POLITEKNIK BANTING SELANGOR

AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)

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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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SESSION 1 2024/2025

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

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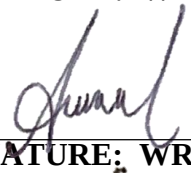

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ABSTRACT

A portable aircraft refueling system is a simple and compact device designed to efficiently refuel aircraft in various locations, and it is suitable to be provided at the institutions for the training and learning process. “The Portable Fuel System" present a full fuel system learning kit created to provide aircraft maintenance students especially a hands-on practical task, interesting, and informative experience. The kit provides a practical way on comprehending aircraft fuel systems, at the same time reducing the difficulties associated with conventional learning method such as, learning theoretically in the classroom without any practical section. The issue found that students insufficient practical experience in regular classrooms makes it difficult for them to understand complicated ideas and solve real-world problems with the aviation fuel systems. Students should have a better understanding of fuel system components, operation, and troubleshooting strategies after using this learning kit. The combination of the interactive modules syllabus, practical simulations and the real hand tools can create a futuristics and effective learning environment for a better comprehension of the aircraft refueling system. On a final note, the objective of this learning kit is to close the knowledge gap between the theoretical and practical knowledge between the aviation maintenance students and also create a better learning environment in the institutions.

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LIST OF ABBREVIATIONS

AI	ARTIFICAL INTELIGENT
AFSLK	AIRCRAFT FUEL SYSTEM LEARNING KIT
AMM	AIRCRAFT MAINTENANCE MANUAL
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
IATA	INTERNATIONAL AIR TRANSPORT ASSOCIATION
CAD	COMPUTER AIDED DESIGN
QR	QUICK RESPONSE
LCD	LIQUID CRYSTAL DISPLAY
LED	LIGHT EMITTER DIODE
L	LITRE
RPK	REVENUE PASSANGER KILOMETER
RFID	RADIO FREQUENCY IDENTIFICATION
ASK	AVALIBLE SEAT KILOMETER
ICAO	INTERNATIONAL CIVIL AVIATION ORGANISATION
FAA	FADERAL AVIATION ADMINISTRATION
JIG	JOINT INSPECTION GROUP
PBS	POLITEKNIK BANTING SELANGOR
GPI	GREAT PLAINS INDUSTRY
IDE	INTEGRATED DEVELOPMENT ENVIROMENT

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Performing aircraft refueling following the correct procedures is paramount within any aviation institution. Not only does it ensure the safety of personnel and the integrity of the aircraft, but it also serves as a critical aspect of operational efficiency and regulatory compliance.

Firstly, adhering to established refueling protocols mitigates the risk of accidents or incidents that could jeopardize the safety of both personnel and aircraft. Aviation fuel is highly flammable, and any deviation from proper procedures, such as improper grounding or mishandling of fueling equipment, can lead to catastrophic consequences. By strictly following procedures, candidates for upcoming on-the-job training can internalize the importance of safety protocols and develop the necessary skills to mitigate risks effectively.

Furthermore, correct refueling procedures contribute to operational efficiency. Precise procedures streamline the refueling process, minimizing downtime, and maximizing aircraft availability. This efficiency is vital for meeting demanding flight schedules and ensuring that aircraft are ready for dispatch in a timely manner. By understanding and practicing correct refueling procedures during their training, candidates can contribute to the smooth operation of aviation activities in their future roles.

FIGURE 1.1 C-GAUN, THE AIRCRAFT INVOLVED IN THE ACCIDENT, PHOTOGRAPHED 2 YEARS AFTER THE INCIDENT.

The Gimli Glider incident occurred 40 years ago when an Air Canada Boeing 767 ran out of fuel at 41,000 feet, but the pilots successfully glided the plane to a former airfield turned racetrack for a safe landing. The plane lost all power, including its electronic instrument system, but the pilots were able to use the ram air turbine for emergency instruments and hydraulic support to maneuver the aircraft. The incident was caused by a combination of technical issues, organizational challenges, human error, and a misunderstanding about fuel measurements in the metric system. The pilots were later awarded for their outstanding airmanship. (BY SIMPLE FLYING STAFF UPDATED AUG 6, 2023)

The specter of an aircraft running out of fuel mid-air due to ground crew negligence casts a chilling shadow over the aviation industry. Such a scenario is not just a theoretical concern but a tangible risk that highlights the paramount importance of rigorous adherence to proper refueling procedures. The consequences of inadequate fueling can be catastrophic, jeopardizing the safety of passengers, crew, and the aircraft itself. Any oversight or error during the refueling process, whether it's miscalculating fuel quantities, improper fueling connections, or failure to detect contaminants, can lead to dire outcomes once the aircraft takes to the skies.

In the event of an aircraft running out of fuel mid-flight, the situation rapidly escalates into a life-threatening emergency. As the aircraft's engines lose power, panic ensues among passengers and crew. Pilots are forced to navigate the aircraft to the nearest suitable landing site, all while contending with dwindling altitude and diminishing control. The repercussions of such an incident

extend far beyond the immediate disruption, serving as a sobering reminder of the critical role that meticulous ground crew procedures play in ensuring the safety and integrity of air travel. Only through unwavering diligence and adherence to strict protocols can the aviation industry mitigate the risk of such calamities, safeguarding the lives and well-being of all those who take to the skies.

1.2 PROBLEM STATEMENT

Upon the previous year in Polytechnic Banting, Selangor, students in this institution are not exposed to aircraft refueling and defueling system. This issue occurs due to lack of instruments and devices required to do practical learning. For the previous years, students only exposed the learning of refueling and defueling system of the aircraft on theoretical method only. This problem occurs due to lack of an instrument system or learning kit to carry out the practical learning of the aircraft refueling system.

PBS - AIRCRAFT MAINTENANCE TRAINING
M07: MAINTENANCE PRACTICES

- The aircraft should be earthed
- The refuelling tanker should be earthed
- The nozzle of the fuel hose should be electrically bonded to the fuelling point.

Refuelling

When refuelling the AMM should always be consulted so that the positions and capacities of the fuel tanks and also the type of fuel, position of the refuelling point(s) and refuelling procedures are known. There are two general re-fuelling methods:

- Gravity or over-wing refuelling: which is, essentially, the same method as used to refuel a motor car (automobile), with a similar type of refuelling hose being used. As the name suggests, the filler points are, generally, on the upper surface of the wing and the tank is open when refuelling is done
- Pressure refuelling: in which the fuel may be pumped into the aircraft via a pressure refuelling coupling at very high rates. The refuelling pressures and the rates of fuel delivery may be quite different for individual aircraft types, so great care must be taken, to ensure no damage occurs to an aircraft through incorrect refuelling settings.

Checking Fuel Contents

This is normally done, using the aircraft fuel gauges, which may be calibrated in kilograms (kg), gallons (Imperial or US) or pounds (lb). If a double check is required, then the contents may be determined, on the ground, by using 'dip sticks' (installed into the top of the tanks) or by 'drip sticks' (or magnetic 'drop sticks') which are installed in the bottom of some aircraft tanks.

The aircraft fuel gauges will normally be positioned on the flight deck, but they can, on some aircraft, be duplicated at a fuelling panel, adjacent to the pressure refuel coupling. The Relative Density (RD) of fuel will vary with temperature and so the weight of a certain quantity of fuel will also vary.

For example, ten gallons (Imperial) of fuel, with an RD of 0.8, will have a weight of 80 lb, while ten gallons (Imperial) of fuel, with an RD of 0.78, will weigh 78 lb. It is crucial, for balance purposes that the weight of fuel is known and this is the reason why many aircraft fuel gauges are calibrated in units of weight rather than in volume.

When fuelling aircraft, it is essential that the technician is aware of the RD of the fuel, so that the necessary weight calculation may be done, if necessary.

For Training Purposes Only
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PBS - AIRCRAFT MAINTENANCE TRAINING
M07: MAINTENANCE PRACTICES

Defuelling

Occasionally, it is necessary to remove fuel from an aircraft, to facilitate fuel tank maintenance, or because the aircraft is too heavily loaded for the next flight. Removing fuel from an aircraft can be accomplished by either the gravity or by the pressure defuelling method.

The gravity method entails draining the fuel into a suitably earthed container, and this is typical of light aircraft, which are normally 'gravity' refuelled. The fuel removed must be disposed of in the correct manner, with regard to local instructions and to the environment.

Aircraft that are normally pressure refuelled are normally equipped with a pressure defuelling facility. Pressure defuelling is achieved by utilising a small negative pressure (suction), which effectively draws the fuel out of the tank and returns it into the fuel tanker (bowser).

Current rules will normally only allow the fuel, removed from an aircraft, to be placed into a dedicated defueller vehicle and the fuel will not be permitted to be used in another aircraft. This ensures that any contamination such as water or debris will not be transferred to other aircraft.

8.7 Ground De-icing / Anti-icing of aircraft

Ice Types

There are three main types of ice/frost that can effect an aircraft's performance, Hoar Frost, Rime Ice and Glaze Ice. The temperature and weather conditions will determine the type of ice that forms, but all three types can have a detrimental effect.

The Dew Point is the temperature at which moist air becomes saturated and deposits dew if in contact with a colder surface or the ground. Above ground, condensation into water droplets takes place.

Hoar Frost is a deposit of ice crystals that form on an object when the dew point is below freezing point. High humidity will normally produce hoar frost, as these are similar to conditions that produce dew. Hoar frost can form when the air temperature is greater than 0°C, but the aircraft skin temperature is less than 0°C. This type of frost produces a very rough surface which leads to turbulent airflow.

Rime Ice is a light coloured opaque rough deposit that has a porous quality. At ground level it forms in freezing fog from water droplets with very little spreading. It adds very little weight but it can disrupt the smooth flow of air over the wing, and block pitot and static vents.

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FIGURE 1.2 PBS. AIRCRAFT MAINTENANCE TRAINING, M07: MAINTENANCE PRACTICES (PAGE 37-38)

Besides, students are also facing problems with difficulty understanding during theoretical learning session.

''The findings indicated that a number of students obtained better results as they learnt and remembered better through hands-on experiments. There was generally a higher level of participation and intrinsic motivation shown in the students when they learnt through hands-on experiments. The researchers are of the opinion that Kolb's experiential theory is very effective when doing the hands-on experiments for it ensures students grasp knowledge taught effectively.'' **(**Allen, L. (1973. An examination of the ability of third grade children from the science curriculum improvement study to identify experimental variables and to recognize change. Science Education, 57 (1), 123–151.)

Regarding this statement, it is crucial that a hands-on learning system should be applied in this institution. As stated before, Polytechnics Banting, Selangor does not have any special instrument to conduct hands-on learning on the aircraft refueling system. Based on a survey that we have conduct, many students claim that learning theory in class are more difficult to understand rather than doing the practical learning session for example, some student could not imagine the procedure of doing the refueling system on the aircraft.

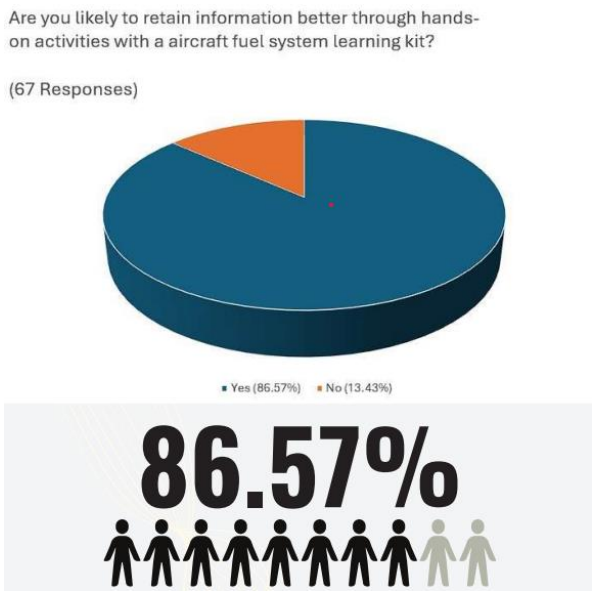

FIGURE 1.3 SURVEY EXPERIENCE AMONG PBS STUDENTS

After that, we were also concerned about the safety issue that became one of the reasons for us developing this product. Safety in practical work becomes the most important thing that should be focused on. Without the mechanical device, which is the fuel learning kit product, students may not receive comprehensive training on safety protocols that related to the refueling procedure of the aircraft.

Trajectory Analysis of Basket Engagement during Aerial Refueling

O. Khan* and J. Masud†
Department of Mechanical & Aerospace Engineering, Institute of Avionics & Aeronautics, Air University, Islamabad 44000, Pakistan

In this paper trajectory analysis for the aerial refueling basket for a modern fighter aircraft is presented. The under study aircraft has a probe and drogue arrangement for aerial refueling. Thus the aircraft has to be carefully positioned behind the extended refueling basket is such a way that positive engagement of refueling basket and probe takes place accounting for the complex flow field around the aircraft as it approaches the refueling basket. In the current study an initial location of the refueling basket has been selected such that, the aircraft flow field have minimal aerodynamic effects on the basket at this location and, then the basket is allowed to move towards the aircraft using Six Degree of Freedom Solver with appropriate boundary and limiting conditions. The initial location of the basket is iteratively improved until engagement of refueling probe and basket is achieved. Further optimization of initial location and some worst case scenarios have also been simulated. The results indicate significant effect of aircraft aerodynamics on basket trajectory. An optimum initial basket location that results in positive engagement with the refueling probe has been determined.

Nomenclature

AOA	Angle-of-Attack (Degrees)
β	Sideslip angle (Degrees)
CFD	Computational Fluid Dynamics
6DOF	Six degree of freedom
M	Mach number
P	Static pressure
P_∞	Free stream static pressure
SA	One equation Spalarat-Allamaras turbulence model
V_∞	Free stream velocity
ρ_∞	Free stream density
CG	Center of gravity
x, y, z	Cartesian ordinates
y^+	Non-dimensional length scale associated with turbulence model
RANS	Reynolds Averaged Navier-Stokes

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FIGURE 1.4 TREAJECTORY ANALYSIS OF BASKET ENGAGEMENT DURING AERIAL REFUELING (O. KHAN AND J. MASUD)

Regarding this analysis, we shall notice that safety in doing practical training or working in real industry are the most important things that we must be concerned about. It is critical that we prioritize and thoroughly handle safety regulations and procedures in order to protect every person involved. We can avoid accidents, reduce risks, and enhance safety for both learning and working if we comply with exceeding safety standards.

Last but not least, the portability and the cost of this learning kit have also become some of our priorities in conducting this idea. The innovation of this fuel system learning kit will be more suitable to be provided in the institution for learning purpose. Additionally, it's also required minimum number of tools and devices to be use as an exposure among the student about the basic procedure of refueling the aircraft.

''Lab kits allow students to take home laboratory equipment to complete experiments on their own time. Kits like these can expand access to hands-on experiences for online courses and to budget-strapped campuses.'' (Rebecca M. Reck; Ramavarapu S. Sreenivas; Michael C. Loui 2015)

Referring to this citation, the portability of the learning kit can help students improve their learning experience. This flexibility not only caters to diverse learning environments but also supports personalized learning paces, encouraging continuous and uninterrupted learning opportunities. By having access to the learning kit at their convenience, students can make the most of their study time, leading to a deeper understanding of the subject matter and better retention of information

1.3 PROJECT OBJECTIVES

1.3.1 General Product Objectives

The Project Objectives:

- To provide hands-on experience for the students to learn about Fueling System in the aircraft.
- To help lecturers with their lectures and explanation on how Fueling System works.
- To demonstrate how Fueling System works.
- To evaluate user's satisfactions towards security and functionality using post survey.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure

The specific project objectives are:

- To design a mini fuel bowser for educational purposes with many features same as a truck fuel bowser have.
- To develop a Fuel System Learning Kit which consists of fuel tanks, fuel pump with gauge, and a fully mobilized cart.
- To design a cart with a space compartment which consist of 2 spaces in total.

1.3.2.2 Mechanical Mechanism

The specific project objectives are:

- To design a fully functional cart with parking brake system.
- To design a cart that can withstand heavy weight tanks that are filled with fuel.
- To design a cart with a rigid handle to easily maneuver the fuel cart.

1.3.2.3 Software / Programming

The specific project objectives are:

- To develop appropriate software programming which encodes Arduino programming language as part of the overspeed sensor.
- Develop essential features and functionalities based on user requirements.
- Provide options for user customization and configuration.

1.3.2.4 Accessories /Finishing

The specific project objectives are:

- To provide extra safety equipment for the system and enhance the safety measurement.
- To provide an attractive finishing on the fuel cart and
- To demonstrate a proper working system on the fuel cart.

1.4 PURPOSE OF PRODUCT

This product can be used by students who study in the field of aviation for practical purposes. This product is very important because it ensures that students are proficient in applying theoretical learning to practical skills. As a result, this product can increase student knowledge in terms of procedures using the fuel system, safety precautions, and further procedures.

This product can have a high impact on institutions, industry, and students. This is because it can make it easier for instructors to demonstrate how to use the aircraft fuel system. In addition, students have been exposed to this kind of learning, which makes it easier for the industry in terms of safety and guidance to train the students who will do practical work there in the future.

"A mismatch exists between the typical learning style of engineering students and the traditional teaching style of engineering professor style. As a result, students become bored and careless in class, do weak tests, despair about courses, curriculum, curriculum and themselves, and in some cases, change to another curriculum or drop out of school." (RICHARD M. FELDER, NORTH CAROLINA STATE UNIVERSITY, LINDA K. SILVERMAN, INSTITUTE FOR THE STUDY OF ADVANCED DEVELOPMENT,1988)

1.5 SCOPE OF PROJECT

1.5.1 General Project Scopes

Firstly, this product is for aviation training institutions for training purpose. This Fuel System Learning Kit is more efficient because it is cheaper than the real bowser and is more portable and makes practical sessions in lessons easier. This kit also provides the real refuelling procedure so that it will help student prevent making mistakes during practical refuelling sessions.

Rather than that, This Fuel System Learning Kit also provide compartment to store tool related to refuelling session so that, the tool is easy to reach when the refuelling is in process.

1.5.2 Specific Individual Scope

1.5.2.1 Product Structure

First, this Fuel System Learning Kit be focusing on the aviation training institute due to the real aviation field need more bigger size tank such as the bowser. The product structure will comply to the aircraft real refuelling point and all of the procedure based can be performed.

Then, based on occupational safety and health administration (OSHA) the refuelling process should follow the correct procedure for every aircraft and should be conducted by a responsible person or better known as a refuelling operator.

1.5.2.2 Mechanical Mechanism

Foremost, this Fuel System Learning Kit is a specialized vehicle equipped with a fuel tank and pumping system designed to refuel aircraft. It is constructed with a robust chassis and Airless tyre, enabling it to be easily moved around. This mobility is achieved through a tow truck or a tow bar mechanism. The tow truck can attach to the cart using a hitch system, allowing it to be pulled efficiently.

Alternatively, a tow bar, which is a rigid metal bar, can be manually connected to the cart and then can be pulled manually but it needs an effort to do it. This dual mechanism ensures that the refuelling cart can be maneuverer precisely and positioned conveniently for refuelling operations, enhancing operational flexibility and efficiency on the training institution.

1.5.2.3 Software/Programming

This Fuel System Learning Kit includes essential software and programming to ensure any electronic parts are functioning as we need them to use. The software we use, Arduino IDE, is designed to give instructions to our Fuel Quantity Level Sensor (Ultrasonic Sensor) to read the quantity of fuel inside the fuel tank. Furthermore, the software can programme any electronic or electrical part in many variants of coding languages.

Next, we used AutoCAD to draw our product model in 3D/2D view and orthographic view. AutoCAD is software that is used to draw any model product before starting to make it in real life. AutoCAD is easier to use compared to other CAD software, and the accuracy of the size is 100% exact.

Finally, we used AI software, ChatGPT, to do research about our product. Today, AI is a programme that can answer any question asked. We used it to make it easier to search for any related product and other documents that we need to use for our product.

1.5.2.4 Accessories & Finishing

The AFSLK provides a Hazard Lamp to give indication when refuelling or defueling is ongoing. The Hazard Lamp will give a signal to surrounding area and giving an aural signal. The people surrounding the area will notice the signal and take safety precautions. These safety features ensure that the refuelling process is conducted safely and efficiently.

The AFSLK also provides grounding cable for extra safety measurement. Grounding cable is essential to ensuring the safety of the user. Currently, grounding point is not provided at Polytechnic Banting Selangor. The grounding cable is provided for future learning when the grounding point is built at Polytechnic Banting Selangor.

The AFSLK use spray paint for the finishing. The main purpose of the spray paint is to provide a better look for the AFSLK. Colour combinations help to make the AFSLK have much attractive looks.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

Aircraft refueling is a critical aspect of aviation operations, and this area is primarily focused on efficiency, safety, and sustainability. There are many factors that affect aircraft refueling operations worldwide such as influencing demand, including increasing air traffic, fuel prices, regulatory requirements, and technological advancements.

2.1.1 Demand in Aviation

The International Air Transport Association (IATA) released data for February 2024 global passenger demand with the following highlights: Total demand, measured in revenue passenger kilometres (RPKs), was up 21.5% compared to February 2023. Total capacity, measured in available seat kilometres (ASK), was up 18.7% year-on-year. The February load factor was 80.6% (+1.9ppt compared to February 2023). (IATA FEB 2024)

The demand for aviation services has been consistently rising, driven by globalization, economic growth, and technological advancements. According to the International Air Transport Association (IATA), the number of air travelers is expected to double by 2037, necessitating increased operational efficiency and safety in aviation practices, including refueling operations. This surge in demand underscores the need for well-trained personnel to manage refueling processes, ensuring

quick turnaround times and minimizing delays. Additionally, the growth of low-cost carriers and expansion of air cargo services have heightened the need for streamlined and safe refueling operations.

2.1.2 Safety of refueling

Safe refueling operations require strict adherence to procedures and careful application of the safety precautions, not only by the refueling operators but also flight crew, the cabin crew, and the other ground operators.

This article highlights the safety precautions that must be considered when refuelling an aircraft. It also describes supplementary tasks that are necessary if refuelling when passengers are on-board. (Safety first | April 2020 - Airbus S.A.S. All rights reserved. Proprietary document.)

Therefore, Safety is another major concern in aircraft refueling. Scholars explore risk management strategies, human factors, and technological innovations to enhance safety protocols and prevent accidents or fuel-related incidents. This includes the development of robust training programs for refueling personnel and the implementation of advanced monitoring systems to detect and mitigate potential hazards.

2.1.2.1 Regulatory Standards

Agencies like the Federal Aviation Administration (FAA) and the International Civil Aviation Organization (ICAO) set stringent guidelines to ensure the safety of refueling operations. These include protocols for grounding and bonding, fuel quality checks, and emergency response procedures.

The refuelling operator must also observe CAD748 Aircraft Fuelling and Fuel Installation Management which provides guidance on safety measures during fuelling operations, as well as the internationally recognized operating standards maintained by the Joint Inspection Group (JIG) for into-plane fuelling services. (APPENDIX 6.2 AIRCRAFT REFUELING PROCEDURE)

Therefore, we can all know that the aviation industry is setting standards before, during, and after the refuelling session. Maintenance personnel who are responsible for aircraft refuelling have to follow the standardized refuelling process instructed and written in Appendix 6.2.

2.1.3 Educational approach in aviation training.

The educational approaches in aviation training have evolved to meet the complex demands of modern aviation operations. Several methodologies are employed to train personnel effectively:

2.1.3.1 Traditional Classroom-Based Learning

This approach involves theoretical instruction through lectures, textbooks, and manuals. While foundational, it is often complemented by practical training to provide a comprehensive understanding of refueling procedures.

2.1.3.2 Simulation-Based Training

High-fidelity simulators offer a risk-free environment for students to practice refueling procedures. Research indicates that simulation-based training enhances learning outcomes by providing realistic scenarios that prepare students for real-world challenges.

2.1.3.3 E-Learning and Blended Learning

These approaches combine online learning with traditional classroom instruction. E-learning modules can include interactive content such as videos, quizzes, and real-time feedback, offering flexibility and accessibility. Blended learning integrates these online modules with hands-on practice sessions, ensuring a balanced and effective training experience.

2.1.3.4 Technological Integration

Integrating technologies such as Augmented Reality (AR) and Virtual Reality (VR) in training programs has shown promising results. These technologies provide immersive experiences that enhance understanding and retention of complex procedures. Mobile and tablet-based applications further support training by offering portable and interactive learning tools that can be used in various settings.

Figure 2.1 Augmented Reality (AR) and Virtual Reality (VR)

Therefore, simulation-based learning is very important to give students exposure on the refueling procedure to these hands-on practical learning kits so that they understand better and can apply them during upcoming on-the-job training and when they want to start working in the aviation field

2.2 SPECIFIC LITERATURE RIVIEW

2.2.1 Product Structure of Aircraft Fuel System Learning Kit

In creating this product, some research has been done to ensure this product is ergonomic and suitable for use by the targeted institution. Among the things considered are material selection and structural design, component and functional elements, mechanical mechanism, and lastly electrical/electronic mechanism.

2.2.1.1 Material selection and Structural design

Metal as Primary Material: Metals, particularly steel and aluminum, are commonly used in aviation equipment due to their durability, strength, and resistance to wear and tear. There are several reasons for choosing these materials.

2.2.1.1.1 Durability and Longevity

Metal was chosen as the primary material for the aircraft refuelling learning kit due to its exceptional durability and longevity. Metals such as stainless steel and aluminum provide this. These materials are well-known for their ability to withstand the harsh conditions of frequent use in training environments, where equipment is repeatedly handled, transported, and operated by multiple users.

2.2.1.1.2 Realistic Training Experience

The use of metal components in the aircraft refueling learning kit significantly improves the authenticity of the training experience. By closely replicating the actual tools and equipment used in real-world refueling operations, students can gain a better understanding of the procedures and nuances involved. This realistic simulation is critical for developing the confidence and competence needed to perform refueling tasks safely and efficiently in real-world operational settings.

2.2.1.2 Plywood

Using plywood as a barrier and support structure for the fuel tank supported by a metal structure offers a versatile and robust solution for various applications. Plywood, made from layers of wood veneer bonded together with adhesive, provides strength, durability, and ease of customization. Its uniform strength and smooth surface make it ideal for constructing compartments of different shapes and sizes. This combination offers a balance of strength, flexibility, and cost-effectiveness, making it suitable for projects ranging from furniture and cabinetry to industrial enclosures and storage units.

Figure 2.2 Plywood

2.2.2 Mechanical mechanism

2.2.2.1 Refueling nozzle and hose assembly.

The refuelling nozzle and hose assembly are critical components that must be precisely replicated in the training kit for effective learning. The nozzle should have features like automatic shut-off mechanisms and flow control. These components are critical for teaching students the precise handling and operational skills required for refuelling, ensuring they understand how to manage fuel flow and respond appropriately to automatic shutoffs. Furthermore, the hose material should be metal reinforced to prevent kinks and punctures, which improves the training tool's durability while also providing a realistic simulation of actual refuelling equipment. This realistic and robust design allows students to practice with equipment that closely resembles the physical characteristics and operational challenges they will encounter in real-world refuelling scenarios, improving their practical skills and preparedness.

