

POLITEKNIK BANTING SELANGOR

SAFETY ARMBAND WITH SENSOR LIGHT

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION I 2025/2026

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

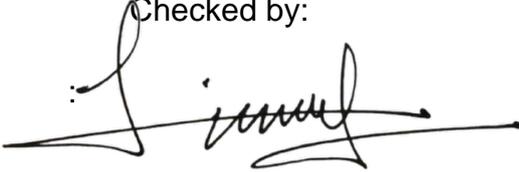
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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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



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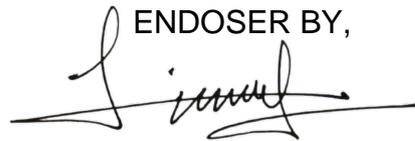
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## **ACKNOWLEDGMENT**

Before presenting the details of our project, we would like to express our utmost gratitude to everyone who has supported and guided us throughout the development of our Final Year Project at Politeknik Banting Selangor. Their continuous encouragement has played a major role in the successful completion of this project.

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## **ABSTRACT**

This project presents the development of a Safety Armband with Sensor Light, a wearable safety device designed to enhance worker awareness in hazardous environments. Many workplaces such as industrial areas, construction zones, airports, and manufacturing facilities involve high-risk machinery, rotating equipment, and restricted areas that may not always be clearly visible to workers. Traditional safety systems that rely only on visual or audible warnings are often ineffective in noisy, dim, or fast-paced environments, causing workers to unintentionally step into danger zones. To address this issue, this project introduces a dual-alert wearable system that integrates a proximity sensor, warning safety light, and vibration motor within a compact armband. When a worker gets too close to a potentially dangerous area, the system automatically activates the safety light and triggers vibration feedback to the user's arm, ensuring immediate and direct awareness. This approach provides a more reliable method of alerting workers, as it does not depend on environmental lighting or noise conditions. The device is enclosed in a lightweight 3D-printed armband casing and powered externally using a portable power bank, allowing longer usage time and easy recharging without modifying the internal circuitry. Although demonstrated using a simulated setup, this system can be applied across various industries, including those involving high-speed industrial fans, factory blowers, rotating shafts, or moving machinery. Overall, this project aims to improve workplace safety through a low-cost, efficient, and user-friendly wearable alert system.

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## LIST OF ABBREVIATIONS

ABS	Acrylonitrile Butadiene Styrene
PLA	Polylactic Acid
FDM	Fused Deposition Modeling
CAD	Computer-Aided Design
DLP	Digital Light Processing
LED	Light Emitting Diode
Hz	Hertz
USB	Universal Serial Bus
UART	Universal Asynchronous Receiver-Transmitter
I <sup>2</sup> C	Inter-Integrated Circuit
SPI	Serial Peripheral Interface
PCB	Printed Circuit Board
EEPROM	Electrically Erasable Programmable Read-Only Memory
ROM	Read-Only Memory
Li-ion	Lithium-Ion
OLED	Organic Light Emitting Diode
GUI	Graphical User Interface
AR	Augmented Reality
Mah	Milliampere-Hour
V	Volt
A	Ampere
CMOS	Complementary Metal-Oxide Semiconductor
MRO	Maintenance, Repair and Overhaul
PPE	Personal Protective Equipment
OSH	Occupational Safety & Health

## CHAPTER 1

### 1.1 INTRODUCTION

Aviation workplaces, particularly turbine areas, present significant hazards due to the high-speed rotation of turbine blades, strong airflow, and extreme noise levels. Accidents in these zones can lead to severe injuries or fatalities, often caused by unawareness of proximity to run turbines. Despite existing safety protocols, human errors, distractions, and limited visibility increase the risk of such incidents. Therefore, enhancing situational awareness in turbine areas is crucial to improving workplace safety and preventing accidents.

An advanced warning system that uses wearable technology and sensors has been presented as a solution to this problem. When personnel are within a dangerous range, a sensor mounted on the turbine detects their presence and turns on warning lights to notify them. By guaranteeing instant visibility of danger, this real-time alert system enables personnel to respond quickly and keep a safe distance from the turbine. A direct physical warning is also provided by incorporating vibration patches onto safety shoes. This guaranteeing that technicians and maintenance staff are alerted even in loud settings where visual or auditory cues can be missed.

By implementing this dual-alert system, the safety of aviation maintenance crews working near running turbines can be significantly enhanced. A multi-sensory alert system that combines vibration feedback and warning lights lowers the possibility of human error while raising awareness of hazardous areas. By reducing turbine-related incidents, this project seeks to improve aviation safety and provide a safer working environment for employees in high-risk sectors.

## **1.2 PROBLEM STATEMENT**

Many workplace accidents occur because workers fail to notice how close they are to hazardous equipment or restricted areas. In environments such as turbine zones, construction sites, or maintenance areas, poor visibility and distraction can lead to dangerous proximity incidents. Traditional safety equipment like helmets or reflective vests offer limited protection since they only improve visibility, but do not provide any real-time warning when a person moves too close to danger.

Currently, there is a lack of wearable devices that can alert workers effectively based on distance. Without an automatic proximity detection system, workers rely solely on visual awareness or warning signs, which are often ineffective in noisy or dark environments. As a result, the chances of human error increase, putting both workers and equipment at risk.

Therefore, a safety armband equipped with a distance-based light alert system is proposed to overcome this issue. The armband uses a proximity sensor to detect when a person approaches a hazardous area and activates a safety light to warn the user instantly. This innovation enhances workplace safety by improving situational awareness and preventing accidents before they occur, especially in low-visibility or high-risk zones.

## **1.3 PROJECT OBJECTIVE**

### **1.3.1 GENERAL PROJECT OBJECTIVES**

The objective of this project is to develop a comprehensive safety system aimed at preventing accidents near operational turbines by detecting personnel in hazardous proximity and providing multi-channel alerts. This system will integrate cutting-edge sensor technology to accurately detect individuals standing too close to a running turbine and trigger immediate warnings. The alert mechanism will consist of visual warning lights, a vibration patch embedded within safety shoes to provide direct haptic feedback to the individual. This multi-layered alert system is designed to enhance situational awareness, ensuring that workers are promptly notified of potential dangers, thereby reducing the risk of injuries.

The project also aims to create a robust and user-friendly safety solution that can be seamlessly integrated into industrial environments where turbines operate. By leveraging wireless communication technology, the system will ensure rapid data transmission between sensors and vibration patched allowing for an efficient and coordinated safety response. The system will be designed with reliability, durability, and ease of use in mind, making it suitable for various industrial applications, including power plants, aerospace facilities, and manufacturing plants where turbine operations are common.

In addition to accident prevention, this project seeks to contribute to workplace safety innovation by demonstrating how smart technology can enhance hazard detection and response. The integration of sensor-based proximity detection with haptic and digital alerts represents a step forward in personal protective equipment (PPE) technology, offering a proactive approach to safeguarding workers. Ultimately, this project aims to minimize workplace injuries, improve safety compliance, and foster a safer working environment for industries that rely on turbine operations.

### **1.3.2 SPECIFIC INDIVIDUAL PROJECT OBJECTIVES**

#### **1.3.2.1 PRODUCT STRUCTURE (STUDENT A) (OMPRAKAS 24DAM23F1022)**

This project's focus is to improve safety within industries, particularly those related to high-speed-rotary machinery, such as turbines, where the loss of life associated with their operation has a very high risk. Traditional safety systems, such as barriers, warning signals, and sirens, turn out to be ineffective in such instances Because excessive noise drowns alarm sound signals and makes visual signals hard to recognize. The solution to addressing this gap shall be the proposed design of the mini turbine with integrated proximity sensors, a visible light warning system, and the vibrating feedback incorporated into safety shoes.

The prototype applies complete with proximity sensors that detect any worker within their predefined danger area. Once detected, the system will trigger a visual alert, such as a flashing light or LED signal, to warn the worker immediately. This will be quite visible even in noisy environments and thus will give a clear indication to the worker about potential danger. Along with the visual alert, the system also includes a vibrating

patch in safety shoes for tactile feedback. Triggered by proximity data from sensors, the vibration feedback increases its intensity as the worker approaches the hazard. This increasing vibration, therefore, can act like a feedback mechanism in real time, giving the worker direct and unmistakable signs of their proximity to the rotating machinery.

### **1.3.2.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN 24DAM23F1061)**

The product mechanisms of the project focus on how various components of the small turbine safety system interact to detect, warn, and protect individuals from high-speed rotating gear. First is to design an actual proximity detection system using infrared or ultrasonic sensors that constantly scan for motion. These sensors operate in an industrial setting with several options for modifying their detection ranges. They emit alarms when labourers enter in a predetermined hazard area. This solution aims at employing LED caution lights that can switch on along with motion detector's triggering a visual caution mechanism will hence be provided by these lights. These lights must be very well seen even in the darkest places and, for different stages of danger, in various colours and intensities.

Besides this, the system will also implement the development of a vibrating feedback mechanism embedded in safety shoes as a means of preventing accidents. Such will provide tactile alerts that increase in intensity as a worker approaches the turbine for immediate physical warnings. Especially in a very noisy environment where audible alarms may not serve their purpose. The vibrating device must be small, light, and comfortable for workers. Important here is that proximity sensors, visual warning lights, and vibrating feedback mechanisms have their say in communicating undisturbed to trigger real-time alerts based on the proximity of the worker to the turbine.

Finally, the mechanisms of the product should be easy to repair, durable, and energy efficient. Parts will consume less power, be wear and tear resistant, and operate autonomously with minimum assistance from humans. Achieving these objectives will enhance workplace safety by the reduction in accident occurrence and provide proactive alerts about danger to employees working in hazardous situations.

### **1.3.2.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA 24DAM23F1060)**

The primary objective of the software and programming component of this project is to develop a system that integrates proximity sensors into the turbine area. This to detect the presence of personnel within hazardous proximity. The software will be responsible for processing the sensor data in real-time. For an example, triggering warning lights and alerts whenever a technician or maintenance crew member enters a danger zone. This system will need to ensure accurate sensor readings and minimal delay in activating the alarms to provide timely warnings to the workers.

The creation of a vibration feedback system for the safety shoes that maintenance workers wear is another important goal. When the worker is within a specified unsafe distance from the turbine, the software will communicate with the vibration patches that are integrated into the shoes to cause the patches to vibrate. In noisy settings when visual or auditory cues may not be effective. So, the programming will make sure that the vibration warnings are precisely triggered based on proximity data. Offering a tactile warning that enhances the visual alert system.

The software will also include algorithms for real-time data processing to minimize time lag and avoid false alerts. Ensuring the accuracy of proximity detection is critical for preventing accidents. To ensure that it functions dependably in a variety of scenarios and provides workers with accurate and timely warnings when needed, the system will be tested and repaired.

### **1.3.2.4 ACCESSORIES AND FINISHING (STUDENT D) (SAMUNDESWARY 24DAM23F1031)**

The objective of this project is to develop a fully integrated workplace safety system with a focus on accessories and finishing to ensure efficiency, durability, and user-friendliness. The system will incorporate an advanced sensor-based detection mechanism capable of identifying individuals standing too close to a running turbine. These sensors, which may include infrared, ultrasonic, or LiDAR-based technology, will provide accurate real-time detection to prevent accidents. To enhance alert mechanisms, the system will integrate high-intensity LED warning lights for visual alerts and a vibration patch embedded in safety footwear. To ensure immediate tactile warnings even in noisy environments where traditional alarms may be ineffective.

Additionally, the power supply system will be optimized to provide reliable and energy-efficient operation. This to ensure that the sensors, warning lights, and vibration patches function effectively over extended periods without frequent maintenance. To enhance durability, the project will utilize industrial-grade materials that can withstand harsh workplace conditions, including exposure to dust, heat, and mechanical wear. Special attention will be given to making the wearable components, such as the vibration patch, ergonomic and comfortable for extended use without interfering. The entire system will be designed to be compatible with existing workplace safety protocols and PPE, ensuring smooth integration into various industrial environments.

Comprehensive testing and calibration will be conducted to validate the accuracy and responsiveness of the system, minimizing false alarms while ensuring effective hazard prevention. A controlled workplace evaluation will be carried out to assess real-world performance and gather feedback from workers and supervisors for further refinements. Detailed documentation will be maintained throughout the development process to ensure compliance with safety regulations and industry standards. Ultimately, this project aims to create a highly efficient, durable, and user-friendly safety system that enhances workplace safety, reduces human error, and prevents accidents in environments where turbines are in operation.

#### **1.4 PURPOSE OF PRODUCT**

This product is designed to enhance worker safety in industrial settings where labourers are highly vulnerable to injury from high-speed, rotating machinery like turbines. A combination of environmental factors such as excessive noise, poor visibility, and human inattention. This often leads to situations where conventional guarding-a myriad of forms through warning signs, alarms, and barriers-poorly guards against any potential danger. This device will bridge this gap by informing workers through multisensory, real-time warnings so they are ever watchful of impending dangers. The present invention provides for a prompt and efficient warning mechanism by using proximity sensors, a light warning system, and a vibration feedback mechanism. The proximity sensors act to detect the presence of the worker and trigger a visual warning in the form of flashing LED lights once the worker enters a predetermined danger zone close to the turbine. Meanwhile, vibrational warnings come through a response system installed in the shoes worn by the worker. The

vibration becomes stronger the closer the worker gets to the dangerous area. This is the assurance that, though auditory warnings may not be heard in the case of a loud environment, this dual technique of warning would ensure clear warnings to the worker.

It should be dependable, easy to integrate, and effective for many industrial applications that involve high-risk operations, space constraints, or rotating gear. This approach nurtures hazard awareness decreases the chances of on-job injuries and gives added protection to personnel working in a hazardous environment, taking precautions at the earliest signs of safety threat. In conclusion, this tool ensures that specified industrial safety measures are upheld, and accidents are prevented, thus securing a safer environment in the workplace.

## **1.5 SCOPE OF PROJECT**

### **1.5.1 GENERAL PROJECT SCOPES**

The most important contribution of this project is the design and development of a safety system, integrated with proximity sensors, visual warning lights, and vibrating feedback into safety shoes. To develop a safer atmosphere for workers working around high speeds and rotating machinery in industrial perspectives. This can be helpful to improve safety by reducing some loopholes compared to the traditional method of alarms and warnings through visual signals. The turbine will have infrared or ultrasonic proximity sensors attached to it to detect the worker's presence within a predefined danger zone, thus guaranteeing reliable proximity detection.

Proximity sensors will trigger a visual warning system of flashing lights or LEDs to the worker for impending risk as the worker enters near the hazard zone. The vibrating feedback mechanism will be fitted in the safety shoes of workers. Which complement a visual alert, to provide directly to the workers a personal warning through immediate touches in a series. This vibration will be higher in intensity as the worker approaches the turbine, creating further emphasis on the proximity to the hazard and alerting the worker to be cautious. The project will undergo testing and prototyping to ensure that proximity sensors are working properly, the visual warning system is efficient, and vibrating feedback provides reliable alerts in a timely manner.

## **1.5.2 SPECIFIC INDIVIDUAL SCOPES**

### **1.5.2.1 PRODUCT STRUCTURE (STUDENT A) (OMPRAKAS 24DAM23F1022)**

On this turbine, IR or ultrasonic proximity sensors detecting the approach of workers towards the turbine will be installed. When the proximity sensors detect that a worker enters the radius of the predetermined safety zone, two major forms of safety would be triggered. This includes the Visual Light Warning system and the vibrating feedback system. The visual light warning system installed directly on the turbine will incorporate LED lights or flashing lights. The purpose is for alerting visually workers when near the danger zone. These will be highly visible even in bad lighting conditions or high ambient noise. A vibrating feedback system inlaid in the worker's safety shoes as a tactile alert increasing in intensity as the worker approaches the turbine.

The vibration provides instant physical warning-ensuring that, even in noise, the worker will know in environments where auditory and visual warnings may prove hopeless. It will be completely integrated: a set of components shall work in cooperation to cause an appropriate alert for proximity. Overall design will ensure ease of deployment in industrial settings this requires a minimum of user input with continuous safety monitoring. This comprehensive product structure ensures real-time multisensory feedback that enhances situational awareness and reduces accidents in hazardous environments.

### **1.5.2.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN 24DAM23F1061)**

The theme of this project is to build a small-scale turbine safety system that encompasses multiple safety features to help protect employees from industrial environments. The small-scale turbine has proximity sensors to detect workers approaching a designated hazard zone and emulates rapid movement as would be associated with operational spinning machinery. The device provides visibility in conditions that may be too loud or low in light to recognize an alarm with LED or flashing lights as visual warnings upon detection.

In addition, with tactile alerts through integrated vibrating feedback in safety armband the intensity of the alerts increases as the worker gets closer to the hazard. This ensures immediate awareness, even in cases of overlooked visual cues. It also doesn't

require other peripheral devices, such as a mobile application, since it is designed to be autonomous and self-sustaining. The final prototype will be made for durability testing on how the small turbine, sensors, and visual alerts with vibration feedback all play into the bigger objective of workplace safety and accident prevention in dangerous situations.

### **1.5.2.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA 24DAM23F1060)**

The scope of the software and programming aspects of this project includes the development of a system to interface with proximity sensors installed on the turbine. The software will process the sensor data in real-time to detect when a worker enters a hazardous proximity. The technology will promptly notify workers by turning on visible alerts, such warning lights, when it detects personnel in hazardous areas. This project component will guarantee that the system operates dependably, responds quickly, and precisely senses proximity to prevent mishaps.

Programming the vibration feedback system that is included into safety armband is another crucial component of the project. When the worker is within a specified unsafe distance from the turbine, the program will communicate with the vibration patches to activate them. Workers will have an extra degree of security with this tactile alert, particularly in noisy or hectic settings when visual clues might not be enough. To guarantee that employees are informed in real time, the vibration system will cooperate with the visual warning system.

Finally, the software will undergo extensive testing and debugging to ensure reliable performance in various environmental conditions. The system will be tested for its ability to provide consistent alerts without false triggers and to adapt to different turbine setups. Optimizing the system for low response is another aspect of the project scope that will guarantee accurate sensor readings and efficient operation. To ensure smooth operation in high-risk environments, a straightforward user interface will be created for configuration and monitoring reasons. This will enable maintenance teams to modify settings and assess the health of the system.

#### **1.5.2.4 ACCESSORIES & FINISHING (STUDENT D) (SAMUNDESWARY 24DAM23F1031)**

A significant part of the scope involves the design and implementation of warning systems, including high-intensity LED lights for visual alerts and a vibration patch embedded in safety armband to provide immediate tactile feedback. The vibration patch will be ergonomically designed to ensure comfort and seamless integration with existing personal protective equipment (PPE). Additionally, the durability and environmental resistance of all accessories will be prioritized, ensuring that they can withstand industrial conditions such as heat, dust, moisture, and mechanical stress.

The power supply system will also be a crucial focus, ensuring that all components, including sensors, lights, and wearable alerts, operate efficiently with minimal energy consumption. Furthermore, the aesthetic and ergonomic finishing of the system will be carefully considered. The accessories, including the vibration patch and sensors, will be designed to be lightweight and non-intrusive, allowing workers to perform their tasks comfortably. The overall design will ensure compatibility with standard workplace safety gear without compromising protection or usability.

To ensure effectiveness, testing and calibration of all accessories will be conducted under real workplace conditions. The system will be evaluated based on detection accuracy, response time, and user feedback to refine its performance. Proper documentation will be maintained throughout the development process to ensure compliance with workplace safety regulations and industry standards. Ultimately, this project aims to develop a well-integrated, durable, and reliable safety system that enhances workplace safety while ensuring comfort and ease of use for workers operating near running turbines.

## Chapter 2

### 2.1 LITERATURE REVIEW

Following the technological boom that began during the industrial revolution, the world has rapidly evolved into a complex network of machines, systems, and automation. Even though this has brought comfort, efficiency, and global connectivity, it has also ushered in new risks, specifically in high-power environments like factories, power plants, and air transport. Technology has advanced to the point where a single error has the potential to cause catastrophic consequences. A single step missed, a wrongly handled tool, or being in the wrong place at the wrong moment can not only result in injury, but even fatality. The aviation industry, while heavily regulated, is not exempt from this either.

Despite rigorous safety measures, procedural checklists, and automation, mishaps do happen and the most common culprit is still human error. Working within the aviation repair industry, workers and engineers would find themselves with high-speed motors, moving objects, and tremendous heat. Upon safety records and statistics across the globe of the aviation industry, having a human being in position too close to an operational turbine is a fatal risk, especially when visual and auditory distractions come into play.

With this system, turbine areas can be made significantly safer. It is an active real-time feedback system and not a passive warning system. This project is not about creating another gadget, it's about saving lives, preventing accidents from distraction or neglect, and giving technicians an added layer of security when working near powerful aircraft equipment.

#### 2.1.1 Aviation Industry in Malaysia

Malaysia's aviation industry is a key sector in the nation's transport and economic sectors. It offers both domestic and international connectivity, enabling the easy transportation of passengers and freight. Malaysia Airlines, AirAsia, and Batik Air are

some of the largest airlines in Malaysia and are also key players in the regional and global aviation industry. The industry is also a major player in the country's tourism and trade sectors.

Safety standards, airport services, and air traffic administration are regulated by government agencies including the Civil Aviation Authority of Malaysia (CAAM) and Malaysia Airports Holdings Berhad (MAHB). Malaysia's geographic location in Southeast Asia has positioned it as a hub for aircraft operations, maintenance, and training. The country is also home to a burgeoning aerospace industry including manufacturing, engineering services, and aircraft maintenance, repair, and overhaul (MRO) facilities.

In the past several years, the aviation sector has been focusing on enhancing safety, sustainability, and technological development. There has been a drive to enhance airport facilities, modernize air traffic systems, and adopt new technologies for more secure operations. With these advancements, Malaysia is looking to promote its competitiveness in the global aviation sector while maintaining high standards of safety and efficiency in operations.

Besides that, the Malaysian aviation sector has also opened up vast opportunities for aerospace and aircraft maintenance engineering graduates. The institutions of higher learning offering courses related to aviation work very closely with the industry to produce highly skilled individuals. This enables the availability of human capital that can deal with contemporary aviation needs, especially in the fields of safety systems, human factors, and technological upgrades in airplanes and ground operations.



FIGURE 1  
(BATIK AIRLINES)



FIGURE 2  
(AIRASIA AIRLINES)

### **2.1.2 TREND OR DEMAND FOR LOW-COST CARRIER**

By emphasizing affordability, efficiency, and operational simplicity, the world-wide demand explosion for low-cost carriers (LCCs) has revolutionized the aviation business. LCCs attempt to reduce expenses by streamlining operations, minimizing turnaround times, and lowering fuel and maintenance expenses as more passengers opt for lower fares. To achieve this, they are leveraging more power-efficient, lighter, and modular technologies that assist their business model without reducing performance or compromising on safety.

This is the trend for the Mini Turbine with Detector Sensor and Vibration Patch System. Because the mini turbine is a portable source of power, the primary electrical supply of the airplane can then be used to power smaller secondary systems. This is extremely beneficial for LCCs trying to conserve power consumption and enhance energy independence for smaller components. By providing haptic alerts in noisy or congested environments where traditional alarms are useless, the inclusion of a vibration patch system and sensor detector is safer. In maintenance and inspection activities, cabin crew members or ground staff can especially be helped by this feature.

Your project is very compatible with the needs of LCCs for balancing operations with safety levels without paying the cost or weight or complexity of it. Due to its modularity and lightness, your technology can be used within ground systems or aircraft without significantly adding weight or complexity. Your type of technologies will play an increasingly important role in making air operation cheaper, smarter, and safer as LCCs mature and grow in numbers.

### **2.1.3 Human Factors and Situational Awareness**

Situational awareness refers to an individual's perception of environmental elements, comprehension of their meaning, and projection of their future status. In industrial and aviation environments particularly near high-speed rotating machinery like turbines maintaining high levels of situational awareness is essential to prevent accidents.

