DETAILED DESIGN REPORT

PREPARATION GUIDE

THE SCIENTIFIC AND TECHNOLOGICAL RESEARCH COUNCIL OF TURKEY

UAV

INTERNATIONAL UNMANNED AERIAL VEHICLES COMPETITION

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TEAM NAME : DEWANAGARI	
VEHICLE TYPE : FIXED WING	
UNIVERSITY : STATE UNIVERSITY OF SURABAYA	
TEAM CAPTAIN : DIMAS SURYA PRATAMA	

1. PROJECT SUMMARY

Dewanagari is a research team in the field of UAV, especially the fixed wing, who is spiritually responsible, diligent, sincere, and able to work hard. Guided by people who are critical in guiding, and have good analytical skills, and are responsible for the financial needs of this research. The UAV made by the DEWANAGARI team to take part in the TÜBİTAK UAV TURKEY 2021 this time is a TALON UAV. This UAV has a mission to fly manually and around the mast. Then for the second mission it flies autonomously and carries a payload and is able to drop it at a predetermined point. The shape of the body of this vehicle has a body cavity that can accommodate additional loads that are dropped. For the type of Talon used, one motor is located at the back.

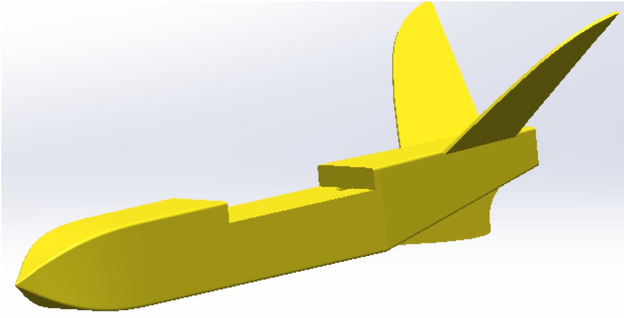
1.1 The method followed design

1.1.1 Design Process

After brainstorming and testing, the UAV is designed with the goal of getting maximum points in mind during the mission in competition. body structure, wing structure and tail structure are determined according to mission requirements. Thus, the proposed design aims to make the UAV resistant to air and wind, air pressure, and possibly be able to complete challenges during competition.

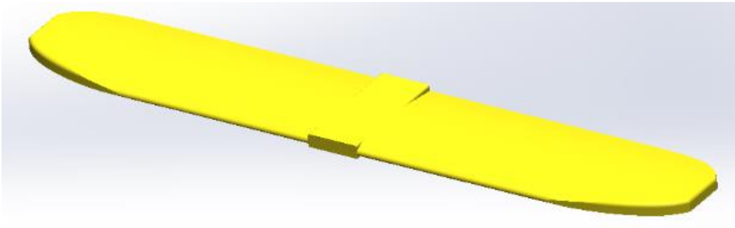
a) Body Structure

The manufacture of the UAV body refers to the laws of aerodynamics by having the ability to maneuver high and fast, so it was made with a body design that is shaped like the picture below.



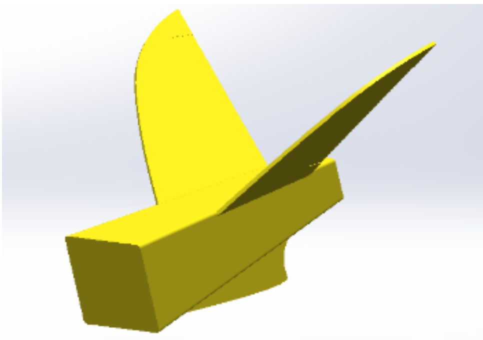
b) Wing Structure

The TALON UAV is designed to take off and land steadily and the UAV is able to fly in a glider even though there are obstacles when the motor is off when the UAV is flying, so the wing design is chosen as below.



c) Tail Structure

The tail making process was considered with the ability of the high maneuverability to complete the mission so that it used a double wing or V-Tail in the tail as shown below. With the V-Tail-shaped rear wing the UAV can move quickly and maneuver high. In addition, there is a driving motor at the back.



