NSBM GREEN UNIVERSITY TOWN

Multi UAV

Automated System

1st Year Project

NATIONAL SCHOOL OF BUSINESS MANAGEMENT

Faculty of Engineering

Module : ME101.1

Introductory Design Project

Project Report

Name with initials	Registration Number
C. N. Bandaranayake	22988
J. A. U. I. Jayaweera	23915
R. M. T. D. B. Rajakaruna	23891
R. M. A. D. Rajapaksha	23030
G. R. K. C. Godamunne	23234
H. M. M. L. Herath	23786

Date of Submission: 10/07/2022

Abstract

*Our **main purpose** of this project is to make an automated system to control multiple UAVs by a single user located in a distant position. There would be a main UAV followed by other UAVs in a systematic way. By doing so, we can reduce human labor used to control UAVs. The UAVs will be both automated as well as remote controlled.*

Acknowledgement

- Our sincere efforts have made us to accomplish the task of completing the project. However, it would not have been possible without the kind support and help of many individuals.

- We would like to express our sincere gratitude to our Dean of the Faculty of Engineering Dr. Chandana Perera and NSBM for providing us facilities and requirements to do our project.

- We are highly indebted to our lecturers and staff of the Engineering Faculty for all the valuable guidance which has promoted our efforts in all the stages of this project work.

- I would also like to thank the establishments and individuals that have provided us with the required components in these dire times.

- Finally, words are not sufficient to express gratitude to all the members of our group. Without everyone's dedication and hard work, we would have not reached our goal.

Table of Contents

List of Figures

List of Tables

Introduction

Our project is to make an ***automated system to control multiple UAVs by a single user located at a distant position***.

We had multiple plans at the beginning, each of which had their own pros and cons. At last, we went with the plan to control one UAV using a remote controller, along with the intention of using two other Arduino nano boards and transceivers for communication between the UAVs.

Figure 1. Final Project Structure

Background and Problem to solve

The goal is to make a transportation system of goods or other services using only a single user. By achieving this we can reduce cost, make day to day tasks easier and reduce human labour as well. Currently, drones are being used in delivering goods and for services such as applying pesticides to farms and taking out forest fires. Drones are also used in obtaining data from areas which are dangerous for humans to travel to.

So, the problem we are trying to solve is increasing the efficiency and cost of doing the above tasks mentioned. If a single user can control multiple UAVs, those UAVs can cover more ground when applying pesticides to farms and taking out forest fires or carry more heavy goods when delivering or gather more data by covering more ground.

Objective of Project

The objective of the project is to make a system that can control multiple UAVs by a single user.

Stakeholders of Project

Dean of faculty of Engineering

Other lecturers and staff

Team members

Colleagues

Suppliers

Scope and Limitation of Project

There are still a few limitations of our project. One of the limitations is the limitation of components flight time depending on the battery capacity used and Closeness of the UAVs depending on the accuracy of GPS and communication distance between two UAVs. Also, the distance that the UAV can travel will depend on the range of the transmitter.

Here, by using expensive components we can overcome these limitations by increasing performance, efficiency and accuracy.

Another limitation is the number of UAVs in the system. By increasing the number of UAVs, the complexity of the system would increase as well.