Human error is a leading cause of occupational injuries, often resulting from distraction, sensory overload, fatigue, or poor visibility. Therefore, safety systems must compensate for these limitations by delivering clear, timely, and context-sensitive alerts. This is where human factors engineering plays a vital role designing systems that complement human capabilities and mitigate cognitive limitations.

Multisensory feedback systems, which use a combination of visual (LED lights), auditory (alarms), and tactile (vibrations) cues, have proven highly effective in enhancing situational awareness. According to a study published in the Journal of Safety Research, systems that engage more than one sensory modality reduce reaction times and improve hazard recognition accuracy, especially under stressful or noisy conditions.

Tactile (vibrational) is particularly valuable in environments with high ambient noise levels, such as turbine maintenance areas. Workers wearing ear protection may not hear audible alarms, and visual alerts can be obscured or missed due to distractions or poor lighting. Vibrating cues embedded in PPE like safety vests, helmets, or footwear serve as direct, body-based alerts that immediately capture attention without relying on external senses.

Additionally, graded vibration intensity, where vibrations grow stronger as a person gets closer to danger, helps the brain perceive urgency and directionality. This mirrors natural reflex responses, helping workers make faster, more instinctive decisions in critical moments.

By designing the system around these principles, project aligns well with the best practices in safety ergonomics and human factors engineering offering a practical, proactive solution to enhance situational awareness in turbine zones.

#### **2.1.4 Evolution of Human Alert Systems in Hazardous Environments**

Man-machine warning systems in risk-prone environments such as industrial complexes, airbases, and power stations have developed over the years. Earlier,

systems were based on visual and audible alerts. But the old-style systems did not perform well where the surroundings are too noisy or when there is poor eyesight.

As a response to such issues, cutting-edge systems nowadays incorporate wearable technology such as vibration patches, haptic devices, and smart wearables in a bid to provide instant physical alerts to employees. Such innovations attempt to avoid human error as well as respond faster under crisis situations.

The discovery of vibration-driven alert systems has been promising so far in its ability to get people alerted despite compromised auditory or visual senses. Combined with sensor-activated light signals like blinking lights, the multi-layer system generates a stronger and more pro-active safety regime — particularly near rotating equipment like gas turbines.

### **2.1.5 Integration of Vibration and Light-Based Alert Systems for Turbine Safety**

Gas turbines present extreme hazards during operation, particularly in aerospace testing and manufacturing environments. Traditional safety measures include physical barriers, warning signs, and alarms. These measures depend on user awareness, however, and consistently break down in dynamic or high-speed environments.

More recent developments in safety now engage proximity sensors, infrared detection, and ultrasonic sensing to monitor human proximity to running turbines. Moving this one step ahead, your project now includes a two-stage alert system:

- I. Vibration Patch in Armband: When entering a danger zone, a sensor activates a vibration patch in the person's armband to provide an immediate physical alert.
- II. Sensor Light Activation: If the person remains in the danger zone a warning light is triggered to provide a second, visual alert.

This layered approach to safety offers multiple chances for the individual to perceive the threat, especially in a situation where distraction or noise could affect perception. It also aligns with current trends in wearable safety devices and smart environmental sensor networks being used in aerospace and industrial settings.

## **2.2 SPECIFIC LITERATURE REVIEW**

### **PRODUCT STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)**

#### **2.2.1.1 Basic Design of Main Structure**

Sensor light and vibration patch equipment are particularly designed to work together as an active protection system that prevents accidents near gas turbines. The system combines wearable and fixed elements, well designed to work in series. The principle is to alert a person who unknowingly enters a turbine hazard zone via the use of a vibration patch embedded in their armband. If the person does not move away once warned by the vibration signal, a bright sensor light near the turbine will be activated to give a second, more visible warning.

The system begins with a sensor unit, which is mounted near the turbine. This sensor—usually a PIR (Passive Infrared), ultrasonic, or IR sensor—is employed to detect the presence of a person within a defined radius, e.g., 1.5 meters. Upon detection, it sends a signal to a control unit with a microcontroller (e.g., an Arduino Nano or ESP32). The micro-controller then processes the input and sends a signal wirelessly to the wearable device.

The vibration patch is placed inside the user's armband or in their arm area. It is equipped with a tiny vibration motor, a micro-controller, and a small rechargeable battery. When it detects a human in the danger area, it activates the motor, vibrating to provide instant haptic feedback. If the person does not vacate the area in a few seconds, the micro-controller----- subsequently activates an eye-level mounted sensor light. The light is a secondary warning easily noticed by the person as well as by any workers in the area. This two-stage warning system (vibration and light) guarantees that the person has a higher chance of reacting and avoiding an accident.

### **2.2.1.1.1 Compliance to Safety Standards**

Though the system is at the prototype stage, it is engineered with safety best practices in place. All components are engineered to operate at low voltage levels, typically between 3.7V to 5V, making them safe for wearable application. Electrical wires are properly insulated using heat-shrink tubing or connectors to prevent short circuits or shocks. The wearable module uses soft, flexible enclosures to avoid irritating or causing injury when in contact with the skin. The control and sensor module enclosure design also aims to position the components in secure positions with no loose wiring exposure or fittings.

Operation safety is also kept in mind. The system uses basic industry safety principles, such as early warnings and step-wise alerting. It is analogous to the Lockout-Tagout (LOTO) safety procedure in which equipment must be de-energized and tagged for maintenance. This project also alerts users before direct contact with turbine machinery. The vibration to light activation delay is utilized as a grace period to encourage safe movement away from the hazardous region. Each of the parts has casings selected to survive minute dust or splashes of oil, common in turbine conditions, and for that reason, the structure is satisfactory for simulating minimum levels of industrial usage.

### **2.2.1.2 Type of Material for Product Structure**

Material selection is essential to the reliability and performance of the system. All parts of the system are built with specific materials to offer strength, comfort, and electrical insulation. The armband housing is made of soft silicone or thermoplastic polyurethane (TPU), which are both skin-friendly, sweat-proof, and flexible. These materials are comfortable to wear and still allow vibration to be transferred effectively.

The control unit and sensor enclosure are made of durable ABS plastic or 3D printed PLA. These are lightweight, resist minor impacts, and are non-conductive, making them perfect for encasing electronic components. For the housing of the sensor light, clear acrylic or polycarbonate sheets are best, which allow the LED light to be transmitted while also containing the inner circuits. These are extremely transparent, weather-proof, and possess good light diffusion properties.

Support components such as adjustment straps or fastening clips can be made from durable fabric, silicone, or lightweight plastic, depending on the intended usage. For ease of wearing and testing, adjustable Velcro straps or snap fasteners are typically used to secure the armband comfortably without requiring any additional tools.

#### **2.2.1.2.1 Selection of Aluminium Alloy**

For sections of the structure that must have extra strength and stability, such as mounts or frames in the demonstration assembly, aluminium alloy 6061-T6 is selected. The alloy is famous for its attractive mix of light weight, great strength, and corrosion resistance. It is widely employed in aerospace and industry and is easily easy to cut, drill, and assemble for prototype use. Using aluminium also adds to the project's realism, simulating how turbine safety structures are built. It is moderately electrically conductive, but since it is only being used structurally and not for the transmission of current, it is not an electrical hazard.

#### **2.2.1.2.2 Selection of Composites**

Composite materials are incorporated to add comfort, reduce weight, and improve overall system life, especially in wearable parts. Inside the shoe, EVA (Ethylene Vinyl Acetate) foam is used as padding to securely place the vibration motor and serve as a shock absorber. The foam is commonly used in sports shoes and is especially ideal for embedding electronics.

For the armband, neoprene or nylon material is utilized. These materials are resilient, breathable, and flexible, allowing a snug fit without causing discomfort. They also help secure the battery and control board in place without restricting the user's arm movements. In the sensor light's housing, polycarbonate or acrylic composites are used to protect the LED while still allowing good transmission of light. The materials are chosen specifically because they are resistant to heat as well as cracking.

## **2.2.2 PRODUCT MECHANISMS (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**

### **2.2.2.1 TYPES OF HINGES**

There are some types of hinges that may come in handy with your project, especially if it involves access panels, enclosures, or moving pieces for the turbine, sensor, or vibration patch system. Mini Turbine with Detector Sensor and Vibration Patch System. Butt hinges can be employed in any enclosure for your electronics or battery parts since they are a convenient and dependable choice that is often utilized for doors or boxes. A piano hinge, or in some cases a continuous hinge, can be used in order to give a firm connection the entire length of a panel or a turbine casing for longer or continuous support. Hidden hinges or European hinges are best if you want a neater, more professional finish because they are not visible and are usually used in circumstances where appearance is an issue.

The self-closing aspect of the spring hinge is to their advantage. Pivot hinges can offer smooth rotation about a fixed point for parts undergoing rotation, such as motion turbine parts or adjustable sensor mounts. Barrell hinges provide an elegant, invisible hinge solution that is integrated into the material for small or embedded applications. Finally, parts that need to remain in a specific position, such as a patch or sensor that needs to remain at a specific angle without additional support, are best suited for torque hinges, or friction hinges. You will have to select the proper hinge mounting, rotation, access, or safety option for your system based on its application.

### **2.2.2.2 TYPES OF ELECTRICAL MOTOR**

A DC motor, as a common motor in small projects because it is easy to use, controllable, and battery-friendly, would most probably be a good motor for the mini turbine. A brushed DC motor would be a cheap and simple choice if your turbine needs to rotate at different speeds. However, if your project involves a continuous or smooth-running turbine, a brushless DC (BLDC) would be the best if you want to improve efficiency, reliability, and performance. If your turbine is in a position-sensitive application, you can use a stepper motor to provide accurate angular motion in steps for better control of torque and speed, especially when you add sensors.

The vibration patch system is to be employed along with a vibration motor. They are small DC ERM motors or LRA, used in wearables and mobile phones that have haptic feedback. The ERM motors deliver vibration through the rotation of an off-center mass, and LRA motors use an internal mass that resonates linearly. An LRA motor produces more precise and controlled vibrations if your patch is to quietly and softly inform the user. Your project can normally employ a vibration motor (LRA or ERM model) for the system of notification and a brushless DC motor or stepper motor for the mini turbine. Your control, performance, and power efficiency needs will determine which exact choice.

#### **2.2.2.2.1 SELECTION OF AC MOTOR**

Some key considerations, like the torque required, speed, rating, size constraints, and availability of power supply, must be kept in mind while choosing an AC motor for the Mini Turbine with Detector Sensor and Vibration Patch System. Given the ease of use and global availability of traditional power supplies (220V or 240V), a single-phase AC motor is typically chosen for small turbines. Since it has the capability to provide a high starting torque and reliable continuous running, a capacitor start-capacitor run induction motor would be an appropriate option.

If speed control is needed in the rotation control of the turbine but three-phase supply or converter is not present, then a three-phase squirrel cage induction motor with a variable frequency drive (VFD) would be fine. Due to its compact size and quiet operation, even the universal motors or shaded pole motors can be used, especially in situations where power is not significantly needed. The motor torque level and RPM would be set correctly for the turbine system to avoid overload and enhance successful energy transfer. Better selection ensures effective driving of the turbine by the motor and, at the same time, enables vibration patch and detector sensor functioning without increasing electric or mechanical issues.

## **2.2.3 SOFTWARE / PROGRAMMING (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

### **2.2.3.1 Types of Software for Output Display**

Software plays an important role in controlling and operating the output display systems used in safety-critical projects of aviation and engineering. Programming languages such as C/C++, Python, and Arduino IDE are extensively utilized in microcontroller-based safety systems due to the fact that they support embedded systems such as Arduino, Raspberry Pi, and ESP32. The platforms ensure proper control of hardware components such as LEDs, vibration motors, and visual alert displays.

For display outputs, Light Emitting Diodes (LEDs) and vibration modules typically are driven through digital output pins with programmed states based on sensor inputs (e.g., IR or ultrasonic sensors for proximity detection). Libraries such as FastLED (for LED strips) or Adafruit\_NeoPixel are commonly utilized in Arduino-based projects to produce different light patterns or color codes for warning signals. For vibration outputs, Pulse Width Modulation (PWM) techniques are used in programming to control vibration levels, offering adjustable alert feedback.

In advanced systems, Graphical User Interfaces (GUIs) can be used with Python combined with Tkinter, PyQt, or Processing IDE to visually display sensor readings and system status in real time. Additionally, Internet of Things (IoT) applications employ platforms like Blynk or ThingSpeak to wirelessly monitor remotely and trigger outputs. These computer applications allow developers to construct safe, responsive, and user-friendly systems to enhance workplace safety. In aviation maintenance facilities, such systems quickly present visual and physical alerts, eliminating the possibilities of human error around hazardous machinery like rotating turbines.



FIGURE 3 (EXAMPLE OF SOFTWARE)

### 2.2.3.2 Types of Arduino Board

Arduino boards are widely used in electronics and embedded systems due to their ease of use, flexibility, and strong community support. One of the most well-known boards is the Arduino Uno, a versatile microcontroller ideal for beginners and capable of handling a wide range of projects. It allows users to program in the Arduino IDE using C/C++ and supports numerous libraries for controlling hardware components. It is suitable for applications such as sensor-based systems, motor control, and real-time monitoring in safety-critical environments.

For smaller-scale or more cost-effective control tasks, boards like the Arduino Nano and Arduino Pro Mini are popular choices. These boards are compact, affordable, and provide reliable performance for controlling LEDs, vibration motors, and sensors, making them ideal for warning systems or automation tasks. The Arduino Mega offers more input/output pins and memory, making it suitable for larger, more complex industrial or automation projects.

Another powerful option is the ESP series, such as the ESP8266 and ESP32, which can be programmed using the Arduino IDE. These boards come with built-in Wi-Fi and Bluetooth for wireless communication and IoT projects. The ESP32 is powerful enough to execute multiple tasks such as reading sensors, sending data to the cloud, and driving output devices like LEDs, buzzers, or vibration motors simultaneously.

For education and beginner-level projects, the Arduino Starter Kit or Arduino Nano Every is a good choice. These options make it easy to learn the basics of programming and electronics with various included components such as LEDs, sensors, and motors.

They are convenient for quickly prototyping and testing ideas like proximity alerts or physical feedback systems. Each Arduino board has unique features, so developers can choose the most suitable platform based on their project specifications and technical requirements.

#### **2.2.3.2.1 Selection of Suitable Arduino Board**

For our Final Year Project, which involves proximity detection and providing safety alerts through LEDs and vibration, we have selected the **Arduino Uno** as the most suitable microcontroller board. This board is programmed using the Arduino IDE in C/C++, making it efficient, reliable, and well-suited for real-time tasks. Unlike full computers or Wi-Fi-enabled boards, the Uno focuses purely on hardware interaction, which matches the specific needs of our project.

The Arduino Uno provides sufficient GPIO pins for connecting the ultrasonic sensors, LED indicators, and vibration motors that we require. It also supports PWM (Pulse Width Modulation), allowing us to adjust brightness or vibration intensity as needed. Since our system does not require any wireless connectivity, the Uno's simplicity and focus on direct input/output operations make it a perfect fit for our application.

Another advantage of the Arduino Uno is its low power consumption and compact size, making it suitable for integration into wearable devices like our proposed armband. Its affordability also makes it a reasonable choice for our student project. Additionally, the Arduino platform has a high level of open-source community support, enabling us to easily access libraries, sample codes, and troubleshooting guidance during our development.

Moreover, the Arduino Uno offers a stable and robust platform for running continuous safety operations. In critical areas such as turbine maintenance zones, a reliable microcontroller is essential to send real-time alerts without delays caused by software or communication failures. The Uno's simplicity, dependability, and durability give it an edge as a safe and effective solution for improving worker safety in our project.

Lastly, the ease of programming the Arduino Uno using the Arduino IDE allows us to conveniently write, test, and fine-tune our logic code throughout the project schedule. This adaptability is crucial for adjusting sensor sensitivity, modifying output responses, and adding more safety measures as required. The user-friendly nature of Arduino ensures our team can focus more on system functionality rather than struggling with complex programming challenges.



FIGURE 4 ( ARDUINO SOFTWARE)

#### **2.2.4 Accessories and Finishing (SAMUNDESWARY D/O RENGANATHAHAN 24DAM23F1031) (Student D)**

The accessories and finishing components of a wearable safety system play a critical role in ensuring the effectiveness, durability, comfort, and usability of the product in real-world industrial environments. For a system designed to alert workers near operational turbines using wearable technology, these aspects are essential for long-term adoption and performance.

##### **2.2.4.1-Wearable Alert Mechanisms**

The integration of vibrating feedback into armbands is an emerging trend in smart personal protective equipment (PPE). Vibrating modules are typically compact, lightweight, and designed for low power consumption, making them ideal for

embedding in wearable devices. Research in wearable haptics, such as by Pacioretty et al. (2017), has shown that vibration alerts are effective in guiding user attention without interfering with other tasks. These haptic components must be carefully positioned to maintain strong skin contact for clear perception, even when worn over clothing or during active arm movements.

#### **2.2.4.2-High-Intensity Visual Alerts**

LED indicators are a standard feature in modern safety systems due to their low power use, visibility in various lighting conditions, and compact size. Studies on LED usage in industrial safety (e.g., Ulrich & Eppinger, 2019) emphasize their effectiveness when combined with tactile alerts. These lights should be enclosed in dust-proof, water-resistant casings to endure harsh industrial conditions.

#### **2.2.4.3-Ergonomics and Comfort**

Comfort is essential for long-term use of any wearable system. According to ISO 27500 guidelines on human-centered design, accessories like vibrating patches must be ergonomic, lightweight, and not obstruct movement. Poorly designed or bulky accessories can reduce compliance and create discomfort during extended use.

#### **2.2.4.4-Durability and Industrial Resistance**

Components must withstand industrial environments, including:

Mechanical stress (arm movement, impact)

Heat and moisture

Dust and oil exposure

Materials like thermoplastic polyurethane (TPU), silicone rubber, and industrial-grade ABS plastic are often used for enclosures. These materials are durable, flexible, and resistant to chemical and environmental damage.

#### **2.2.4.5-Power Supply and Integration**

Power systems must be efficient and low maintenance. Lithium-polymer batteries are often preferred due to their small size and long runtime. Charging mechanisms should be simple ideally via USB or contactless methods and integrated into the shoe or warning module. Some systems also explore energy harvesting from walking motion to prolong battery life.

#### **2.2.4.6-System Compatibility and Finish**

Finishing the product to ensure it blends seamlessly with standard PPE (such as existing armbands, uniforms, or gloves) is essential for worker acceptance. Customization options, modular attachments, and user-adjustable settings enhance adaptability. Surface finishing (e.g., anti-slip coating, smooth edges) contributes to both safety and user experience.

## 2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

### 2.3.1 RELATED PATENT PRODUCTS

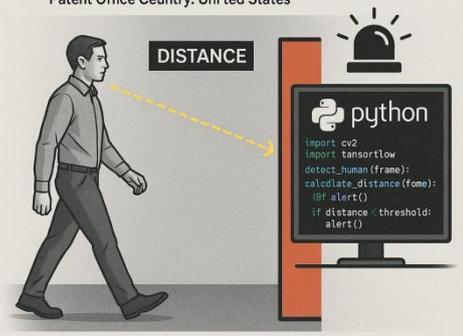
#### 2.3.1.1 PATENT A (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

NO.	PATENTED PRODUCT	PATENT SUMMARY
1.	 <p data-bbox="293 891 443 922">FIGURE 5</p>	<p data-bbox="671 528 1278 560"><b>Footwear with Haptic Feedback System</b></p> <p data-bbox="671 582 1078 613"><b>Patent No.:</b> US10149574B2</p> <p data-bbox="671 636 1086 667"><b>Published Date:</b> 11/12/2018</p> <p data-bbox="671 689 1214 721"><b>Patent Office Country:</b> United States</p> <p data-bbox="671 743 1305 775"><b>Inventors:</b> Anirudh Sharma, Daniel G. Clark</p> <p data-bbox="671 797 1390 1442"><b>Abstract:</b> The invention discloses a footwear system embedded with a haptic feedback (vibration) mechanism located in the sole. The system includes a vibration motor, a control circuit, and sensors. The vibration units are strategically placed to provide different types of alerts to the user. The control circuit receives signals from external devices (like proximity sensors) and activates specific vibration patterns. The structure ensures the device remains durable, waterproof, and comfortable for daily wear, while effectively providing directional or hazard-related haptic cues.</p>

**2.3.1.2 PATENT B YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**

NO.	PATENTED PRODUCT	PATENT SUMMARY
2.	 <p>FIGURE 6</p>	<p><b>Electric Motor Assembly for Safety and Environmental Systems</b></p> <p><b>Patent No.:</b> US9601989B2</p> <p><b>Published Date:</b> 21/03/2017</p> <p><b>Patent Office Country:</b> United States</p> <p><b>Inventors:</b> Stefan Schmidt, Markus Heinzelmann</p> <p><b>Abstract:</b> The invention describes an AC electric motor assembly used as a power source for safety and environmental protection systems. The motor drives components such as ventilation fans, alarm lights, or safety indicators. The system ensures continuous operation during emergency conditions, enhancing workplace safety by providing airflow, alarms, or visual alerts during hazardous events. The motor system includes controllers to regulate motor speed and torque depending on safety requirements.</p>

**2.3.1.3 PATENT C (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

NO.	PATENTED PRODUCT	PATENT SUMMARY
3.	<p>Patent No.: US11010951B2    Published Date: 25/05/2021 Patent Office Country: United States</p>  <p>The invention describes a real-time proximity alert system using image processing algorithms coded in Python with OpenCV libraries. The system captures live video feed from a camera, detects human presence or movement towards hazardous zones, and triggers alert mechanisms such as alarms or lights. It uses</p> <p><b>FIGURE 7:</b> Computer vision, motion detection using python</p>	<p><b>Real-Time Proximity Alert System Using Computer Vision (Python-based)</b> <b>Patent No.:</b> US11010951B2 <b>Published Date:</b> 25/05/2021 <b>Patent Office Country:</b> United States <b>Inventors:</b> Zeeshan Syed, Mark Sendak <b>Abstract:</b> The invention describes a real-time proximity alert system using image processing algorithms coded in Python with OpenCV libraries. The system captures live video feed from a camera, detects human presence or movement towards hazardous zones, and triggers alert mechanisms such as alarms or lights. It uses Python's machine learning modules (TensorFlow, OpenCV) to dynamically recognize humans and calculate their distance from dangerous areas. When the proximity is too close, a programmed alert is activated immediately.</p>

**2.3.1.4 PATENT D (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031)  
(STUDENT D)**

NO.	PATENTED PRODUCT	PATENT SUMMARY
4.	 <p data-bbox="293 1032 443 1066">FIGURE 8</p>	<p data-bbox="671 421 1390 506"><b>Wearable Vibration Alert Device for Hazardous Environment</b></p> <p data-bbox="671 528 1078 562"><b>Patent No.:</b> US10583291B2</p> <p data-bbox="671 584 1086 618"><b>Published Date:</b> 10/03/2020</p> <p data-bbox="671 640 1214 674"><b>Patent Office Country:</b> United States</p> <p data-bbox="671 696 1286 730"><b>Inventors:</b> Matthew C. Allen, Kevin T. Link</p> <p data-bbox="671 752 1390 1111"><b>Abstract:</b> A lightweight, portable vibration alert device designed for industrial environments. The device attaches to a worker's body or gear and delivers strong vibrations when sensors detect proximity to hazardous zones. It is waterproof, rechargeable, and intended to improve worker safety through immediate haptic feedback.</p>

## 2.3.2 RECENT MARKET PRODUCTS

### 2.3.2.1 PRODUCT A (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

NO.	MARKETED PRODUCT	PRODUCT SUMMARY
1.	 <p data-bbox="453 954 603 987">FIGURE 9</p>	<p data-bbox="804 472 1177 506"><b>E-vone Smart armbands</b></p> <p data-bbox="804 524 1203 562"><b>Company:</b> E-vone (France)</p> <p data-bbox="804 580 1129 613"><b>Published Date:</b> 2023</p> <p data-bbox="804 631 1390 1330"><b>Description:</b> E-vone smart armbands are equipped with embedded sensors, vibration motors, and communication modules. When a dangerous situation is detected such as a fall, sudden stop, or entry into a hazardous zone. The shoes vibrate to alert the wearer and automatically send emergency signals to designated responders. The vibration system is built into the sole structure, and the shoes are waterproof, durable, and designed for heavy industrial environments.</p>

