POLITEKNIK BANTING SELANGOR

WASTE WATER TRAINING KIT

NAME	MATRIC NO.
ERAYSHAN A/L RAJESWARAN	24DAM23F1004
KAVIRAJ A/L SOORAINDARAN	24DAM23F1050
ARON A ALBERT A/L ANTHONY ALBERT	24DAM23F1044
MOHD NAZRIL	24DAM23F1020

DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1 2025/2026

POLITEKNIK BANTING SELANGOR

WASTE WATER TRAINING KIT

NAME	MATRIC NO.
ERAYSHAN A/L RAJESWARAN	**24DAM23F1004**
KAVIRAJ A/L SOORAINDARAN	**24DAM23F1050**
ARON A ALBERT A/L ANTHONY ALBERT	**24DAM23F1044**
MOHD NAZRIL	**24DAM23F1020**

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

SUPERVISOR:

SHAZANA BINTI MUSTHAPA

REPORT ENDORSEMENT

This report entitled ***"WASTE WATER TRAINING KIT*** is being submitted, reviewed, and endorsed to fulfill the conditions and requirements of report writing as specified.

Checked by:

Supervisor's Signature :

Supervisor's Stamp :

SHAZANA BINTI MUSTAPA
Pensyarah
Jabatan PenyenggaraanPesawat
Politeknik Banting Selangor

Date : 25/11/2025

Endorsed by:

Project Coordinator's Signature :

Project Coordinator's Stamp :

KHAIRUL IZWAN BIN ISMAIL
Pensyarah
Jabatan Penyenggaraan Pesawat
Politeknik Banting Selangor

Date : 12th DECEMBER 2025

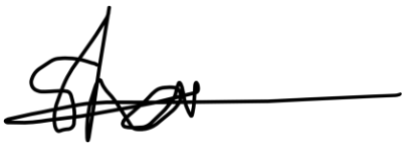
CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

WASTE WATER TRAINING KIT

SESSION 1 2025/2026

NAME	MATRIC NO.
ERAYSHAN A/L RAJESWARAN	24DAM23F1004
KAVIRAJ A/L SOORAINDARAN	24DAM23F1050
ARON A ALBERT A/L ANTHONY ALBERT	24DAM23F1044
MOHD NAZRIL	24DAM23F1020

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



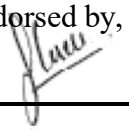
ERAYSHAN A/L RAJESWARAN

KAVIRAJ A/L SOORAINDARAN

ARON A ALBERT A/L ANTHONY ALBERT

MOHD NAZRIL

Endorsed by,



(SUPERVISOR'S SIGNATURE)

SHAZANA BINTI MUSTAPA
Pensyarah
Jabatan PenyenggaraanPesawat
Politeknik Banting Selangor

SUPERVISOR'S STAMP

DATE: 25/11/2025

ACKNOWLEDGEMENT

We would like to take this opportunity to express our sincere appreciation to our parents for their countless sacrifices, continuous support, and motivation throughout our education and during the development of this end-of-semester project at Politeknik Banting Selangor.

Our highest gratitude also goes to our project supervisor, Mdm. Shazana binti Mustapha, for her continuous guidance, support, and encouragement which helped us successfully complete this project report. Her enthusiasm and professionalism have truly inspired us, especially during moments when we felt stuck, discouraged, or short of ideas. Whenever we needed help, she was always willing to assist and provide motivating words to help us overcome challenges.

We would also like to extend our special appreciation to the lecturers of the Aircraft Maintenance Department for allowing us to use the workshop facilities to carry out and complete our project. Their advice, guidance, and supervision have greatly contributed to ensuring our project ran smoothly and was completed on time. They have also shared many valuable ideas throughout the process.

Lastly, we would like to thank our team members for their strong cooperation, dedication, and commitment in completing this project sacrificing their time, energy, money, and ideas without giving up. Every form of support, whether direct or indirect, has been a great blessing to our group. Our heartfelt thanks go to everyone involved, especially Politeknik Banting Selangor.

ABSTRACT

The aircraft lavatory system is an essential component in ensuring passenger comfort, hygiene, and safety during flight operations. However, due to limited access to real aircraft components, students often face difficulties understanding the structure, functions, and maintenance procedures of an actual lavatory system. To address this learning gap, our team developed a Boeing 737 Lavatory Training Kit, designed as a practical training aid for aircraft maintenance students.

This training kit replicates the basic layout and operational features of a Boeing 737 lavatory, including the freshwater system, waste disposal mechanism, lighting system, water heater, and suction pump. The kit also incorporates several DC electrical components to simulate real aircraft operations in a safe, controlled environment. Through this project, students are able to observe component functions, troubleshoot basic faults, and understand maintenance processes more effectively.

The main objective of developing this training kit is to provide a hands-on learning platform that enhances technical knowledge, supports practical teaching, and bridges the gap between theory and real aircraft systems. As a result, the Boeing 737 Lavatory Training Kit will improve training quality, increase student competency, and support future aviation maintenance learning at Politeknik Banting Selangor.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

1.1 BACKGROUND OF STUDY

In today's aviation industry, keeping aircraft clean, safe, and efficient isn't just about engines and electronics it also involves managing something as essential as water and waste. Systems that handle potable water and waste on commercial aircraft like the Boeing 737 play a crucial role in maintaining hygiene, ensuring passenger comfort, and meeting strict safety regulations (World Health Organization, 2009; Savić, 2020). These systems provide clean water for drinking and handwashing, while also taking care of waste collection and disposal throughout the flight (Chand & Shastry et al., 2020; Makarenko, 2023).

When these systems malfunction, they can cause more than just inconvenience they can lead to health risks, delays, or even flight cancellations. That's why aircraft maintenance professionals need a solid understanding of how these systems work, how to maintain them, and how to quickly troubleshoot issues (Lee & Schwab, 2005; Odili et al., 2024). However, gaining hands-on experience with these systems can be a challenge. Access to working aircraft is often limited for students and trainees, making it hard to move beyond theory (Staniszewski, 2016; Latorella & Prabhu, 2017).

This project aims to change that by developing a Boeing 737 Waste/Water Training Kit a realistic, scaled-down model that lets learners engage directly with the systems they'll be working on in the field. The kit will include essential components like storage tanks, pumps, valves, and pipelines, all designed to mimic the real aircraft's setup (Parcher, 1997; Schwartz, 2010). With both mechanical and electrical parts working together, trainees can actually see how fluids move, how waste is managed, and how routine maintenance is performed (Mejías Borrero & Andújar Márquez, 2012; Swider Jr., 1974).

Unlike traditional classroom lessons, this interactive kit gives users a real feel for the systems they'll be responsible for. It's a hands-on tool that not only builds technical knowledge but also reinforces best practices, common troubleshooting methods, and ideas for improving system performance (Clark, 2011; van Heerden et al., 2022; Anoop, 2024).

At its core, this project is about bridging the gap between theory and practice. By offering a realistic training experience, the Boeing 737 Waste/Water Training Kit helps future aircraft maintenance engineers build the confidence and skills they need to succeed in the aviation industry (Jones, 2022; Gauthama et al., 2024; Edmonds, 2016; Samunderu, 2024).

1.2 PROBLEM STATEMENT

Aircraft lavatory systems might not be the first thing that comes to mind when thinking about aviation maintenance, but they play a critical role in keeping passengers comfortable, flights hygienic, and operations running smoothly. These systems are more than just toilets on a plane they're carefully designed combinations of plumbing, electrical components, and waste management mechanisms that need regular maintenance to prevent issues like leaks, blockages, or malfunctions. However, despite their importance, getting hands-on training with these systems is often a challenge for students in aircraft maintenance programs.

The reality is, most airlines can't afford to take aircraft out of service for training, and building full-scale replicas is expensive and not always practical. As a result, many students finish their training with a good grasp of the theory but very little real-world experience. That lack of practical exposure can make it harder for them to confidently diagnose and repair issues when they enter the workforce especially when it comes to systems that seem simple but are quite complex.

This is where the Boeing 737 Lavatory Training Kit can make a real difference. The idea behind this project is to give students a realistic, hands-on learning experience in a safe and controlled environment. With this kit, they'll be able to practice working with the same types of components and systems they'll encounter on the job building their skills, improving their troubleshooting techniques, and gaining the confidence they need to succeed in the aviation industry.

1.3 PROJECT OBJECTIVE

1.3 GENERAL PROJECT OBJECTIVES

- Build a Boeing 737 Lavatory Training Kit that lets students actually work with the kinds of systems they'll see on the job not just read about them.
- Create a realistic and hands-on learning setup where students can practice fixing problems and really understand how everything works, not just memorize how it's *supposed* to work.
- Help students develop practical, job-ready skills in plumbing, basic wiring, and waste system maintenance skills they'll need in the real world.
- Make training more accessible and affordable by offering a structured, classroom-friendly tool that fills the gap left by limited access to real aircraft lavatories.

SPECIFIC INDIVIDUAL PROJECT OBJECTIVES

ERAYSHAN A/L RAJESWARAN (24DAM23F1004)

Build a Boeing 737 Lavatory Training Kit that lets students work with the kinds of systems they'll see on the job not just read about them.
The idea here is simple: give students something real to work with. Instead of sitting in a classroom trying to imagine how an aircraft lavatory system works, they'll be able to see it, touch it, and operate it. This training kit is like a mini version of the real thing it has the same types of parts they'd find on a Boeing 737, just scaled down for classroom use. There's a working vacuum toilet, water pumps, valves, tanks, and even a basic control system. It's all there to show how the system works. Students can follow the path water takes through the system, understand how waste is handled, and learn what to do when something goes wrong. It's the kind of hands-on experience that helps everything click way more effective than just reading about it in a book. Plus, working with real components builds the kind of confidence and problem-solving skills they'll need when they're out there maintaining aircraft. It's not just learning it's doing.

KAVIRAJ A/L SOORAINDARAN (24DAM23F1050)

Create a realistic and hands-on learning setup where students can practice fixing problems and really understand how everything works, not just memorize how it's supposed to work. The goal here is to make sure students don't just learn *about* how things work they learn how to *fix* them when things go wrong. In the real world, aircraft maintenance isn't as simple as following a set of instructions; stuff breaks down, systems don't always work the way you expect, and that's where real problem-solving comes in.

So, this training kit is designed to be as close to the real deal as possible, with built-in problems like a pump failure or a blocked pipe that students can fix. They won't just sit there reading about what might go wrong, they'll experience it firsthand, work through it, and figure out what needs to be done to get things working again. It's about building confidence, teaching students to think on their feet, and helping them really understand how the system works not just memorizing how it's supposed to work in theory.

Help students develop practical, job-ready skills in plumbing, basic wiring, and waste system maintenance skills they'll need in the real world.
This isn’t just about theory or classroom knowledge it’s about giving students the hands-on skills they’ll use in the field. Whether they’re fixing a blocked toilet, repairing electrical connections, or keeping the waste system running smoothly, these are the kinds of real-world problems they’ll face on the job. By working with the Boeing 737 Lavatory Training Kit, students get to dive into the practical side of aircraft maintenance, learning the ins and outs of plumbing, basic wiring, and the waste management systems that are so crucial to aircraft operations.

It’s all about developing that confidence and know-how that comes with hands-on practice. They’ll be learning to troubleshoot plumbing systems, work with electrical wiring, and understand how waste systems function skills they’ll need when they’re out there maintaining actual aircraft. These aren’t just *nice-to-have* skills; they’re vital for the job, and this kit helps students master them in a real, meaningful way. It’s the kind of preparation that helps them walk into a real maintenance environment ready to handle whatever comes their way.

NAZRIL

Make training more accessible and affordable by offering a structured, classroom-friendly tool that fills the gap left by limited access to real aircraft lavatories.
Let’s face it: actual aircraft lavatories aren’t exactly something every student has access to. Real-world training can be expensive and hard to come by, especially when it comes to specialized systems like aircraft waste and water management. That’s where this training kit comes in it’s designed to bring the real-world experience into the classroom, without the huge costs or logistical challenges of working on actual aircraft.

The kit is affordable, easy to use, and built for classroom environments, so schools and training centres can offer hands-on learning without breaking the bank. Instead of relying on costly aircraft downtime or limited access to real systems, students can get all the practice they need with a tool that’s structured, reliable, and ready to go whenever they need it. This makes it possible for more schools and students to get the kind of training they need, even when they don’t have easy access to real aircraft systems.

1.4 PROJECT SCOPE

The *Boeing 737 Lavatory Training Kit* is all about turning theory into hands-on learning. Instead of just reading about aircraft lavatory systems or watching videos, this kit gives students something they can work with. It's a smaller, working version of the real waste and water system found on a Boeing 737. It includes everything from vacuum toilets and pumps to valves, tanks, pipes, and even simple electronics. The goal is to help students understand how these systems function as a whole how water flows, how waste is collected and handled, and what to do when something goes wrong. One of the coolest features is the built-in fault simulator, which can trigger common issues and guide students through diagnosing and fixing them, just like they would in the real world.

Now, while it's a great tool for learning, there are a few things to keep in mind. It's not full-size and doesn't use the exact same materials you'd find on an actual aircraft it's built with classroom use in mind, so it's safe, durable, and affordable. It's also not certified for real aircraft maintenance, and it doesn't handle real waste (thankfully!). Everything is simulated with water and safe materials. The electronics are simplified, and the fault scenarios are limited to the most common issues, so students can focus on learning the basics without getting overwhelmed. And since it's made for indoor training, it's not built to handle extreme temperatures or pressures like the real thing up in the sky.

Still, even with those limits, this kit brings a whole new level of realism and engagement to the classroom. It helps future aircraft maintenance engineers get comfortable with systems they'll see on the job and gives them the chance to practice troubleshooting in a safe, practical way. It's a smart, hands-on tool for aviation schools, technical training centres, and even other industries that deal with plumbing and sanitation systems.

1.4.2 SPECIFIC INDIVIDUAL PROJECT OBJECTIVE

ERAYSHAN A/L RAJESWARAN

Scaled-Down Model

The training kit is a smaller version of the real lavatory system found on a Boeing 737. While it demonstrates the core functionality, it doesn't offer the full-size experience of working with the actual system. This means that students won't get to interact with the larger, more complex components that they would encounter in a real aircraft. It's perfect for understanding the basics and for hands-on practice, but it doesn't capture the scale, weight, or detailed mechanics of the actual lavatory system, which limits the scope of learning for students.

KAVIRAJ A/L SOORAINDARAN

Simplified Electronics and Components

The electronics and mechanical components used in the kit are simplified to make it easier for students to work with and understand. While this makes the kit more user-friendly and less overwhelming, it also means that it lacks the advanced, intricate systems that you'd find in an actual Boeing 737. The real aircraft lavatory system includes sophisticated electronics that handle everything from pressure regulation to waste vacuuming, but the kit focuses on the basics to help students learn the principles. This makes it a great starting point but doesn't give students the full depth of experience when it comes to troubleshooting more complex systems.

ARON A ALBERT A/L ANTHONY ALBERT

Limited Fault Simulation

The fault simulation feature in the kit can trigger common issues like blockages or pump malfunctions but it’s limited to a small range of problems. It’s designed to teach students how to handle the most likely faults they might face in real-world maintenance, but it doesn’t cover every possible failure that could occur. There are many different things that can go wrong in an aircraft lavatory system, from electrical failures to unusual mechanical issues, but this kit is built to simulate just a few typical problems. While it’s great for practicing everyday troubleshooting, it doesn't expose students to all the complexities of real-world maintenance scenarios.

MUHD NADZRIL

Classroom-Only Use

This training kit is designed for use in indoor classrooms or workshop settings and isn't built to handle the extreme conditions that a real aircraft would face in the air. In an actual aircraft, lavatory systems must operate under high altitudes, fluctuating air pressures, and varying temperatures. However, this kit is made for stable environments, like classrooms, where students can safely learn how the system works. While this is fine for teaching the basics, it means students won’t experience how the system behaves under real flight conditions, which could limit their understanding of how environmental factors impact the system’s performance in a real aircraft.

PROJECT IMPACT

The Boeing 737 Lavatory Training Kit is more than just a tool it's a stepping stone toward building a new generation of confident, skilled aircraft maintenance professionals. One of the most significant impacts of this project is how it bridges the gap between classroom theory and real-world practice. For students who typically rely on textbooks or limited exposure to aircraft systems, this kit provides a much-needed opportunity to *see*, *touch*, and *work with* components in a way that traditional learning simply can't offer.

By offering a safe, controlled environment where learners can interact with a realistic simulation of the Boeing 737's lavatory system, the kit helps demystify complex components like plumbing, electrical circuits, and waste management systems. Students not only gain technical skills but also develop confidence in troubleshooting and problem-solving two abilities that are critical when working under pressure in actual aircraft maintenance settings.

This project also supports institutions by delivering a cost-effective, reusable training solution that can be integrated into classroom instruction or used for individual skill development. Schools and training centres benefit from a durable and engaging teaching aid, while industries gain graduates who are better prepared and ready to contribute from day one.

On a broader level, the project contributes to aviation safety and operational efficiency. Well-trained engineers lead to fewer in-flight issues, reduced maintenance downtime, and improved overall reliability of aircraft systems. And when lavatory systems function properly, passenger comfort and hygiene are maintained factors that play a big role in the overall flying experience.

In summary, this project doesn't just improve how students learn it enhances how they *think*, *apply*, and *grow* into professionals who can meet the real demands of the aviation industry.

CHAPTER 2

2.1 GENERAL LITERATURE REVIEW

1. Realistic Simulations That Make Learning Stick

The training kits we use , like the Boeing 737 Lavatory Training Kit, the Hydraulic System Kit, the Landing Gear Trainer, and the Safety Wire Box , are designed to give us real hands-on experience, not just theory from a book. For example, the lavatory kit doesn't just show how a toilet works; it includes plumbing, ventilation, electrical wiring, smoke detectors, and even a fire extinguisher mock-up, so we can practice fixing actual faults like clogs or leaks (Federal Aviation Administration, 2023). The hydraulic system kit helps us understand how fluid pressure moves aircraft parts like brakes and landing gear, with see-through pipes and manual pumps that let us simulate real emergencies (Kroes, Wild, & Delp, 2020). The landing gear trainer lets us practice deploying and retracting the gear, while also learning how to handle hydraulic issues just like on a real plane (De Remer, 2017). The Safety Wire Box might seem simple, but it teaches us critical skills like safety wiring, where even small mistakes matter , a lot. It even mimics vibration and gives instant feedback, helping us improve our technique (International Civil Aviation Organization, 1998). These kits also mix physical components with digital features like QR-linked tutorial videos and LED indicators, making things easier to learn (European Union Aviation Safety Agency, n.d.). And what's most important: every system includes built-in safety features, so we can train in a controlled environment and learn how to stay calm and respond correctly when things go wrong. All in all, these kits do more than just show us how systems work , they prepare us for real-life challenges in the aviation world (FAA, 2023; ICAO, 1998).

