“Teknofest 2022”

Unmanned Aerial Vehicle

“Preliminary Design Review”

Report

Team Name: BTU ANKA
UAV Type: Fixed Wing
University: Bursa Technical University
Team Captain: Batuhan AKKAYA

1. Team Organization

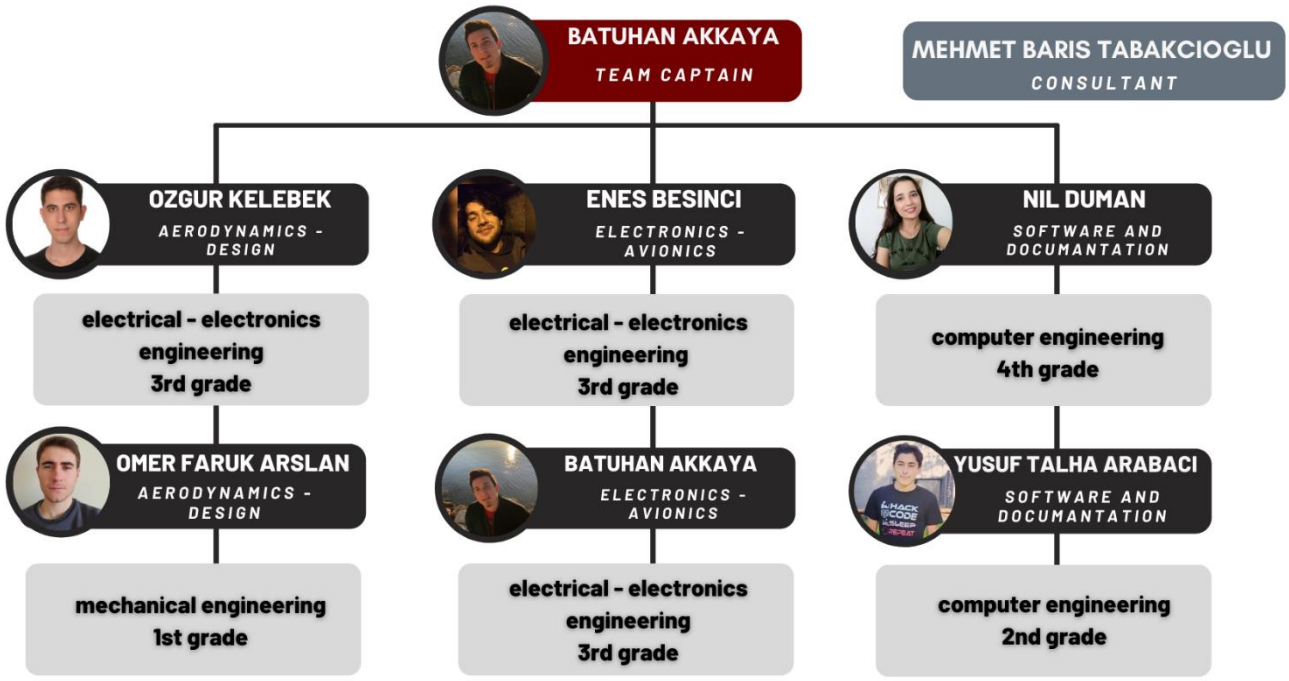


Figure 1: Team Organization Chart

2. Current Problem

What problem does the planned mission to address in this section?

During a possible war, fires may occur on the battle line. These fires can damage soldiers fighting on the front, combat vehicles or civilians. In other words, these fires can cause high loss of property and life. Unfortunately, it is not possible to extinguish these fires under enemy fire.

(Enemy is defined as someone or something that manifests itself as a threat to citizens or country)

3. Proposed Solution

The innovative road (roads) that are described as problematic in this section should be described in an open and successful way.

As a solution to this problem, An UAV is designed to stall the enemy line in order to extinguish the fire. The designed UAV throw a smoke bomb to the enemy side and drop water to the fire area. In this way, the enemy is stalled, and the fire is extinguished.

UAV will carry 2 payloads: 1 that represents a smoke bomb, and 1 that represents a water bomb.

The mission flight will be autonomous.