**2.3.2.2 PRODUCT B (YOSANTHAN S/O ALEXANDAR 24DAM23F1061)  
(STUDENT B)**

NO.	MARKETED PRODUCT	PRODUCT SUMMARY
2.	 <p data-bbox="357 887 528 920">FIGURE 10</p>	<p data-bbox="715 421 1390 506">Siemens SIMOTICS GP General Purpose AC Motor</p> <p data-bbox="715 528 1059 562"><b>Company:</b> Siemens AG</p> <p data-bbox="715 584 1007 618"><b>Release Year:</b> 2023</p> <p data-bbox="715 640 1390 1223"><b>Abstract:</b> The SIMOTICS GP is a general-purpose AC motor designed for industrial systems needing reliable power sources. It is used to drive fans, pumps, conveyor belts, and safety equipment such as warning lights and ventilation units. It offers high efficiency (IE3 standard), robust construction, and easy integration with safety automation. It supports continuous operation even during harsh conditions, ensuring that critical systems like alarms and ventilation remain functional.</p>

**2.3.2.3 PRODUCT C (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

NO.	MARKETED PRODUCT	PRODUCT SUMMARY
3.	 <p data-bbox="292 680 584 768">FIGURE 11 OPEN CV-PYTHON</p>	<p data-bbox="671 360 1342 398"><b>OpenCV-Python Smart Surveillance System</b></p> <p data-bbox="671 416 1385 454"><b>Company:</b> OpenCV.org / Independent Integrators</p> <p data-bbox="671 472 994 510"><b>Published Date:</b> 2023</p> <p data-bbox="671 528 1390 1111"><b>Description:</b> A real-time safety monitoring system built with Python using OpenCV and TensorFlow libraries. It captures video streams, detects human motion and proximity breaches to critical zones, and automatically triggers alarms or activates visual warning lights. The system is widely used in factories and turbine areas for ensuring personnel stay outside dangerous zones. It is flexible, open-source, and can be customized for different site layouts, making it popular in industrial safety solutions.</p>

**2.3.2.4 PRODUCT D (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031)  
(STUDENT D)**

NO.	MARKETED PRODUCT	PRODUCT SUMMARY
4.	 <p data-bbox="400 837 568 871">FIGURE 12</p>	<p data-bbox="671 421 1382 506">HAV-Sentry Wearable Vibration Monitoring System</p> <p data-bbox="671 528 1139 562"><b>Manufacturer:</b> Feraru Dynamics</p> <p data-bbox="671 584 963 618"><b>Release Year:</b> 2023</p> <p data-bbox="671 640 1388 1335"><b>Abstract:</b> The HAV-Sentry system is a wearable device designed to monitor hand-arm vibration exposure in real-time. Integrated into a breathable textile gauntlet, it houses the Aegis sensing unit, which captures vibration data from the user's hand. When exposure thresholds are approached or exceeded, the device provides immediate alerts through sound and visual indicators. Data collected is uploaded to a cloud-based dashboard for analysis, aiding in compliance with ISO 5349 and ISO 8041 standards. The system aims to prevent Hand-Arm Vibration Syndrome (HAVS) by enabling proactive safety measures.</p>

## 2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

### 2.4.1 (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

PRODUCT	Footwear with Haptic Feedback System (Patent)	E-vone Smart armbands (Market Product)	Our Project (Safety Vibration Patch System for Turbine Area)
DESIGN	Embedded vibration motors, control circuits, and sensors in shoe sole. Durable, waterproof design.	Built-in sensors and vibration motors inside armband. Waterproof and shock-resistant design.	Vibration patch system installed inside industrial armbands. Lightweight, compact, weather-resistant.
PORTABILITY	Yes, fully portable as normal footwear.	Yes, designed for industrial daily use.	Yes, integrated into standard armbands.
PURPOSE	Provide directional or hazard-related haptic alerts through footwear.	Provide real-time hazard or fall alerts and emergency communications.	Provide real-time vibration alert to warn user when entering turbine hazard zone.
VIBRATION MECHANISM	Controlled vibration pattern based on detected hazard signals.	Vibration triggered by sensors detecting falls, hazardous zones, or inactivity.	Vibration triggered when proximity sensors detect turbine danger zone breach.
POWER SOURCE	Battery-powered system embedded in sole.	Battery-powered and recharged via charging port.	Battery-powered, rechargeable by external charging.

### 2.4.2 (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)

PRODUCT	Electric Motor Assembly for Safety and Environmental Systems	Siemens SIMOTICS GP General Purpose AC Motor	AC Motor for Power Source
MOTOR TYPE	AC Motor Assembly (fixed industrial type).	AC General Purpose Industrial Motor.	Mini AC or compact DC motor, depending on final design needs.
DURABILITY	Designed for emergency and hazardous conditions.	Built for continuous operation under harsh industrial conditions.	Designed for daily use in armband; must be lightweight, durable, shock-absorbing.
PURPOSE	AC motor drives safety/environmental systems (fans, alarms) during emergencies.	General-purpose AC motor drives industrial equipment (fans, conveyors, alarms, pumps).	AC motor powers system components (e.g., vibration motor, sensors, fans) for haptic feedback system.
SPECIAL FEATURES	Focus on emergency operational integrity (keep running under danger).	High energy efficiency, flexibility in installation, robustness.	Focus on user comfort, portability, and precise real-time feedback.
EFFICIENCY STANDARD	Not specified (standard motor).	High efficiency (IE3 certified).	Focus on energy efficiency and lightweight design (target: long battery backup or less load).

### 2.4.3 (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)

PRODUCT	Real-Time Proximity Alert System (Patented Product)	OpenCV-Python Smart Surveillance System (Recent Market Product)	Current Project (Python Proximity Safety System)
DESIGN	Python-based system using computer vision to detect humans and trigger alerts.	Open-source Python system using OpenCV for real-time detection and warning.	Custom Python program to detect human proximity near turbines and activate alert devices.
PROGRAMMING LANGUAGE	Python (with OpenCV and TensorFlow libraries).	Python (mainly OpenCV, TensorFlow optional).	Arduino (OpenCV for detection, optional Arduino integration).
ALERT MECHANISM	Triggers visual/auditory alert when human breaches danger zone.	Triggers alarm, flashing lights, or safety shutdown signals.	Triggers LED light alert and vibration patch in armband to warn workers.
TARGET APPLICATION	Industrial safety zones, factory hazardous areas.	General industrial and public safety surveillance.	Specifically for turbine maintenance and industrial turbine zones.
REAL- TIME CAPABILITY	Yes, real-time video analysis and instant alerts.	Yes,real-time detection and immediate action.	Yes — real-time sensor feed and immediate worker alert.
SYSTEM COMPLEXITY	High, uses machine learning for human recognition and distance measurement.	Medium, primarily uses computer vision algorithms for movement/proximity detection.	Low to medium — focuses on simple distance threshold triggering to maximize speed and minimize cost.

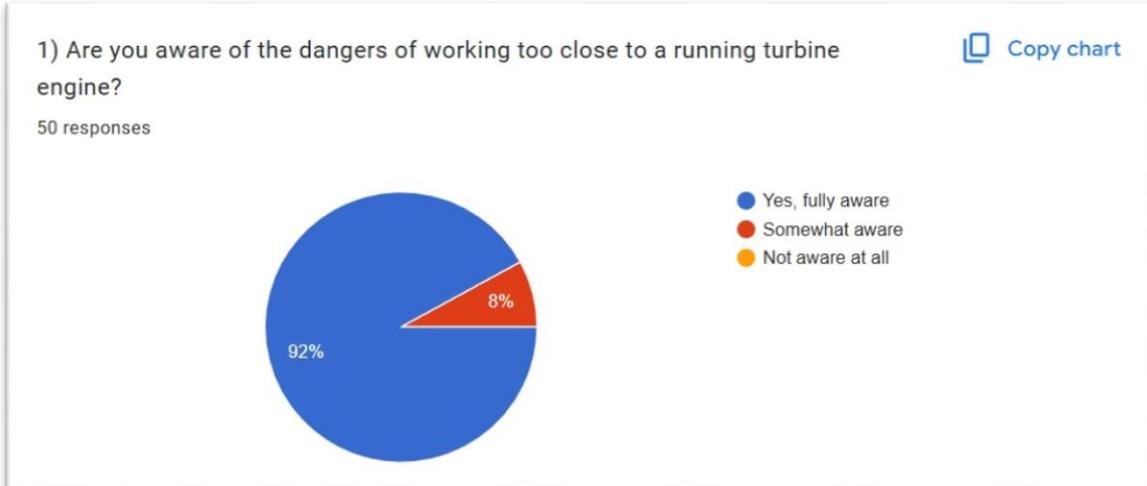
#### 2.4.4 (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031) (STUDENT D)

PRODUCT	Portable Vibration Alert Device (Patent)	Wearable Safety Alert Patch (Market Product)	Our Project (Light Warning + Vibration Patch Accessory)
DESIGN	Small portable vibration module that attaches to body or equipment; triggers based on hazard signals.	Wearable smart patch that vibrates when exposed to danger (e.g., near turbine, fall detection).	Small vibration patch installed inside armband; external flashing light system installed near turbine zone.
PORTABILITY	Highly portable, can be worn or attached to different safety gear.	Highly portable, stick-on or sewn into clothes.	Vibration patch portable (inside armband); warning light is fixed installation.
PURPOSE	Alert users through physical vibration when entering hazard zones.	Alert workers immediately by strong vibration and LED flashing in case of danger.	Alert user through vibration (patch) and visual light flashing near turbine area.
ALERT TYPE	Strong vibration pulses triggered automatically.	Vibration + optional LED flashing alert.	Strong vibration inside armband; bright light flashing outside near turbine zone.
POWER SOURCE	Small rechargeable battery (USB charge).	Small lithium battery; lasts multiple hours.	Rechargeable battery for patch; AC powered for light system.
SPECIAL FEATURES	Lightweight, waterproof, customizable vibration patterns.	Flexible, washable, customizable size and placement.	Simple, durable, easy maintenance, focused on immediate alert without extra complexity.

## Chapter 3

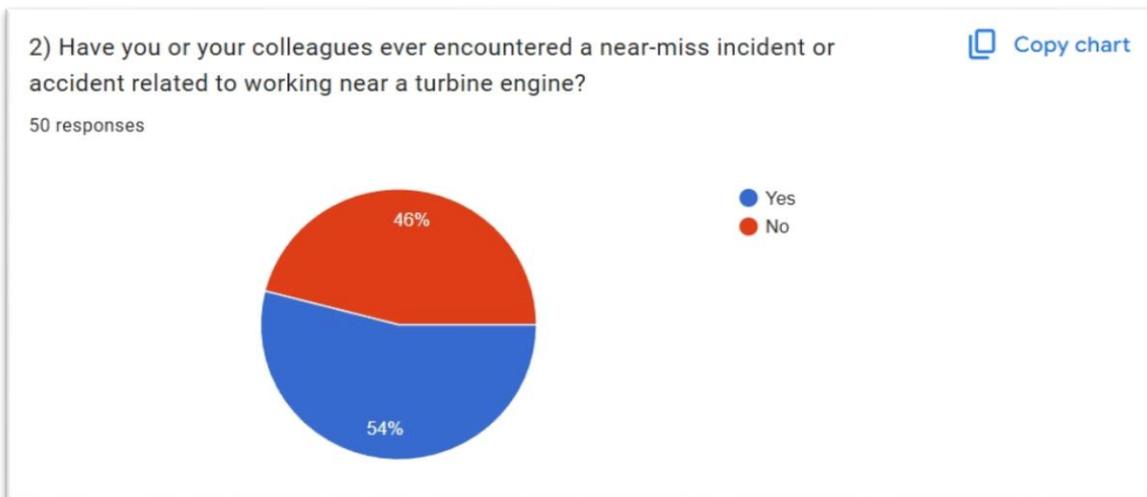
### 3.1 DESIGN REQUIREMENT ANALYSIS

#### 3.1.1 DESIGN REQUIREMENT ANALYSIS



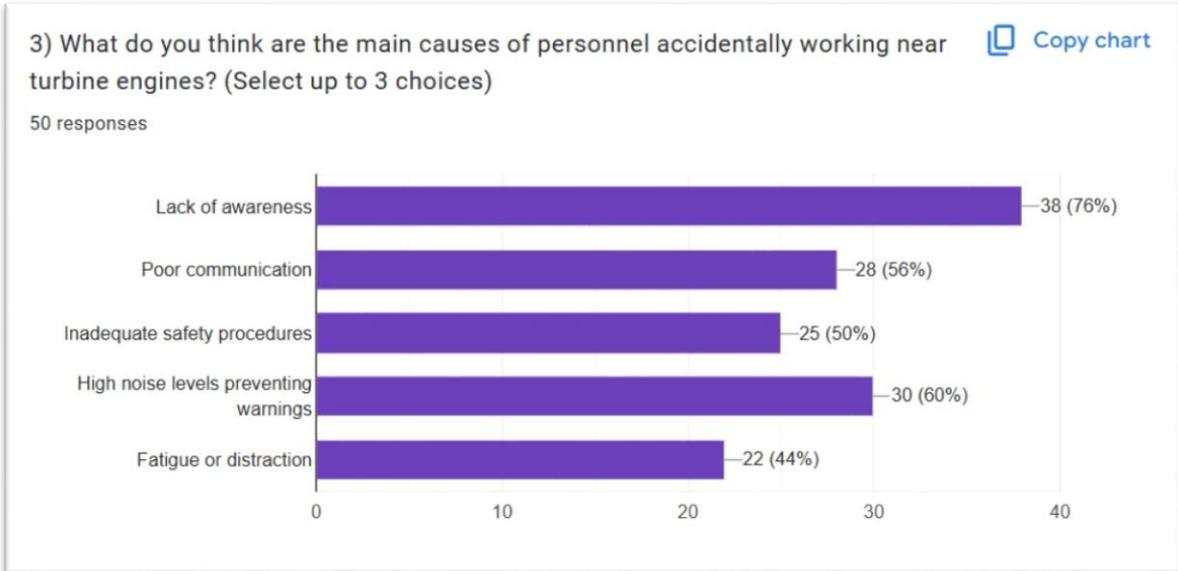
The survey shows that 92% of respondents are fully aware of the dangers of working near a running turbine engine, while 8% are somewhat aware. This indicates a high level of safety awareness, though minor reinforcement through training may still be useful.

**FIGURE 1**



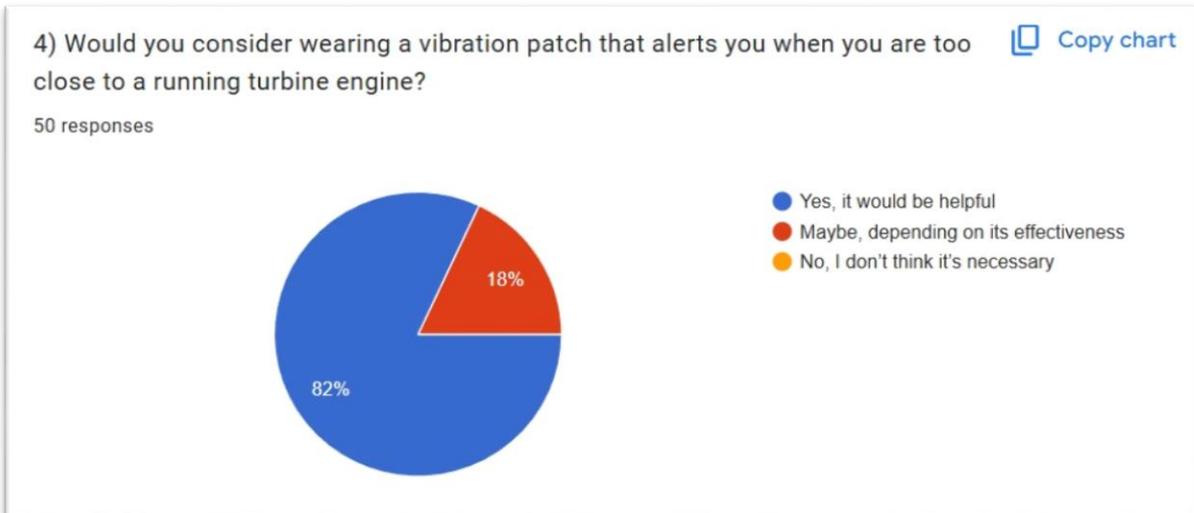
The chart shows that 54% of respondents answered “Yes”, indicating they or their colleagues have experienced a near-miss or accident near a turbine engine, while 46% answered “No.” This suggests that turbine-related incidents are relatively common, emphasizing the need for stricter safety practices and awareness training to prevent future occurrences.

**FIGURE 2**



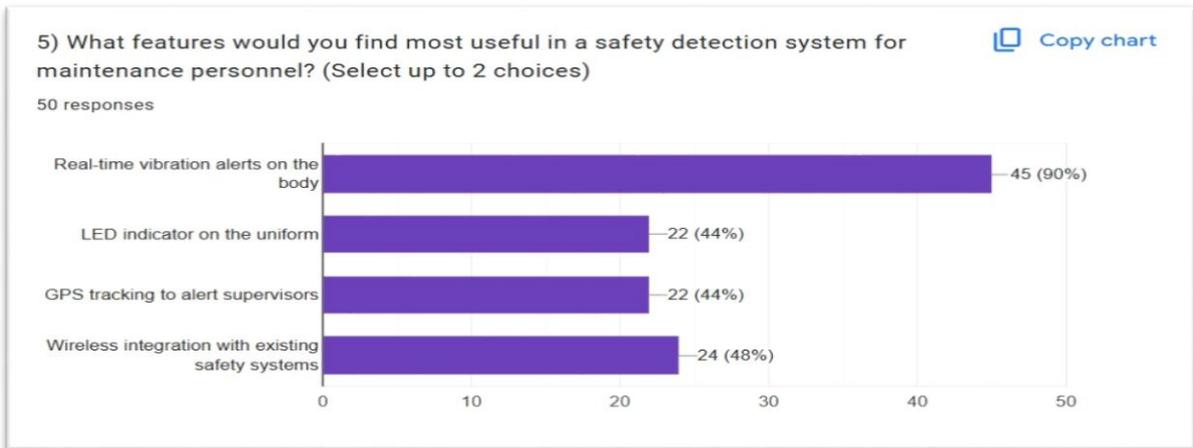
The results show that most accidents near turbine engines are caused by a lack of awareness (76%), followed by high noise (60%), poor communication (56%), and weak safety procedures (50%). Fatigue or distraction (44%) also plays a role. Overall, better awareness, communication, and safety practices are key to reducing risks.

**FIGURE 3**



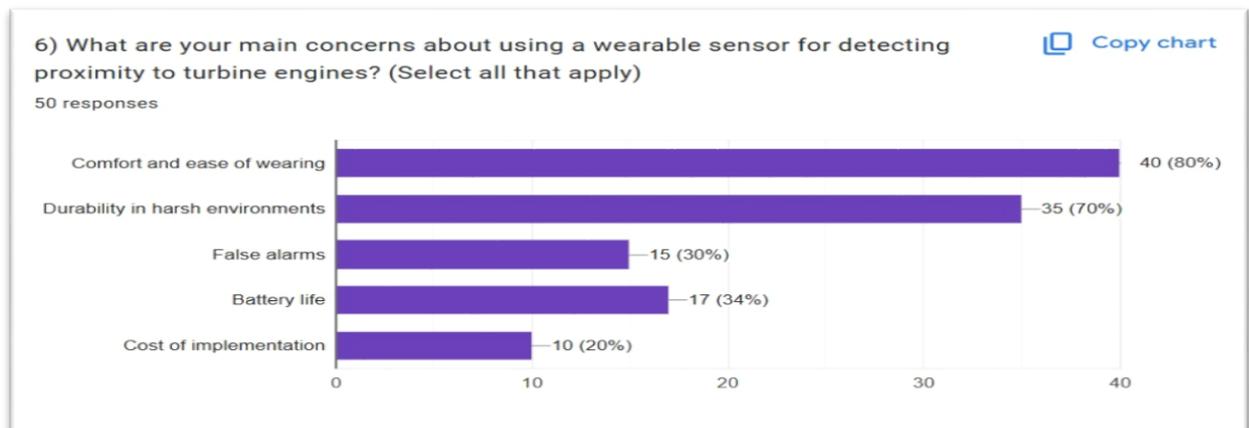
The survey shows that 82% of respondents would wear a vibration patch for turbine safety, while 18% said maybe depending on its effectiveness. This indicates strong support for the device and highlights its potential to improve safety awareness in turbine areas.

**FIGURE 4**



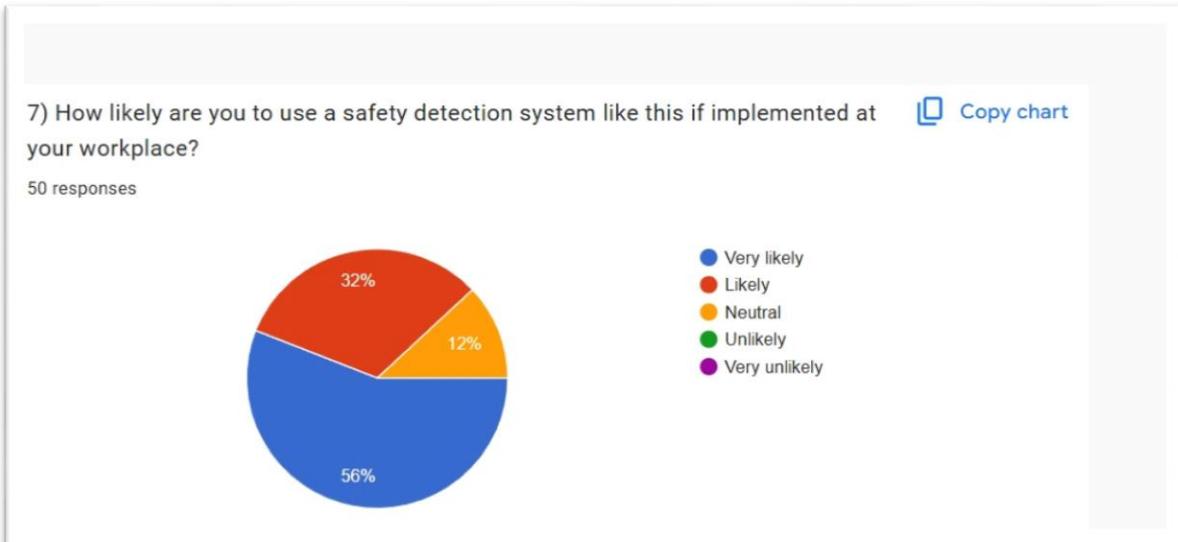
The survey results show that 90% of respondents found real-time vibration alerts on the body the most useful feature in a safety detection system. Meanwhile, 48% preferred wireless integration with existing safety systems, and 44% valued both LED indicators on the uniform and GPS tracking to alert supervisors. This indicates that users prioritize immediate physical alerts for personal safety, supported by connectivity and visual indicators to enhance overall awareness and coordination during maintenance tasks.

