PROJECT TITLE – **DRONE-IN-A-BOX SETUP – BASE ROOF MECHANISM**

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ME 325-MECHANICAL ENGINEERING GROUP PROJECT

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DECLARATION

We, Members of Group 03, declare that the work presented in this report of Drone-In-A-Box Setup - Base Roof Mechanism is entirely our own work, except where explicitly referenced. The ideas, methods, and techniques presented in this report are a result of our own research and development. We have read and understood the academic regulations of Faculty of Engineering, university of Peradeniya regarding plagiarism and academic integrity, and We confirm that this work complies with these regulations. We confirm that the work presented in this report has not been submitted for assessment in any other course or program of study. We also confirm that any codes, software or hardware developed as part of this project are our own work, and that they do not infringe the intellectual property rights of any third party. We are aware that any false declaration is considered as a serious academic offense and We will take full responsibility for our work.

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APPROVAL

This report entitled Drone-In-A-Box Setup- Base Roof Mechanism has been submitted by Ahamad I.L.A. (E/18/014), Munathanthri M.D.H.I. (E/18/230) and Zameer M.H.M. (E/18/406) in partial fulfillment of the requirements for the degree of BSc Mechanical Engineering at University of Peradeniya

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We also grateful to our peers and colleagues who provided us with valuable feedback, suggestions, and support throughout the project. Their ideas and suggestions helped us to improve the design and functionality of the DIBs.

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ABSTRACT

The project aim to design a weather proof system to the DIBs and field repairable base roof mechanism. The design of the DIB has a simple structure made up with stainless steel, aluminum, alloys and PVC plastic. These materials have used in way that utilizes the cost and it will give the structure a durable effect.

The central control system of the greenhouse is based on Node MCU controller, which is programmed to LCD display and control various drone parameters such as temperature, humidity, windspeed, fly time and smart dryer. The data collected by the sensors is sent to the Node MCU, which then analyzes the data and adjusts the systems accordingly, to provide a better flying experience to the drone. And PC which is connected to the Node MCU, allows the user to monitor and control and process the real time data collected by the drone components.

This repairable and removable design of DIB makes it easy to transport and set up, making it suitable for various industrial applications where space is limited. This project shows us the potential collaboration of Mechanical engineering with IoT technologies in drone application, and how it can be used to improve the durability and reduce the cost of the DIB products in market.

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DIB	–	Drone in a box
UAV	–	Unmanned aerial vehicle
LCD	–	Liquid crystal display
MCU	–	Micro-controller unit
IoT	–	Internet of things
IP	–	Ingress protection
SM	–	Synchronous motor
AC	–	Alternating current
PC	–	Personal computer
PVC	–	Polyvinyl chloride

Chapter 1

INTRODUCTION

A drone is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, that work in conjunction with onboard sensors and a global positioning system (GPS). UAVs were most often associated with the military. They were initially used for anti-aircraft target practice, intelligence gathering and, more controversially, as weapons platforms. Drones are now also used in a range of civilian roles, search and rescue, surveillance, traffic monitoring, weather monitoring, firefighting, personal use, drone-based photography, videography, agriculture as well as for delivery services.

Most of the times drones are controlled by humans to take off the drone, landing the drone, collecting the information, charging the power source, battery swapping of the system, and there are more and it will depend on the purpose of the drone. However, these works should be automated to overcome several problems facing by humans when handling of drones. In order to overcome these challenges, this project aims to design a Drone-In-A-Box. In addition to providing an efficient solution for constant drone flights, DIB virtually removes the need for human operators – saving time and payroll. Clients of DIB firms can have peace of mind, knowing the system is a “one-stop shop,” covering aviation regulations, insurance and liability. Several DIB platforms also interface with data-analysis software to seamless integrate flight telemetry.

Figure 1.1 Drone and a Drone In a Box

1.1 Background

DIBs usually include installing a weatherproof box (refers to as the base), and the UAV is "parked" inside this base when not being actively operated. This base provides protection from environmental factors, as well as a safe place for recharging the UAV batteries, enabling fully remote operation of the drone. Such systems are called Drone-in-a-Box (DIB) solutions and several companies designs and operates such systems for commercial customers.

One critical part of the base is the roof, which should be automatically open and close for the UAV takeoff and landing, while keeping rain, dust and snow out of the base when its closed. As such, the main objective of this project is to design the roof and its operating mechanism of a DIB system. The roof needs to be weather-proof when it's closed, while the operating mechanism needs to be reliably operated without any onsite maintenance crew for a reasonable time period. In addition, entire mechanism needs to be simple enough to meet field reparability as it is not uncommon for such systems to be installed at remote locations.

Other important thing is the weather proof ability of the DIB. There are many chances to water, dust can get into the DIB when it is opening and closing for the drone. In available DIBs in the market the outside surface of existing weatherproof DIBs is made from weatherproofing materials which stop entering the water, dust, and other outside particles into the DIB. Some DIBs have made from weatherproofed electronics and this is very much expensive in cost. In our DIB we are making a draining system in the lander to remove water getting inside the DIB and using a blower to remove water drops and dust as well.

Finally, the alignment of the drone in the base should be done accurately to do the other requirements without any error. The alignment will be key role to battery swapping and data collecting of the system. For this we are using guided bars to align drone precisely to a location.

1.2. Methodology

The methodology implemented for problem-solving in this project is based on research and experimentation. The research was conducted to understand the challenges faced by DIB manufacturing companies as well as the customers who are using the DIBs for several requirements such as military, agriculture, etc. This included investigating the problems from Dr. Kanishka Gamegedara who is working in a DIB manufacturing company in America.

The research findings were used to design and develop the DIB system. We are designing a DIB that guarantees a roof open/close mechanism with suitable material selection which is less expensive and reach required specifications. Moreover, to not over complicate the system we are trying to design a roof mechanism which gives an opening with one door and a smaller number of connecting parts. Although the designing roof will be replaced easily by a new roof when the existing roof was failed to open and close. The outside of the roof should be design in a way that it protects the inside of DIB from weather. Designing an auto cleanable tray in the lander that removes all the water and the dust inside the DIB and make the DIB in a weather proofed condition. Finally, aligning the Drone in the DIB by guided bars as well.

We physically implement and build a model of a roof with simple and high accuracy roof mechanism with all the interior mechanical drive system, Roof opening during roof open/close mechanism failure and auto cleanable tray inside of the DIB to remove dust, water. The parts will be design using by low-cost material such as wood, and aluminum/steel and also some motors will be used.

1.3 Results and Future Scope

The results of the project are a simple roof mechanism has been designed for easy maintenance and field reparability with a maintenance manual, weather proof system done by a drainage system with a blower, accurate positioning of the drone in the base and portable roof system in case of a roof mechanism failure.

Overall, this project demonstrates that DIBs can use to automating UAVs. The weather proof ability idea done by this project will affect the overall cost of DIB manufacturing.

However, it will reduce the cost of DIBs and by that normal people also can afford and use DIBs for their drones. The maintenance of the DIB is get more easy and reliable by the simple roof mechanism system and it will easily commercialize among the people who are using drone. Therefore, more of the work will be done by drone and automated by the DIBs in the future world.

Chapter 2

PROJECT REVIEW

A literature review of Drone-In-A-Box which we were build versus existing DIBs available in the market shows that our DIB is far ahead in compare to the DIBs which are available. The major advantage of our DIB is that it has a simple roof mechanism with one opening and closing door will reduce the cost of production of roof as well as in roof mechanism failure it can be repair easily. The roof can be separate from the box(portable) therefore when a mechanism failure happens, no need to replace whole DIB. Only the roof should be separated from it and can replace with another roof for the usage.

Another advantage is it is weather proofed from water and dust by draining and blowing system in the lander. The available DIBs use more expensive weather proofing materials to protect the parts from water and dust. Although electronics parts are made from weatherproofed materials will cost DIBs more expensive. In our case we will remove the water through a draining system build in the lander and it will remove the water from the DIB and the blower will remove the dust and water droplets inside the lander.

The other added advantage is the accurate drone alignment in the base. It will align the drone more precisely by two guided bars in x and y axis. Most of the DIB’s alignment is not precisely located and it will rise some problems for other requirements of the drone in DIB. Mostly it will affect when battery swapping in the working area. However, but the method we were used will do the work accurately.

In addition, our DIBs are cost-effective when compared to existing DIBs. The simple roof mechanism and weather proofing technology will reduce the cost of building materials, and the field reparability reduces the labor costs associated with monitoring and controlling the DIBs.

In conclusion, the literature review suggests that Our DIB have several advantages over existing DIBs. The advantages Weather-proof, reliably operated roof and operating mechanism of a DIB system, a draining system that allows the DIB to safely operate in challenging weather conditions, align the drone precisely for other operations, the roof opens during open/close mechanism failure and the cost effectiveness. These features make our DIB a promising technology for the future of all the purposes which drone are using such as military, agriculture, videography, surveillance. However, further research and development is needed to address the potential drawbacks and ensure the successful implementation of this technology in practical settings.

Chapter 3

DATA COLLECTION

This chapter mainly contains the data collected for our design. The details such as dimensions, technologies used in existing DIBs, components and their importance and their advantages and disadvantages are described in here. DIBs of popular drone manufacturing companies such as Percepto, DJI, DBX, Airrobotics, Heisha are used for this data collection.

3.1. Sizes Of Existing Dibs

Sizes of DIBs differ in wide range. The size off the DIB is mainly depends on the features of DIB and the protection it provides for the drone. Dimensions and the weights of popular DIBs are listed below.

	Droneport	Heisha D50	Heisha D80	Heisha D135	DBX-G7
Dimensions(m)					
Length	0.8	0.92	1.07	1.65	2.78
Width	0.8	0.7	0.89	1.29	1.42
Height	0.27	0.69	0.93	1.58	1.96
Weight(kg)	37	55	75	275	450

Table 3.1 Dimensions and the weights of popular DIBs

3.2 Roof Open Close Mechanism

Roof open close mechanism is one of major mechanism of the DIB. The roof of the DIB should be able to open and close when drone enters and leaves the DIB. Existing DIBs have different types of mechanisms for roof open and close.

3.2.1 Canopy Type Roof

Canopy type roof is a popular roof type used in existing DIBs. A hollow semi cylindrical shaped roof is hinged to the Drone box at to edges as shown in Figure 3.1. This roof can rotate for 180 degrees which eases the parking procedure of the drone. This is a simple mechanism and all Hiesha DIBs use this roof type.

Figure 3.1 DIB - Canopy type roof

3.2.2 Single Flat Roof Mechanism

Figure 3.2 DIB - Single flat roof mechanism

3.2.3 Double Side Sliding Roof Mechanism

Two sliding roofs are used in this mechanism. This mechanism takes less time to open/close compare to single door mechanisms. But this mechanism requires a n additional space compare to single type mechanisms. Drone manufacturing companies such as airobotics uses this mechanism for their DIBs.

Figure 3.3 DIB - Double side sliding roof mechanism

3.2.4 Double Side Roof

DIB manufacturing companies such as DJI dock uses this mechanism.

Figure 3.4 DIB - Double side roof mechanism

3.3 Weather Resistant Ability

There are drone in boxes that have the weather resistant ability. It is indicated by the "IP ratings".

3.3.1 IP Rates

The IP rating or IP code classifies the degree of protection provided by an enclosure, for electrical equipment with a rated voltage not exceeding 72.5 kV. IP ratings are defined by the international standard EN 60529.

This standard defines levels of sealing effectiveness against intrusion from foreign bodies such as tools, dirt and liquid water. The rating consists of the letters IP followed by two digits, the higher the number the better the protection. Sometimes a number is replaced by X, which indicates that the enclosure is not rated for those specifications.

First Digit – Solids

The first digit indicates the level of protection that the enclosure provides against the ingress of solid foreign objects, from tools or fingers that could be hazardous.

Second Digit – Liquids

The second digit defines the protection of the equipment inside the enclosure against various forms of moisture.

First Digit	Intrusion Properties
0	or X - see section below): No special protection. Not rated (or no rating supplied) for protection against ingress of this type
1	Protection from a large part of the body such as a hand (but no protection from deliberate access); from solid objects greater than 50mm in diameter.
2	Protection against fingers or other object not greater than 80mm in length and 12mm in diameter (accidental finger contact).
3	Protection from entry by tools, wires etc, with a diameter of 2.5 mm or more.
4	Protection against solid objects larger than 1mm (wires, nails, screws, larger insects and other potentially invasive small objects such as tools/small etc).
5	Partial protection against dust that may harm equipment
6	Totally dust tight. Full protection against dust and other particulates, including a vacuum seal, tested against continuous airflow.