4. Detailed Description of The Mission

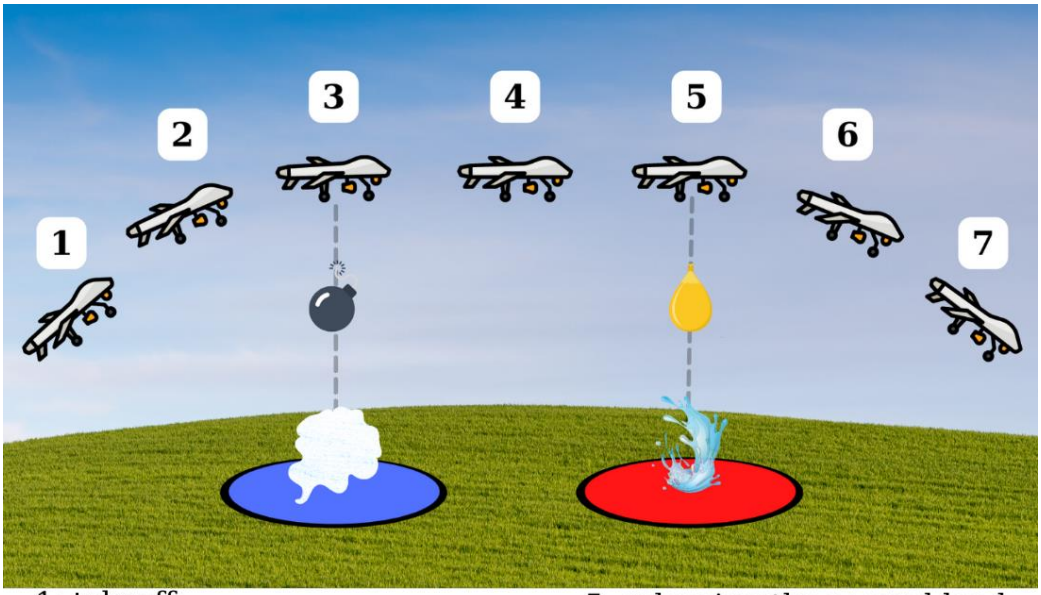
In this section, a visual description of all stages of pre-flight, post-flight and after-flight operations should be presented, and a written description of the definition, characteristics of the UAV, the total take-off weight should be recorded.

The environment and additional supplies required for the fulfillment of the mission must be noted.

The visual description should be prepared based on the following example.

Before the mission, the UAV will be prepared for the flight. The loads will be checked and loaded. After the technical controls are made, UAV will start the flight manually and then will switch to auto flight mode in 5 seconds and will start the autonomous flight mission.

During the mission, the UAV will fly by itself, without human control. It will start to follow the route which will previously be given from the ground control station. When it arrives at the first target - blue area -, the first load -which represents the smoke bomb- will be released. Likewise, when the UAV reached the second target - red area -, it will release the second load symbolizing water bomb. Mission will be accomplished after releasing both loads. UAV will fly back, and land manually. The visual description is given in Figure 2 below.



1: takeoff
2: autonomous mission start
3: releasing the first load
4: autonomous flight
5: releasing the second load
6: autonomous mission finish
7: landing

Figure 2: UAV Flight Visual

It is aimed that the UAV characteristically has high maneuverability and light weight. The weight of the UAV is 1496,9 grams.

The competition requires the UAV to be manufactured with a budget of $700. Therefore, cheapest components were selected as much as possible.

The required flight area for the selected mission is shown below. In addition, two rectangular zones measuring 10 m * 25m are needed in the area, one red and one blue. These zones represent the areas where the payloads will be released, and they will be located anywhere on the flight route.

Figure 3: Flight Area

5. Reports on Mission Fulfillment

For the selection of components in this section, such as the cylinder, the flight time, the lifting power, the electrical reports, the rabbit, the software, and so on. reports should be published. Reports relating to the useful load should be published in this section.

5.1 General Description of The Location of The Payload on The UAV And the System

At the design stage, parameters such as load to be transported, drag force, lifting force, ease of production and cost were considered. Therefore, the traditional - middle wing and the traditional tail were selected as the configuration.