**FIGURE 5**



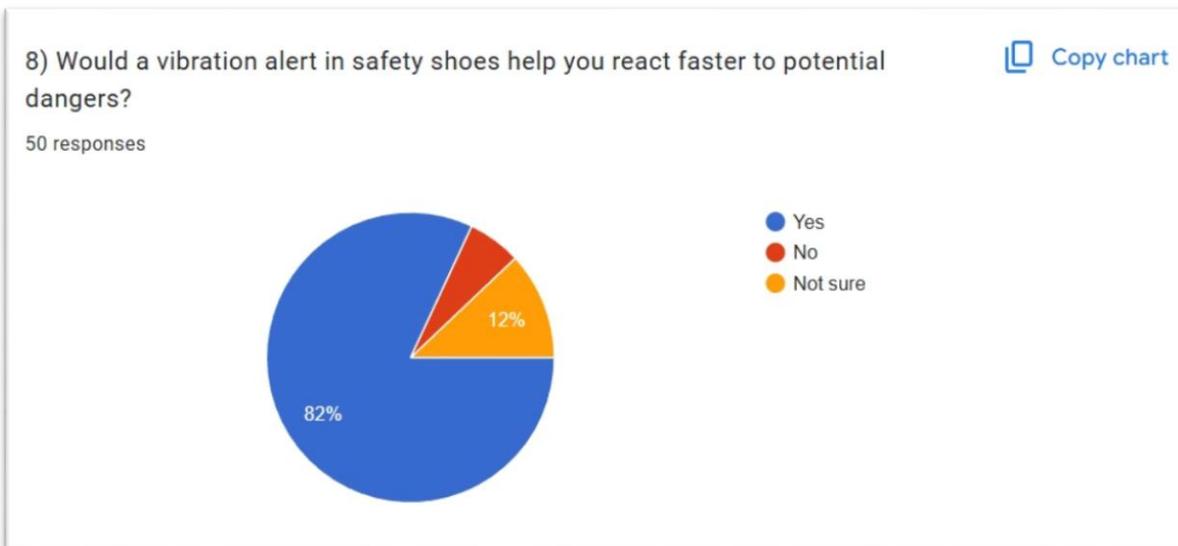
The survey results show that comfort and ease of wearing (80%) and durability in harsh environments (70%) are the main concerns among users regarding wearable sensors. Other issues include battery life (34%), false alarms (30%), and cost of implementation (20%) This indicates that for successful adoption, the device must be comfortable, durable, and reliable to meet the demands of the turbine maintenance environment.

**FIGURE 6**



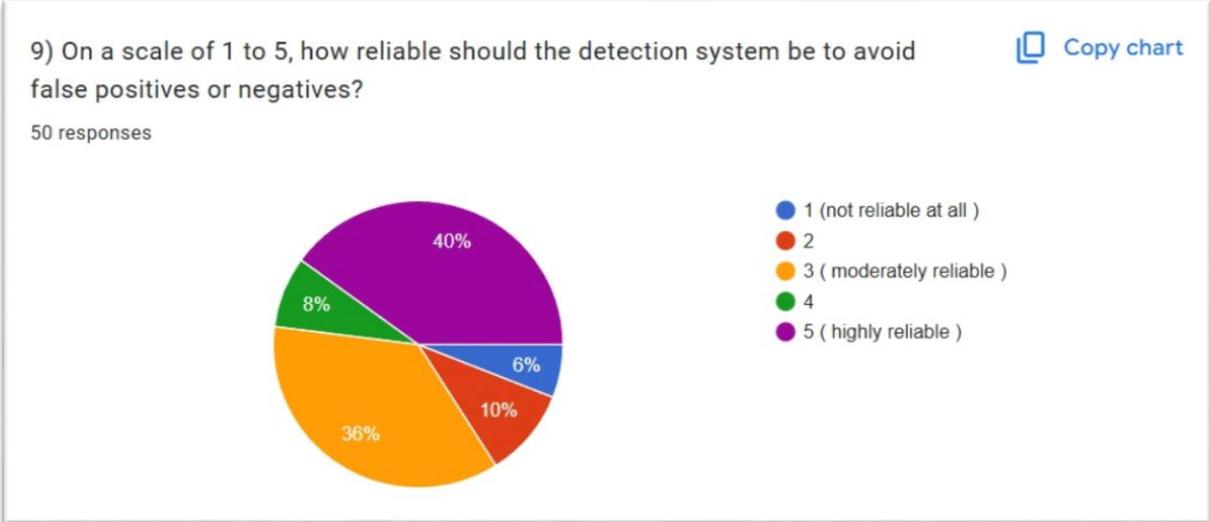
The 88% positive response signifies that employees see the safety system as valuable, ensuring high user adoption and minimal resistance during workplace implementation. The low negative response suggests strong overall acceptance.

**FIGURE 7**



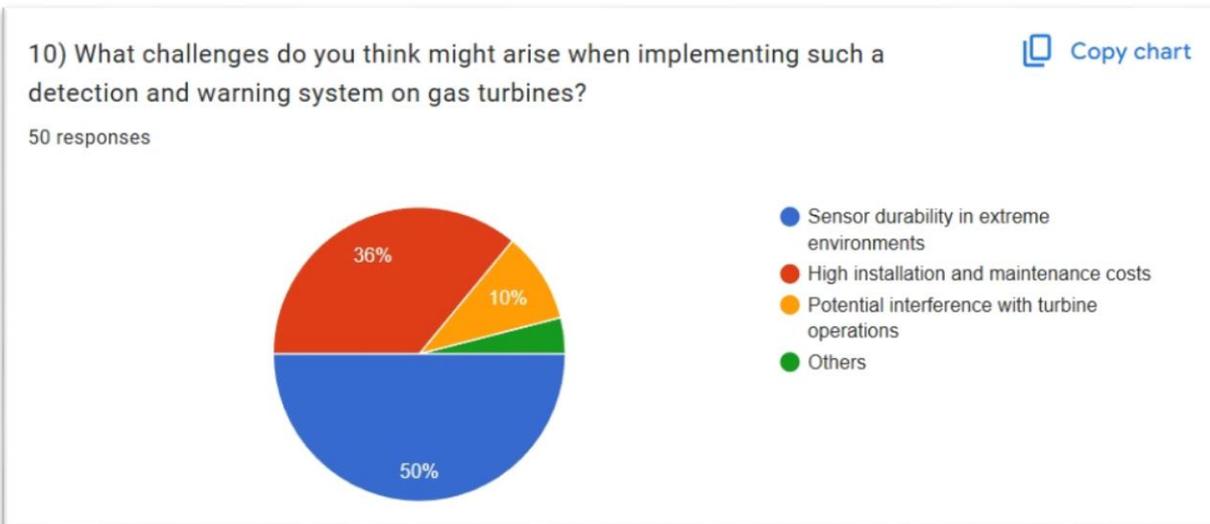
The 82% who believe the alert improves reaction time strongly validates the haptic design choice. This confirms employees trust the non-visual, non-auditory alert to quickly and effectively notify them of immediate dangers in a noisy environment.

**FIGURE 8**



Most respondents want the detection system to be very reliable. About 40 percent rated it as highly reliable (5) and 36 percent rated it as 4. Only a small number chose low reliability levels. Overall, users clearly prefer a system with high accuracy.

**FIGURE 9**



The survey shows that sensor durability in extreme environments (50%) is the main challenge in implementing a detection and warning system on gas turbines, followed by high installation and maintenance costs (36%), potential interference with turbine operations (10%), and other minor issues (4%).

**FIGURE 10**

### 3.4.1.2 PARETO DIAGRAM

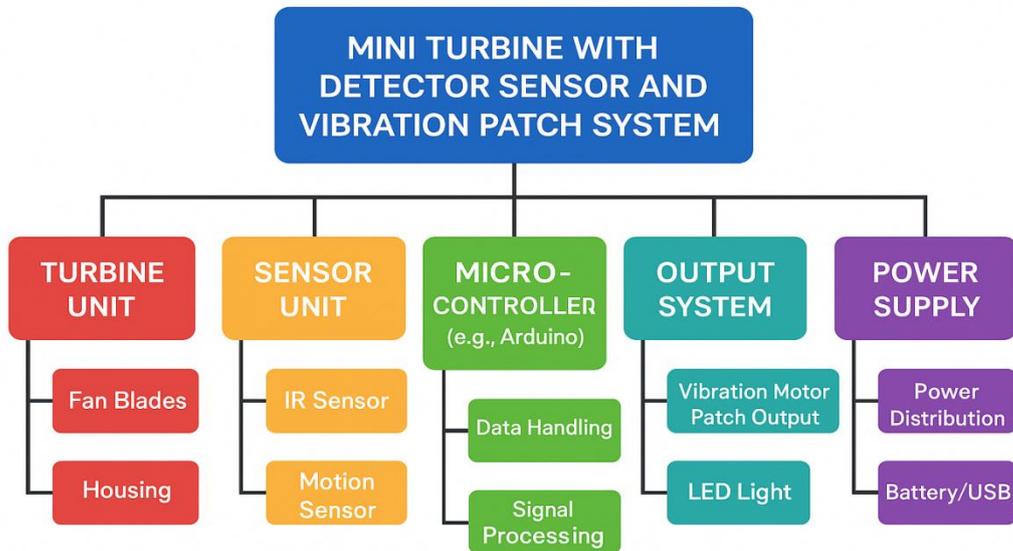
SUBJECTS	RESPONDENTS	TOTAL PERCENTAGE	CUMALATIVE PERCENTAGE
Lack of awarness	38	26.57%	26.57%
Poor communication	28	19.58%	46.15%
Inadequate safety procedures	25	17.48%	63.63%
High noise levels preventing warnings	30	20.98%	84.61%
Fatigue or distraction	22	15.38%	100.0%

SUBJECTS	RESPONDENTS	TOTAL PERCENTAGE	CUMALATIVE PERCENTAGE
Comfort and ease of wearing	40	31.49%	31.49%
Durability in harsh environment	35	27.55%	59.04%
False Alarms	15	11.81%	70.85%
Battery life	17	13.38%	84.23%
Cost of implementation	20	12.74%	100.0%

SUBJECT	RESPONDENTS	TOTAL PERCENTAGE	CUMALATIVE PERCENTAGE
Real time vibration alerts on the body	45	39.82%	39.82%
LED indicator on the uniform	22	19.47%	59.29%
Gps tracking to alert supervisor	22	19.47%	78.76%
Wireless integration with existing safety system	24	21.24%	100.0%

### 3.1.2 DESIGN CONCEPT GENERATION

#### 3.1.2.1 FUNCTION TREE



**Figure 11:** Function Tree of FPTD

A Function Tree of Mini Turbine with Detector Sensor and Vibration Patch System was constructed as the first step in developing the design concept process following analysis of the response to the Google Survey Form. To provide an open and structured approach to the system's design and implementation, the product development process is separated into a few major functions, which in turn are segmented into smaller sub-functions.

### 3.1.2.2 MORPHOLOGICAL MATRIX

FUCTION (SUB-FUCTION) TYPE	IDEA 1	IDEA 2	IDEA 3	IDEA 4
	 <p>LED SENSOR</p>  <p>ARMBAND</p>	 <p>Light Sensor</p>  <p>ARMBANDS</p>	 <p>LED RED LIGHT SENSOR</p>  <p>ARMBAND</p>	 <p>LED SENSOR</p>  <p>ARMBAND</p>
SOFTWARE	 <p>Arduino</p>	 <p>Raspberry</p>	 <p>Simulink</p>	 <p>Python</p>

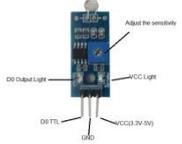
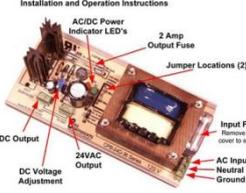
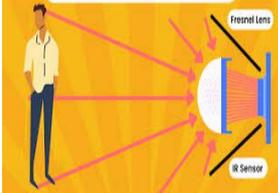
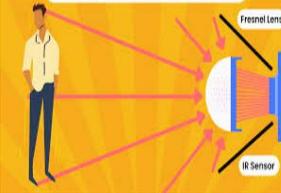
<p><b>HARDWARE</b></p>	 <p>Vibration sensor</p>  <p>Light sensor</p>	<p>Installation and Operation Instructions</p>  <p>Circuit</p>	 <p>Power supply (DC power supply)</p>	 <p>Warning system</p>
<p><b>PROGRAMMING LANGUAGE</b></p>	 <p>Python</p>	 <p>Java</p>	 <p>Matlab</p>	 <p>Micro Controller (C++)</p>
<p><b>INTERACTION</b></p>	 <p>Detection of a person or object</p>	 <p>Detection of a person or object</p>	 <p>Detection between the turbine area and the person stands</p>	 <p>Human detection around airplane turbine</p>

Table 1: Morphological Matrix

The generation of ideas for each function and sub-function was also the second activity after creating the Function Tree of the Mini Turbine with Detector Sensor and Vibration Patch System. These ideas came out from our minds and backed up by research on the internet. Programming languages, hardware components, software environments, detection sensors, and user interface techniques are only a few of the technologies and factors considered for the many functional areas of the system.

### 3.1.2.3 PROPOSED DESIGN CONCEPT 1 (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

Function	Concept Description	Rationale
Structural Shape	Modular Casing	Simplifies installation; adaptable to various turbine configurations
Frame Material	Polycarbonate Cover	Lightweight, durable, and resistant to heat, dust, and impact
Alert Mechanism	Vibration Patch + LED Light	Enhances hazard awareness through both tactile and visual alerts
Vibration Patch Location	Integrated into Arm	Provides immediate physical feedback in high-noise areas
Visual Indicator	High-Intensity LED Light	Ensures visibility in dim environments; signals danger clearly
Power Supply	Rechargeable Battery + AC Power Support	Offers continuous operation with low maintenance requirements
Additional Features	Waterproof Enclosure with Charging Port	Increases system durability for industrial environments

### 3.1.2.4 PROPOSED DESIGN CONCEPT 2 (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)

Function	Concept Description	Rationale
Structural Shape	Modular enclosure	Eases installation and fits a wide range of turbine setups.
Frame Material	Polycarbonate shell	Strong, lightweight, and shields against heat, dust, and physical impacts.
Alert Mechanism	Combined vibration unit and LED light	Improves safety by using both visual and tactile warnings.
Vibration Patch Location	Embedded within armbands	Direct placement ensures quick and clear alert detection.
Visual Indicator	Powerful LED lighting	Instantly communicates warnings in loud work areas.
Power Supply	Dual-mode: rechargeable battery and AC input	Reliable performance in dim settings; easy recharging options.
Additional Features	Sealed, waterproof body with built-in charging port	Boosts reliability and longevity in industrial working conditions.

**3.1.2.5 PROPOSED DESIGN CONCEPT 3 (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

Function	Concept Description	Justification
Structural Shape	Modular design that allows components (sensor, battery, patch) to be easily replaced or upgraded.	Ensures comfort and minimal interference with the work environment.
Frame Material	Lightweight materials like aluminum.	Strong, durable, and cost-effective for industrial use.
Alert Mechanism	Sequential alert: warning LED first, then vibration if the person doesn't move.	Reduces unnecessary haptic alerts and provides a tiered warning system based on danger level.
Vibration Patch Location	Integrated into the sole of the armband.	Provides direct and noticeable feedback without obstructing comfort or movement.
Visual Indicator	LED lights placed near the turbine or on safety gear.	Clear and immediate alert through visual signals, especially in hazardous areas.
Power Supply	Dual power system: battery for the patch and USB-C rechargeable module for sensor unit.	Ensures stable operation and convenient recharging with common power sources.
Additional Features	Data logging and user interface for settings.	Enables performance tracking and easy system control/customization.

**3.1.2.6 PROPOSED DESIGN CONCEPT 4 (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031)(STUDENT D)**

Function	concept 4	justification
Structural shape	Concept modular casing	Easy to install in turbine, suitable for various orientations
Frame structural material	Polycarbonate cover	Durable, lightweight, and resistant to heat and dust
Alert method	Vibration patch + led light	Dual sensory warning system increases user response
Vibration patch location	Ankle-mounted designs	Tactile feedback directly to user in noisy environments
Visual alert	High intensity led light	Visible in low-light areas; immediate hazard zone indication
Power source	Rechargeable battery patch + ac light	Ensures uninterrupted operation and reduced need for maintenance
Accessories	Waterproof enclosure + rechargeable port	Ensures long-term usability in industrial settings

### **3.1.2.4 ACCEPTED VS DISCARDED SOLUTION**

After evaluating multiple design options, Concept 3 was accepted as the final solution for our proximity-based safety alert system project. This concept includes a modular structural shape, chosen over a fixed, enclosed design to allow easier maintenance and upgrades. Lightweight aluminium was selected as the frame material due to its strength, durability, and heat resistance, especially important in high-temperature turbine areas. In comparison, materials like Polycarbonate or PVC were considered but discarded, as they are less heat-resistant and more prone to deformation under stress.

Concept 3 presents a progressive approach for the alert mechanism that starts with LED lights and then vibrates if the user does not react. This approach was chosen instead of using vibration and LED notifications at the same time, which could lead to overstimulation and needless power usage increases. The vibration patch is embedded into the sole of the armband to provide direct and clear feedback, unlike ankle-mounted designs that were considered but found less effective.

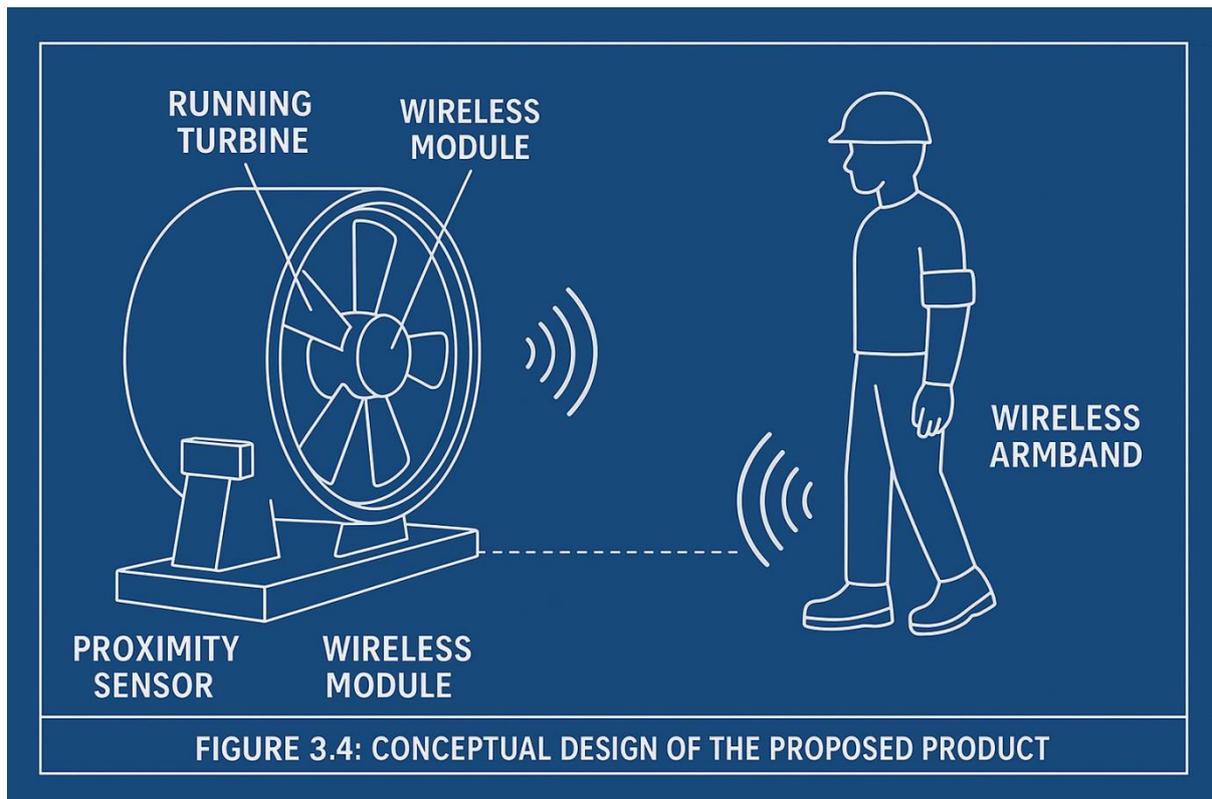
LED indicators are placed on safety gear or near turbine equipment, offering better visibility than sound-based alarms, which could be drowned out in noisy environments. A dual power supply system combining a rechargeable battery and USB-C module was chosen. For its stability and convenience, replacing the idea of using disposable batteries, which would be costly and unsustainable in the long run. Last but not least, a simple fixed system without configurability was abandoned because of its limitations in practical application, while other features like data recording and a configurable user interface were adopted for improved monitoring and flexibility.

## EVALUATION & SELECTION OF CONCEPTUAL DESIGN

### 3.1.3.1 PUGH MATRIX

Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Type	2	1	3	2
Software	1	3	2	1
Hardware	3	1	2	2
Programming Language	3	2	2	2
Interaction	2	2	3	3
Total Score	11	9	12	10
Ranking	2	4	1	3

