the product's overall performance. The results showed a significant improvement in user confidence and satisfaction. Approximately 90% of the respondents agreed that the automated system effectively reduced the risk of pitot blockage and improved operational safety. Users also appreciated the automatic control mechanism, noting that it eliminated the need for manual installation and removal. Many participants highlighted the product's lightweight design, quick response time, and ease of operation. Furthermore, maintenance personnel reported that the built-in LED indicator and micro:bit control system made it easier to verify the cover's status during ground checks.

## **4.3 Analysis of Problem Encountered and Solutions**

### **4.3.1 Product Structure**

The Smart Pitot Guard was assessed through a pre-test and post-test analysis to evaluate its impact on safety, durability, and functionality compared to traditional pitot tube covers. In the pre-test phase, conventional pitot covers were manually attached and removed, often causing delays and inconsistencies during maintenance operations. Participants observed that standard covers were sometimes difficult to handle and did not always provide a tight fit, leading to potential exposure to dust or insects. In contrast, the post-test evaluation of the Smart Pitot Guard demonstrated major improvements in both design quality and structural reliability. The product's body, made from filament polypropylene, proved to be lightweight yet strong enough to withstand high temperatures, humidity, and ultraviolet (UV) radiation. This material performed exceptionally well under test conditions, maintaining its shape and integrity even after repeated trials.

The base ring and movable cover were key structural elements tested for fit and performance. During the post-test, the base ring provided a secure attachment to the pitot tube, preventing any looseness or vibration that could compromise accuracy. The movable cover, designed with a smooth aerodynamic profile, functioned effectively during all test cycles. It opened and closed automatically without obstruction, demonstrating precise alignment and consistent balance. These results showed a significant improvement over the pre-test manual system, where misalignment or incorrect positioning sometimes caused operational delays. The aerodynamic structure also helped minimize drag and maintained airflow stability when retracted, ensuring that the Smart Pitot Guard would not interfere with pitot readings during flight operations.

#### **4.3.2 Product Mechanisms**

During the development stage, several issues related to the product's mechanical functionality were identified. One of the earliest challenges involved the reliability of the proximity-based warning buzzer. The initial configuration showed inconsistent activation as the sensor occasionally failed to detect nearby objects within the intended 100 cm range. After troubleshooting, this issue was traced to inaccurate sensing angles and environmental interference. To resolve this, the sensor was repositioned, and sensitivity calibration was performed to ensure dependable detection during ground operation.

Another problem arose from the integration of multiple mechanisms within a compact housing. Since the buzzer, proximity sensor, and temperature-triggered system shared similar electronic pathways, cross-signal disturbance sometimes occurred, causing delayed or continuous activation. The team addressed this by reorganising the circuit layout and introducing basic signal isolation between components, improving both responsiveness and reliability.

In addition, early tests showed that the buzzer output was too weak to be noticed in noisy ramp environments. To overcome this, the speaker module was

upgraded to a higher-output version, and the enclosure was redesigned to better channel the sound outward. Collectively, these enhancements provided a more dependable and practical alert system capable of supporting operational safety.

### **4.3.3 Software/Programming**

The software and programming of the Smart Pitot Guard played a vital role in controlling the system's overall operation and determining its effectiveness in both pre-test and post-test evaluations. In the pre-test phase, aircraft maintenance personnel relied entirely on manual placement and removal of pitot tube covers, which often depended on human attention and timing. This process carried the risk of mistakes that could lead to safety issues or flight delays. With the integration of the BBC micro:bit controller in the Smart Pitot Guard, the post-test results showed significant improvements in accuracy and automation. The programmed system successfully detected the required conditions and executed the opening and closing sequence automatically, eliminating human error and ensuring consistent operation.

The programming was developed using Microsoft MakeCode, which allowed for clear logic flow and easy debugging. During testing, the micro:bit consistently processed input signals from the system sensors and sent precise output commands to the servo motor. This demonstrated that the software was reliable and capable of maintaining stability even after multiple cycles of operation. The LED matrix display provided real-time visual feedback on system status, showing a red icon when the cover was closed and a green icon when it was open. This feedback helped users monitor the system easily without needing to inspect it manually. The comparison between pre- and post-test phases showed that automation improved the response time and reduced the workload during aircraft preparation.