1.1.2 System Performance Capability

When designing the TALON UAV, we are highly paying attention to the suitability of the mission in the competition, it aims to take performance at the best level. Anticipated design features:

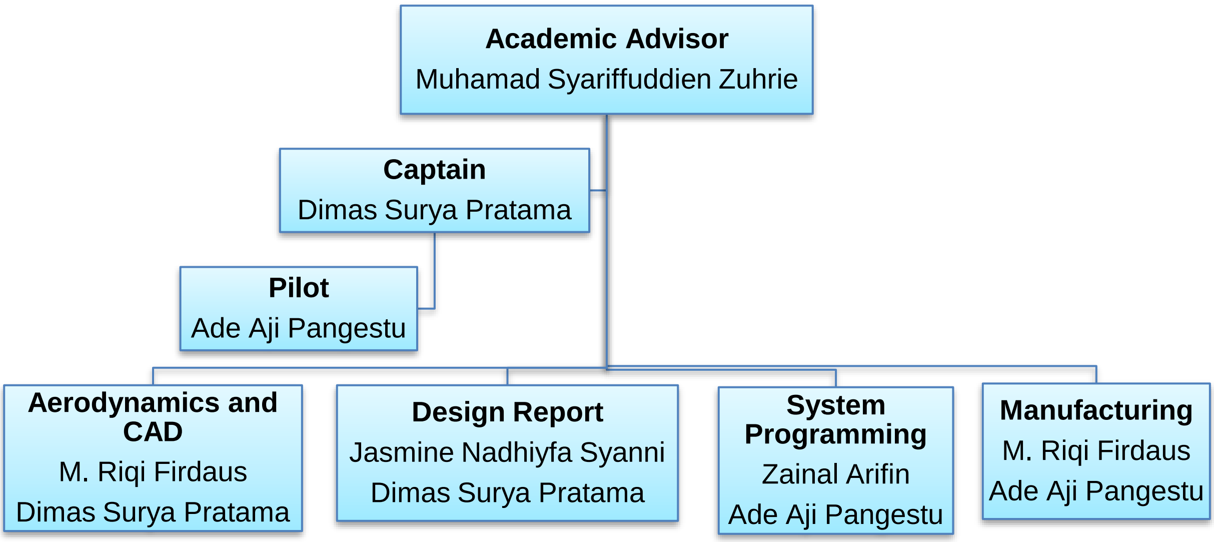
- To balance the system and improve maneuverability, a propeller drive engine is used in the tail.

- The calculations are made so that the vehicle can carry the maximum load. (Calculations are made according to the materials used and include electrical components and dropping loads)

1.2 Team Organization

The DEWANAGARI team consists of students who are passionate, persistent and have knowledge and research abilities about UAVs. The division of tasks is divided according to the student's expertise and the guidance of the academic advisor. The division of tasks is explained as follows:

1. **Academic Advisor**, is a member of the association who guides the team within the scope of the competition and is responsible for executive and financial matters.
2. **Captain,** is the person selected by the team according to the needs of the group and is responsible for communication with TÜBİTAK. It is mandatory for the team leader to be on the competition field during the technical control and competition registration week.
3. **Aerodynamic and CAD**
   The division is responsible for analyzing and simulating fuselage, wing, and empennage designs with software, then creating 2D and 3D designs with CAD applications to determine lift and drag levels.
4. **System Programming**
   The division that served as hardware installation technician. Their duty is programming the hardware to suit the vehicle conditions. For antenna systems, tracker antennas are used by utilizing a microcontroller so that vehicle radio communication with GCS is better and to minimalize loss signals that can cause fatal damage.
5. **Manufacturing**
   The division is in charge of implementing design that have been made into vehicles that ready to fly, starting from making body molds, and designing dropping mechanism systems.
6. **Design Report**
   This division is in charge of compiling reports to make the information conveyed clear and understandable by readers / recipients.



1.3 Business Timetable Planned and Actual

DEWANAGARI, FIXEDWING / STATE UNIVERSITY OF SURABAYA													
PROJECT TIMELINE													
WORK PACKAGES AND ACTIVITIES		Start Date	End Date	Duration (days)	January	February	March	April	May	June	July	Agustus	September
1.	**Registration**	**5th January**	**13rd April**										
1.1	Choosing team members			40									
1.2	Registration			1									
1.3	Proposal making			20									
2.	**Vehicle Designing**	**5th Januari**	**29th April**										
2.1	Choosing vehicle type			35									
2.2	Weight analyzing			20									
2.3	Airfoil analyzing			20									
2.4	Wingloading			20									
2.5	Vehicle size			15									
2.6	Vehicle construction			60									