Fuselage

It is aimed to design the smallest fuselage (frame) that can cover the selected electronic components. The dimensions of the fuselage were calculated as 417×55×55 mm, considering the center of gravity and the dimensions of the electronic components. The fuselage construction material was chosen as plywood because it is low in cost and easy to produce.

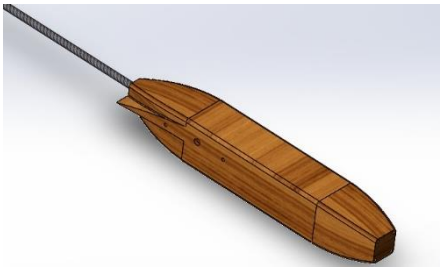


Figure 4: Fuselage

Wings

To ensure flight stability, minimum drag force and maximum lift force were aimed at the design. In this direction, profiles from Airfoiltools were examined and the USA-35B airfoil was selected.

it is determined as follows. The UAV will have a wing area of 0.17 m2, a wingspan of 1412 millimeters, and a wing length of 150 millimeters.

These values have been placed in their places in the formulas given below and the lift (Formula 1) and drag (Formula 2) forces have been calculated.

$$\boldsymbol{F_{Lift}} = \frac{1}{2} pV^2 AC_L \qquad \boldsymbol{F_{Drag}} = \frac{1}{2} pC_D V^2 A$$

Formula 1 *Formula 2*

(p: density, V:fluid velocity, C_L : coefficient of lift C_D: coefficient of drag, A: area)

To reduce the vortex, the wing will be shaped like a delta wing, that is, the wing profiles will shorten towards the ends.

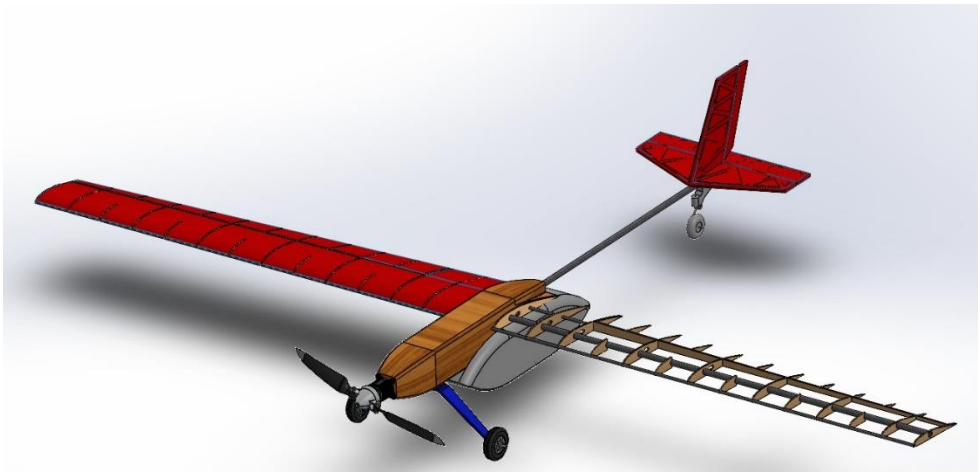


Figure 5: Internal Structure of the Wing

Tails

To facilitate the control and production of tail control surfaces, the traditional tail type has been selected. This designed tail will be connected to the fuselage with a carbon fiber pipe.

Figure 6: Tail

Landing Gear

To minimize the damage to the fuselage during landing, it was decided to use a landing gear. The landing gear will be manufactured from 3D Printer using PLA filament and will be reinforced with steel wire and mounted on the UAV.

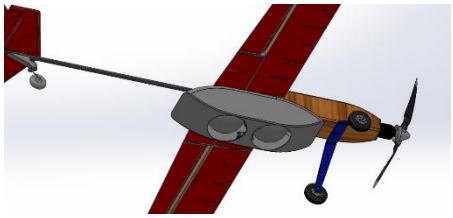


Figure 7: Landing Gear

Mission Mechanism

The mission – payload releasing - mechanism will be positioned in such a way as not to change the center of gravity and aerodynamic structure. The mechanism will be made of plywood to be inexpensive and lightweight. There will be 2 servo motors in the mechanism to hold the mission payloads.

The design of the payload-release mechanism and its location is given below.