Responsibilities and Performance of Team Members

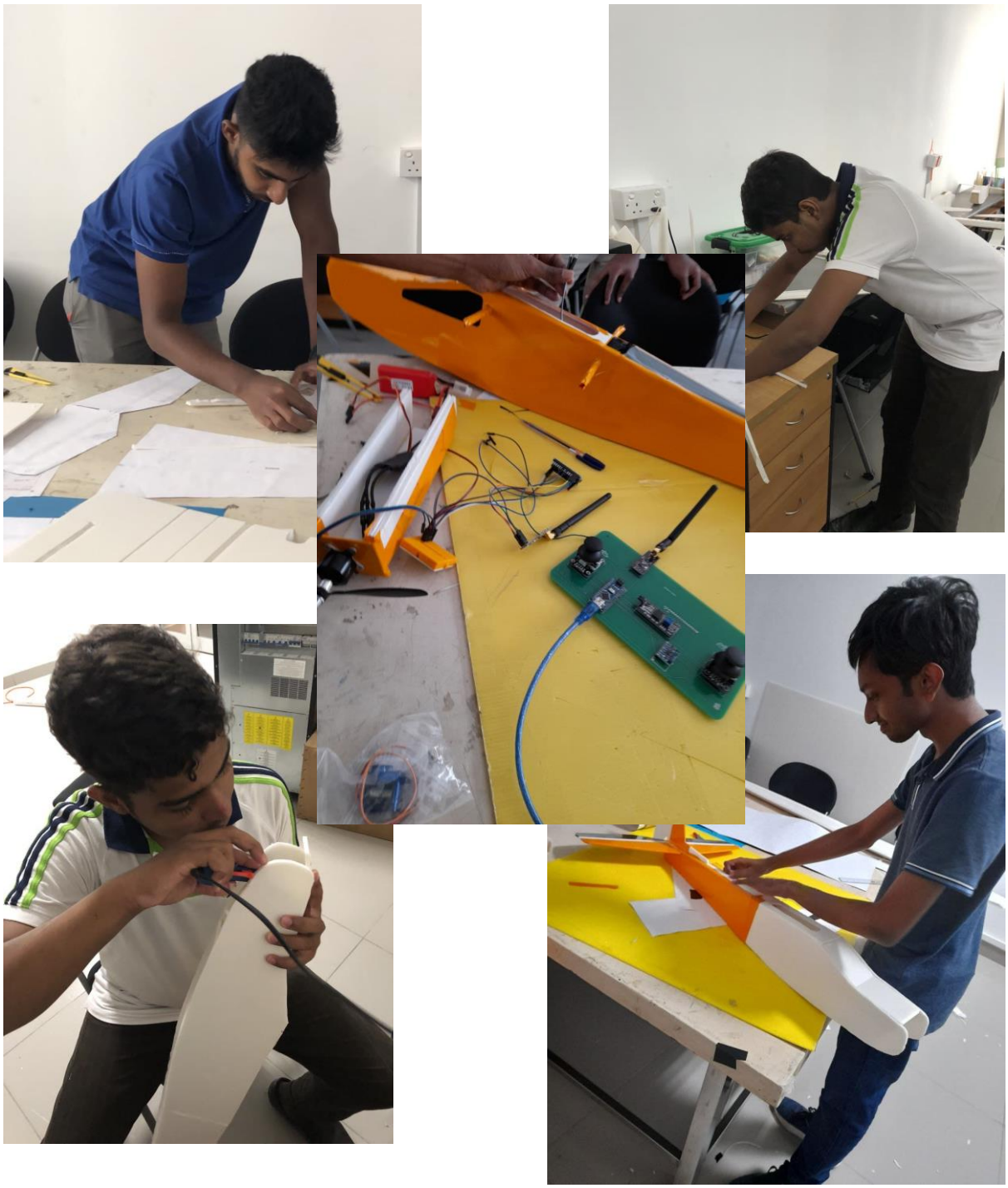

Figure 2. Team Performance

Literature Survey

Similar Systems Available at Present

Currently, only individual drones or UAVs are being used for tasks. There has been research done by students at different universities to have multiple drones controlled by single user. Our system would be to control multiple UAVs by single user which is much more complicated than drones.

Suitability of the Available System to Solve the Problems

The system we are currently researching, and building is suitable for following applications

- Military purposes such as unmanned attacks or carrying resources to war zones.
- Automated delivery systems which would reduce traffic as well as time.
- Carry heavy weights to distant locations by using multiple UAVs simultaneously.
- Observe and gather data from dangerous places where humans can't visit.
- For medical situations such as delivering medicine and medical equipment as soon as possible
- Applying pesticides to fields and taking out forest fires

By using multiple UAVs in a system, we can achieve the above in a reduced time, efficiently and can carry more resources.

Figure 3. Practical Applications of Project

Identified Gap in the Available Systems

The gap in the current available system id that is does not support multiple UAVs being controlled by a single user. If multiple UAVs are required, each of them must be controlled by multiple users making the labour cost go higher.

Methodology

Research

First, we began our research on the system to initiate the final goal. We had discussion in order to figure out the best way to implement this.

How to implement	Reasoning
Method 1	
Using a ground station to receive data from the transceiver and then send two signals separately to the two UAVs.	Since the two UAVs face different conditions (Air resistance) this method cannot be used as different movements should be done by them.
Method 2	
Using LiDAR or ultrasonic sensors to detect position of one plane from the other.	Since the probability of errors is high in this method, we did not choose it.
Method 3	
Using transceivers send location and movement data from one plane to the other so it can adjust its position and movement based on the provided data.	We used this method as this given high accuracy and the plane would adjust according to the external conditions affected on it.

Table 1. Different methods to implement the Project

Next, we had planned our starting point and final objective as well. Then we started our research on how to achieve our objective the most efficient way. Initially we began researching on equipment and components that would be required for the project. We considered mostly accuracy per cost when selecting our components to have more accurate and within our budget. Here we found that we could use either Pixhawk or ArduPilot as our flight controller. Even though Pixhawk is more accurate than ArduPilot, we went with ArduPilot since it is cheaper.

Then research on coding on done. We mainly used Arduino and Mission Planner to code the Arduino Nano and ArduPilot flight controllers.

For our research we had discussions with team members as well as with lecturers and professionals in the field. We also searched google and read articles on the topics. We used Arduino, ArduPilot, Mission Planner websites to gather information and ideas.

Theory

The main theory behind the project is the remote controller would send data and control the main UAV. That UAV would gather data and send them to another UAV for it to interpret and perform based on the data.

The transmitter would send data to the flight controller on the main UAV for it to change its movement. The main UAV consists of a GPS and a transceiver. The flight controller would gather location information such as longitude, latitude and altitude from the GPS and motor speed and send them to the transceiver. The transceiver would collect that data and send it to the transceiver from the other plane. That transceiver would send the data into its own flight controller. The flight controller would process the provided data and adjust its position thus following the main plane.

The second plane would always try to main the same altitude and motor speed with the first plane. The longitude and latitude would be maintained based on a specific radius (from the centre point of first plane) provided (2 m) so that the two planes would not crash. Even in take-off and landing the two planes will maintain same altitude and motor speed for a safe landing.