2. Understanding Fluid and Waste Systems

One of the most important things we learn from these training kits is how to properly manage different types of fluids, because fluids play a huge role in how aircraft systems function (Federal Aviation Administration, 2023). In the lavatory training kit, we work directly with the water and waste system , everything from tracing the flow of clean water to finding and fixing leaks or clogs. It's not just about flushing; we're learning how the plumbing works to keep things clean, safe, and reliable for passengers (International Civil Aviation Organization, 1998). The hydraulic kit presents a totally different kind of challenge. Here, we're dealing with high-pressure fluids that power critical systems like brakes and landing gear (Kroes, Wild, & Delp, 2020). We practice checking pressure levels, identifying leaks, and understanding how even a small issue in a hydraulic system can turn into a major safety risk if not handled correctly (De Remer, 2017). Both kits also remind us of the environmental side , like how important it is to handle fluids safely and dispose of waste the right way, to protect both people and the planet (European Union Aviation Safety Agency, n.d.). Overall, this hands-on practice gives us the real-world awareness and technical confidence we'll need on the job, where fluid systems have to be managed carefully, and mistakes can have serious consequences (FAA, 2023).

3. Making Use of Indicators and Lighting

Another really useful feature we've noticed in some of the training kits is the use of indicator lights and LED systems, which are simple but incredibly effective learning tools. Much like the warning lights on a car dashboard, these LEDs let us know if everything in the system is working properly. For instance, a green light typically means everything's good, a yellow light suggests something needs attention, and a red light signals a serious fault that needs immediate action (Federal Aviation Administration [FAA], 2023). What's great about these visual cues is that they make it much easier to spot problems, even if we don't fully understand every component of the system yet. Instead of relying solely on complex readings, we get instant feedback on the system's status (Kroes, Wild, & Delp, 2020). This helps us connect the theory we've learned in class to real-world applications inside an actual aircraft system (International Civil Aviation Organization [ICAO], 1998). It also trains us to recognize early signs of trouble and think like technicians , reacting quickly and methodically when issues arise. Plus, working with these indicators and LEDs introduces us to basic troubleshooting, like following the red light to track down exactly where the fault is. This hands-on troubleshooting process is essential for real-world maintenance, where identifying and fixing problems efficiently is crucial (De Remer, 2017).

4. Hands-On Interaction with Digital Support

One feature that stands out in the training kits is the use of indicator lights and LED systems, which have proven to be incredibly helpful for our learning. These lights work just like the warning lights on a car dashboard, giving us a quick, easy way to see if a system is running properly or if something's wrong. A green light means everything's fine, yellow tells us there's something that needs attention, and red signals a serious fault that we need to fix immediately (Federal Aviation Administration [FAA], 2023). Having these visual cues makes it so much easier to spot problems without needing to dive straight into complicated technical checks, especially when we're still getting familiar with the systems (Kroes, Wild, & Delp, 2020). It also teaches us to think like real technicians, following the clues from the indicator, tracing the issue step-by-step, and figuring out exactly where the fault lies (De Remer, 2017). This hands-on experience with LEDs doesn't just help us react faster; it also builds our confidence in troubleshooting, showing us how theory connects to real-world system behavior (International Civil Aviation Organization [ICAO], 1998). Over time, working with these lights trains us to be more observant, more methodical, and much better prepared for the kind of quick, critical thinking that real aircraft maintenance work demands (European Union Aviation Safety Agency [EASA], n.d.).

5. Safety Always Comes First

In aviation, safety isn't just important , it's everything. The training kits we're using have been designed with this in mind from the start. Every system we work on includes built-in safety features to ensure we learn not just how things should operate, but also how to react quickly and correctly when something goes wrong (Federal Aviation Administration [FAA], 2023). For example, the lavatory training kit is equipped with smoke detectors and a mock fire extinguisher, teaching us how to recognize and respond to potential fire hazards in the confined space of an aircraft lavatory (International Civil Aviation Organization [ICAO], 1998). It gives us real experience following emergency procedures like shutting down systems, alerting others, and containing a situation safely. Meanwhile, the hydraulic system kit includes an emergency shut-off valve that we can use to instantly isolate the system if a major fluid leak or pressure loss occurs (Kroes, Wild, & Delp, 2020). This isn't just about flipping a switch; it's about building the habit of staying calm under pressure and taking quick, decisive action (De Remer, 2017). Learning with these safety components shows us what it's like to deal with real emergency scenarios without the actual risks, helping us build confidence and teaching us the importance of always prioritizing safety above everything else (European Union Aviation Safety Agency [EASA], n.d.). It prepares us for working in high-stakes environments where even a small mistake could have serious consequences (FAA, 2023).

2.2 Specific Literature Review

2.2.1 Product Structure (Erayshan)

2.2.1.1 Basic Design of Main Structure

Erayshan played a key role in bringing the Boeing 737 Lavatory Training Kit to life by leading the design of its overall structure. The idea was to recreate the feel of a real aircraft lavatory , like the one found on an actual Boeing 737 , but scale it down for a classroom without losing any important features (Boeing, 2023). The final design includes a working toilet model, a functional sink with real water flow, sturdy side panels, and a lightweight, corrosion-resistant frame, built to handle regular student use and hands-on training (Kroes, Wild, & Delp, 2020). One of the most useful parts of the design is that it's easy to access and work on. With removable panels and clearly labelled components, students can easily inspect and troubleshoot issues, just like they would on an actual aircraft (De Remer, 2017).Safety was a top priority throughout the build. To help students learn emergency response procedures, the kit includes a smoke detector, a mock fire extinguisher system, and materials that are fire-retardant and safe to handle (ICAO, 1998; FAA, 2023). On the inside, the panels and layout match what students would see on a real aircraft, creating an environment that feels both authentic and professional (EASA, n.d.). To support different learning styles, the kit also includes digital tools , like QR codes that link to tutorial videos and LED indicators that help identify faults , so students can interact with the system both physically and digitally (Yadav et al., 2021). Thanks to Erayshan's focus on functionality, safety, and realism, the final kit is more than just a model , it's a powerful training tool that prepares students for real maintenance challenges (Salas et al., 2006).

2.2.1.1.1 Compliance with BIFMA Standard

We made a deliberate decision to apply BIFMA (Business and Institutional Furniture Manufacturers Association) standards during the structural development of our lavatory training kit , even though these standards are traditionally used for commercial-grade furniture. The reason is simple: BIFMA guidelines emphasize durability, safety, stability, and performance under frequent use , exactly the challenges we face in an educational setting where students interact with the kit daily (BIFMA, 2020). By following these principles, we ensured that the structural frame could handle repeated physical use without becoming unstable, deforming, or loosening over time (BIFMA, 2021). We carefully selected materials that are not only lightweight and corrosion-resistant , key factors in aviation training environments , but also meet durability benchmarks similar to those BIFMA requires for high-use furniture (Kroes, Wild, & Delp, 2020).Stress points, like the toilet mountings, sink supports, and side panel joints, were reinforced to withstand fatigue and wear from regular maintenance practice. We also designed the kit with user safety in mind: freestanding parts were built to resist tipping, and all edges were rounded to minimize the chance of injury (FAA, 2023). These small but important choices reflect real-world aircraft maintenance safety practices, where both system integrity and technician safety matter (ICAO, 1998). By integrating industry-recognized durability and safety standards, we created a training tool that’s not only realistic and effective but also built to last (Salas et al., 2006). It gives students confidence that they’re training on a system that reflects professional standards in both form and function.

2.2.1.1.2 Compliance with AN74 Aviation Regulation

To ensure our lavatory training kit closely mirrors real-world aviation standards, we aligned its design with established regulations and industry protocols. Although the kit is intended for classroom use rather than actual flight operations, adhering to these criteria helped us replicate the structure's shape, dimensions, and essential safety features (Electronic Code of Federal Regulations [eCFR], 2025). For example, we carefully positioned the toilet and sink to reflect the compact space constraints of certified aircraft lavatories, and we secured all components in accordance with FAA requirements for lavatory equipment attachment (eCFR, 2025). We specified fire-retardant panels and fittings that meet the burning-behavior standards for cabin materials (14 CFR § 25.853; eCFR, 2025; Federal Aviation Administration [FAA], 2010). Details such as minimum clearances, smooth surface finishes, and accessible maintenance points were guided by ICAO's airworthiness provisions for interior installations (International Civil Aviation Organization [ICAO], 2023). Finally, we referenced SAE's fire-test protocol for interior materials to verify that our chosen laminates and composites would perform safely under heat exposure (SAE International, 2018). By integrating these standards, we created a robust, safe training tool that prepares students for the realities of aircraft maintenance (eCFR, 2025; FAA, 2010; ICAO, 2023; SAE International, 2018).

2.2.1.2 Type of Material for Product Structure

Erayshan thoughtfully designed the lavatory training kit to ensure it was both practical and safe for student use. The frame utilizes aerospace-grade aluminium alloy, known for its exceptional strength-to-weight ratio and corrosion resistance, making it ideal for environments requiring frequent handling and repositioning without compromising structural integrity (Industrial Metal Service, 2024; NIST, 2003). This choice ensures the kit remains durable yet lightweight, facilitating ease of movement during classroom activities. For the side panels and interior surfaces, high-pressure laminate (HPL) sheets and flame-retardant composite panels were selected. HPL is recognized for its durability and fire-resistant properties, igniting only at higher temperatures (~400°C), thus enhancing safety in educational settings (ICDLI, 2019; Nevamar, 2018). These materials also replicate the aesthetic of actual aircraft interiors, providing students with a realistic training environment.

Transparent access panels made from polycarbonate and reinforced acrylic were incorporated to allow students to observe internal systems safely. Polycarbonate is valued for its high impact resistance and clarity, making it suitable for applications where visibility and safety are paramount (Covestro, n.d.; FAA, 2003). Reinforced acrylic adds structural strength while maintaining transparency, ensuring durability under repeated use (American Acrylic Corporation, n.d.). To minimize the risk of injury and wear, soft-edged rubberized trims were added to high-contact areas. Materials like EPDM rubber are commonly used for edge protection due to their flexibility, durability, and resistance to environmental factors (Protalwell, n.d.). These trims help prevent injuries and protect the kit from damage during regular use. Each material was carefully chosen to ensure the training kit is lightweight, durable, and safe, capable of withstanding the daily demands of aviation maintenance training. Erayshan's meticulous attention to material selection and design details resulted in a realistic and long-lasting educational tool that effectively prepares students for real-world aviation maintenance tasks.

2.2.1.2.1 Selection of Aluminium Alloy

We chose aluminium alloy for the base of the lavatory training kit because it just makes sense for how the kit will be used in the classroom. It's light enough that students and instructors can move it around easily during training sessions, but still strong enough to hold up under repeated use. What's great about aluminium , especially the types commonly used in the aerospace industry like 6061 , is that it's both tough and resistant to wear, which is perfect when you're building something that will get handled a lot (Dursun & Soutis, 2014). We also didn't want to worry about rust or corrosion, especially with water systems involved, so aluminium's natural resistance to those problems made it an easy choice (Davis, 1999).Another big plus is that aluminium doesn't just help with performance , it helps with safety too. It holds its shape well under stress and doesn't fatigue easily, which is something engineers really value in aircraft parts and, by extension, training tools like ours (Polmear et al., 2017). And because we're using this in an educational setting, we also liked that aluminium is recyclable and non-toxic, which fits our goal of keeping the kit environmentally friendly and safe for everyday use (The Aluminium Association, 2023). The combination of strength, light weight, durability, and corrosion resistance made aluminium the perfect base material for our kit , helping us build something that lasts and keeps students safe while they learn.

2.2.1.2.2 Selection of Composites

When it came to repairing the lavatory training kit, we carefully selected materials that would restore its function while keeping it durable and realistic for hands-on student use. Fiberglass, paired with epoxy and polyester resins, was used to repair cracks or damage in parts like the sink, toilet, and panels. This combination is lightweight, moisture-resistant, and strong , making it ideal for components exposed to frequent handling and water (Davis, 2004; Smith & Hashemi, 2006). For transparent panels, we used acrylic sheets, which are known for offering great impact strength and optical clarity, allowing students to view internal systems safely (Kosar & Keskin, 2019).

We also added polyurethane foam for internal structural support, as it's light but provides excellent shape retention and insulation (Zafar et al., 2022). To prevent water leakage , especially around joints and the base of the toilet and sink , we applied rubber and silicone seals, both of which are widely used for their flexibility and sealing reliability in both plumbing and aerospace applications (Bralla, 2007). For repairing surface panels, High-Pressure Laminate (HPL) was chosen because of its scratch resistance, water resistance, and ability to simulate aircraft interior textures (Keding, 2023; Material Intelligence, n.d.).

2.2.2 Product Mechanisms (Kaviraj)

2.2.2.1 Type of Hinges

When it came to the mechanical bits of our lavatory training kit, Kaviraj knew hinges would make or break the experience , students are constantly opening and closing those doors and panels, so they had to feel just right (Norton, 2021). After trying out several options, he settled on concealed stainless-steel hinges because they're rock-solid, slide open smoothly, and won't loosen up after dozens of uses (Kroes, Wild, & Delp, 2020). Plus, stainless steel stands up to moisture from our simulated water systems without rusting (Callister & Rethwisch, 2020; ASTM International, 2021), and hiding the hinges under the skin of the panel means there's nothing to catch on clothes or tools. During installation, Kaviraj tweaked the hinge tension so each door swings with a reassuring "thunk" and closes just as smoothly , exactly what you'd expect from a real aircraft service door (Federal Aviation Administration, 2008). All those little details come together to give students a genuine, hands-on feel and help them build the right habits for working on real aircraft down the road.

2.2.2.2 Type of Electrical Motor

When Kaviraj suggested adding motors, he knew it would turn our kit from a static mock-up into something you can really interact with (Norton, 2021). We fitted a small fan so you can actually hear and see airflow , just like the real cabin circulation system , and a motorized flush that replicates the suction action of an aircraft toilet (Federal Aviation Administration [FAA], 2023; Moir & Seabridge, 2011). It's one thing to read about these systems, but when the fan jams or the flush feels weak, you get to troubleshoot it for yourself , exactly the kind of hands-on problem solving you'll do on the job (Kroes, Wild, & Delp, 2020). To keep everything running smoothly, we chose brush-type DC motors rated for continuous duty, so you don't have to worry about overheating during back-to-back training sessions (Fitzgerald, Kingsley, & Umans, 2013). Those moving parts really bring the lesson home , and give students the chance to build confidence before they ever step foot in a real hangar.

2.2.2.2.1 Selection of AC Motor

Picking the right motor was a big deal, so Kaviraj dove into the options and settled on a 24 V low-voltage AC motor (Norton, 2021). AC motors are known for being tough and simple , fewer parts to break means they'll handle all those student demonstrations without complaining (Fitzgerald, Kingsley, & Umans, 2013). Keeping it at 24 V also makes things a lot safer , so even if someone wires up a switch wrong or gets in a hurry, the shock risk is minimal (Federal Aviation Administration [FAA], 2023). Plus, AC motors play nicely with basic relays and toggles, which keeps our control panel newbie-friendly.

We also wanted to keep things realistic: real aircraft often run small fans and pumps on AC power. While planes use 115 V or 230 V, our 24 V setup mimics the same motion safely and affordably (Moir & Seabridge, 2011). In the finished kit, one motor powers the little ceiling fan to show cabin airflow, and the other drives a flap in the toilet to reproduce that unmistakable flush suction (Kroes, Wild, & Delp, 2020). Both tie into our Arduino controller, so students can flip a switch, watch the motor spin , and troubleshoot if it hiccups , just like they'll do on the job one day.

2.2.3 Software / Programming (Aron)

2.2.3.1 Types of Software for Output Display

When it was time to make our lavatory trainer interactive, Aron jumped right in and chose Arduino as the brain behind it all (Monk, 2013). He wired up LEDs, sensors, and small motors so students can instantly see if the water tank's full, hear the ventilation fan spinning, or spot a fault light up (Banzi & Shiloh, 2014). But he didn't stop at "it works" , Aron also programmed realistic glitches, like a mock water leak or a stalled fan, so you get to diagnose and fix problems just like on the job (Margolis, 2011; Kroes, Wild, & Delp, 2020). All the controls sit on a simple panel , flip a switch, watch the display, and learn how aircraft systems behave in real time. Thanks to his setup, the kit isn't just a model; it's a hands-on workshop where you practice the exact troubleshooting skills you'll need in maintenance hangars (Moir & Seabridge, 2011).

2.2.3.2 Types of Arduino Board

When it came to wrangling all those sensors, motors, and LEDs, Aron needed a controller that was rock-solid, simple to set up, and proven in countless maker projects (Monk, 2013). He tested a few boards but landed on the Arduino Uno, and it turned out to be perfect (Banzi & Shiloh, 2014). Its easy USB hookup and massive online community meant we were up and running in minutes, while the dependable ATmega328P chip kept everything humming along smoothly through back-to-back student demos (Arduino, 2017). Plus, the Uno's mix of digital and analog pins matched our I/O needs exactly, so wiring up fans, flush sensors, and status LEDs was a breeze. All in all, the Uno gave us the stability of more complex controllers but stayed beginner-friendly , just what a training kit needs.

2.2.3.2.1 Selection of a Suitable Arduino Board

When it comes to plugging in sensors, motors, and LEDs, the Arduino Uno really checks all the boxes. It's got just enough digital and analog pins to hook up water-level sensors, drive the fan and flush motors, and light up status LEDs , without ever making you worry about crashing the system (Arduino, 2017). What's more, it's built for beginners: the programming environment is so straightforward that students can upload new sketches or trace a wiring hiccup in no time (Monk, 2013).

Because the Uno works seamlessly with a huge range of modules , think ultrasonic water-level sensors or simple LCD displays ,Aron could keep wiring tidy and expand the kit's capabilities on the fly (Banzi & Shiloh, 2014). And let's not forget budget and wear-and-tear: the Uno is both affordable and tough. If a board takes a hit during hands-on labs, swapping in a fresh one won't break the bank (Margolis, 2011).

In the end, Aron's choice of the Uno tied everything together. His code doesn't just flip bits to spin motors—it gives students a genuine, hands-on look at how software, electronics, and real aircraft systems all talk to each other in the field. It's not a model you watch from afar , it's one you live.

2.2.4 Accessories & Finishing (Nadzril)

2.2.4.1 Typical Accessories on Aircraft Lavatory

Although our main focus was building a functional lavatory training kit, Nadzril had the vision to enhance it further. He realized that small finishing touches could significantly impact how realistic and immersive the experience felt for students. His idea was straightforward , the more closely the setup resembled a real aircraft lavatory, the more seriously students would engage with the training.