#### 4.3.4 Accessories & Finishing

During the fabrication and testing stages of the SPG, several issues were identified within the accessories and finishing components that initially affected product performance.

One of the primary challenges encountered during the early development phase was related to the material selection for 3D printing. The first prototype was produced using polylactic acid (PLA) filament. However, this material proved unsuitable for the operational environment of the product. PLA softened and deformed when exposed to elevated temperatures during pitot-heating simulations, and it also exhibited brittleness, breaking easily when dropped or subjected to mechanical stress. To overcome this limitation, the filament was replaced with polypropylene (PP) filament, which offers superior heat resistance, maintaining structural integrity at temperatures up to 130 °C. This material selection for SPG was inspired by existing aviation safety products, particularly those developed by DeGross Aviation Technologies. Their PitotShield V2 utilizes a sintered polypropylene (PP) body, selected for its durability, heat resistance, and lightweight characteristics suitable for turbine aircraft pitot-tube protection (DeGross Aviation Technologies, 2021).

Another issue was the design of the cover. The first 3D-printed prototype of the SPG did not fit properly onto the pitot tube. The inner sleeve design was based on estimated dimensions, resulting in a slight gap between the sleeve and the pitot surface. This gap reduced stability and caused the cover to loosen easily during installation. To resolve this, new and precise dimension measurements of the actual pitot tube and redesigning the internal contour of the SPG were made. The modified version achieved a snug and secure fit, ensuring reliable attachment during ground operations. Through these corrective measures, the SPG's accessories and finishing were optimized to withstand operational environments, maintain regulatory compliance, and ensure long-term functionality during ground-handling operations.

# CHAPTER 5

## CONCLUSION AND RECOMMENDATIONS

### 5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

#### 5.1.1 General Achievements of the Project

- **XBIC:**

The project achieved a notable milestone when it was awarded a Gold Medal in the XBIC competition. This recognition highlights the team's innovative approach, technical accuracy and the strong educational value offered by the system. The award reflects the project's success in addressing real aviation safety needs while providing a practical and impactful learning experience.

- **IMAN25 :**

A remarkable achievement was secured when our project earned a Silver Medal at the prestigious IMAN25 competition. This accolade serves as a testament to the team's originality, high technical precision, and the substantial pedagogical benefit derived from our system. Ultimately, the award confirms the project's efficacy in tackling pertinent challenges in Aviation industry and *Alam Melayu*.

- **AeroMech:**

We are thrilled to announce that the project hit its highest mark by winning First Place and taking home the title of Overall Champion at the competitive AeroMech challenge. This huge success really shows off the team's strong technical skills, and how much we genuinely understood the core concepts behind the system.

## **5.1.2 Specific Achievement of Project Objectives**

### **5.1.2.1 Product Structure**

The Smart Pitot Guard is designed with a durable and aerodynamic structure that accurately conforms to the dimensions of a standard aircraft pitot tube. The cover is made of polypropylene, selected for its high temperature resistance and flexibility, enabling operation between  $-20\text{ }^{\circ}\text{C}$  and  $130\text{ }^{\circ}\text{C}$ . The design ensures a secure fit while maintaining a lightweight form to avoid any potential damage to the pitot system. It also incorporates clear labeling and an integrated warning tag to enhance visibility and operational safety during pre flight inspections.

### **5.1.2.2 Product Mechanisms**

The product features a smart warning and auto disengage system programmed to alert users if the pitot cover remains installed before flight. Using a micro bit microcontroller, the system senses motion and automatically disengages when simulated aircraft movement is detected. This mechanism helps prevent takeoff with the cover still in place, thereby reducing the risk of flight data inaccuracies. The design mirrors real maintenance procedures, enabling users to appreciate both manual and automated safety functions in pitot tube management.

### **5.1.2.3 Software and Programming**

The warning system is programmed using Microsoft Make Code for micro bit, allowing for clear signal logic and sensor based triggers. The software controls LED indicators and buzzer alerts, notifying users when the pitot cover must be removed. The code ensures stable operation with minimal latency between motion detection and system response. This embedded programming demonstrates the integration of basic electronics with aviation safety practices, reinforcing awareness of proper maintenance procedures.