Table 3.2 Description of first digit of IP rating

Second Digit	Intrusion Properties
0	(or X - see section below): No protection
1	Protection against vertically falling droplets, such as condensation. ensuring that no damage or interrupted functioning of components will be incurred when an item is upright.
2	Protection against water droplets deflected up to 15° from vertical
3	Protected against spray up to 60° from vertical.
4	Protected against water splashes from all directions. Tested for a minimum of 10 minutes with an oscillating spray (limited ingress permitted with no harmful effects).
5	Protection against low-pressure jets (6.3 mm) of directed water from any angle (limited ingress permitted with no harmful effects).
6	Protection against direct high-pressure jets.
7	Protection against full immersion for up to 30 minutes at depths between 15 cm and 1 meter (limited ingress permitted with no harmful effects).
8	Protection against extended immersion under higher pressure (i.e. greater depths). Precise parameters of this test will be set and advertised by the manufacturer and may include additional factors such as temperature fluctuations and flow rates, depending on equipment type.

Table 3.3 Description of second digit of IP rating

Existing DIBs and their IP ratings

- DJI dock - IP 55
- Optimus airobotics - IP 54
- Heisha D50 - IP 55
- Heisha D80 - IP 54
- Heisha D153 - IP 54
- DBX-G7 - IP 66

3.4 Drone Alignment Mechanism

In some DIBs, drone is aligned to a specific place(mainly to the center of plane) using some methods. This alignment is important for the activities/operations done inside the DIB such as battery placement, battery charging and other maintenance activities.

3.4.1 Alignment from Guild Bars

In this mechanism, the drone is aligned to the wanted location by two guider bar pairs. These guide bars align the drone to the center of the plane. Afterward, the drone is rotated to the wanted direction using the rotational pad as in (1)

Figure 3.5 DIB - Alignment from guild bars

3.4.2 Thread Mechanism

These thread version drones can stay in the air for unlimited flight time without landing (as long as power is provided to the system). The tether cable provides constant electrical power and a secure 2-way communication between the ground station and the drone. For the landing the thread will be shortened up to the DIB lander surface and it will be loosened at the landing ground unit. ICAROS Aerial Intelligence and Height Technologies used this mechanism in their DIBs.

Figure 3.6 DIB – Thread Alignment

3.4.3 Drone Leg Placing In The Hole

In these types of alignment, the four legs of the drone will be placing into the ground landing station holes by the detection pf the drone camera with the help of sensors. Sometimes they use a leg placing cover on the top of the lander to align the drone. Some of the DIBs in Airobotics and Fly Base companies used this type of alignment.

Figure 3.7 Drone Leg Placing in the Hole Alignment

3.4.4 Ring & Cup Mechanism

Here the drone has a ring attached to the bottom of its’ four legs has been land on a cup with similar radius which situated on the grounding station of DIB. With the help of the drone sensor, it stops its’ propellers to landed on the ring correctly. American Robotics is the leading DIB company that use this landing system.

Figure 3.8 - DIB Drone placement by ring and cup mechanism

3.4.5 No Mechanism For Alignment

In these types of DIBs, there is no such alignment mechanism for accurate drone alignment because there is no need of that technology. That is because of there is no such battery swapping done in the operation area of these DIBs. In this drone, it senses the lander of DIB and it will land on the surface of the grounding station. Drone Hub has this type of DIBs.

Figure 3.9 DIB – No Mechanism

Chapter 4
DESIGN OF DIB SETUP

The project DIB aims to create an intelligent and efficient system for safe landing and monitoring of UAVs. The compact design of the DIB allows for easy transportation and storage, making it a suitable option for many industries such as surveillance, agriculture etc.. The project utilizes a Node MCU controller as the main brain of the system, which is responsible for collecting data from various purposes such as

- Real time data taken by UAV : This data Images, Videos....) is transferred to Node MCU directly from drone and it can be transferred to PC to gather further information
- UAV real time status update : Position, Altitude, Temperature, Air speed & Direction So the sensors we use in drone gather this data and will send it to the DIB.
- DIB status update : This sensor will gather information about the DIB roof whether its open/close and by analyzing this it also generates the Fly time, this data is shown in a in built LCD screen on DIB.

These sensors gather information about the UAV send it to the Node MCU, which then analyzes the data and makes adjustments and indications. The real time data taken by UAV's will be transferred to the DIB and it can be transferred to PC to gather further operations and also this DIB consist a battery swapping system for the UAV which is not a scope of our project but to facilitate that process and for the expansion, we as a group have considered the UAV alignment system as a part of this project. Finally, we are planning to design a DIB that guarantees a Roof opening during roof open/close mechanism failure with suitable material selection with IP55 standard which is less expensive and reach required specifications. Moreover, to not over complicate the system we are trying to design a roof mechanism which gives an opening with one door and less number of connecting parts. Although the designing roof will be replaced easily by a new roof when the existing roof was failed to open and close. Finally, the outside of the roof should be design in a way that it protects the inside of DIB from weather. Making the maintenance manual using a word and image processing software.

4.1 Basic Design

All existing drones only has the weather proofing materials in the outer layer which stops entering water, dust and other outside particles into the DIB. Also, there are some DIBs which are made from water resistant electronic components which are very expensive.

In this design it is planned to filter out/remove water in a upper platform which is placed above the operation area. Water (which gets into the DIB when the roof opens to enter the drone) is removed in this upper platform and the dry drone is sent to the operation area. The following sketches illustrates the process happen in the design.

Step 1) Drone lands on the platform

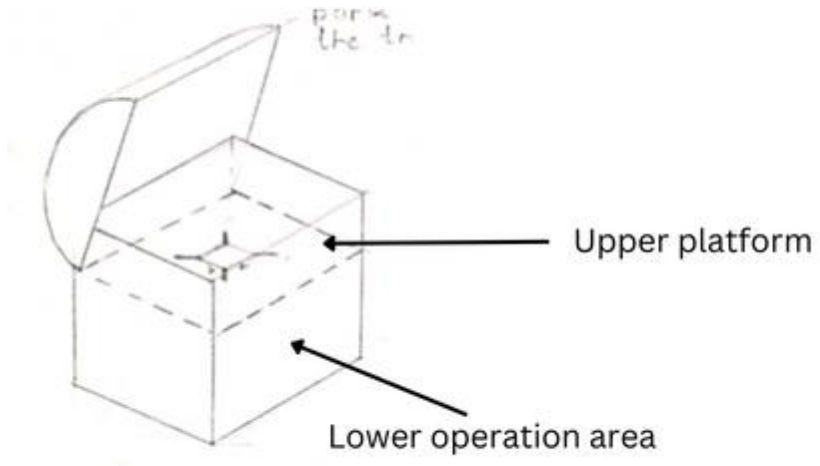

Figure 4.1 - DIB Design

Step 2) Roof/Door closes. Water drainage and alignment processes happen simultaneously.

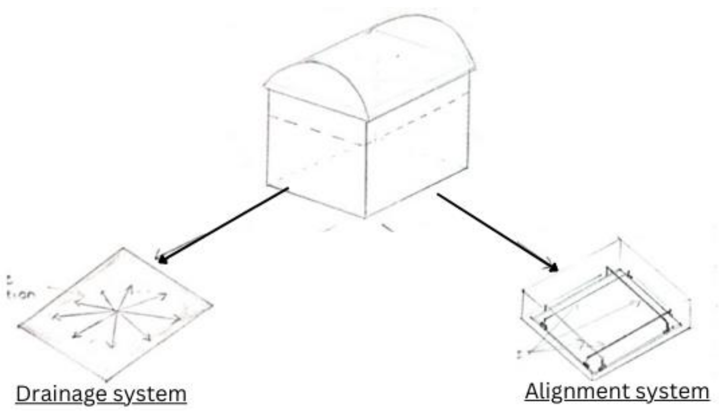

Figure 4.2 - DIB Design - exploded view

This design is a portable and a simpler mechanism with a smaller number of connecting parts. The customer requirements for this design include easy assembly and disassembly.

The design specifications for this DIB design include a drainage system and an alignment system. The drainage system is the bottom plane of the upper platform. As shown in the picture it has a slope towards the edges in the direction of arrows. This feature facilitates the system to remove the water easily under the gravity. After the water removal process. A dryer will turn on it will dry the water droplets on the drone and DIB surface.

The alignment system helps make sure the drone is placed in the DIB for the next process which is the battery swapping process (which is not the scope of this project). So, it will align the drone with the guided bars and gives a pin point alignment to the next step.

4.2 Modelling The Design

The above discussed idea was modeled using “SolidWorks “. The data collected from the existing DIBs were helpful when modeling the design. The dimensions of parts of the DIB were modeled according to the dimensions of an existing drone. The details of the drone were described as follows.

- Drone modal – DJI inspire 3

- Basic dimensions

  Length - 500.5 mm

  Width - 709.8 mm

  Height - 176 mm

Figure 4.3 DJI inspire 3

According to the dimensions of the drone, dimensions of the DIB were selected as follows.

Length - 105 cm

Width - 95 cm

Height - 89 cm

When deciding the above dimensions, following factors were considered.

- Parking space for the drone
- Space for the water drainage system
- Operation area of existing DIBs

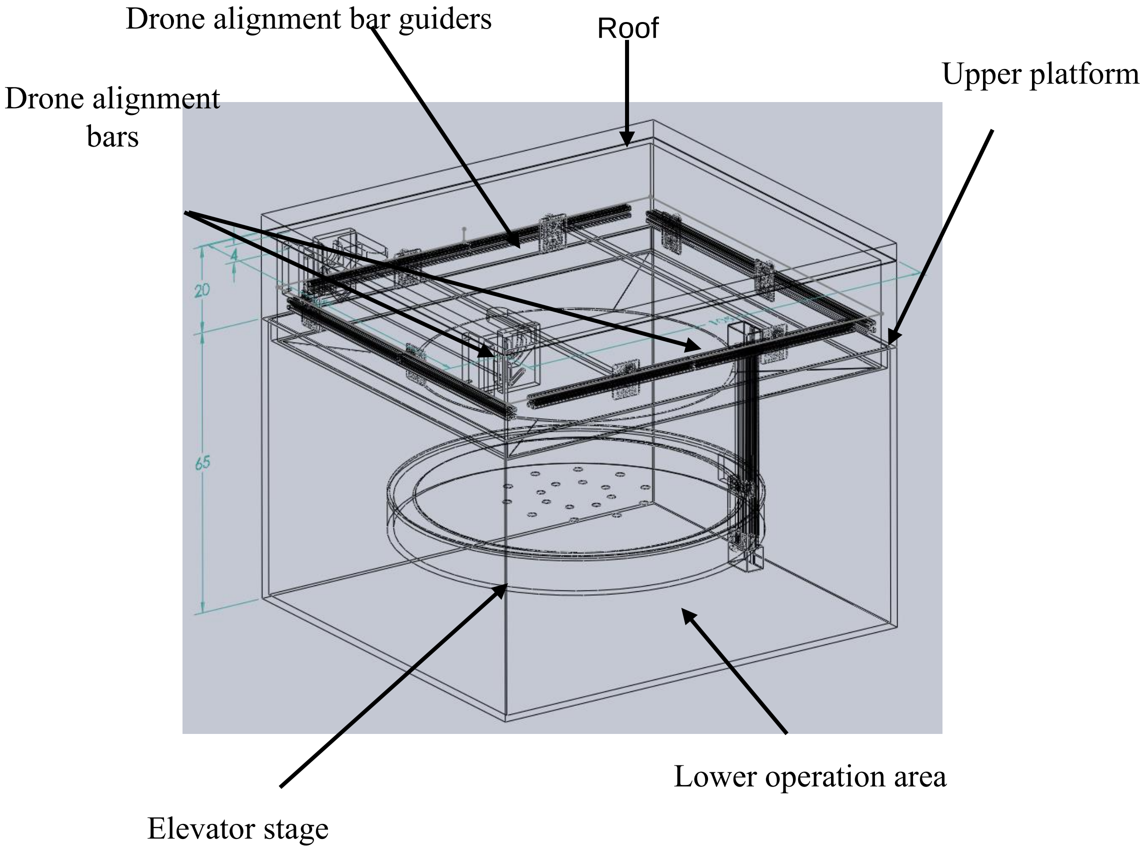

Figure 4.4 Parts of the DIB design(Isometric view)