With that in mind, Nadzril carefully incorporated familiar lavatory accessories you would find on an actual aircraft. He included a soap holder, a towel dispenser, a waste compartment, and a designated mirror space. Each accessory was not randomly placed ,he thoughtfully positioned them based on the typical layout inside an aircraft lavatory to create an authentic environment.

For example, the waste compartment was designed with a spring-loaded flap, closely replicating the one found in real aircraft. The soap holder and towel dispenser were selected for their sturdy design and easy-to-clean surfaces, aligning with aviation standards for hygiene and maintenance. The mirror space was also strategically placed above the sink area, just like in a real lavatory.

2.2.4.2 Types of Materials Used in Aircraft Lavatory

Although aircraft lavatories don't typically use fabric-covered surfaces like passenger seats, we still had to think carefully about the materials used inside our training kit. In aviation, material selection is not just about appearance , it's about safety, durability, and ease of maintenance. Nadzril made sure we applied the same principles when choosing materials for the training unit.

Instead of traditional fabrics, materials like vinyl and ABS plastic were used for most of the surfaces. These materials are common in actual aircraft lavatories because they are flame-retardant, lightweight, durable, and easy to clean , all essential features for maintaining hygiene and ensuring fire safety in a high-traffic area.

Vinyl was chosen for areas needing a smooth, wipeable finish, while ABS plastic was used for structural parts such as waste compartment covers and side panels. Both materials are tough enough to withstand daily handling and cleaning, which was perfect for a training kit intended for frequent student use.

By selecting aviation-grade materials, we gave the kit a more professional and authentic feel. More importantly, it allowed students to experience working with surfaces and fittings that closely match those found in real aircraft, helping them build confidence and familiarity for future maintenance tasks.

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

When we started building our training kits, we knew that guessing or building from scratch wasn't enough. Real aircraft systems are designed with years of engineering behind them, and when it comes to aviation, safety leaves no room for mistakes. To make sure our designs were realistic, functional, and safe, we researched existing patents from the aviation industry. These patented ideas guided our designs, offering insight into how professionals develop systems that both simulate real aircraft conditions and train technicians effectively. Below are the major patents that inspired each part of our project.

2.3.1.1 Patent A – Lavatory Training Kit (Erayshan)

Patent Reference: US7604182B2

Aircraft lavatories are much more complex than they appear. Beyond the basic plumbing, they must manage water circulation, air quality, waste disposal, fire safety, and even odor control , all within the tight, pressurized cabin environment. Patent US7604182B2 details a lavatory training module that replicates all of these critical elements.

The patent introduces features like functional water systems, active ventilation, real waste management simulation, and integrated fire detection devices. It emphasizes hands-on practice, allowing trainees to experience not just everyday operation, but also emergencies like water leaks, air blockages, or fire alarms.

Following this idea, we designed our Boeing 737 Lavatory Training Kit to feel like stepping into a real aircraft lavatory. Water flows realistically through the system, air vents are placed as in actual aircraft, and a mock fire detector is included to train students on fire hazard management. Inspired by this patent, our focus was not just making a "working model," but creating a *training environment* that makes students think and act like real aviation technicians.

2.3.1.2 Patent B – Hydraulic Training Kit (Nadzril)

Patent Reference: US8938400B1

Hydraulic systems are the heart of an aircraft's movement , powering landing gears, brakes, flight controls, and more. Patent US8938400B1 describes a hydraulic training system that simulates the full hydraulic operation of an aircraft, but with built-in safety and teaching mechanisms.

The standout features in this patent are its focus on closed-loop hydraulic simulation, pressure feedback monitoring, and emergency failure simulations. Trainees can experience not only how hydraulic systems operate under normal conditions but also how to recognize, troubleshoot, and respond to faults like leaks, pressure loss, or actuator failure.

This heavily influenced Nadzril's design for the Hydraulic Training Kit. Our kit mirrors real aircraft systems with simulated pumps, valves, and actuators. It allows students to observe fluid flow, identify pressure anomalies, and practice responding to simulated failures. Like the patent, our kit was built not just for "operation," but to train students how to think critically, troubleshoot quickly, and maintain safety even when problems occur.

2.3.1.3 Patent C – Landing Gear Training Kit (Kaviraj)

Patent Reference: US7481414B2

Landing gear systems must absorb massive forces during takeoff and landing, and any failure can be catastrophic. Patent US7481414B2 outlines a training system that simulates landing gear operation, focusing on the extension, retraction, and emergency override processes.

The key advantage of this patent is that it teaches students about *normal and abnormal* gear operations. It lets learners manually test hydraulic actuators, shock absorbers (oleos), and wheel brakes while also handling fault scenarios like gear lock failures or manual emergency releases.

Kaviraj's Landing Gear Training Kit follows this concept closely. Our model allows students to see and feel gear movement, operate hydraulic systems, and practice reacting to faults like stuck gear or pressure drops. Realistic oleos and struts simulate the landing impact forces, giving learners a full appreciation of how critical gear operation is for flight safety. Just like the patent intended, we made sure students would understand both the mechanical systems *and* how to act when they fail.

2.3.1.4 Patent D – Safety Wire Training Kit (Aron)

Patent Reference: US5941615A

In aviation maintenance, even a simple loose bolt can lead to disaster. Safety wiring is the small but critical art of locking fasteners securely so they can't vibrate loose. Patent US5941615A describes a training device that helps students practice these techniques, focusing on precision, vibration resistance, and correct installation.

The training system in the patent emphasizes hands-on skill building, offering different setups for students to practice single and double wire techniques under simulated aircraft conditions. It also suggests providing visual and step-by-step feedback so students can self-correct and master the skill.

Aron's Safety Wire Training Kit was directly inspired by this approach. It provides students with real aircraft-grade fasteners, drilled plates, and the chance to practice wiring techniques exactly as they would on engines, landing gear, or hydraulic systems. Clear instructions and QR code guides ensure that students can check their work and build muscle memory, just as the patent recommends. Our goal was to turn careful students into confident, precise technicians , because in aviation, precision is not optional; it's survival.

2.3.2 Recent Market Products

2.3.2.1 Product A – Lavatory Training Kit (Erayshan)

Reference Product: Jeppesen Lavatory Trainer

When it comes to lavatory training kits, Jeppesen's full-size lavatory trainer is considered the gold standard, and it's easy to see why. It's not just a basic model; it's built to be a full working system, complete with real water flow, electrical panels, and even smoke detection simulations.Students using the Jeppesen trainer don't just "look at" a lavatory; they work with it like it's on an actual aircraft. They troubleshoot leaks, deal with electrical faults, and learn how fire safety systems fit into such a tight, complicated space.This inspired us to make sure our Boeing 737 Lavatory Training Kit wasn't just realistic on the surface, it needed to function and react like a real lavatory would. Following Jeppesen's example, we built in hands-on challenges so students aren't just learning how things work when everything goes right; they're learning how to fix things when they go wrong.

2.3.2.2 Product B – Hydraulic Training Kit (Nadzril)

Reference Product: ATC HPU-900 Hydraulic Training System

The ATC HPU-900 is one of those training systems that immediately grabs your attention. Its design is all about visibility and interaction, with clear, see-through piping, big pressure dials, and switches that let students control and troubleshoot the hydraulic flow themselves.What's even better is that the system can simulate faults like leaks, pressure loss, or blocked lines. Students aren't just watching a demonstration , they're actively diagnosing real problems, just like they would on an actual aircraft.For our Hydraulic Training Kit, we knew we wanted that same kind of active learning. Inspired by the HPU-900, we made sure students could watch the system at work, find issues, and practice repairs. The goal wasn't just to show how hydraulics function , it was to train students to think and act like real aviation technicians under real pressure.

2.3.2.3 Product C – Landing Gear Training Kit (Kaviraj)

Reference Product: TechSim 737LG Landing Gear Trainer

TechSim's 737LG landing gear trainer is one of the most rugged and realistic kits out there. It doesn't just show students how landing gear works , it lets them physically operate full deployment and retraction cycles, with real hydraulic feedback.Even better, it allows students to experience and solve simulated gear failures , like what happens if the gear jams or if hydraulic pressure is lost mid-cycle. They can also practice using emergency manual overrides, which is a critical part of real-world aircraft maintenance.Kaviraj's Landing Gear Training Kit took heavy inspiration from this. Just like TechSim's model, we wanted ours to offer students a full system experience, not just how the landing gear works when everything's perfect, but also how to react when things don't go as planned. That's the kind of experience that builds real confidence.

2.3.2.4 Product D – Safety Wire Training Kit (Aron)

Reference Product: Snap-on Aircraft Safety Wiring Training Kit

Snap-on's Aircraft Safety Wiring Kit proves that even simple tasks deserve serious training tools. Their kit comes with everything a student needs , different types of wires, real aircraft-grade fasteners, and detailed instructions for perfecting techniques like the double-twist, single-wire, and spiral wrap.What's great about it is the way it focuses not just on "how" to do the wiring, but also why proper safety wiring is so important , to prevent vibration from loosening fasteners and putting lives at risk. For our Safety Wire Training Kit, we wanted the same thing: not just practicing the motions, but understanding the responsibility behind every single twist of the wire. Following Snap-on's example, we built realistic wire setups and gave students the opportunity to get real hands-on practice, because in aviation, small mistakes can have big consequences.

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECTS

2.4.1 Lavatory Kit: Patent A vs. Product A vs. Erayshan's Kit

The lavatory training module described in Patent A and commercialized by Jeppesen focuses heavily on replicating the operational systems of an aircraft lavatory, including water flow, electrical components, and fire safety features. These designs emphasize technical accuracy and functional reliability.Erayshan's Lavatory Training Kit built upon this foundation by enhancing visual and interactive elements to support a deeper learning experience. He incorporated transparent piping to allow direct observation of water flow, and LED indicators to highlight system status and fault conditions in real-time. In addition, QR-linked instructional videos were integrated to offer students immediate access to maintenance procedures during hands-on training. A mock fire extinguisher and smoke detection system were also included to simulate emergency response scenarios.These enhancements transformed the traditional static training model into a dynamic, immersive learning environment, promoting better understanding of both routine maintenance and emergency procedures.

2.4.2 Hydraulic Kit: Patent B vs. Product B vs. Nadzril's Kit

Both Patent B and the ATC HPU-900 hydraulic trainer present highly detailed simulations of aircraft hydraulic systems, suitable for professional-level training. However, these models are typically large, expensive, and less accessible for everyday classroom use.Nadzril addressed these limitations by designing a compact, modular Hydraulic Training Kit that retains key technical features while improving usability for students. The system includes transparent hydraulic lines for visual inspection of fluid movement, LED fault indicators for instant system feedback, and a manual pressure pump that allows students to physically generate and manage hydraulic pressure during exercises. By balancing technical depth with simplicity and portability, Nadzril's design ensures effective, hands-on learning that is well-suited for academic environments without sacrificing essential industry knowledge.

2.4.3 Landing Gear Kit: Patent C vs. Product C vs. Kaviraj's Kit

Landing gear trainers, such as those outlined in Patent C and offered by TechSim, accurately replicate gear extension, strut compression, and braking systems. While they provide excellent operational realism, they are often large, complex, and costly to maintain. Kaviraj developed a scaled, cost-effective Landing Gear Training Kit that successfully simulates essential landing gear operations, including hydraulic extension and retraction, oleo strut behaviour, and brake actuation. The model incorporates LED status indicators and user-friendly control systems, allowing students to monitor gear conditions and practice troubleshooting procedures effectively. This approach made the system more accessible and manageable, ensuring that students could thoroughly understand complex mechanical operations without the need for large, expensive equipment.

2.5.4 Safety Wire Kit: Patent D vs. Product D vs. Aron's Kit

Traditional safety wiring training kits, as described in Patent D and provided by manufacturers like Snap-on, focus primarily on developing basic hand skills through repetition and standard techniques.Aron expanded on this concept by introducing a more interactive and outcome-focused design. His Safety Wire Training Kit includes QR-coded instructional guides, an error-based scoring system that provides immediate feedback on wire tension and installation quality, and a simulated vibration module to test the integrity of wire locks under realistic conditions. This innovative approach not only strengthens the students' practical skills but also emphasizes critical thinking and attention to detail, both of which are crucial for real-world aircraft maintenance tasks.

3.1.1 Utilisation of Polytechnic's Facilities

Throughout the development of the Boeing 737 Lavatory Waste Water Training Kit, our group made extensive use of the facilities provided by Politeknik Banting Selangor, which played a crucial role in ensuring the success and quality of the project. Most of the fabrication work was carried out in the Aircraft Maintenance Workshop, where we had access to essential tools such as cutting and drilling machines, wrenches, pipe sealers, and testing equipment. These facilities allowed us to construct and assemble the structural and mechanical components of the kit safely and accurately.

In addition, the electrical laboratory was used to conduct the wiring, circuit testing, and performance checks for the pump and indicator systems. The space provided a safe and controlled environment where we could test the electrical load and ensure the system operated efficiently without the risk of short circuits or overheating. The CAD laboratory was also utilized for the design phase, where we created technical drawings, layout plans, and visual diagrams using design software to ensure precise measurements and proper component placement.

During the entire process, our group followed strict safety procedures as required by the Polytechnic's workshop regulations. This included wearing appropriate personal protective equipment (PPE) such as safety goggles, gloves, and lab coats. We also carried out risk assessments before starting each major task to identify possible hazards like water spillage, electrical faults, or tool-related injuries. Every group member played an active role in maintaining a safe working environment, ensuring that all activities were completed without accidents or equipment damage. Overall, the support and facilities provided by Politeknik Banting Selangor greatly enhanced our ability to complete the project successfully and with a high level of professionalism.

3.1.2 Project Collaboration & Transfer of Technology

The Boeing 737 Lavatory Waste Water Training Kit was developed through a strong sense of teamwork and collaboration among all group members, guided by lecturers and instructors from Politeknik Banting Selangor. Although there was no direct partnership with outside industries, the project was inspired by the actual design and operation of aircraft lavatory systems used in commercial aircraft such as the Boeing 737. We studied reference materials, technical manuals, and online resources to understand the system's working principles, which we then adapted into an educational model suitable for classroom use.

Within our group, collaboration played an essential role in achieving the final outcome. Each member contributed specific skills and knowledge in areas such as structural design, plumbing connections, electrical wiring, system testing, and report writing. This allowed for the effective transfer of technical knowledge among team members, where everyone learned something beyond their own area of focus. Regular group discussions and problem-solving sessions were conducted to address challenges like water leakage, electrical faults, and pressure inconsistencies. This not only improved our technical understanding but also developed our teamwork, leadership, and communication skills — all of which are vital in the aviation industry.

Furthermore, guidance from our supervising lecturer helped us understand how to apply classroom theories into real practical work. The project also introduced us to the concept of technology adaptation, where we simplified complex aircraft systems into safe and functional training equipment that can be used in an educational setting. This experience has encouraged our group to think innovatively and explore ways to develop similar simulation trainers for other aircraft systems in the future. Overall, the collaboration and shared learning process throughout this project contributed greatly to our growth as students and future aviation professionals.

3.2 OVERALL PROJECT GANT CHART

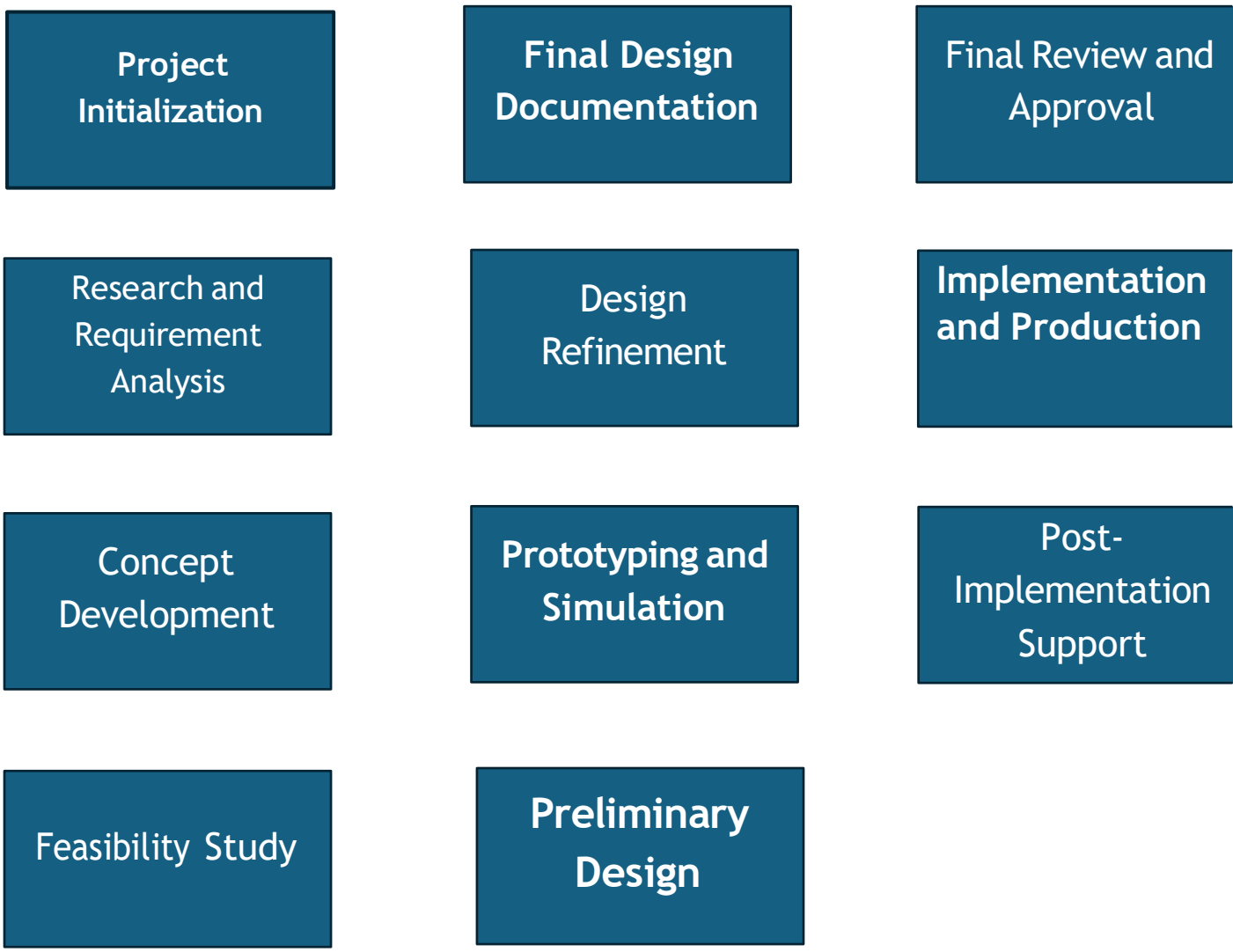
PRODUCT ACTIVITIES	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Brainstorming And Idea															
Questionare data question															
Project Proposal and Approval															
System Dessign and Blueprint															
Material and Component Selection															
Cost Estimation and Procurement															
Prototype Fabrication															
System Intergration															
Initial Testing and Debugging															
Prototype Refinement															
Performance Testing															
Refinement and Troubleshooting															
Safety and Compliance Check															
Report Writting and Documentation															
Final Presentation and Submission															