Planned
Actual

3.	**Electrical Design**	**20th April**	**20th Juli**	
3.1	Analyzing electrical system			20
3.2	Analyzing propulsion system			30
3.3	Maiden flight			15
4.	**Practice**	**5th Februari**	**10thSeptember**	
4.1	Design of unloading mechanism			15
4.2	Trial and error dropping			60
4.3	Full trial mission competition			70
4.4	Pilot practice			200
4,5	Test of maximum distance of the radio antenna			20
4.6	Competition week			5

2. DETAILED DESIGN

In this Tubitak competition we from the Dewanagari team used the Talon UAV which we named Deltawing. This type of UAV has advantages, including good stability even in strong winds or rain. One of the advantages of Talon UAVs is having good stability, and maneuverability that is no less agile, and capable of carrying cargo. Our UAV has a wingspan of 1400 mm and a body length of 830 mm, and has a control surface in the form of:

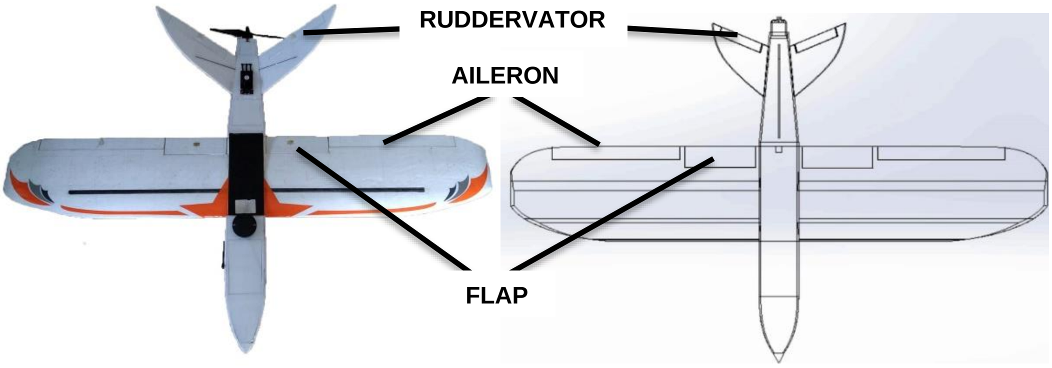
1. V-Tail

   Using V-Tail aims to increase efficiency and also make aircraft lighter, because the functions of Rudder and Elevator controls are combined into one into ruddervator or commonly referred to as V-tail, so it moves pitch and yaw in one control surface.

2. Flaps

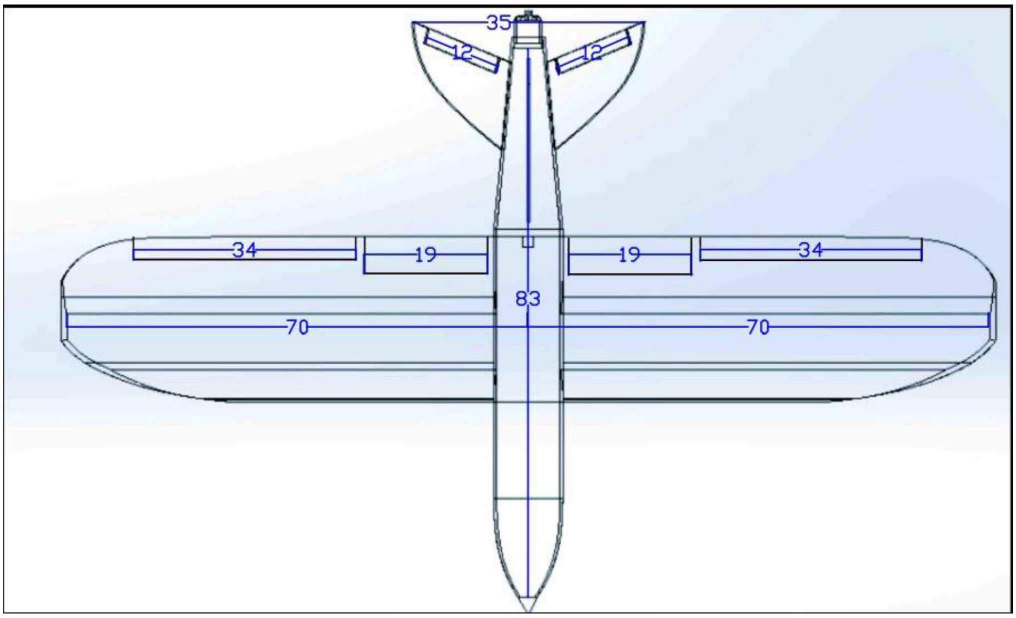
   The use of a flap aims to increase the lift force on the wing of the aircraft, the use of a flap is often used when the aircraft takes off or landing. Because during landing and also take-off the aircraft must still have lift force at low speeds. To take off without a flap or low flap, it will require a longer runway. As a result, when the aircraft is flying its climbing performance, it will be better. Conversely, using high flap will reduce take-off distance, but because the drag is high, the climb ability will be low. Conversely, if the runway is short, the flap must be used to accelerate lift-off or airborne.