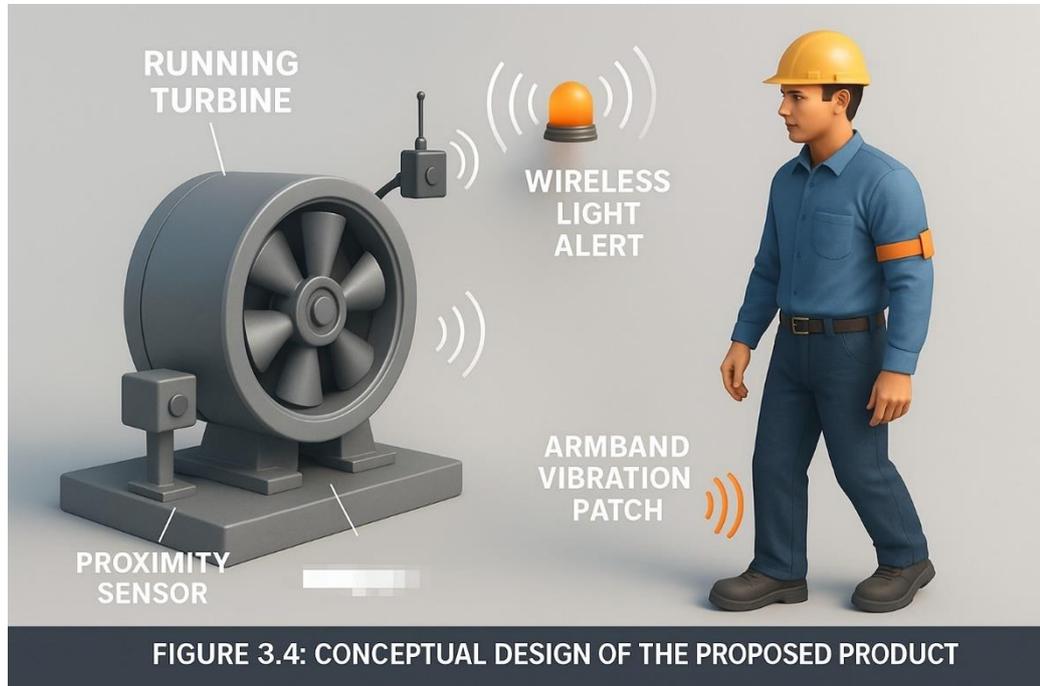
### 3.1.4 CONCEPTUAL DESIGN OF THE PROPOSED PRODUCT



**FIGURE 12**

## 3.2 PRODUCT SKETCHES

### 3.2.1 GENERAL PRODUCT SKETCHING



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**FIGURE 13**

### 3.2.2 SPECIFIC PART SKETCHING

#### 3.2.2.1 PRODUCT STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

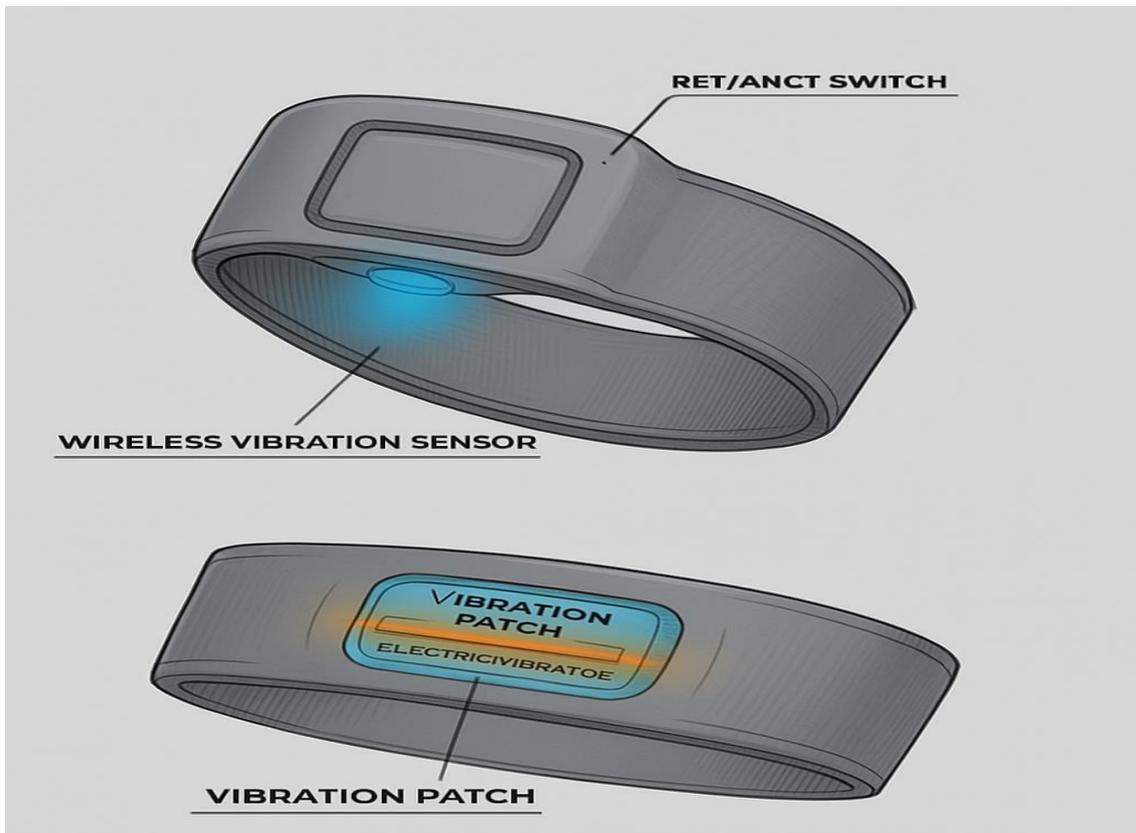
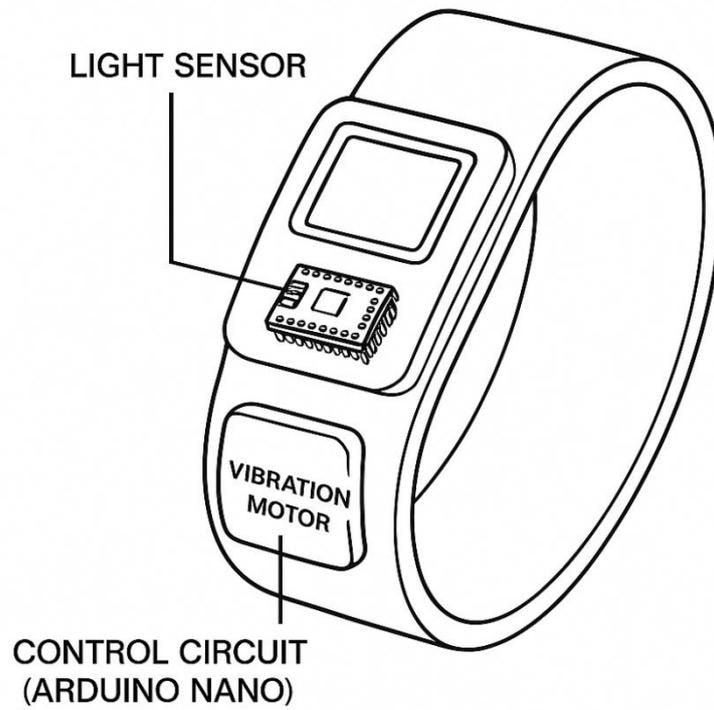


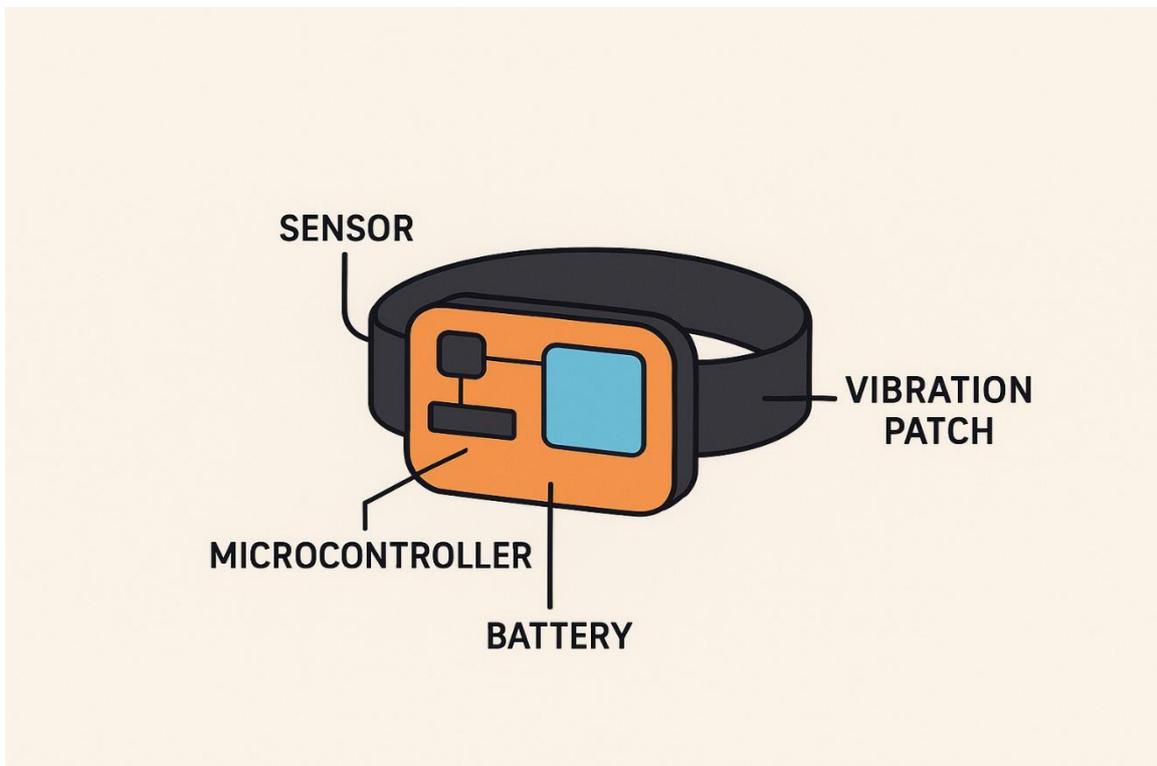
FIGURE 14

**3.2.2.2 PRODUCT MECHANISMS (YOSANTHAN S/O ALEXANDAR  
24DAM23F1061)(STUDENT D)**



**FIGURE 15**

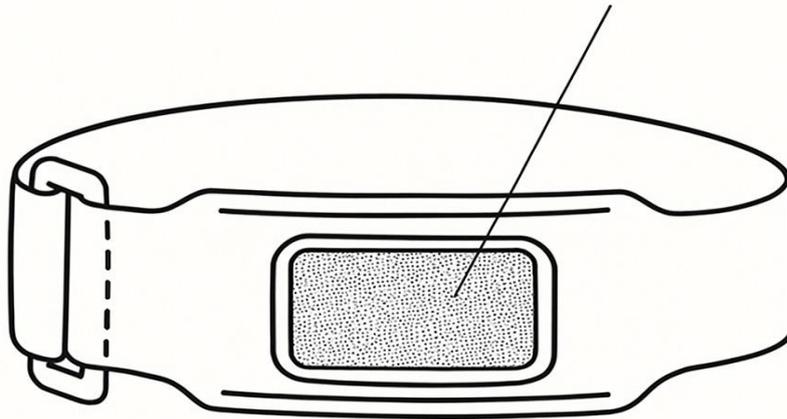
**3.2.2.3 SOFTWARE / PROGRAMMING (SWETA D/O S GANESAN  
24DAM23F1060) (STUDENT C)**



**FIGURE 16**

**3.2.2.4 ACCESSORIES & FINISHING (SAMUNDESWARY D/O RENGANATHAN  
24DAM23F1031) (STUDENT D)**

**VIBRATION PATC  
60 mm x 35mm x 10**



**ARMBAND**

**FIGURE 17**

### 3.2.4 DETAILED DIMENSION ON THE PRODUCT PARTS

#### 3.2.4.1 BASE/ MAIN STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

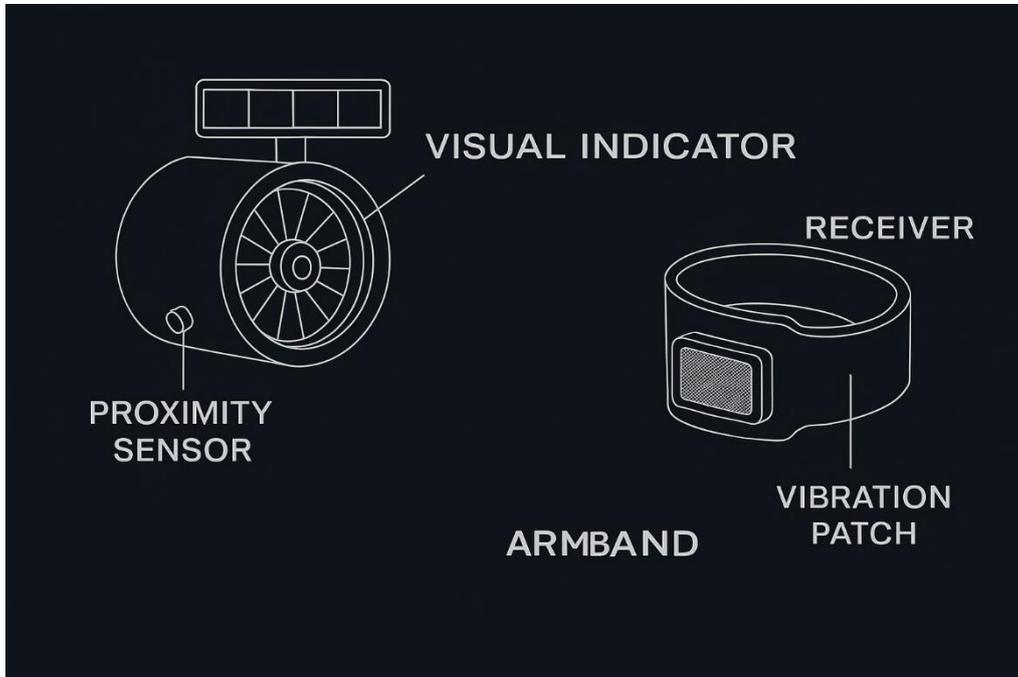
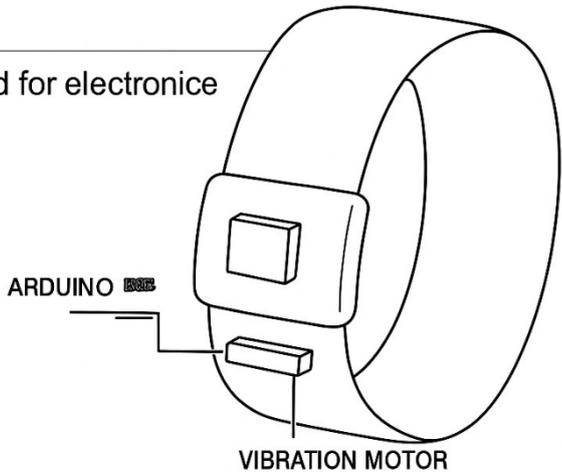


FIGURE 18

**3.2.4.2 INNER SECTION/ COMPART (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**

Component	Dimension (mm)	Description
Vibration Motor	25 x 10 x 5	Mini coin type motor
Arduino Nano	45 x 18 x 7	Microcontroller board
Rechargeable Battery	40 x 20 x 6	Li-ion type
Connecting Wires (x4)	≈ 100 m	
Patch Housing Compartment	60 x 40 x 10	
Armband Shell	Protective shell	
Armband Heel Area (for fitting)	Space for electronic parts	



**FIGURE 19**

3.2.4.3 TOP/ FRONT/ SIDE SECTION (SWETA D/O S GANESAN 24DAM23F1060)  
(STUDENT C)

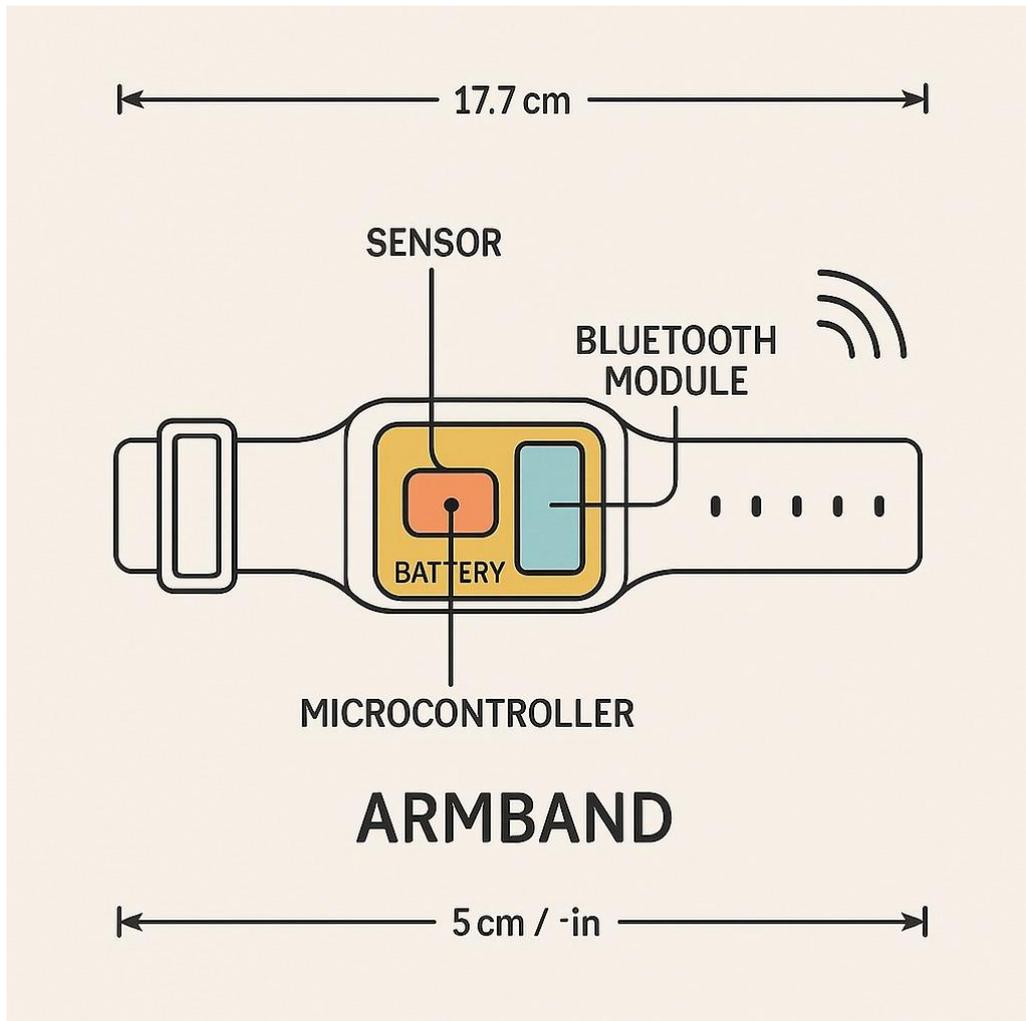
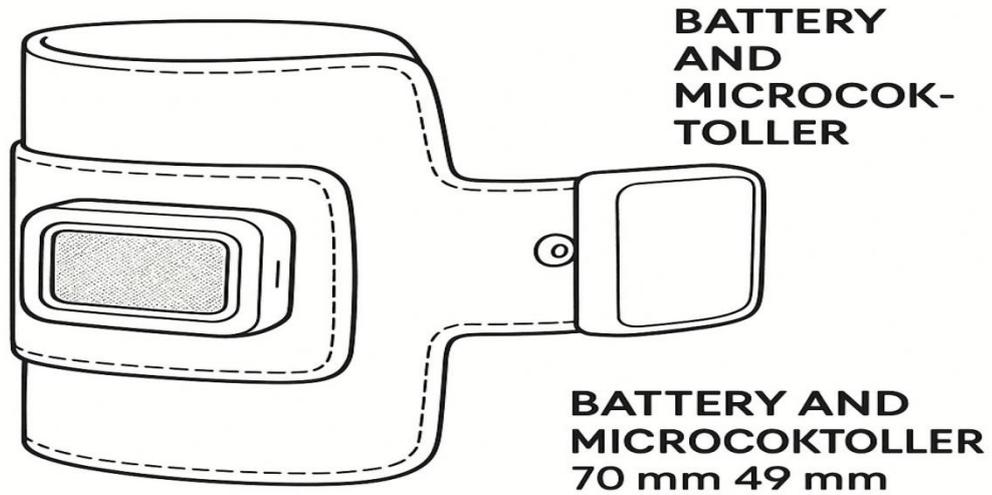


FIGURE 20

**BATTERY AND  
MICROCOKTOLLER UNIT**  
70 mm-45 mm 20 mm



**VIBRATION  
PATCH**  
60 mm-35 mm

**SAFETY ARMBAND**

FIGURE 21

### 3.3 PROJECT FLOW CHART

#### 3.3.1 OVERALL PROJECT FLOW CHART

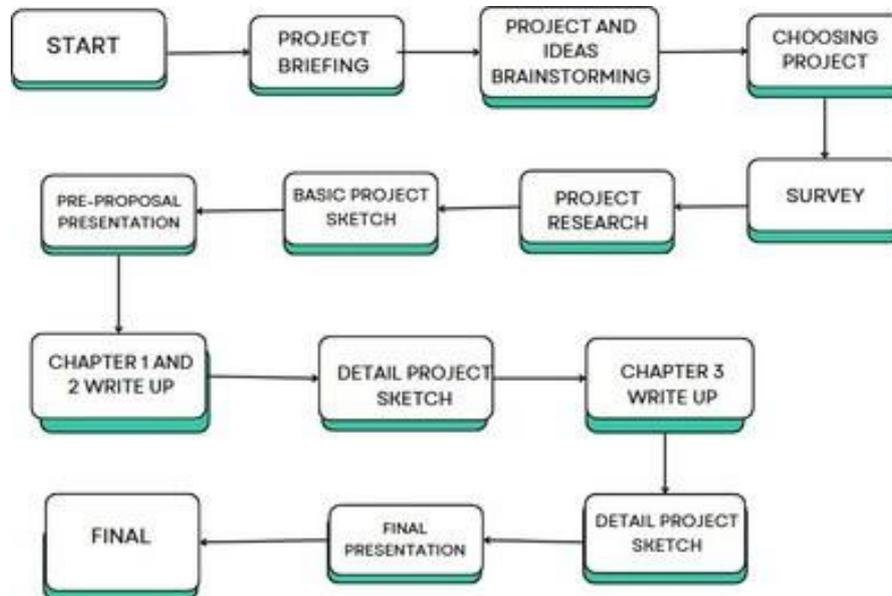
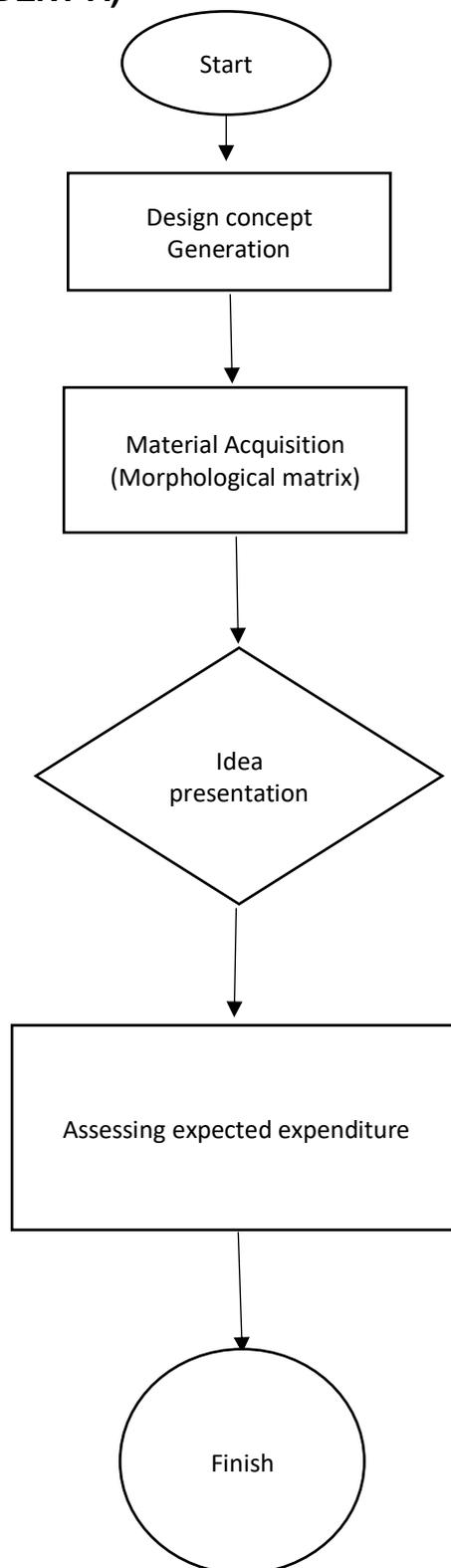