#### **5.1.2.4 Accessories and Finishing**

The Smart Pitot Guard is finished with attention to detail to enhance both functionality and appearance. Its outer surface features smooth contouring and a matte finish for improved aerodynamics and grip. The warning tag is produced from a polypropylene material to ensure visibility under low light conditions. All components are precisely aligned and rigorously tested for durability, resulting in a professional and polished product that adheres to real world aviation maintenance standards.

### **5.2 Contribution or Impact of the Project**

The Smart Pitot Guard project gives a new way to improve safety awareness and maintenance learning for aviation students. It shows the real function of pitot tube protection and how it helps prevent flight data errors and system problems. This project acts as a practical learning tool that makes classroom lessons more effective by giving real examples related to aircraft safety.

Second, the Smart Pitot Guard helps aviation schools give safety training without needing real aircraft or expensive tools. It reduces training cost and still provides a realistic experience for students to learn about pitot cover systems. Because of its simple and low cost design, this project can be used by many training centers, including small institutions, to give students a better understanding of safety equipment.

Lastly, the system with smart warning and auto disengage feature helps students learn both the mechanical and electronic parts of aircraft safety. It shows how technology can prevent human error and improve flight safety. This project helps aviation schools produce students who are more aware, skilled, and ready to work in real maintenance environments.

## **5.3 Improvement and Suggestions for Future Research**

### **General Improvement**

#### **5.3.1 Product Structure**

For future improvement, the Smart Pitot Guard can be redesigned using lighter or more durable materials to improve strength and lifespan. The structure can also be modified to fit different sizes and types of pitot tubes used on various aircraft. Research can focus on improving the aerodynamics and fitting mechanism to make the cover more stable during ground operation and storage.

#### **5.3.2 Product Mechanisms**

The system can be improved by adding more advanced sensors to increase accuracy of motion detection and auto disengage timing. Future research can also explore using wireless connection between the pitot cover and the control unit for better monitoring. Other improvements could include weather resistant features or a manual override switch for maintenance use.

#### **5.3.3 Software and Programming**

Future work can focus on upgrading the micro bit code with more advanced microcontrollers that support data logging or wireless alert systems. This can allow the system to record the number of activations and warnings for better analysis. Research can also look into integrating mobile notification features or LED display modules for clearer alerts during aircraft inspection.

#### **5.3.4 Accessories and Finishing**

The product can be improved by adding protective coating or color options for better visibility and weather resistance. Future versions could include a detachable tag system

with reflective surface. More research can also be done on user friendly design, such as grip texture, shape, and overall appearance, to make it easier for engineers to handle during operation.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

**Table 22 : Appendix A - Mirza**

SUB-CHAPTERS	DESCRIPTION
<b>MIRZA FAQIHAH BINTI MUHAMAD NAZERI</b>	
1.1	Background of Study
1.2	Problem Statements
1.3.1	General Project Objectives
1.3.2.1	Specific Individual Project Objectives : Product Structure
1.4	Purpose of Product
1.5.1	General Project Scopes
1.5.2.1	Specific Individual Scope : Product Structure
2.1.1	Aviation Industry in Malaysia
2.2.1	Specific Literature Review : Product Structure
2.3.1.1	Review of Recent Research / Related Product : Patent A
3.3.2.1	Project Flow Chart : Patent A
3.4.1	Design Requirement Analysis
3.4.2.3	Design Concept Generation : Concept 1
3.5.2.1	Specific Product Drawing : Product Structure
4.1.1	General Product Features and Functionalities
4.1.2.1	Specific Part Features : Product Structure
4.1.3	General Operation of the product
4.1.4.1	Operation of the specific parts : Product Structure
4.2.1	Survey Questions
4.3.1	Evaluating the impact of Smart Pitot Guard Knowledge : A Pre Test and Post Test Analysis : Product Structure
5.1.2.1	Specific Achievement of Project Objectives : Product Structure
5.3.1	Improvement and suggestions for future research : Product Structure