3. Aileron
   Located on the tip of the wing, use to rotate to the right or left (roll) maneuver, with the wing located at the top so that the plane roll movement is not too extreme



2.1 Dimensional Parameters of the Design

In the design we made the dimensions of the UAV by considering the safety lot, that the estimated total weight of the vehicle is about 1.9 Kg, including the battery and payload from the provisions of the competition a maximum weight of 4 kg. So with that selected polyfoam material for the manufacture of the body and styrofoam material for the manufacture of wings. In order to achieve good stability, the UAV needs to measure the dimensions as follows: (in cm)



To compensate for this weight, this UAV uses a brushless motor measuring X2814 1250 KV, combined with a PVC 1050 propeller and a 4S battery that produces 824 Watts of power at 100% throttle. While the battery power with a 45C 5200 mAH battery is 2308.8 Watt/H. Therefore, the need for motor power is very fulfilled.

Table A. Fixed UAV Parts and total weight table

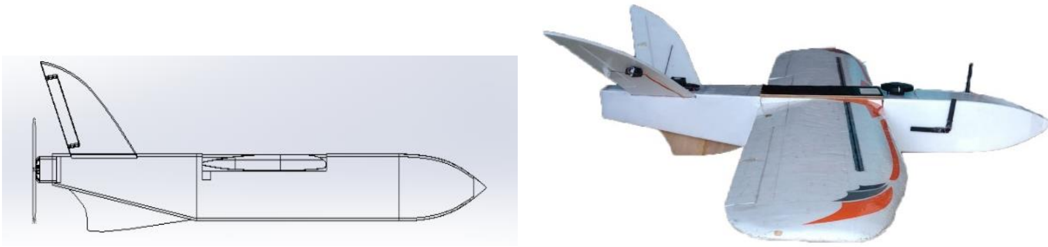
No.	Track Name	Weight (Gram)	QUANTITY	Total Weight (Gram)
1	PIXHAWK CUBE	245	1	245
2	BATERRY	485	1	485
3	GPS HERE	87	1	87
4	SERVO	17	8	136
5	POWER MODUL	24	1	24
6	ESC	137	1	137
7	MOTOR BRUSHLESS	143	1	143
8	FUSE + SAKLAR	10	1	10
9	PROPELLER	22	1	22
10	TELEMETRI	43	1	43
11	UBEC 5V	7	1	7
TOTAL				1339

Table B. Weight and material balance of fixed wing UAV

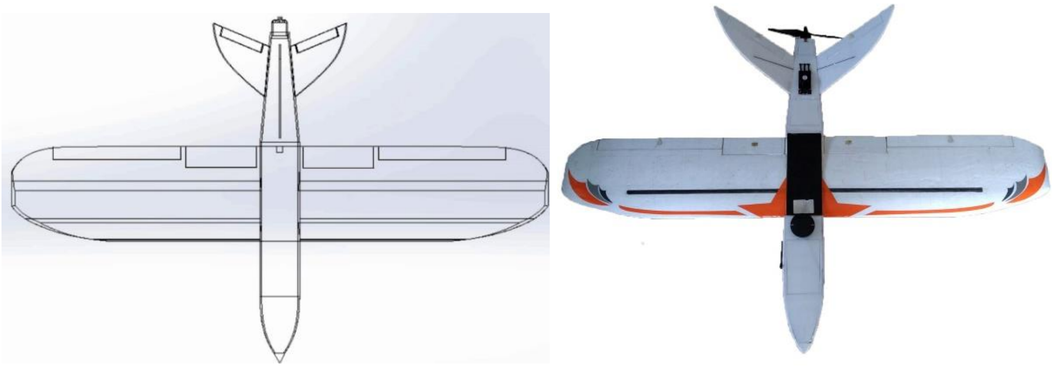
No.	Tracak Name	Weight (gram)	X distance (mm)	Y distance (mm)	Z distance (mm)
1	Body (Polyfoam)	213	83	11	12
2	Wing (Sterofoam)	334	25	140	3
	TOTAL	547			