2.2.2.2 Moving mechanism

This Fuel system learning kit uses airless tires and swivel tires because their solid construction makes them more durable and better suited for heavy-duty use, providing consistent performance even under heavy loads. This means they can't go flat or blow out, reducing the risk of downtime and maintenance. Additionally, as a portable learning kit, this Fuel System Learning Kit is designed with a push rod attached at the back of the cart. This rod is to ease the users to move the AFSLK anywhere to conduct the refueling system procedure.

Figure 2.3 Swivel tires

2.2.2.3 Type of Fuel Pump

In this Aircraft Fuel System Learning Kit, we used portable Electrical Fuel Transfer Pump. This pump operates with a supply power of 12V DC, making it both portable and versatile for various training applications. The 12V DC power supply ensures compatibility with standard low-voltage power sources, enhancing its usability in educational settings. By using this portable pump, trainees can simulate real-world refueling operations, gaining practical experience with the components and procedures essential for safe fuel handling and transfer within an aircraft system.

Figure 2.4 Fuel Pump

2.2.2.4 Fuel Tank

Figure 2.5 Fuel Container

Fuel tanks are one of the important elements that we consume in our product. The choice of a cylinder shape of a fuel tank is to make it fit in our cart. Besides, it is also easy to find and market friendly compared to other shapes of fuel tank. By adding this fuel tank within our cart, it can help students and lecturers in teaching and learning methods, so that they do not need to repeatedly move to get fuel to demonstrate the fuel system procedure. Consequently, this will not only save valuable time and energy on learning practical lessons but also enable a more focused and improved learning environment, ultimately contributing to a deeper understanding of the subject matter.

2.2.3 Software / Programming

2.2.3.1 Digital Fuel Quantity Level

Including a digital fuel quantity level indicator in our aircraft refueling learning kit is critical for providing students with accurate measurements and real-time monitoring of fuel levels during training exercises. This feature raises safety awareness, reinforces fuel management concepts, and teaches practical skills required for real-world refueling scenarios.

2.2.3.1.1 Fuel Level Sensors

The waterproof ultrasonic sensor stands out as an optimal choice for measuring fuel levels in an aircraft refueling learning kit due to several key advantages. Firstly, waterproof ultrasonic sensors offer non-contact measurement, meaning they do not need to physically touch the fuel surface, which eliminates the risk of contamination or damage to the sensor. This feature ensures reliability and longevity, critical for a durable educational tool. Secondly, ultrasonic sensors provide accurate measurements regardless of the fuel type, density, or environmental conditions, ensuring consistent performance in various training scenarios. Finally, waterproof ultrasonic sensors offer real-time measurement capabilities, allowing students to monitor fuel levels instantaneously, enhancing their learning experience and practical understanding of fuel management principles. Overall, the non-contact nature, accuracy, versatility, and real-time capabilities make the waterproof ultrasonic sensor the best choice for measuring fuel levels in an aircraft refueling learning kit.

Figure 2.6 Ultrasonic Sensor

2.2.3.1.2 Microcontroller

Arduino is widely regarded as one of the best microcontroller platforms for educational and prototyping purposes due to several compelling reasons. Firstly, Arduino offers a user-friendly development environment, making it accessible even to beginners with little to no prior programming experience. The Arduino IDE (Integrated Development Environment) provides a simple and intuitive interface for writing, compiling, and uploading code to the microcontroller, streamlining the development process. Additionally, Arduino boards are affordable, widely available, and supported by a vast community of users and developers. The Arduino Uno has plenty of I/O pins and is compatible with a variety of sensors and peripherals, making it ideal for prototyping and educational projects. Overall, Arduino's user-friendly development environment, low cost, extensive community support, and flexible board options make it the best choice for powering the microcontroller in the aircraft refueling learning kit.

Figure 2.7 Arduino UNO

2.2.3.1.3 Display Screen

The LCD (Liquid Crystal Display) is an excellent choice for displaying fuel quantity levels in the aircraft refueling learning kit for a variety of reasons. For starters, LCD displays are inexpensive and widely available, making them a viable option for educational and prototyping projects. Their affordability ensures that the learning kit remains affordable while still providing adequate functionality. Furthermore, LCD displays have good readability and contrast, allowing students to easily view and interpret fuel quantity information under varying lighting conditions. This clear visibility improves the learning experience by giving students a simple interface for tracking fuel levels during training exercises. Furthermore, LCD displays use very little power, making them energy-efficient and suitable for battery-powered systems. This efficiency ensures that portable learning kits' batteries last longer, allowing for extended use without the need for frequent recharging or replacement. Overall, due to its affordability, readability, and energy efficiency, the LCD display is the best choice for visually presenting fuel quantity levels in the aircraft refuelling learning kit, effectively meeting educational objectives while remaining cost-effective and practical.

Figure 2.8 LCD

2.2.3.1.4 Connector and Wiring

Using cables and connectors to connect components in our aircraft refuelling learning kit has several advantages, including reliability, flexibility, and ease of assembly. For starters, cables and connectors ensure a secure and stable connection between components, reducing the likelihood of intermittent connections or disconnections during training sessions. This dependability is essential for ensuring continuous operation and avoiding potential safety hazards caused by loose or faulty connections. Furthermore, cables and connectors provide flexibility in component placement, enabling customizable configurations to suit different learning scenarios and environments. Overall, using cables and connectors as the primary method of interconnecting components in our aircraft refuelling learning kit ensures durability, versatility, and ease of use, which improves the overall learning experience while also ensuring optimal performance and reliability.

Figure 2.9 Cable and Connecter

2.2.3.2 Power Supply

Utilizing a 12V rechargeable battery to energize the fuel pump within our project fuel system learning kit yields a multitude of advantages. Firstly, its portability and versatility empower educators and learners with the freedom to conduct hands-on experiments and demonstrations in diverse settings without tethering to fixed power outlets. This enhances the immersive learning experience by fostering exploration and experimentation. Moreover, the inherent safety and reliability of rechargeable batteries ensures consistent performance, mitigating the risk of interruptions during instructional sessions. Integrating such batteries into the learning kit is straightforward, requiring minimal setup, which expedites the development process and enhances usability, particularly for those less familiar with intricate electrical systems. Despite a potentially higher initial investment, the long-term cost efficiency of rechargeable batteries is evident through their extended lifespan and reduced operational expenses. Furthermore, their eco-friendly nature aligns with sustainability goals, promoting responsible energy consumption and minimizing waste.

Figure 2.10 12V Battery

2.2.3.2.1 12 V Single Channel Relay module

The **relay module** in the Aircraft Refueling Learning Kit (AFSLK) is a critical component that facilitates the control of high-power devices, such as the beacon light, using the low-power Arduino system. This **single-channel 12V relay module** acts as an electrically operated switch, allowing the Arduino to safely manage the beacon light's power requirements without direct electrical connection to the Arduino's lower-voltage circuits. By utilizing a relay, the module ensures that the 12V beacon light can be activated or deactivated seamlessly when the refueling system is operational, signaling to users that the refueling kit is in use. The relay is triggered through an input signal from the Arduino, which energizes the relay coil, closing the circuit and allowing current to power the beacon light. This setup not only maintains safety by isolating the Arduino from higher voltage but also adds an intuitive and visual layer to the system's functionality.

Figure 2.11 12 V Single Channel Relay module

2.2.3.3 Arduino IDE

The Arduino Software (IDE) includes a text editor for writing code, a message area, a text terminal, a toolbar with buttons for basic operations, and a series of menus. It links to Arduino and Genuine hardware in order to upload and interact with programming. (Arduino, 2021) Sketches are programmed created with the Arduino Software (IDE). These drawings were created with a text editor and saved with the. Uno file extension. Cutting/pasting, as well as searching/replacing text, are all available in the editor. The message box highlights problems and provides feedback while storing and exporting. The Arduino Software (IDE) outputs text to the console, which includes comprehensive error messages and other information. The configured board and serial port are displayed in the window's bottom righthand corner. You may check and upload programming, generate, save, and save drawings, and open the serial monitor using the toolbar buttons. (Arduino, 2021)

Figure 2.12 Arduino IDE software

2.2.3.4 AutoCAD (CAD)

AutoCAD, developed by Autodesk, is a popular computer-aided design (CAD) software that is a valuable tool for architects, engineers, and designers. AutoCAD provides a versatile platform, allowing users to create precise and detailed 2D drawings as well as complex 3D models. Its user-friendly interface, which includes both a command line and a graphical user interface, allows for quick navigation and command execution. AutoCAD's extensive set of drawing and drafting tools, combined with customization options, enables users to easily create, edit, and annotate designs. As an industry standard, AutoCAD continues to evolve, incorporating new features to meet the changing needs of designers and architects, making it a must-have software for digital design and drafting across multiple disciplines.

Figure 2.13 AutoCAD

2.2.3.5 ChatGPT 3.5

ChatGPT is an advanced language model developed by OpenAI that uses the GPT-3.5 architecture to understand and generate human-like text. While it excels at natural language understanding and generation, it is not designed specifically for coding tasks. It can help you discuss coding concepts, explain them, and give general programming advice. However, for hands-on coding tasks, dedicated programming environments and tools, such as integrated development environments (IDEs) and code editors, are preferable. ChatGPT's strength lies in its ability to generate coherent and contextually relevant responses across a wide range of topics, including coding and programming, making it an invaluable resource for participating in discussions and learning about the field.

Figure 2.14 ChatGPT

2.2.3.6 QR Code

Integrating QR code into our fuel system learning kit offers a streamlined solution for both websites about our product and guiding users through the refueling process. Each component of the kit can be assigned a unique QR code, enabling users to scan them with their smartphones or tablets. This process records the usage of each part, allowing educators to monitor kit utilization and identify any missing or damaged components easily. Additionally, QR codes can link directly to digital resources such as instructional videos or step-by-step guides on refueling procedures. By scanning the code associated with refueling, users gain instant access to clear and concise instructions, including safety precautions, fueling techniques, and troubleshooting tips. This approach enhances the learning experience by providing on-demand guidance and reinforcing best practices in a user-friendly and accessible manner.

Figure 2.15 QR Code

2.2.3.7 Google Form

Using Google Forms to survey and administer a pre-test for our fuel system learning kit is a simple and effective way to collect valuable information. By creating customized forms, we can tailor questions to participants' knowledge levels, expectations, and preferences for the learning kit. The user-friendly interface of Google Forms enables easy distribution via email or shared links, maximizing respondents' accessibility. Its built-in features, such as multiple choice, checkbox, and rating scale questions, allow us to efficiently collect various types of feedback. Furthermore, the form's automatic data collection and organization speed up the analysis process, providing us with actionable insights for refining and improving our product.

Furthermore, the ability to generate real-time summaries and reports enables rapid decision-making and adaptation to user feedback. Overall, using Google Forms to survey and pre-test our fuel system learning kit allows us to collect comprehensive feedback from participants, which informs us of iterative improvements.

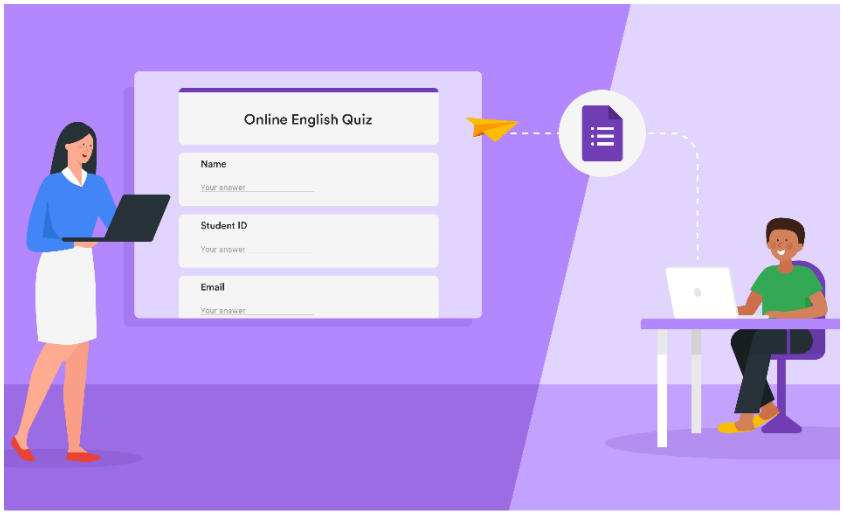


Figure 2.16 Google Form

2.2.4 Accessories & Finishing

2.2.4.1 Beacon Light

In our fuel system learning kit training institution, the beacon light serves as a vital safety feature during transportation and usage. The beacon light will automatically activate whenever the main switch is turned on to alert others of its presence, reducing the risk of accidents. Additionally, during training sessions, the beacon light remains illuminated to indicate that the kit is in use, ensuring that participants and instructors are aware of potential hazards associated with the equipment. This simple yet effective measure enhances safety protocols, promoting a secure learning environment and minimizing the likelihood of mishaps throughout the training process.

Figure 2.17 Hazard Lamp

2.2.4.2 Grounding Cable & Grounding Point

When refueling, it is very important to obey every rule that states in the Aircraft Maintenance Manual (AMM) to prevent any incident from occurring. Bonding and grounding are a vital process before, when and after fueling an aircraft. The bonding process is electrical between aircraft and fuel bowser are continuing to prevent any spark that might occur during connection of the refueling hose and aircraft's coupling. For grounding process, it is ensuring a electrical between the aircraft and the earth or ground continuing. Grounding cable is a good safety measurement for the system due to its importance role during fueling align with our product.

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

Table 2.1: AIRCRAFT REFUELLING SYSTEM KIT

No.	Marketed Product	Product Summary
1.	N/A	Patent Title: Aircraft refuelling system Patent No: GB202218415D0 Published Date:Pending Pattent Office Country: United Kingdom Inventors: Airbus Operations Ltd Abstract: The patent pertains to an innovative aircraft refueling system

2.3.2 Recent Market Products

Table 2.2: AIRCRAFT FUEL SYSTEM KIT (BOWSER)

No.	Marketed Product	Product Summary
1.		Product Name: Transfueler Fuel System kit Published Date:2020 Inventors:TransFueler Inc Description: • Superior engineering. Designed to tow safely whether full, or empty. • Used a Baffled Tank, A36 Mild Steel and Aluminum DOT 406 code tank • Powder coat finish, in a wide choice of colors • Fuel Level Gauge • Top Quality Components: GPI, Fill-Rite, Dixon, Hannay, Reelcraft, Betts, etc…
2.		Product Name: Model TSS-500-SS-7D4H-RD-BTN Published Date:N/A Inventors: Safe T-Tank corp Description: • Double wall 500-gallon jet a fuelling trailer (not for road or highway use) • with hose,meter,venting ,level alarm and hose bin storage.

3.		Product Name: 2,000L Highway Aviation Bowser Published Date:N/A Inventors: Safe T-Tank corp Description: • Ideally suited to small-to-medium scale refuelling applications, such as airfields and flying clubs
4.		Product Name: Aircraft Aiviation Fuel Tank Truck Mobile Fuel Refueling Published Date:N/A Inventors: FTJ-5 Description: • The car is suitable for the transport of dangerous goods. Tank effective volume 8.5 cubic meters, tank dimensions (long x long axis x short axis) (mm): 3700x2100x1450. Protective materials: q235a carbon Steel, Connection mode: Left and right side and rear part protection are welded connection, rear protection section size (mm): 110x50, rear protection off-ground height (mm): 390.

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

2.4.1 Patent product vs. Product A vs. Your Product

PRODUCT	AIRCRAFT REFUELING SYSTEM	TRANSFUELER FUEL SYSTEM KIT	AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)
DESIGN	N/A		
PORTABLE	NO	YES	YES
PURPOSE	THE PATENT PERTAINS TO AN INNOVATIVE AIRCRAFT REFUELING SYSTEM	ALLOWS FOR EASY TRANSPORTATION OF FUEL TO AIRCRAFT, ESPEACIALLY IN LOCATIONS WHERE FIXED REFUELING INFRASTRUCTURE IS UNAVAILABLE OR IMPRACTICAL.	PRACTICAL & LEARNING ABOUT REFUELING PROCEDURE
MOVING MECHANISM	FIXED	TOW TRUCK	PUSH BAR
CAPACITY	N/A	250 GALLONS	>100L
FEATURES	FEULING SCREEN PANEL	• GPI & FILL-RITE 12V HIGH-OUTPUT 15 GALLON PER MINUTE PIUMPS • 12V BATTERY WITH BOX • 12’ UL HOSE WITH MANUAL SHUTOFF NOZZLE • FUEL FILTRATION SYSTEM • EMERGENCY VENT	• DIGITAL FUEL QUANTITY LEVEL • AIRLESS TIRE • 12V ELECTRICAL FUEL TRANSFER PUMP • QR CODE WITH WEBSITES

Table 2.3: AIRCRAFT REFUELLING SYSTEM KIT VS TRANSFUELER FUEL SYSTEM KIT VS AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)

2.4.2 Patent product vs. Product B vs. Your Product

PRODUCT	AIRCRAFT REFUELING SYSTEM	MODEL TSS-500-SS-7D4H-RD-BTN	AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)
DESIGN	N/A		
PORTABLE	NO	YES	YES
PURPOSE	THE PATENT PERTAINS TO AN INNOVATIVE AIRCRAFT REFUELING SYSTEM	PROVIDES ACCESS TO FUEL IN REMOTE OR UNDERVELOPED AREAS WHERE PERMANENT FUELING INFRASTRUCTURE IS LACKING	PRACTICAL & LEARNING ABOUT REFUELING PROCEDURE
MOVING MECHANISM	FIXED	TOW TRUCK	PUSH BAR
CAPACITY	N/A	250 GALLONS	>100L
FEATURES	FEULING SCREEN PANEL	• DOUBLE WALL 500-GALLON JET A FUELING TRAILER WITH HOSE • EQUIP WITH	• DIGITAL FUEL QUANTITY LEVEL • AIRLESS TIRE • 12V ELECTRICAL FUEL TRANSFER

		METER • VENTING SYSTEM • ACCESSORIES SUCH AS LEVEL ALARM AND HOSE BIN STORAGE	PUMP • QR CODE WITH WEBSITES

Table 2.4: AIRCRAFT REFUELLING SYSTEM VS MODEL TSS-500-SS-7D4H-RD-BTN VS AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)

2.4.3 Patent product vs. Product C vs. Your Product

PRODUCT	AIRCRAFT REFUELING SYSTEM	2000L HIGHWAY AVIATION BOWSER	AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)
DESIGN	N/A		
PORTABLE	NO	YES	YES
PURPOSE	THE PATENT PERTAINS TO AN INNOVATIVE AIRCRAFT REFUELING SYSTEM	IDEAL SUITED TO SMALL-TO-MEDIUM SCALE REFUELING APPLICATIONS, SUCH AS AIRFEILDS AND FLYING CLUBS	PRACTICAL & LEARNING ABOUT REFUELING PROCEDURE
MOVING MECHANISM	FIXED	TOW TRUCK	PUSH BAR
CAPACITY	N/A	2000L	>100L
FEATURES	FUE LING SCREEN PANEL	• 110% BUNDED WITH STAINLESS STEEL INNER TANK • TOUGH STEEL CONSTRUCTION THROUGHOUT	• DIGITAL FUEL QUANTITY LEVEL • AIRLESS TIRE • 12V ELECTRICAL FUEL TRANSFER PUMP • QR CODE WITH

		• FULLY COMPLIANT WITH CURRENT REGULATIONS • BUILT IN ACCORDANCE WITH CAA GUIDELINES • SUITABLE FOR USE WITH AVGAS AND JET A-1	WEBSITES

Table 2.5: AIRCRAFY REFUELLING SYSTEM KIT VS 2000L HIGHWAY AVIATION BOWSER VS AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)

2.4.4 Patent product vs. Product D vs. Your Product

PRODUCT	AIRCRAFT REFUELING SYSTEM	AIRCRAFT AVIATION FUEL TANK TRUCK MOBILE FUEL REFUELING	AIRCRAFT FUEL SYSTEM LEARNING KIT (AFSLK)
DESIGN	N/A		
PORTABLE	NO	YES	YES
PURPOSE	THE PATENT PERTAINS TO AN INNOVATIVE AIRCRAFT REFUELING SYSTEM	REDUCES THE NEED FOR EXPENSIVE PERMANENT FUELLING INSTALLATIONS, OFFERING MORE ECONOMICAL SOLUTION FOR SMALLER AIRFIELDS OR TEMPORARY OPERATIONS	PRACTICAL & LEARNING ABOUT REFUELING PROCEDURE
MOVING MECHANISM	FIXED	MOVEABLE	PUSH BAR
CAPACITY	N/A	500L TO 10000L	>100L
FEATURES	FEULING SCREEN PANEL	• THE TRUCK IS SUITABLE FOR THE TRANSPORT OF DANGEROUS GOODS. • PROTECTIVE MATRERIALS SUCH AS Q235A CARBON STEEL • CONNECTION MODE: LEFT AND RIGHT SIDE AND REAR PART PROTECTION ARE WELDED CONNECTION	• DIGITAL FUEL QUANTITY LEVEL • AIRLESS TIRE • 12V ELECTRICAL FUEL TRANSFER PUMP • QR CODE WITH WEBSITES

Table 2.6: AIRCRAFT REFUELLING SYSTEM VS AIRCRAFT AVIATION FUEL TANK TRUCK MOBILE FUEL REFUELLING VS AIRCRAFT FUEL SYSTEM LEARNING KIT

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

This chapter will list the various steps that were successfully completed in order to reach the goals and objectives of the experiment. These included filling out all the necessary forms and approvals from the supervisor. During the course of the project, various stages were involved in the production of hazardous materials such as plywood cutting, painting, and testing. This safety measure was taken seriously by the team members and proper equipment was utilized.

3.1.1 Utilisation of Polytechnic's facilities

In order to utilise all the facilities such as equipment, consumable materials and tools provided by Polytechnic, permission has to be granted from the supervisor and workshop coordinator by filling up the necessary form. This form will specify the tools and equipment that are being used in order to complete the project.

Example of Polytechnic's facilities that our group use:

- Workshop 2
- Project Workshop JKM
- Composite Workshop

3.1.2 Project collaboration & Transfer of technology

Our Aircraft Fuel System Learning Kit is designed as an advanced learning tool and practical solution for fuel management, particularly suited for light aircraft, including Cessna planes and helicopters. This innovative system provides real-time fuel level monitoring, control mechanisms for fuel pumps, and safety alert functionalities, making it highly valuable for educational, training, and small-scale aviation operations.

Besides,the objective of this project collaboration is to build strong partnerships with academic institutions, aviation training centers, and industry stakeholders. Through these alliances, we aim to facilitate knowledge exchange on the use of sensor-based fuel monitoring, electronic display systems, and control circuits. This collaboration will enhance skills in fuel management for students, trainees, and professionals, providing hands-on experience with real-world aviation applications. Additionally, by combining expertise, we can advance research and development efforts to continuously improve the product, ensuring it meets evolving aviation standards and technological advancements.

3.2 OVERALL PROJECT GANTT CHART

3.2.1 Overall AEM Project Gantt Chart

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
DISCUSS WITH SUPERVISOR ABOUT PROJECT TITLE	P															
	E															
FINALIZE IDEA AND DISCUSS ABOUT CHARACTERISTICS	P															
	E															
CONDUCT SURVEY AND PRE-TEST (ASSIGMENT 1).	P															
	E															

COLLECT INFORMATION ON SURVEY AND PRE-TEST TO MAKE PARETO CHART.	P																
	E																
PRE-TEST AND SURVEY BEEN RECORDED (ASSIGMENT 2)	P																
	E																
COMPLETION OF THE PUGH MATRIX WHICH IS BASED ON ASSIGMENT 3.	P																
	E																
PRE-PROPOSAL PRESENTATION TO PANEL	P																
	E																
DISCUSSION ABOUT CHAPTER 1.	P																
	E																

CORRECTION OF CHAPTER 1 AND DISCUSSION ABOUT CHAPTER 2.	P															
	E															
COMPLETION OF CHAPTER 2.	P															
	E															
DISCUSSION AND COMPLETION OF CHAPTER 3.	P															
	E															
PREPARING SLIDE FOR FINAL PROPOSAL PRESENTATION.	P															
	E															
FINAL PROPOSAL PRESENTATION.	P															
	E															

3.2.2 Overall AEP Project Gantt Chart

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
MATERIAL ACQUISITION (PHASE 1) • Angle bar (2 pcs – 40ft) • Fixed tires (2 pcs) • Swivel tires (2 pcs) • Hollow steel (1 pcs - 20ft)	P															
	E															
MEASURING, FILLING, LEVALING, AND CUTTING (PHASE 2) • Angle bar ➢ (4.2ft x 2) ➢ (3 ft x 6) • Hollow steel ➢ (3 ft x4) ➢ (2 ft x 4)	P															
	E															
WELDING AND GRINDING (PHASE 3) ➢ Learn arc welding ➢ Learn how to use MIG welding ➢ MIG welding used to join GITK base structure ➢ Grinder	P															
	E															