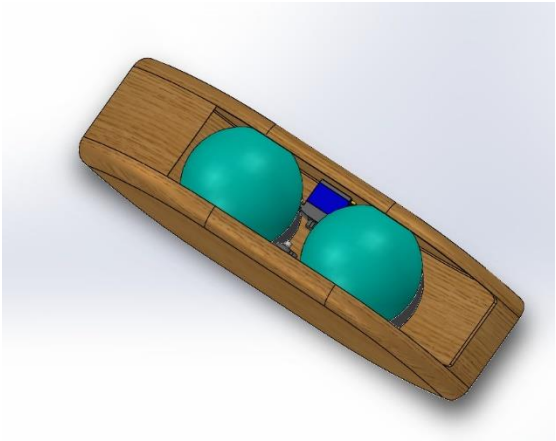


Figure 8: Payload Release Mechanism

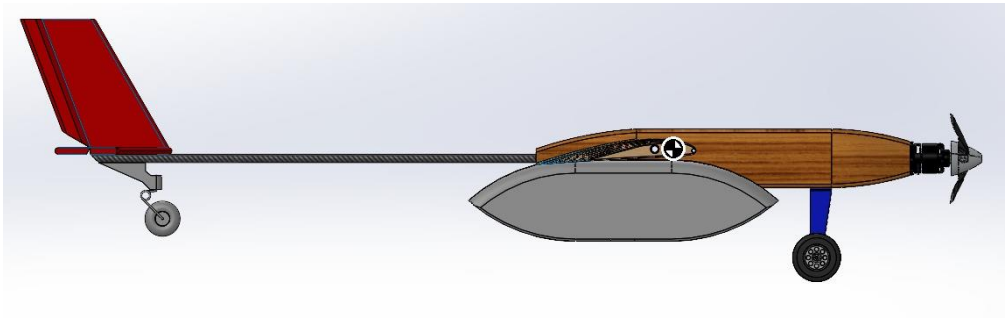


Figure 9: UAV Side View

The planned construction material and installation method of the mechanical components are briefly given in Table 1.

Mechanical Parts	Construction Material	Additional Materials	Installation Method
Wing	balsa, plywood	carbon fiber pipe, heat shrink covering film	Pasting, tight passing
Fuselage (Frame)	plywood	carbon fiber pipe	Pasting, tight passing
Tail	balsa	carbon fiber pipe	Pasting
Mission Mechanism	plywood	steel wire	Pasting, tight passing
Landing Gear	PLA	steel wire	pasting, tight passing, screw