2.2 Body and Mechanical Systems

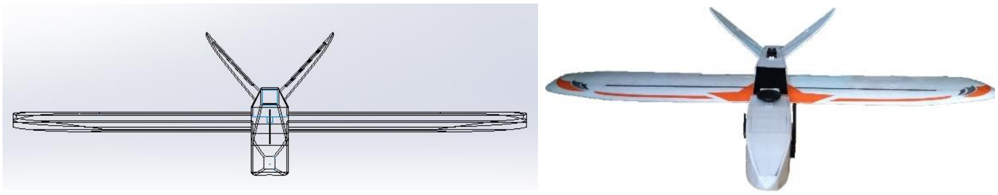
For the body structure, a lightweight polyfoam reinforced with balsa is used, and plywood as reinforcement so that the polyfoam does not break easily when exposed to strong winds. After that the body is coated with solation. Besides being economical, polyfoam was chosen because it has a light weight making it suitable for aeromodelling. For the load and unloading mechanism, the load is placed on the aircraft hull at the point around CG (Center of Gravity) point being held by the servo. The placement of the load at the hull CG point of the aircraft is intended so that when the load is dropped the aircraft stability is maintained, because the load is in the middle - so it does not affect the roll or pitch much after the load is dropped.



Right Look

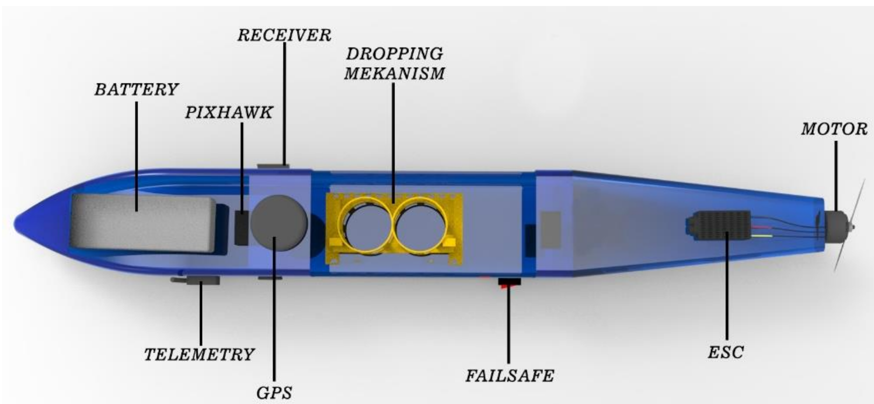


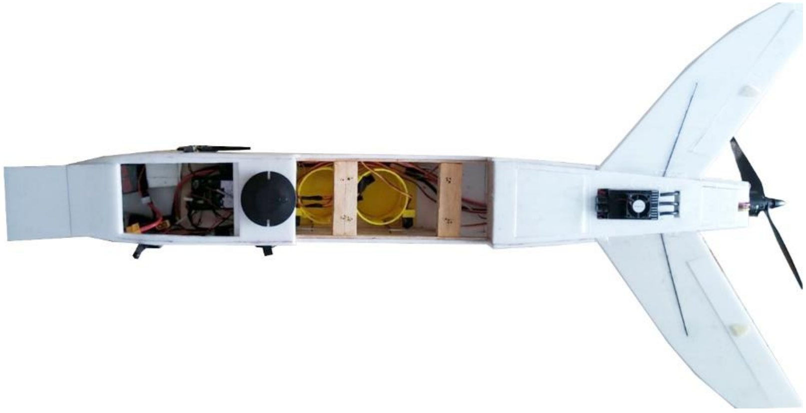
Upper Look



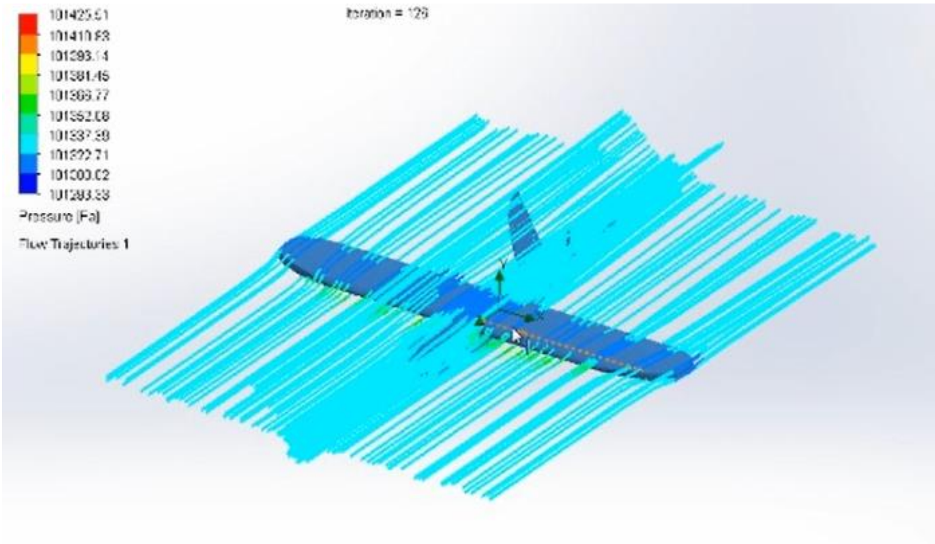
Front Look

System layout on the uav to stabilize the uav during flight (equipment, layout of internal – external components). System settings are placed on the UAV body.





2.3 Aerodynamics, Stability and Control Features



Thrust and Lift Calculations

Variable Specifications	Unit	Magnitude
Weight		
Take Off Weight	gram	1900
System Weight (electric motor, controller, servo, etc.)	gram	682
Battery Weight	gram	485
Dimensions		
Overall length	cm	83
Wingspan	cm	140
Propulsion		
Type of electric motor		Brushless
Number of electric motors	Piece	1
Power / electric motor	Watt	824

Propeller (diameter x pitch)	Cm	10x5