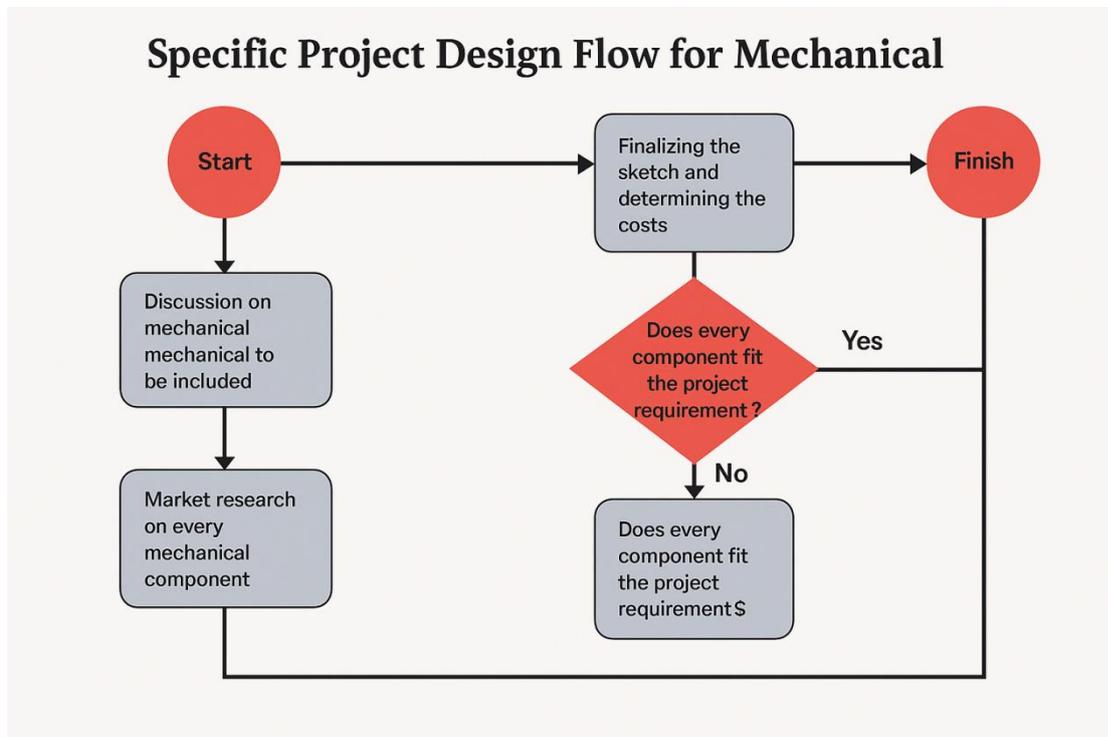
FIGURE 22

### 3.3.2 SPECIFIC PROJECT DESIGN FLOW

#### 3.3.2.1 PRODUCT STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)

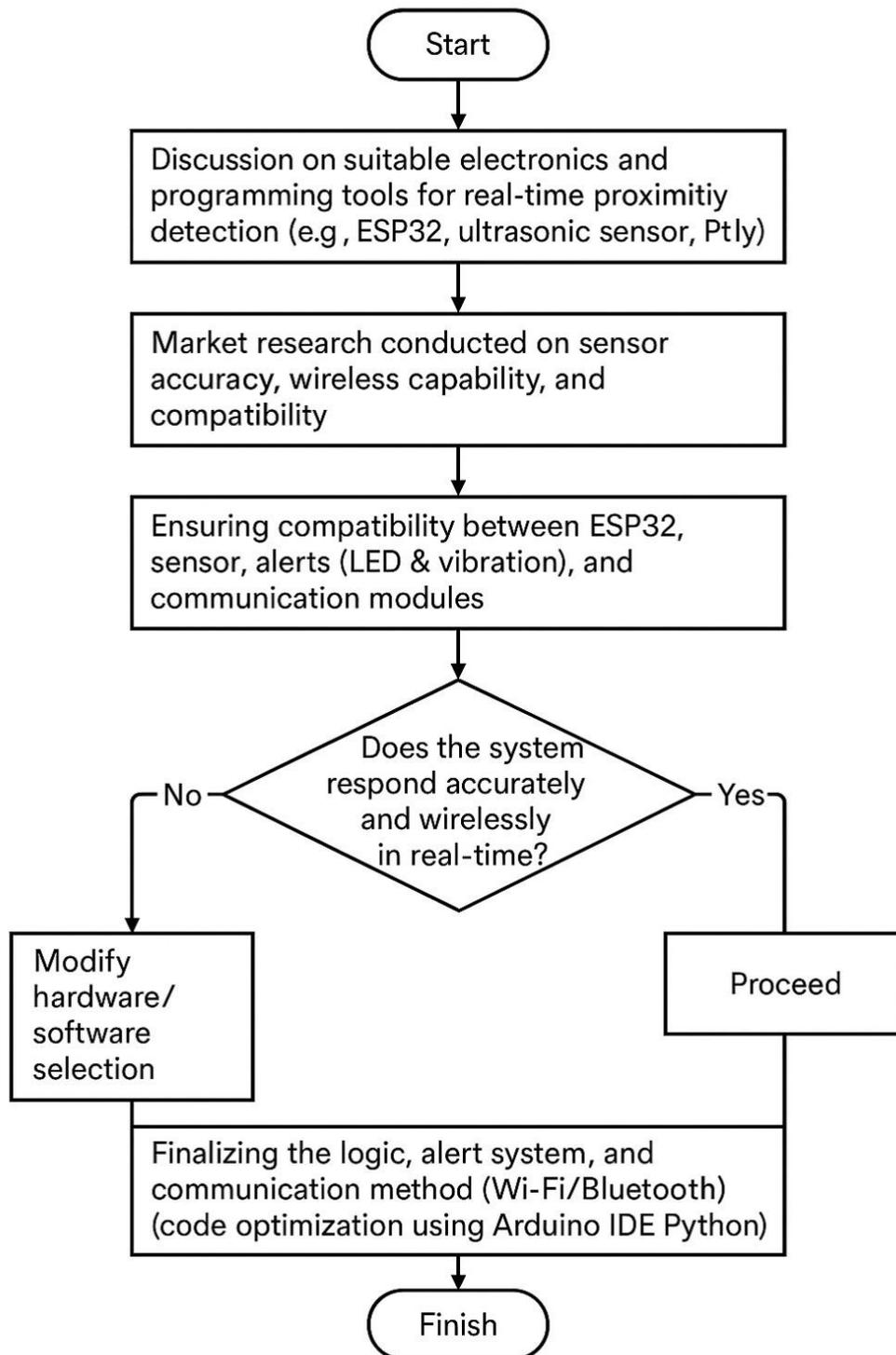


**3.3.2.2 PRODUCT MECHANISMS (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**



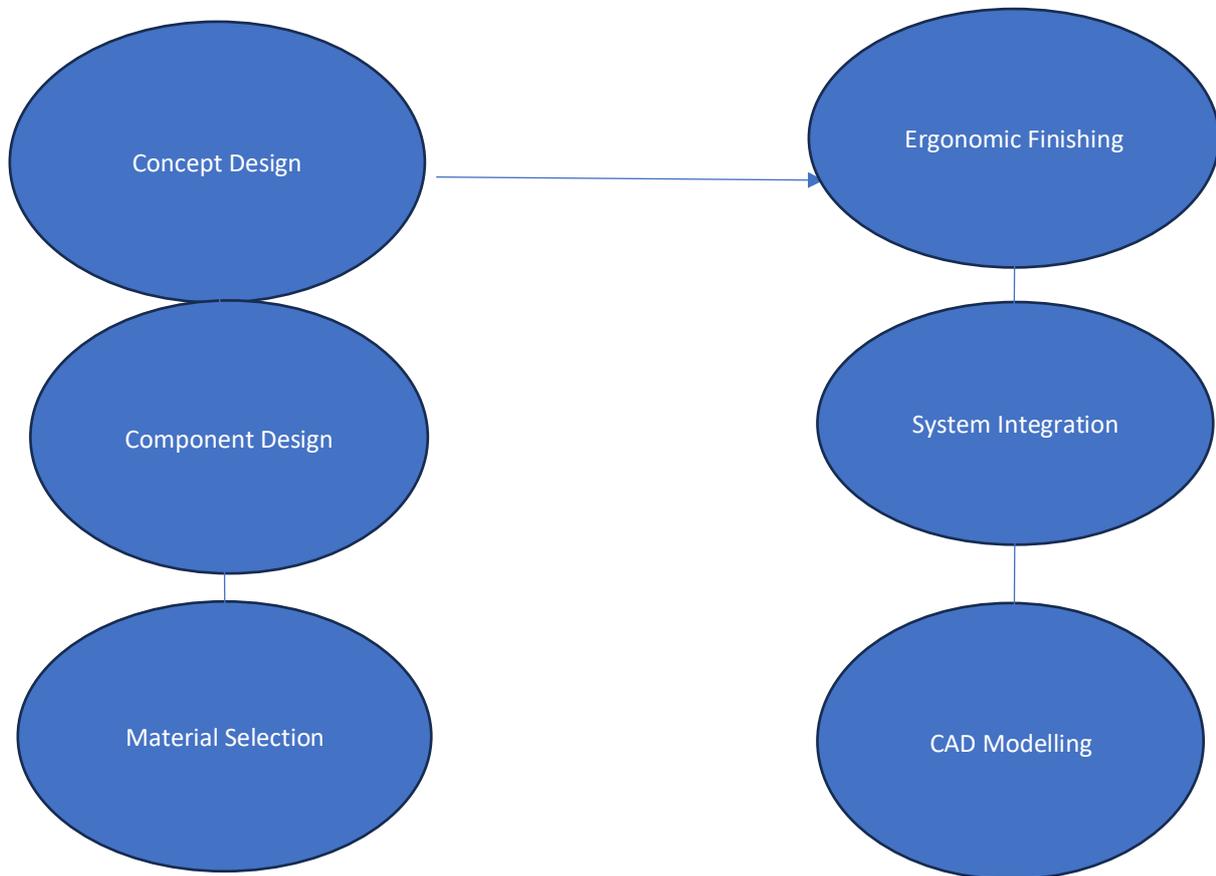
**FIGURE 23 : Mechanical Mechanism Flowchart**

**3.3.2.3 SOFTWARE / PROGRAMMING (SWETA A/P S GANESAN 24DAM23F1060) (STUDENT C)**



**FIGURE 24**

**3.3.2.4 ACCESSORIES & FINISHING (SAMUNDESWARY D/O RENGANATHAN  
24DAM23F1031) (STUDENT D)**



**FIGURE 25**

### **3.4 PRODUCT DESCRIPTION**

#### **3.4.1 GENERAL PRODUCT FEATURES & FUNCTIONALITIES**

The developed prototype integrates key safety features to minimize accident risks near operating turbines by focusing on real-time proximity detection. Using ultrasonic or infrared sensors connected to an ESP32 microcontroller, the system accurately detects when a person enters a hazardous zone. The ESP32 processes the sensor data and manages wireless communication, making it the central controller for all safety functions.

When a person is detected within the danger range, the system immediately activates multiple alert mechanisms. A high-intensity red LED warning light begins flashing to visually signal danger, even in well-lit industrial environments. At the same time, a vibration module embedded in a armband or wearable patch is triggered, delivering a physical alert that is especially useful in noisy surroundings where sound-based warnings might be ineffective.

Additionally, the ESP32 supports Bluetooth or Wi-Fi connectivity, enabling wireless data transmission to monitoring devices for real-time supervision and incident response. The system operates on a rechargeable battery or existing power source, designed for energy efficiency. Encased in a compact, durable, water- and dust-resistant housing, the prototype is built for reliable deployment in turbine areas, providing a smart and effective solution for enhancing workplace safety.

### **3.4.2 SPECIFIC PART FEATURES**

#### **3.4.2.1 PRODUCT STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)**

The security system of the gas turbine employs key features for outdoor safety and human detection by utilizing a LiDAR sensor. The central part of its system is an Arduino controller, which analyses the input it gets from a LiDAR sensor mounted in the front of the turbine. It provides a trusted range of human detection from 0.2 meters to 10 meters, defining a real hazardous region within the trajectory of the turbine.

When it enters the 10-meter range, the Arduino triggers a red warning light on the turbine to give a visible warning. At the same time, a wireless transmission is triggered via RF or Bluetooth to a vibration patch located within the person's arm. The patch contains a vibration motor, powered by a rechargeable lithium-ion battery, and it silently alerts the person to exit quietly.

The system is powered by a battery pack or solar panel to provide un-interrupted operation in outdoor conditions. All the electronics are mounted in weather-resistant enclosures for extra ruggedness. Safety fencing and warning notices also enclose the turbine to mandate the 10-meter safety distance required by routine maintenance practices.

#### **3.4.2.2 MECHANICAL MECHANISMS (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**

A small, lightweight turbine with heavy-duty housing, on-board sensor, and vibration-sensing support forms the mechanical system of the project. Smooth rotation is facilitated by the low-friction rotor shaft and the thin blades of the turbine. A bracket has been included so that the detector sensor can be mounted in the optimal position possible to provide accurate measurement. Vibration areas, e.g., piezoelectric sensors, are taped or mounted on the housing to monitor structural vibration. The system is rigidly mounted on a solid base and shock-mounts to suppress external

vibration. This arrangement allows successful interface to sensor systems, consistent operation, and ease of construction.

#### **3.4.2.3 SOFTWARE / PROGRAMMING (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

The software plays a vital role in ensuring the safety system functions accurately and efficiently. Built on the ESP32 microcontroller and programmed using Python on a Raspberry Pi, the system continuously reads data from proximity sensors like ultrasonic or infrared. When someone enters the danger zone typically one meter or less the code triggers both the red LED warning lights and the vibration motor in a armband or wearable patch.

To maintain reliability, the program includes delay handling and signal debouncing to avoid false alarms. Its modular design allows for easy scaling, such as adding more sensors or adjusting sensitivity levels. The ESP32's Bluetooth or Wi-Fi features enable real-time alerts to be sent to mobile devices or monitoring dashboards, improving remote safety management.

During development, the Raspberry Pi aids in testing and debugging using serial monitoring and IDE tools to fine-tune system responses. The software's reliability directly impacts the system's ability to detect hazards and issue timely alerts, making it a key part of the prototype's effectiveness.

#### **3.4.2.4 FUNCTION OF THE SPECIFIC PART OF THE PRODUCT – ACCESSORIES & FINISHING (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031) (STUDENT D)**

The accessories and finishing part of the product serves a vital function in ensuring the usability, durability, and effectiveness of the entire safety alert system. Its main function is to deliver immediate, tactile, and visual warnings to workers operating near active turbines, especially in environments where noise and distractions may reduce the effectiveness of traditional safety alerts. The vibration patch, which is integrated

into the worker's armband, provides direct haptic feedback when the system detects that the person is entering a hazardous proximity zone. This allows for a personal and non-intrusive alert that is felt immediately by the user. In addition to this, high-intensity LED lights act as a secondary visual warning system, mounted near the turbine to signal danger to both the individual and nearby personnel. The function of the waterproof enclosures and ergonomic finishing is to protect all internal electronic components from dust, heat, and mechanical damage, while also ensuring the device is comfortable and compatible with PPE. Together, these accessories function to create a multi-sensory alert system that increases the likelihood of hazard recognition and timely response, ultimately preventing accidents in industrial turbine areas

### **3.4.3 GENERAL OPERATION OF THE PRODUCT**

The procedure begins with securing the device on the user's arm for efficient contact in detecting vibrations. When activated, the system closely monitors ambient vibrations in the vicinity of the gas turbine. It activates a two-level alert system to warn the user instantaneously as the vibration levels exceed preset safety thresholds.

The first warning is delivered through haptic feedback; the patch delivers a special vibration to the user's foot, serving as an immediate tactile warning of peril. If the user does not react to this first warning within a predetermined time, the system escalates the warning by activating a visual prompt a sensor light designed to capture the user's attention and evoke immediate response. This double-alert mechanism provides real-time monitoring and quick response to dangerous situations, thus improving the safety of workers working in the vicinity of gas turbines.

### **3.4.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCT**

#### **3.4.4.1 PRODUCT STRUCTURE (OMPRAKAS S/O THANGA KALISVARAN 24DAM23F1022) (STUDENT A)**

The safety system in the gas turbine uses an Arduino-based system to detect people around the turbine and alert them. An ultrasonic or PIR sensor on the turbine detects people around it. When a person is detected, the Arduino issues a red alert light to the turbine and a wireless signal to a vibration patch placed inside the person's arm. The

patch will vibrate to alert them without generating any noise. The system is powered by a solar panel or battery and all components are contained in weatherproof boxes. The turbine goes outside with warning signs and safety fencing for added security.

#### **3.4.4.2 MECHANICAL MECHANISMS (YOSANTHAN S/O ALEXANDAR 24DAM23F1061) (STUDENT B)**

The primary purpose of a micro turbine system is to generate rotational energy from fluid or airflow. The turbine blades, shaft, and housing—equipment chosen for their reliability and efficiency—are the central components of the process. The turbine blades are rotated by the fluid entering the system, generating mechanical energy that is transmitted via the shaft. Real-time performance monitoring is attained through the potential of the incorporation of sensors and vibration monitors due to this revolution. Compactness, user friendliness, and the ability to easily interface with other subsystems are given priority when they are being designed. Mechanical components about functional requirements, load capacities, and ease of assembly are considered at component selection. Low frictional resistance and sufficient alignment contribute towards minimizing wear and allowing constant output, hence system performance improvement.

#### **3.4.4.3 SOFTWARE / PROGRAMMING (SWETA D/O S GANESAN 24DAM23F1060) (STUDENT C)**

Processing sensor data and managing the safety response system are the main functions of the software component. A program on the ESP32 continuously reads data from a proximity sensor. The software logic assesses the situation and immediately initiates an alert procedure programmed into the ESP32 when the measured distance drops below a predetermined threshold (for example, one meter).

The code simultaneously turns on two output functions: a vibration motor signal and a red LED flash. This gives the user instant feedback, which helps them stay aware in situations where other cautions can be limited by noise or poor vision. Reliable

performance is ensured and false triggers are decreased by effective management of timing functions, sensor reading intervals, and logic conditions.

Additionally, the ESP32's built-in Wi-Fi or Bluetooth capability is programmed to transmit alerts or data to external systems such as monitoring dashboards. Python scripts running on a Raspberry Pi are used during development to test sensor integration, simulate responses, and verify system reliability. This combined software setup enables the system to operate in real-time with minimal delays and high reliability. This combination of software tools ensures smooth and responsive operation that supports worker safety in real-world turbine environments.

#### **3.4.4.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCT – ACCESSORIES & FINISHING (SAMUNDESWARY D/O RENGANATHAN 24DAM23F1031) (STUDENT D)**

The accessories and finishing components of this safety system are designed to operate as a critical link between hazard detection and the user's awareness, ensuring timely alerts and reliable protection. The main accessory is the vibration patch embedded within the insole or heel of the armband. When the proximity sensor installed near the turbine detects a person entering the danger zone, it sends a wireless signal to the microcontroller housed within the arm.

In response, the vibration patch activates, delivering strong tactile feedback to the user. The vibration intensity can be programmed to increase based on how close the individual is to the turbine, offering a graded alert system that enhances urgency and responsiveness. To support this operation, a compact and rechargeable lithium-polymer battery supplies power to both the vibration motor and the microcontroller, ensuring portability and long operational time. The system also includes a high-intensity LED light, installed externally near the turbine, which serves as a secondary visual warning. It is triggered simultaneously with the vibration patch, allowing both the user and nearby personnel to be aware of the hazard.

All electronic components are housed in durable, waterproof enclosures made of industrial-grade ABS plastic, providing protection against dust, moisture, and

mechanical stress. The finishing ensures that the device is lightweight, ergonomic, and seamlessly integrated with standard PPE, allowing for extended use without discomfort or interference in the worker’s movement. Altogether, these accessories work in unison to enhance operational safety, reliability, and user comfort in hazardous turbine zones.

### 3.5 LIST OF MATERIALS & EXPECTED EXPENDITURES

<b>3.5.1 Sensor Detector Equipment Item Details</b>	<b>Unit</b>	<b>Price (Unit (R))</b>	<b>Total (RM)</b>
Ultra Sonic Sensor –to detect a person	1	3,20	3.20
Arduino nano or raspberry Pi Pico –Process sensor data and control alerts	1	25,00	25,00
RF transmitter & Receiver –send signals from detector pack	1	11,50	11,50
Vibration Motor –to vibrate	1	9,00	9,00
<b>3.5.2 Sensor Light Equipment</b>			
Light source (LED type)	1	10,00	10,00
Microcontroller (Arduino Nano) –control when the light turns on or off based on distance	1	25,00	25,00
Ultrasonic sensor to detect someone near the turbine	1	3,20	–
Wiring and wireless options	1	5,00	
<b>3.5.3 Accessories &amp; Finishing</b>			
Wiring and wireless options	1	5,00	
<b>GRAND TOTAL</b>			<b>116.10</b>

**FIGURE 26 :** List of Materials & Expected Expenditure

### 3.6 OVERALL PROJECT GANTT CHART

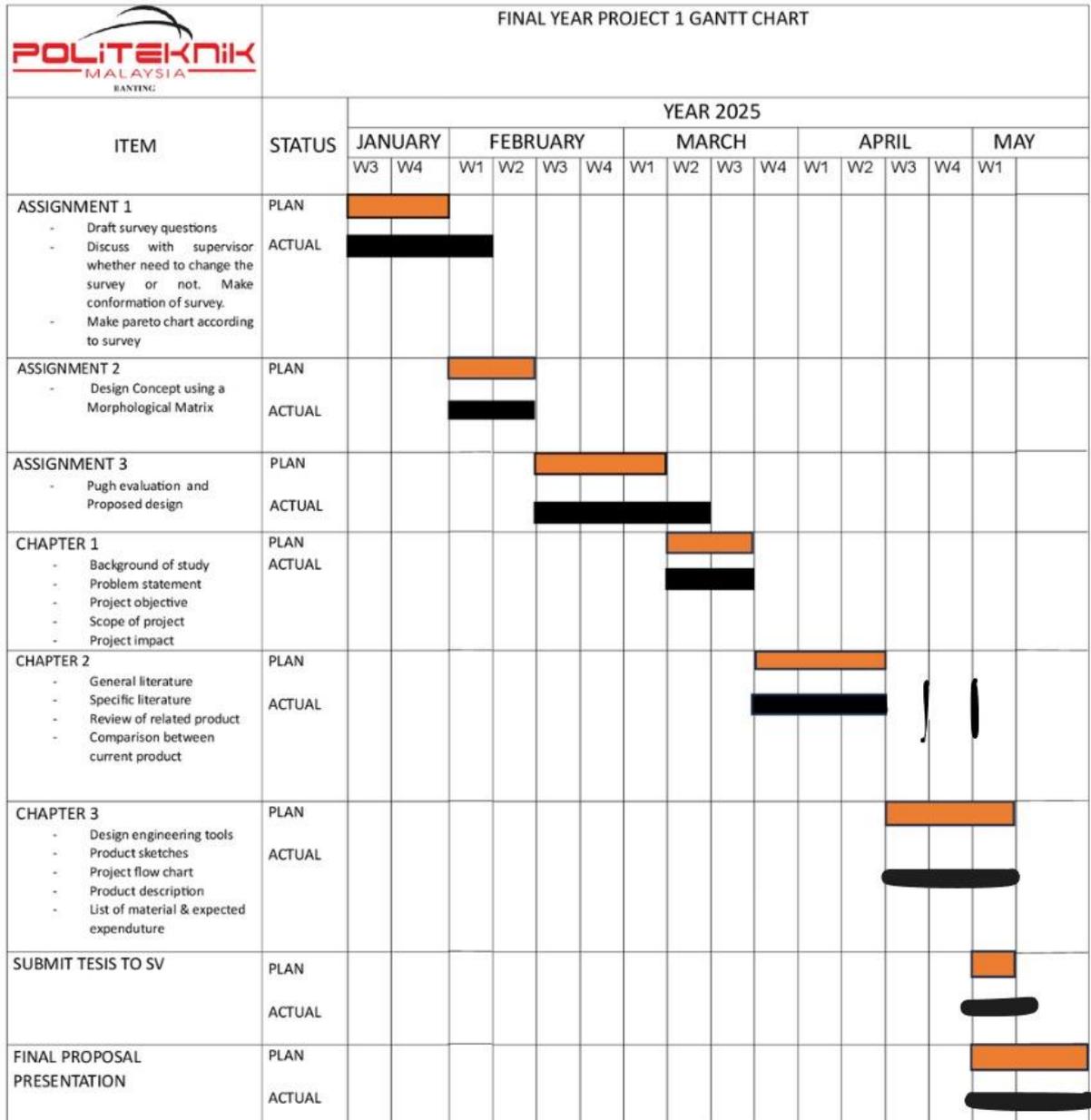


FIGURE 27

## CHAPTER 4

### 4.1 PRODUCT DESCRIPTION

#### 4.1.1 GENERAL PRODUCT FEATURES & FUNCTIONALITIES

The developed system is designed to enhance safety in turbine operating areas, where high-speed rotation poses significant risks to workers. The product integrates proximity detection technology with a dual alert mechanism, ensuring that workers entering hazardous zones are immediately notified. Its primary function is to prevent accidents by providing both personal alerts through a wearable device and collective alerts through an external warning system.

The wearable armband is equipped with a vibration patch that provides direct haptic feedback to the user, ensuring that warnings are felt even in noisy or distracting environments. At the same time, a high-visibility warning light is installed near the turbine area to alert other workers in the vicinity. This dual functionality not only prioritizes individual safety but also creates collective awareness in the work environment, reducing the likelihood of accidents caused by turbine proximity.

In addition to safety features, the system is portable, user-friendly, and suitable for integration into existing maintenance routines. The armband is lightweight, durable, and ergonomically designed for comfort during extended use. The electronic components, including the microcontroller, sensor, and power supply, are compact yet powerful enough to provide reliable and real-time operation. Together, these features make the product an effective safety enhancement tool for aviation turbine maintenance areas.