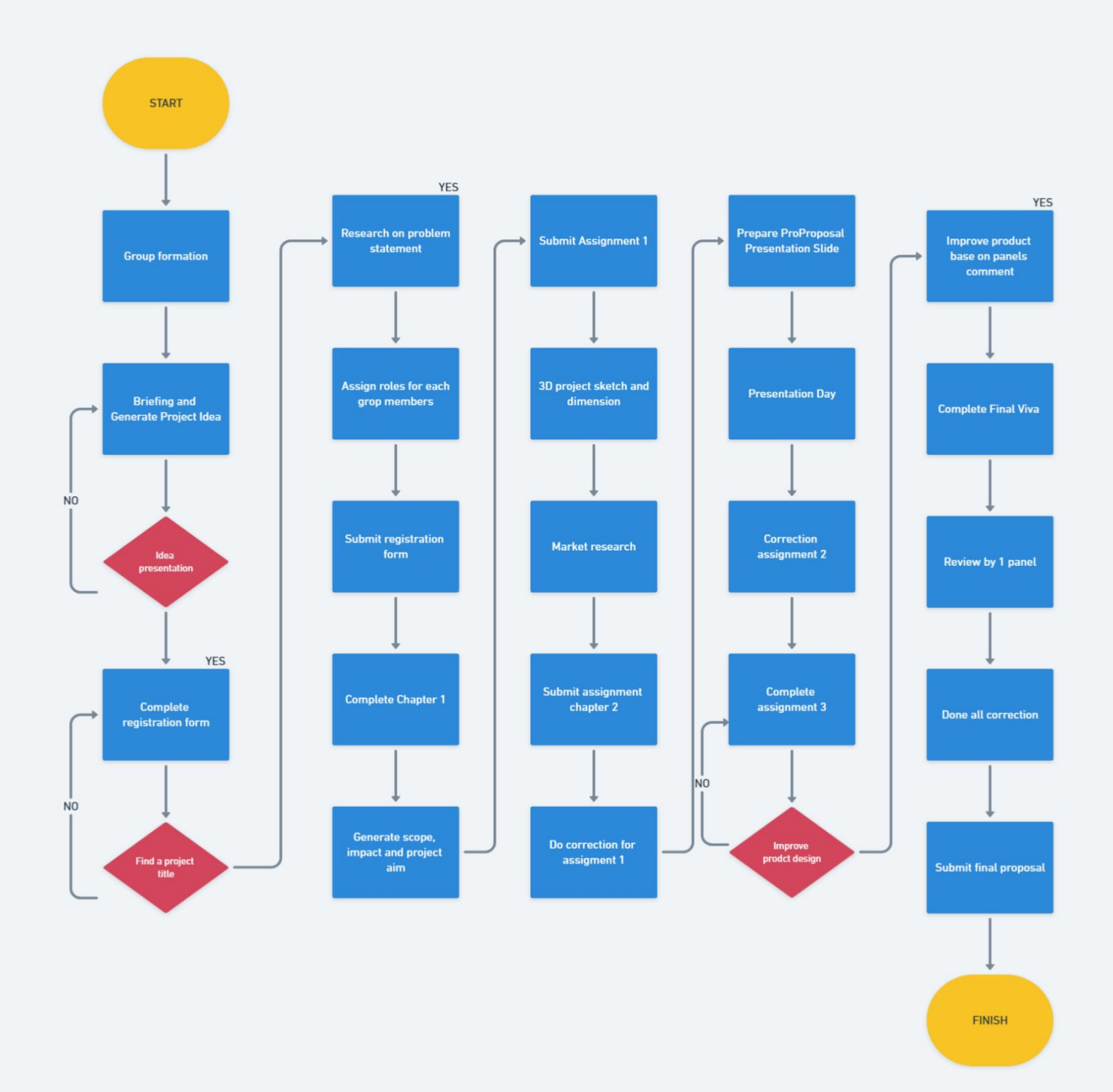
PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Programming (Phase 4) • Download Arduino IDE for programming • Add a coding in Arduino IDE • Setup the Arduino uno • Connect all related component to Arduino board	P															
	E															
Project Progress Presentation • Update logbook to supervisor • Do a slide presentation • Meeting with supervisor • Review slide with supervisor	P															
	E															
Troubleshooting • Tow bar structure • 1 front tires not stable Add on website and QR code for user • Discuss what to put in the website	P															
	E															

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
+FINALIZE AND FINISHING • Spray the oil drum • Cleaning the structure • Testing fuel pump and cart movement • Final presentation	P															
	E															
AEROMECH																
CONDUCT THESIS JOIN COMPETITION																

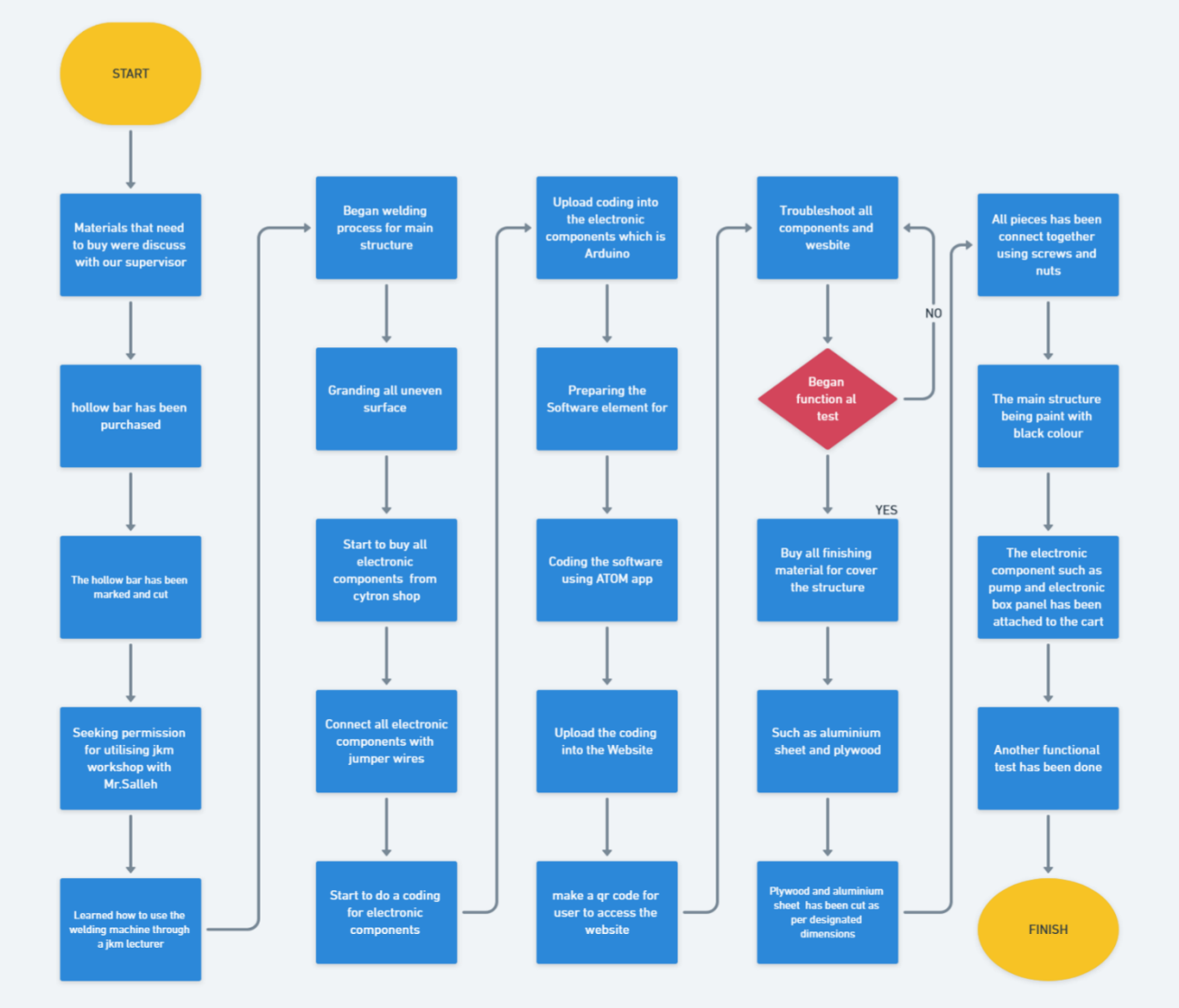
3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

Overall AEM Project Flow Chart

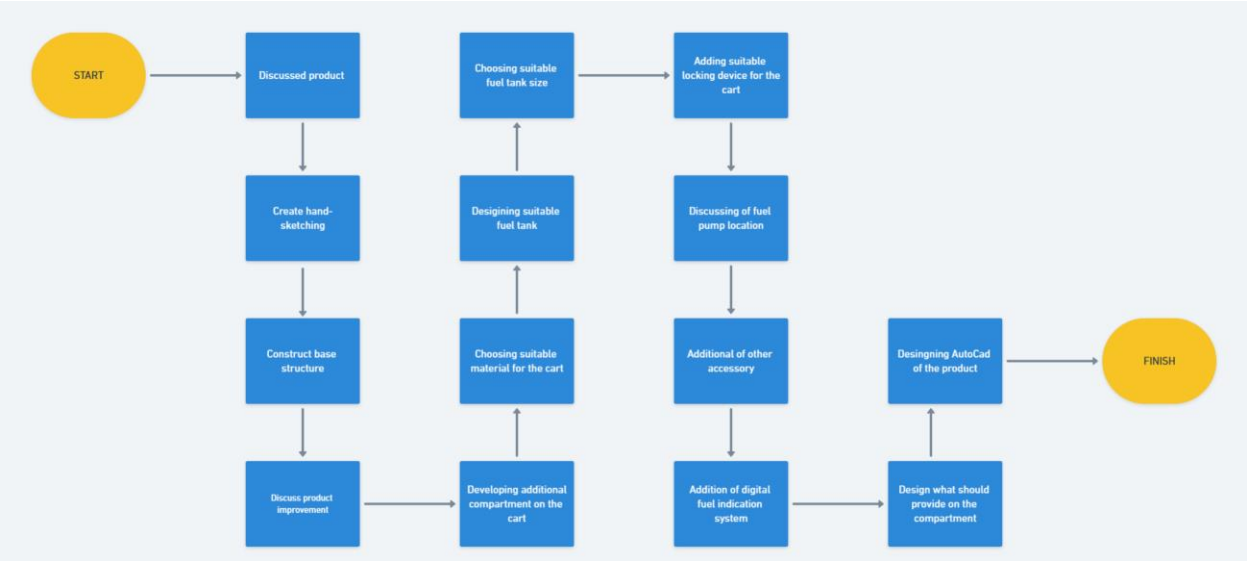


Overall AEP Project Flow Chart

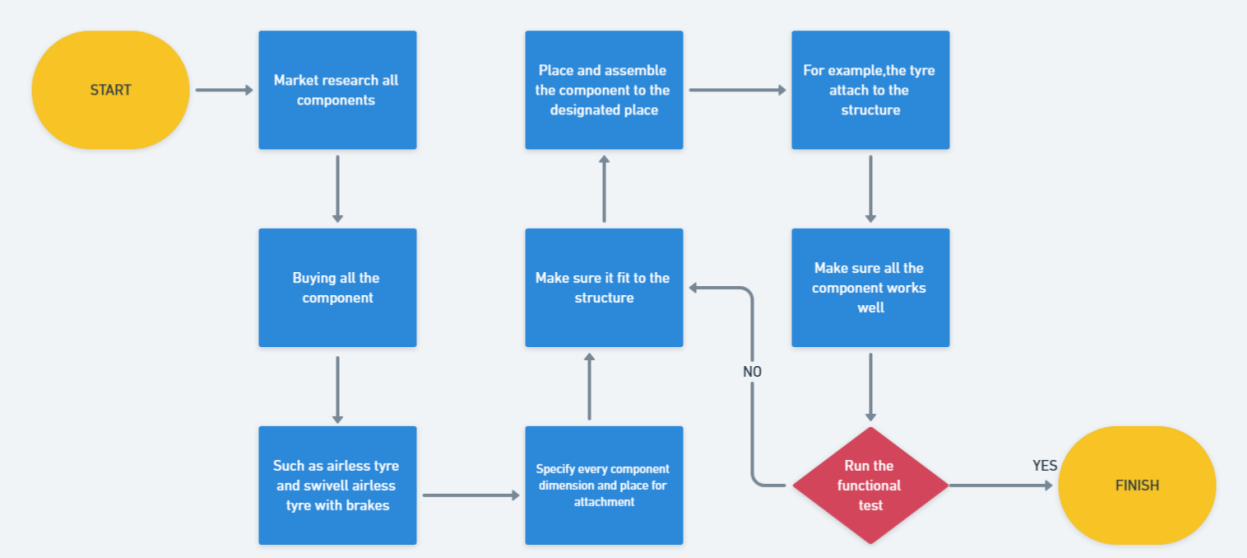


3.3.2 SPECIFIC PROJECT DESIGN FLOW / FRAMEWORK

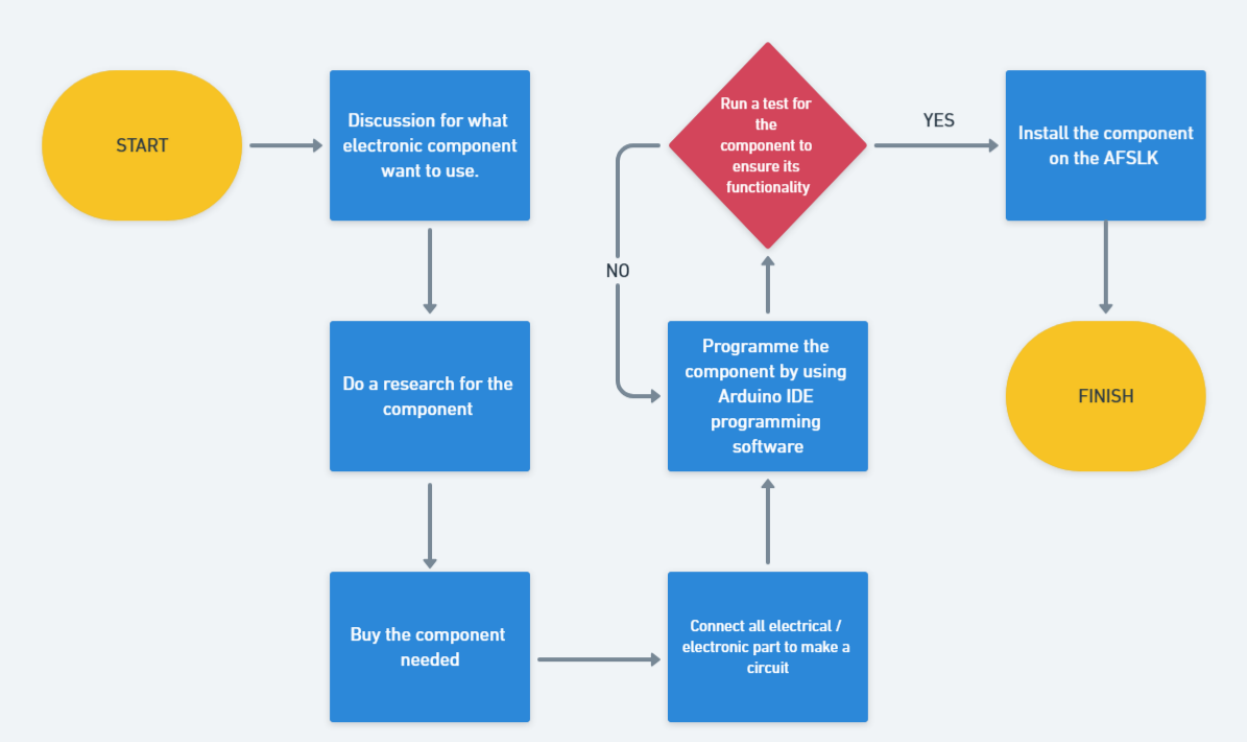
3.3.2.1 Product structure



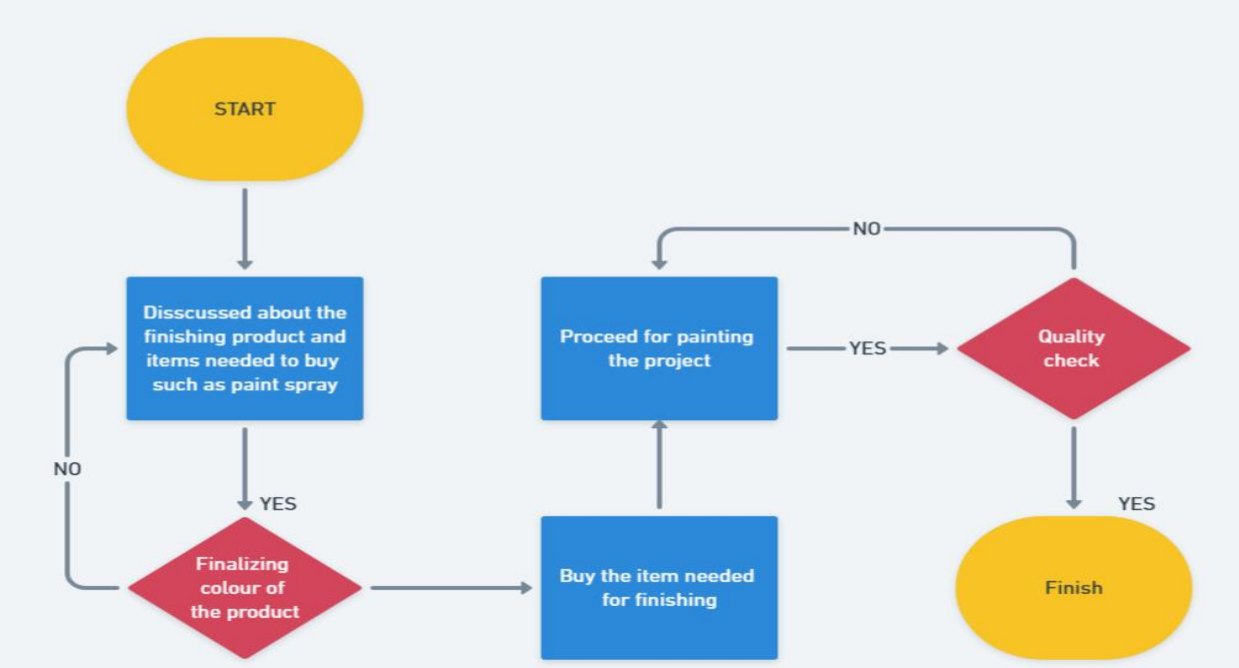
3.3.2.2 Mechanical Mechanism



3.3.2.3 Software/Programming



3.3.2.4 Accessories / Finishing



3.4 DESIGN ENGINEERING TOOLS

3.4.1 Design Requirements Analysis

3.4.1.1 Questionnaire Survey

Comparison about learning methods

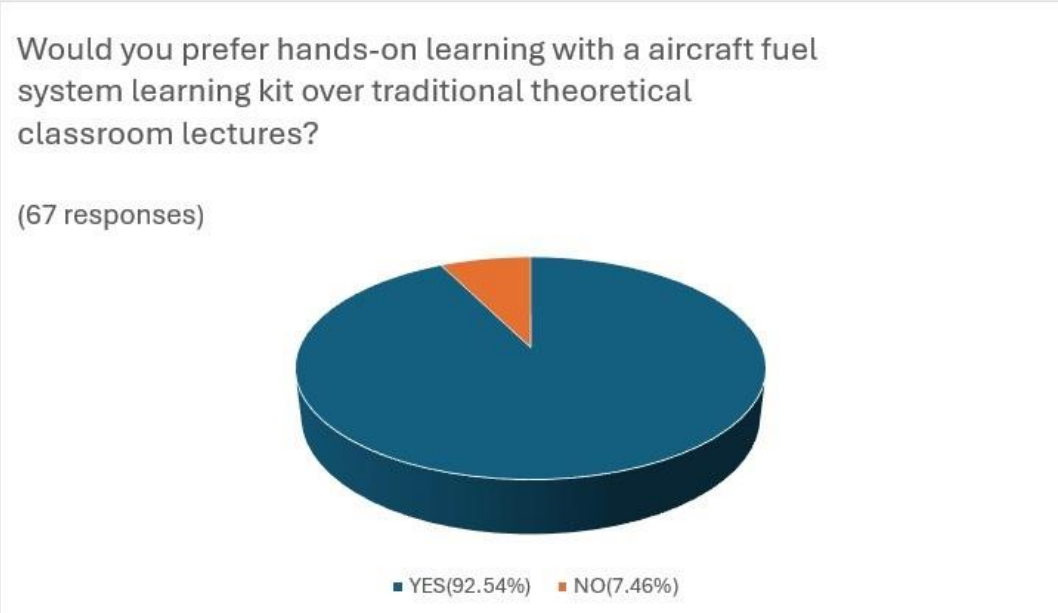


FIGURE 3.1 COMPARISON ABOUT LEARNING METHOD

Majority of respond prefer hands-on learning over theoretical learning method.

Understanding when performing practical work.

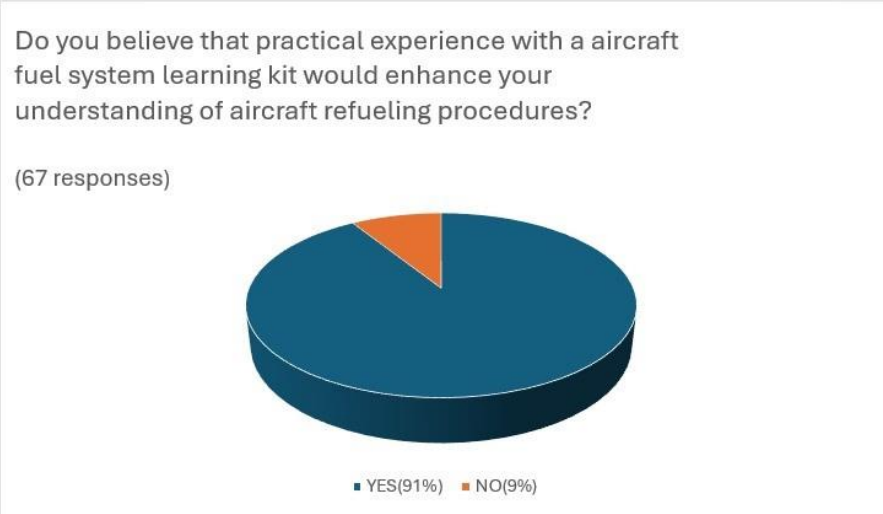


FIGURE 3.2 UNDERSTANDING WHEN PERFORMING PRACTICAL WORK

We found out that the most major respond prefers practical learning to enhance understanding on aircraft fuel system.

Experience in practical learning system

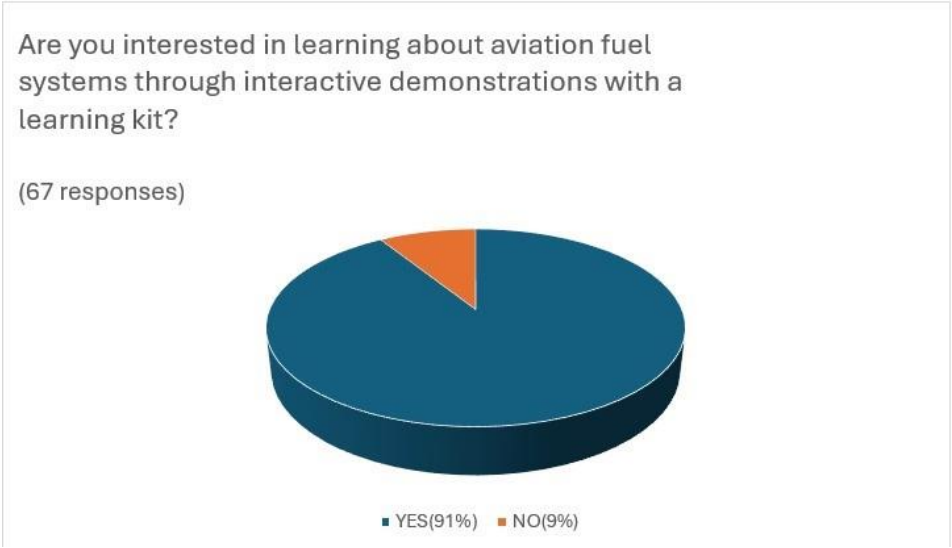


FIGURE 3.3 EXPERIENCE ABOUT PRACTICAL

Majority of the responded interested in learning by demonstrations with a learning kit.

Beneficial to access to an aircraft fuel system learning kit.

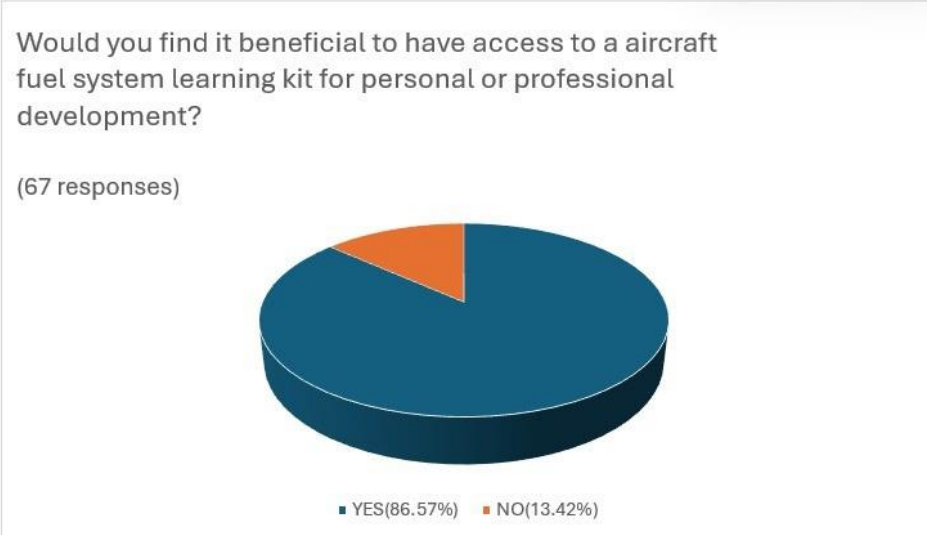


FIGURE 3.4 BENEFICIAL TO ACCESS TO AN AIRCRAFT FUEL SYSTEM LEARNING KIT

Our respondents are agreed that this learning kit bring benefit for personal and professional development.

The attractiveness of using this learning kit

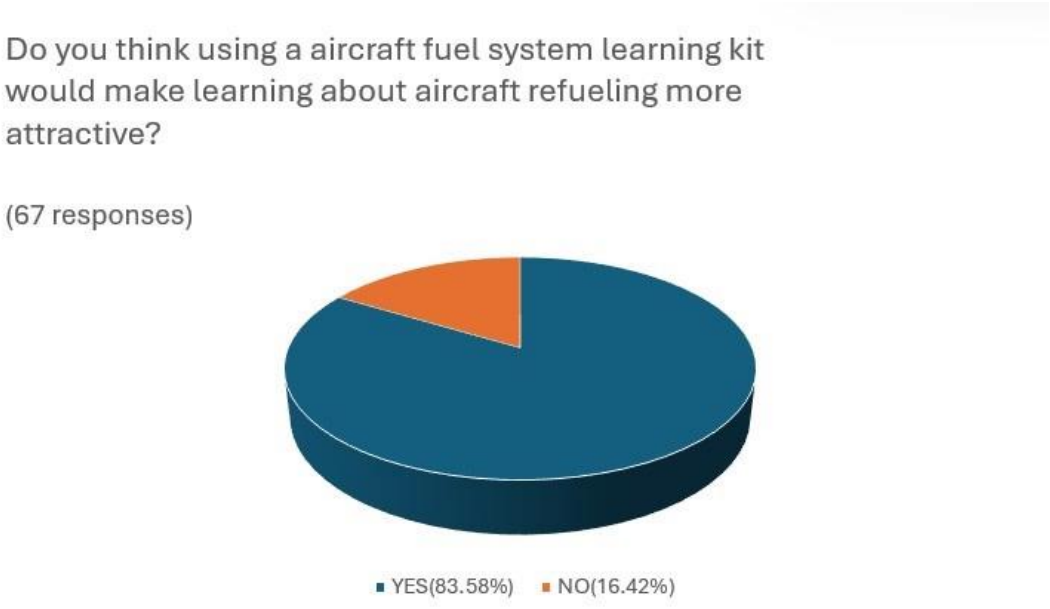


FIGURE 3.5 THE ATTRACTIVE OF USING AFSLK

The most of our respondents agreed that the aircraft fuel system learning kit are more attractive than theoretical learning method.

Ability to retain information through hands-on activities.