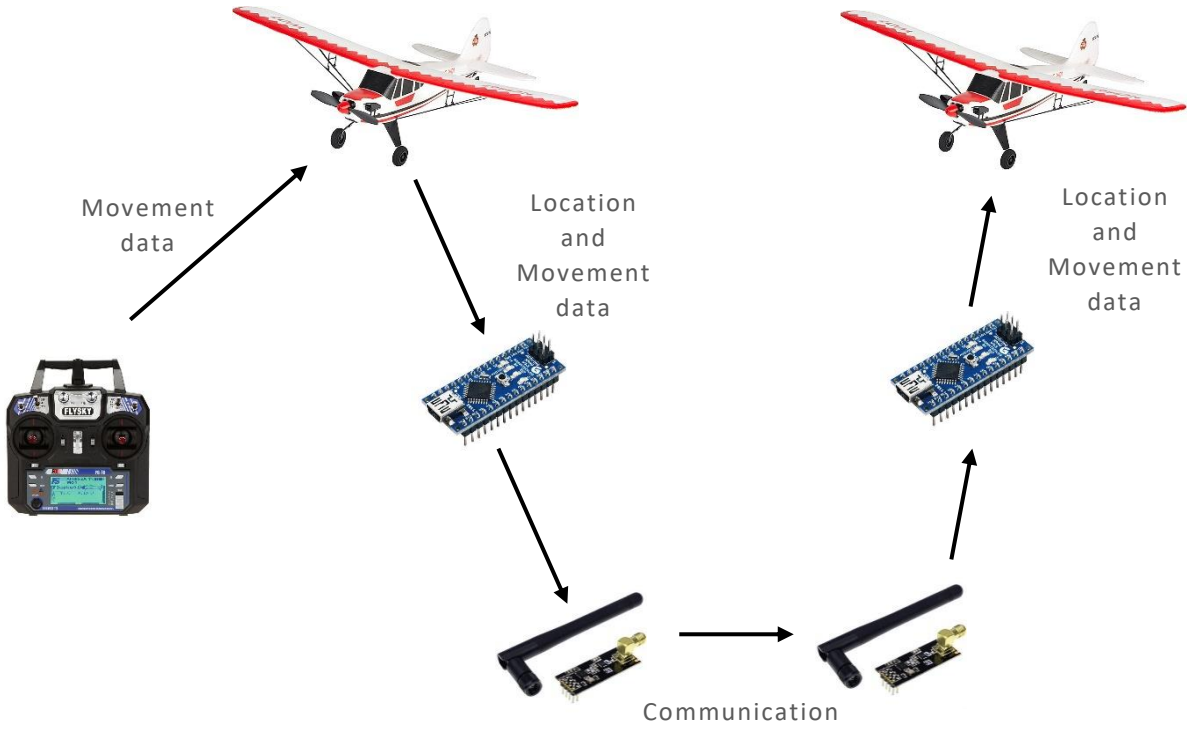

Figure 4. How the system works and the communication between the UAVs

Design

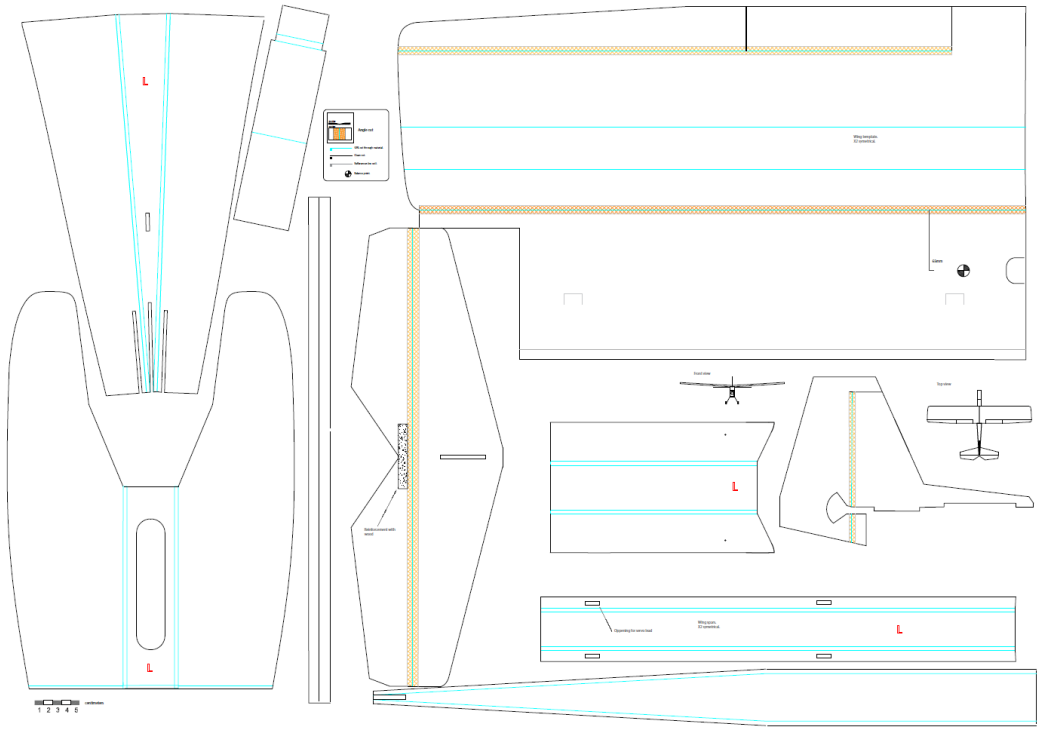

Figure 6. Design of the structure of the UAV

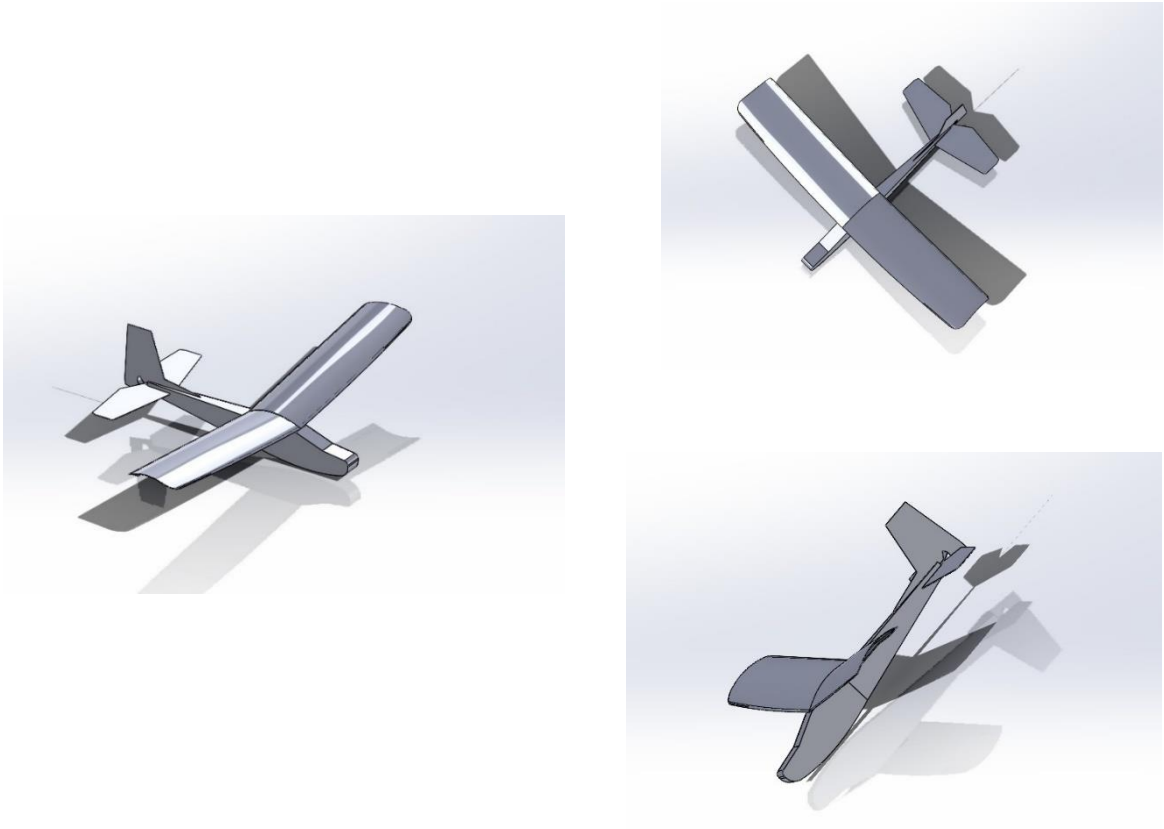

Figure 5. CAD model of the UAV

Circuit

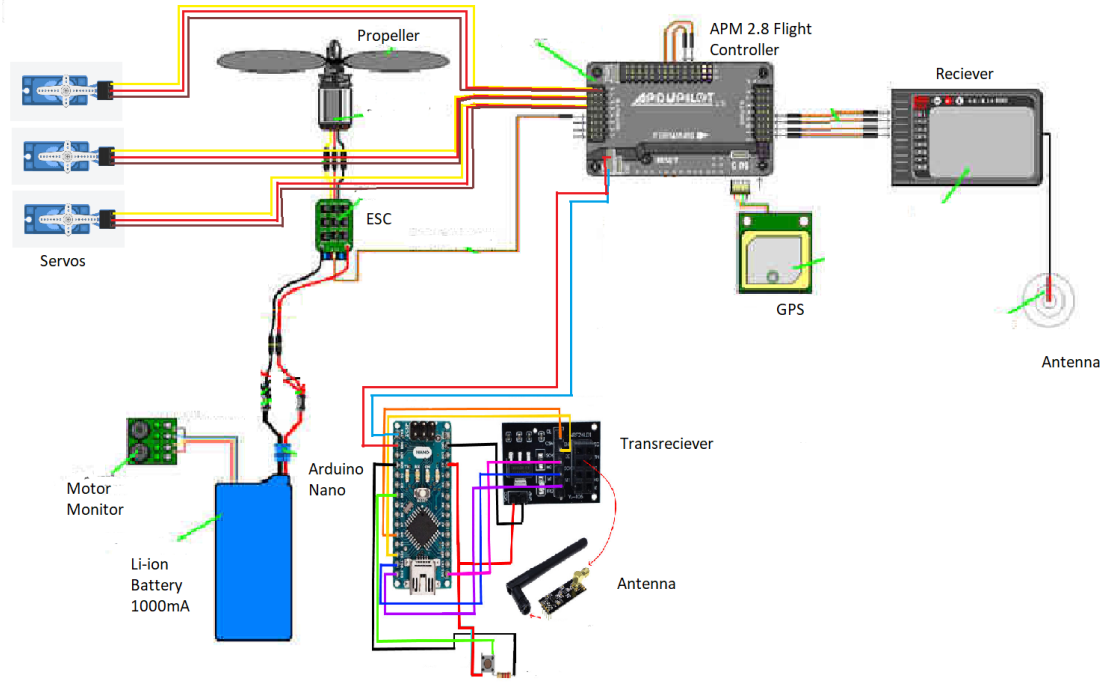

Figure 7. Circuit of the System

Specifications of the UAV

- Altitude – 15 m
- Motor speed – 1400 rpms
- Accuracy of GPS – about 60 cm
- Flight time – about 30 min