Number of Battery Cells	Cell	4
Battery capacity	mAh	5200
Thrust motor	gram	2700
Production		
The main material is used		Polyfoam, sterofoam
Other materials		Balsa, plywood, carbon fiber tube

2.4 Mission Mechanism System

The payload is loaded on the hull which is placed on the aircraft CG. The load is loaded on the hull so that when one of the loads is dropped, the stability of the UAV is not much affected. Because when the load is placed on the wing the placement must be really balanced between the two loads, when one of the loads is dropped then one of the wings will be heavier and make the aircraft unstable and difficult to control. In the hull there are 2 doors, so each load has its own door. When the UAV passes through the first drop zone then door 1 will open and drop the first load. And when it passes through the second drop zone, the second load is automatically dropped.

2.5 Electrical Electronic Control and Power Systems

1. Flight Control

   Pixhawk is an advanced autopilot system designed by the PX4 project. This controller features advanced processors and sensor technology and the NuttX real-time operating system. The Pixhawk module is accompanied by new peripheral options, including air speed sensors, support for external multi-color LED indicators and external magnetometers.

2. GPS

   We use GNSS Here type of GPS that has well high accuracy because it has used satellite navigation systems from Glonass, BeiDou, and Galileo and equipped with HMC5983 MAG sensors, and LIS3MDL Mag. With these features, it makes the GPS accuracy better than before.