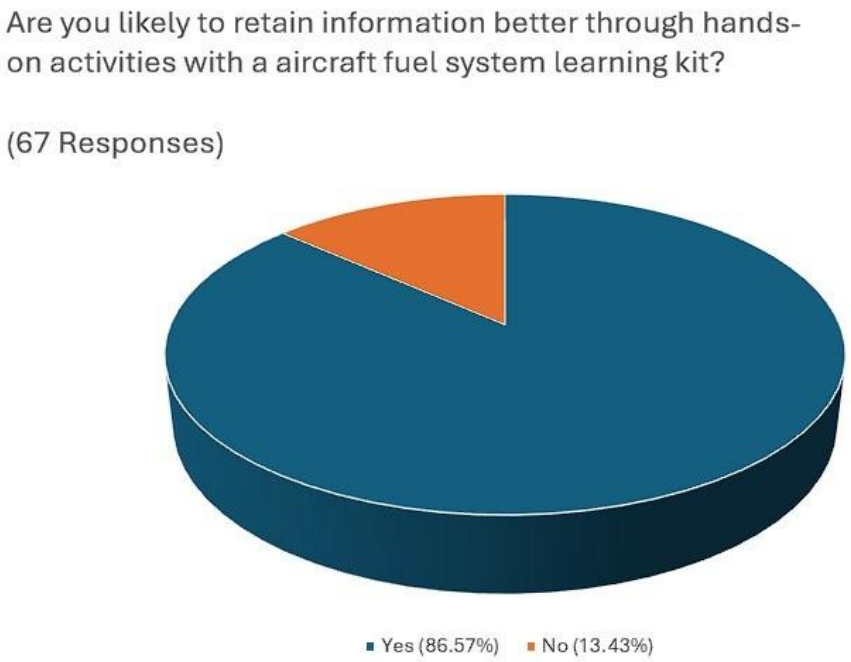


FIGURE 3.6 ABILITY TO RETAIN INFORMATION THROUGH HANDS-ON ACTIVITIES

Our respondent agreed that it is better to retain information through hands-on activities with the learning kit.

Consideration in investing in an aircraft fuel system learning kit.

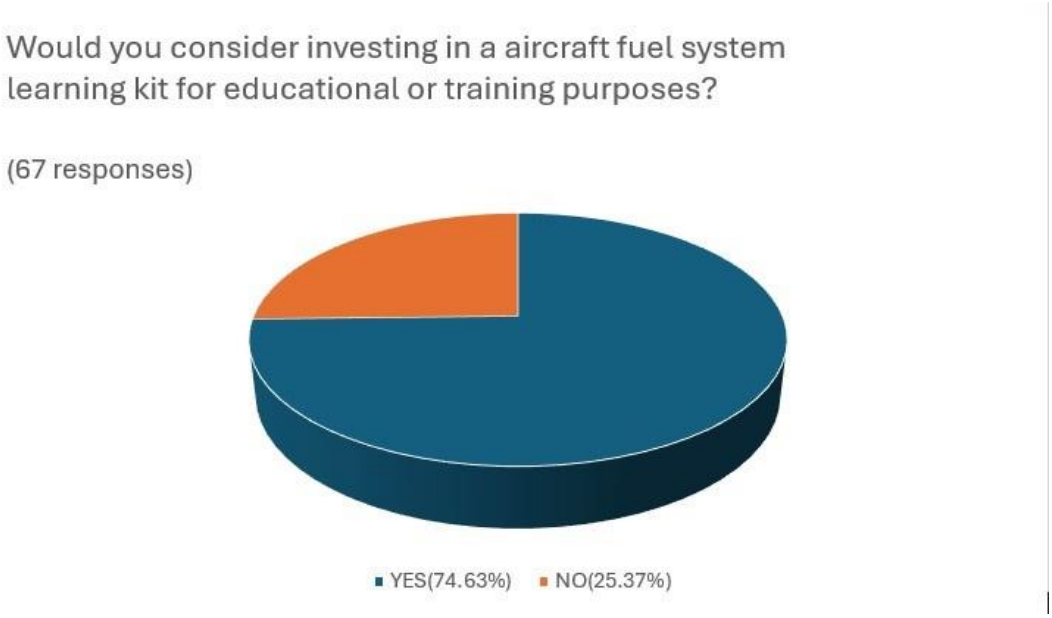


FIGURE 3.7 CONSIDERATION IN INVESTING IN AN AFSLK

It founds that it is effective to invest in aircraft fuel system learning kit in the institution.

Improvement of problem-solving skills in aviation context

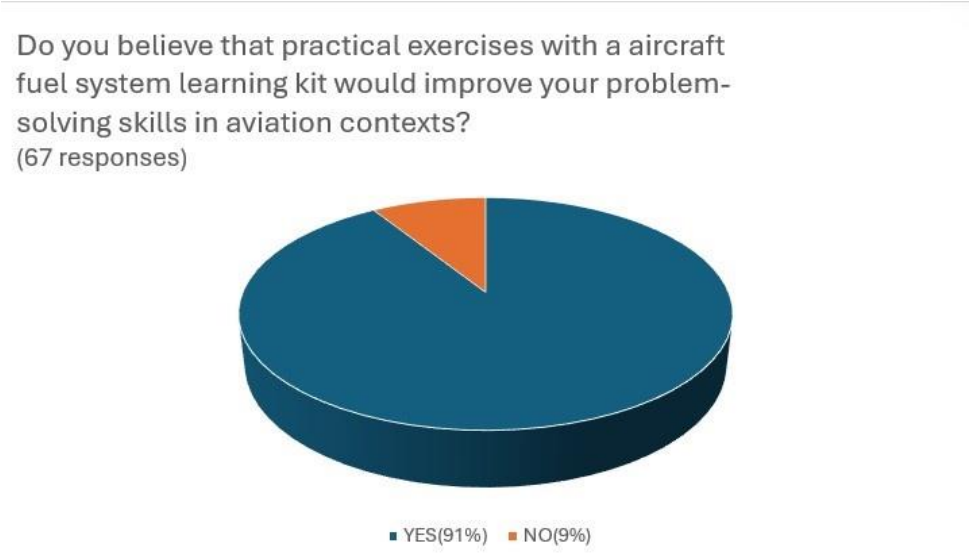


FIGURE 3.8 IMPROVEMENT OF PROBLEM-SOLVING SKILLS IN AVIATION CONTEXT

Our respondent agrees that this fuel system learning kit will improve in problem-solving skills in aviation contexts

Incorporating an aircraft fuel system learning kit in curriculum syllabus.

FIGURE 3.9 INCORPORATING AN AFSLK IN CIRRICULUM SYLLABUS

The majority of our respondents agree to incorporate this aircraft fuel system learning kit in the curriculum or training program.

Perspective on preparing better real-world scenarios.

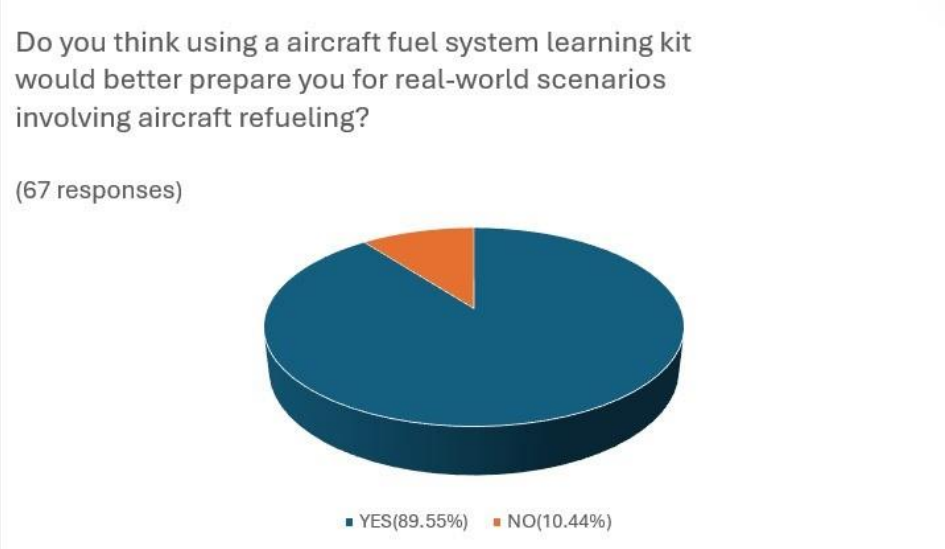


FIGURE 3.10 PRESPECTIVE ON PREPARING BETTER REAL-WORLD SCENARIOS

The data shows that by using the fuel system learning kit can prepare better real-world scenarios in aircraft refueling procedure

Product Improvement

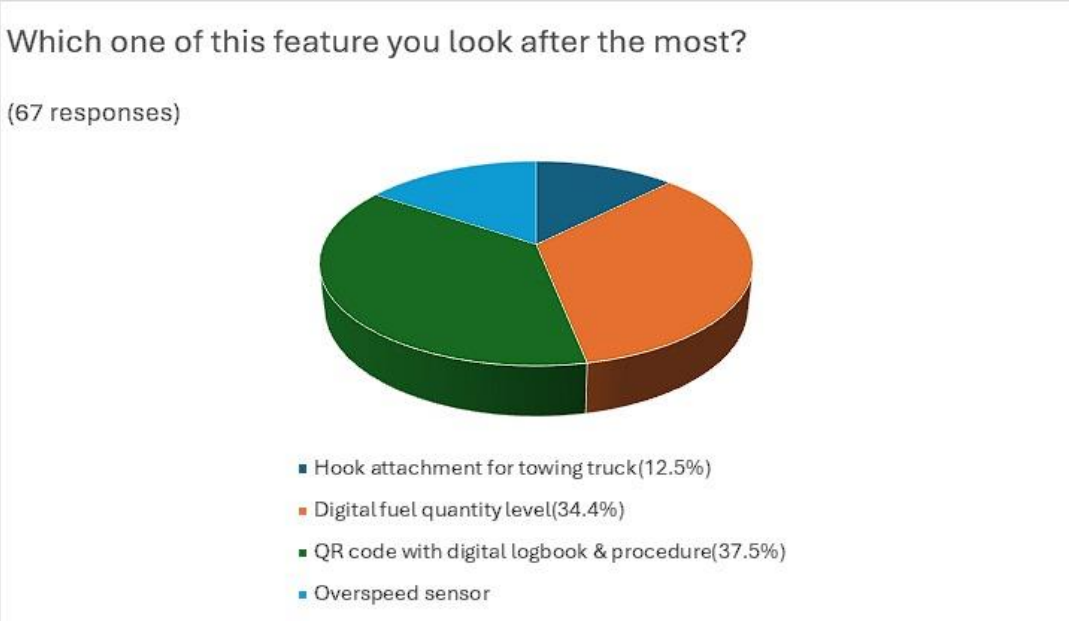


FIGURE 3.11 PRODUCT IMPROVEMENT

Based on the result we found that QR code with digital logbook and procedure and digital fuel quantity level is most likely by the respondent

Rate of effectiveness in enhancing understanding in aircraft refueling procedures.

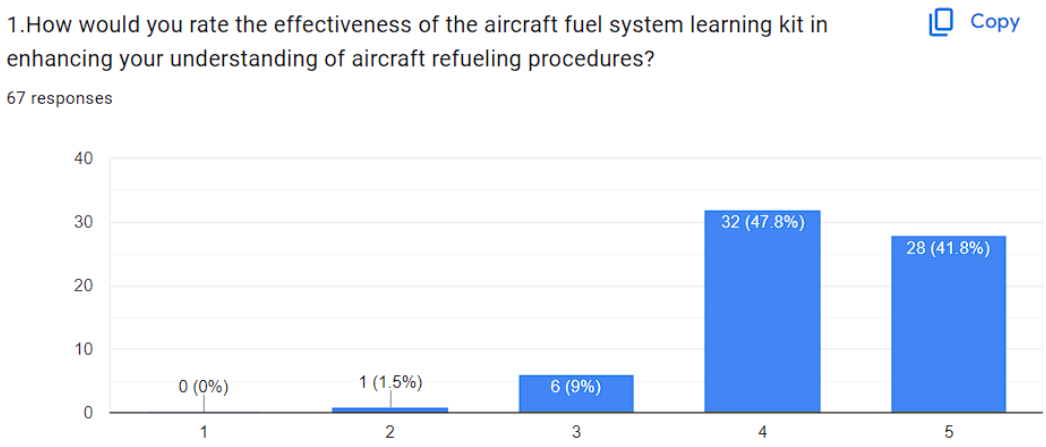


FIGURE 3.12 RATE OF EFFECTIVENESS IN ENHANCING UNDERSTANDING

Based on the data collected, we found that by providing this aircraft fuel system learning kit can gain more effectiveness in understanding the aircraft refueling procedures.

Rate of effective in contributing practical application of theoretical knowledge

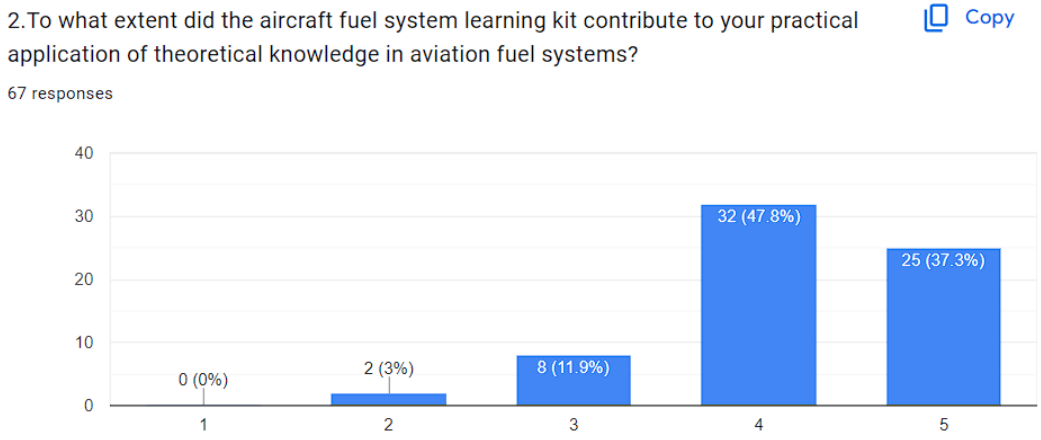


FIGURE 3.13 RATE OF EFFECTIVE IN CONTRIBUTING PRACTICAL APPLICATION OF THEORETICAL KNOWLEDGE

The data found that the contribution of practical application in theoretical knowledge has become more effective.

Rate of recommendation of aircraft fuel system learning kit in the industry

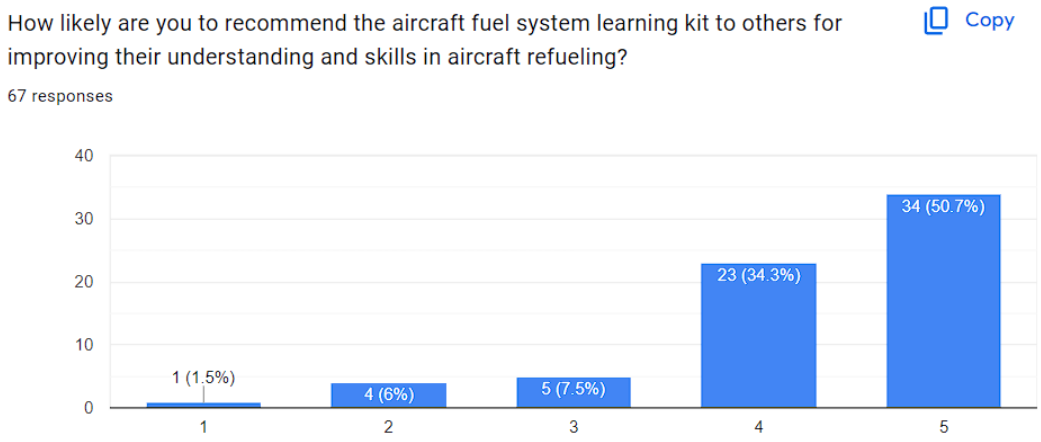


FIGURE 3.14 RATE OF RECOMMENDATION IN INDUSTRY

The data collected shows that the recommendation of providing the aircraft fuel system learning kit to enhance understanding in aircraft refueling is very recommended.

3.4.1.2 PARETO DIAGRAM

Pareto Data

Pareto Diagram: Fuel System Learning Kit

Features	Frequency	Cummulative	Cummulative Percentage	Pareto Baseline
Hands-on	61	61	18%	80%
Valueable	60	121	36%	80%
Excercises	58	179	53%	80%
Attractive	56	235	70%	80%
Cost	50	285	85%	80%
Portability	50	335	100%	80%
GRAND TOTAL	335			

Pareto Diagram

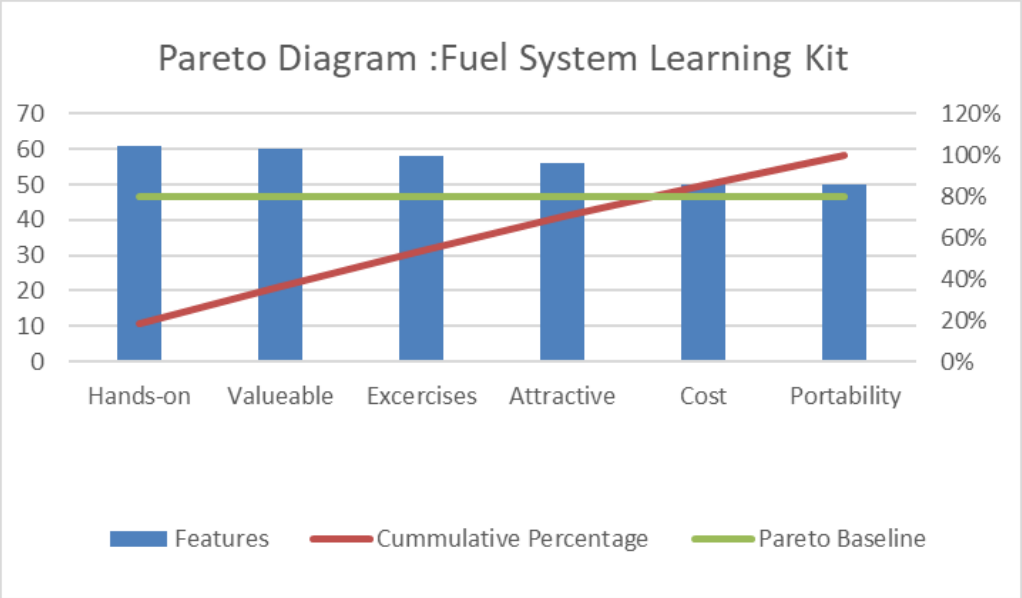
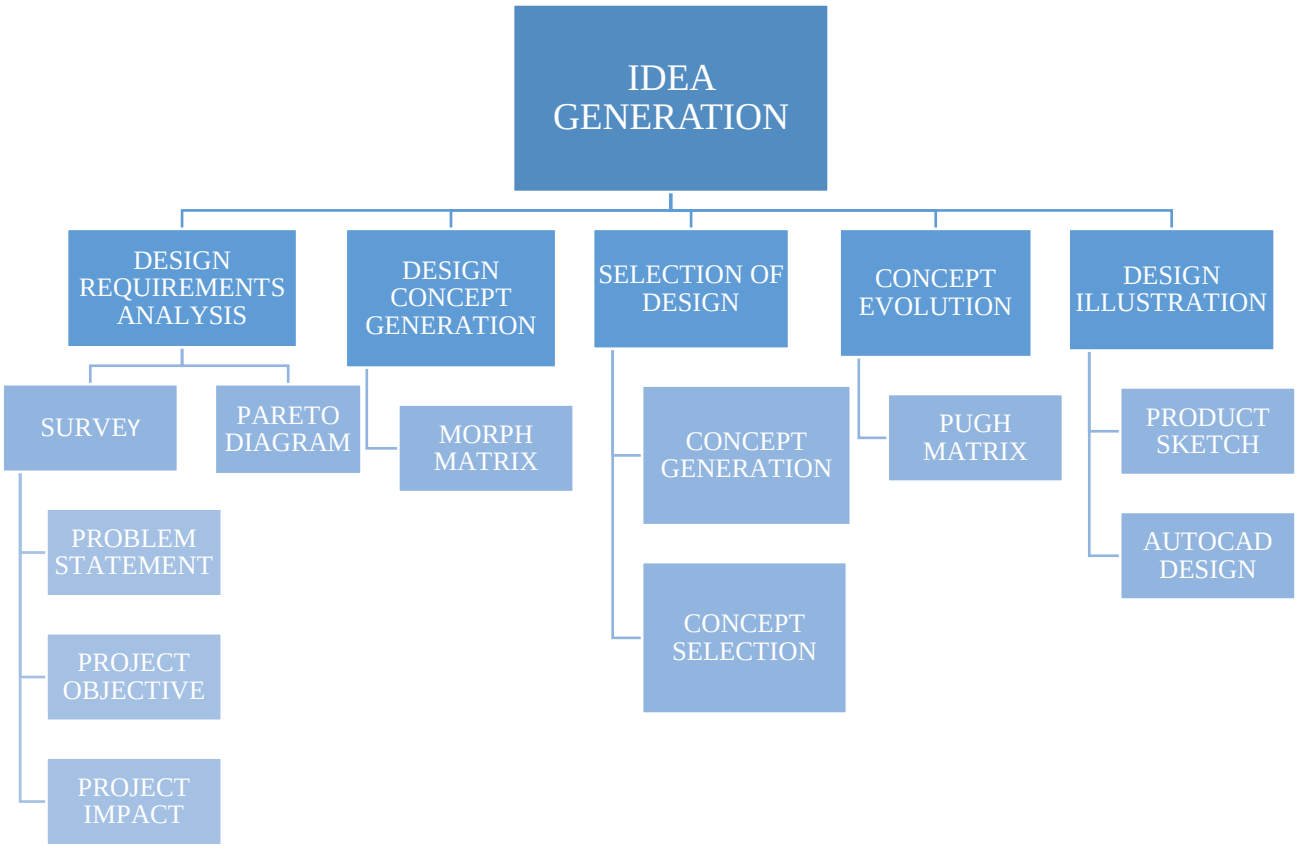


FIGURE 3.15 PARETO DIAGRAM

Upon inventing this final year project, several surveys were conducted to gain the information required in designing this Fuel system Learning Kit. This data is collected from students, lecturers, staff and other people. Respondents found that it is convenient for this fuel system kit to be Hands-on, Valuable, Exercises, Attractive, Low cost, and Portable. The highest selected choice is to provide Hands-on work that holds 61 frequencies. The second highest frequency is the value of the fuel system kit. Then, it followed by the Exercises which contain 58 frequencies from the data. After that, the attractiveness while using the kit contains 56 of the frequency, and lastly the cost and portability of the product have the lowest frequency which is 50 respondent choices

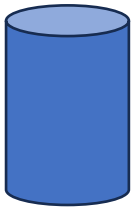
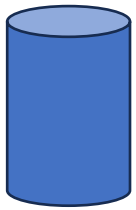
3.4.2 DESIGN CONCEPT GENERATION

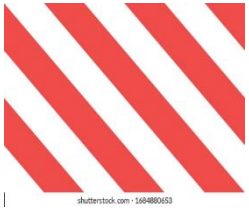
3.4.2.1 Function Tree



3.4.2.2 Morphological Matrix

FUNCTION	IDEA 1	IDEA 2	IDEA 3	IDEA 4	IDEA 5
MATERIAL	METAL 	STAINLESS STEEL 	METAL 	STAINLESS STEEL 	METAL 
SHAPE & SIZE					
ACCESSORIES	DIGITAL FUEL QUANTITY LEVEL 	WARNING LIGHT 	SPEED SENSOR 	LED LIGHT 	DIGITAL FUEL QUANTITY LEVEL 

MOBILITY	WHEEL 	WHEEL 	AIRLESS TYRE 	AIRLESS TYRE 	AIRLESS TYRE 
CAPACITY	30 LITRES	30 LITRES	40 LITRES	20 LITRES	200 LITRES
COMPARTMENT STYLE					
LOCK & SECURITY	PARKING BRAKE 	LATCH LOCK 	PADLOCK 	RFID 	SAFETY BRAKES 

COLOUR	STRIPED, RED & WHITE 	FLUORESCENT GREEN 	SILVER 	FLUORESCENT YELLOW	SILVER 
MOVING MECHANISM	TOWTRUCK 	TOWBAR 	PUSHBAR 	REMOTE 	PUSHBAR 

3.4.2.3 Proposed Design Concept 1

FEATURES/FUNCTION	IDEATION 1	JUSTIFICATION
MATERIAL	METAL	Metals provide high strength and durability.
SHAPE AND SIZE	RECTANGULAR	Rectangular shapes allow for optimal use of space.
ACCESSORIES	DIGITAL FUEL QUANTITY LEVEL	Digital systems provide precise measurements of fuel quantity, ensuring accurate monitoring.
MOBILITY	WHEELS	Wheel provide easier movement for the kit.
CAPACITY	30L	30L fuel tank make the refueling session not too long or too short.
COMPARTMENT STYLE	RECTANGULAR	A rectangular shaped compartment can store many things and can become like a toolbox.
LOCK AND SECURITY	PARKING BRAKE	Parking brake can be use when the refueling session begin to ensure the cart not moving.
COLOUR	STRIPES RED AND WHITE	The advantage of using a striped red and white color scheme is its high visibility and attention-grabbing nature. This color combination is often associated with warning signs, such as those found in construction zones, roadways, or hazardous areas.
MOVING MECHANISM	BY TOW TRUCK	Refueling kit can be moved easily around the hangar with the least effort.

3.4.2.4 Proposed Design Concept 2

FEATURES/FUNCTION	IDEATION 2	JUSTIFICATION
MATERIAL	STAINLESS STEEL	Stainless steel is corrosion resistance material
SHAPE AND SIZE	SQUARE	A square shaped cart provides more efficient space for storing.
ACCESSORIES	WARNING BRAKE	Warning brake can ensure if there was vehicle behind the kit will notice for slow down.
MOBILITY	WHEEL	Wheel can carry high load but may be flat.
CAPACITY	30L	30L fuel tank storage provides more efficient refueling time.
COMPARTMENT STYLE	RECTANGULAR	Can store equipment such as emergency batteries if needed.
LOCK AND SECURITY	LATCH LOCK	They work by catching onto a metal piece called a strike plate, keeping things closed until you turn the handle to release them. They're easy to use and provide basic security for keeping things safe and accessible.
COLOUR	FLOURESCENT GREEN	Firstly, its high visibility makes it ideal for safety purposes, especially in low-light conditions or environments where visibility is crucial.
MOVING MECHANISM	TOWBAR	Another advantage of a pulled towbar is its durability and strength. Constructed from robust materials such as steel.

3.4.2.5 Proposed Design Concept 3

FEATURES/FUNCTION	IDEATION 3	JUSTIFICATION
MATERIAL	METAL	Metal structure is more solid and stronger than stainless steel.
SHAPE AND SIZE	SQUARE	A square shaped cart provides more efficient space for storing.
ACCESSORIES	SPEED SENSOR	Speed sensor will ensure that the cart is not moved over the limit that can occur danger.
MOBILITY	AIRLESS TYRE	Their solid construction means they can withstand greater wear and tear, offering longer lifespan and reduced maintenance costs over time.
CAPACITY	200L	200L fuel tank will ensure the long-time refueling session.
COMPARTMENT STYLE	CYLINDER	Can fit tool required or helped for refueling session and can be putted vertically inside the cylinder-shaped compartment.
LOCK AND SECURITY	PADLOCK	Padlock will ensure that the refueling kit is not used by unauthorized personnel that may cause danger.
COLOUR	SILVER	Silver color refueling cart will ensure the cart is not too dark which might cause an incident if it's stored in dark place.
MOVING MECHANISM	PUSHBAR	Pushbar moving mechanism is to ensure that the cart can be moved precisely and can prevent it from moving too fast.