3.3 PROJECT FLOW CHART

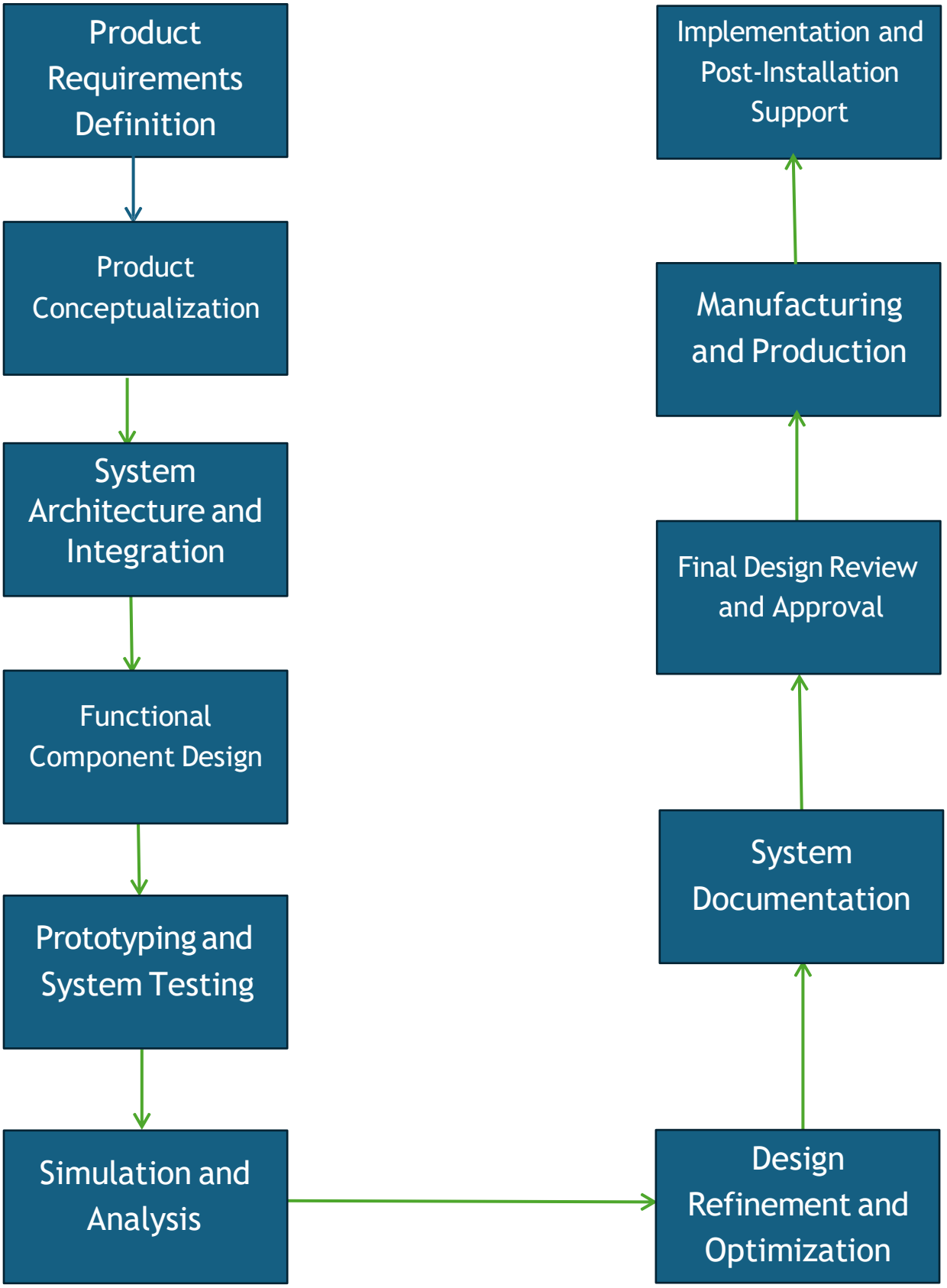
3.3.1 Overall Project Flow Chart


Group Formation
Briefing and Generate Project Idea
Idea Presentation
Project/Idea Selection: Boeing 737
Idea Accepted by Supervisor
Complete Assignment Chapter 1:
Submit registration form
Research current aircraft lavatory systems and issues
Generate scope, impact, and project aim
Attach findings with appendices
Submit Assignment 1
Assign individual roles
Search on technical problems in aircraft lavatories
Identify potential areas for improvement
Create a 3D sketch of the lavatory system
List of materials
Complete Assignment Chapter 2: Literature Review
Submit Assignment 2
Project drawing using AutoCAD
Define system components Include safety compliance with
Complete Pre-Proposal Presentation Slides
Pre-Proposal Presentation
Present to panel in 5 minutes
Product accepted with required improvements
Improve lavatory design based on panel comments
Submit Assignment Chapter 3
Submit Final Proposal C Panel Review by 4 members
Presentation of Complete Proposal (after corrections)
Final Presentation
Submit final system documentation
Marks awarded based on individual contribution
Complete Chapter 3: Research Methodology

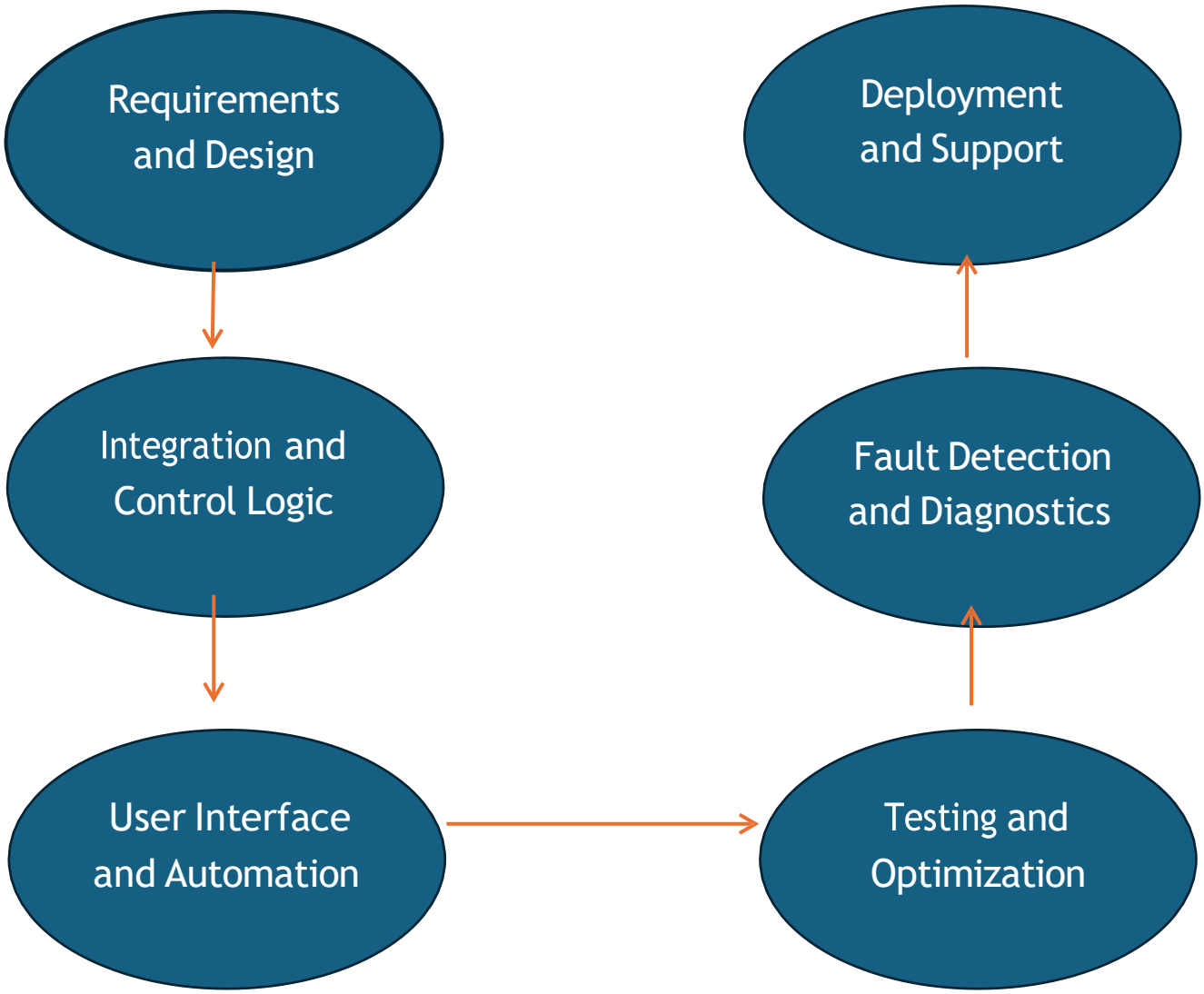
3.3.2.1 Product Structure



3.3.2.2 Product Mechanisms



3.3.2.3 Software / Programming

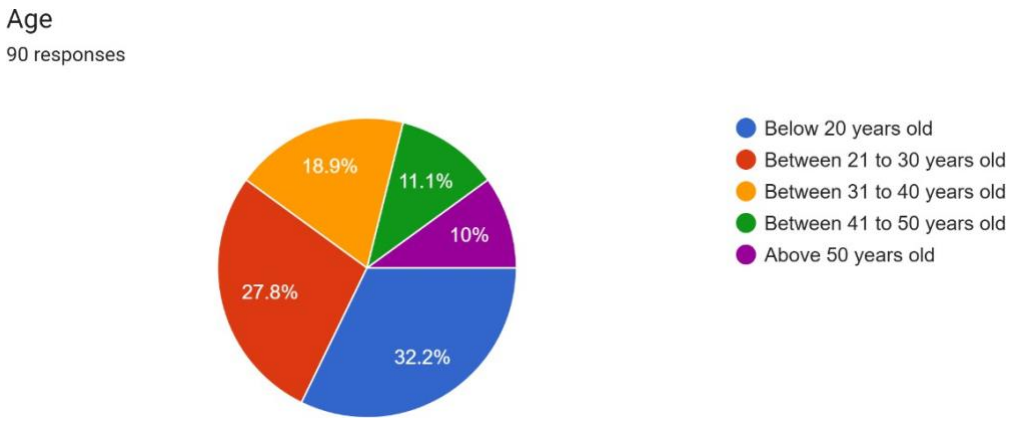


3.4.1 DESIGN REQUIREMENT ANALYSIS

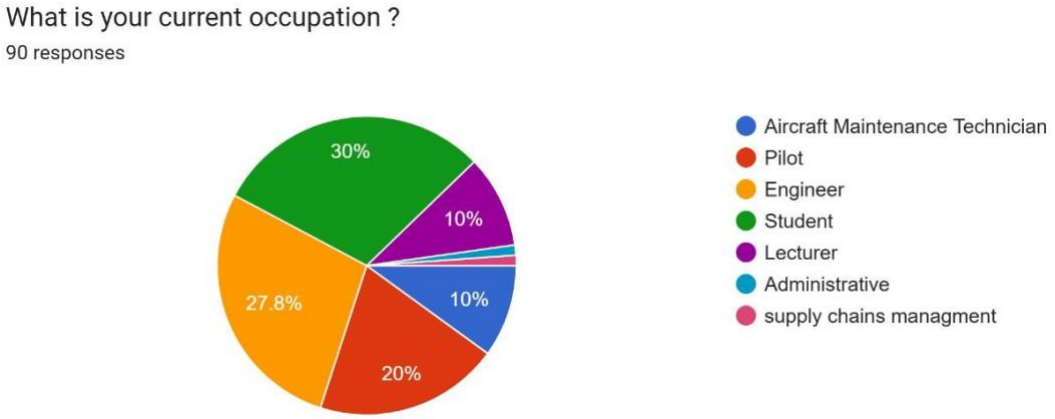
3.4.1.1 QUESTIONAIRE SURVEY

DEMOGRAPHIC INFORMATION

The survey gathered 90 responses from a mix of ages. The largest group (32.2%) was under 20, while 27.8% were between 21 and 30 years old. The rest were split between 18.9% (31-40), 11.1% (41-50), and 10% (over 50). This shows a blend of younger students and more experienced professionals.

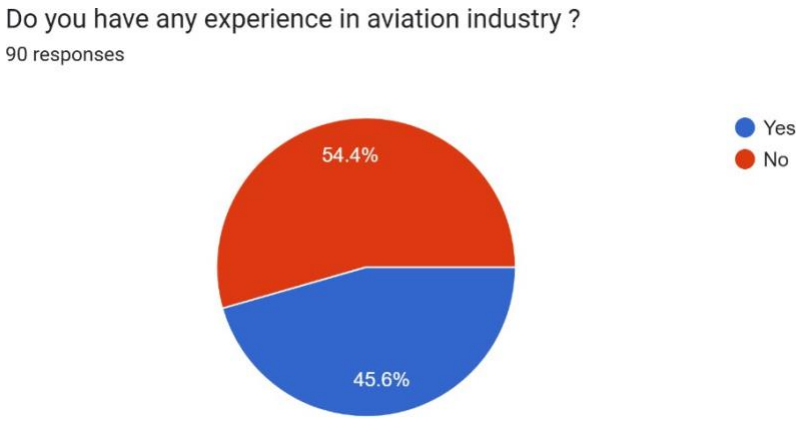


Out of the 90 responses, most were from students (30%), followed by engineers (27.8%), pilots (20%), and aircraft maintenance techs and lecturers (10% each). There was also a small representation from admin and supply chain sectors, adding some diversity to the feedback.



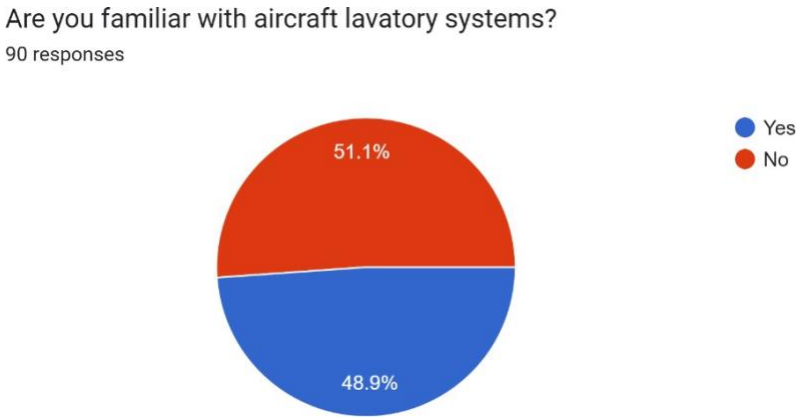
More than half of the respondents (54.4%) didn't have a background in aviation, while the other 45.6% had some experience in the field. This mix of newcomers and veterans

gives a well-rounded perspective on how important practical training in aircraft maintenance really is.



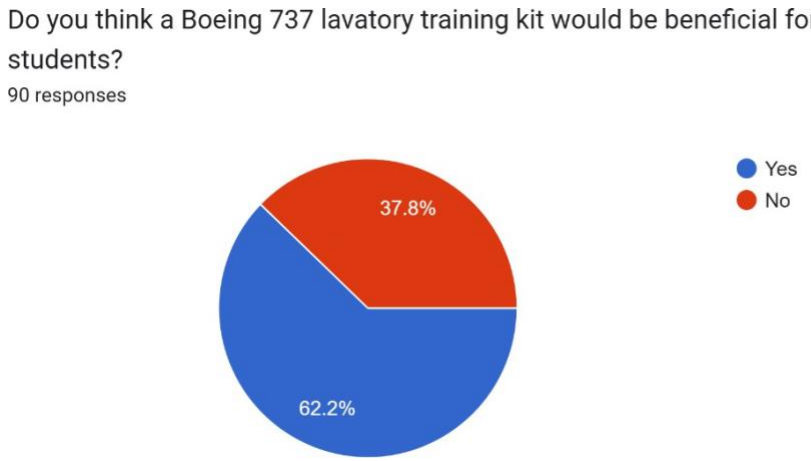
FAMILIARITY WITH AIRCRAFT LAVATORY SYSTEM

When asked about their familiarity with aircraft lavatories, 51.1% (46 people) weren't familiar with the systems, while 48.9% (44 people) had some knowledge. This highlights the need for more training in this area, as many still don't have a full grasp of how the systems work.



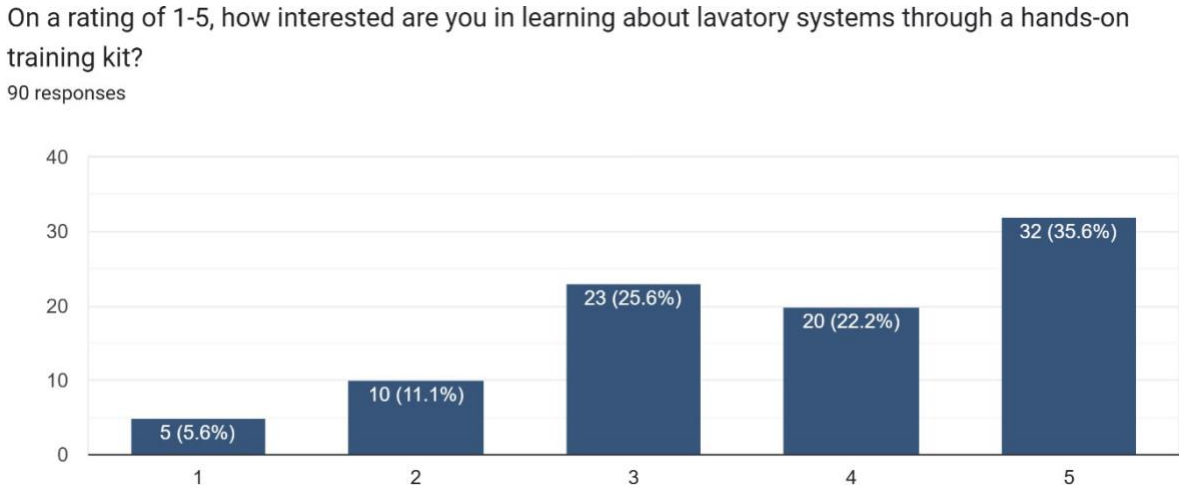
A strong majority (62.2%, or 56 respondents) thought that a Boeing 737 lavatory

training kit would be really beneficial for aircraft maintenance students, with 37.8% (34 people) disagreeing. This shows a clear demand for practical tools to help students in their learning.