- Communication range – 100m (In Open space)
- Weight – 692g (without battery)
- Material used – KT board
- Length – 950 mm
- Wingspan – 1400 mm

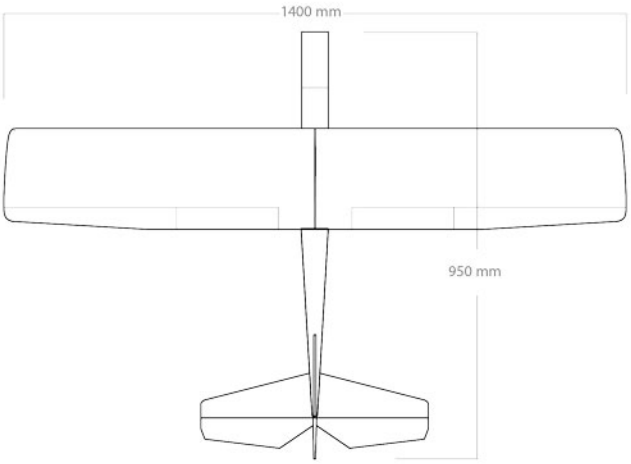

Figure 8. Specifications of UAV

Resources used for the project

Resource	Usage
Arduino [1] [2]	To code the Arduino nano boards in the system
ArduPilot [3]	Autopilot system used for the UAVs
Mission Planner [5]	Ground control station for the plane
ArduPilot APM 2.8 Flight Controller [6]	To gather data and send them to the motors
FLYSKY FS-i6 2.4GHz 6-Channel AFHDS RC Transmitter with FS-iA6 Receiver	To control the UAV
GPS Module	To gather location data (Longitude, Latitude, Altitude)
NRF24L01+PA+LNA 2.4G Wireless Transceiver Module with SMA Antenna [4]	To send data from one UAV to another
Arduino Nano	To process data
ESC	To regulate speed of motor
1450k brushless motor	Throttle of UAV
1000 mA battery	Power supply of the UAV
Power distribution board	To distribute power between components of the UAV
Servos	To control aileron, elevator and rudder