Figure 10: Mechanical Parts' Construction

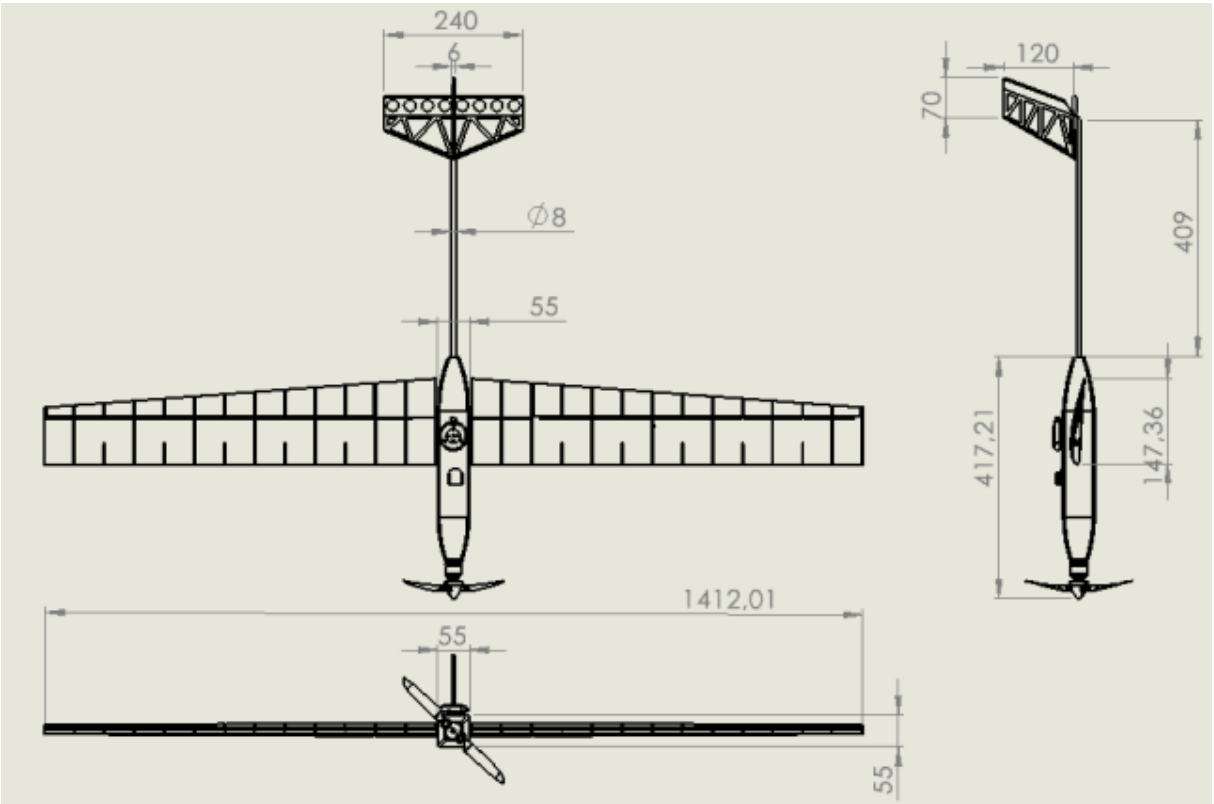


Figure 11: UAV's CAT Drawing

5.2 UAV's Mass Report

UAV Mass Report is given in Figure 13, The reference point is given in Figure 12.

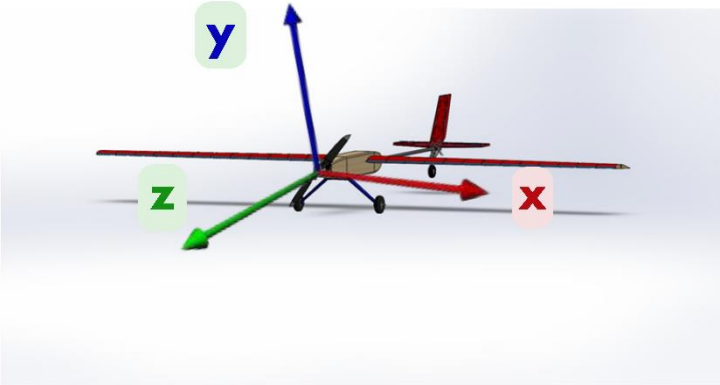


Figure 12: Reference Point

Component	Unit Weight (g)	Unit	Total Weight (g)	X (mm)	Y (mm)	Z (mm)
Fuselage	170	1	170	0	0	52
Servo Motor	11,5	4	46	0	0	-264
Receiver	14,9	1	14,9	10	12	59
Telemetry	5	1	5	0	27	59
Power Module	35	1	35	-15	12	59
GPS	31	1	31	0	27	-22
Flight Control Card	20	1	20	0	-21	65
Landing Gear	40	1	40	0	-62	135
Rear Landing Gear	10	1	10	0	-23	-500
Mission Mechanism	150	1	150	0	-47	-44
Mechanism's Servo Motor	11,5	2	23	0	-60	-44
Wing	150	1	150	0	0	0
Tale	50	1	50	0	20	-528
Tail Pipe	30	1	30	0	0	-323
Glue	100	1	100	0	0	0
Motor	57	1	57	0	0	240
Battery	107	1	107	-10	11	168
ESC	41	1	41	16	11	168
Cable	50	1	50	0	0	0
Payload	150	2	300	0	50	0
Prop	32	1	32	0	0	267
Safety Switch	10	1	10	-20	0	96
Fuse	25	1	25	20	0	96
TOTAL WEIGHT : 1496,9						

Figure 13: UAV'S Mass Report

5.3 Flight Report of UAV With Payload

UAV's airtime depends on 2 parameters: flight distance and flight speed. (Formula 3)

$$Airtime\ (t) = \frac{Flight\ Distance\ (\mathcal{X})}{Flight\ Speed\ (\mathcal{V})}$$

Formula 3

Flight Distance

Mission's flight distance was calculated using Mission Planner, a ground control station program. The planned flight route was created using the Mission Planner (Figure…), and then the distances got calculated by the program. As can be seen in the figure… below, flight distance was found to be around 400 meters.