3. Radio Frequency

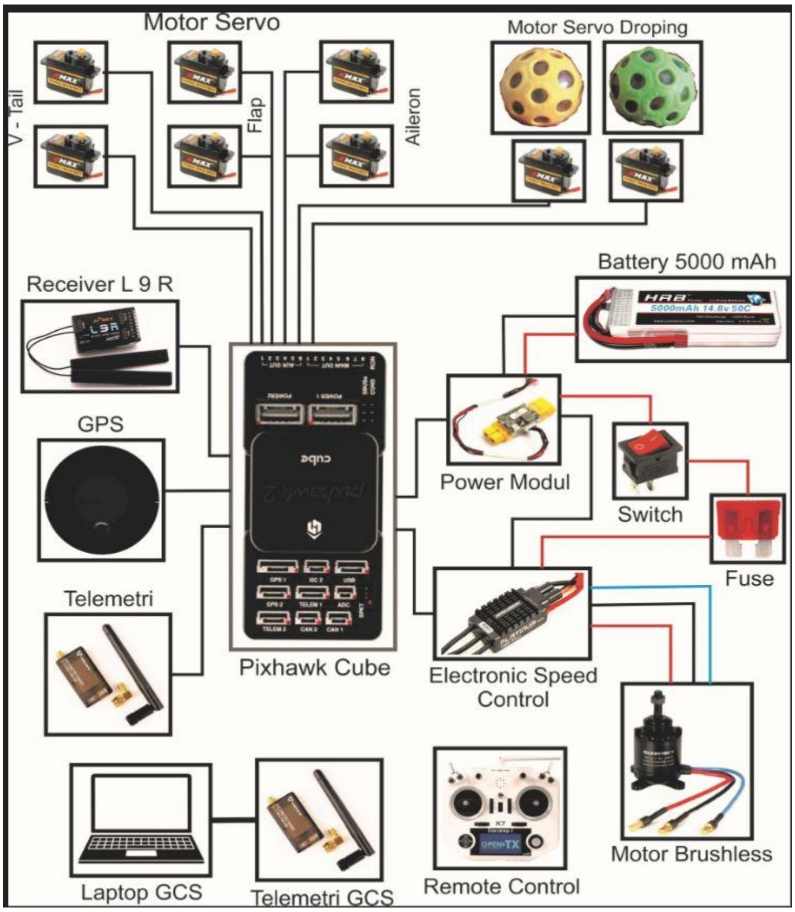
New FrSKY has a frequency in the 2.4Ghz band. Advanced Continuous Channel Shifting (ACCST) technology can reach areas of around 1.5 km to 2.5 with the right servo response. This technology has channels that can be programmed with Failsafe to produce fast and easy performance.

4. Battery System

The batteries used are 4 Lithium Polymere (Li-Po) with a voltage of 14.8V 45 C with a capacity of 5200 mAH. This battery is parallelized with ESC, Power Module, and Power Distribution Board (PDB), PDB is an electronic circuit that takes power from a battery pack or other DC source, and lowers it to a 5V and 12V voltage level.

5. Power Modules

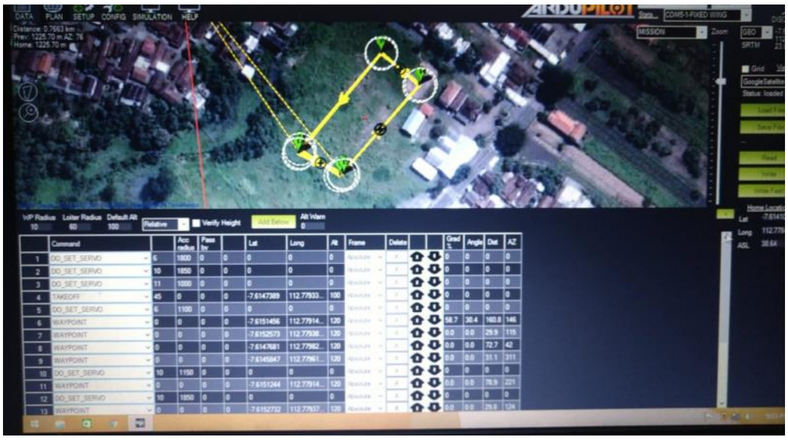
The Power Module used is the XT60 with an onboard switching regulator producing 5.3V output and a maximum of 2.25A from LiPo batteries. Excess can be given a maximum input voltage of 20V, the maximum current that can be measured is 90A



2.6 Target Detection and Recognition System

In the second mission of the fixed wing, the UAV is required to carry out a ball dropping mission. our team installed servo dropping using do set servo on full parameters in mission planner software. This aircraft using servo and GPS to detect the coordinates of the place where the logistic falls. When the plane has detected the intended coordinates, the servo will automatically move at a certain angle that will move the door on the hull to drop the logistic.

Dropping Trial



Software Mission Planer

2.7 Flight Performance Parameters

The battery configuration to accommodate all the way through both missions was chosen from a variety of alternatives. The battery of choice is the Lipo Pack 4S 45C Infinity 5200mAh Battery. The team retrieved the battery with the help of online forums and websites. The table below shows the specifications of the selected battery

Minimum Capacity	5200mAh
Configuration	4S1P / 14.8v / 4Sel
Peak Discharge (10 sec)	45C
Weight	485g
Size	135x43x40mm

Parameter	**Misi 1**	**Misi 2**
Take Off Weight	**1.8 kg**	**1.9 kg**
Thrust	2.7 kg	2.7 kg
V_{STALL}	10 km/h	10 km/h
V_{MAX}	110 km/h	110 km/h
Airtime	20 minutes	20 minutes
Flight duration	100 seconds	120 seconds