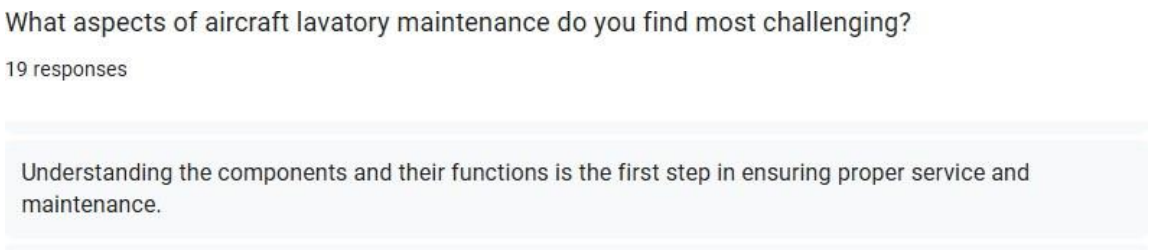
AUDIENCE INTEREST IN TRAINING KIT

When asked about their interest in a hands-on training kit, most gave it a solid score of 3.71 out of 5. 35.6% (32 people) rated it a perfect 5, showing strong enthusiasm, while 22.2% (20 people) gave it a 4. Some were more neutral (25.6% rated it a 3), but overall, there was a lot of excitement about the idea of getting practical experience with the kit.

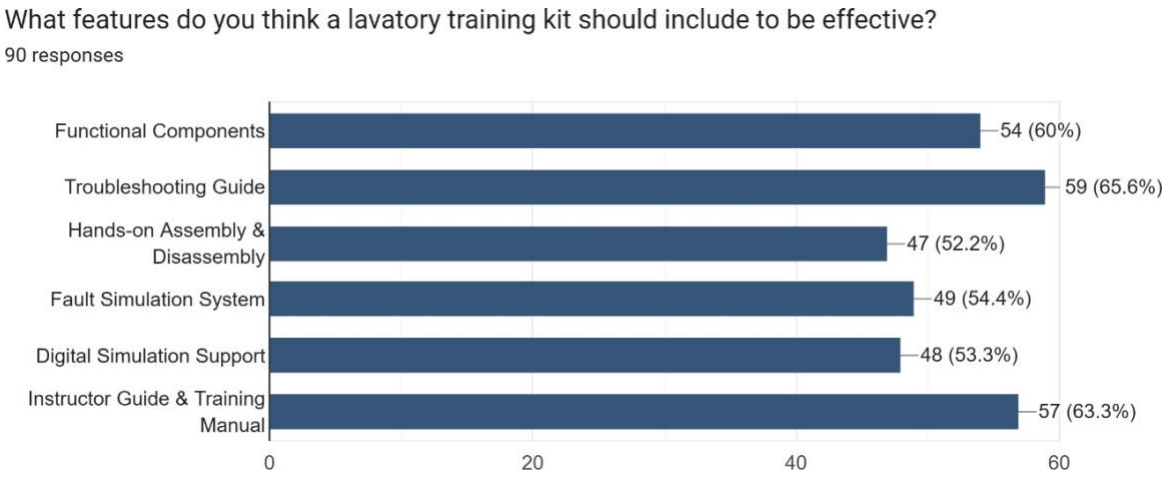


CHALLENGES IN LEARNING

A lot of respondents noted that one of the biggest challenges in lavatory maintenance is understanding the different parts and how they all work together. This knowledge is essential for troubleshooting and making sure the systems are running smoothly.



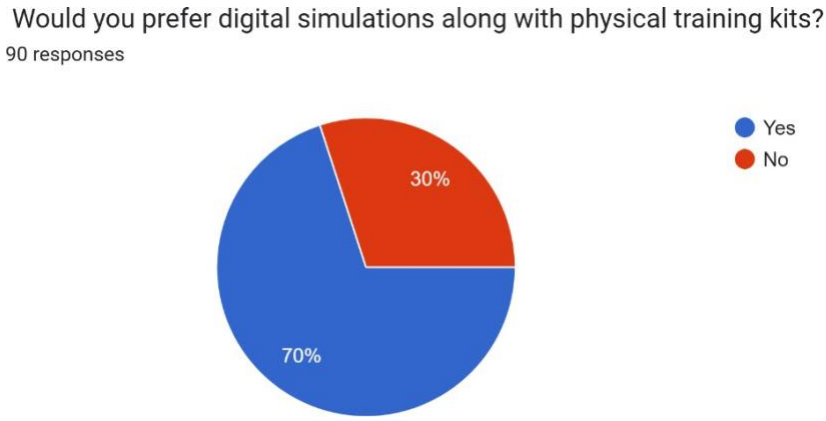
The survey showed that 65.6% of people felt a troubleshooting guide would be key for the training kit's effectiveness. Similarly, 63.3% said an instructor guide and manual were important. Other features like functional components (60%), fault simulation (54.4%), and digital support (53.3%) were also highlighted as essential for creating an effective training experience.



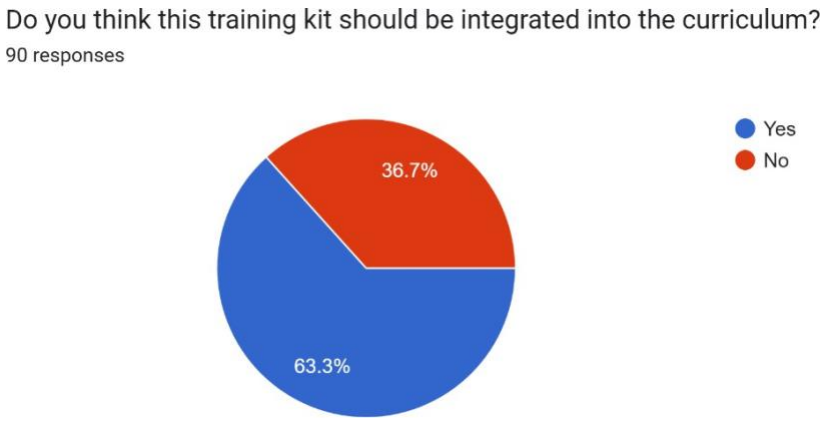
TARGETTED AUDIENCE NEEDS

A large group (63 out of 90) favored combining digital simulations with physical training kits, while 27 disagreed. This shows that most people see the value in blending traditional

hands-on experience with digital resources to help students better understand aircraft lavatory systems.



When asked about adding the training kit to educational programs, 57 respondents were in favour, and 33 felt it might not be necessary. This suggests a strong belief in the importance of practical, hands-on learning tools for improving students' understanding of maintenance systems.



A significant number of people (73) gave feedback on how to improve the kit, with many suggesting it should be more engaging and fun to use. This reflects the need for

interactive and enjoyable features that would keep students interested and make learning more effective.

3.4.1.2 PARETO DIAGRAM

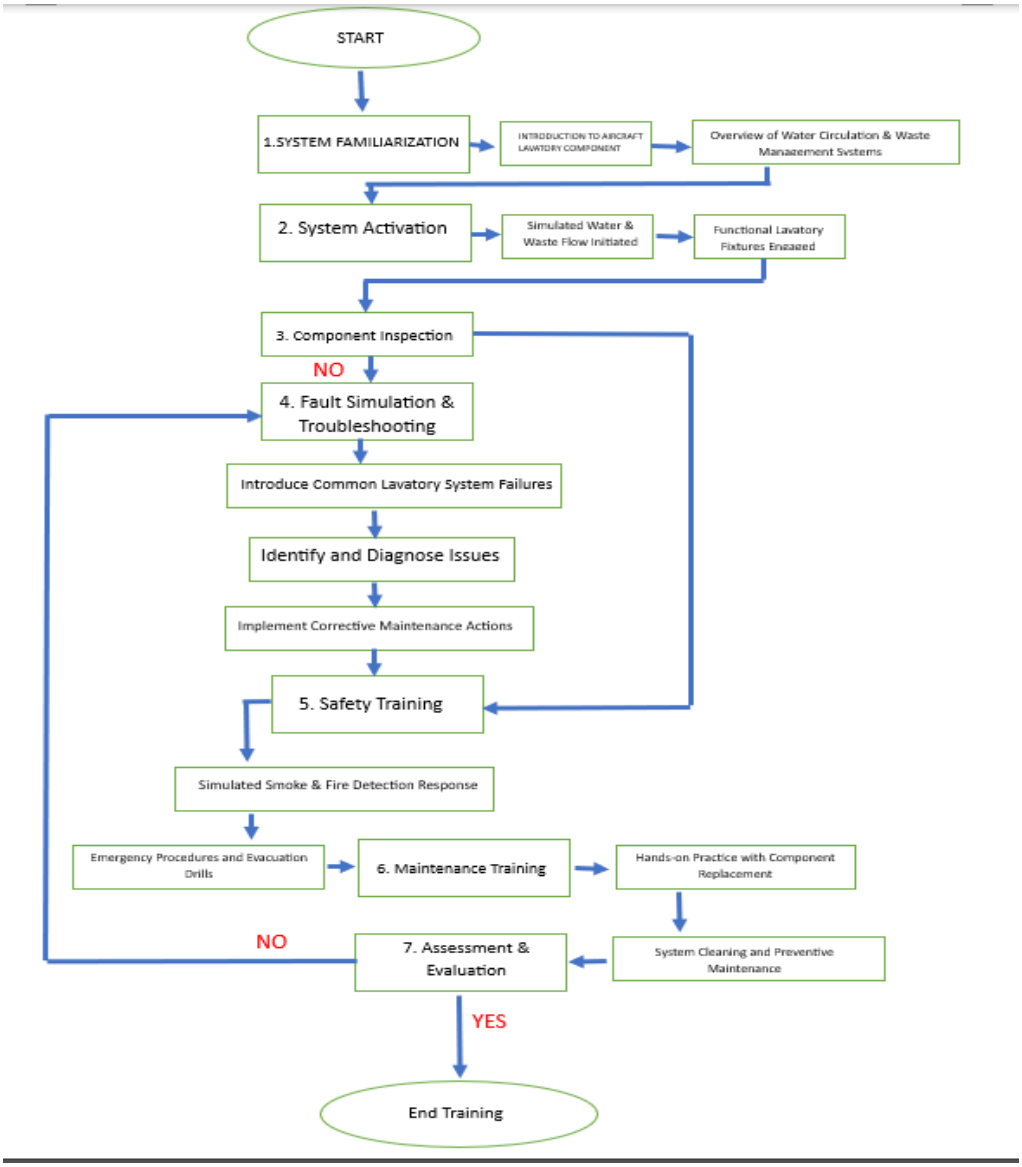
The highest vote: (34 votes)

the lowest vote: (5 votes)

Baseline Pareto:80%

3.4.2 DESIGN CONCEPT GENERATION

3.4.2.1 FUNCTION TREE


START
1.SYSTEM FAMILIARIZATION
INTRODUCTION TO AIRCRAFT LAVATORY COMPONENT
Overview of Water Circulation & Waste Management Systems
2. System Activation
Simulated Water & Waste Flow Initiated
Functional Lavatory Fixtures Engaged
3. Component Inspection
NO
4. Fault Simulation & Troubleshooting
Introduce Common Lavatory System Failures
Identify and Diagnose Issues
Implement Corrective Maintenance Actions
5. Safety Training
Simulated Smoke & Fire Detection Response
Emergency Procedures and Evacuation Drills
6. Maintenance Training
Hands-on Practice with Component Replacement
System Cleaning and Preventive Maintenance
NO
7. Assessment & Evaluation
YES
End Training

3.4.2.2 MORPHOLOGICAL MATRIX

PARAMETER	Boeing 737 Lavatory Training Kit (ERAYSHAN)	Hydraulic Training Kit (NADZRIL)	Landing Gear Training Kit (KAVIRAJ)	Safety Wire Box Training Kit (ARON)
System Functionality	Simulated and Functional Lavatory System	Closed Loop Hydraulic Sysletem	Simulated and Functional Landing Gear	Secure storage & organization for safety wires
Fluid Circulation System	Real Water Circulation	Hydraulic Fluid Circulation	Real Hydraulic Fluid Circulation	Not Applicable
Waste Management	Functional Waste System	Functional Hydraulic System	Functional Brake Mechanism	Not Applicable
Lighting System	LED Lights	Pressure & Flow Indicator Lights	Simulated Oleos and Struts	Not Applicable
Training Interactivity	Hands-on and QR-Code Guides	Physical Model With Hands On Work	Hands-on and QR-Code Guides	Hands-on Wire Twisting & Locking Practice
Simulation Type	Realistic Training	Aicraft Hydraulic System	SimulationTraining	Aircraft Safety Wiring Simulation
Safety Features	Fire Extinguisher Model and Smoke Detector	Emergency Shutoff Valve	Hydraulic Leak Detection, Emergency Retraction Simulation	Prevents Loose Bolts & Secures Fasteners
Maintenance Training	Fault Diagnosis and Component Replacement	Fault Diagnosis and Repair	Fault Diagnosis and Component Replacement	Safety Wire Techniques & Fault Prevention

ERAYSHAN A/L RAJESWARAN (24DAM23F1004)

SYSTEM FUNCTIONALITY : SIMULATED AND FUNCTIONAL LAVATORY SYSTEM

The Boeing 737 Lavatory Maintenance Kit replicates the appearance and feel of an actual aircraft lavatory, allowing students to gain hands-on experience in the domain of lavatory maintenance and trouble-shooting. It consists of real-life components including a lavatory, sink, waste disposal, and air vents, and trainees are able to activate the components in the same fashion in the mockup as in the real aircraft. Through real-life applications, the trainee acquires the skills necessary to maintain and repair lavatory components in the absence of having to use an aircraft.

PLUMBING SYSTEM : REAL WATER CIRCULATION

The kit also consists of a mock plumbing system replicating the water pressure in an aircraft lavatory, tanks, and pumps. This gives students the tools to observe and experience how water flows through the system. Where a real system isn't available, the water pressure can be replicated by the use of pressure-based mechanisms and LED lights. This aspect in the training kit familiarizes students with the normal problems in the plumbing, such as leakage, pipe blockages, and pressure problems.

WASTE DISPOSAL : FUNCTION WASTE SYSTEM

A functional waste disposal mechanism is built in to emulate the vacuum-based mechanism in aircraft lavatory’s. The function provides students the experience to see how the waste flows through the piping to the storage tanks and how the technicians service and maintain the same. The students are provided hands-on experience in identifying blockages, leakage, and other potential failures through the use of a real-life model of waste disposal.

LIGHTING SYSTEM : LED LIGHTS

For illumination, the training kit employs the use of LED strip lighting, standard in most modern aircraft lavatory uses. LED lighting uses less energy, lasts longer, and provides steady light, and so are the most suitable in real applications and in the trainee's working environment. The trainee develops the expertise to identify and replace the failing lighting elements in aircraft lavatory uses by learning about LED systems.

TRAINING INTERACTIVITY : HANDS-ON AND QR-CODE GUIDES

The training kit provides hands-on experience, and the trainees are actually working with the doors, the flush mechanisms, and the maintenance panels. The different components are labelled with QR codes linked to video tutorials, and the trainees are shown the step-by-step instructions to maintain them. This provides the trainees with additional technical expertise during the hands-on exercise, and the trainee experience is enhanced and interesting.

SIMULATION TYPE : REALISTIC TRAINING

The training kit provides real-life hands-on simulation of an aircraft lavatory system. Trainees are able to see and use the lavatory by hand, so they are familiar with real-life maintenance practices. This hands-on methodology ensures students are exposed to the necessary experience handling lavatory components without the use of an actual aircraft.

SAFETY FEATURES : FIRE EXTINGUISHER MODEL AND SMOKE DETECTOR

To reinforce the fire protection and security of the aircraft, the kit also offers fire protection items, such as fire model fire extinguishers to simulate fire suppression methods. A functional smoke detector is also included to prepare students to test, check, and replace aircraft lavatory smoke detecting units. The items are to familiarize the trainees with fire protection practices and response techniques in the tight lavatory compartment of an aircraft.

MAINTENANCE TRAINING : FAULT DIAGNOSIS AND COMPONENT REPLACEMENT

The training package gives students the tools to model the diagnostic tests in various lavatory systems, including water leakage, electricity failure, and failure in the waste system. It also offers replaceable and interchangeable parts, the flush mechanism, water pumps, and the locks, to train students in the appropriate ways to replace them. The hands-on education ensures future technicians are thoroughly qualified to maintain and repair aircraft lavatories in the real world.

MUHAMMAD NADZRIL HAZIQ BIN ZAINUDDIN(24DAM23F1020)

SYSTEM FUNCTIONALITY:CLOSE LOOP HYDRAULIC SYSTEM

The Boeing 737 Hydraulic systems are vital to modern aviation, providing the power needed for essential aircraft operations such as landing gear, flight control surfaces, and braking systems. This is the system where the hydraulic fluid continuously circulated in close loop system.

FLUID CIRCULATION SYSTEM:HYDRAULIC FLUID CIRCULATION

The Boeing 737 hydraulic fluid circulation refer to a process by hydraulic is pumped and circulate through the hydraulic system of a aircraft. This can provide the student doing the hands on to stimulate the student how to change the oil in hydraulic system in aircraft hydraulic system.

WASTE MANAGMENT : FUNCTIONAL HYDRAULIC SYSTEM

The Training Kit is to make student learn about the environment and compliant with safety. There is four important way for student need to know is Hydraulic Fluid Handling And Disposal , Filtration System , Part Replacement Waste , and Training on Waste Management.

LIGHTING SYSTEM : PRESSURE AND FLOW INDICATOR LIGHTS

The Training Kit is to make sure that for student to get a understanding about the system performance and troubleshoot problems. Also student need to know about colour coding has three colour which is green , yellow , and red.

TRAINING INTERACTIVITY : PHYSICAL MODEL WITH HANDS ON WORK

The Training Kit can help student to physically manipulate the component such as pump , valve , and actuator. This kit can make a student to do a troubleshoot about the physical model to diagnose and repair fault in simulated environment.

SIMULATION TYPE :AIRCRAFT HYDRAULIC SYSTEM

Hydraulic System Training Kit can significantly enhance learning by replicating real-world behaviours of the hydraulic system found in aircraft like the Boeing 737. This type of simulation provides student with a controlled environment where they can learn about the components, functions, and maintenance of an aircraft hydraulic system.