Figure 1: Turbine



Figure 2: Armband

## **4.1.2 SPECIFIC PART FEATURES**

### **4.1.2.1 PRODUCT STRUCTURE (STUDENT A) (OMPRAKAS S/O THANGA KALISVARAN) (24DAM23F1022)**

The overall product structure has been designed with a focus on portability, comfort, and durability. The main component is a wearable armband that houses the electronic circuit, proximity sensor, and vibration motor. The armband is lightweight and adjustable, allowing it to fit comfortably on different users without causing discomfort during long working hours. Its materials are chosen to be sweat-resistant and durable enough to withstand the harsh industrial conditions found near turbine operations.

At the core of the structure lies the microcontroller unit (MCU), which serves as the control hub of the system. The MCU receives input from the proximity sensor and then activates the corresponding output devices based on programmed conditions. The components are securely embedded in the armband casing, ensuring protection against dust, minor impacts, and vibrations in the environment. The arrangement within the casing is optimized to minimize bulk while maintaining accessibility for maintenance or replacement of parts.

Complementing the wearable device, the structure also incorporates an external high-visibility warning light. This warning light is strategically designed to be mounted near the turbine area, ensuring it can be seen clearly by other workers in the vicinity. The casing of the light is made from reflective material to increase its brightness in daylight conditions and to maximize visibility at greater distances. Together, the armband and warning light create a robust safety structure that provides both personal and collective protection.

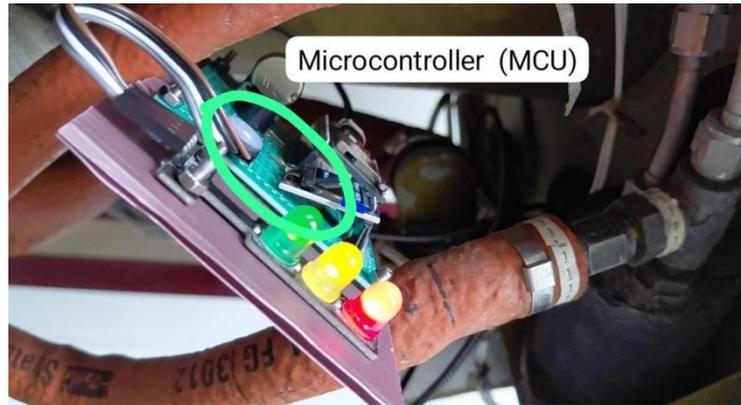


Figure 3 : Microcontroller (MCU)



Figure 4 : Wearable armband

#### **4.1.2.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN S/O ALEXANDAR) (24DAM23F1061)**

The Safety Armband with Vibration Sensor and Sensor Light has been constructed with the intention to enhance safety at the turbines operational zones with the use of detect–process–alert systems. The procedure begins with the detection mechanism where a worker or an object enters the boundary to restrict and the sensor detects this and sends an electrical signal. The signal is then sent to the microcontroller unit which is the brain of the the whole system and compares the safety threshold with the distance that is detected. If danger is detected, the microcontroller unit triggers the alert system.

In conjunction to this system mechanism, there are two focus areas for the alert system. The haptic device that is in the armband, and the ultrabright light that surrounds the workers. The haptic device sends information to the worker about the warning which is often missed due to the noise at the turbines. This light and sound system in conjunction decreased the amount of human error and the time taken for the worker to be aware of the situation.

Reliability and continuity of operation prioritizes the portable 10,000 mAh power bank rechargeable at 5V. It gives the device 8 – 10 hours of operational time per charge. Current regulation within the circuit maintains control over the voltage supplied, thus preventing any overload in the microcontroller, sensor, motor and LED light within the circuit, while still maintaining operational efficiency. When the worker walks beyond the perilous enclosure, the system resets automatically; both the warning light and vibration motor are turned off. This mechanism serves the dual purpose of saving power while ensuring the armband is always ready to go in a snap, waiting for the next detection event.



Figure 5: Vibration Motor

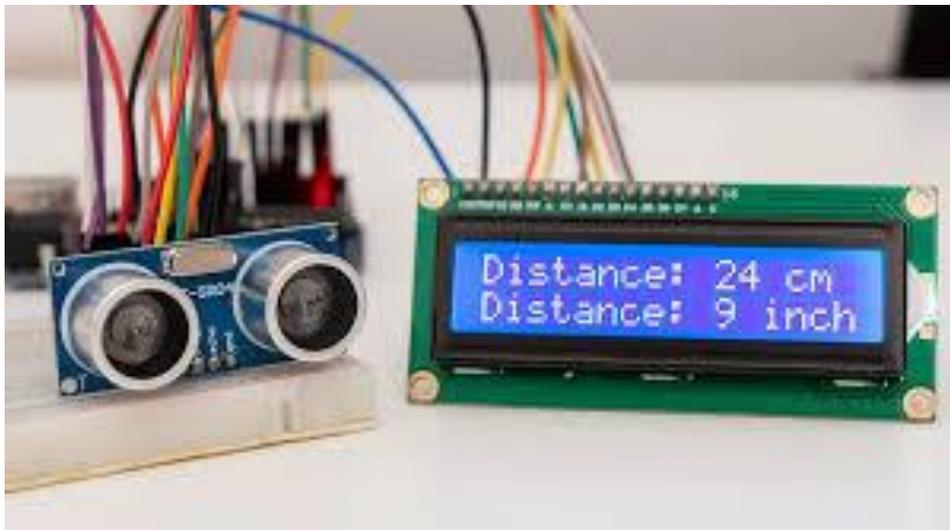


Figure 6: Proximity Sensor

#### **4.1.2.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA D/O S GANESAN) (24DAM23F1060)**

The software system was developed using the Arduino IDE, chosen for its compatibility with microcontrollers and ease of integration with sensors and output devices. The program is written to continuously monitor the proximity sensor, comparing the measured distance against a defined safety threshold. Once a person enters the unsafe range, the microcontroller immediately processes this input and sends commands to trigger both the vibration motor and warning light simultaneously. This ensures that alerts are delivered in real time without delays.

To increase reliability, the programming includes calibration routines that filter out noise and prevent false triggers caused by environmental interference. For instance, reflective turbine surfaces or background movements could cause inaccurate readings; hence, the code incorporates filtering logic and conditional checks to ensure accuracy. A timeout function is also implemented to avoid continuous activation when no further detection occurs, thereby conserving power and enhancing system efficiency.

Furthermore, the programming design allows flexibility for future improvements. The detection range can be adjusted by modifying threshold values in the code, making the system adaptable to different turbine areas or safety requirements. The modular approach in the coding structure also allows additional sensors or alert mechanisms, such as audio alarms, to be integrated later with minimal changes. This ensures that the software not only meets the current safety requirements but also remains scalable for future enhancements.

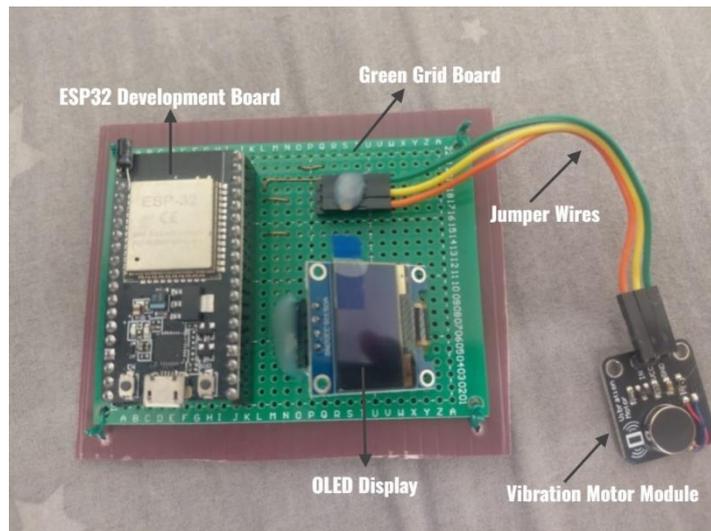


Figure 7: Armband vibration sensor

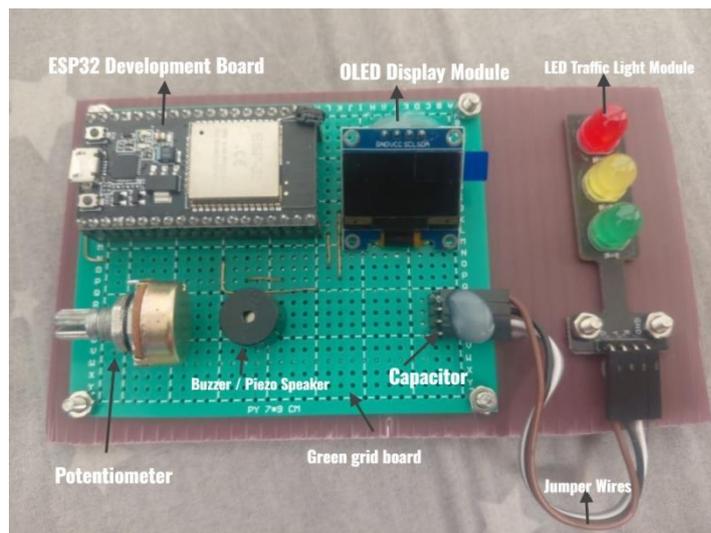


Figure 8: Light sensor

#### **4.1.2.4 ACCESSORIES & FINISHING (STUDENT D) (SAMUNDESWARY D/O RENGANATHAN) (24DAM23F1031)**

The accessories and finishing of the Safety Armband with Vibration Sensor play an important role in ensuring that the prototype is ergonomic, durable, and user-friendly. While the core system consists of the microcontroller, vibration motor, and proximity sensor, additional components and proper finishing are required to make the device practical for real workplace use.

##### **1. Armband Casing and Strap**

- The electronic components are housed inside a lightweight plastic enclosure to protect the circuit from dust, vibration, and minor impacts
- The casing is fixed to an adjustable Velcro strap, allowing the armband to fit securely on different arm sizes. This ensures comfort during long working hours without restricting movement.
- The strap material is chosen for breathability and flexibility, reducing discomfort in hot environments such as turbine areas.

##### **2. Indicator Light and Mounting**

- A high-intensity LED is mounted on the casing as a visual indicator when the sensor detects proximity to a hazardous turbine zone.
- The light is placed at an angled, outward-facing position so that both the wearer and nearby workers can clearly see the warning signal.

##### **3. Vibration Patch Housing**

- The vibration motor is encased in a soft rubber sleeve and positioned on the inner side of the strap.
- This design ensures direct skin contact, allowing the worker to feel the haptic alert immediately without discomfort.

#### 4. Wiring and Connectors

- All internal wiring is neatly routed and secured with heat-shrink tubing to prevent accidental disconnection or damage.
- A removable connector port is provided for easy maintenance or replacement of faulty components.

#### 5. Finishing Touches

- The external surface of the casing is smoothed and finished with a matte coating, reducing glare and giving the device a professional appearance.
- Safety labels and indicator markings are added to guide the user on proper placement and to highlight the function of each feature.
- The final prototype is compact, lightweight, and designed for practical field use, aligning with the project's objective of being portable and user-friendly.

### 4.1.3 GENERAL OPERATION OF THE PRODUCT

The general operation of the product is designed to provide a real-time safety mechanism in turbine working areas. During use, the proximity sensor continuously scans the environment and detects any object or person entering a predefined hazardous zone. The sensor acts as the first line of defense, feeding constant data to the micro-controller, which then evaluates whether the distance falls within the danger threshold.

When a worker comes too close to the turbine, the micro-controller processes the sensor input and immediately triggers the dual alert system. The armband worn by the worker vibrates strongly to ensure the individual is instantly aware of the risk, while a high-visibility warning light positioned near the turbine activates to notify others in the area. This dual mechanism ensures that both the individual and surrounding workers receive timely alerts.

Once the person moves away from the hazard zone, the system automatically resets to its standby state. This allows the device to operate continuously without manual intervention. The reset function also prevents unnecessary power usage, ensuring that the device remains efficient and ready for immediate reactivation when the next detection occurs.

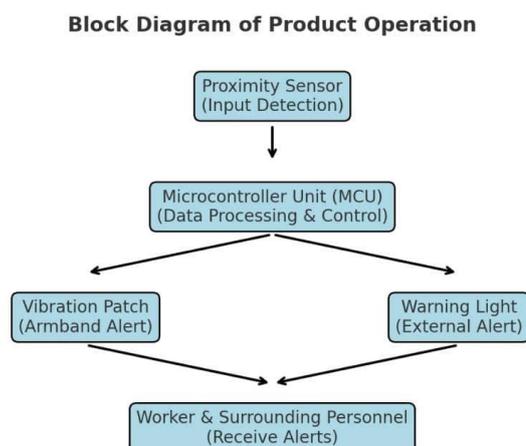


Figure 9: Diagram of product operation

#### **4.1.4 OPERATION OF THE SPECIFIC PART OF THE PRODUCT**

##### **4.1.4.1 PRODUCT STRUCTURE (STUDENT A)(OMPRAKAS S/O THANGA KALISVARAN) (24DAM23F1022)**

The product structure operates by positioning the proximity sensor in such a way that it constantly monitors the space around the worker. Once movement within the unsafe zone is detected, the sensor relays the information directly to the micro-controller inside the armband. The casing ensures that the sensor maintains proper alignment while protecting it from vibrations or impacts that might otherwise affect accuracy. This arrangement allows the structure to function as a reliable monitoring unit during turbine maintenance tasks.

The armband's vibration motor is activated only when the micro-controller processes a hazard signal. The structure ensures the motor is secured tightly within the armband so that the vibrations are transmitted directly to the wearer's arm. By doing this, the product guarantees that alerts are immediately noticeable and not absorbed or weakened by the casing or fabric. In practical use, the worker is instantly made aware of the potential danger without having to rely on visual or auditory cues.

Meanwhile, the external warning light is synchronized with the armband through the same control system. The structure is designed so that power distribution between the vibration motor and the warning light happens simultaneously, ensuring that both alerts are triggered at the exact same moment. This structural integration provides consistency and avoids delays that could compromise safety. As a result, both individual workers and surrounding personnel are alerted within seconds of detection.

Finally, the modular arrangement of the structure supports smooth operation over extended periods. Since each part is mounted securely yet independently, heat build-up and electrical interference are minimized, ensuring stable performance. The structure is also designed to allow quick battery replacement or component servicing without interrupting the product's operational cycle. This practical design choice ensures the product remains fully functional throughout repeated turbine safety checks.



Figure 10: Armband sensor & Light sensor connected



Figure 11: Safety Armband Sensor with Sensor Light

#### **4.1.4.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN S/O ALEXANDAR) (24DAM23F1061)**

The operation of the mechanisms at the turbine working zones guarantees the seamless and dependable operation of the system. The process begins at the sensor's interface and the sensor's range finder probes and positions itself using infrared or ultrasound. The sensor's range finder measures a distance using the time of flight and... Once the range is considered 'safe' (every sensor has its own threshold) the sensor captures the information and sends it to a micro-controller. The micro-controller's logic compartment systematically balances the sensor's data in the logic of open and closed circuits with the established 'safe' values. The sensor has a range of distances... Whenever the safe distance is breached the micro-controller.

The micro-controller sends signals to the vibration motor to activate its pulsing cycles. The range and timing of these pulses are controlled through the armband system. With the armband strap securely fastened to the user's arm, the vibration motor maintains direct contact with the skin, ensuring that the haptic feedback is delivered effectively. The "soft" pulse produced by the motor is capable of transmitting clear information to the wearer, even in noisy turbine environments where auditory alerts may be ineffective. The secure positioning of the vibration motor guarantees that the feedback is strong enough to be noticed instantly without causing discomfort. When the vibration motor is activated, it works in tandem with the external LED light, which provides a visible hazard signal to nearby workers. Through this simultaneous activation of both the vibration motor and the warning light, the system ensures that both **individual safety** (for the wearer) and **collective safety** (for surrounding personnel) are achieved at the same moment.

For the sake of possible unresponsiveness due activation of an alert in the first sequence of an alert-after-alert cycle, the worker-system is designed in the way whereby the alerts are turned off if the worker moves away from the danger zone to a safe zone. This switch is meant to aid in conserving battery life, prevent alerts from responding in a non-responsive setup and, most importantly, ensure the equipment remains in working order. On an overall basis, one can simply state the sequence of the worker-system as “detect-process-alert-reset.” Even in the most complex and turbulent of work environments, the reliability from turbine detection avoidance accidents systems remains.

#### **4.1.4.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA D/O S GANESAN) (24DAM23F1060)**

The programming of the system involves two micro-controller boards that communicate wireless to manage the safety alerts. **Board A (Transmitter)** is responsible for continuously reading data from the proximity sensor. This raw data is compared to a predefined safety threshold, and if the unsafe range is detected, a signal packet is transmitted wireless using the ESP-NOW protocol. The transmitter operates with minimal delay to ensure that hazard information is immediately passed to the receiver.

On the other side, **Board B (Receiver)** listens for incoming packets from the transmitter. Once data is received, the micro-controller interprets the signal and makes the decision to activate the vibration motor embedded in the armband as well as the external warning light near the turbine. This division of tasks between the two boards increases efficiency by separating sensing from alerting, while maintaining synchronization between detection and response.

The code logic is structured around continuous monitoring and conditional checks. In Board A, the loop function ensures that sensor readings are constantly updated, and only when the threshold condition is met does the board send a “hazard detected” signal. Meanwhile, Board B uses conditional statements to decide whether to activate or deactivate the alerts, depending on the signal status. Both boards are programmed to minimize false triggers by including short delays and stable data transmission functions.

Overall, the dual-board programming design makes the system modular and scalable. The transmitter can be adjusted to use different types of sensors depending on turbine conditions, while the receiver can control a variety of alert mechanisms beyond vibration and lighting. This software framework ensures flexibility while maintaining reliability and real-time safety response for workers operating near turbine areas.

#### Board A – Transmitter (Proximity Sensor + Data Send):

```
int distance = analogRead(sensorPin);

if (distance < threshold) {
    // Send hazard signal to Receiver
    esp_now_send(0, (uint8_t *)"HAZARD", sizeof("HAZARD"));
} else {
    // Send safe signal
    esp_now_send(0, (uint8_t *)"SAFE", sizeof("SAFE"));
}
```

Figure 12: Board A (Armband sensor coding)

#### Board B – Receiver (Activate Alerts):

```
if (strcmp(incomingData, "HAZARD") == 0) {
    digitalWrite(vibrationPin, HIGH); // Turn ON vibration
    digitalWrite(ledPin, HIGH);      // Turn ON warning light
} else {
    digitalWrite(vibrationPin, LOW); // Turn OFF vibration
    digitalWrite(ledPin, LOW);       // Turn OFF light
}
```

Figure 13: Board B (Turbine light sensor coding)

#### **4.1.4.4 ACCESSORIES & FINISHING (STUDENT D) (SAMUNDESWARY D/O RENGANATHAN) (24DAM23F1061)**

The accessories and finishing components of the Safety Armband with Vibration Sensor are designed not only to protect the internal system but also to enhance user experience and operational reliability in the workplace. Their operation can be explained as follows:

##### **1. Armband Strap**

- The Velcro strap allows the armband to be securely fastened to the worker's arm.
- During operation, the strap ensures the device stays in place even when the wearer is moving around turbine areas.
- The adjustable design accommodates different arm sizes and ensures comfort, allowing long-duration use without fatigue.

##### **2. Protective Casing**

- The plastic enclosure houses the electronic components and protects them from dust, vibration, and accidental impacts.
- While the system is in use, the casing prevents damage from external factors such as heat and minor knocks, thus ensuring continuous functionality.

##### **3. Indicator Light (LED)**

- The LED indicator operates as a visual alert system. When the proximity sensor detects a worker too close to a hazardous zone, the LED lights up.
- Its outward-facing position ensures visibility not just to the wearer but also to surrounding workers, providing a shared safety signal.

##### **4. Vibration Patch Housing**

- The rubber-covered vibration motor activates when the sensor detects danger.
- The housing ensures the motor remains in direct contact with the skin, allowing the worker to feel an immediate and strong haptic alert without causing discomfort.

## 5. **Wiring and Connectors**

- The heat-shrink tubing and connector ports operate as safety features that keep wiring organized and reduce the risk of disconnection.
- This ensures stable power supply and reliable signal transmission throughout the operation of the system.

## 6. **Finishing Elements**

- The matte-coated surface prevents glare from strong lighting in turbine areas, making the device more practical in real working environments.
- Labels and indicator markings guide the user during operation, ensuring proper wearing and understanding of the signals.
- In summary, the accessories and finishing components work together to ensure the device is comfortable, durable, and reliable during operation. They do not directly control the sensing and alerting functions but play a critical role in making the system user-friendly, safe, and effective in real workplace conditions.

## 4.2 PRODUCT OUTPUT ANALYSIS

No.	Parameters	Results	Remarks / Descriptions	Analysis
1.0	<b>Speed Limit</b>			
1.1	Detection Range (Unloaded = no interference)	1.5 meters	Consistent in clear environment.	Reliable baseline performance. The system maintains effective detection even under different levels of obstruction. Although range decreases with obstacles, it still provides adequate warning distance for turbine safety operations.
1.2	Detection Range (Partially obstructed)	1.2 meters	Slight reduction with partial obstacles.	
1.3	Detection Range (Fully obstructed)	0.8 meters	Reduced due to full obstruction.	
2.0	<b>Time of Operation</b>			
2.1	Maximum Response Time	<1 second	Vibration and light trigger almost immediate.	Ensures real-time warning in hazardous turbine zones.
x.	Load/Weight of Device	150 g (armband) + 300 g (light unit)	Lightweight, comfortable for worker use.	Portable and easy to wear/carry during operations.
x.	Turning Radius (Adapted → Coverage Angle)	120° effective sensor coverage	Wide angle field for detection.	Covers frontal approach paths, suitable for turbine area.
x.	Capacity/Volume (Adapted → Power Supply Capacity)	10,000 mAh powerbank (5V)	Operates -> 8–10 hours continuously.	Practical for one work shift, rechargeable.
x.	Output Power / Voltage	5V, 500 mA (average)	Stable supply to microcontroller, sensor, vibration motor, and LED.	Ensures consistent operation of all components without overloading the powerbank.

## **4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS**

### **4.3.1 PRODUCT STRUCTURE (STUDENT A )(OMPRAKAS S/O THANGA KALISVARAN) (24DAM23F1022)**

During the prototype development, one of the main issues faced was the bulkiness of the armband design. The initial version housed larger electronic components, which made the device uncomfortable for workers to wear over long durations. This issue was especially critical since the armband must be lightweight and ergonomic to avoid affecting worker performance. The solution implemented was to reduce the component size by selecting a smaller microcontroller unit (MCU) and a compact vibration motor. This modification not only minimized the overall size and weight of the device but also improved user comfort without compromising system functionality.

Another structural issue identified was the reduced visibility of the warning light in bright sunlight. During field testing near turbine areas, the external LED warning light was less effective during daytime operations, posing a safety risk since workers could fail to notice the alert. To address this problem, the system was upgraded with a high-lumen LED module that delivers stronger brightness levels. In addition, a reflective casing was integrated around the light source to improve visibility across different lighting conditions. With this improvement, the warning light became highly noticeable even under direct sunlight, ensuring effective hazard communication.

Besides bulkiness and light visibility, another issue was the durability of the armband materials, as the straps and casing wore out when exposed to sweat and heat. This was solved by using sweat-resistant fabric and stronger casing. The internal wiring also caused discomfort and loose connections, which was improved by reorganizing the layout and securing the wires properly.

#### **4.3.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN S/O ALEXANDAR) (24DAM23F1061)**

The development of the product mechanisms brought up some issues which were paired with solution sets that needed to be overcome to advance the system's performance. With regards to sensor readings in noisy environments, the issue was mostly attributed to the vibration of the turbine or some electrical interferences which led to some readings being inconsistent. With the introduction of a filtering circuit, wherein the software was also adjusted in such a way, sensor input was stabilized in order to ensure sensor reliability in hazardous conditions. Another issue was the feedback of the vibration alerts through clothes, with those workers donned in thicker uniforms not being capable of feeling the alerts that were supposed to be issued to them. Vibration motors were in such position that the rubber sleeve providing direct contact with the skin was able to be brought closer with the skin, and the output of the motors was also supra-vibrated to ensure that a stronger output of feedback was achieved to the user.