**Table 23 : Appendix A - Wajdi**

SUB-CHAPTERS	DESCRIPTION
<b>WAJDI BE' AUNILLAH BIN MOHD NURI</b>	
2.1.2	Trend or Demand for Low-Cost Carrier
2.2.3	Specific Literature Review : Software / Programming
3.1	Product Description
3.2	Overall Project Gantt Chart
3.4.2.2	Design Concept Generation : Concept 2
3.5.2.3	Specific Product Drawing : Software/Programming
4.1.2.3	Specific Part Features : Software/Programming
4.1.4.3	Operation of Specific Parts : Software/Programming
4.3.3	Evaluating Impact : Software/Programming
5.1.2.3	Specific Achievement : Software/Programming
5.3.3	Improvement & Suggestions : Software/Programming

**Table 24 : Appendix A - Uweis**

SUB-CHAPTERS	DESCRIPTION
<b>MUHAMMAD UWEIS QAWI BIN AHMAD FAUDWAZ</b>	
1.3.2.4	Specific Individual Project Objectives :Accessories & Finishing
1.5.2.4	Specific Individual Scope : Accessories & Finishing
2.1.3	Type of Pitot Cover In Aviation
2.2.4	Specific Literature Review :Accessories & Finishing
2.3.1.3	Review of Recent Research / Related Product : Patent C
3.3.2.3	Project Flow Chart : Patent C
3.4.2.5	Design Concept Generation : Concept 3
3.5.2.4	Specific Product Drawing :Software / Programming
4.1.4.4	Specific Part Features : Accessories & Finishing
4.3.4	Evaluating the impact of Smart Pitot Guard Knowledge : A Pre Test and Post Test Analysis :Accessories & Finishing
5.1.2.4	Accessories & Finishing
5.3.4	Accessories & Finishing

**Table 25 : Appendix A - Arif**

SUB-CHAPTERS	DESCRIPTION
<b>MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI</b>	
1.3.2.2	Specific Individual Project Objectives :Product Mechanisms
1.5.2.2	Specific Individual Scope : Product Mechanisms
2.1.4	Research of Previous Study
2.2.2	Specific Literature Review :Product Mechanisms
2.3.1.4	Review of Recent Research / Related Product : Patent D
3.3.2.4	Project Flow Chart : Patent D
3.4.2.6	Design Concept Generation : Concept 4
3.5.2.2	Specific Product Drawing :Product Mechanisms
4.1.4.2	Specific Part Features : Accessories & Finishing
4.3.2	Evaluating the impact of Smart Pitot Guard Knowledge : A Pre Test and Post Test Analysis :Product Mechanisms
5.1.2.2	Product Mechanisms
5.3.2	Product Mechanisms

## APPENDIX B: SUMMARY OF SIMILARITY

E-THESIS ( FINAL YEAR PROJECT ) paling latest[2].pdf By Mirza Faqihah Binti Muhamad Nazeri

1% match (student papers from 19-Jun-2021) <a href="#">Submitted to Jabatan Pendidikan Politeknik Dan Kolej Komuniti on 2021-06-19</a>	<table border="1"> <thead> <tr> <th colspan="2">Similarity Index</th> <th colspan="2">Similarity by Source</th> </tr> </thead> <tbody> <tr> <td colspan="2" style="text-align: center;">5%</td> <td>Internet Sources:</td> <td>3%</td> </tr> <tr> <td colspan="2"></td> <td>Publications:</td> <td>1%</td> </tr> <tr> <td colspan="2"></td> <td>Student Papers:</td> <td>3%</td> </tr> </tbody> </table>	Similarity Index		Similarity by Source		5%		Internet Sources:	3%			Publications:	1%			Student Papers:	3%
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<p>&lt; 1% match (student papers from 10-Feb-2017)  <a href="#">Submitted to Universiti Tenaga Nasional on 2017-02-10</a></p>
<p>&lt; 1% match (student papers from 20-Dec-2021)  <a href="#">Submitted to University of Leeds on 2021-12-20</a></p>
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<p>&lt; 1% match (student papers from 20-Apr-2020)  <a href="#">Submitted to University of Queensland on 2020-04-20</a></p>
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<p>&lt; 1% match (student papers from 25-Sep-2025)  <a href="#">Submitted to WorldQuant University on 2025-09-25</a></p>
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<p>&lt; 1% match (publications)  Ton Duc Thang University</p>
<p>&lt; 1% match (student papers from 28-Mar-2025)  <a href="#">Submitted to University of the Highlands and Islands Millennium Institute on 2025-03-28</a></p>
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[Colin Turner. "International Business - Themes and Issues in the Modern Global Economy", Routledge, 2024](#)