Table 2. Resources used in the project

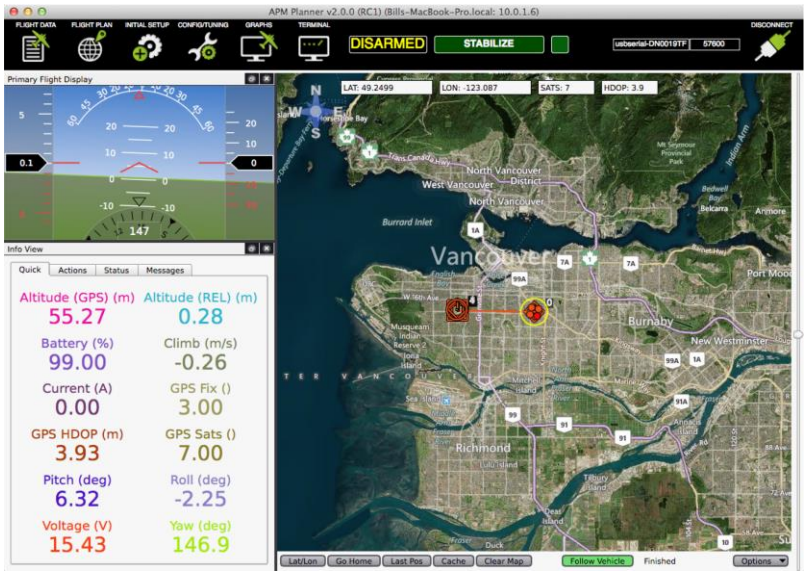

Figure 9. Interface of Mission planner

Figure 10. Technology used for the Project

Funding / Budgeting

Supplier	Item Name	Price Per Unit (Rs.)	Number of Units	Total Cost (Rs.)	Budget (Rs.)	Deviation (Rs.)
Senith Electronics	Micro Servo	350.00	10	3,500.00	5,400.00	-1,900.00
	Arduino Nano	1,150.00	2	2,300.00	2,400.00	-100.00
Alphatronics	Glue Gun	495.00	3	1,485.00	1,500.00	-15.00
	Glue Stick	25.00	10	250.00	500.00	-250.00
	Transceiver	750.00	2	1,500.00	1,700.00	-200.00
Tronic.lk	Flysky Transmitter	21,600.00	1	21,600.00	16,000.00	5,600.00
	ArduPilot Flight Controller	21,300.00	1	21,300.00	10,000.00	11,300.00
	GPS Module	4,110.00	1	4,110.00	4,000.00	110.00
HobbyTech	KT Board	750.00	5	3,750.00	4,000.00	-250.00
	ESC	1,650.00	2	3,300.00	2,000.00	1,300.00
	1450k Motor	1,900.00	2	3,800.00	4,000.00	-200.00
	8x6 Propellors	150.00	2	300.00	500.00	-200.00
	Battery Charger	1,350.00	1	1,350.00	2,000.00	-650.00
	1000 mA Battery	3,500.00	2	7,000.00	8,000.00	-1,000.00
	Power Distribution Board	500.00	2	1,000.00	1,000.00	0.00
	Control Horn Pack	500.00	2	1,000.00	1,000.00	0.00
	1 mm rods	200.00	3	600.00	600.00	0.00
	Y harness	200.00	2	400.00	400.00	0.00
	Extensions	200.00	2	400.00	400.00	0.00
New Senadeera Bookshop	Stationery	25.00	10	250.00	500.00	-250.00
	Paper Cutter	120.00	2	240.00	500.00	-260.00
	Ruler	35.00	1	35.00	35.00	0.00
	Black Sticker	130.00	5	650.00	1,000.00	-350.00
	Yellow Sticker	130.00	15.5	2,015.00	1,000.00	1,015.00
	Sticker	350.00	2	700.00	1,000.00	-300.00
Glo-Mark	Rubber Bands	500.00	1	500.00	500.00	0.00
	BBQ-Sticks	500.00	1	500.00	500.00	0.00
NSBM Bookshop	Printing	760.00	1	760.00	1,000.00	-240.00
J-Net Office Works	Printing	1,940.00	1	1,940.00	2,000.00	-60.00
				86,535.00	**73,435.00**	**13,100.00**

Table 3. Budget of the Project

Debit **Project Cash Book** **Credit**

Date	Description	Amount (Rs.)	Date	Description	Amount (Rs.)
01/01/2022	Capital Collected	50,000.00	09/02/2022	NSBM Book Shop	760.00
27/05/2022	NSBM	47010.00	09/02/2022	HobbyTech	3,000.00
			18/02/2022	Senith Electronics	4,000.00
			18/02/2022	HobbyTech	15,850.00
			18/02/2022	Travelling	4,000.00
			21/02/2022	Alphatronics	2,120.00
			21/02/2022	J-Net Office Works	940.00
			21/02/2022	Travelling	700.00
			02/03/2022	Senith Electroncis	1,750.00
			02/03/2022	HobbyTech	3,300.00
			02/03/2022	HobbyTech	2,250.00
			02/03/2022	Travelling	2,000.00
			21/03/2022	New Senadeera Bookshop	3,850.00
			21/03/2022	J-Net Office Works	1,000.00
			21/03/2022	Glo-Mark	1,000.00
			21/03/2022	Alphatronics	1,240.00
			21/03/2022	Travelling	3,000.00
			27/05/2022	Tronic.lk	47,010.00
		97,010.00			**97,010.00**