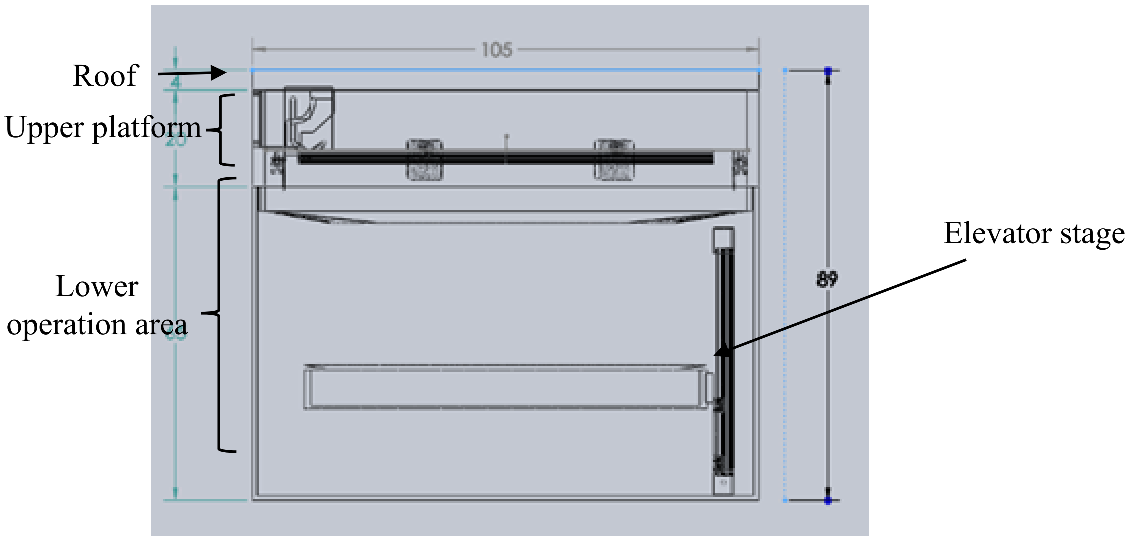

Figure 4.5 End view of DIB design

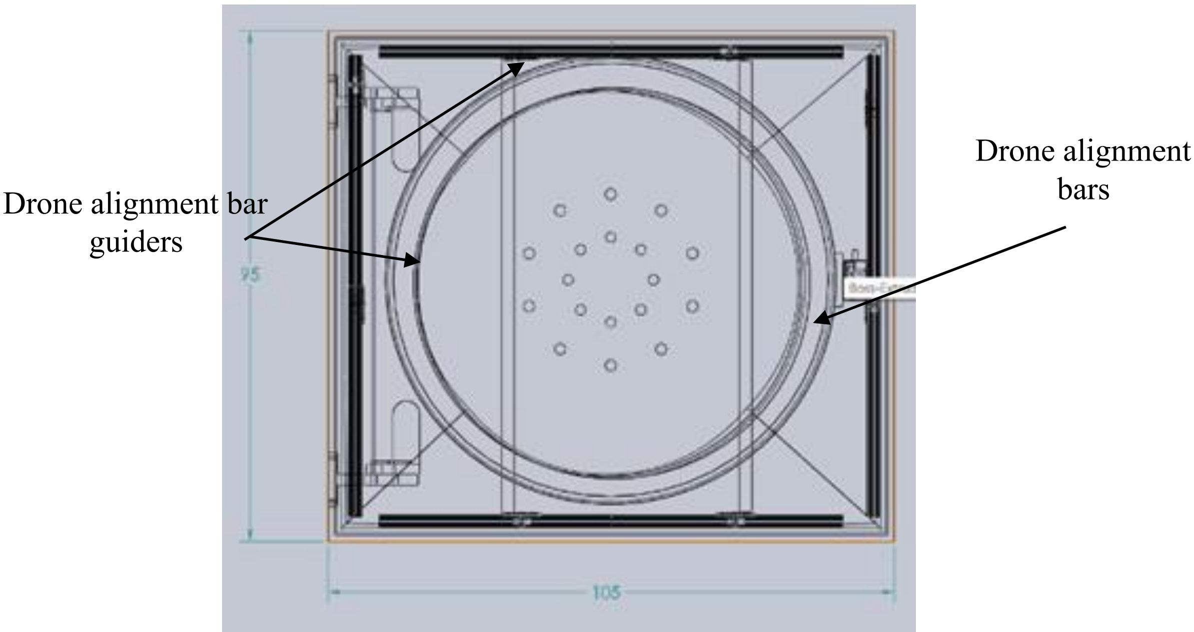

Figure 4.6 Top view of DIB design

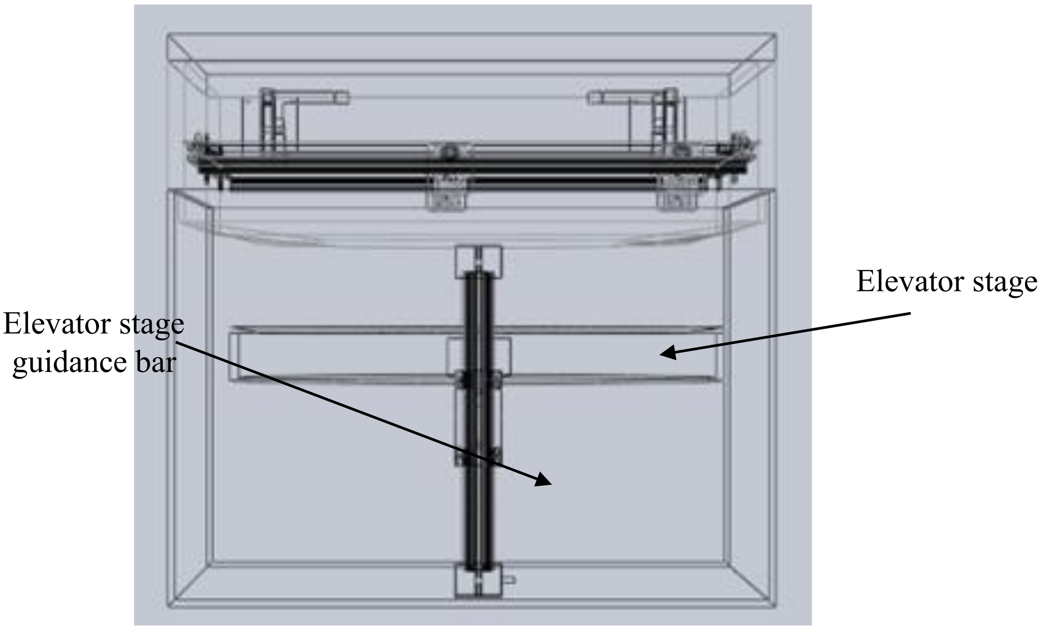

Figure 4.7 Front view of the DIB design

Following figures and details give more information about the main components of the design.

4.2.1 Upper platform

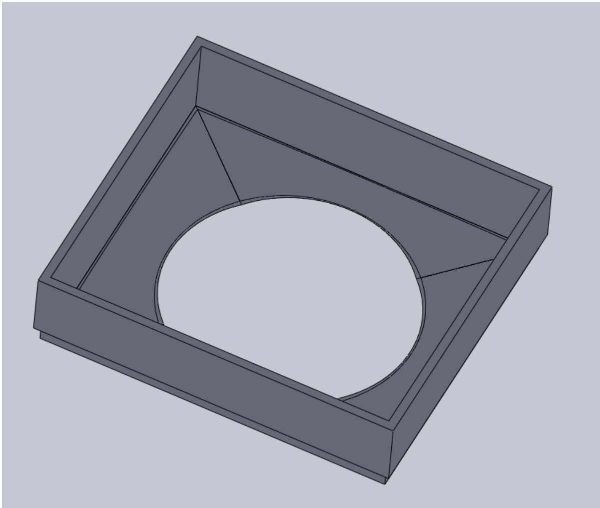

Figure 4.8 Isometric view of upper platform

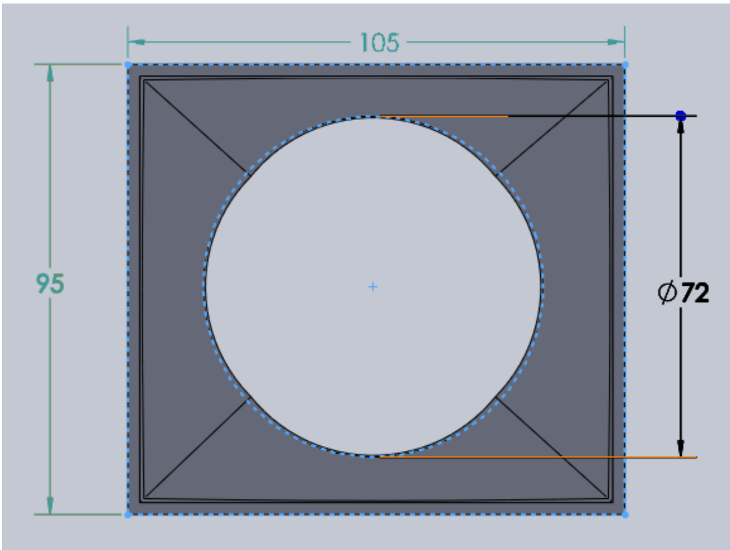

Figure 4.9 Top view of upper platform

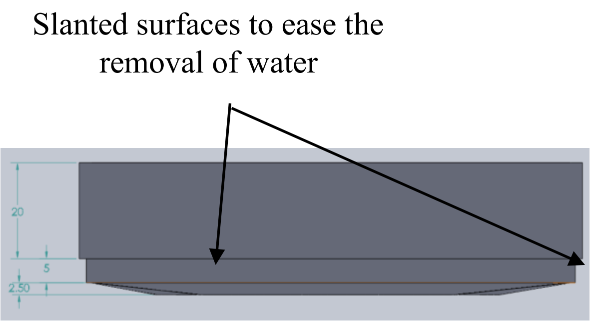

Figure 4.10 End view of upper platform

Upper platform is the place where the drone parked initially. The elevator stage has to be inContact with the upper platform as shown in below figures. when the drone enters to the DIB.

The upper platform has to protect the lower operation area from the water. Therefore, the upper platform should have good water sealing mechanism and water drainage abilities. The attached combination upper platform and the elevator stage provides a complete surface for the parking of drone. As shown in the below figures, the bottom surface of the upper platform has a slope towards to the circular hole. This allows rain water to flow towards the elevator stage easily, which helps the drainage system of the design.

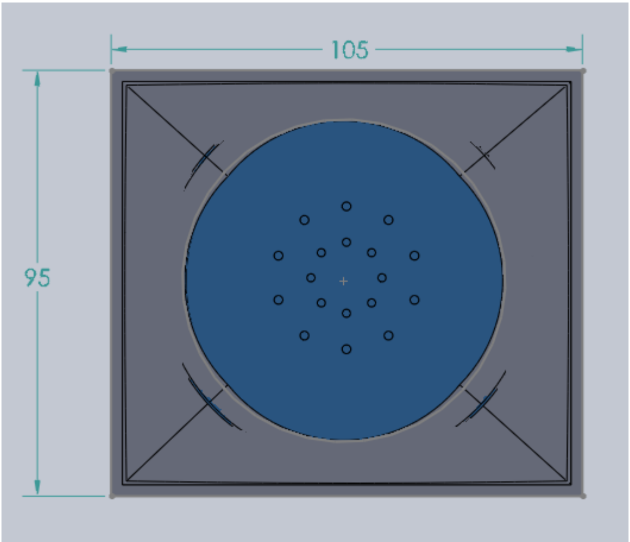

Figure 4.11 Combination of upper platform and elevator stage (Top view)

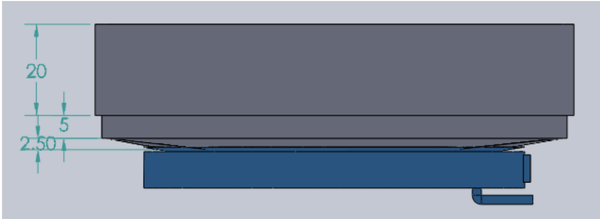

Figure 4.12 Combination of upper platform and elevator stage (End view)

4.2.2 Elevator stage

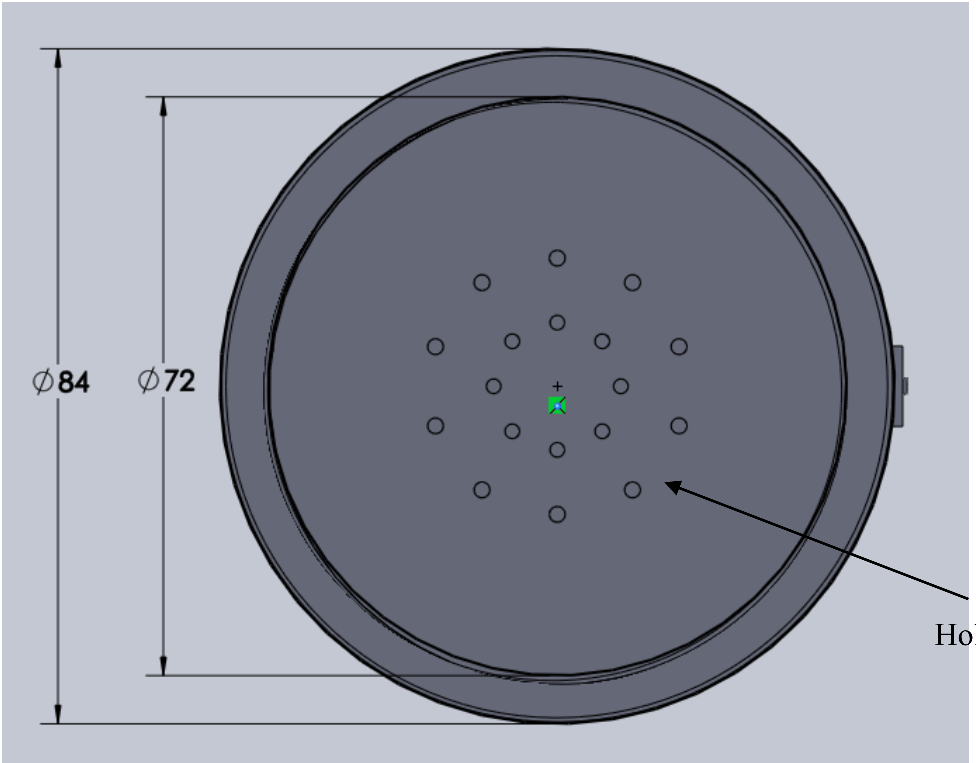

Figure 4.13 Top view of the Elevator stage

Figure 4.14 End view of the elevator stage

Elevator stager provides the following functionalities to the DIB.