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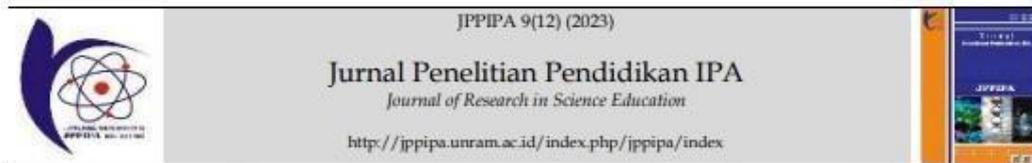
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## Design Pitot Tube Cover with Artificial Intelligence (Arduino) Based Warning System on Piper Seneca V Aircraft

Dimas Endrawan Putra<sup>1</sup>, Untung Lestari Nur Wibowo<sup>1</sup>, Wisnu Kuncoro<sup>2\*</sup>, Muhamad Khoiril Anam<sup>2</sup>

<sup>1</sup> Education Facilities Department, Banyuwangi Indonesian Aviation Academy, Blimbingsari, Banyuwangi, Indonesia

<sup>2</sup> Mechanical Engineering Department, PGRI Banyuwangi University, Kertosari, Banyuwangi, Indonesia.

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Corresponding Author:  
 Wisnu Kuncoro  
 wiisnukuncoro@gmail.com

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**Abstract:** The pitot tube is a component in the fuselage to measure the pressure generated by air movement or wind, while the placement of the pitot tube is usually on the wing. A trivial thing that can be fatal is that before flying, sometimes the pilot/flight instructor neglects to remove the pitot tank cover. This negligence resulted in the malfunctioning of the Air Speed Indicator (ASI), Vertical Speed Indicator and Altimeter. Appropriate technology in the form of a pitot tube cover with a warning using an ultrasonic sensor with the support of artificial intelligence technology using Arduino has been applied to the Piper Seneca V aircraft to prevent negligence in removing the pitot tube cover before flying. The Piper Seneca V has been chosen as the object of the application of technology because the Piper Seneca V type aircraft is of the low wing type so that the pitot tubes are not visible when not inspecting the underside of the aircraft's wings. During 30 days of testing with 12 hours of testing time each day and exposure to different temperatures and humidity each day, both battery life and component resistance can be ensured that they are still in optimal conditions. During testing in the simulation room, the tool worked well with a 1 meter object detection configuration. Using a 3.7 volt battery with a storage capacity of 1600 mAh can make the device last for 4 days with 2 hours of recharging time.

**Keywords:** Aeroplane; Piper Seneca V; Pitot Tube; Plane Malfunction

### Introduction

Airplanes are one of the modes of air transportation needed to accelerate long-distance transportation (Kiraci & Bakir, 2019; Zhang & Graham, 2020). In the world of aviation whose development is relatively very rapid, there is still a need to evaluate and improve aspects of safety and security in aviation (Ancel et al., 2022; Kakaletsis et al., 2021; Lager & Melin, 2021; Majid et al., 2022; Peysakhovich et al., 2018). Overall aviation always pays attention to flight safety, flight discipline, flight efficiency and comfort (Chen & Zhang, 2022; Patel & D'cruz, 2017; Priyambodo & Nugraha, 2019). Safety factors are a top priority in the world of destination flights so that passengers and crew on flights get maximum comfort (Badi & Abdulshahed, 2019; Şenol, 2020). Airlines can measure the level of safety they have, the level of safety is not an easy job because there are

many aspects related (Kim et al., 2020). In flight school, flight operations become one of the aspects that must be complied with which is regulated in ICAO (Agustini et al., 2021).