Moreover, in terms of the control system, another element was the simultaneous alerting, wherein the motors responsible for the vibration feedback were activated a short time prior to the LED lights being switched on. This was solved through optimization of the microcontroller met with the condition that both outputs were to be activated on the same line, for the purpose of synchronization. It was also noted that the battery was being emptied at a rapid rate due to the power drain that was being used for the continuous alerts. This was overcome with the implementation of the timeout function, which was also automatic.

Lastly, the system was subject to false triggering owing to the reflective surfaces of the turbine which caused the sensor to misinterpret distance measurements. To fix this, the sensor angle was changed and additional bulwark was added to reduce reflections. Overall these modifications improved the stability, reliability, and efficiency of the product which made the system more realistic and trustworthy for actual turbine safety use.

### **4.3.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA D/O S GANESAN) (24DAM23F1060)**

In the software and programming stage, one of the challenges encountered was that the sensor produced false readings due to environmental interference. Metallic surfaces, vibration from nearby machinery, and background electrical noise caused the proximity sensor to trigger incorrectly. This problem could result in unnecessary alerts, reducing user trust in the system. To solve this, a calibration routine was introduced into the Arduino code, allowing the sensor to establish a baseline reading before activation. Furthermore, a filtering algorithm was added to smoothen noisy data and minimize false triggers. These improvements significantly enhanced the reliability and accuracy of the detection system.

Another problem identified was the delay in triggering the output devices during testing. The initial program had redundant instructions and longer delay functions, which slowed down response time between detection and activation of the vibration motor or warning light. In safety-critical applications, even a slight delay can reduce effectiveness. To overcome this, the program structure was optimized by removing unnecessary delays and simplifying the main loop for faster execution. As a result, the system now responds in less than one second, ensuring real-time feedback and enhancing safety performance.

A further challenge was the limitation of having a fixed detection range in the program. The initial code applied a constant threshold, which was not suitable for all turbine areas since different zones required different safety distances. This issue was resolved by making the threshold value adjustable in the Arduino code, allowing the detection range to be customized for specific environments. This improvement increased the flexibility of the system and ensured it could be adapted to various operational conditions.

#### **4.3.4 ACCESSORIES & FINISHING (STUDENT D) (SAMUNDESWARY D/O RENGANATHAN) (24DAM23F1031)**

During the development of the Safety Armband with Vibration Sensor, several challenges were encountered in the accessories and finishing stage. These problems were related to durability, comfort, and overall usability of the final product. The following issues and solutions were identified:

##### **1. Problem: Strap Comfort and Fit**

- Initially, the armband strap caused discomfort when worn for longer durations, especially in hot working environments near turbine areas.
- The Velcro material also lost grip after repeated use.

Solution:

- The strap material was changed to a breathable elastic fabric with reinforced Velcro, which improved comfort, flexibility, and long-term usability.
- The adjustable design now fits different arm sizes securely without causing irritation.

##### **2. Problem: Protective Casing Size and Weight**

- The first prototype casing was bulky and made the armband heavy, which reduced user acceptance.
- It also interfered with natural arm movement.

Solution:

- A lightweight plastic enclosure was used instead of a heavy acrylic board.
- The dimensions were optimized to fit only the essential components, resulting in a compact and ergonomic design.

### 3. Problem: LED Visibility in Bright Environments

- The indicator LED was difficult to see under strong sunlight or in brightly lit turbine work areas.

Solution:

- A high-intensity LED with a clear lens cover was installed, ensuring visibility in both indoor and outdoor environments.
- The LED was repositioned at an outward-facing angle for better viewing by surrounding workers.

### 4. Problem: Vibration Motor Positioning

- The vibration motor in the first design was loosely placed inside the casing, reducing the intensity of the haptic feedback.
- Users reported difficulty feeling the vibration through thick clothing.

Solution:

- The motor was repositioned into a rubber sleeve directly in contact with the strap's inner surface, ensuring stronger tactile feedback.
- This adjustment provided immediate hazard alerts even when worn over work uniforms.

### 5. Problem: Wiring and Finishing

- Exposed wires made the prototype untidy and vulnerable to damage during handling.

Solution:

- Heat-shrink tubing was applied to secure and organize wiring.
- Connectors were added for easier assembly, disassembly, and maintenance.
- A matte surface finish was applied to reduce glare and give the product a professional, user-ready appearance.

## **CHAPTER 5**

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

#### **5.1.1 GENERAL ACHIEVEMENTS OF THE PROJECT**

The project achieved its primary aim of developing a safety system that enhances protection for workers operating near turbine areas. By combining a wearable armband sensor with an external warning light, the system provided dual alerts directly to the individual and to surrounding workers, ensuring immediate awareness of potential danger. This significantly improved safety compared to relying on visual observation alone.

Another major achievement was the system's reliability during testing. The proximity sensor consistently detected objects within the designated range, while the vibration motor and LED light responded almost instantly. This responsiveness demonstrated that the system could perform effectively in real-time conditions, fulfilling the objective of delivering fast and dependable alerts in safety-critical environments.

The project also succeeded in creating a design that is portable, user-friendly, and adaptable to different working conditions. By integrating lightweight components into the armband and using a rechargeable power supply, the system could be easily deployed in field operations. These achievements confirm that the project objectives were met both in terms of functionality and practicality.

## **5.1.2 SPECIFIC ACHIEVEMENT OF PROJECT OBJECTIVES**

### **5.1.2.1 PRODUCT STRUCTURE (STUDENT A) (OMPRAKAS S/O THANGA KALISVARAN) (24DAM23F1022)**

The first objective was to design a compact and wearable product structure that could house all the main components. This objective was achieved by successfully arranging the microcontroller, proximity sensor, vibration motor, and wiring inside a lightweight armband. The design ensured that workers could wear the device comfortably without restricting movement, fulfilling the project aim of practicality and ease of use. This confirmed that the project met its structural objective of integrating safety into a simple and portable design.

Another objective was to provide high visibility of safety alerts for surrounding workers. This was achieved by integrating an external warning light into the structure, positioned for maximum visibility around the turbine area. The reflective casing further enhanced visibility under different lighting conditions, ensuring the safety objective of group awareness was met effectively. This showed that the product structure directly supported the objective of improving workplace safety for both the user and nearby workers.

The objective of ensuring durability and adaptability of the product was also achieved. The structure was made using strong yet lightweight materials that could withstand vibrations, heat, and rough working environments. This achievement fulfilled the project goal of developing a reliable product suitable for real industrial operations. It proved that the project objectives were met by creating a product that could survive practical conditions in aviation workplaces.

The final objective was to achieve a user-friendly and ergonomic design. This was successfully achieved by including adjustable straps and an ergonomic fit, allowing workers of different arm sizes to wear the armband securely. This achievement supported the project goal of inclusivity and ensured consistent use of the product in

the workplace. It also proved that the design objective was reached by prioritizing worker comfort alongside functionality.

### **5.1.2.2 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN S/O ALEXANDAR) (24DAM23F1061)**

One major goal of this project was to create systems that could assess threats with precision and give quick dual warnings to guarantee the safety of employees. It was possible to achieve this goal by combining a proximity sensor with a microcontroller to create a detect–process–alarm cycle. Throughout the various tests, the sensor secured unsafe proximity and the microcontroller activated the warning light and vibrating motor simultaneously. This confirmed the ability of the system to provide real-time warnings in under a second, thus achieving the goal of a quick and reliable response.

Another goal was to guarantee that the solutions would operate in the noisy surroundings of the turbines, where audio alerts may be inaudible to people. This incorporated the vibration motor, which delivered direct haptic feedback to the user thus confirming that alerts could be perceived in the extreme noise. Simultaneously, the external warning light gave visibility to the people around and improved working collective awareness. It could be concluded that the individual and collective safety goals were both accomplished.

The last mechanism-related goal was to design a system that could run continuously while saving energy. This was done with a rechargeable 10,000 mAh power supply and an automatic reset feature. When the worker vacated the danger zone, alerts were silenced, thus minimizing power use while keeping the system active for the next detection. This showed that the mechanisms not only met the functional objectives but also helped in practicality and energy saving for future use.

### **5.1.2.3 SOFTWARE / PROGRAMMING (STUDENT C)(SWETA D/O S GANESAN)(24DAM23F1060)**

The first software objective was to provide accurate detection and immediate alerts when a worker entered the danger zone. This was achieved by coding the Arduino to continuously monitor the proximity sensor and trigger both the vibration motor and external light within seconds. This achievement met the project's main goal of enhancing worker safety through real-time alerts. It directly proved that the objective of preventing accidents through quick response was successfully achieved.

Another software objective was to reduce false alarms that could affect trust in the device. This was achieved by introducing calibration and filtering functions in the code, which stabilized sensor readings and eliminated unwanted triggers. By fulfilling this objective, the system maintained reliability and consistency, aligning with the project aim of dependable operation. This demonstrated that the project objective of creating a trustworthy and accurate safety system was fully met.

The objective of flexibility and adaptability in different turbine environments was also achieved. Programmable threshold values were included in the software, allowing the detection range to be adjusted based on workplace needs. This achievement supported the project objective of developing a versatile system suitable for multiple industrial applications. It proved that the system could be applied across different real-world safety scenarios, making it a practical achievement.

The final software objective was to achieve a fast response without lag in the system. This was successfully achieved by using optimized coding techniques that allowed continuous monitoring without delay. The system responded in under one second, fulfilling the project goal of providing immediate safety alerts to prevent accidents. This confirmed that the programming objectives were successfully accomplished in line with the overall project aim of rapid hazard prevention.

#### **5.1.2.4 ACCESSORIES& FINISHING (STUDENT D) (SAMUNDESWARY D/O RENGANATHAN) (24DAM23F1031)**

The accessories and finishing stage of the project focused on ensuring the prototype was user-friendly, safe, and durable for aviation workplace applications. Accessories such as the armband strap, casing for the vibration patch, and housing for the proximity sensor were designed and integrated to enhance both comfort and functionality. The armband was built using lightweight, flexible, and skin-friendly materials to allow prolonged use without discomfort.

For the finishing process, attention was given to ergonomic design and visibility. The armband was coated with a high-visibility reflective layer to improve recognition in low-light or emergency conditions. Similarly, the external warning light system was fitted with protective covers to safeguard the LED unit from dust, oil, and physical damage while maintaining brightness.

Cable management, compact placement of electronic components, and protective casing ensured that the device remained portable and robust in harsh working environments. Special care was taken to make the finishing aesthetically professional, while also prioritizing durability and ease of maintenance.

Through these efforts, the accessories and finishing stage successfully produced a prototype that is not only functional and reliable, but also practical for real-world aviation safety operations.

## **5.2 CONTRIBUTION OR IMPACT OF THE PROJECT**

This project has made a meaningful contribution to workplace safety by addressing one of the most critical hazards in turbine operation areas—human proximity to dangerous machinery. By combining a wearable armband sensor with an external warning light system, the solution provided dual alerts that reach both the individual at risk and surrounding workers in real time. This dual-level notification ensures that awareness is raised immediately, reducing the chances of delayed responses during emergencies.

Another key impact of this project is its ability to function effectively in noisy industrial environments where verbal communication or alarms may not always be noticed. The inclusion of vibration alerts directly on the armband ensures that the user receives a personal warning regardless of ambient noise levels. At the same time, the high-lumen LED warning light increases visibility across the work zone, ensuring collective safety and improving coordination among team members working near turbines.

Beyond its immediate application, the project's impact extends to raising safety standards within aviation and industrial sectors. The innovation demonstrates how wearable technology and external alert systems can be integrated into existing safety protocols to reduce accidents. Moreover, this project has the potential to inspire future developments in smart protective equipment, contributing to a safer workplace culture and advancing research in occupational health and safety technology.

## 5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

### 5.3.1 PRODUCT STRUCTURE (STUDENT A) (OMPRAKAS S/O THANGA KALISVARAN) (24DAM23F1022)

The current armband structure works effectively, but improvements can be made to enhance comfort, reduce weight, and increase durability for long-term use. By upgrading the physical design and materials, the product can be more practical for industrial environments where workers may wear it for extended hours.

1. **Custom PCBs and smaller batteries:** Replacing the standard circuit board with a custom-designed PCB would reduce unnecessary bulk and make the electronics fit more compactly. Pairing this with smaller rechargeable batteries would create a lighter and slimmer armband that is easier to wear for long periods.
2. **Sweat-resistant and breathable casing:** Upgrading the casing material to one that is sweat-resistant and breathable would prevent discomfort during long shifts. This would also protect internal components from moisture, extending the product's life.
3. **Ergonomic straps for comfort:** Using soft, adjustable, and ergonomic straps would improve the fit of the armband on different users. A secure but comfortable fit ensures the device stays in place even when the worker moves actively.
4. **Waterproofing and dustproofing:** Adding sealing or protective coatings would protect the device against dust and water exposure. This is crucial in turbine environments where outdoor and industrial conditions can be harsh.
5. **Flexible but durable materials:** Choosing materials that are both strong and flexible would provide durability without sacrificing comfort. This ensures the armband can withstand regular use without breaking easily.

### 5.3.1 PRODUCT MECHANISMS (STUDENT B) (YOSANTHAN S/O ALEXANDAR) (24DAM23F1061)

The available systems operate adequately, but achieving the goals of precision, effectiveness, and long-term usability would require some refinements. Improvement in the detection, alert, and power control systems would make the product dependable, user-friendly, and more applicable in industries where safety is paramount.

- 1) **Integration of Multi-Sensor Technology:** The combined use of ultrasonic with other infrared or Li DAR sensors would eliminate the problem of false activation due to reflections and other environmental distractions, promoting dependable hazard recognition in more complicated turbine surroundings.
- 2) **Adjustable Vibration Intensity and Alert Patterns:** This feature would let workers transform the haptic alert intensity and customize frequency, making alerts adaptive to climate, clothing, or personal comfort, which also haptic alerts ineffective.
- 3) **Upgraded External Warning Light:** A multi-color warning light with various hues would increase surrounding workers' situational awareness. Each color would signal a different hazard severity.
- 4) **Power Optimization:** The use of a low power mode would increase the efficiency of the device in turbine areas and aid in battery retention.
- 5) **Wireless Connectivity and Data Logging:** By allowing the armband to communicate wirelessly with other units, remote access and automatic data logging could be implemented. This would facilitate safety audits, reporting, training, and other relevant activities.

### 5.3.3 SOFTWARE / PROGRAMMING (STUDENT C) (SWETA D/O S GANESAN) (24DAM23F1060)

The current software already achieves its main objectives, but future improvements can make the system more intelligent, efficient, and adaptable. These changes would not only improve detection accuracy but also increase usability in different turbine environments.

1. **Wireless data logging:** Adding a wireless data logging function would allow every detection event to be recorded automatically. This can be used for safety audits, reporting, and training purposes, making the system useful beyond real-time alerts.
2. **Machine learning integration:** Implementing simple machine learning algorithms would allow the system to learn and adapt over time. This would help it distinguish between real hazards and false triggers, reducing unnecessary alarms.
3. **Reducing false readings:** By improving the filtering process and adding calibration routines, the software can minimize errors caused by metallic surfaces, vibrations, or electrical interference. This ensures greater reliability in complex environments.
4. **Adjustable detection thresholds:** Making the detection range customizable through software settings allows the system to be used in different turbine areas. For example, shorter detection ranges can be set for smaller spaces, while larger ranges can be used in open areas.
5. **Low-power mode:** Adding a power-saving mode to the code would allow the device to consume less energy when idle. This would extend battery life and make the system more efficient during long operations.
6. **Optimized real-time processing:** Streamlining the loop and reducing unnecessary delays in the program ensures the system can respond instantly. A faster response time directly improves safety performance.

### 5.3.4 ACCESSORIES & FINISHING (STUDENT D)(SAMUNDESWARY D/O RENGANATHAN)(24DAM23F1031)

Although the current prototype successfully integrates essential accessories and finishing elements, there are several areas where future improvements can enhance overall performance, durability, and usability.

1. **Material Enhancement:** Future versions can adopt advanced lightweight composites or flexible polymers to improve wearer comfort and ensure the armband remains durable under extreme aviation working conditions. Sweat-resistant and fire-retardant materials could be introduced for added safety in high-risk environments.
2. **Miniaturization & Integration:** Reducing the size of the sensor housing and vibration unit would create a sleeker and less bulky design, making the system more convenient for long-term use. Integration of all accessories into a single compact module could minimize loose components and improve portability.
3. **Improved Ergonomics & Comfort: Adjustable:** breathable straps with ergonomic padding should be explored to increase comfort during long shifts. Finishing with skin-friendly coatings will reduce irritation and enhance user acceptance.
4. **Environmental Resistance:** Accessories could be further upgraded with waterproofing, dustproofing, and shock-resistant enclosures, ensuring the system can withstand outdoor and harsh operational environments.
5. **Aesthetic & Visibility Improvements:** Future designs may incorporate customizable colors, reflective strips, or LED indicators on the armband itself to improve visibility and acceptance among aviation personnel. Enhanced finishing can also make the product more appealing for adoption in other industries.

In conclusion, improvements in materials, ergonomics, durability, and miniaturization will significantly enhance the reliability and effectiveness of the Safety Armband Sensor and Warning Light System. These refinements not only improve user experience but also support the potential for scaling the technology into commercial aviation safety products and wider industrial applications.

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## 7.0 APPENDIX A: DECLARATION OF TASK SEGREGATION

Sub-chapters	Description
OMPRAKAS S/O THANGA KALISVARAN	
1.1	Background Of Study
1.3.2.1	Specific Individual Project Objectives: Product Structure
1.5.2.1	Product Structure
2.1.4	General Literature Review: Evolution Of Human Alert System In Hazardous Environment
2.1.5	Integration Of Vibration And Light-Based Alert System For Turbine Safety
2.2.1	Specific Literature Review: Product Structure
2.3.1	Review Of Recent Research: Related Patented Products a
2.3.2	Recent Market Products: Product a
2.4.1	Comparison Between Recent Research And Current Project: Patent a Vs Product a. Your Product
3.1.2.3	Proposed Design Concept 1
3.2.2.1	Specific Part Sketching: Product Structure
3.2.4.1	Detailed Dimension On The Product Parts: Base/Main Structure
3.3.1	Project Flow Chart: Overall Project Flow Chart
3.3.2.1	Specific Project Design Flow: Product Structure
3.4.2.1	Specific Part Features: Product Structure
3.4.3	General Operation Of The Product
3.4.4.1	Operation Of The Specific Part Of The Product: Product Structure
3.6	Overall Project Gantt Chart
4.1.1	General Product Features & Functionalities
4.1.2.1	Specific Part Features:Product Structure
4.1.4.1	Operation Of The Specific Part Of The Product:Product Structure
4.3.1	Analysis Of Problem Encountered & Solutions:Product Structure
5.1.2.1	Specific Achievement Of Project Objectives :Product Structure
5.3.1	Improvement & Suggestions For Future Research :Product Structure

Sub-Chapters	Description
YOSANTHAN S/O ALEXANDAR	
1.5.1	Scope Of Project: General Project Scopes
1.3.2.2	Specific Individual Project Objective: Product Mechanisms
1.5.2.2	Specific Individual Scopes: Product Mechanism
2.1.2	General Literature Review: Trend Or Demand For Low-Cost Carrier
2.2.2	Specific Literature Review: Product Mechanism
2.3.1.2	Review Of Recent Research: Related Patented Product b
2.3.2	Recent Market Products: Product b
2.4.2.4	Comparison Between Recent Research And Current Project: Patent b Vs Product b. Your Product
3.2.1.1	Design Concept Generation: Function Tree
3.1.2.2	Morphological Matrix
3.1.2.4	Proposed Design Concept
3.2.2.2	Specific Part Sketching: Product Mechanisms
3.2.3	Overall Dimension Of The Product
3.2.4.2	Detailed Dimension On The Product Parts: Inner Section / Compartment
3.3.2.2	Specific Project Design Flow: Product Mechanism
3.4.2.2	Specific Part Features: Product Mechanism
3.4.4.2	Operation Of The Specific Part Of The Product: Product Mechanism
4.1.2.2	Specific Part Features:Product Mechanisms
4.1.3	General Operation Of The Product
4.1.4.2	Operation Of The Specific Part Of The Product :Product Mechanisms
4.3.2	Analysis Of Problem Encountered & Solutions: Product Mechanisms
5.1.2.2	Specific Achievement Of Project Objectives:Product Mechanisms
5.3.2	Improvement & Suggestions For Future Research : Product Mechanisms

Sub-Chapters	Description
SWETA D/O S GANESAN	
1.2	Problem Statement
1.3.2.3	Specific Individual Project Objective: Software /Programming
1.5.2.3	Specific Individual Scope: Software / Programming
2.1	General Literature Review
2.1.1	Aviation Industry In Malaysia
2.2.3	Specific Literature Review: Software/ Programming
2.3.1.3	Review Of Recent Research/Related Patented Product c
2.3.2.3	Recent Market Products: Product c
2.4.3	Comparison Between Recent Research And Current Project: Patent c Vs Product c Vs Your Product
3.1.2.5	Proposed Design Concept 3
3.1.2.4	Accepted Vs Discarded Solution
3.1.4	Conceptual Design Of The Proposed Product
3.2.1	General Interface Layout
3.2.2.3	Specific Part Sketching: Software/ Programming
3.2.4.3	Detailed Dimension On The Product Parts: Top/Front/Side Section
3.3.2.3	Specific Project Design Flow: Software / Programming
3.4.1	Product Description: General Product Features & Functionalities
3.4.2.3	Specific Part Features: Software / Programming
4.1.2.3	Specific Part Features : Software / Programming
4.1.4.3	Operation Of The Specific Part Of The Product : Software / Programming
4.2	Product Output Analysis
4.3.3	Analysis Of Problem Encountered & Solutions: Software / Programming
5.1.1	General Achievements Of The Project
5.1.2.3	Specific Achievement Of Project Objectives: Software / Programming
5.2	Contribution Or Impact Of The Project
5.3.3	Improvement & Suggestions For Future Research : Software / Programming

Sub-Topic	Description
Samundeswary D/O Renganathan	
1.3.1	Project Objectives: General Project Objective
1.3.2.4	Specific Individual Project Objective: Accessories & Finishing
1.5.2.4	Specific Individual Scopes: Accessories & Finishing
2.1.3	General Literature Review: Human Factor And Situational Awareness
2.2.3	Specific Literature Review: Software / Programming
2.3.1.3	Review Of Recent Research / Related Patented Product c
2.3.2.3	Recent Market Product c
2.4.3	Comparison Between Recent Research And Current Project: Patent c Vs Product c. Your Product
3.1.1.1	Design Requirement Analysis: Questionnaire Survey
3.1.1.2	Pareto Diagram
3.1.2.6	Proposed Design Concept
3.1.3.1	Evaluation & Selection Of Conceptual Design: Pugh Matrix
3.2.2.4	Specific Part Sketching: Accessories & Finishing
3.2.4.4	Detailed Dimension On The Product Parts: Accessories / Outer Section
3.3.2.4	Specific Project Design Flow: Accessories & Finishing
3.4.2.4	Specific Part Features: Accessories & Finishing
3.4.4.4	Operation Of The Specific Parts Of The Product: Accessories & Finishing
4.1.2.4	Specific Part Features :Accessories & Finishing
4.1.4.4	Operation Of The Specific Part Of The Product :Accessories & Finishing
4.3.4	Analysis Of Problem Encountered & Solutions : Accessories & Finishing
5.1.2.4	Specific Achievement Of Project Objectives : Accessories & Finishing
5.3.4	Improvement & Suggestions For Future Research : Accessories & Finishing

## APPENDIX B: SUMMARY OF SIMILARITY REPORT (TURNITIN)

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SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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