2.8 Aircraft Cost Distribution

No	Tools and Material	Unit Price (TL)	Quantity	Total (TL)
1	Brushless motor Sunnysky	3,738.23	1	3,738.23
2	Pixhawk 2 cube	32,276.75	1	32,276.75
3	Esc 120 A	7,335.63	1	7,335.63
4	GPS	5,868.50	1	5,868.50
5	Proppeller 10 x 5	293.43	1	293.43
6	Battery 5200 mah	5,281.65	1	5,281.65
7	Telemetri 433	4,694.80	1	4,694.80
8	Remote FrSky Taranis x7	13,497.55	1	13,497.55
9	Servo	205.40	8	1,643.18
10	Ubec 5v	264.08	1	264.08
11	Fuse 70A	58.69	1	58.69
12	Polyfoam	575.11	1	575.11
13	Sterofoam	704.22	1	704.22
14	Balsa 3mm	82.16	3	246.48
15	Astro Glue	293.43	1	293.43

16	**Isolation**	**70.42**	**1**	**70.42**
17	**Plywood**	**146.71**	**1**	**146.71**
18	**Filament 3D print**	**1,115.02**	**1**	**1,115.02**
TOTAL				**78,103.87**

2.9 Nativeness

Our team considered the UAV's light weight, with our mindset to complete the mission and the UAV can be highly maneuverable, so we used domestic materials such as polyfoam for the body and styrofoam was used for the wings. For dropping system we use filament material with 3D Print tool.

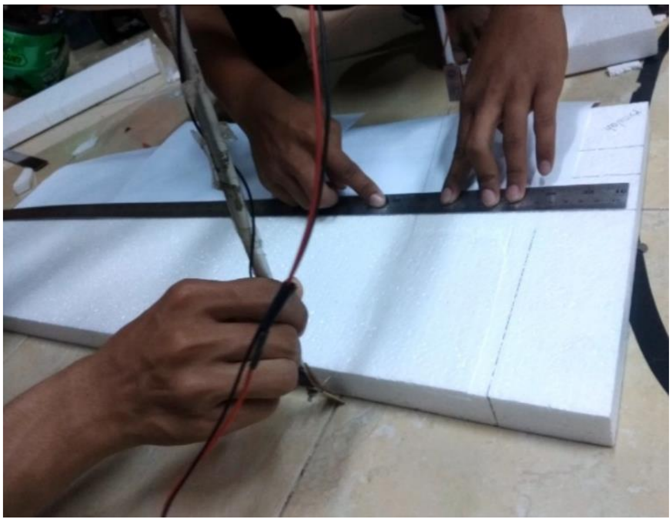
a) Body

For the manufacture of the body we use polyfoam material. After we finish making the body design, we print it with duplex paper as a form of body print. After finishing making the mold, proceed to the process of printing the body on polyfoam with a chassis made of 3mm balsa so that the UAV body is stronger. Then the body is glued and isolated according to the initial design that has been made.

Body Manufacture Process

b) Wing

In the manufacture of UAV wings, we use styrofoam material which has light but strong criteria, besides that styrofoam material is easy to shape according to airfoil. Styrofoam is cut using hot wire and sanded according to the airfoil that has been designed earlier.

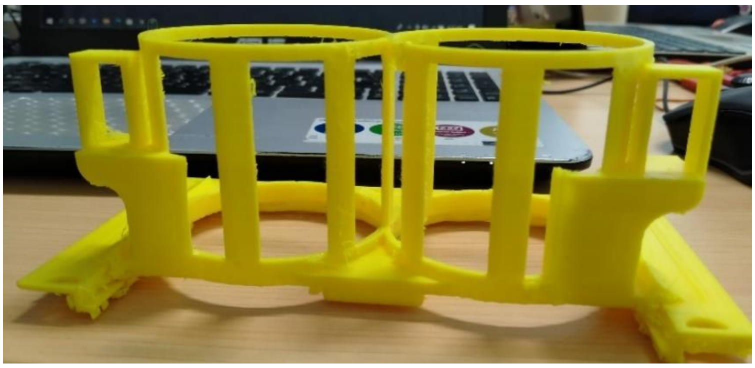


Wing Manufacture Process

c) Dropping mekanisme

We design the dropping place using AutoCAD software which is connected to the maker bot software to realize the design into a 3D dropping place with PLA type filament material.

Dropping Part Manufacture Process



3D print result of dropping mechanism