- Move the drone to the lower operation area – The drone has to be moved from the upper platform to the lower operation area for activities such as battery swapping, and take the drone has to move back to the upper platform for the departure.
- Rotate the drone to the wanted orientation – The drone should rotate to a proper side before it moves to the lower operation area. This proper side rotation is especially important for the battery swapping operation.
- Drain the water of the upper platform area – The rain water enters/fall into the upper platform flows to the elevator stage due to the slope of the upper platform. The elevator stage can store water inside it because it is designed as coreless cylinder. Water enters into the elevator stage from the holes at the top surface and get collected. Then the collected water is removed from the pipe from the pipe at the bottom. This pipe carries out the water to the bottom of the DIB and remove them from DIB.

The elevator stage should not allow water to flow out from the top surface edges which is highlighted from the red color circle. To ensure that, the surface between the large circle (circle which has a diameter of 84 cm) and the small circle (circle which has a diameter of 72 cm) has a slope.

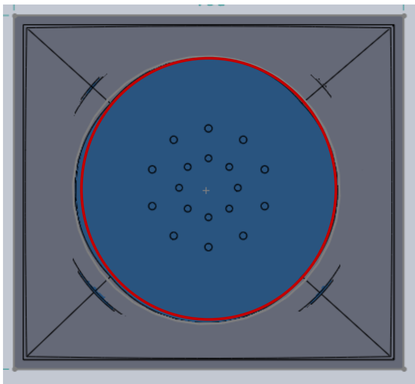

Figure 4.15 Elevator stage attached to the upper platform (Top view)

4.2.3 Drone alignment system

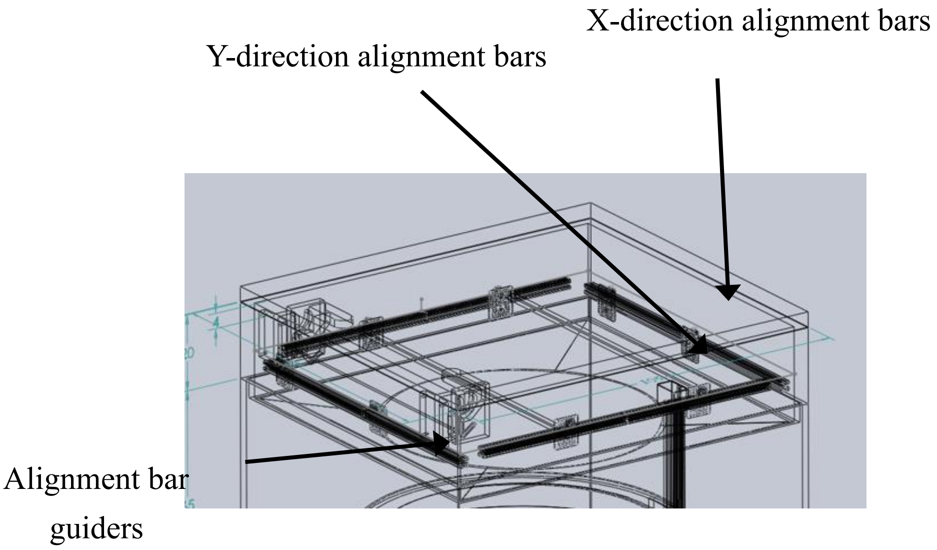

Figure 4.16 Drone alignment system

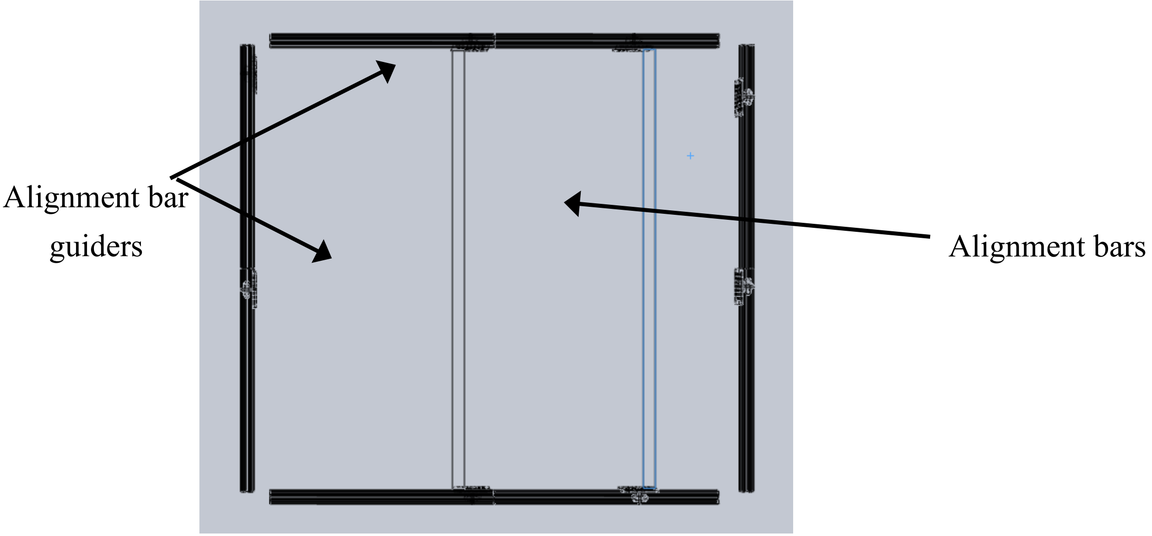

Figure 4.17 Drone alignment system (Top view)

Figure 4.18 Drone alignment system (End view)

As explained above, drone alignment is an important factor in this DIB. The drone has to be placed to the middle of the upper surface, to move it to the lower operation area. Also, alignment is important for the battery swapping process.

The drone is aligned to the proper position from the support of four moving bars. These bars are oriented in two directions. Two bars are used to align the drone in X direction, while the other 3 align the drone in Y direction. These bars are synchronously moved towards the center of the upper surface from the edges. Due to this movement, the drone pushed towards the middle of the upper platform, which is the top of elevator stage. Following figures illustrates the alignment mechanism in a one direction.

The hexagon represents the drone in following diagrams. As shown in Figure 4.17, the alignment bars move towards the center of the upper platform while pushing the drone to the middle. The Figure 4.18 shows the new position of the drone after alignment bars pushes it towards to the middle of the platform.

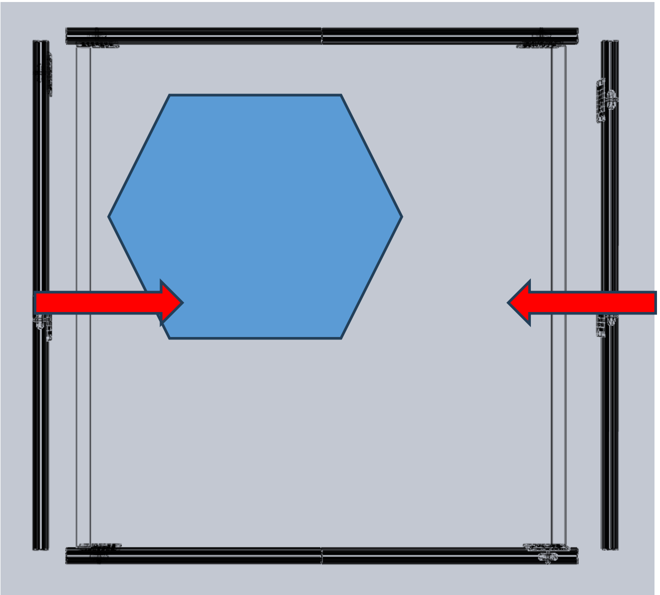

Figure 4.19 Initial position of the drone before the alignment

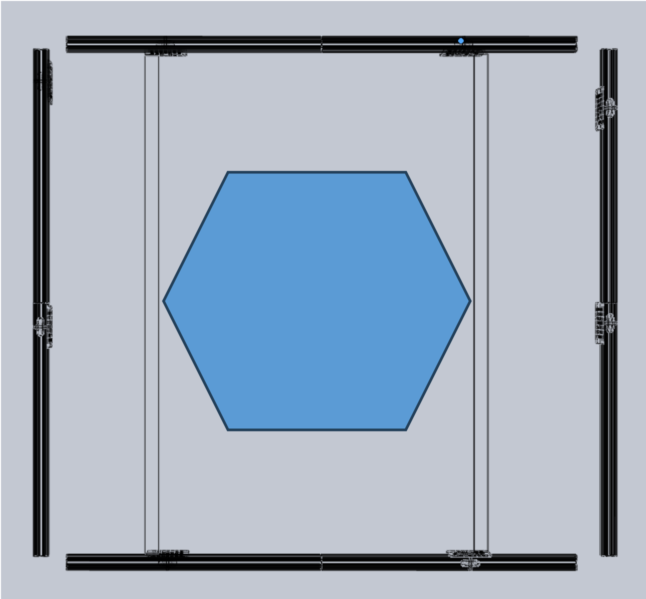

Figure 4.20 Final position of the drone after alignment

A similar process happens in the Y direction, which aligns the drone in the Y direction.

4.2.4 Roof mechanism

Roof mechanism is one of the important features of this DIB design. The roof mechanism should be able to protect the DIB from the outside obstacles. Also, the roof mechanism should operate efficiently. That means the roof should open and close quickly which ease the arrival and departure of the drone. Also the roof mechanism should be simple and less energy consumable when considering the overall power consumption of the DIB. The roof mechanism used for this DIB design is very simple and reliable. This single flat roof mechanism is controlled by a cogwheel which is connected to a servo motor. Below figures are the positions of roof moving operation.

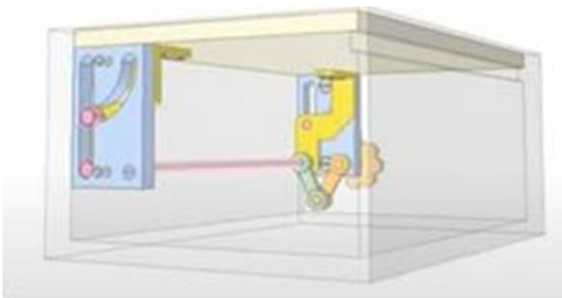

Figure 4.21 Roof closed position

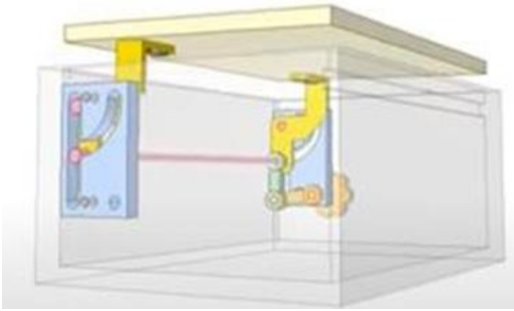

Figure 4.22 Roof starts to open

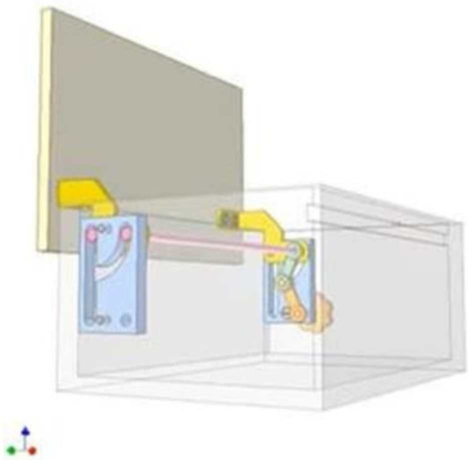

Figure 4.23 Roof full opened position

It was well planned to repair the roof easily when failure happen on the roof mechanism. The roof mechanism consists of small number of parts without chain operation in the roof opening mechanism with simple idea. The available DIBs' mostly consist of chain operation results failure most of the times. In our roof mechanism it has been avoided by the idea. The parts that needed are roof hinge, path profile, profile connector, gear box connector and DIB box connector.