Figure 14: Flight Route

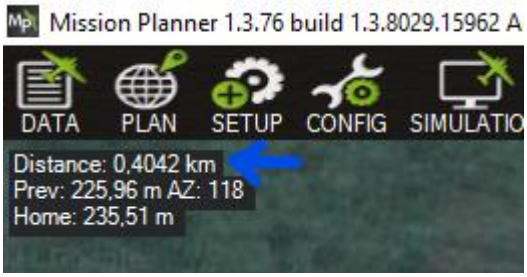


Figure 15: Flight Distance

Flight Speed

The minimum speed required for an airplane to produce lift. -stall speed- is about 11 m/s. The flight speed was determined as 15 m/s in accordance with the aerodynamic characteristics of the UAV and mission. The UAV will follow this route twice to complete the mission.

Based on these two determined values, the autonomous flight time was found to be approximately 54 seconds. When manual takeoff and landing were added, it was decided that the intended flight time would be 75 seconds.

5.4 Electrical Power Sheet

The absorbed energy was calculated with the Formula 4 using the planned flight time. The obtained data are found in joules and are indicated in table xxx.

$$\text{Absorbed Energy(J)} = \text{Flight time}(s) \times* \text{Absorbed Power(W)}$$

Formula 4

Components / Flight Mode	Motor	Control Surfaces' Servo Motors	Mission Mechanism's Servo Motors	Flight Control Card	SUM
Manuel (21 sec)	8515,92 J	621,18 J	0 J	0 J	9137,1 J
Autonomous (54 sec)	21898 J	1597,32 J	421,2 J	810 J	24726,52 J
				TOTAL SUM	33863,62 J

Figure 16: Absorbed Energy Calculation

5.5 The Block Diagram Description of Flight Controller and Software Block

The flow chart of the autopilot is given as below. The process that will take place between the start mission and complete the mission steps (indicated by stars) is described in the payload release flow chart.

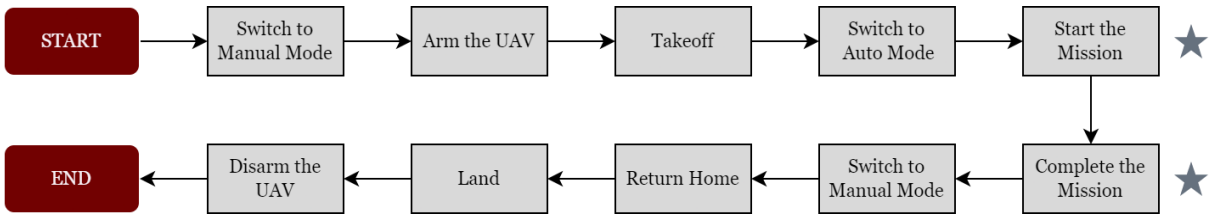


Figure 17: Autopilot Flow Chart

Payload Release:

The UAV will release 2 payloads within the mission. The process of releasing the payload is shown in detail below.