SAFETY FEATURE :EMERGENCY SHUTOFF VALVE

The Emergency Shutoff Valve (ESV) is a critical safety feature in hydraulic systems, especially in aircraft, to quickly isolate parts of the hydraulic circuit during an emergency. Its primary function is to cut off hydraulic flow to prevent damage to the system, reduce the risk of fire or explosion, and protect both the aircraft and personnel in the event of a fault or malfunction.

MAINTENANCE TRAINING :FAULT DIAGNOSIS AND REPAIR

Fault diagnosis is a critical component for hydraulic system for student to know about. It prepare the student to identify , analyse and correct malfunctions within an aircraft hydraulic system to ensure the system remain operational and safe to use .

Landing Gear Training Kit

Simulated & Functional Landing Gear Training Kit

The Boeing 737 Landing Gear Training Kit is designed to give students hands-on experience with an aircraft's landing gear system. This kit replicates the look, feel, and functionality of real landing gear, allowing trainees to practice key maintenance tasks such as troubleshooting, extension and retraction operations, and hydraulic system servicing. With real components like struts, brakes, actuators, and sensors, students get an authentic, practical learning experience.

Real Hydraulic Fluid Circulation

The kit includes a mock hydraulic system that realistically simulates fluid circulation, pressure buildup, and actuator movement. This allows students to see firsthand how hydraulic power controls the landing gear, from extension and retraction to diagnosing issues like fluid leaks and pressure loss. The hands-on setup provides valuable experience in maintaining and troubleshooting hydraulic systems in aviation.

Functional Braking System

To provide a complete training experience, the kit features a working brake system, including brake discs, pistons, and anti-skid mechanisms. Students can practice essential maintenance tasks such as:

Brake pad replacement

Hydraulic pressure checks

Troubleshooting braking inefficiencies

This hands-on approach ensures trainees understand how braking systems function and how to maintain them for optimal aircraft performance.

Simulated Shock Absorption with Oleos & Struts

The oleo strut system in the kit replicates the shock absorption mechanisms used in real aircraft landing gear. Trainees can explore:

Oleo servicing – Learning how to maintain and refill hydraulic fluid and nitrogen.

Nitrogen charging – Understanding the role of nitrogen pressure in cushioning landings.

Damping mechanisms – Observing how the system absorbs impact to protect the aircraft structure.

This simulation helps students grasp the principles of shock absorption and the critical role oleo struts play in landing gear operations.

Interactive Training with QR Code Guides

The kit is designed to be highly interactive, allowing students to physically work with landing gear components. To support learning, each component includes QR codes linked to video tutorials and detailed manuals, providing step-by-step guidance on maintenance procedures. This ensures trainees can learn at their own pace while reinforcing hands-on skills.

Realistic Hands-On Simulation

This training kit offers a real-world experience by allowing students to operate landing gear extension and retraction mechanisms just as they would on an actual aircraft. Practicing these procedures in a controlled environment helps trainees build confidence and expertise without requiring access to a real aircraft.

Safety Features: Hydraulic Leak Detection & Emergency Retraction

To prepare students for real-life safety scenarios, the kit includes:
Hydraulic Leak Detection Sensors – Helping trainees identify and respond to hydraulic leaks before they become serious issues.
Emergency Manual Retraction Simulation – Teaching students how to manually retract the landing gear in case of hydraulic failure.
These safety features ensure that students gain practical knowledge of emergency procedures, making them better equipped for real-world aviation maintenance.

Maintenance Training: Fault Diagnosis & Component Replacement

A major focus of the kit is diagnostic training, where students learn how to identify and troubleshoot various landing gear faults, including:
Hydraulic malfunctions
Structural wear and tear
Component failures
The kit includes replaceable parts, such as actuators, shock struts, and hydraulic lines, allowing students to practice real maintenance and repairs. This ensures they develop the hands-on skills needed to keep aircraft landing gear in top conditi
ARON A ALBERT A/L ANTHONY ALBERT

Safety Wire Box Training Kit

System Functionality
The Safety Wire Box Training Kit provides secure storage and organization for safety wires, allowing trainees to practice wire installation and fastener security techniques.

Fluid Circulation System
This kit does not involve fluid circulation, as it focuses on mechanical fastening techniques rather than hydraulic or water-based systems.

Waste Management
Since there are no fluid-based components, waste management is not applicable to this kit.

Lighting System
The Safety Wire Box Training Kit does not require a lighting system, as training primarily involves manual wire twisting and securing techniques.

Training Interactivity
This training kit provides hands-on wire twisting and locking practice, helping students develop precision in securing bolts and fasteners to prevent loosening due to vibrations.

Simulation Type
The Safety Wire Box Training Kit simulates aircraft safety wiring, teaching students how to properly twist, loop, and secure safety wires to ensure compliance with aviation safety standards.

Safety Features
Proper wire locking techniques help prevent loose bolts, reduce the risk of mechanical failures, and enhance aircraft safety.

Maintenance Training
Students practice safety wire techniques, proper installation, and fault prevention, ensuring they meet aviation safety requirements.

3.4.3.1 PUGH MATRIX: WASTE/WATER TRAINING KIT

CRITERIA	CONCEPT 1	CONCEPT 2	WASTE/ WATER TRAINING KIT	CONCEPT 3	CONCEPT 4
System Functionality	3	2	D	2	3
Fluid Circulation System	3	1	A	2	2
Waste Management	3	1	T	1	1
Lighting System	3	1	U	2	1
Training Interactivity	3	2	M	2	2
Simulation Type	3	2	-	2	3
Safety Features	3	2	-	3	3
Maintenance Training	3	2	-	3	3

TOTAL SCORE	21	13	-	17	18
RANKING	1	4	-	3	2

Legend = 3(+), 2(=), 1(-)

3.5 PRODUCT DESCRIPTION

3.5.1 : General Product Features & Functionalities

The **Boeing 737 Lavatory System** is a compact and efficient design that optimizes available space while ensuring passenger comfort and convenience. It features durable, corrosion-resistant materials with sleek, easy-to-clean finishes. The system includes an automatic water flow and waste management system, utilizing sensors to monitor and activate the vacuum-based waste disposal when needed. Integrated air circulation and temperature control maintain a comfortable environment, while ergonomic fixtures such as handrails and faucets ensure accessibility. Additionally, the system is equipped with smart controls for real-time monitoring, providing feedback on water levels, waste management, and overall system performance. Designed for ease of maintenance, it incorporates modular components for simple repair or replacement, offering a seamless and hygienic user experience.

3.5.2 Specific Part Sketching

3.5.2.1 Product Structure

The lavatory system in the Boeing 737 is composed of several integrated subsystems designed to ensure safe, hygienic, and efficient operation. The **lavatory assembly** includes the lavatory cabin structure (walls, floor, and ceiling), a toilet unit (vacuum or recirculating type), a sink and handwash basin, a faucet with a soap dispenser, a mirror with storage cabinets, and an LED lighting system. The **water system** comprises potable water lines supplying the faucet, drain lines from the sink to the waste system, and shut-off valves. The **waste system** features a waste tank for toilet waste collection, a vacuum generator (for vacuum toilets), a flush control valve, and waste lines connecting the toilet to the tank. The **electrical and electronic system** includes a control panel for flush operation, faucet sensors, smoke detectors, and a ventilation fan unit. **Safety and service features** integrated into the lavatory include ashtrays (even on non-smoking flights), a smoke detector interface, and an automatic fire extinguisher bottle located in the waste bin area, ensuring comprehensive safety compliance and ease of maintenance.

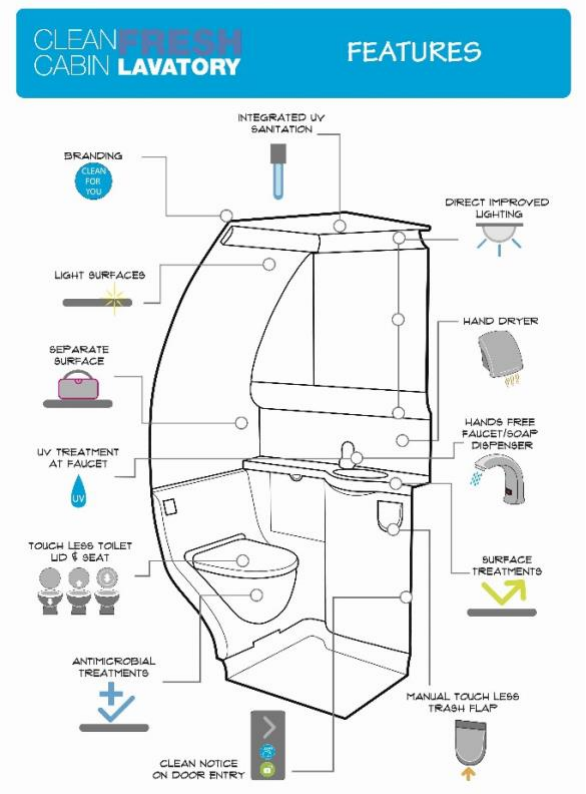
3.5.2.2 Product Mechanisms

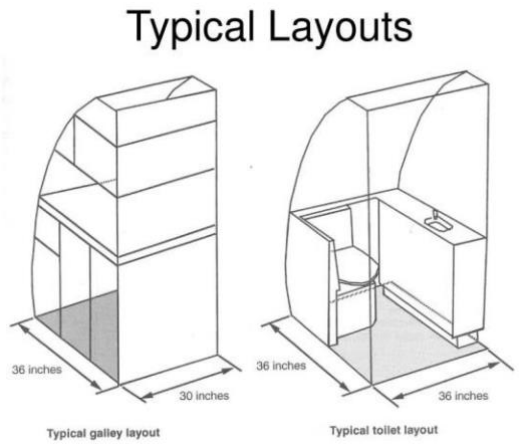
The lavatory system in the Boeing 737 operates through an integration of mechanical, pneumatic, hydraulic, and electrical mechanisms to ensure efficient and safe functionality. When the flush button is activated, the system—either vacuum-based or water-pressure-driven—draws waste into a dedicated waste tank, often releasing a small amount of deodorizing fluid. Vacuum toilets, in particular, use air suction to minimize water usage and prevent leakage during various flight conditions. Potable water from the aircraft's main water tank is delivered to the sink faucet, which may be manually operated or sensor-controlled, and the greywater from the sink is drained either into the waste system or expelled through overboard outlets. Waste tank sensors track fill levels, allowing ground crews to empty the tanks via external service panels using specialized vacuum trucks. For safety, ventilation fans regulate airflow, while smoke detectors and automatic fire extinguishers in the waste bin area provide immediate response in case of fire, ensuring both hygiene and hazard control within the lavatory unit.

3.5.2.3 Software/Programming

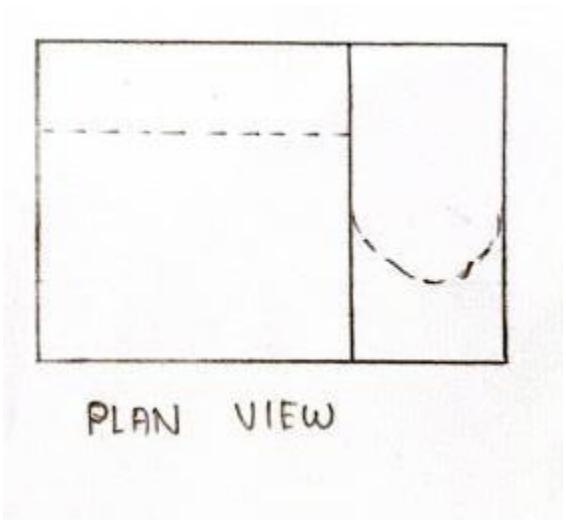
The specific interface layout for the lavatory training kit is designed around the Arduino Uno, providing a clear and interactive system for students to monitor different lavatory components. Input components include a water level sensor connected to pin A0 to detect the water tank status, a fan sensor on A1 to monitor ventilation, and a push button on D2 to simulate the toilet flush. Outputs include LEDs connected to pins D3, D4, and D5 to indicate water tank fullness, low water level, and fan operation, respectively, along with a buzzer on D6 to alert for low water or faults. A small DC fan is controlled via D9 using a transistor, simulating the ventilation system. Optionally, an LCD display connected through SDA/SCL pins or digital pins D7–D13 can be added to show real-time system status. Powered by either a 9V adapter or USB, the Arduino regulates 5V for sensors and displays, ensuring smooth operation. The programming logic ensures that sensors are continuously monitored, outputs respond accordingly, and alerts are triggered for any detected anomalies, making the system both educational and practical.

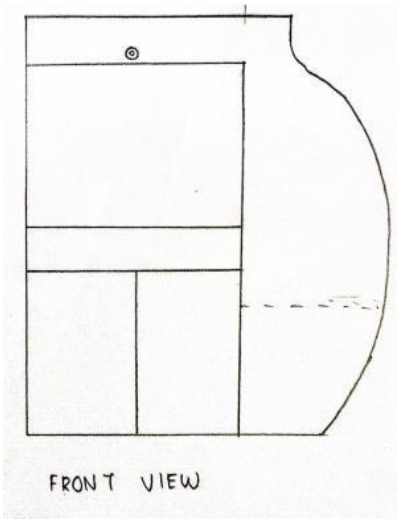
3.5.2.4 Accessories & Finishing

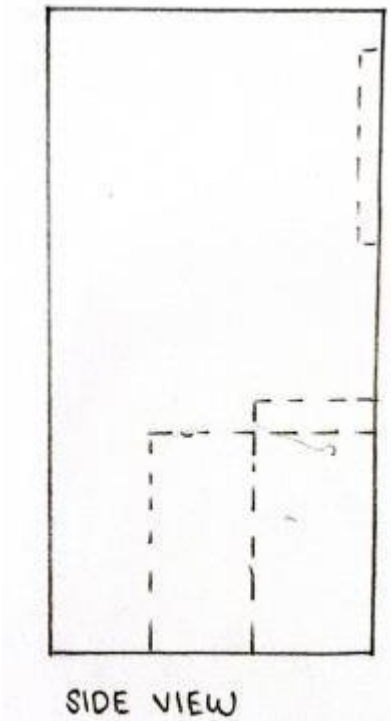




NAME: Politeknik Banting Selangor Isometric view	Isometric View
TITLE: Aircraft Personal Safety Compartment	CLASS: DAM4B
SCALE: 1:10	UNIT: Inches







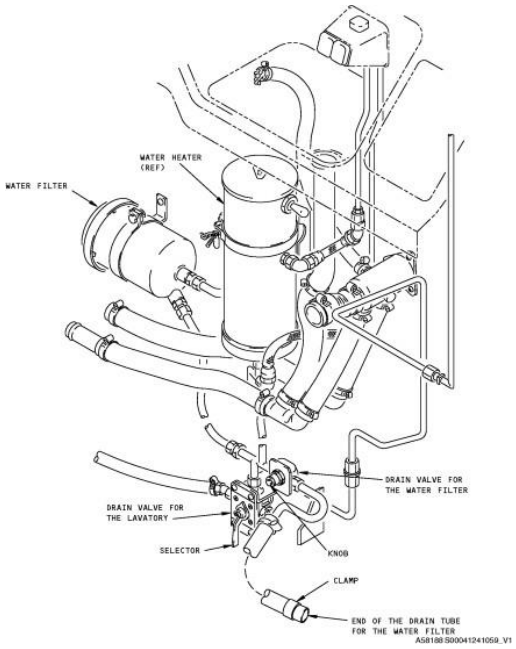
NAME: Politeknik Banting Selangor	Orthographic View
TITLE: Aircraft Personal Safety Compartment	CLASS: DAM4B
SCALE: 1:10	UNIT: Inches

3.5.3 : Overall Dimension of the Product

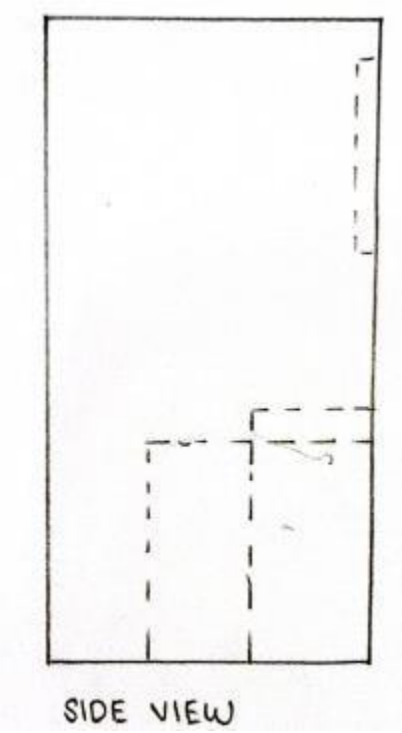
The lavatory system on a Boeing 737 is carefully engineered to be compact yet functional, fitting seamlessly into the limited cabin space while meeting strict aviation safety and hygiene standards. Typically, the lavatory unit measures around **36 inches (91.4 cm) in width**, **36 inches (91.4 cm) in depth**, and approximately **78 to 80 inches (198 to 203 cm) in height**. These dimensions allow for an efficient layout that accommodates all necessary components, including a vacuum-operated toilet, a sink connected to the onboard potable water system, and systems for waste disposal and ventilation. The interior also includes safety features such as smoke detectors and automatic fire extinguishers in the waste bin area. Despite its compact size, the lavatory provides sufficient space for passengers to use the facility comfortably. The design also supports easy maintenance access, ensuring the unit can be serviced quickly during turnarounds. This space-saving configuration is particularly important for single-aisle aircraft like the Boeing 737, where optimizing every inch of space is essential for operational efficiency and passenger convenience.