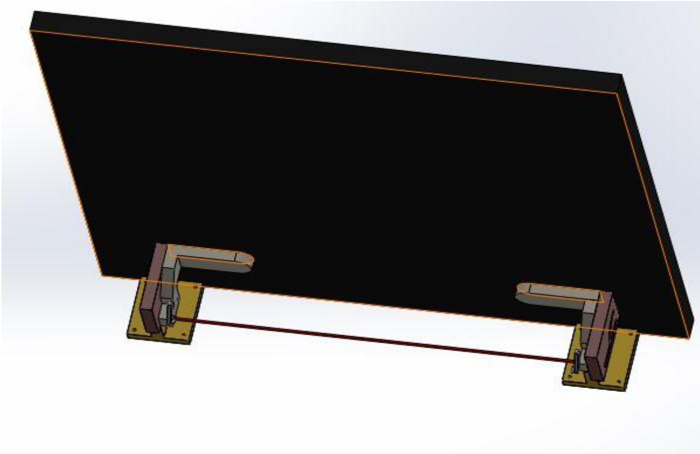

Figure 4.24 Roof Mechanism (Isometric view)

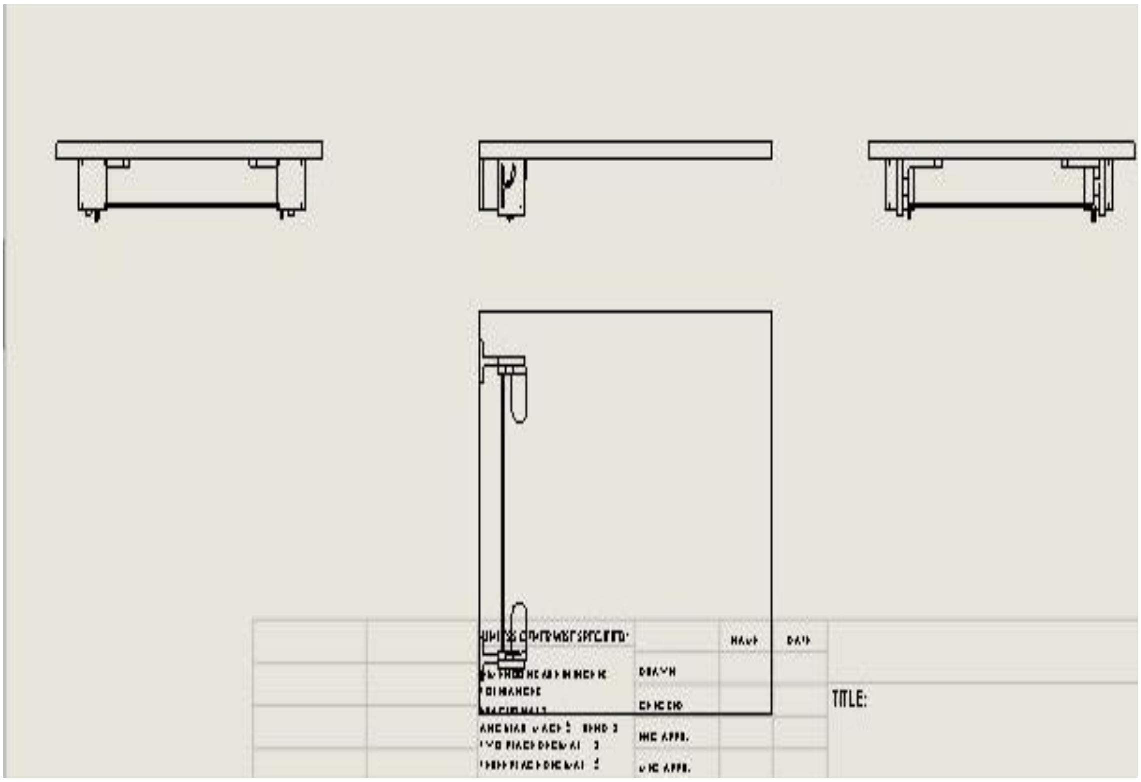

Figure 4.25 Roof Mechanism (2D Drawing)

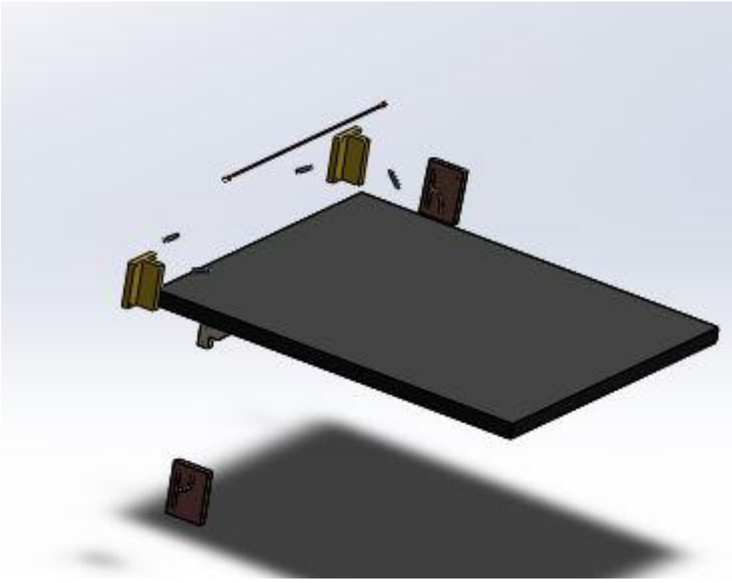

Figure 4.26 -Roof Mechanism– Exploded View

The other parts SolidWorks designs are showed below.

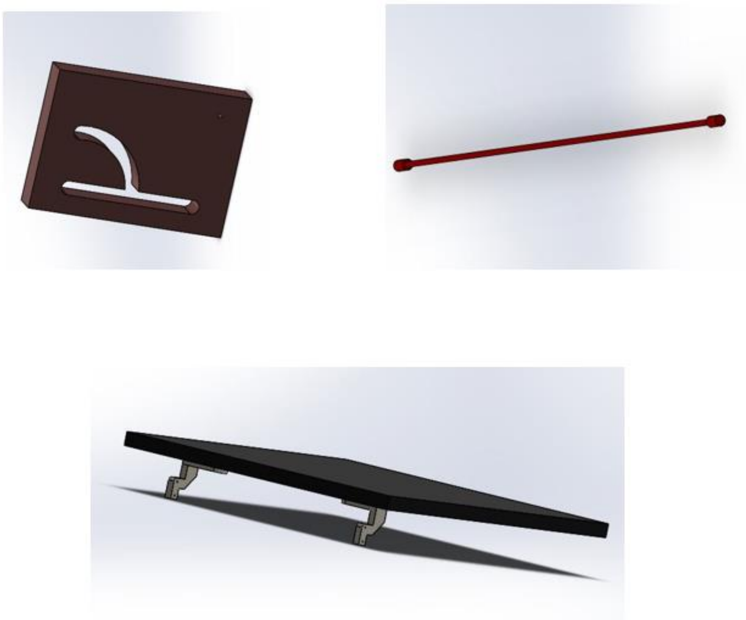

Figure 4.27 Roof Mechanism(Main Parts)

In the roof, the main concern in other DIB is when failure occur the whole DIB should be replaced. Here our challenge is to make the roof separate and portable when it damaged. Therefore, the roof was designed separately and connected to the DIB box by a connector. When failure happens, it can be removed from the DIB and by that whole roof mechanism can be separated.

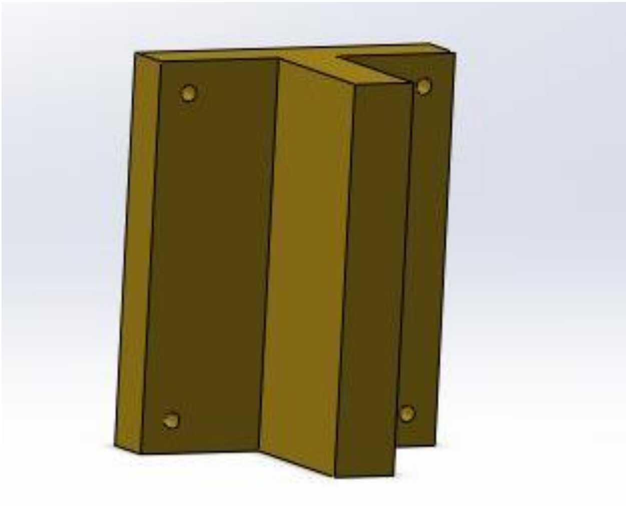

Figure 4.28 DIB Box Connector Hinge

Finally, the mechanism connected to the gear box to drive the roof. The motor which will drive the roof will be SM (Synchronous) series AC servo Motor.

Figure 4.29 Roof Mechanism(AC Servo Motor)

The suitable power of the motor will be 100 w with estimation time to open the roof is 5 seconds. The advantage of this motors is maintenance free, excellent environmental resistance, higher torque, compact and lightweight, high-power rate and power generation control during blackouts.

4.3 IoT Technology of DIB

IoT technology in DIB involves the use of various devices and equipment to monitor and control the UAV by transferring real-time data to DIB system. One key component is the use of a Node MCU, which is a microcontroller unit that acts as the brain of the system. It is responsible for collecting data from sensors, processing that data, and sending commands to actuators.

Sensors such as humidity sensors, soil pH sensors, water pH sensors, and air temperature sensors are used to collect data from the UAV and DIBs. These sensors communicate with the Node MCU and send data to it for processing. Actuators such as fans, ventilation systems, irrigation systems, humidifiers and heaters are used to control the environment inside the greenhouse based on the data received from the sensors. The Node MCU sends commands to these actuators to adjust the environment as needed.

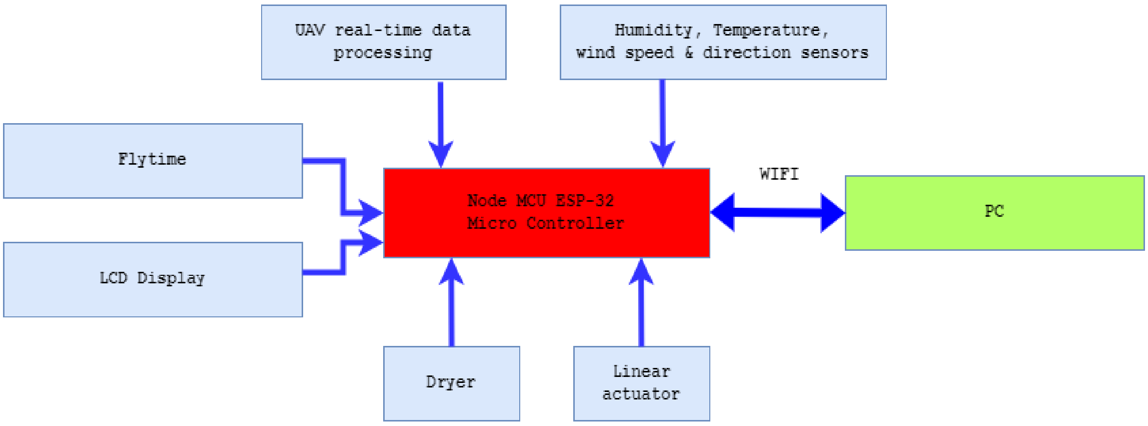

Figure 4.30 IoT technology of DIB

4.3.1 Node MCU ESP-32 Micro-Controller

The ESP-32 chip, a low-cost, low-power system on a chip (SoC) with Wi-Fi and Bluetooth capabilities, serves as the foundation for the microcontroller board known as the Node MCU ESP-32. It is frequently utilized in projects that call for wireless communication and is developed for Internet of Things (IoT) applications. A 13-microcontroller unit (MCU), flash memory, and a range of digital and analog input/output (I/O) pins are all included in the Node MCU ESP-32. It is simply attached to a number of sensors and actuators and may be quickly programmed using the Arduino IDE. Additionally, the Nedelcu ESP-32 enables OTA (over-the-air) firmware upgrades, enabling remote firmware changes without physically attaching the device to a computer.