3.4.2.6 Proposed Design Concept 4

FEATURES/FUNCTION	IDEATION 4	JUSTIFICATION
MATERIAL	STAINLESS STEEL	Stainless steel structure will ensure the structure will not be corroded easily such as rust.
SHAPE AND SIZE	CIRCLE	The circle shape of the training kit and can be same shaped as the tank.
ACCESSORIES	LED	LED light will ensure enough source of lighting if the practical is being performed at night or where there is not enough lighting.
MOBILITY	AIRLESS TYRE	Airless tires, or non-pneumatic tires, are better for carrying heavy loads compared to conventional tires because they don't rely on air pressure to support the weight.
CAPACITY	20L	20L of fuel tank will provide fast operation of refueling process practical.
COMPARTMENT STYLE	CYLINDER	Cylinder compartment style can fit tool vertically such as torque wrench or spanner.
LOCK AND SECURITY	RFID	RFID lock and security will ensure that the person who conducted the training kit is approved and the usage of the training kit will be recorded.
COLOUR	FLOURESCENT YELLOW	Fluorescent yellow color is a very bright color that will make people notice the cart there.
MOVING MECHANISM	CONTROL BY REMOTE	Operator can control the cart using remote wirelessly.

3.4.2.7 Selected Idea (Ideation 5)

FEATURES/FUNCTION	IDEATION 5	JUSTIFICATION
MATERIAL	METAL	Metal structure is more solid and strong rather than stainless steel.
SHAPE AND SIZE	CYLINDER	Cylinder shape and size are an ergonomic design which is easy to get.
ACCESSORIES	DIGITAL FUEL QUANTITY LEVEL	Making it easier for operators to see the exact fuel level immediately. This system ensures precise fuel management and helps prevent overfilling or running out of fuel.
MOBILITY	AIRLESS TYRE	Their solid construction makes them more durable and better suited for heavy-duty use, providing consistent performance even under heavy loads. This means they can't go flat or blow out, reducing the risk of downtime and maintenance.
CAPACITY	200L	200L fuel tank capacity is enough to feel the real-world refueling session that will not be too long or too short.
COMPARTMENT STYLE	RECTANGULAR	A rectangular shaped compartment will fit most of the common tools required for refueling.
LOCK AND SECURITY	SAFETY BRAKE	Safety brake will ensure safe operation which will ensure the refueling kit is not moving during refueling process.
COLOUR	SILVER	A silver colored refueling cart will ensure the cart is not too dark and may cause accident if it I parked at night.
MOVING MECHANISM	PUSHBAR	Pushbar moving mechanism is to ensure that the cart can be moved precisely and can prevent it from moving too fast.

3.4.3 EVALUATION & SELECTION OF CONCEPTUAL DESIGN

3.4.3.1 Pugh Matrix

PUGH MATRIX: CONCEPT 1 AS DATUM

CRITERION	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5 (SELECTED)
TOUGHNESS	**D**	+	=	+	=
CAPACITY	**A**	=	+	-	+
MOBILITY	**T**	=	+	+	+
SHAPE	**U**	=	=	-	+
MOVING MECHANISM	**M**	-	-	-	-
SECURITY	-	-	-	+	=
SUM OF +'S	-	1	2	3	3
SUM OF -'S	-	2	2	3	1
SUM OF ='S	-	3	2	0	2
RANKING	-	4	2	3	1

TABLE 3.3 PUGH MATRIX

PUGH MATRIX: CONCEPT 2 AS DATUM

CRITERION	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5
TOUGHNESS	0.3	D	3	2	3	2
CAPACITY	0.2	A	2	3	1	3
MOBILITY	0.1	T	2	3	3	3
SHAPE	0.1	U	2	2	1	3
MOVING MECHANISM	0.2	M	1	1	1	1
SECURITY	0.1	-	1	1	3	2
TOTAL SCORE	1.0	-	11	12	12	14
RANKING	-	-	4	2	3	1

TABLE 3.4 PUGH MATRIX

The Pugh matrix is a decision-making tool that compares various design concepts to a set of predefined criteria. To use it, first make a list of key criteria such as cost, ease of use, and durability. Then, create a few design concepts and choose one as a baseline for comparison. Each concept is compared to the baseline for each criterion, using a scale of 3 (better), 2 (same), or 1 (worse). Add the scores to determine which concept performs the best overall. This process helps identify the most promising design by highlighting strengths and weaknesses in a structured, objective manner, allowing for more informed decision-making.

3.5 PRODUCT DRAWING / SCHEMATIC DIAGRAM

3.5.1 General Product Drawing

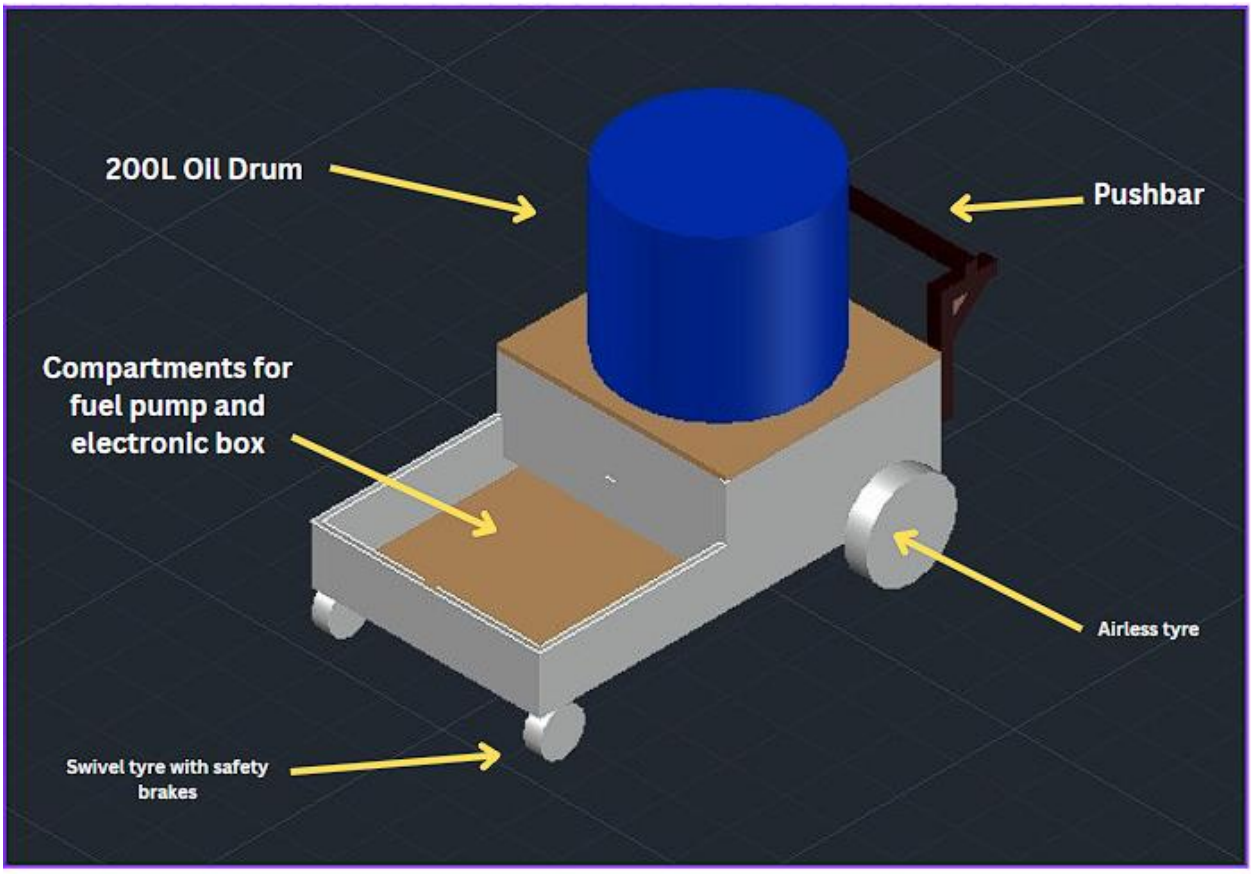


Figure 3.16: Product sketching and labelling

3.5.2 SPECIFIC PART DRAWING / DIAGRAM

3.5.2.1 Product Structure

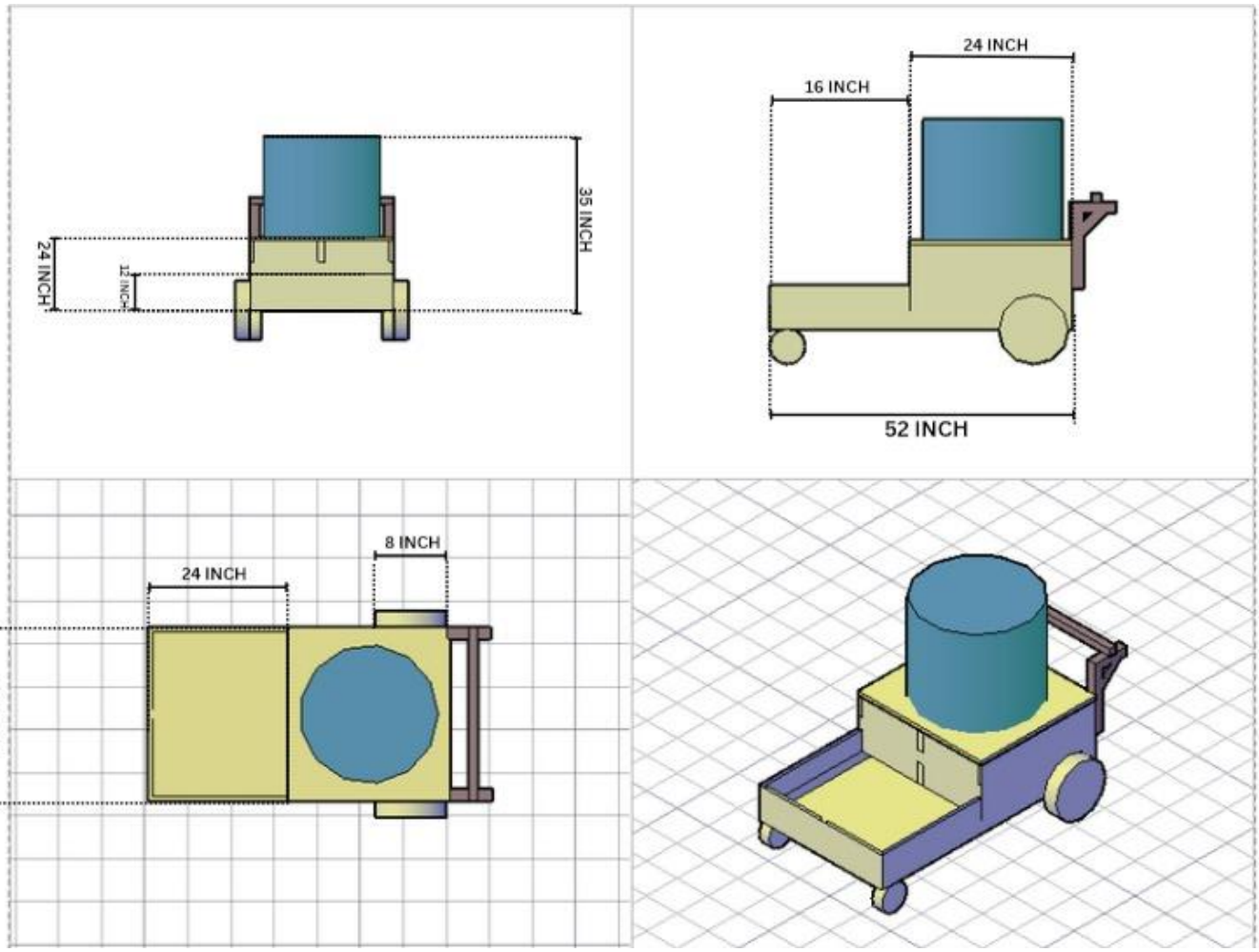


Figure 3.17: Orthographic view sketching of product

3.5.2.2 Product Mechanism

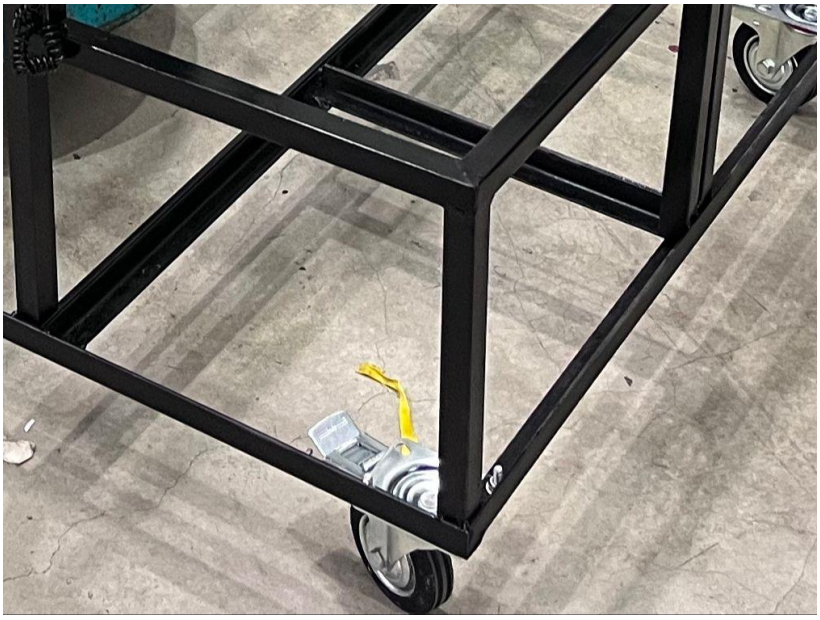


Figure3.18 : Swivell tyre with safety brakes

Figure 3.19: Airless tyre

3.5.2.3 Software / Programming

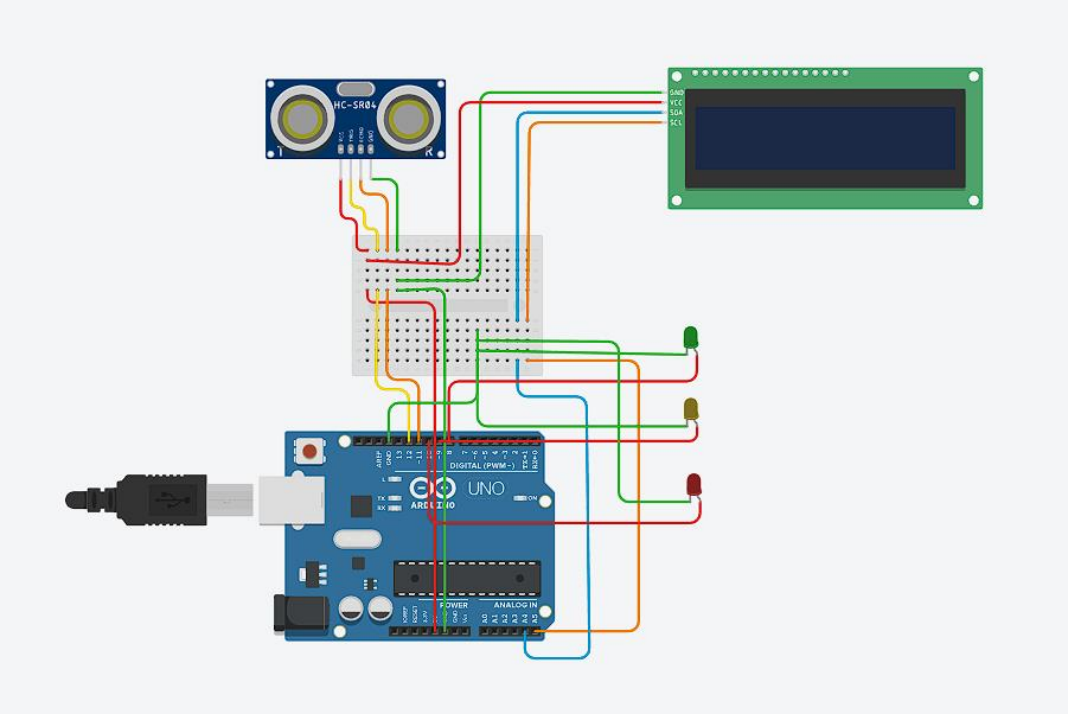


Figure 3.20 : Arduino Circuit Diagram Sketching

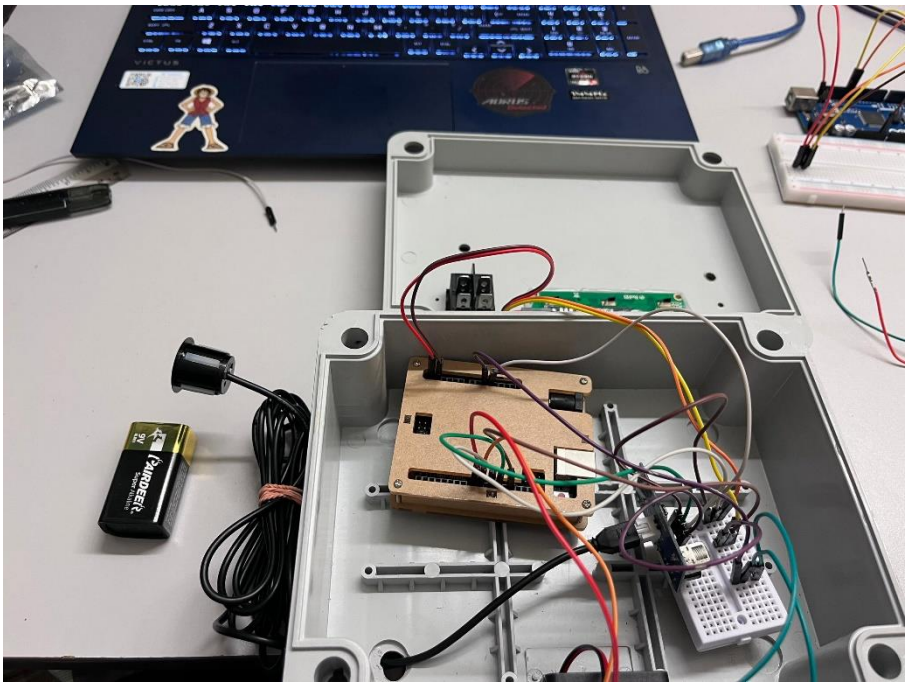


Figure 3.21: Picture inside the electronic box

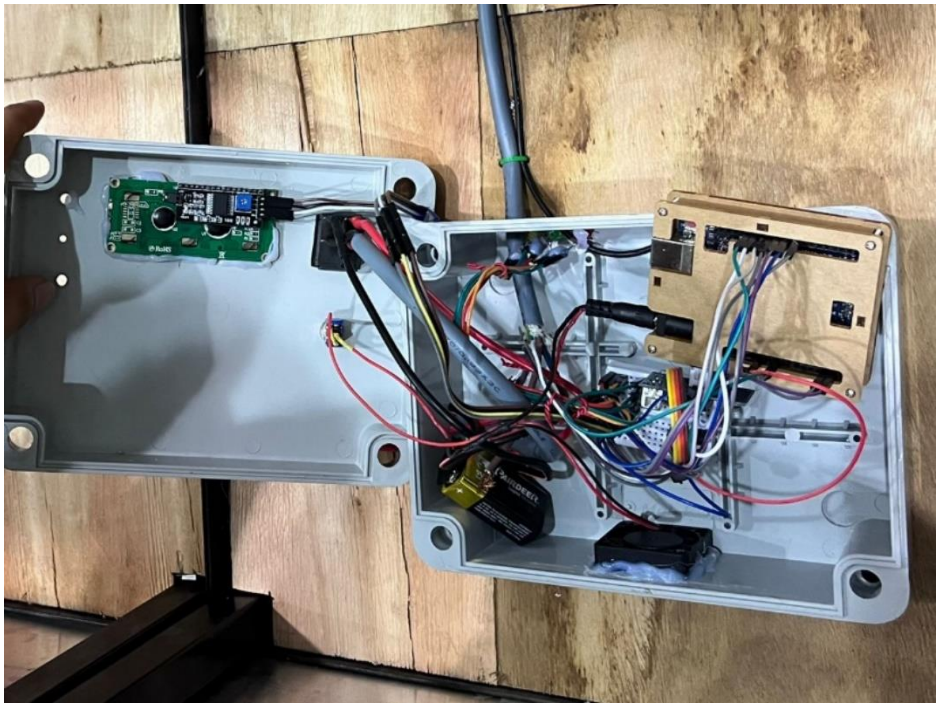


Figure 3.22: Electronic components box attaching at the cart compartment

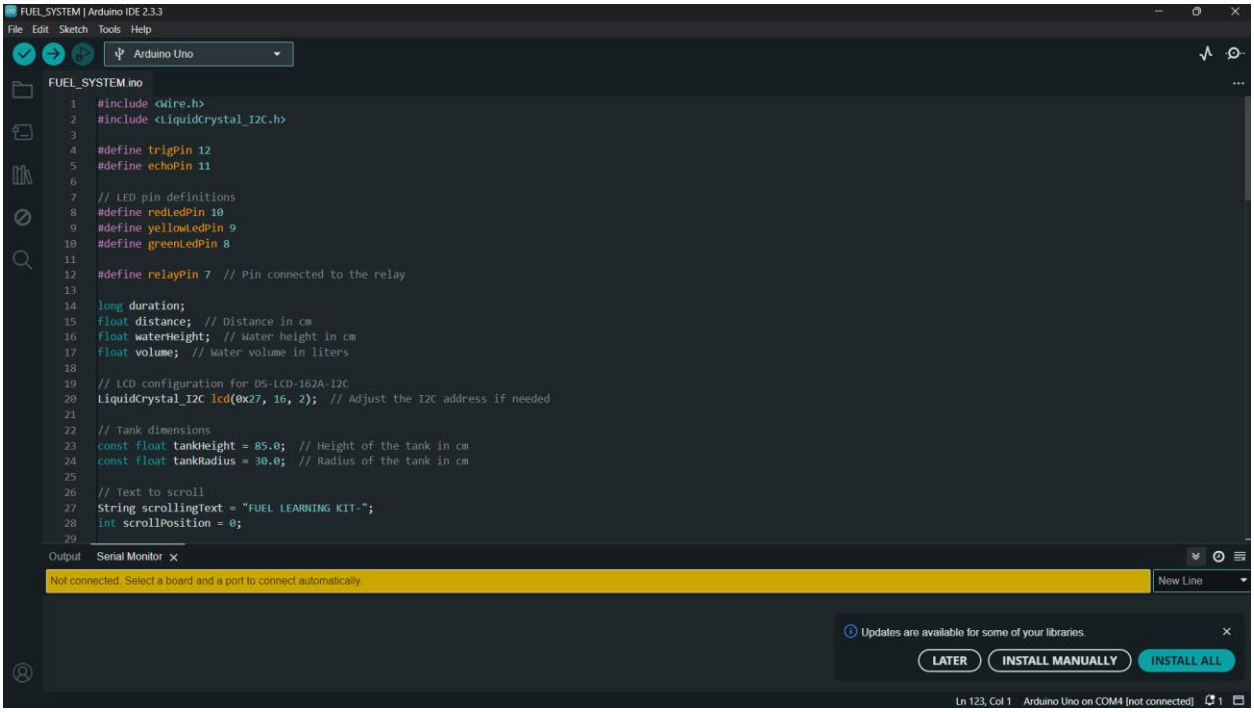


Figure 3.23: Programming code from Arduino IDE software

```
14  long duration;
15  float distance;  // Distance in cm
16  float waterHeight;  // Water height in cm
17  float volume;  // Water volume in liters
18
19  // LCD configuration for DS-LCD-162A-I2C
20  LiquidCrystal_I2C lcd(0x27, 16, 2);  // Adjust the I2C address if needed
21
22  // Tank dimensions
23  const float tankHeight = 85.0;  // Height of the tank in cm
24  const float tankRadius = 30.0;  // Radius of the tank in cm
25
26  // Text to scroll
27  String scrollingText = "FUEL LEARNING KIT-";
28  int scrollPosition = 0;
29
30  void setup() {
31    pinMode(trigPin, OUTPUT);
32    pinMode(echoPin, INPUT);
```

Figure 3.24: Coding for AJ-SR04M Ultrasonic Sensor

```
// Display the water volume on the first line of the DS-LCD-162A-I2C
lcd.clear();
lcd.setCursor(0, 0);  // First line
lcd.print("Volume: ");
lcd.print(volume, 1);  // Display volume with 1 decimal place
lcd.print(" L");

// Scroll the "FUEL LEARNING KIT" text on the second line
lcd.setCursor(0, 1);  // Second line
lcd.print(scrollingText.substring(scrollPosition, scrollingText.length()));

// Add blank spaces after the text to clear the remaining screen space
if (scrollPosition > 0) {
  lcd.print(scrollingText.substring(0, scrollPosition));  // Display the beg
}

// Update the scroll position
scrollPosition++;
if (scrollPosition >= scrollingText.length()) {
  scrollPosition = 0;  // Reset scroll position after text moves off screen
}

delay(500);  // Delay to control the speed of the scrolling
}
```

Figure 3.25: Coding For LCD 16X2 I2C

```
85    if (volume < 50) {
86      digitalWrite(redLedPin, HIGH);
87      digitalWrite(yellowLedPin, LOW);
88      digitalWrite(greenLedPin, LOW);
89    } else if (volume < 120) {
90      digitalWrite(redLedPin, LOW);
91      digitalWrite(yellowLedPin, HIGH);
92      digitalWrite(greenLedPin, LOW);
93    } else {
94      digitalWrite(redLedPin, LOW);
95      digitalWrite(yellowLedPin, LOW);
96      digitalWrite(greenLedPin, HIGH);
97    }
```

Figure 3.26: Coding for red, green & yellow LED

```
// Relay setup
pinMode(relayPin, OUTPUT);  // Set relay pin as output

// Turn the relay ON when the Arduino powers up (assuming active LOW)
digitalWrite(relayPin, LOW);  // Activate relay to turn on 12V LED
```