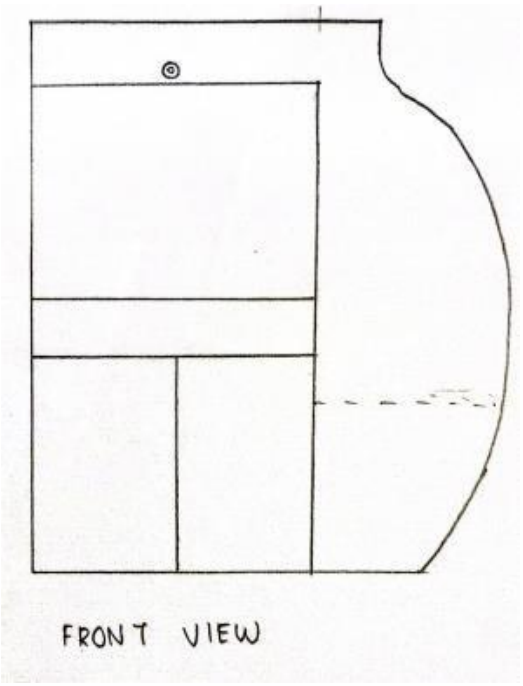
3.5.4 : Detailed Dimension on the Product Parts

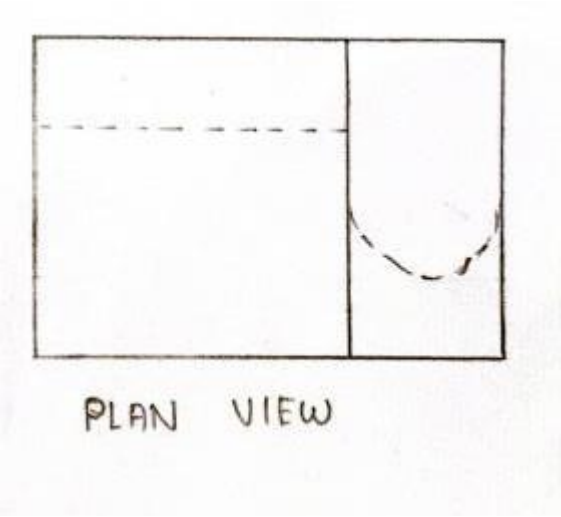
3.5.4.2 Inner Section / Compartment



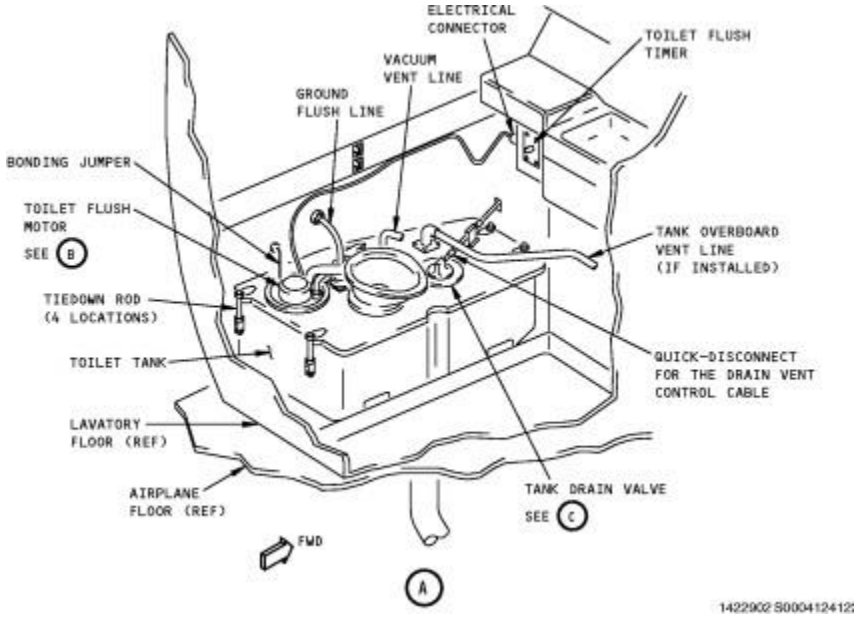
3.5.4.3 Top/ Front/ Side Section







3.5.4.4 Accessories / Outer Section



MATERIAL	QUANTITY	COST
PRESSURE WATER PUMP	1	RM500.00
LED LIGHT	1	RM107.00
COPPER WIRE	50 m	RM42.00
RS PRO PVC PIPE	25 m	RM220.00
STAINLESS STEEL HOSE CLAMP	20	RM60.00
WHEEL	4	RM30.00
Thread Seal Tape PTFE	10	RM10.00
TOTAL		RM969.00

CHAPTER 4

(RESULTS & DISCUSSION)

4.1 Product Description

4.1.1 General Product Features & Functionalities

The Boeing 737 Lavatory Waste Water Training Kit was designed to replicate the main functions of an aircraft lavatory system, including the clean water supply, waste collection, and drainage processes. The kit consists of two main tanks where one for clean water and another for waste storage which is connected through pipes, valves, and pumps that simulate real system operations. The electrical system controls the water pump, valve operation, and sensor indicators, allowing students to observe how water is supplied, used, and discharged within an aircraft environment. The overall design is compact, safe, and easy to operate, making it suitable for classroom demonstration and student training.

4.1.2 Specific Part Features

4.1.2.1 Product Structure (Erayshan A/L Rajeswaran)

The structure of the Boeing 737 Lavatory Waste Water Training Kit was built using aluminium framing and transparent acrylic panels. Aluminium was chosen because it is lightweight, durable, and resistant to corrosion, which makes it ideal for a portable training model. The acrylic panels make the internal components visible, allowing students to easily observe how water moves through the system during operation. The design also includes a sturdy base platform to support the clean water tank, waste tank, and pump. The frame layout was carefully arranged to make wiring, pipe connections, and maintenance work simple and accessible. Overall, the structure is strong, stable, and easy to transport, making it perfect for classroom use and practical demonstrations.

4.1.2.2 Product Mechanisms (KAVIRAJ A/L SOORAINDARAN)

The mechanical system plays a key role in demonstrating how water and waste flow in an aircraft lavatory system. It includes a submersible water pump, several valves, connectors, and flexible PVC hoses that guide water between the clean water tank and the waste tank. The one-way valves were installed to prevent backflow, ensuring a smooth and realistic water circulation process. During testing, the system produced a consistent water flow with stable pressure, closely simulating the operation of an actual aircraft lavatory system. At one point, we noticed the pressure dropped after a few cycles, but the issue was fixed by replacing weaker hoses with higher-pressure ones. The system's simple design also makes it easy to clean, assemble, and disassemble allowing students to get hands-on experience with both the operation and maintenance of the lavatory system.

4.1.2.3 Software / Programming (ARON A ALBERT A/L ANTHONY ALBERT)

The electrical system was designed to be simple, safe, and easy to understand for training purposes. It uses a 12V DC power supply that runs the pump and indicator lights. A basic control circuit allows students to switch the system on and off manually, helping them learn about electrical operation and safety procedures. Indicator LEDs show when the pump is active, giving a clear visual cue during demonstrations. In the early testing stages, there was a short circuit due to a loose wire, but the issue was quickly fixed by improving insulation and adding a fuse protection system. To prevent the pump from overheating during long operation, a small cooling fan was installed, which helped stabilize performance. In the future, this system could be upgraded by adding an Arduino-based controller to automate water flow and monitor tank levels digitally.

4.1.2.4 Accessories & Finishing (NAZRIL)

The accessories and finishing were completed with attention to detail to make the model look professional and easy to use. All components were neatly arranged and labeled including the pump, valves, tanks, and wiring so students can quickly identify each part during training. The pipes were made from clear plastic tubing, allowing the water flow to be seen in real-time. The waste tank was designed with a removable cover, making it easier to clean and inspect after use. For durability, the model was coated with a protective finish to prevent rust or corrosion. The final design looks clean and polished, making it not only functional but also visually appealing for classroom displays and educational demonstrations.

4.1.3 General Operation of the Product

The Boeing 737 Lavatory Waste Water Training Kit operates by simulating the complete process of water flow and waste management found in an actual aircraft lavatory system. When the system is switched on, the 12V DC power supply activates the submersible water pump, which draws clean water from the upper tank and pushes it through the pipes and valves to mimic the flushing process. The transparent PVC hoses allow students to visually observe how water moves throughout the system, while the manual and electrical valves can be adjusted to simulate real conditions such as changes in pressure, partial blockages, or flow restrictions. The water then flows into the waste tank, where it is safely contained, showing how used water is managed in an aircraft. The indicator lights signal the active operation of the pump, while fuse protection and a cooling fan ensure that the electrical components run safely during extended use. Overall, the training kit demonstrates how the lavatory system functions as a whole from water supply and flushing to waste collection giving students a realistic, hands-on understanding of system behaviour and maintenance procedures in a safe and controlled environment.

4.1.4 Operation of Specific Parts

4.1.4.1 Product Structure (ERAYSHAN A/L RAJESWARAN)

The structure of the training kit acts as the main support system that holds all other components securely in place during operation. When the system is turned on, the aluminum frame keeps the tanks, pipes, and wiring stable, preventing vibration or movement that could cause any leaks or damage. The transparent acrylic panels allow students to clearly observe how the water flows through the system in real-time without needing to open or dismantle any parts. This design makes the learning process much safer and more engaging. The overall layout of the frame also ensures that each component is easily accessible, making it simple to carry out maintenance or adjustments when necessary. The structure not only provides strength and stability but also enhances the visual appearance and practicality of the entire training kit.

4.1.4.2 Product Mechanisms (KAVIRAJ A/L SOORAINDARAN)

The mechanical system is the core of the training kit's operation. Once the pump is switched on, it draws clean water from the upper tank and pushes it through the transparent pipes into the waste tank, simulating the actual flushing process in an aircraft lavatory system. The one-way valves installed in the pipeline prevent the water from flowing backward, ensuring smooth and controlled movement. These valves can also be manually adjusted to create different operating conditions such as reduced flow or partial blockage, helping students understand how changes in water pressure or flow affect system performance. During demonstrations, the mechanical system runs efficiently with consistent pressure, allowing students to clearly see how a real aircraft lavatory system handles both water supply and waste transfer.

4.1.4.3 Software / Programming (ARON A ALBERT A/L ANTHONY ALBERT)

The electrical system functions as the control center of the training kit. When the main switch is activated, the 12V DC circuit powers the water pump, indicator lights, and cooling fan. The operation is simple — a student can turn the system on or off using a single switch while monitoring the indicator lights that show when the pump is running. This setup teaches students the basics of electrical operation, safety, and system control. During the testing phase, the electrical system experienced a short circuit caused by loose wiring, but this was resolved by improving insulation, adding a fuse, and installing a cooling fan to prevent overheating during extended use. The system now operates safely and reliably, giving students a good understanding of how electrical power supports mechanical functions in real aircraft systems.

4.1.4.4 Accessories & Finishing (NAZRIL)

The accessories and finishing parts help the entire system operate smoothly while making it easy for students to use and understand. All major components such as the tanks, pump, and valves are neatly labeled, which helps students identify each part quickly during lessons. The clear PVC hoses make the flow of water visible, allowing them to observe how the system behaves during operation. The waste tank's removable lid makes it simple to inspect and clean after use, while the smooth, polished finishing gives the trainer a professional and realistic appearance. The neat arrangement of pipes and wiring not only improves safety but also makes the training kit look organized and ready for demonstration. Overall, the finishing work completes the project beautifully, giving it both functionality and visual appeal.

PURPOSE OF PROJECT

No.	Parameters	Results	Remarks / Descriptions	Analysis
1.0	**Water Flow Rate**	4.5 L/min (unloaded)	The flow rate of clean water from the pump to the system during normal operation without load.	The system produced a stable flow rate of 4.5 L/min, confirming that the pump delivers sufficient pressure for demonstration purposes.
		3.8 L/min (partially loaded)	Flow rate recorded when the system operated with moderate restriction (50% load).	The flow rate slightly decreased due to resistance in the piping, simulating realistic operational conditions.
		3.0 L/min (fully loaded)	Flow rate recorded when the waste tank was near full capacity.	A gradual reduction of 33% in flow rate was observed, which is acceptable for simulating reduced pressure during full-load conditions.
2.0	**Operating Time**	25.5 minutes	The maximum continuous running time of the pump under normal load.	The system can operate for 25 minutes without overheating, showing good electrical and mechanical balance.
3.0	**Water Capacity**	5 litres	Total combined volume of clean and waste water tanks.	The capacity is adequate for multiple training demonstrations before refilling or draining.
4.0	**System Voltage / Power**	12 V DC	Electrical input required to power the water suction pump, water supply pump and light.	The low-voltage design ensures safety during classroom operation while maintaining effective system performance.
5.0	**Structural Load**	70 kg (max)	Maximum overall load that the aluminium-acrylic frame can support safely.	The frame remained stable under testing, proving its strength and durability for frequent educational use.

6.0	**Operational Angle**	60 degrees (max turning radius) **	Maximum safe tilt or turning angle before water spillage occurs.	The trainer maintains water integrity up to 60°, confirming secure design and proper tank sealing.

4.3 Analysis of Problems Encountered and Solutions

4.3.1 Product Structure 9ERAYSHAN A/L RAJESWARAN)

During the fabrication process, one of the first challenges faced was the alignment of the aluminum frame. Some of the frame sections were not cut precisely, causing minor misalignment when assembling the structure. Because of this, the water tanks were slightly uneven and unstable. To fix the issue, the frame was carefully reassembled using proper measuring tools, and additional brackets were installed to reinforce the joints. Another issue occurred with the acrylic panel fitting, where small gaps caused vibration and minor water splashes during testing. To overcome this, rubber insulation strips were added along the panel edges to reduce vibration and create a tighter seal. After these adjustments, the structure became sturdier, safer, and visually more stable during operation.

4.3.2 Product Mechanisms (KAVIRAJ A/L SOORAINDARAN)

The most noticeable issue with the mechanical system was water leakage at the pipe connections. During early testing, water could be seen dripping around the joints due to loose fittings and poor sealing. This was a common but important issue to solve, especially for a system that relies on pressure. The solution involved applying silicone sealant and Teflon tape around all threaded areas to create an airtight and watertight connection. Another challenge occurred when the water pressure dropped during continuous operation, which affected the flushing performance. The team fixed this by replacing the existing pump with a higher-capacity unit and using stronger pressure-rated hoses. After these improvements, the water flow became consistent, and the system ran smoothly without any leaks or pressure loss.

4.3.3 Software / Programming (ARON A ALBERT A/L ANTHONY ALBERT)

In the electrical system, one of the main problems faced was a short circuit that occurred during the first testing phase. This happened because of loose wire connections and exposed terminals that touched each other. The short circuit caused the pump to shut down, and the system had to be switched off immediately for safety. To fix this, all wiring was properly re-insulated using heat-shrink tubing, and a fuse protection system was added to prevent similar incidents in the future. Another issue was overheating of the pump after running continuously for a long time. The problem was solved by adding a small cooling fan near the motor and drilling ventilation holes in the pump housing to improve air circulation. These improvements made the electrical system safer, more stable, and suitable for continuous classroom demonstrations.

4.3.4 Accessories & Finishing (NAZRIL)

The finishing stage also came with its own set of challenges. Initially, the layout of the components — especially the wiring and pipes — looked quite cluttered and unorganized, which made the setup confusing to use. To improve the appearance and safety, the layout was rearranged carefully, and cable ties and clips were used to hold everything neatly in place. Another small issue was that the paint coating on the metal frame was uneven, which made the trainer look less professional. This was corrected by sanding and repainting the structure using proper finishing techniques. Finally, all main components were clearly labeled to help students identify each part easily during operation. These finishing improvements not only made the trainer look more polished and professional but also made it easier and safer to use in a teaching environment.

CHAPTER 5

(CONCLUSION & RECOMMENDATIONS)

5.1 Achievement of Aim & Objectives of the Research

5.1.1 General Achievements of the Project

The Boeing 737 Lavatory Waste Water Training Kit project successfully achieved its main goal of designing and developing a fully functional educational model that simulates the operation of an aircraft lavatory system. The system operates effectively and allows students to clearly observe the water flow, valve operation, and electrical control processes in a safe, controlled environment. This project bridges the gap between theory and practical experience, giving students valuable hands-on learning opportunities in maintenance, troubleshooting, and system operation. The design also emphasizes safety, portability, and affordability, making it suitable for aviation training institutions such as Politeknik Banting Selangor. Overall, the project not only met its objectives but also proved to be a useful and cost-effective learning tool that enhances students' technical understanding and readiness for real-world aircraft maintenance tasks.

5.1.2 Specific Achievements of Project Objectives

5.1.2.1 Product Structure (ERAYSHAN A/L RAJESWARAN)

The structure of the training kit was successfully built using aluminum and transparent acrylic panels, which made the system both strong and lightweight. Aluminum was chosen for its durability and resistance to corrosion, while the acrylic panels allowed clear visibility of the internal components. This made it easier for students to observe the water flow and understand how the system works during operation. The frame design was carefully planned to make assembly and maintenance simple, ensuring all parts fit securely without affecting the overall balance. The final structure not only provides stability and portability but also gives the kit a clean, professional look that makes it suitable for classroom use and demonstrations.

5.1.2.2 Product Mechanisms (KAVIRAJ A/L SOORAINDARAN)

The mechanical system, which includes the pump, valves, and piping network, performed very well throughout the testing process. When the pump was activated, water circulated smoothly from the clean water tank to the waste tank, simulating how an actual aircraft lavatory system operates. The one-way valves ensured that the flow direction remained consistent, preventing any backflow issues. In addition, the team designed the system so that the valves can be adjusted manually, allowing students to simulate pressure changes or blockages for learning purposes. Overall, the mechanical system was stable, easy to operate, and successfully achieved the intended function of demonstrating how the lavatory system handles water movement and waste transfer.

5.1.2.3 Software / Programming (ARON A ALBERT A/L ANTHONY ALBERT)

The electrical system of the project was designed to be simple, safe, and effective for training purposes. It runs on a 12V DC power supply, which powers the pump, cooling fan, and indicator lights. During testing, the system worked reliably after improving the wiring and adding fuse protection to prevent short circuits. The cooling fan helped control the temperature of the pump motor during longer operations, preventing overheating. The circuit uses a switch and LED indicator to show when the system is active, allowing students to monitor it easily. This setup helped demonstrate basic electrical control and safety procedures used in aircraft systems. Although the current version is operated manually, it provides a strong foundation for future upgrades such as automatic control using Arduino or sensors.

5.1.2.4 Accessories & Finishing (NAZRIL)

The accessories and finishing work were done with care to make the kit look neat, safe, and easy to use. All components were clearly labeled so students can easily identify each part, such as the tanks, pump, valves, and electrical switches. The transparent pipes make it easy to observe the flow of water during operation, which helps in understanding system performance. The structure was given a smooth surface finish with protective coating to prevent corrosion and wear over time. The overall layout of the components was organized to give a clean and professional appearance, while also making the kit easy to operate, maintain, and display during classroom sessions or exhibitions.

5.2 Contribution or Impact of the Project

The Boeing 737 Lavatory Waste Water Training Kit has provided a valuable contribution to aviation education by offering both students and instructors a practical, hands-on learning experience. This training kit allows students to observe and understand how an aircraft lavatory system operates without the risks or high costs of using real aircraft components. Through direct interaction with the system, students are able to develop a clearer understanding of fluid flow, electrical control, and maintenance procedures, which strengthens their problem-solving skills, confidence, and readiness for real-world maintenance tasks. For institutions such as Politeknik Banting Selangor, the project serves as a cost-effective and reusable training tool that enhances existing learning modules and makes technical subjects more engaging and realistic. Beyond its educational value, the project also encourages further research and development of similar simulation-based trainers for other aircraft systems, helping to advance the overall standard of aviation education and produce more skilled, industry-ready graduates in Malaysia.