Flight operation flight area is an area on land or waters used for flight operations to ensure flight safety (Prasetyo et al., 2021). Safety priorities in aviation are standards that need to be considered in the aviation sector, so aviation facilities and infrastructure, methods, procedures and regulations are needed (Bastola, 2020; K. Ellis et al., 2021; K. K. Ellis et al., 2021). Pilots in aviation must be aware of important information in dealing with their duties and work, as well as the role of situational awareness, especially an important element in their evaluation during flight operations (Kiliç, 2019). In a case study that has been found, there was negligence in removing the pitot tube cover until the plane took off. Pitotube is an object that exists on airplane wings (Jäckel

### How to Cite:

Putra, D. E., Wibowo, U. I. N., Kuncoro, W., & Anam, M. K. (2023). Design Pitot Tube Cover with Artificial Intelligence (Arduino) Based Warning System on Piper Seneca V Aircraft. *Jurnal Penelitian Pendidikan IPA*, 9(12), 11137-11144. <https://doi.org/10.29303/jppipa.v9i12.5614>

et al., 2021). A trivial thing but can be fatal is that before flying, sometimes a pilot / flight instructor fails to remove the pitot tube cover. This negligence resulted in malfunctions of the Air Speed Indicator (ASI), Vertical Speed Indicator and Altimeter (Kuncoro et al., 2022).

The development of appropriate technology in the form of pitot tube covers for Piper Seneca V type aircraft with a warning system using ultrasonic sensors with the support of Arduino-based Artificial Intelligence technology can be applied to prevent negligence in removing the pitot tube cover before flying. Where the ultrasonic sensor is placed on the tag "Remove Before Flight" and the sensor will be integrated with the Buzzer which will sound when there are people around the pitot with a radius of 0-100 cm. Piper Seneca V was chosen as the object of application of appropriate technology because the aircraft is a low-wing type where the location of the pitot tube is not visible when not checking the underside of the aircraft's wings (Ethell, 1986). Warning Alert / The sound issued by the buzzer will be a sign to someone who will use the aircraft that there is

still a pitot cover that has not been separated from the pitot tube.

**Method**

The method used in design research uses direct experimental methods. The implementation of activities contains a frame of mind, product manufacturing, technology testing and evaluation.

*Frame of Mind*

There is a considerable risk that will be faced when there is neglect to remove the pitot tube cover, response before a fatal event occurs needs to be applied as early as possible. With the presence of the water produced by the Beep Buzzer will serve as a reminder that the pitot tube cover has not been released when trying to operate the Piper Seneca V aircraft. Pitot tube cover that has been integrated with artificial intelligence technology is expected to reduce the risk of negligence in removing the pitot tube cover before operating the Piper Seneca V aircraft. The research mindset can be seen in Figure 1.

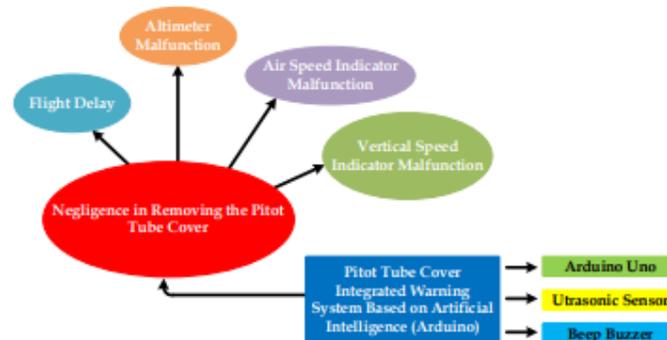


Figure 1. Frame of mind

*Pitot Tube Cover Making*

The implementation of making pitot tube covers is carried out based on the design of the tool that has been made and based on several supporting references including (Akkalkot et al., 2022; Ramisetti et al., 2022; Shivani et al., 2023). The stages of making implementation are as follows: Perform pitot tube cover design and layout for the placement of electronic components on the pitot tube cover; Making a pitot tube cover with a type of taslan fabric coated with perlak fabric, taslan fabric was chosen because it has waterproof properties (Wardaya et al., 2019) while perlak fabric was chosen as the outer coating because it is thick and is assumed to be able to better protect the electronic components inside; Assembling and installing electronic components including conductor pillow,

arduino, battery, PCB charger and ultrasonic sensor; Coding and input coding are done to provide data to Arduino; and Configuration of the ultrasonic sensor is that it will detect objects approaching with a distance of 1 meter by providing a warning sound through the buzzer.