Figure 3.27: Coding for 5 relay breakout board

3.5.2.4 Accessories & Finishing

Figure 3.28 : Process of painting the structure

Figure 3.29: Process of painting the structure

3.6 prototype / product modelling

3.6.1 Prototype / Product Modelling

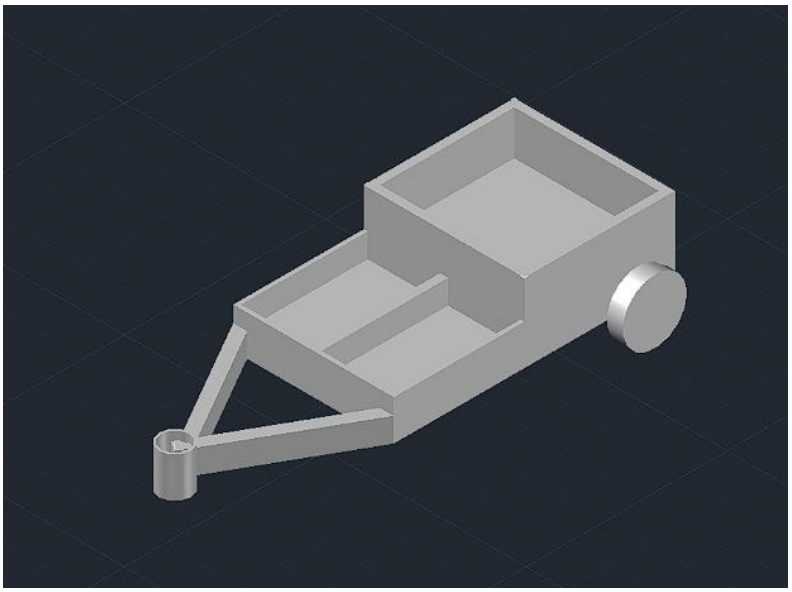


Figure 3.30 : Prototype Sketching

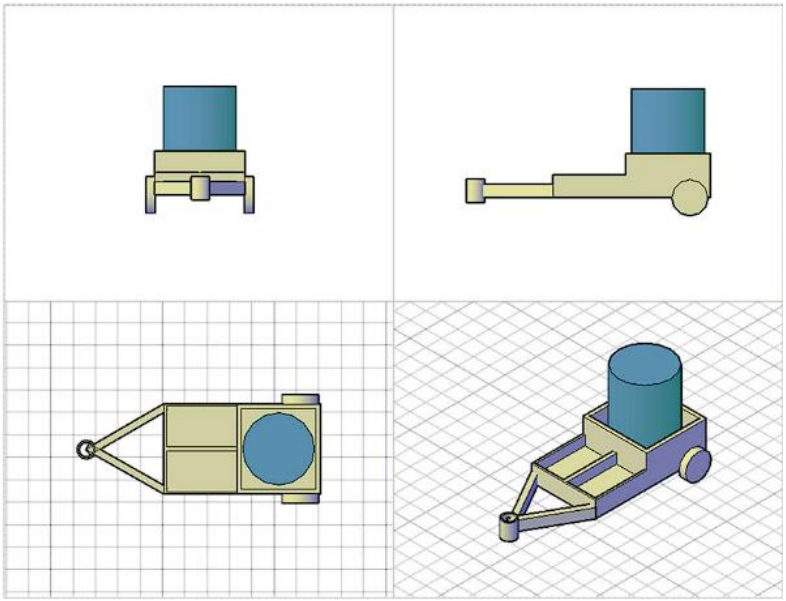


Figure 3.31: Isometric view of prototype sketching

3.6.2 Prototype Development

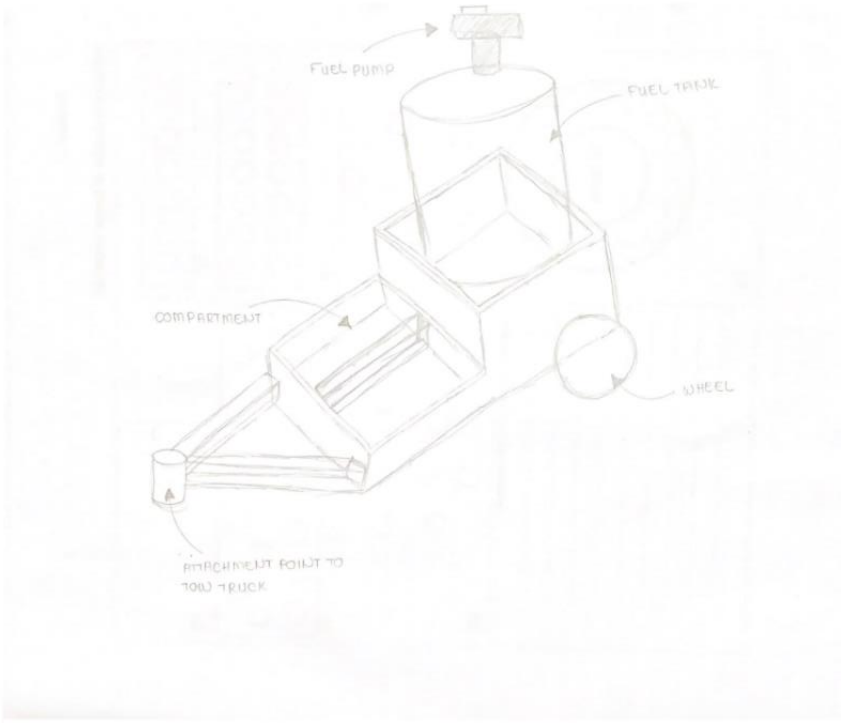


Figure 3.32: Hand sketching of prototype

3.7 Development of Product

3.7.1 Material Acquisition

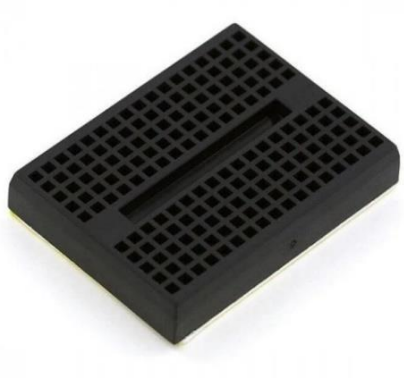
3.7.1.1 Structure Of AFSLK

description	Material
The angle bar is used as a primary structure in AFSLK to withstand heavy loads	 Angle Bar
The hollow bar used as the secondary structure to maintain AFSLK rigidness and reducing structure overall weight	 Hollow bar

Bolt and nut is used to mount the AFSLK handle to the structure to give rigidity of the handle	 bolt and nut
Hex head self-drilling screw is used to mount the beacon light stand and also to hold sheet metal to the structure to ensure its flexibility if maintenance required	 Hex Head self-drilling screw
Plywood is used as a platform of each compartment so that the component such as the fuel pump and battery can be placed	 Plywood

The **three spray paints** used in the Aircraft Refueling Learning Kit (AFSLK) were chosen to enhance both durability and appearance. The **blue spray paint** is applied to the fuel tank, giving it a professional and easily visible finish. This color, combined with **white spray paint** also applied to the tank, creates a sharp contrast that improves visibility and contributes to a polished, clean look. Together, these colors make the tank easily identifiable, which is beneficial during training sessions. The **black spray paint** is used on the main structure of the kit, providing a sleek and uniform appearance. This black finish not only adds a professional touch but also serves a protective purpose by shielding the metal from corrosion, rust, and wear. Altogether, these three colors were selected to ensure that the AFSLK remains visually appealing, durable, and well-suited for long-term use in training environments.	 Spray Paint

3.7.1.2 Electrical amd electronic component of AFSLK

Description	Material
For green its indicate fuel level between 200 Litre to 120Litre yellow LED indicates Between 120 Litre to 50 Litre and Red LED Indicates if it below 50 litre	 Light emitting diode (LED)
The mini Breadboard used to connect the jumper wire and electronic connection	 Breadboard
The Arduino used to read and store code and also give command to the all electronic equipment	 Arduino UNO

The LED is used to display fuel quantity level	 LCD
The relay are switch that used to open and closed circuit that controlled by the arduino and is can withstand untill 12V that powers the Beacon light	 12 V Single Channel Relay Module
The jumper wire used to connect all electronic component	 Jumper Wire
The 9v battery is used to power up the arduino	 9V Battery

The battery holder used for transmit power between the arudino and battery	 Arduino TO 9v Battery holder
12 v battery is used to power up the relay module and also power up the fuel pump	 12 V lead acid Battery
The rocker switch is used to supply and cut off electric	 12V rocker switch

The toggle switch is used for arduino	 Toogle Switch
The fuel pump is used to transfer fuel fromm oil tank to the fuel nozzle	 Fuel Transfer Pump
Auto cut off fuel nozzle is used so that it can prevent form over refuelling	 Fuel Nozzle

3.7.2 Machine And Tools

No	Picture And lebel	Function
1	 Hand Grinder	General Purpose- Cutting and grinding various material Project Purpose- Cutting the structure,Plywood and also grinding welded spot to make it snooth
2	 Portable Electric Drill	General purpose- to perform drilling and screwing Project purpose- Used for screwing between the aluminium sheet and structure and also for various screw.

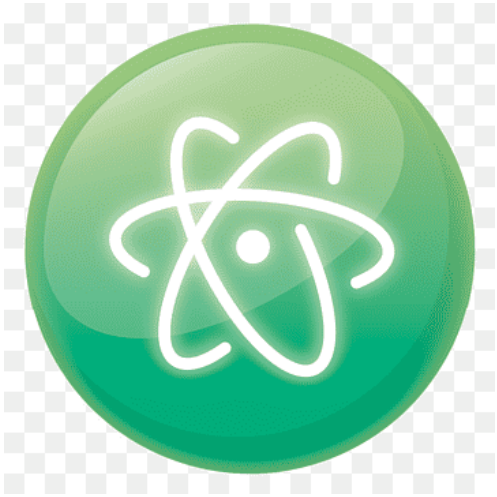
3	 Precision Scrool Jigsaw Machine	General Purpose- cutting plywood Project purpose- Cutting plywood following the desired measurement
4	 MIG welding Machine	General purpose- welding Proect purpose- Welding structure of AFSLK

5	 file	General purpose- The tool used to remove surplus fine amounts of material from a workpiece. Project Purpose- To file the side of the Aluminium Sheet to make a smooth edge
6	 Bench vise	General purpose - It used to secure an object to allow work to be performed on it during saw, drilling, filing and another task Project Purpose- Used to grip the Plywood and hollow bar
7	 Steel Square (L-rule)	General purpose- The tool suitable for carpenters use. It used for measurement, especially for right-angles. Project Purpose – To ensure it is correct 90 degree

8	 Steel ruler	General purpose- The instrument to measure distances or to rule straight line especially in geometry, technical drawing, printing, engineering and building. Project Purpose- Used for measured length and make a horizontal line.
9	 Screw Driver	General purpose- Used for turning (driving or removing) screws. Project Purpose- Used to tight and remove the screw between AFSLK
10	 Solder	General purpose- Used for joined two material together by melting and putting a filler metal (solder) into the joint. Project Purpose- Used to solder the connection of the wire.

11	 Flux core	General purpose- Used to facilitate the soldering process. Project Purpose- Used for make the connection of the separate electrical wire and the molten of braze make the mess strip of copper to stick together.

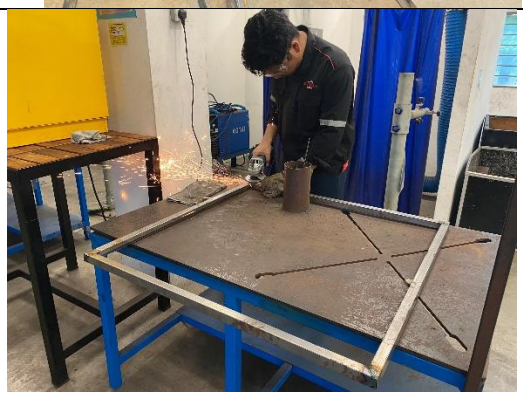
3.7.2 Software for programming and coding

No	Picture And label	Function
1	 Arduino IDE	provide a user-friendly platform for writing, compiling, and uploading code to Arduino-compatible microcontrollers.
2	 ATOM Software	serve as a versatile, user-friendly text editor for writing and editing code in HTML, CSS, JavaScript, and other web languages.

3.7.3 SPECIFIC PRODUCT FABRICATION

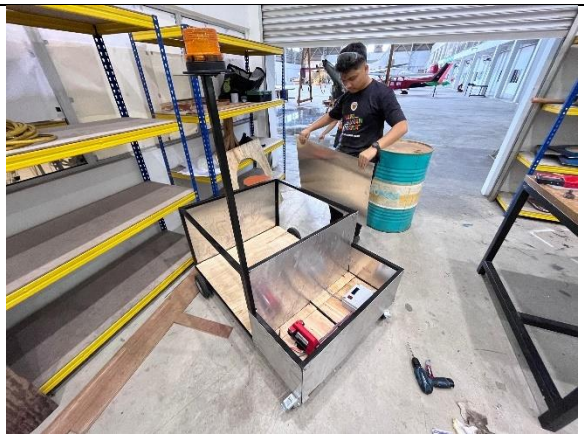
3.7.3.1 Phase 1 (Base structure)

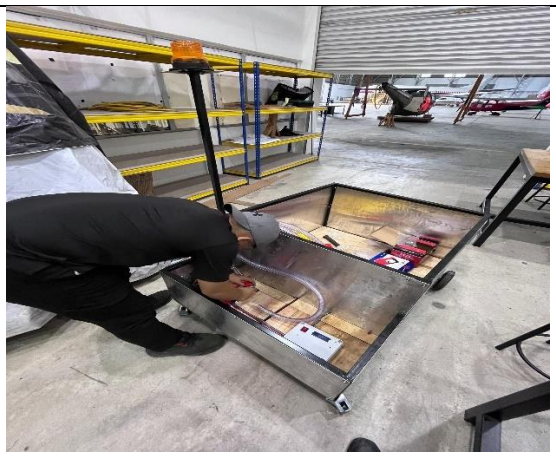
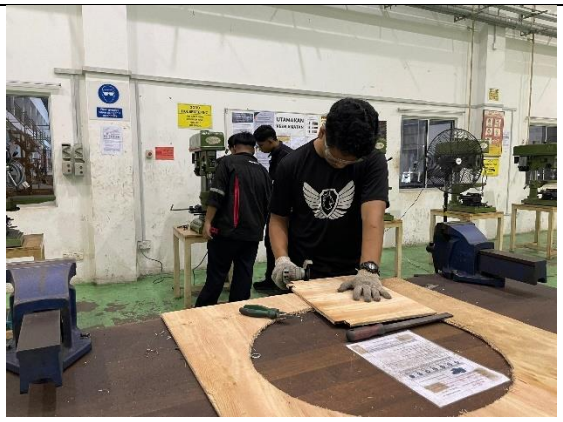
No	Working Procedure	Illustration
1	Material Acquisition:Bought a material for main structure which is hollow bar and angle bar from workshop nearby area	
2	Measuring the material for main structure	
3	Cutting process of the material for base and main structure following the material	

4	Welding process of the material for base structure	
5	Grinding the welded spot for smooth and clean surfaces	
6	Main and base structure was completed	

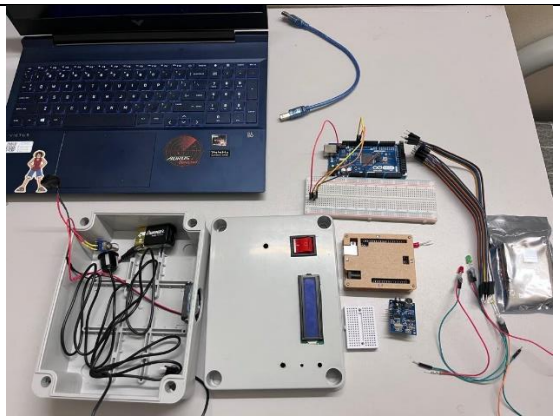
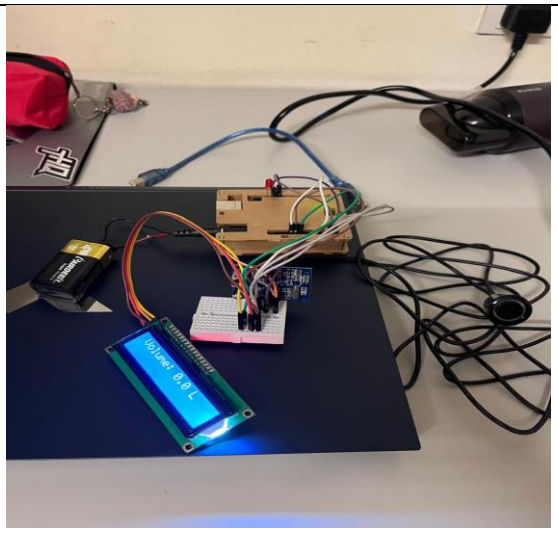
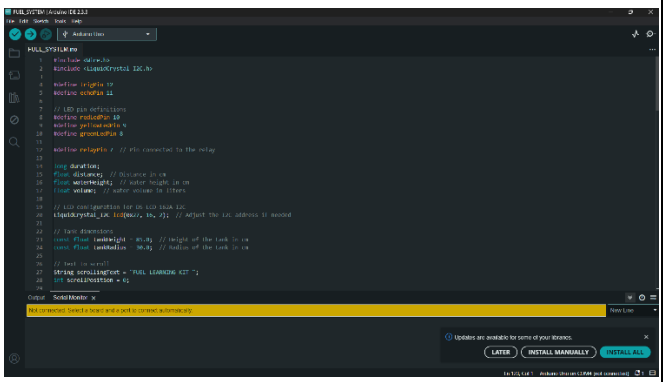
3.7.3.2 Phase 2 (Accessories and Mechanism)

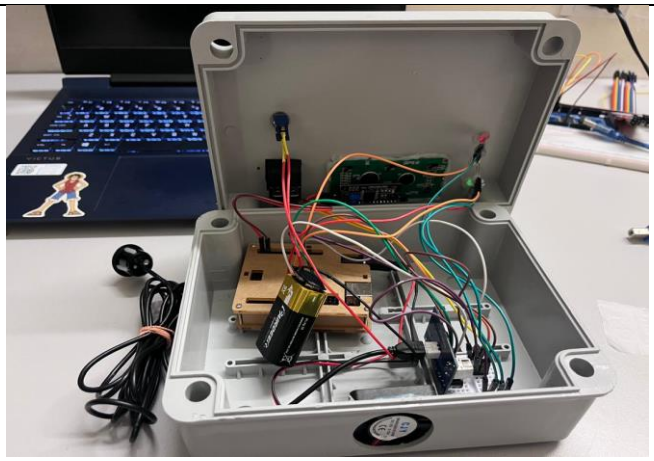
No	Working Procedure	Illustration
1	Process of attaching the airless tyre and the swivel tyre with the safety brakes	
2	The airless tyre and the swivel tyre with the safety brakes has been attached to the structure	
3	Making the stand for the beacon light	

4	Result of the beacon light and stand being attached to the structure	
5	Measuring process of the aluminium sheet before cutting	
6	Attaching the aluminium sheet cover to the cart body	

7	Installing the fuel pump and the electronic box to the cart	
8	Process of cutting the plywood for holding the oil drum and the compartment base cover	
9	The plywood has been completed attach to the cart	

3.7.3.3 Phase 3 (Programming & Electrical Circuit)

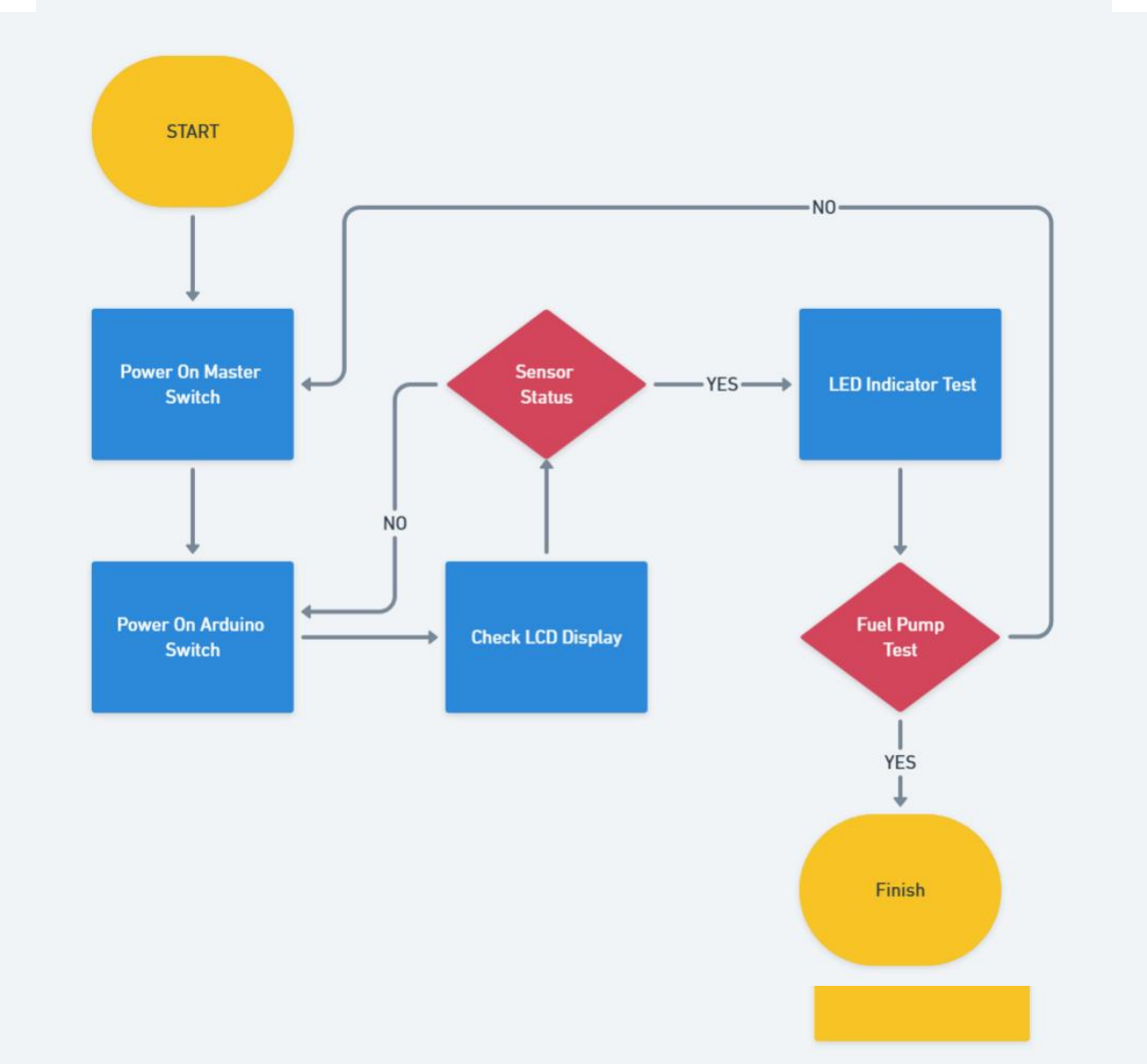
No	Working Procedure	Illustration
1	The electronic component being arranged and identified first before start to build the wiring connection	
2	All the wiring and sensor being connected to the Arduino for programming	
3	Start the programming using the Arduino IDE software	

4	The electronics component being put inside the box for safety after finishing the programming and coding	
5	Result after the electronics box being attached to the cart compartment	

3.7.3.4 Phase 4 (Finishing)

No	Working Procedure	Illustration
1	Painting process of the oil drum before being put into the cart	
2	Main structure being painted with black colour	
3	Result after all the compartment and items being installed to the cart	

3.8 product testing / functionality test



3.9 LIST OF MATERIALS & EXPENDITURES

3.9.1 Product Structure				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Angle Bar	2	RM19.00	RM19.00
2.	**Hollow Steel**	1	RM19.00	RM19.00
3.	**Plywood**	1	RM25.00	RM25.00
4.	**Aluminum Sheet**	1	RM 40.00	RM 40.00
5.	**m6X1/2 Round Head Self Tapping Screw**	10	RM 0.10	RM 1.00
6.	M 6 x ½ Hex Head self-tapping screw	20	RM0.10	RM 2.00
7.	5/8“x 10 # Hex Self Drilling Screw (12)	1	RM4.60	RM 4.60
8.	M8 DIY Stainless Steel Nut (8)	2	RM 2.60	RM 5.20
9.	M8 x 25 Stainless Steel Hex Bolt	2	RM0.90	RM1.80
10.	M8 x 20 Stainless Steel Hex Bolt	5	RM 0.80	RM4.00
11.	M8 x 35 Stainless Steel Hex Bolt	4	RM1.50	RM 6.00
12.	M20 DIY Z/P Washer (8)	1	RM2.60	RM2.60
13	M8 DIY Stainless Steel Flat Washer (16)	2	RM 2.60	RM5.20
14	M8 x 25 Stainless Steel Hex Bolt	1	RM0.90	RM0.90
15	5/8“x 10 # Hex Self Drilling Screw (12)	2	RM2.60	RM5.20
3.9.2 Mechanical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Fixed airless tire	2	RM19.90	RM 19.90
2.	Swivel airless tire	2	RM13.90	RM 13.90
4.	12V Electric Fuel Pump	1	RM70.90	RM 70.90
5.	Fuel Nozzle Full Set	1	RM143.78	RM 143.78

3.9.3 Electrical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	9v Alkaline Battery	3	RM6.50	RM 19.50
2.	12V Battery	1	RM59	RM 59
3.	Mini Breadboard	1	RM0.90	RM0.90
4.	Ultrasonic AJ-SR04M	1	RM29.91	RM29.91
5.	LCD I2C 16X2	1	RM14.90	RM14.90
6.	Arduino Cover	1	RM2.99	RM2.99
7.	Battery holder connector	1	RM1.00	RM1.00
8.	Toggle switch	1	RM1.50	RM1.50
9.	LED RED, GREEN, YELLOW	3	RM0.10	RM0.30
10.	Cooler fan	1	RM4.90	RM4.90
11	3 Core wire	1	RM4.00	RM4.00
12	PVC Box	1	RM15.00	RM15.00
13	Wire Jumper Male to Female	1	RM2.50	RM2.50
14	Wire Jumper Male to Male	1	RM2.50	RM2.50
15	Single Channel 5V Relay Breakout Board	1	RM5.00	RM5.00
16	Rocker switch big 4 pin red	1	RM3.50	RM3.50
3.9.4 Accessories & Finishing				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Beacon Light	1	RM24.19	RM 24.19
2.	Spray paint Black,Blue,White	6	RM6.90	RM 41.40
GRAND TOTAL				RM 622.97

Table 3.8: List of Materials and Expected Expenditures

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

The **Aircraft Refueling Learning Kit (AFSLK)** is an advanced training system designed to provide aviation students with practical, hands-on experience in aircraft refueling procedures. The kit offers a realistic simulation of the refueling process, allowing students to practice key skills in a safe and controlled environment. Built with high-quality, durable components, it mimics the essential equipment used in real-world aviation refueling operations, ensuring students learn with tools that closely resemble those used in professional settings.

The AFSLK is equipped with essential features such as a fuel pump, a nozzle with automatic shut-off, fuel sensors, and a display that provides real-time information about fuel levels. These elements work together to create a comprehensive learning experience, where students can practice everything from the operation of the fuel pump to the proper handling of refueling nozzles. The system also integrates visual indicators to signal fuel levels, helping students understand how to monitor and manage the refueling process effectively.

Designed for easy movement and use, the AFSLK's structure is built to withstand the demands of training, featuring a robust frame and mobile components that make it simple to maneuver. The kit is designed with safety in mind, offering features that help prevent overfilling and ensuring that students are familiar with proper safety procedures while performing refueling operations.

To support the training experience, AFSLK includes an online platform accessed via a QR code. This platform provides users with valuable resources such as safety guidelines, instructional materials, and demonstration videos, helping students gain a deeper understanding of both the theory and practical aspects of aircraft refueling. Additionally, it offers a digital logbook for recording user information, allowing instructors to track training progress.