Figure 4.31 Node MCU ESP-32 Micro-Controller

4.3.2 Adjustable limit linear actuators - FA-AL-35-12-10

Adjustable linear actuators are commonly used electronic device in industry by using this we can now adjust and fine-tune the end-of-stroke stopping position of the Actuator, simply by adjusting the slider on the body. This clever device allows you to adjust the end of stroke limit by up to 1" (Inch) giving you the ultimate flexibility to install and integrate the actuator into your device quickly and easily. It has manufactured with aerospace-grade aluminum to resists corrosion, IP 66 rated, maintenance free and built-in limit switches to automatically stop the Actuators at each end of the stroke, this Actuators provide consistent 100% reliable performance.

Figure 4.32 Adjustable limit linear actuators - FA-AL-35-12-10

It has some product variations which differ according to the load, weight retracted and extended length. So, to make sure which is most preferable and low cost our group has analyzed to the performance tables and graphs and came into a conclusion.

Dimensions and Weight

Stroke	Retracted Length	Extended Length	Weight
1 "	5.53 "	6.53 "	1.60 lbs
2 "	6.53 "	8.53 "	1.68 lbs
3 "	7.53 "	10.53 "	1.84 lbs
4 "	8.53 "	12.53 "	1.92 lbs
6 "	10.53 "	16.53 "	2.12 lbs
9 "	13.53 "	22.53 "	2.48 lbs
12 "	16.53 "	28.53 "	2.78 lbs
18 "	22.53 "	40.53 "	3.40 lbs
24 "	28.53 "	52.53 "	4.02 lbs
30 "	34.53 "	64.53 "	4.68 lbs

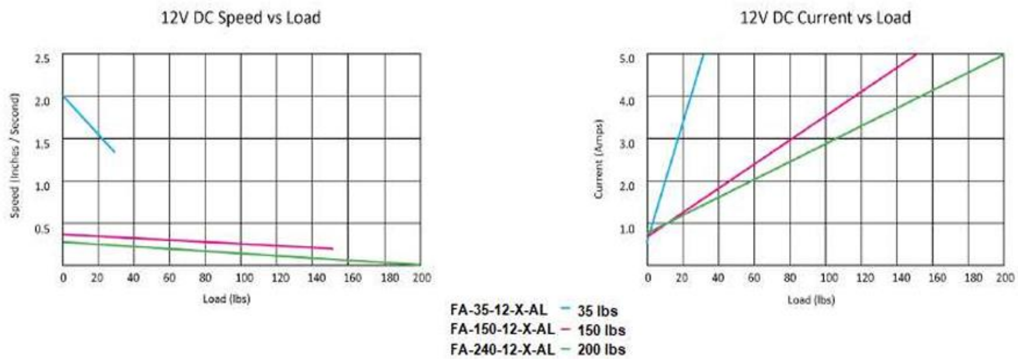

Figure 4.33 Selection of linear actuator

4.3.3 Humidity & Temperature sensor – DHT11

A cheap digital humidity and temperature sensor is the DHT11 sensor. It measures the air around it using a capacitive humidity sensor and a thermistor and delivers a digital signal to the Node MCU ESP-32 microcontroller. The sensor has an accuracy of 5%

and can measure temperature with a range of 0–50°C and humidity with a range of 20–90%. A single data pin can be used to interface with the Node MCU ESP-32, and a straightforward communication protocol can be used to read the data. In order to regulate the ventilation and heating systems, the DHT11 sensor can be used to measure the humidity and temperature inside the greenhouse.

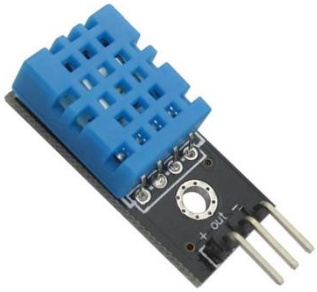

Figure 4.34 Humidity & Temperature sensor

4.3.4 Wind speed & Wind direction – Ultrasonic Wind Sensor WMT700

Wind Sensor WMT700 is a robust, reliable ultrasonic anemometer that provides surface wind direction and wind speed measurement that is WMO, CIMO, and ICAO compliant. Ultrasonic wind sensor technology in the WMT700 delivers highly accurate wind speed and direction information ranging from barely perceptible winds to extremely high gusts.

It is also highly accurate in conditions where mechanical instruments fail, including heavy precipitation, severe icing, strong winds, heavy sand and dust, and offshore maritime installations. Optional heaters in the transducer, arm, and/or body prevent build-up of freezing precipitation.

Figure 4.35 Ultrasonic Wind Sensor

4.3.5 Node MCU Smart dryer

This Dryer setup for to build an automatic dryer which activates when the Box is wet to a certain degree. As the amount of water in the target material changes, the corresponding resistance changes, and based on that Node MCU turns on or off the fans. To build this setup our group have used several components. Resistors, Transistor, Capacitor, Motors, Handmade propellors, Battery pack and jumper wires. This setup allows us to dry the DIB and helps to protect the DIB from water.

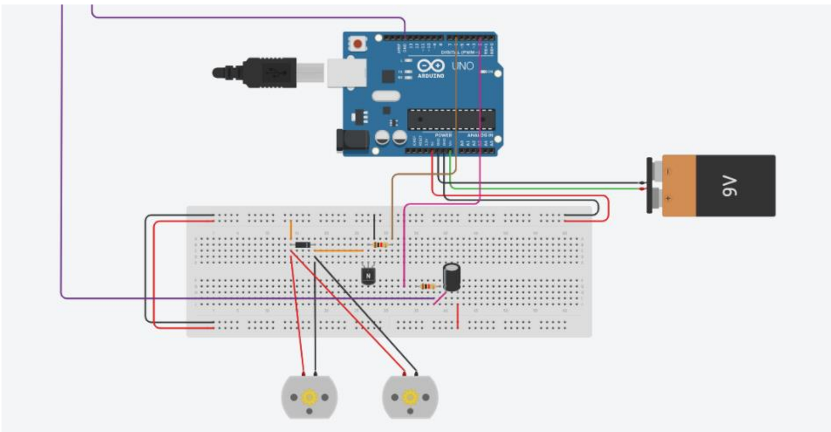

Figure 4.36 Node MCU Smart dryer

4.3.6 Blue backlight LCD screen

A LCD screen used in an IoT based greenhouse project as a display for showing various information such as temperature, humidity and wind speed. The LCD screen could also be used to display the fly time of the UAV. The information displayed on the LCD screen could be monitored through a PC connected to the IoT system of the DIB. The LCD screen could be connected to the Node MCU or microcontroller of the project, which would be responsible for displaying the information on the screen. The size and resolution of the LCD screen would depend on the specific design of the project and the customer requirements.

Figure 4.37 Blue backlight LCD screen

4.4 Material Selection

Here is the material selection done for most important parts of DIB.

4.4.1 DIB

Figure 4.38 - Material Selection – DIB

Design Requirements	
Function	Keep the drone and all needed operation equipment safely
Constraints	Do not affect by the environmental conditions Do not fracture Higher strength
Objectives	Maximize weather proof
Free variable	Choice of material

Table 4.1 Material selection of DIB

Material Selected – Stainless Steel

Stainless steel contains chromium, which forms a passive protective layer on the surface, making it highly resistant to corrosion and rust. This inherent weatherproof property ensures the material can withstand harsh weather conditions without degradation. Stainless steel is stronger and more robust than aluminum, making it suitable for applications that demand greater structural integrity or resistance to heavy loads and impacts.

4.4.2 Drone Lander

Figure 4.39 - Material Selection – Drone Lander

Design Requirements	
Function	Grounding station for Drone A lift for the operation area
Constraints	Light Weight Reliable Resistance for environmental changes and climate
Objectives	Minimize mass
Free variable	Choice of material

Table 4.2 Material selection of drone lander

Material Selected – Aluminum

Aluminum is naturally corrosion-resistant due to the formation of a thin oxide layer on its surface, which protects it from the elements. This makes it suitable for outdoor applications, where exposure to rain, sunlight, and other weather conditions is a concern. Aluminum is known for its low density, making it one of the lightest engineering metals available. Its lightweight nature makes it easier to handle, reduces the overall weight of the machine, and allows for smoother and more efficient operation of the open and close mechanism.

4.4.3 X&Y Guided Bars

Figure 4.40 - Material Selection – X&Y Guided Bars

Design Requirements	
Function	Aligning the drone on the lander
Constraints	Light Weight Weatherproof Lower wear rate Lower deformations
Objectives	Minimize mass Minimize deformation
Free variable	Choice of material

Table 4.3 Material selection of guide bars

Material Selected - Cobalt-Chromium (Co-Cr) Alloys

Co-Cr alloys offer high strength, low deformation, and good wear resistance, making them popular for dental and orthopedic implants.

4.4.4 Roof Mechanism

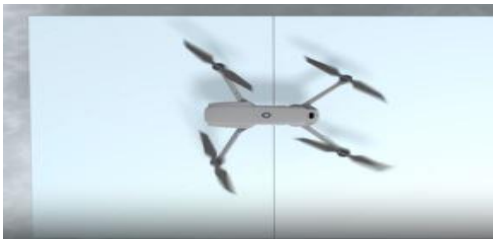

Figure 4.41 - Material Selection of Roof Mechanism

Design Requirements	
Function	Open and Close the DIB
Constraints	Light Weight Weatherproof Lower wear rate Lower deformations Higher durability
Objectives	Minimize mass Minimize deformation
Free variable	Choice of material

Table 4.4 Material selection of roof mechanism

Material selected - Austenitic Stainless Steel

Austenitic stainless steels have excellent ductility and can withstand deformation without permanent damage. They exhibit good wear resistance due to the presence of nickel and chromium, which form a passive oxide layer on the surface. Austenitic stainless steel, particularly grade 316L, is highly corrosion-resistant, making it suitable for marine and outdoor applications.

4.4.5 Water Drainage Pipe

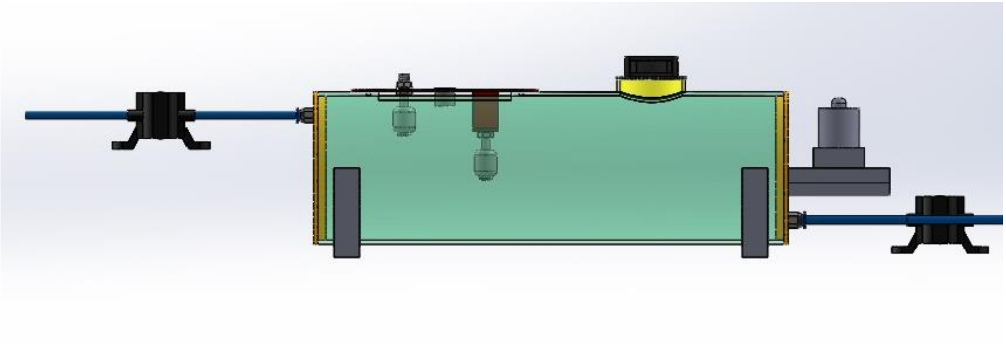

Figure 4.42 - Material Selection of Water Drainage pipe

Design Requirements	
Function	Release the collected water from lander and other parts of DIB
Constraints	Prevent leakage Adjustable height Corrosion resistance Smoother Inner Surface Light Weight
Objectives	Minimize leakage
Free variable	Choice of material

Table 4.5 Material selection of water drainage pipe

Material Selected - Double-wall Aluminum foil with additional seat.

Thick layer of grey PVC on this ducting prevents light leaks and height can be adjusting when lander lifting purposes. They are joined using heat fusion techniques, creating seamless connections that minimize the chances of leaks

Chapter 5

PROTOTYPE AND TESTING

As described in the above chapters, main objective of this project is designing a DIB which can operate reliably and effectively in rainy weather conditions. The chapter 4 describes the overall information of the DIB design. When considering the operating ability in rainy conditions, the most important parts are the water drainage system and the water sealing system. Therefore, the water drainage system of the design, which has described in the Chapter 4, has to be tested. This chapter describes the prototype that build in order to test the water drainage and sealing mechanism of the DIB design.