Table 4. Cash Book of Project

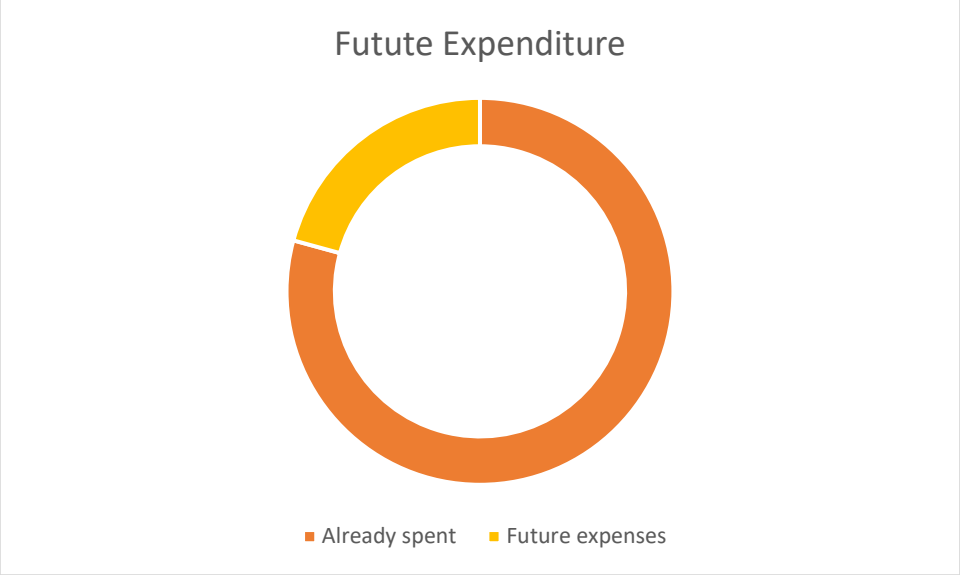

Figure 11. Past and Future expenditure Categorization

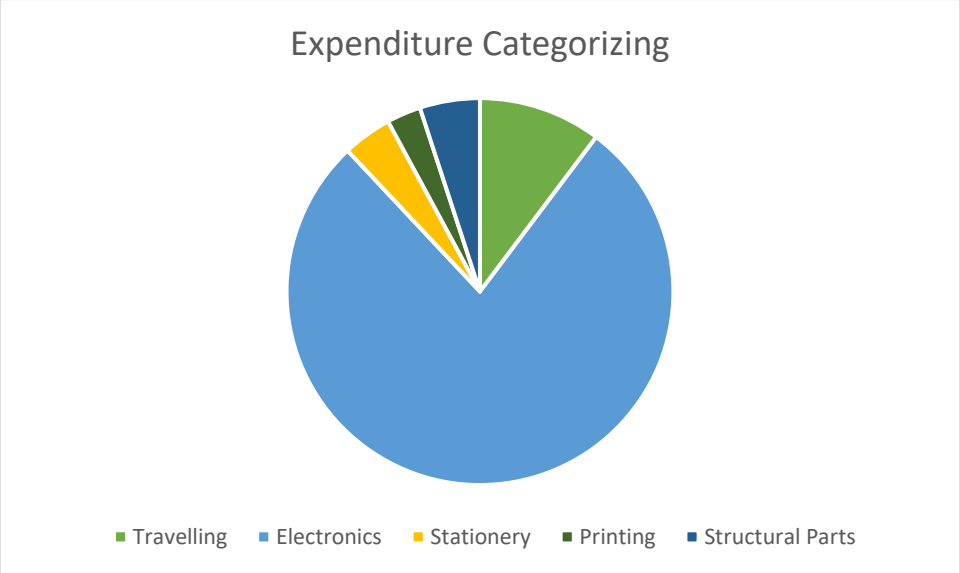

Figure 12. Expenditure Categorization

TimeLine

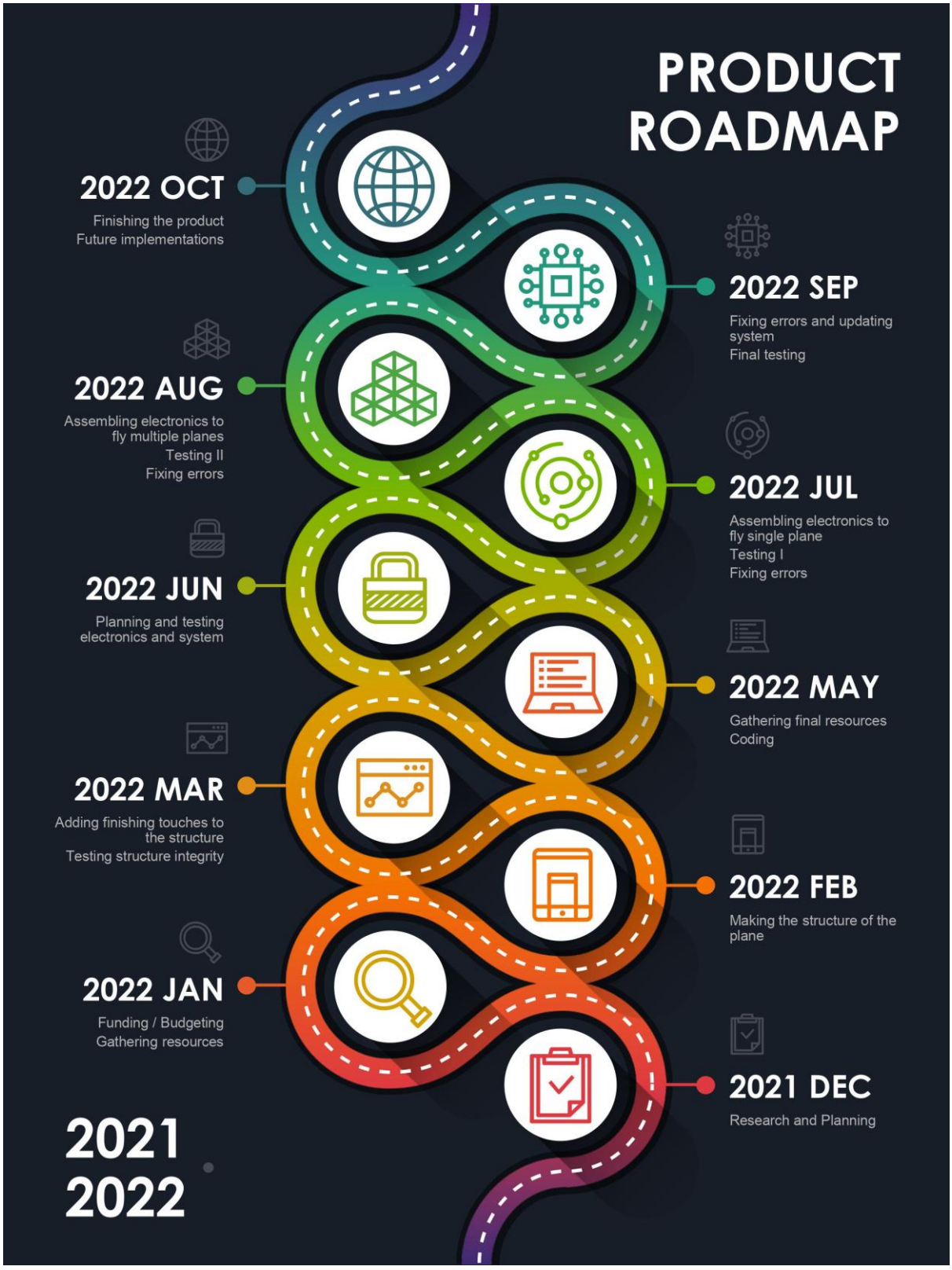

Figure 13. TimeLine of Project

Procedure

We started by having zoom meetings to plan our process to finish up our project successfully. First, we decided on the design of UAV which ended up becoming the “Ft Storch”. Next, we made a list of necessary items for our project and decided on an adequate budget as well. We broke down into a couple of groups and checked online and contacted some retailers to find what was best. After finalizing the stores, we headed out in groups and bought everything we needed that was available.

We started work on our project by dividing into two groups for each UAV and carving out necessary pieces for them. We used a glue gun and some tape to attach the pieces together. We had our ups and downs while making the structures as we made many mistakes and sometimes had to start all over again. After the two structures were completed, we connected the two 1400 kV motors to the UAVs using two small wooden planks to give more rigidity to the structure. While progressing on the structures, we have been working on the coding of the project as well.

As the Fusion 22 was getting closer we had to complete our project to be presented at the exhibition as an ongoing project. We finished up the electronics with the connections of brushless motors, servos, ESC, and the battery. We also covered up our plane using coloured stickers to be more presentable at the exhibition. Since we were only showing the plane at the stall and would not be able to fly it, we connected an Arduino nano board and programmed the plane to rotate its motors and servos in a pattern. We also won the 1st place of the competition.

Results and Analysis

Risks and Error Management

During the beginning of our project, we had to face many errors and risks in order to complete our project. One of the major problems faced by us was finding required components for our project. Since the country is facing an economic crisis, there is a shortage of importing electronic components. This is the main reason for shortage of electronic components. Ultimately, with the help of the university we were able to find the required components for our project.

An error we faced during building the structure of the plane was not getting the parts of the plane accurately. While carving and attaching parts for the plane, there were some defects therefore resulting in asymmetric plane structure. We overcame this by building multiple UAVs until we perfected the structure.