The AFSLK provides students with the opportunity to learn about the entire refueling process—from set up to completion—while promoting safety, efficiency, and best practices. With its durable construction, realistic features, and comprehensive support materials, the AFSLK is an essential training tool for anyone seeking to gain expertise in aircraft refueling

4.1.2 Specific Part Features

4.1.2.1 Product Structure

The **structure** of the Aircraft Refueling Learning Kit (AFSLK) is carefully designed with strength, balance, and functionality in mind, constructed primarily using **angle bar** as the main material and **hollow square steel** as a secondary support material. This combination provides a durable and stable framework, ensuring that the entire system can withstand the demands of regular training use. Angle bars are known for their excellent load-bearing capacity and rigidity, making them ideal for supporting the weight of the fuel drum and associated equipment, while hollow square steel adds reinforcement and stability, particularly in areas where added structural support is needed.

The structure is specifically engineered with a **compartmentalized design**, which includes dedicated sections at the front of the cart. These **front compartments** serve as storage for key components such as the **fuel pump, battery, and electrical components**. By organizing these elements in designated compartments, the design not only protects each component from potential damage during movement but also allows for easy access when needed for maintenance or adjustments. This compartmentalization contributes to both safety and convenience, as it keeps sensitive equipment secure while maintaining a balanced load distribution.

Additionally, the structure is designed to ensure the **stability of the fuel drum**, preventing it from tipping forward or backward when the cart is in motion. The framework provides a snug fit for the drum, effectively holding it in place even during turns or movement over uneven surfaces. This stability is crucial for safety, as it prevents potential spills and helps students practice proper refueling procedures without the risk of equipment imbalance.

Overall, the structure’s robust design with angle bar and hollow square steel, combined with thoughtful compartmentalization, provides a secure and well-balanced platform for the AFSLK, ensuring that it can safely support all components and withstand the rigors of training use. This design maximizes the functionality, safety, and longevity of the refueling kit.

4.1.2.2 Mechanical Mechanism

In the mechanical design of the Aircraft Refueling Learning Kit (AFSLK), we have incorporated a pair of **airless tires** along with a pair of **swivel tires** to enhance mobility, durability, and reliability. The choice of airless tires is intentional, as they offer several advantages that make them ideal for training equipment. Unlike standard pneumatic tires, airless tires are immune to punctures, meaning they require minimal maintenance and can handle rough or uneven surfaces without risk of deflation. This feature contributes to **cost savings** over time by eliminating the need for frequent tire replacements due to punctures or damage, which would otherwise add to the budget.

The airless tires provide **consistent, dependable performance even under heavy loads**, making them suitable for supporting the weight of the AFSLK system, fuel container, and pump assembly. The additional **swivel tires** improve the kit's maneuverability, allowing it to navigate tight spaces and change direction smoothly, which is essential for practical training in constrained environments. This combination of airless and swivel tires ensures that the AFSLK can be transported easily and withstand the demands of training scenarios without compromising on safety or performance.

Furthermore, the AFSLK utilizes an **industrial-grade fuel pump** that is robust and designed to deliver consistent fuel flow, even under continuous use. This heavy-duty pump ensures reliable performance, with a flow rate capable of simulating real-world refueling operations effectively. Its industrial-grade design also means it can handle prolonged usage and a variety of fuel types, adding to the AFSLK’s durability and making it a suitable choice for extended training sessions. This pump, in combination with the rugged tire design, reinforces the kit’s overall reliability, ensuring that it is built to withstand the demands of regular handling and use in training environments.

4.1.2.3 Software / Programming

For programming the Aircraft Refueling Learning Kit (AFSLK), we utilize the **Arduino Integrated Development Environment (IDE)**, which serves as the core platform for coding and managing the interactions between the fuel sensor and the Arduino microcontroller. The Arduino IDE provides a user-friendly and versatile environment for developing the necessary code to monitor and display fuel levels accurately. By using this platform, we are able to program the Arduino to read real-time data from the **ultrasonic fuel sensors** connected to it, which allows the system to gauge the fuel levels in the container and display this information clearly on the LCD screen.

The IDE enables us to write, test, and troubleshoot code efficiently, ensuring that the fuel level readings are reliable and responsive to changes within the fuel tank. The Arduino is programmed to interpret sensor data, converting it into a fuel quantity measurement displayed in liters. Additionally, it activates the **LED indicators** (red, yellow, and green) based on the fuel level thresholds, providing clear visual feedback on fuel status. This functionality enhances the practical training experience by simulating the fuel monitoring systems used in real-world refueling operations.

The simplicity and flexibility of the Arduino IDE make it ideal for educational purposes as well, allowing instructors or students with little to no prior programming experience to modify or adjust code as needed. Through the Arduino IDE, the AFSLK programming can be customized or updated easily, adding to the adaptability of the training kit

4.1.2.4 Accessories & Finishing

For the accessories of the AFSLK, we used beacon light for extra safety measurement. The beacon light is located at the top of a pole for better visibility. The visibility needed for the user to acknowledge that the battery for the electrical is turned on. This also can be an indicator for the user to be extra cautious during the fuelling process.

The beacon light operates on a **12V power source**, provided by a dedicated 12V battery, ensuring it has sufficient and reliable power to remain illuminated as needed. This setup not only provides a clear, bright visual cue but also prevents potential confusion or mishandling of the refueling equipment by drawing attention to active operation. The integration of the beacon light within the AFSLK's design emphasizes safe practices in real-world refueling operations and provides students with an understanding of the critical role visual safety indicators play in aviation settings

For the finishing of the Aircraft Refueling Learning Kit (AFSLK), we use a combination of **blue, white, and black spray paint** to achieve both functional and aesthetic goals. The **fuel tank** is coated in **blue and white paint**, which not only enhances its visibility but also adds a professional look to the system. This color scheme on the fuel tank makes it easily recognizable and visually appealing, while the protective paint layer guards against corrosion. Since the fuel tank may be exposed to moisture and fuel residues, this paint acts as a barrier, helping prevent rust and extend the tank's lifespan.

The **main structure** of the AFSLK is finished in **black spray paint**, providing a sleek and clean look that visually distinguishes it from the fuel tank. This black paint also serves as a protective layer, helping the structure resist wear from handling and environmental exposure. By applying black paint to the structure, we ensure that the AFSLK maintains a **uniform, professional appearance** while safeguarding the metal components from corrosion and degradation over time.

Together, this **strategic color application** of blue, white, and black enhances the AFSLK's durability and functionality, ensuring that it remains visually appealing, structurally sound, and well-suited for long-term use in training environments.

4.1.3 General Operation of the Product

The aircraft refueling learning kit (AFSLK) is designed to give students hands-on experience with refueling procedures in a realistic, yet safe environment. To begin, users simply scan a QR code to activate the system. After this, they switch on the AFSLK and the Arduino module, which powers up the key components. The fuel pump, powered by a 12V battery, starts drawing fuel from the supply container, while a 9V battery powers the sensor system that tracks the fuel level.

As the pump operates, it transfers fuel toward the refueling point, which could be an empty fuel container or a model helicopter for practice purposes. Meanwhile, the sensor keeps an eye on the fuel level inside the supply container, displaying the percentage of fuel left. When the fuel level gets low, a red LED lights up on the sensor, giving a clear warning to turn off the pump to prevent it from running dry.

This setup provides an interactive and practical way for students to learn key aspects of refueling, including safe operation, fuel monitoring, and basic troubleshooting. It’s a valuable tool for building confidence in handling refueling equipment and understanding fuel management in real-world aviation settings

4.1.4 Operation of the Specific Part of the Product

4.1.4.1 Product Structure

The structure of the aircraft refueling learning kit (AFSLK) is built to be both highly durable and easily maneuverable, offering a reliable and practical setup for hands-on training. The frame is constructed from mild steel angle bars and hollow bars, materials chosen for their strength and resilience. Mild steel is known for its ability to withstand heavy loads and provide a stable foundation, essential for supporting the weight of components like the fuel container, pump, and battery system. The use of angle bars enhances structural integrity by adding rigidity and stability to the frame, while hollow bars reduce the overall weight without compromising strength, making the kit easier to handle.

To ensure smooth mobility, the structure is equipped with a set of four airless tires. At the back, two fixed airless tires provide a sturdy base, allowing the kit to remain stable when stationary or in use. These fixed tires help distribute weight evenly and prevent the kit from shifting or tipping. At the front, two swivel airless tires enhance maneuverability, allowing users to easily guide the kit in any direction. The airless design of these tires eliminates the risk of punctures and reduces maintenance needs, which is ideal for frequent use in educational environments.

Overall, the combination of durable mild steel and the strategic placement of airless tires makes the AFSLK both rugged and easy to transport. The structure's strength allows it to withstand daily use and the weight of heavy components, while the swivel wheels offer flexibility, enabling students to move and position the kit with minimal effort. This design provides a stable, low-maintenance platform for realistic training in refueling procedures, making it ideal for institutions aiming to give students practical, hands-on experience

4.1.4.2 Mechanical Mechanism

4.1.4.2.1 Fuel Pump and Fuel Flow System:

The fuel pump is capable of transmitting up to 60 liters per minute, providing the necessary flow rate to simulate real-world refueling operations effectively. Powered by a 12V battery, the fuel pump ensures that the system operates continuously for extended periods without interruption, delivering consistent fuel flow to the refueling nozzle.The fuel pump is securely mounted within the frame, positioned near the fuel tank and fuel hose assembly to ensure efficient fuel transfer. The pump's high flow rate ensures that it can handle the large volumes required for refueling aircraft like the Cessna 172N.

4.1.4.2.2 Industrial Oil Drum:

The fuel container is an industrial oil drum capable of holding 200 liters of fuel. This capacity is more than sufficient to simulate refueling of an aircraft, specifically the Cessna 172N, which has a maximum tank capacity of 211 liters. The oil drum provides the necessary fuel supply for multiple refueling operations, allowing the AFSLK to simulate repeated refueling of aircraft during training without the need for frequent refueling or tank changes.

4.1.4.2.3 Fuel Nozzle with Automatic Cut-Off:

The AFSLK is equipped with a fuel nozzle that features an automatic cut-off mechanism, replicating real-world refueling processes. This nozzle automatically stops the fuel flow once the fuel container reaches its full capacity, ensuring that overfilling or spillage does not occur during training. The auto cut-off feature is activated when the fuel level in the container reaches a pre-determined level, triggering the nozzle to shut off the fuel supply. This provides a safe and controlled fueling experience and is a key safety feature in aviation refueling procedures. It prevents accidental overfilling, ensuring the safety of both the user and the system.

4.1.4.2.4 Mobility System:

- Fixed Airless Tires (Rear): The AFSLK is equipped with two fixed airless tires at the rear of the unit. These tires are made from durable, non-pneumatic materials that do not require inflation, ensuring they are resistant to punctures and can handle heavy loads. The fixed rear tires provide stability, supporting the weight of the refueling kit while allowing for easy maneuvering in a straight line.
- Swivel Airless Tires (Front): At the front of the unit, there are two swivel airless tires. These swivel tires allow for better maneuverability and precision in turning the system around, enabling the AFSLK to be easily repositioned in any direction. Swivel tires enhance the flexibility of movement, making the entire system easier to operate, especially in confined spaces such as classrooms or training areas

4.1.4.3 Software / Programming

4.1.4.3.1 12V Battery

The 12V battery powers the fuel pump, beacon light, and relay module. This battery ensures that these components receive the necessary power to operate during training. The pump switch controls the fuel pump, while the Arduino switch controls the beacon light through the relay module.

4.1.4.3.2 9V Battery

The 9V battery powers the Arduino UNO and the fuel level sensor. This provides independent power to control and monitor components, ensuring the system can operate autonomously to track fuel levels and trigger the appropriate alerts.

4.1.4.3.3 Dual Switch System (Pump and Arduino Switches):

The pump switch controls the fuel pump, allowing the user to start or stop the refueling process. The Arduino switch powers the Arduino UNO and controls the beacon light through the relay module, allowing monitoring and alert functions to operate.

4.1.4.3.4 Arduino UNO Microcontroller:

The Arduino UNO serves as the central control unit for the system, processing input from the fuel level sensor and managing the outputs to various components. The Arduino reads the fuel level data, displays it on the 16x2 LCD, and activates the appropriate fuel level indicator LEDs (red, yellow, or green) based on the current fuel quantity. It also manages the red warning LED and controls the beacon light.

4.1.4.3.5 Fuel Level Sensor:

The fuel level sensor continuously measures the fuel volume in the container. The sensor sends real-time fuel data (in liters) to the Arduino UNO, which processes and uses this data to determine the fuel level. Based on the level, the Arduino turns on one of the three LEDs (red, yellow, or green) to indicate whether the fuel level is below 50 liters (red), between 50-120 liters (yellow), or above 120 liters (green).

4.1.4.3.6 Red, Yellow, and Green LEDs:

- Red LED: This LED lights up when the fuel level drops below 50 liters, indicating that the fuel supply is critically low. This acts as an urgent warning for the user to stop the pump and refuel the container.
- Yellow LED: The yellow LED illuminates when the fuel level is between 50 and 120 liters, signaling a moderate fuel level. This indicates that the fuel supply is sufficient but needs to be monitored closely.
- Green LED: The green LED lights up when the fuel level exceeds 120 liters, indicating that there is ample fuel in the container. This LED signals that the refueling system is fully operational and that there is enough fuel for continued use.

4.1.4.3.7 16x2 LCD Display:

The 16x2 LCD display provides real-time feedback of the fuel volume in liters. It continuously updates to show the current fuel level, allowing users to monitor fuel consumption during the refueling process. This display works alongside the LEDs to provide detailed visual information about the fuel quantity.

4.1.4.3.8 Single-Channel 12V Relay Module:

The single channel 12V relay module is used to control the 12V beacon light via the Arduino UNO. When the Arduino is powered on and the refueling system is active, it sends a signal to the relay module, which then powers the beacon light to indicate system readiness

4.1.4.3.9 **QR Code Integration:**

The AFSLK unit is equipped with a **QR code** that users can scan using a smartphone or tablet. Scanning the code directs them to the AFSLK's official **website**, where they can access a range of helpful resources to support their learning experience.

4.1.4.3.10 **Online Logbook for User Information:**

The website features a **digital logbook** designed to **collect user information**. This allows users to register and store their details for future reference, making it easy for instructors to track who has used the AFSLK system. The logbook collects **basic user information**, such as name, email address, and training dates, to maintain a record of student participation without collecting detailed usage data such as fuel amounts or session duration.

4.1.4.3.11 **Safety Precautions and General Refuelling Information:**

The website provides users with essential **safety precautions** and **general refueling information**. Users can access detailed guidelines on safe refueling practices, helping them understand both the theoretical and practical aspects of aircraft refueling.

Information on **fuel handling**, potential risks, and safety measures ensures users are fully aware of the protocols needed to maintain a safe refueling environment.

4.1.4.3.12 **Access to Training Resources**

The platform offers access to **tutorials**, **step-by-step guides**, and **educational videos**. These resources help users learn how to operate the AFSLK and follow safe refueling practices effectively.

Demonstration videos are included on the website, showing the proper usage of the AFSLK, the steps in the refueling process, and how to handle the system safely. These videos act as a visual guide, making it easier for users to understand the process and ensure they are performing tasks correctly during training.

These **demonstration videos** provide visual instructions for both instructors and students, covering topics such as:

- Setting up the AFSLK for refueling.
- How to safely operate the fuel pump and nozzle.
- How to monitor fuel levels and recognize warning signals.

4.1.4.3.13 **Instructor and Student Support**

Instructors can use the online platform to **guide students** through training. The provided video demonstrations and resources can be integrated into training lessons to reinforce the practical skills learned on the AFSLK unit. This structure supports a blended learning approach, combining hands-on experience with digital content to ensure better understanding and retention

4.1.4.4 Accessories & Finishing

4.1.4.4.1 Spray Can

The spray we use is intended to be life-long and anti-rust for the metal part of the system. The area that uses most metal is for the structure part which is hollow steel and angle bar. Both types of the metal mention are easily exposed to rusting and corrosion. When the surfaces are layered with spray paint, the chances for the metal to be exposed to corrosion and rusting are lowered.

4.1.4.4.2 Beacon Light

The beacon light is powered through the 12V relay module, which is activated by the Arduino UNO. The beacon light serves as a visible indicator that the system is active and ready for refueling. When the Arduino switch is turned on, the Arduino sends a signal to the relay, activating the beacon light.

4.2 PRODUCT OUTPUT ANALYSIS'

No.	Parameters	Time of Operation	Remarks
1.	Time	12L/MIN	The time taken to fill fuel tank per litres.
2.	Weight/ Load	70 kg	The total weight of the fuelling cart without load.
3.	Capacity	200 litres	The maximum capacity of the oil drum.
4.	Output Power / Voltage	12V	The output power for the DC battery.

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 Product Structure

The problem we encountered during the construction of the structure was the welding process for hollow square steel where the welding machine provided is not suitable for hollow square steel. When welding the hollow steel, the material won't welded together, instead, the material pierced a hole on it. We managed to gain access to Mechanical Workshop to weld our hollow steel under Mr Salleh's supervision.

We also faced troubles where the towbar attachment for tow truck from the original idea cannot be attached due to the lack of material and complexity of the design itself. We decided to change it from towbar to push bar. The push bar helping the user to ease the movements of the cart.

4.3.2 Mechanical Mechanism

During the construction of the Aircraft Fuel System Learning Kit (AFSLK), there's a few problems we encountered, and we managed to find the solutions.

Problems	Solutions
The washers to hold the tyre on the rod are not fitted with the rod.	We weld the washer to the tyre and the rod to prevent the tyre from moving around the rod.

4.3.3 Software / Programming

During construction of this project, we faced problems where the battery we bought from local store is not long-lasting like what we expected it to be. The battery is supposed to lasting for more than 30 days but instead, the battery dead a few days later after we bought it. To overcome this problem, we bought another battery with bigger MAH which have better battery lifetime than the old battery.

For the software / programming, we faced problems where the sensor we bought is difficult to calibrate with small diameter and caused the data we acquired is not accurate. The way we overcome is by calibrate the sensor with much higher diameter and we managed to get an accurate data.

4.3.4 Accessories & Finishing

For accessories & finishing, we faced problems where the spray can we bought is not enough for the structure. We initially bought only 2 can of black spray for the structure but the spray ran out before we can finish the finishing. We overcome it by bought another can from the same store and same brand to prevent colour different.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

Our product is working properly as what we desired based on our aim and objectives. The moving mechanism and the all the electronic including the software programming are working perfectly supporting our aims to develop a learning kit for students at Polytechnic Banting Selangor.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

The structure of our product is working excellently including supporting the weight of the oil drum when it being filled in with water. The weight of the oil drum can be more than 50Kg when it filled with water. This showed that the structure is strong and capable of supporting the oil drum.

5.1.2.2 Mechanical Mechanism

Upon the designing and planning of inventing the similar product that has the content of a real aircraft refuelling procedure, the main objectives and aims that we targeted and set for before inventing this AFSLK are considered as successfully accomplished. The main point of this mechanical mechanism is to provide and give an exposure about the real aircraft refuelling system that completed with a fuel cart and fuel nozzle.

A product of an aircraft refuelling system that comes with portable fuel cart with a pair of compartment space in front of the cart are designed and developed by using several mechanical mechanisms. This includes, hollow steel, angle bar and plywood as a main structure for the fuel cart body. Before this product is developed, there are several research that have been done to determine the perfect mechanism that can sustain and strong enough to carry all the load within this product. The portability of this product is designed with an airless tire, swivel tire and the push rod as a moving mechanism.

5.1.2.3 Software / Programming

This AFSLK is completed with a box that stored all the electrical mechanism that we use in the system of this product. The AFSLK is designed with the fuel quantity level that helps user to indicate the fuel/liquid that filled in the oil drum. Moreover, the achievement of the project objective for electrical/electronic mechanism is succeeded to create this electrical system.

5.1.2.4 Accessories & Finishing

Our market value for this product is a user-friendly product as this AFSLK is easy to use and designed with a lot of features to ease users on how to conduct the refuelling procedure. That is why this AFSLK is designed simply and straight forward. Furthermore, additional accessories and finishing also become our priority on completing this product. The designed QR code that comes with a website able to demonstrate and ease user on using this product. For the finishing of this project, we use a spray to make the oil drum more aesthetic and some cable tie to tie all the mechanism in the compartment as is not moving.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The contribution of this development of an Aircraft Fuel System Learning kit can be referred to the aims and objective of our product which is to provide practical learning about refuelling procedure in Polytechnic Banting Selangor. Meanwhile, the contribution of the product to the institution also to increase understanding among students about the refuelling procedure. Besides, it will also enhance the learning environment with a practical hand on learning method. The impact of this AFSLK product towards the society is to increase the amount of effectiveness in learning within the field of Aircraft Maintenance Engineering student.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

The product improvement that we seek in future is by replacing the hollow steel that we use in the current product into aluminium profile that founds to be lighter, sustainable and easy to connect compared to the hollow steel that we should weld to connect it together. Suggestions for our future research is to develop the attachment for tow bar and tow truck to make it easier to move.

5.3.2 Mechanical Mechanism

Our aim in the future is to build a greater effort and commitment on upgrading and improve this product into a better version. Certain place or technology that are wished to be added to the Aircraft Fuel System Learning Kit are includes:

- Tow bar and tow truck attachment panel
- Upgrading to a better version of fuel pump
- Change the design of the fuel cart for the front panel, to make it more user-friendly and easier to access.

5.3.3 Electrical/electronic mechanism

The improvement & suggestion for electrical/electronic mechanism is to replace the 12V battery into a higher voltage of battery for a long time running of the system. Besides, we also planning on replacing the waterproof ultrasonic sensor into another accurate and can be immerse into a fuel of kerosene. This is because the ultrasonic sensor that measure the distance cannot properly read the fuel quantity level accurately when the fuel is shaking or not in static position.

5.3.4 Accessories & Finishing

The refinement of the AFSLK in the concept of accessories is to provide more IOT features that helps student in learning and understanding the procedure. For example, the addition of the VR element of the fuel panel of the aircraft. Furthermore, for the concept of the product finishing, we are planning on adding more colour on the fuel cart body to make it more aesthetic. We also want to make an accessible door to secure the electrical equipment and other things that stored within our compartment space.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

ITEMS	DESCRIPTION
	AMIEROL HAZIQ BIN SHAMSOL ANUAR 24DAM22F1045
1.3.2/1.3.2.2	Specific Individual Project Aims: Product Mechanisms
1.4.2/1.4.2.2	Specific Individual Scope: Product Mechanisms
2.2.2	Specific Literature Review: Product Mechanisms
2.3.1/2.3.1.1	Related Patented Products: Patent A
2.3.2.1	Recent Market Products: Product A
2.4.1	Comparison Between Recent Research and Current Project: Patent A vs. Product A vs. Your Product
3.1.2.3	Design Concept Generation: Proposed Design Concept 1
3.2.1	General Product Sketching
3.2.2	Specific Part Sketching
3.4.2.2	Specific Part Features: Product Mechanisms
3.4.4.2	Operation of the Specific Part of the Product: Product Mechanisms
4.3.2	Analysis of problem encountered & solutions: Mechanical mechanism
5.1.2.2	Specific achievement of project objectives: Mechanical Mechanism
5.3.2	Contribution or impact of the product: Mechanical Mechanism

	MUHAMMAD AIZAT BIN NORDIN HAMAD 24DAM22F1008
1.3.2/1.3.2.3	Specific Individual Project Aims: Software / Programming
1.5.2/1.5.2.3	Specific Individual Scope: Software / Programming
2.2.3	Specific Literature Review: Software / Programming
2.3.1/2.3.1.1	Related Patented Products: Patent A
2.3.2.2	Recent Market Products: Product B
2.4.2	Comparison Between Recent Research And Current Project: Patent A vs. Product B vs. Your Product
3.3.2/3.3.2.3	Specific Project Design Flow / Framework: Software / Programming
3.4.2	Design Concept Generation: Proposed Design Concept 2
3.5.2/3.5.2.3	Specific Part Drawing / Diagram: Software / Programming
3.7.3/3.7.3.3	Specific Project Fabrication: Phase 3 (Programming & Electrical Circuit)
3.9	List Of Materials & Expenditures: 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
4.3.3	Analysis Of Problem Encountered & Solutions: Software / Programming
5.1.2.3	Specific Achievement of Project Objectives: Software / Programming
5.3.3	Improvement & Suggestions For Future Research: Software / Programming

	AKMAL IZZUDDIN BIN ABU WAHID 24DAM22F1004
1.3.2/1.3.2.1	Specific Individual Project Aims: Product Structure
1.4.2/1.4.2.1	Specific Individual Scope: Product Structure
2.2.1	Specific Literature Review: Product Structure
2.3.1	Related Patented Products: Patent A
2.3.2	Recent Market Products: Product A
2.4	Comparison Between Recent Research and Current Project
3.1.2	Project Collaboration and Transfer of Technology
3.3.2.1	Specific Project Design Flow / Framework: Product Structure
3.4.2.1	Design concept generation: Function Tree
3.5	Product Drawing/Schematic Diagram
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

	NADIA NAZIRA BINTI ZAMRI 24DAM22F1011
1.3.2/1.3.2.4	Specific Individual Project Aims: Accessories & Finishing
1.5.2/1.5.2.4	Specific Individual Scope: Accessories & Finishing
2.2/2.2.4	Specific Literature Review: Accessories & Finishing
2.3.1/2.3.1.4	Related Patented Products: Patent D
2.3.2.4	Recent Market Products: Product D
2.4.4	Comparison Between Recent Research and Current Project: Patent D Vs. Product D Vs. Your Product
3.3.2/3.3.2.4	Specific Project Design Flow / Framework: Accessories & Finishing
3.4.2.6	Proposed Design Concept 4: Accessories & Finishing
3.5.2.4	Specific Part Drawing: Accessories & Finishing
3.7.3.4	Specific Project Fabrication: Phase 4 (Finishing)
3.9/ 3.9.4	List of Materials & Expenditures: Accessories & Finishing
4.1.2/ 4.1.2.4	Specific Part Features: Accessories & Finishing
4.1.4 / 4.1.4.4	Operation of the Specific Part of the Product: Accessories & Finishing
4.3 / 4.3.4	Analysis of Problem Encountered & Solutions: Accessories & Finishing
5.1.2 / 5.1.2.4	Specific Achievement of Project Objectives: Accessories & Finishing
5.3 /5.3.4	Improvements & Suggestions for Future Research: Accessories & Finishing

APPENDIX B: THE INCREDIBLE STORY OF THE GIMLI GLIDER

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The Incredible Story Of The Gimli Glider

It has been four decades since this unbelievable incident occurred.