*Pitot Tube Cover Testing*

To ensure the pitot tube cover can work properly, testing of the tool is needed. The stages implemented are as follows: Pitot tube cover testing was carried out directly on the pitot tube of the Piper Seneca V aircraft that had been detached; Pitot tube cover testing was carried out in a simulated room with air conditioning designed to resemble outdoor air with a duration of 30 days of testing, where temperature and humidity for 30

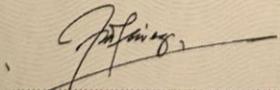
# APPENDIX D: CERTIFICATE OF COPYRIGHT NOTIFICATION



**COPYRIGHT ACT 1987**  
**COPYRIGHT (VOLUNTARY NOTIFICATION) REGULATIONS 2012**  
**CERTIFICATE OF COPYRIGHT NOTIFICATION**  
[Subregulation 8(2)]

Notification Number : CRLY2025W09504  
Title of Work : SMART PITOT GUARD  
Category of Work : LITERARY  
Date of Notification : 26 SEPTEMBER 2025  
Date of Creation : 26 SEPTEMBER 2025

This is to certify, under the Copyright Act 1987 [Act 332] and the Copyright (Voluntary Notification) Regulations 2012 that the copyrighted work bearing the Notification No. above for the applicant POLITEKNIK BANTING SELANGOR as the **OWNER** and **MOHAMMAD AZMIN BIN ZAINAL** (870206385049), **MIRZA FAQIHAH BINTI MUHAMAD NAZERI** (050927060216), **MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI** (050309160041), **MUHAMMAD UWEIS QAWI BIN AHMAD FAUDWAZ** (050803101231), **WAJDI BE'AUNILLAH BIN MOHD NURI** (050706030283) as the **AUTHOR** have been recorded in the Register of Copyright, in accordance with section 26B of the Copyright Act 1987 [Act 332].

  
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## APPENDIX E: CERTIFICATE OF ACHIEVEMENTS



The certificate features a red and purple background with a yellow vertical stripe on the left. It includes logos for iMAN25, Universiti Teknologi MARA, and Nova Fire. The title 'Sijil ANUGERAH' is written in large, stylized yellow and orange letters. The competition name 'PERTANDINGAN INOVASI ALAM MELAYU ANTARABANGSA 2025 (iMAN25)' is in yellow. The winner's name, project title, achievement, and organizers are listed in white and yellow text. Three signatures are at the bottom, each with a name and title in white text.

**iMAN25**

**UNIVERSITI TEKNOLOGI MARA**

**NOVA FIRE**

# Sijil ANUGERAH

**PERTANDINGAN INOVASI ALAM MELAYU ANTARABANGSA 2025 (iMAN25)**

**NAMA AHLI:**  
MOHAMMAD AZMIN BIN ZAINAL  
MIRZA FAQIHAH BINTI MUHAMAD NAZERI  
MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI  
WAJDI BE'AUNILLAH BIN MOHD NURI  
MUHAMMAD UWEIS QAWI BIN AHMAD FAUDWAZ

**TAJUK PROJEK:**  
THE DEVELOPMENT OF SMART PITOT GUARD (SPG)

**PENCAPAIAN: PERAK**

**TREK INOVASI: Teknologi**  
**KOD PROJEK: IM25-PI-024**  
**ORGANISASI:**  
POLITEKNIK BANTING

**ANJURAN:**  
INSTITUT PEMIKIRAN DAN KEPIMPINAN MELAYU (IMPAK)  
PEJABAT PEMERKASAAN ADIWANGSA, UNIVERSITI TEKNOLOGI MARA

**Dr. Khairuddin Murad**  
Pangarah  
Institut Pemikiran dan Kepimpinan Melayu (IMPAK)  
Pejabat Pemerkasaan Antarabangsa  
Universiti Teknologi MARA (UiTM)

**Tuan Lim See Peng**  
Pensyarah Pembangunan Perniagaan  
Nova Fire (Malaysia) Sdn. Bhd.

**Prof. Dr. Poppy Anjelisa Zaitun Hasibuan**  
(S.Si., M.Si., Apl)  
Wakil Rektor III Bidang Penyelidikan  
Pengabdian kepada Masyarakat dan Kerja Sama  
Universitas Sumatera Utara



NUWA PIERRE



اينوؤاسى عالم ملايو  
انتارابغسا ٢٠٢٥

# INOVASI ALAM MELAYU ANTARABANGSA 2025

## Sijil Penyertaan

NAMA AHLI:

MOHAMMAD AZMIN BIN ZAINAL  
MIRZA FAQIHAH BINTI MUHAMAD NAZERI  
MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI  
WAJDI BE'AUNILLAH BIN MOHD NURI  
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**Dr. Khairuddin Murad**

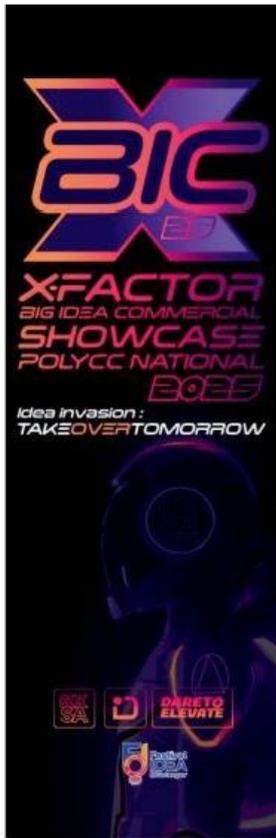
Pengarah  
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Pejabat Pemerkasaan Adiwangsa  
Universiti Teknologi MARA (KIN)

**Tuan Lim See Peng**

Pensihat Pembangunan Perniagaan  
Nuwa Pierre (Malaysia) Sdn. Bhd.

**Prof. Dr. Poppy Anjelisa Zaitun Hasibuan**  
(S.Si., M.Si., Apt)

Wakil Rektor II Bidang Penyelidikan  
Pembelajaran kepada Masyarakat dan Kerja Sama  
Universitas Sumatera Utara



## SIJIL ANUGERAH

ADALAH DENGAN INI DISAHKAN BAHAWA  
WAJDI BE'AUNILLAH BIN MOHD NURI  
MIRZA FAQIHAH BINTI MUHAMAD NAZERI  
MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI  
MUHAMMAD UWEIS QAWI BIN AHMAD FAUDWAZ  
MUHAMMAD AZMIN BIN ZAINAL

TELAH MEMENANGI PINGAT  
**EMAS**

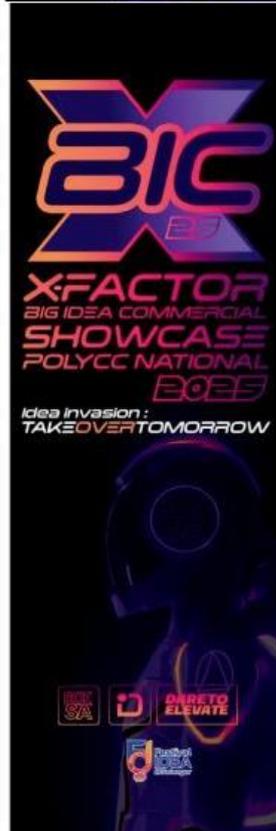
DI PROGRAM  
**X-BIC'25**  
X-FACTOR BIG IDEA : COMMERCIAL SHOWCASE POLYCC NATIONAL 2025  
8 OKTOBER 2025

PROJEK AKHIR/ INOVASI BERTAJUK  
THE SMART PITOT GUARD

TEMPAT  
DEWAN AL-JAZARI  
POLITEKNIK PREMIER SULTAN SALAHUDDIN ABDUL AZIZ SHAH

ANJURAN  
UNIT PENYELIDIKAN, INOVASI & KOMERSIALAN  
KOLEJ KOMUNITI SHAH ALAM

DR. SHAMSURI BIN ABDULLAH  
TIMBALAN KETUA PENGARAH (PERANCANGAN)  
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI



## SIJIL PENYERTAAN

KEPADA  
WAJDI BE'AUNILLAH BIN MOHD NURI  
MIRZA FAQIHAH BINTI MUHAMAD NAZERI  
MUHAMMAD ARIF HIFZAN BIN HALIM HARIRI  
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TELAH MENYERTA

**X-BIC'25**  
X-FACTOR BIG IDEA : COMMERCIAL SHOWCASE POLYCC NATIONAL 2025  
8 OKTOBER 2025

PROJEK AKHIR/ INOVASI BERTAJUK

THE SMART PITOT GUARD - ANUGERAH UTAMA PELAJAR (EMAS)

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