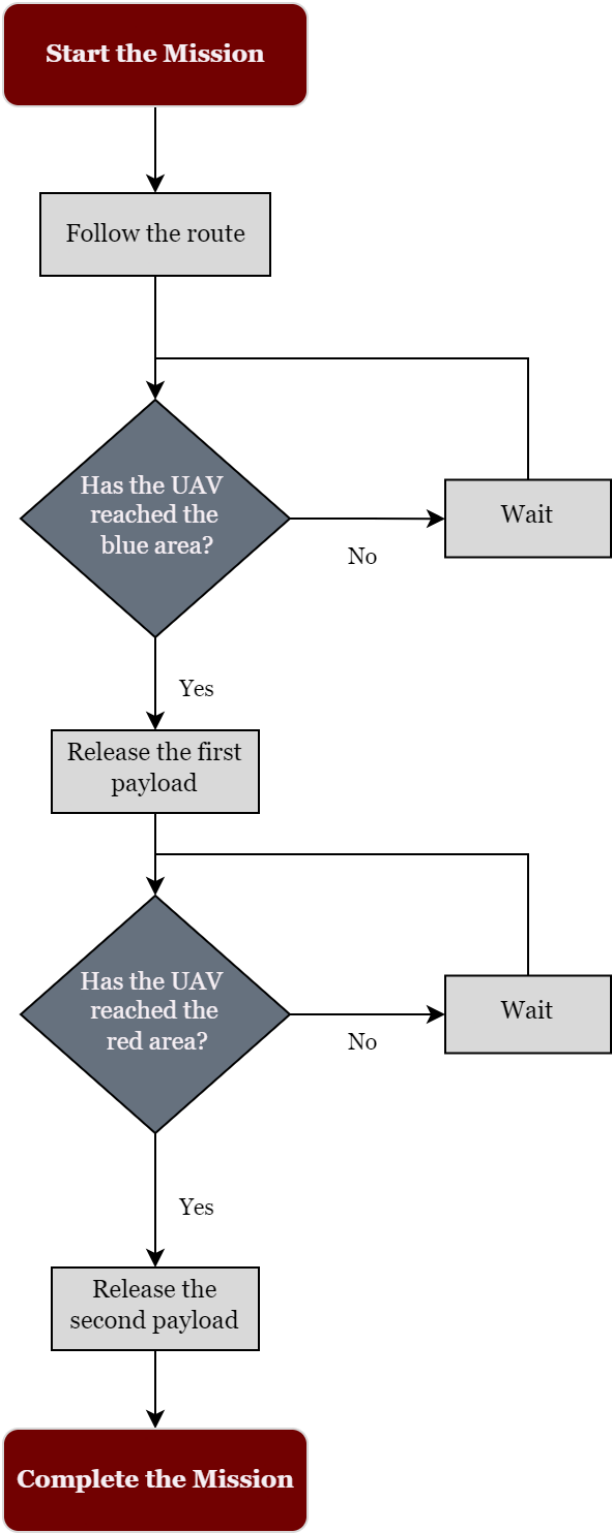


Figure 18: Payload Release Flow Chart

The Block Diagam of The Ground Control Base Station (GCS):

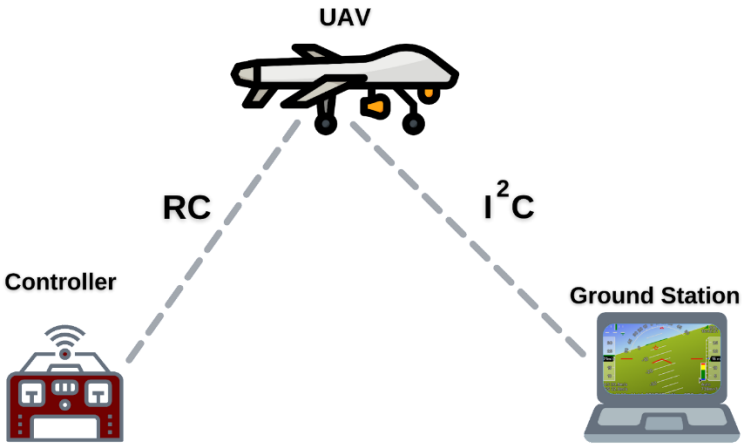


Figure 19: GCS Communication

Fail-safe case

In risky situations that may occur during, pre or post flight; it is important that the UAV has a fuse and safety switch. In case of any problem in the electrical circuits, the fuse of the UAV prevents the possible dangers by cutting the current. For other mishaps, there will be a safety switch on the side of the fuselage so that UAV could be turned off immediately. In the event of a risky situation during the flight; the UAV will also have a fail-safe mode.