Results and Advantages of the Project

This project demonstrates us with many advantages such as:

1. Can be used for military purposes such as unmanned attacks or carrying resources to war zones.

2. Can be used in automated delivery systems which would reduce traffic as well as time.

3. Can be used to carry heavy weights to distant locations by using multiple UAVs simultaneously.

4. Can be used to observe and gather more data from dangerous places where humans can't visit and by taking the average, we can get more accurate readings.

5. For medical situations such as delivering medicine and medical equipment as soon as possible

6. Can be used in applying pesticides to fields

7. Taking out forest fires

By using multiple UAVs in a system, we can achieve the above in a reduced time and can carry more resources.

Conclusion

Present State of the Solution

So far, we are more than halfway through our project, and we are happy with the things we have done so far. We received our transceiver as well our flight controllers to continue our project. After the completion of the plane with the installation the above-mentioned equipment, we plan to conduct a few test flights to ensure that the UAVs are well balanced and could be airborne. Finally, after the flight tests are successful, we hope to install the automated system and test run the dual UAV system at last. With the success of the final test our project would be completed.

Future Implementations

In the future we will be upgrading most of the electronics inside the UAV such as the brushless motor, battery, GPS, transceiver which will increase the speed, flight time, accuracy, and communication distance, respectively.

We will also increase the number of UAVs in order to create a much more complex system, which will be more beneficial in covering more ground in practical situations and in carrying heavier goods.

We can also implement autonomous flight process that when providing the starting point and destination the UAVs would travel autonomously.

References

[1] “Arduino,” [Online]. Available: https://www.arduino.cc/.

[2] “Arduino Playground,” [Online]. Available: https://playground.arduino.cc/Interfacing/.

[3] “ArduPilot,” [Online]. Available: https://ardupilot.org/plane/.

[4] Dejan, “nRF24L01 – How It Works, Arduino Interface, Circuits, Codes,” [Online]. Available: https://howtomechatronics.com/tutorials/arduino/arduino-wireless-communication-nrf24l01-tutorial/.

[5] “Mission Planner,” [Online]. Available: https://ardupilot.org/planner/.

[6] “APM 2.8 Flight Controller,” [Online]. Available: https://ardupilot.org/copter/docs/common-apm25-and-26-overview.html.