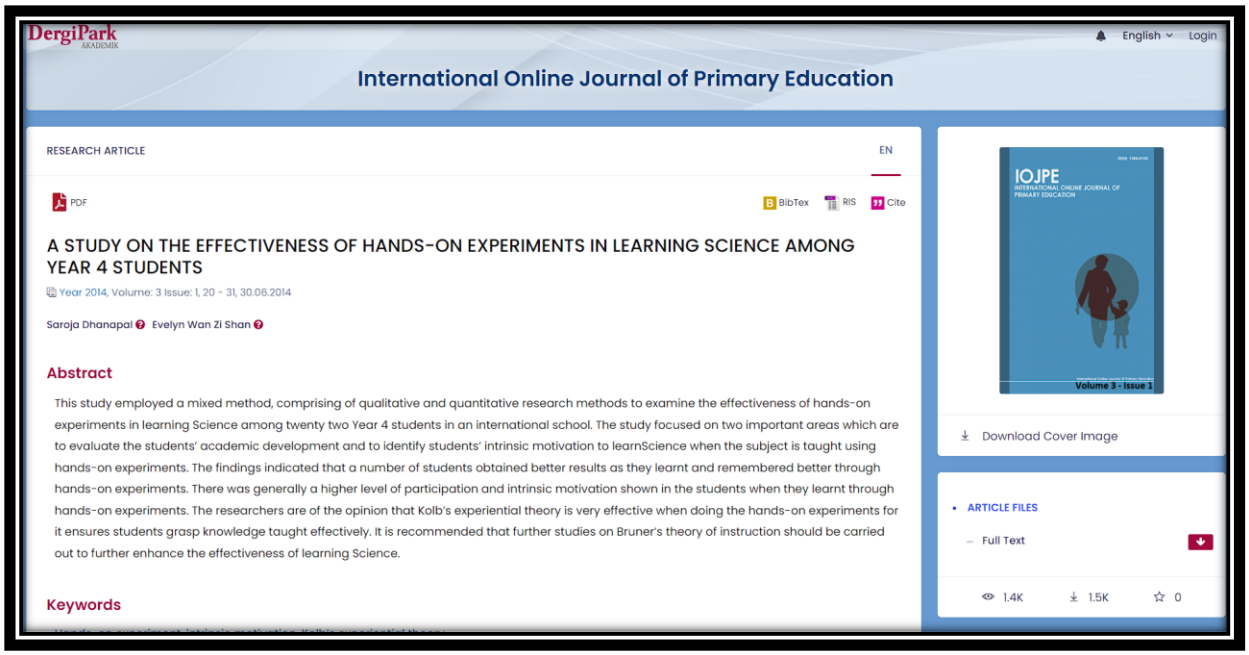
BY **SIMPLE FLYING STAFF**
UPDATED AUG 6, 2023

Photo: Aero Icarus via Wikimedia Commons

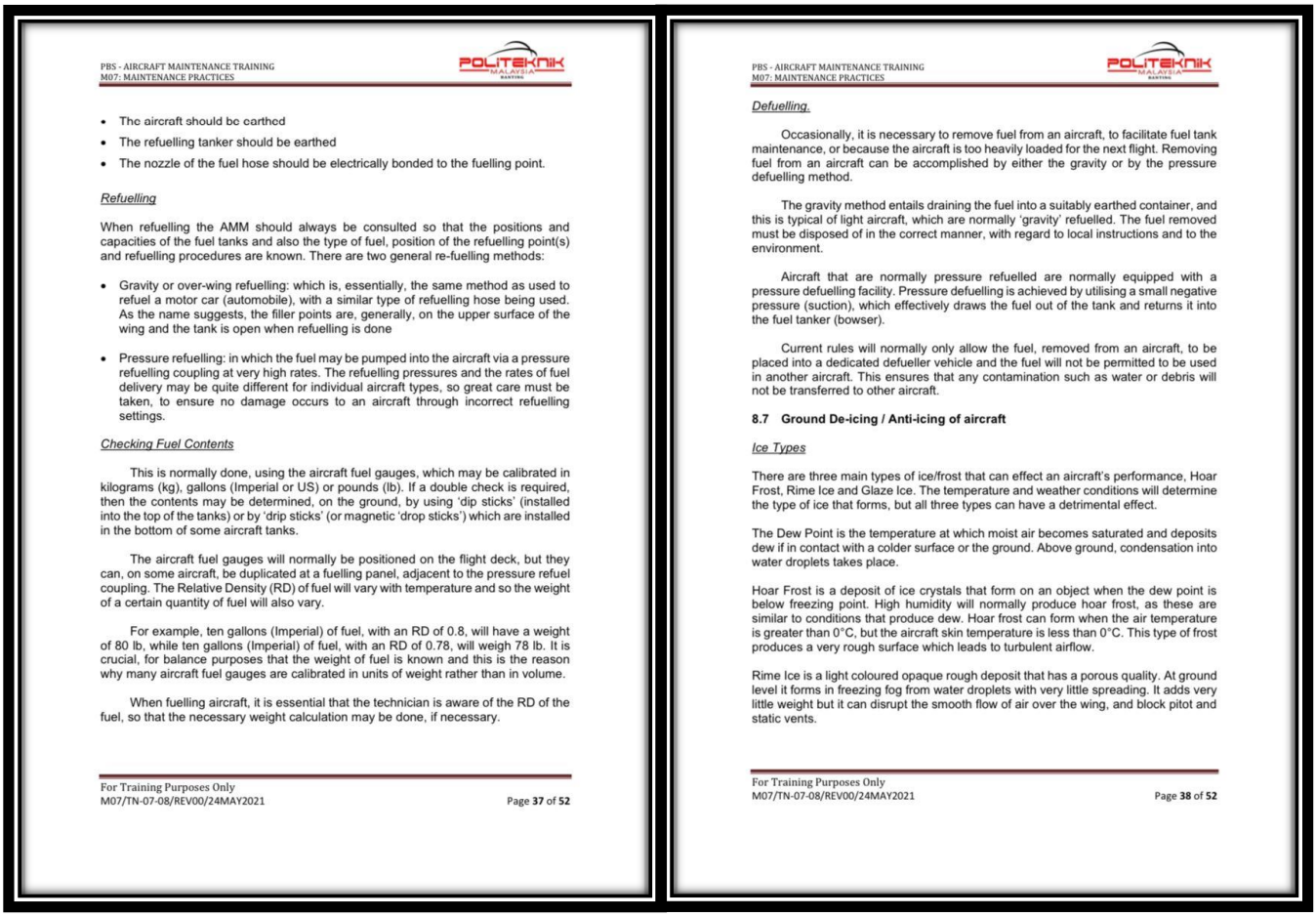
SUMMARY

- **The Gimli Glider incident occurred 40 years ago when an Air Canada Boeing 767 ran out of fuel at 41,000 feet, but the pilots successfully glided the plane to a former airfield turned race track for a safe landing.**
- **The plane lost all power, including its electronic instrument system, but the pilots were able to use the ram air turbine for emergency instruments and hydraulic support to maneuver the aircraft.**
- **The incident was caused by a combination of technical issues, organizational**

APPENDIX C: A STUDY ON THE EFFECTIVENESS OF HANDS-ON EXPERIMENTS IN LEARNING SCIENCE AMONG YEAR 4 STUDENTS.



APPENDIX D: PBS. AIRCRAFT MAINTENANCE TRAINING, M07: MAINTENANCE PRACTICES (PAGE 37-38)



- The aircraft should be earthed
- The refuelling tanker should be earthed
- The nozzle of the fuel hose should be electrically bonded to the fuelling point.

Refuelling

When refuelling the AMM should always be consulted so that the positions and capacities of the fuel tanks and also the type of fuel, position of the refuelling point(s) and refuelling procedures are known. There are two general re-fuelling methods:

- Gravity or over-wing refuelling: which is, essentially, the same method as used to refuel a motor car (automobile), with a similar type of refuelling hose being used. As the name suggests, the filler points are, generally, on the upper surface of the wing and the tank is open when refuelling is done
- Pressure refuelling: in which the fuel may be pumped into the aircraft via a pressure refuelling coupling at very high rates. The refuelling pressures and the rates of fuel delivery may be quite different for individual aircraft types, so great care must be taken, to ensure no damage occurs to an aircraft through incorrect refuelling settings.

Checking Fuel Contents

This is normally done, using the aircraft fuel gauges, which may be calibrated in kilograms (kg), gallons (Imperial or US) or pounds (lb). If a double check is required, then the contents may be determined, on the ground, by using 'dip sticks' (installed into the top of the tanks) or by 'drip sticks' (or magnetic 'drop sticks') which are installed in the bottom of some aircraft tanks.

The aircraft fuel gauges will normally be positioned on the flight deck, but they can, on some aircraft, be duplicated at a fuelling panel, adjacent to the pressure refuel coupling. The Relative Density (RD) of fuel will vary with temperature and so the weight of a certain quantity of fuel will also vary.

For example, ten gallons (Imperial) of fuel, with an RD of 0.8, will have a weight of 80 lb, while ten gallons (Imperial) of fuel, with an RD of 0.78, will weigh 78 lb. It is crucial, for balance purposes that the weight of fuel is known and this is the reason why many aircraft fuel gauges are calibrated in units of weight rather than in volume.

When fuelling aircraft, it is essential that the technician is aware of the RD of the fuel, so that the necessary weight calculation may be done, if necessary.

Defuelling.

Occasionally, it is necessary to remove fuel from an aircraft, to facilitate fuel tank maintenance, or because the aircraft is too heavily loaded for the next flight. Removing fuel from an aircraft can be accomplished by either the gravity or by the pressure defuelling method.

The gravity method entails draining the fuel into a suitably earthed container, and this is typical of light aircraft, which are normally 'gravity' refuelled. The fuel removed must be disposed of in the correct manner, with regard to local instructions and to the environment.

Aircraft that are normally pressure refuelled are normally equipped with a pressure defuelling facility. Pressure defuelling is achieved by utilising a small negative pressure (suction), which effectively draws the fuel out of the tank and returns it into the fuel tanker (bowser).

Current rules will normally only allow the fuel, removed from an aircraft, to be placed into a dedicated defueller vehicle and the fuel will not be permitted to be used in another aircraft. This ensures that any contamination such as water or debris will not be transferred to other aircraft.

8.7 Ground De-icing / Anti-icing of aircraft

Ice Types

There are three main types of ice/frost that can effect an aircraft's performance, Hoar Frost, Rime Ice and Glaze Ice. The temperature and weather conditions will determine the type of ice that forms, but all three types can have a detrimental effect.

The Dew Point is the temperature at which moist air becomes saturated and deposits dew if in contact with a colder surface or the ground. Above ground, condensation into water droplets takes place.

Hoar Frost is a deposit of ice crystals that form on an object when the dew point is below freezing point. High humidity will normally produce hoar frost, as these are similar to conditions that produce dew. Hoar frost can form when the air temperature is greater than 0°C, but the aircraft skin temperature is less than 0°C. This type of frost produces a very rough surface which leads to turbulent airflow.

Rime Ice is a light coloured opaque rough deposit that has a porous quality. At ground level it forms in freezing fog from water droplets with very little spreading. It adds very little weight but it can disrupt the smooth flow of air over the wing, and block pitot and static vents.

APPENDIX E: TRAJECTORY ANALYSIS OF BASKET ENGAGEMENT DURING AERIAL REFUELING

Trajectory Analysis of Basket Engagement during Aerial Refueling

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Department of Mechanical & Aerospace Engineering, Institute of Avionics & Aeronautics, Air University, Islamabad 44000, Pakistan

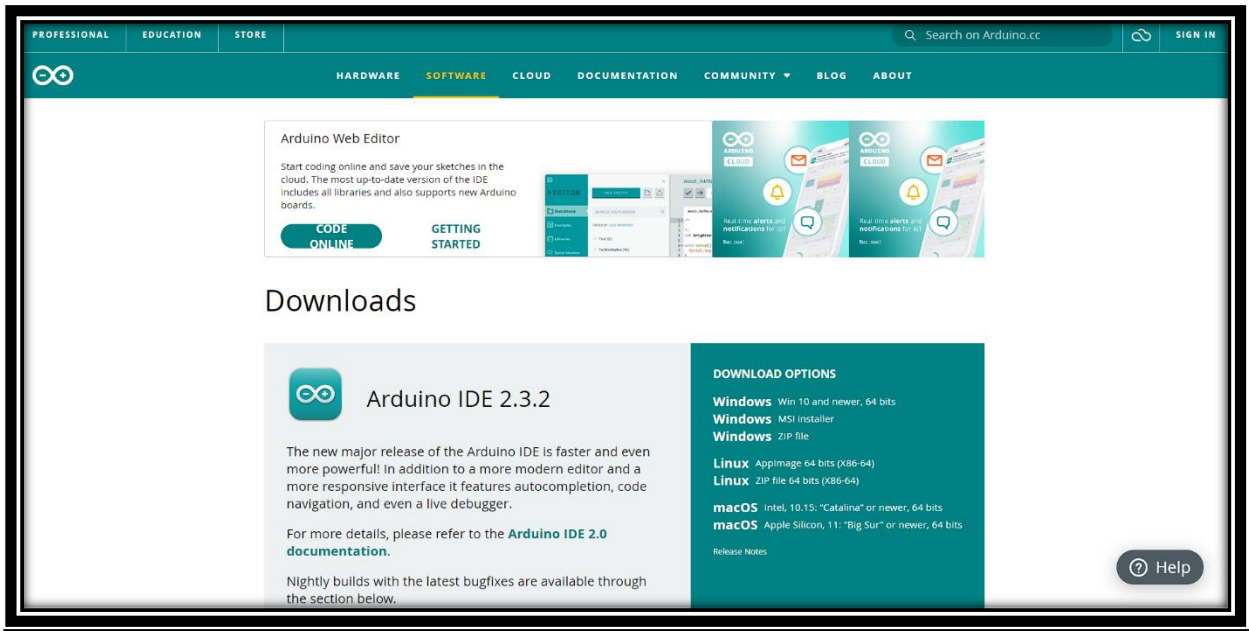
In this paper trajectory analysis for the aerial refueling basket for a modern fighter aircraft is presented. The under study aircraft has a probe and drogue arrangement for aerial refueling. Thus the aircraft has to be carefully positioned behind the extended refueling basket is such a way that positive engagement of refueling basket and probe takes place accounting for the complex flow field around the aircraft as it approaches the refueling basket. In the current study an initial location of the refueling basket has been selected such that, the aircraft flow field have minimal aerodynamic effects on the basket at this location and, then the basket is allowed to move towards the aircraft using Six Degree of Freedom Solver with appropriate boundary and limiting conditions. The initial location of the basket is iteratively improved until engagement of refueling probe and basket is achieved. Further optimization of initial location and some worst case scenarios have also been simulated. The results indicate significant effect of aircraft aerodynamics on basket trajectory. An optimum initial basket location that results in positive engagement with the refueling probe has been determined.

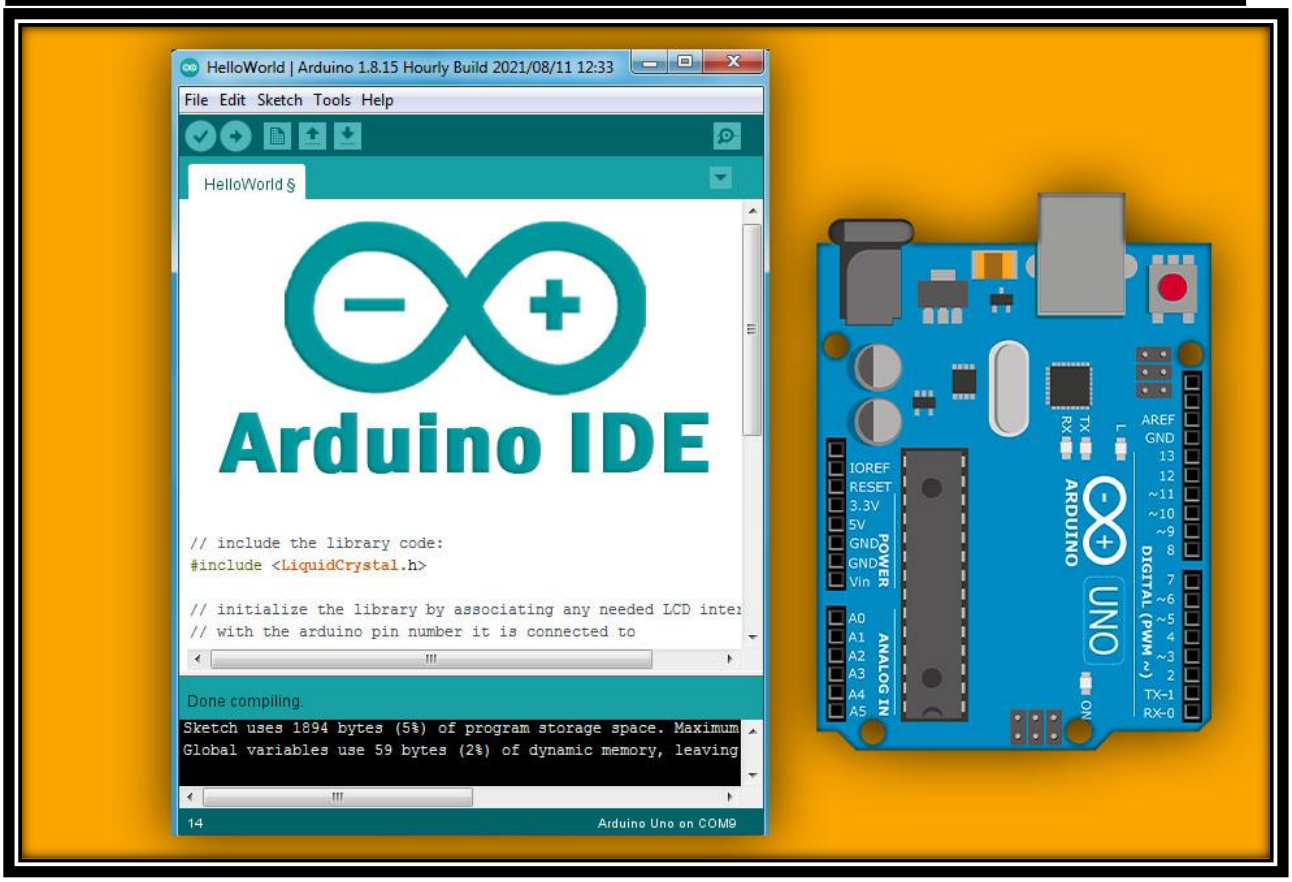
Nomenclature

AOA	Angle-of-Attack (Degrees)
β	Sideslip angle (Degrees)
CFD	Computational Fluid Dynamics
6DOF	Six degree of freedom
M	Mach number
P	Static pressure
P_∞	Free stream static pressure
SA	One equation Spalarat-Allamaras turbulence model
V_∞	Free stream velocity
ρ_∞	Free stream density
CG	Center of gravity
x, y, z	Cartesian ordinates
y^+	Non-dimensional length scale associated with turbulence model
RANS	Reynolds Averaged Navier-Stokes

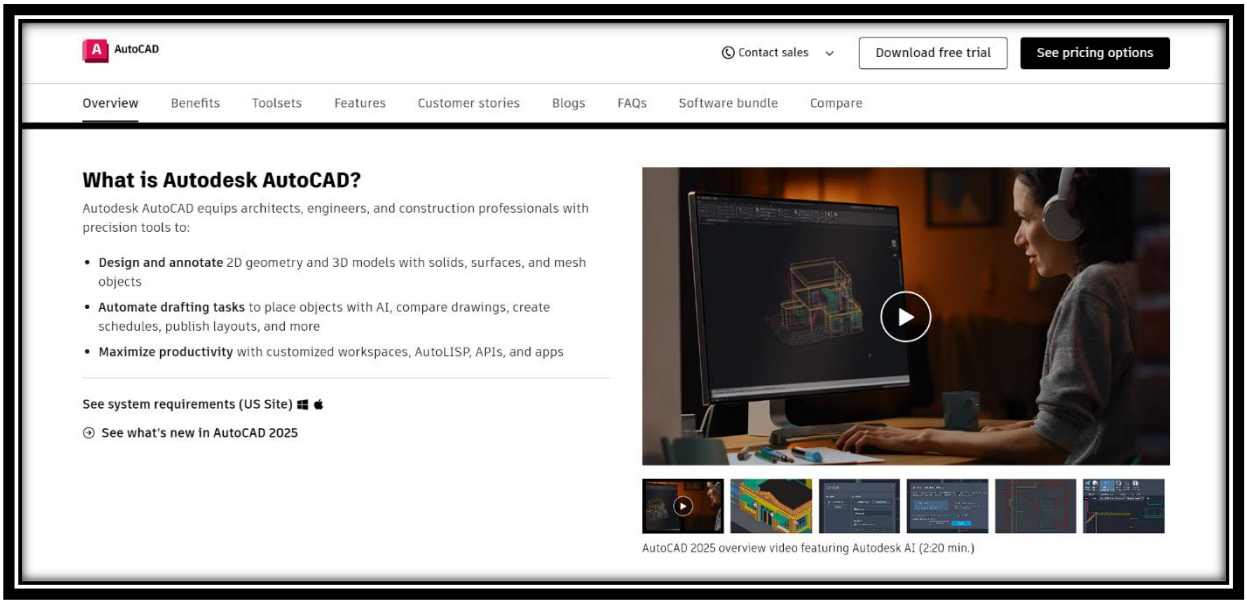
APPENDIX F: SAFE AIRCRAFT REFUELLING AIRBUS(OPERATIONS).PDF

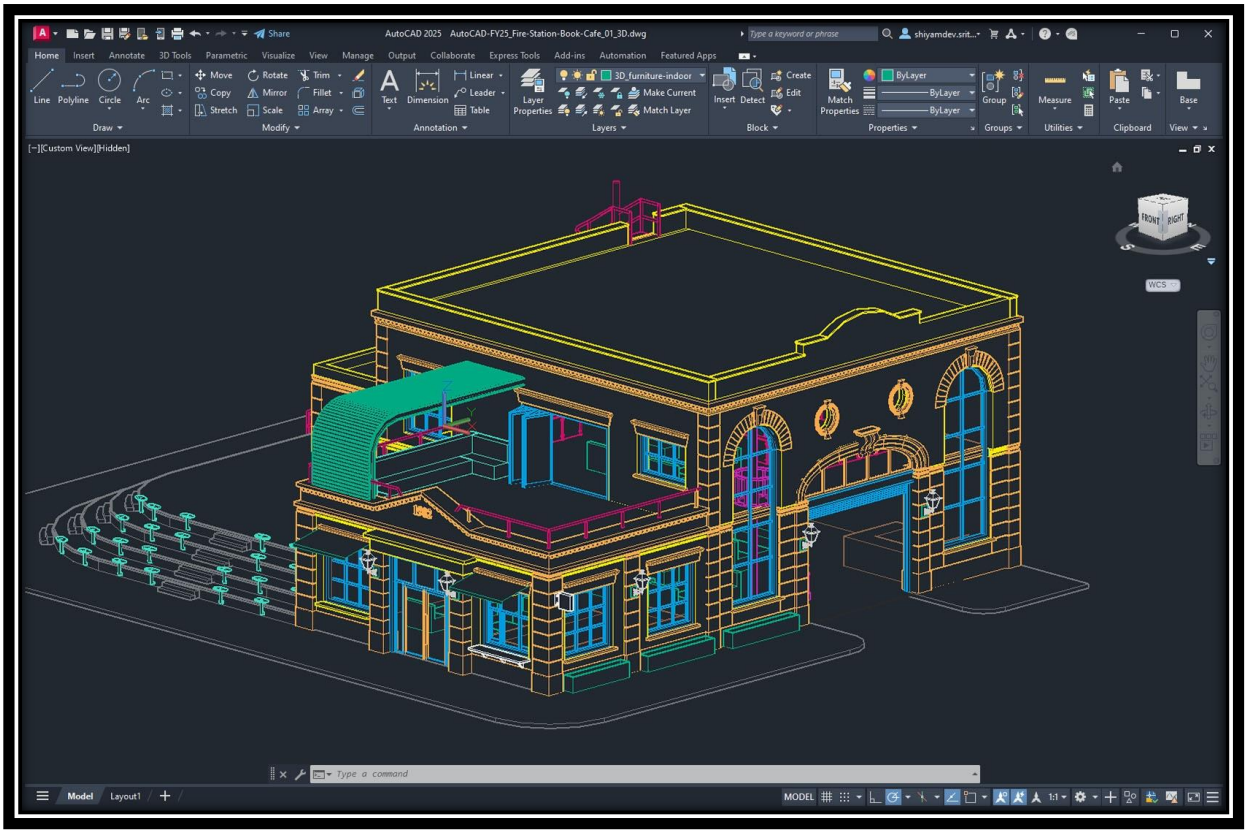
APPENDIX G: ARDUINO IDE





APPENDIX H: AUTOCAD





APPENDIX I: AIRCRAFT FUEL HANDLING AND STORAGE PDF

Civil Aviation Authority

SAFETYSENSE LEAFLET 28
FUEL HANDLING AND STORAGE

1 INTRODUCTION

a) The petroleum industry is the primary source of information about their products. However, there are also regulations which affect the handling of all petroleum products, including aviation fuel.

b) In addition to the regulations listed at paragraph 8, the Air Navigation Order (ANO) lays down certain requirements for the person in charge of an aviation fuel installation at an aerodrome, and also for personnel carrying out refuelling. Aviation fuel is defined as 'fuel intended for use in aircraft' and 'any area of land or water designed, equipped, set apart or commonly used for affording facilities for the landing and departure of aircraft' is an aerodrome. A pilot who stores his fuel, whether AVGAS, JET A-1 or MOGAS, at a strip (or a back-garden landing pad), or even pours it out of a container, has the same safety responsibilities as the fuel installation manager at an aerodrome licensed by the CAA.

c) Licensed aerodromes are guided by CAP 748 'Aircraft Fuelling and Fuel Installation Management'. Although CAP 748 should be referred to as the basis of the safety plan at every fuel installation, this leaflet provides more general advice to those who store or dispense fuel away from licensed aerodromes.

d) Additional information and guidance about fuel handling and storage can be found in Energy Institute or Joint Inspection Group (EI/JIG) publications, some of which are listed in paragraph 8.

e) There are three basic hazards associated with aviation fuel:

i) fire and explosion;

ii) fuel quality; and

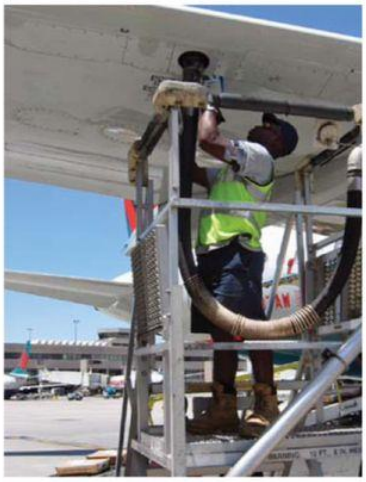
iii) environmental.

Everyone involved in fuel handling should be constantly aware of these and make every effort to minimise the attendant risks.

APPENDIX J: STUDY GUIDE FOR FUEL HANDLERS PDF

STUDY GUIDE FOR FUEL HANDLERS

Revised August 2006



City of Phoenix

Phoenix Sky Harbor International Airport

APPENDIX K: WHAT ARE AIRLESS TYRE?