5.1 Prototype

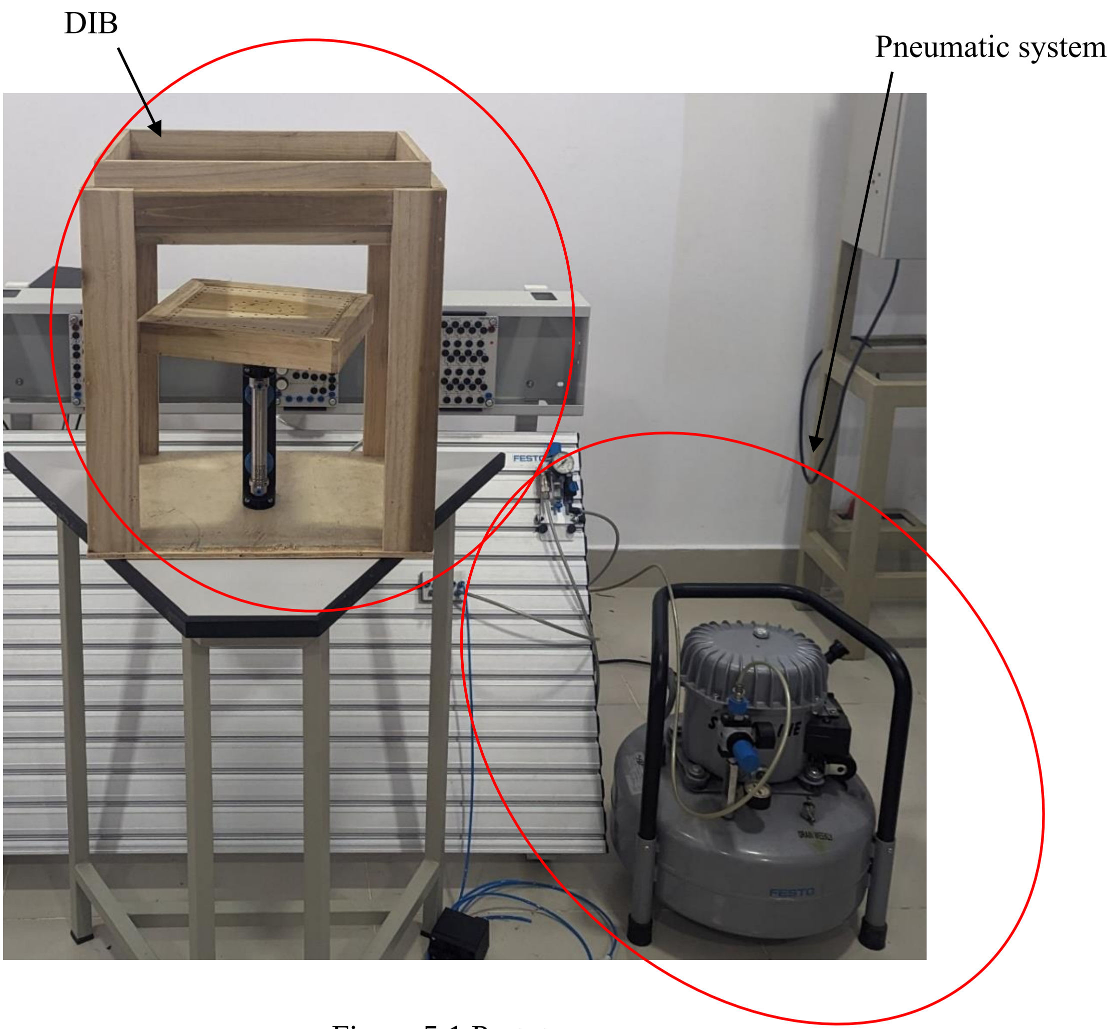

Figure 5.1 Prototype

Figure 5.1 shows the prototype of the DIB design. As explained above, the relevant parts to test the drainage system were selected and they were fabricated. Following parts were found as the critical parts wanted to implement the drainage system and the water sealing mechanism.

- Upper platform
- Lower Operation area
- Elevator stage

Above mentioned parts were fabricated using timber. Timber was used because, timber is a material which can easily found and fabricated. Timber parts were jointed using nails. The joints were water sealed using silicon glue.

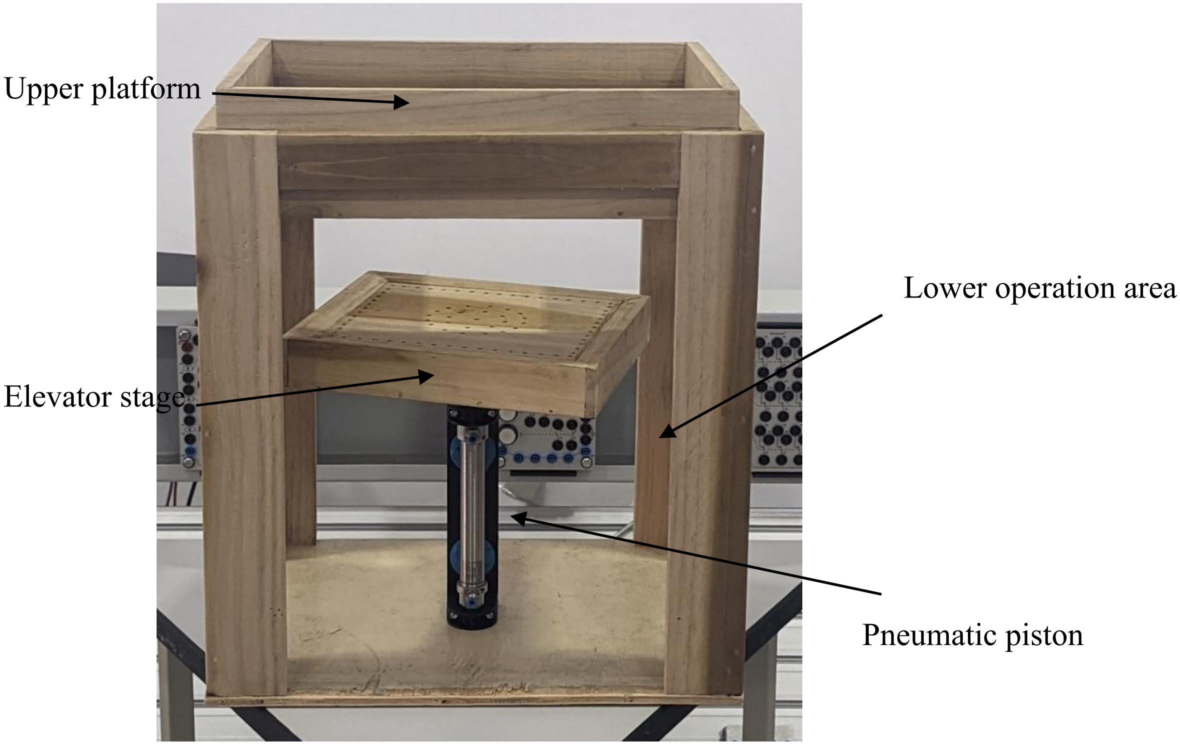

Figure 5.2 Parts of DIB

Elevator stage was moved and controlled by the pneumatic piston. Pneumatic piston was used for the linear actuator of the DIB design. Pneumatic piston was used because it can be operated without a power supply and can be controlled easily without an electronic control unit. Pneumatic piston is a double acting cylinder which can be used to move elevator stage upwards and downwards. The dimensions of the DIB were selected according to the dimensions of the pneumatic piston. The dimensions of the DIB are as follow.

Length - 44 cm
Width - 35 cm
Height - 47 cm

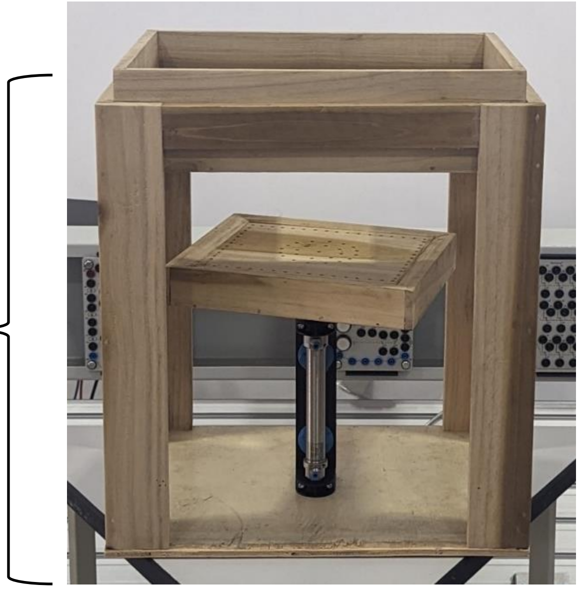

Figure 5.3 Dimensions of DIB (Front view)

Figure 5.4 Dimensions of DIB (Top view)

The components of the prototype of the DIB can be described as follows.

5.1.1 Elevator stage

The elevator stage was designed as a cylinder (has a circular shape) in the design stage. But elevator stage fabricated in rectangular shape because it was difficult to achieve accurate measurements and fabricate circular shapes using timber. The rotation of the elevator pad was not tested in this prototype; therefore, shape of the elevator stage can be changed.

Figure 5.5 Elevator stage

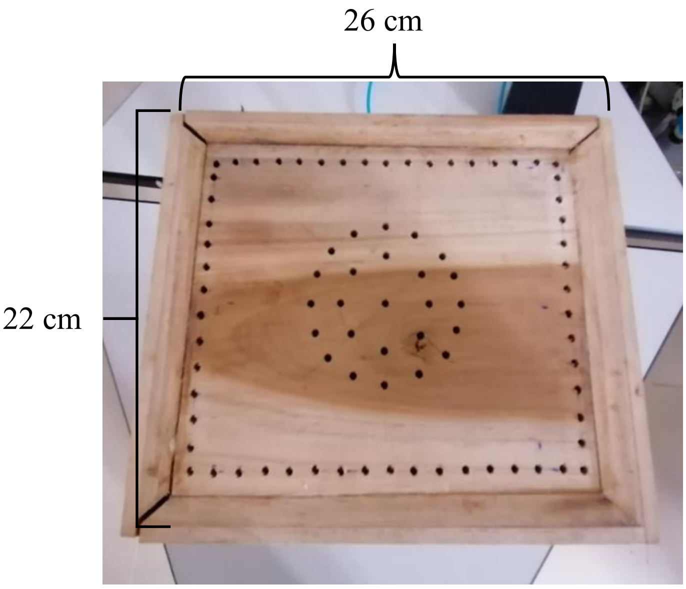

Figure 5.6 Top view of the elevator stage

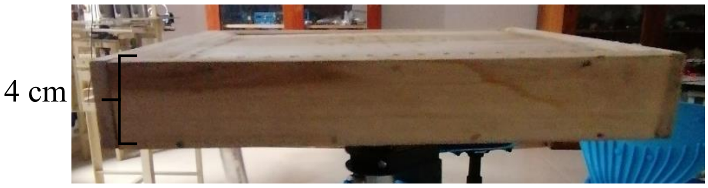

Figure 5.7 Front view of the elevator stage

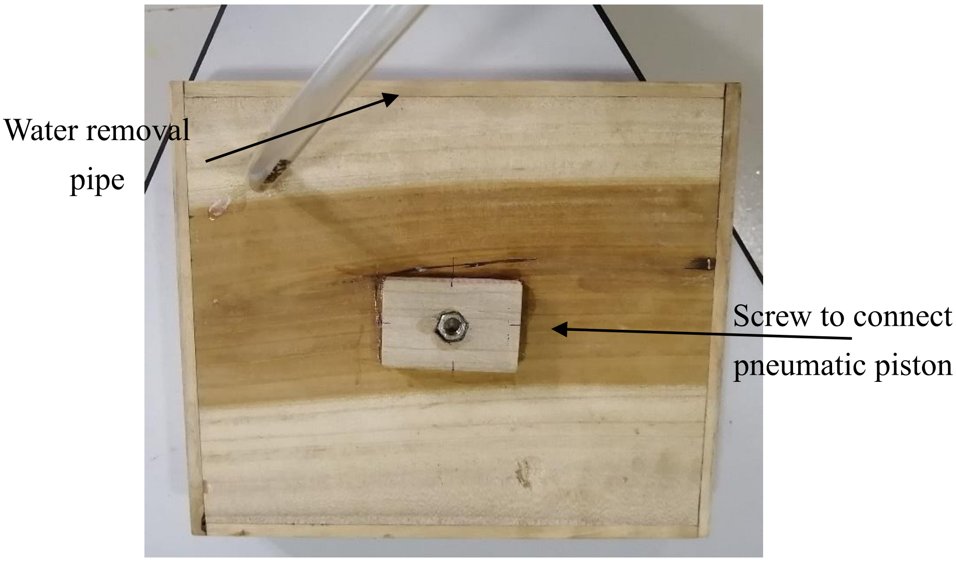

Figure 5.8 Bottom view of the elevator stage

As shown in the Figure 5.6, the elevator stage has holes in the top plane. These holes allow to flow water into the core of the elevator stage, which is used to store water temporarily. Then the stored water is removed/flown out from the water removal pipe which is connected to the bottom of the elevator stage, as shown in the Figure 5.8. There are holes at the edge of the top plate which are used to avoid the water flow over the elevator stage. This is crucial because water cannot be flown over the edges of the elevator stage. There is a slanted plane after the border of holes in order to restrict the flow of water. Following figure shows the slanted plane at the edges of the elevator stage.