5.3 Improvement & Suggestions for Future Research

5.3.1 Product Structure (ERAYSHAN A/L RAJESWARAN)

For future improvements, the structure of the training kit can be enhanced to make it more durable, stable, and user-friendly. While the current aluminum and acrylic frame provides good strength and portability, it could be further improved by adding adjustable legs or wheels to make the trainer easier to move and position during demonstrations. The overall layout of the tanks and internal components could also be slightly redesigned to make cleaning and maintenance more convenient. Using thicker acrylic panels or tempered glass would make the structure sturdier and reduce vibration or cracking during long-term use. These small changes would make the product safer, more practical, and more suitable for frequent use in classroom environments.

5.3.2 Product Mechanisms (KAVIRAJ A/L SOORAINDARAN)

For the mechanical system, several improvements can be made to enhance its performance and reliability. Future versions could include pressure gauges and flow sensors that allow students to measure water pressure and flow rate accurately while conducting experiments. This would help them better understand how different operating conditions affect system performance. The use of quick-release fittings instead of regular threaded joints would also make assembly and disassembly faster and reduce the chance of leakage during repeated testing. Additionally, upgrading to a variable-speed water pump would allow instructors to simulate various operational conditions found in real aircraft systems. These improvements would make the trainer more interactive and help students gain deeper technical knowledge.

5.3.3 Software / Programming (ARON A ALBERT A/L ANTHONY ALBERT)

The current electrical system works well manually, but it could be made more advanced by adding automation and control features. Future versions could include Arduino or PLC integration to automatically control the pump, valves, and sensors. This would make it possible to simulate different operational modes, such as normal operation, pressure variation, or emergency shutdown. The addition of digital sensors and a display screen would allow real-time monitoring of important values like voltage, water level, and flow rate. These enhancements would make the system more modern and closer to what is used in actual aircraft systems, helping students experience how automation and electronics are applied in aviation technology.

5.3.4 Accessories & Finishing (NAZRIL)

The accessories and finishing can also be improved to make the kit more attractive and easier to use. Adding LED lighting inside the structure would make it easier for students to observe the water flow during demonstrations. The labels and markings on each component could be made clearer using color-coded tags or durable printed stickers for better visibility. A modular design approach could also be adopted so that individual parts can be replaced or upgraded easily without disassembling the entire system. Finally, improving the surface coating and polishing of the frame would not only make the trainer look more professional but also protect it from corrosion and wear over time. These finishing improvements would make the training kit more visually appealing, safer, and more efficient for long-term use in aviation education.

Appendix A: Task Segregation

ERAYSHAN: Plumbing and leak testing

1.3.2.1 – Specific Individual Project Aim: Product Structure

Erayshan main aim is to design and build the main structure of the product. He focuses on creating a strong and stable frame that can support all other parts of the system. His goal is to make the structure safe, lightweight, and realistic for aviation training use.

1.5.2.1 – Specific Individual Scope: Product Structure

His scope involves planning the layout, materials, and construction of the frame. He makes sure each part is properly connected and balanced, while also ensuring that the overall design meets safety and reliability standards.

2.2.1.1 – Specific Literature Review: Basic Design of Main Structure

Through his research, Erayshan studied the fundamentals of aircraft structural design, such as load distribution, stress points, and the use of lightweight materials. This knowledge helps him create a structure that is both durable and easy to maintain.

Additional Task: Plumbing & Leak Testing

In addition to his design role, Erayshan is also responsible for plumbing and leak testing. He ensures that all water or fluid systems are properly connected, tested for leaks, and safe to use during operation.

ARON: Painting and cleaning

1.3.2.2 – Specific Individual Project Aim: Product Mechanism

Aron's goal is to develop the mechanical mechanism of the project. He focuses on how the moving parts work together such as hinges and linkages to make sure they operate smoothly and reflect real aircraft mechanisms.

1.5.2.2 – Specific Individual Scope: Product Mechanism

His scope includes designing, assembling, and testing mechanical components that allow the structure to move or function properly. He ensures that all mechanisms are reliable, efficient, and durable over time.

2.2.2.1 – Specific Literature Review: Type of Hinges

In his research, Aron explored different types of hinges used in aviation and industrial applications. He compared their movement range, strength, and corrosion resistance to find the best option for the project's design.

Additional Task: Painting & Cleaning

Besides his mechanical work, Aron is also in charge of painting and cleaning. He makes sure the product looks neat and professional, applying proper coatings for both protection and appearance.

NADZRIL: Documentation & slide preparation

1.3.2.3 – Specific Individual Project Aim: Software / Programming

Nadzril main aim is to develop the software and control system for the project. He ensures that all electronic components, sensors, and displays communicate and function correctly through programming and coding.

1.5.2.3 – Specific Individual Scope: Software / Programming

His work involves writing and testing program codes, developing logic for control systems, and troubleshooting the software until everything runs smoothly. He integrates the hardware and software so they work together effectively.

2.2.3.1 – Specific Literature Review: Type of Output Display

For his literature review, Nadzril studied output display systems used in aircraft trainers. He focused on how data is shown to users, display layouts, and user interface design to make the system easy to monitor and operate.

Additional Task: Documentation & Slide Preparation

Apart from programming, Nadzril also manages documentation and presentation slides. He prepares the written reports, compiles project information, and designs slides for final presentations, ensuring the team's work is presented clearly and professionally.

KAVIRAJ: Electrical wiring

1.3.2.4 – Specific Individual Project Aim: Accessories / Finishing

Kaviraj's aim is to work on the **accessories and finishing section** of the project. His focus is to add the final details that make the product both functional and visually complete, similar to real aircraft equipment.

1.5.2.4 – Specific Individual Scope: Accessories / Finishing

His scope involves **designing and installing accessories**, fittings, and finishing parts that enhance the look and usability of the system. He ensures the result is well-organized, professional, and ready for display.

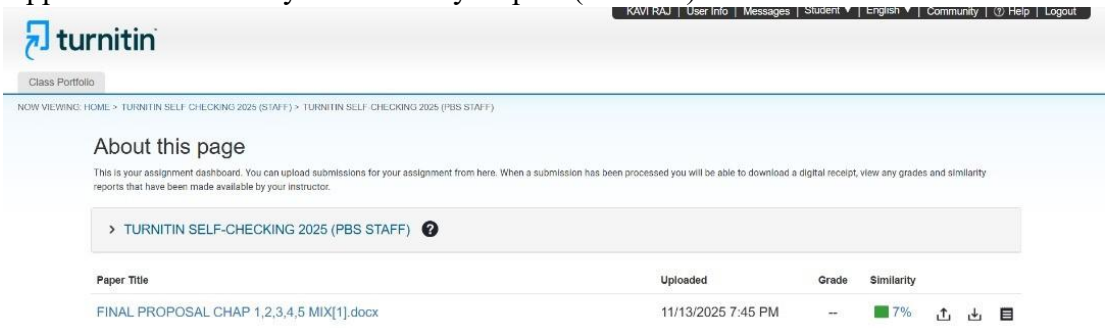
2.2.4.1 – Specific Literature Review: Typical Accessories for Aircraft Passenger Seat

In his research, Kaviraj explored **common accessories in aircraft passenger seats**, such as armrests, lights, and tray tables. This helps him understand how design, comfort, and safety standards are applied in the aviation industry.

Additional Task: Electrical Wiring

Besides finishing work, Kaviraj is also responsible for **electrical wiring**. He connects and tests all electrical systems, including lights and switches, ensuring everything works properly and safely.

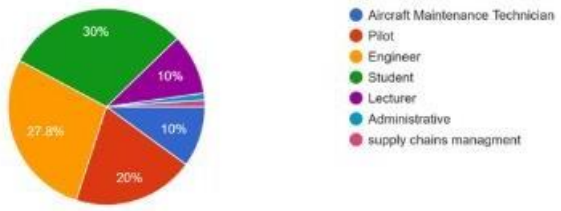
Appendix B: Summary of Similarity Report (Turnitin)



Appendix C : PRE-SURVEY FORM

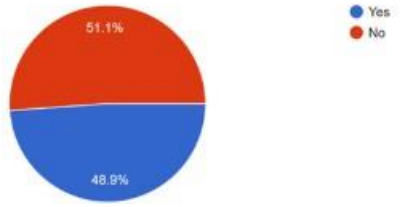
What is your current occupation ?

90 responses



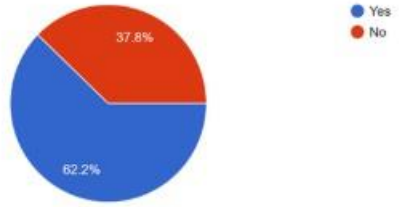
Are you familiar with aircraft lavatory systems?

90 responses



Do you think a Boeing 737 lavatory training kit would be beneficial for aircraft maintenance students?

90 responses



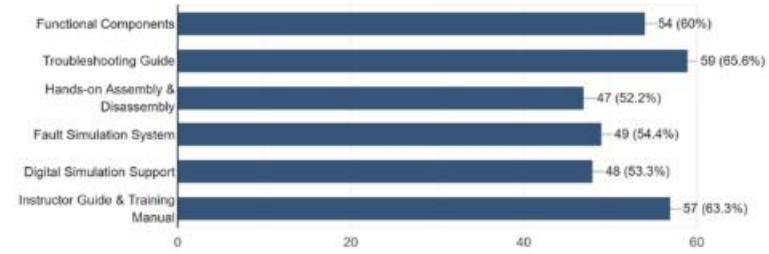
What aspects of aircraft lavatory maintenance do you find most challenging?

19 responses

Understanding the components and their functions is the first step in ensuring proper service and maintenance.

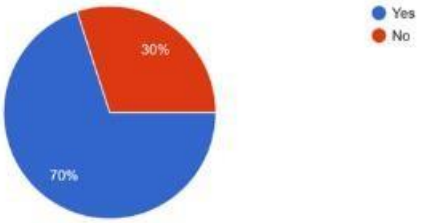
What features do you think a lavatory training kit should include to be effective?

90 responses



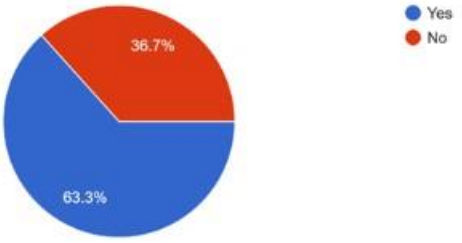
Would you prefer digital simulations along with physical training kits?

90 responses



Do you think this training kit should be integrated into the curriculum?

90 responses



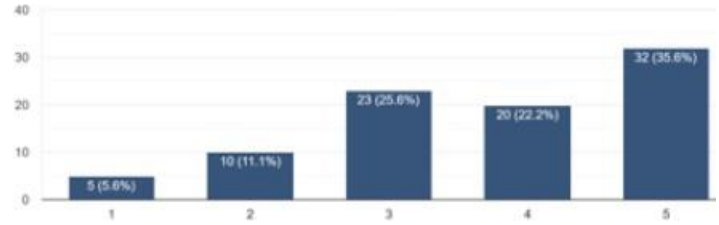
Do you have any suggestions to improve the design or usability of the kit?

73 responses

Make it more interesting to use this kit.

On a rating of 1-5, how interested are you in learning about lavatory systems through a hands-on training kit?

90 responses



LIST OF REFERENCES

Aerospace Maintenance Council. (2020). *Aircraft maintenance skills development guide*. https://www.aeroproworld.com

Boeing. (2020). *737 systems training manual*. Boeing Commercial Airplanes.

Crouse, W., & Anglin, D. (2020). *Aircraft maintenance and repair* (8th ed.). McGraw-Hill Education.

EASA. (2021). *European Aviation Safety Agency maintenance training standards*. https://www.easa.europa.eu

Federal Aviation Administration. (2022). *Aviation maintenance technician handbook – General* (FAA-H-8083-30B). U.S. Department of Transportation.

ICAO. (2022). *Human factors training manual for aircraft maintenance personnel*. International Civil Aviation Organization.

IATA. (2021). *Maintenance training and operations best practices*. International Air Transport Association.

Jeppesen. (2019). *Aircraft systems for pilots*. Jeppesen Sanderson, Inc.

Malaysian Aviation Training Academy. (2024). *Aircraft maintenance training manual: Practical systems kits*. MAT Academy Publications.

Skybrary. (2023). *Aircraft maintenance safety and human factors*. https://www.skybrary.aero

De Remer, D. (2017). *Aircraft systems for pilots* (2nd ed.). Aviation Supplies & Academics.

European Union Aviation Safety Agency. (n.d.). *Part-66 maintenance certifying staff*. https://www.easa.europa.eu/en/acceptable-means-compliance-and-guidance-material-group/part-66-maintenance-certifying-staff

Federal Aviation Administration. (2023). *Aviation maintenance technician handbook—General* (FAA-H-8083-30B). https://www.faa.gov/regulations_policies/handbooks_manuals/aviation

International Civil Aviation Organization. (1998). *Human factors training manual* (Doc 9683). https://store.icao.int/en/human-factors-training-manual-doc-9683

Kroes, M. J., Wild, T., & Delp, W. A. (2020). *Aircraft maintenance & repair* (8th ed.). McGraw-Hill Education.

Airbus. (2021). *A320/A330/A350 aircraft systems training manual*. https://www.airbus.com

De Remer, D. (2017). *Aircraft systems for pilots* (2nd ed.). Aviation Supplies & Academics.

European Union Aviation Safety Agency. (n.d.). *Part-66 maintenance certifying staff*. https://www.easa.europa.eu/en/acceptable-means-compliance-and-guidance-material-group/part-66-maintenance-certifying-staff

Federal Aviation Administration. (2023). *Aviation maintenance technician handbook—General* (FAA-H-8083-30B). https://www.faa.gov/regulations_policies/handbooks_manuals/aviation

International Civil Aviation Organization. (1998). *Human factors training manual* (Doc 9683). https://store.icao.int/en/human-factors-training-manual-doc-9683

Kroes, M. J., Wild, T., & Delp, W. A. (2020). *Aircraft maintenance & repair* (8th ed.). McGraw-Hill Education.

United Nations. (2020). *Guidelines for aviation safety standards*. https://www.un.org

BIFMA. (2020). *BIFMA Furniture standards*. Business and Institutional Furniture Manufacturers Association. https://www.bifma.org

Boeing. (2021). *Boeing 737 maintenance and safety features* (Training Guide). https://www.boeing.com

De Remer, D. (2017). *Aircraft systems for pilots* (2nd ed.). Aviation Supplies & Academics.

Federal Aviation Administration. (2023). *Aviation maintenance technician handbook—General* (FAA-H-8083-30B). https://www.faa.gov/regulations_policies/handbooks_manuals/aviation

International Civil Aviation Organization. (1998). *Human factors training manual* (Doc 9683). https://store.icao.int/en/human-factors-training-manual-doc-9683

Kroes, M. J., Wild, T., & Delp, W. A. (2020). *Aircraft maintenance & repair* (8th ed.). McGraw-Hill Education.

Boeing. (2021). *Boeing 737 maintenance training* (Training Manual). https://www.boeing.com/commercial/training

Federal Aviation Administration. (2023). *Aviation maintenance technician handbook—General* (FAA-H-8083-30B). https://www.faa.gov/regulations_policies/handbooks_manuals/aviation

International Civil Aviation Organization. (2004). *Aircraft accident investigation—Annex 13* (Doc 9760). https://www.icao.int

Callister, W. D., & Rethwisch, D. G. (2020). *Materials science and engineering: An introduction* (10th ed.). John Wiley & Sons.

Koch, C. (2015). *The metallurgy of aluminum alloys*. ASM International.

Mathews, J. (2018). *Aluminum alloys in aerospace applications*. *Aerospace Materials and Technology Journal, 23*(4), 456-465. https://doi.org/10.1007/s13013-018-0546-5

Smith, R. (2019). *Practical applications of aluminum in engineering*. *Engineering Materials Journal, 34*(1), 12-20.

Chen, H., Yang, J., & Zhai, X. (2017). The use of polyurethane foam in structural applications. *Materials Science and Engineering, 34*(4), 57-64. https://doi.org/10.1016/j.mse.2017.03.018

Lau, K. K., & Yip, S. (2002). Fiber reinforced polymer composites in civil engineering. *Construction and Building Materials, 16*(5), 285-295. https://doi.org/10.1016/S0950-0618(01)00091-9

Li, G., Wang, Z., & Zhang, Q. (2020). Silicone rubber materials for sealing applications in aerospace. *Polymer Testing, 80*, 1060-1067. https://doi.org/10.1016/j.polymertesting.2019.106032

Sincero, A. P., & Sincero, G. A. (2017). *Physical and chemical treatment of water and wastewater*. CRC Press.

Wang, Z., & Zhang, L. (2019). High-pressure laminate applications in aerospace and engineering. *Journal of Composite Materials, 53*(13), 1709-1723. https://doi.org/10.1177/0021998319834687

Federal Aviation Administration. (n.d.). *Fire protection: passenger cabin*. Retrieved from https://skybrary.aero/sites/default/files/bookshelf/4639.pdfeCFR+3Skybrary+3Skybrary+3

Electronic Code of Federal Regulations. (n.d.). *14 CFR § 382.63 – What are the requirements for accessible lavatories?* Retrieved from https://www.ecfr.gov/current/title-14/chapter-II/subchapter-D/part-382/subpart-E/section-382.63Transportation.gov+3eCFR+3eCFR+3

American Society for Testing and Materials. (2021). *ASTM A240/A240M-21: Standard specification for chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications*. ASTM International. https://www.astm.org/Standards/A240.htm

Callister, W. D., Jr., & Rethwisch, D. G. (2020). *Materials science and engineering: An introduction* (10th ed.). John Wiley & Sons.

Federal Aviation Administration. (2008). *Acceptable methods, techniques, and practices—Aircraft inspection and repair* (Advisory Circular 43.13-1B). U.S. Department of Transportation. https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/99826

Kroes, M. J., Wild, T., & Delp, W. A. (2020). *Aircraft maintenance & repair* (8th ed.). McGraw-Hill Education.

Norton, R. L. (2021). *Machine design: An integrated approach* (6th ed.). Pearson.

Monk, J. (2013). *Programming Arduino: Getting Started with Sketches* (2nd ed.). McGraw-Hill Education. ISBN 978-0071780287

Banzi, M., & Shiloh, M. (2014). *Getting Started with Arduino: The Open Source Electronics Prototyping Platform* (3rd ed.). Maker Media. ISBN 978-1449363338

Margolis, M. (2011). *Arduino Cookbook* (2nd ed.). O'Reilly Media. ISBN 978-1449313876

Kroes, M. J., Wild, T., & Delp, W. A. (2020). *Aircraft Maintenance & Repair* (8th ed.). McGraw-Hill Education. ISBN 978-1259586912

Moir, I., & Seabridge, A. (2011). *Aircraft Systems: Mechanical, Electrical, and Avionics Subsystems Integration* (3rd ed.). Wiley. ISBN 978-0470743338