Figure 5.9 Zoomed view of an edge of the elevator stage

There is a screw at the bottom of the elevator stage (Figure 5.8). The screw is used to connect the elevator stage to the pneumatic piston.

5.1.2 Upper platform

The upper platform is also fabricated by timber.

Figure 5.10 Upper platform

The dimensions of the upper platform are as follows.

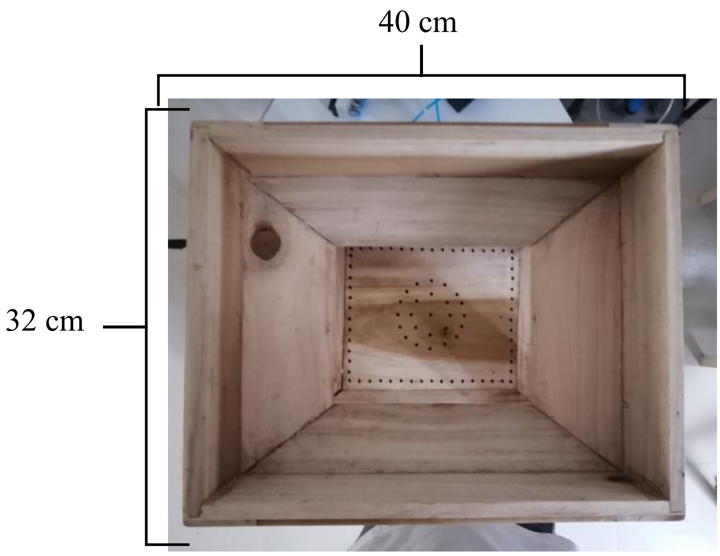

Figure 5.11 Top view of the upper platform

Figure 5.12 Side view of the upper platform

As shown in the Figure 5.10, the bottom plane of the upper platform is slanted, in order to ease the flow of water towards the elevator stage. The connected edges of the bottom surface were pasted from a silicone gel in order to prevents water leakages.

5.1.3 Lower operation area

Lower operation area was fabricated in order to hold the upper platform. The structure of the lower operation area is consisting with 4 columns, which give a proper view of the inside of the lower operation area. It was necessary for the testing process of the prototype.

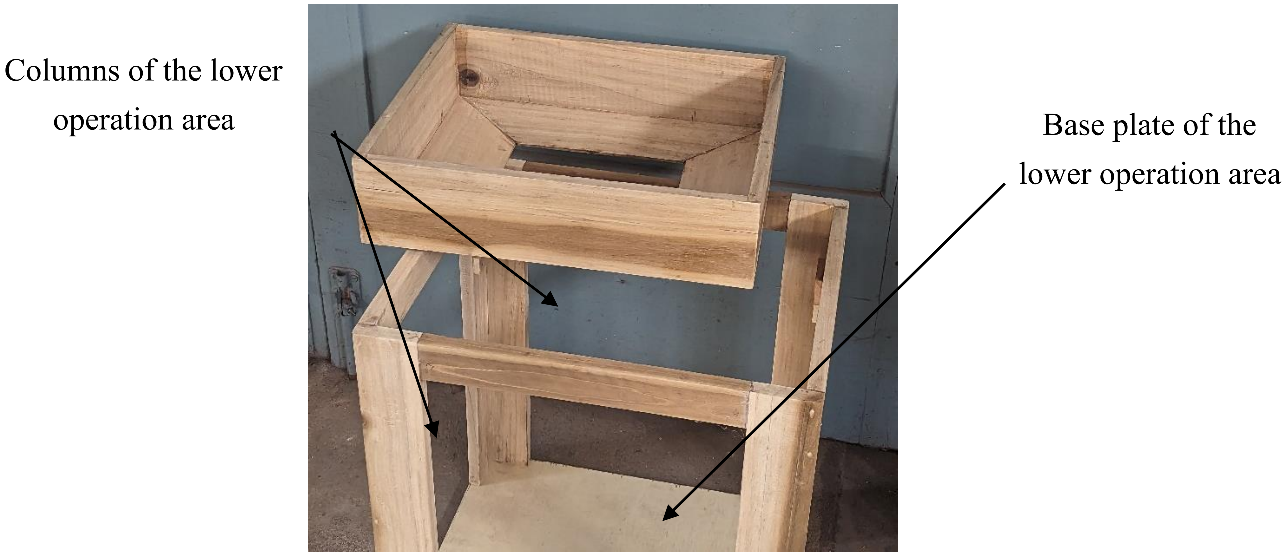

Figure 5.13 Lower operation area

As shown in the above figure, there is a base plate of the lower operation area. This base plate was important to fix the pneumatic piston to the prototype. Also, it stabilizes the prototype.

5.1.4 Pneumatic system

The pneumatic system of the prototype was used to control the pneumatic piston.

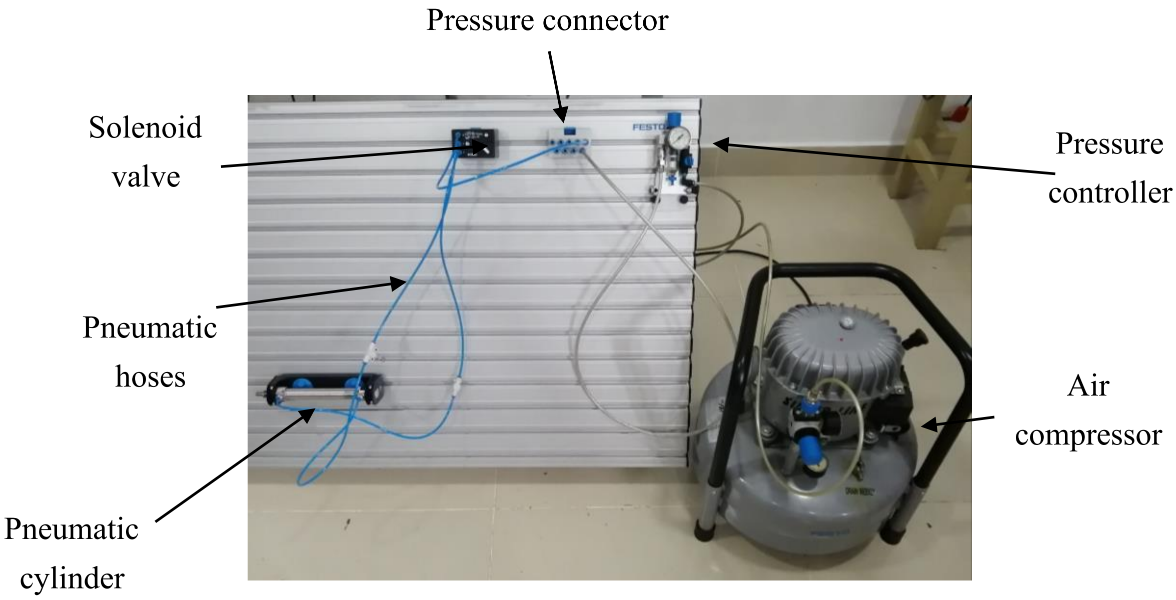

Figure 5.14 Pneumatic system

The air coming from the air compressor was transferred through the pressure controller in order to control the pressure. Then it was connected to a solenoid valve, which controls the upward and downward motion of the double acting piston. The air was sent through pressure regulators before sending to the piston in order to control the speed of the motion of the pneumatic piston.

5.2 Prototype testing

As explained in the above chapters, the most important part of the prototype is the water drainage system and make sure water don’t leak through the upper platform. The prototype was made and tested for that.

Following procedure was followed to find out the water drainage system and to sure water don’t leak through.

Step 1: A paper sheet was kept on the base plate of the lower operation area. This paper was kept in order to find out whether water is leaking or not.

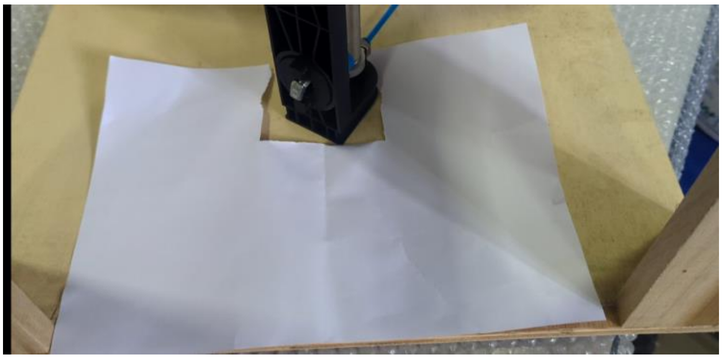

Figure 5.15 Step 1: A paper sheet was kept on base plate

Step 2: The water was showered to the prototype, from nearly 2 feet above from the upper platform.

Figure 5.16 Step 2: Showering water

When the water was pouring, as shown in the Figure, the water was flowed towards the elevator stage's storing area and then drained through the drainage pipe.

Figure 5.17 Drainage pipe drains the water stores in the elevator stage

Step 3: After water was drained, the elevator stage was lowered down. The elevator stage was lowered from the support of the pneumatic system, which explained in chapter 5.1.4

Step 4: Finally, the paper was checked whether there are water drops on it. As shown in the below figure, it was free from water marks.

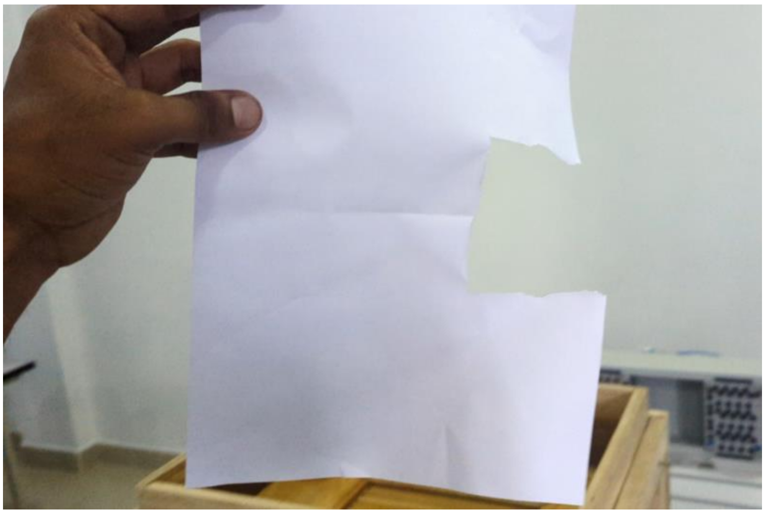

Figure 5.18 Checking of A4 sheet

This gives a clear idea that the water drainage and the water sealing system is working correctly.

Conclusion

the project on designing a DIB system represents a significant step forward in the automation and optimization of UAV operations. By addressing key challenges related to weatherproofing, maintenance, and alignment, the project contributes to the advancement and practicality of DIB technology for both commercial and individual drone users. The successful design of a simple and reliable roof mechanism enhances the DIB's overall performance and ease of maintenance. The ability to repair and maintain the system in the field reduces downtime and operational costs, ensuring continuous and efficient drone flights. The weatherproof system, incorporating a drainage system and blower, represents a cost-effective solution to protect the UAV and DIB from environmental elements without the need for expensive weatherproofing materials. This advancement can have a significant impact on the overall cost of DIB manufacturing, making it more accessible to a broader range of users.

The integration of IoT technology into the DIB system opens up new possibilities for real-time data collection, monitoring, and control. By leveraging sensors and actuators, the DIB can dynamically adjust environmental conditions inside the base, optimizing flight parameters, and ensuring safe and effective drone operations. The IoT capabilities enhance the overall intelligence and adaptability of the DIB, enabling it to respond to changing conditions and user requirements. Looking ahead, the successful implementation of the project's findings will likely contribute to the widespread adoption of DIB technology in the drone industry. As drone usage continues to expand in various sectors, including agriculture, surveillance, delivery services, and more, the automation and weatherproofing capabilities offered by DIBs will become increasingly valuable.

In conclusion, the project represents a valuable contribution to the field of drone engineering and automation. It showcases the potential of DIB technology to revolutionize UAV operations, making them more reliable, cost-effective, and accessible for a wide range of applications. With ongoing advancements in IoT and drone technology, DIBs are poised to play a central role in the future of autonomous aerial systems, paving the way for a more efficient and safer drone-powered world.

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