6. Component Selection

No	Electronic and mechanical parts	Name and brand of the product	Purpose of use	Product technical parameters / components	Unit	Additional Note	Photo
1	**Motor**	SunnySky X Series V3 X2212 V3 Long Shaft Brushless Motors	flight capability	Max thrust: 1650	1		
2	**Fuselage**	birch plywood	lightness and cheapness	Hand + Bunge Cord 2 x (10mm)(30X50 cm)	1		
3	**Electronic Speed Controller (ESC)**	50 A 2S-4S Hobbywing Skywalker ESC - 5V/5A BEC	the control center that manages the motor	50 Amper 2s-4s	1	The back cable of ESC will be connected to the back of Pixhawk	
3	**Battery**	850mAh 14.8V 75C 4S1P Tattu LiPo Battery	To provide the power needed by the UAV	14.8 V 4S LiPo Battery	1		
4	**Prop**	YUENHOANG - 10x8 Folding Propeller with Aluminum Alloy Swivel Cover	thrust force	1 x D30xH30mm Aluminum Alloy Paddle Spinner cover	1		
5	**Flight Controller Kit**	Holybro Pixhawk 4 Flight Controller UBLOX NEO-M8N GPS Module PM02 Power Management Combo for RC Drone	autonomous flight	Main FMU Processor: STM32F76 1 x Pixhawk® 4 flight controller 1 x GPS module 1 x Power Module 1 x cable set	1	Telemetry, GPS, Power Module, Servo Motors will be connected directly to Pixhawk's sockets via cables	
6	**Receiver**	FS-İA6B Receiver	Providing the communication between the UAV and the pilot	6 Channels 1 x Flysky FS-iA6B 1 x Bind plug	1	Compatible with FLYSKY FS-I6 I4 I10 GT2E GT2G Radio System	
7	**Telemetry**	Digi - Xbee 3 Module	Providing the communication between the ground station and the UAV	gravitational field up to 1119.2 meters RF 250 Kbps, Serial 1 Mbps	2	1 will be used on the UAV and 1 will be used in the Ground Control Station	
8	**Servo Motors**	Tower Pro MG90S Micro Servo Motor	aileron, rudder and elevator (control surfaces) movements, payload release	1.8 kg torque	6	They will be connected to the back of the Pixhawk and receive their power from the ESC's back cable	
9	**fuse**	Blade Fuse 40 A	safety	40 amps	1		
10	**safety switch**	Daier / XN	safety	Height: 18.5 mm	1		
11	**XT60 Connector**	XT-60	Installation and connection of electronic components	female-male double package 60 cm	1		
12	**Servo Extension Cable**	Motorobit Servo Extension Cable 60 cm Female-Male	Installation and connection of electronic components		1		
13	**Jumper**	Robotistan - 40 Pin Detachable Female-to-Male M-F Jumper Cable - 200 mm	Installation and connection of electronic components		1		

14	**Mechanical assembly - fasteners components**	Mitre Apel Fast Adhesive	Fast Adhesive	cyanoacrylate, aerosol	1		
		Pattex Epoksi	Fast Adhesive	cyanoacrylate, aerosol	1		
		3M Molding Tape	Tape	polymer elastic lift	1		
		Bimeks Repair & İnsulation Tape	Tape	polymer elastic lift	1		
		Vodaseal Wood Glue	Adhesive	water, coal, lime	1		
		3mm bolt	Attaching electronic components to the body	plastic	10		
		3mm nut	Attaching electronic components to the body	steel	10		
		Haoye plastic tiller	control surfaces' servo connection	plastic	4		
		PRM 1.0mm Steel Wire	control surfaces' servo connection	steel	2		
		Globe Electrical Insulation Tape	For electronic components isolation	polymer elastic lif	1		
		Haoye Pushroad Attacher 2xD8x23mm	For fixing the tiller wire	plastic	4		
		PRM Brass Easy Link D1.6mm H5mm	For fixing the tiller wire	metal	3		
15	**Wing - Tail Manufacturing**	kompozit.net - 10*8 Carbon Pipe	attaching the wing and tail to the fuselage	acrylic fiber (Orlon), tar and nylon.	1		
		kompozit.net - 8*6 Carbon Pipe			2		
		kompozit.net - 4*2 Carbon Pipe			2		
		kompozit.net - 2*1 Carbon Pipe			1		
		pilottr - 5 mm Balsa	wing profiles, tail's control surfaces	wooden	2		
		pilottr - 4 mm Balsa			1		
		pilottr - 2 mm Balsa			2		
		pilottr - 1 mm Balsa			5		
		thk - transparent red coating	wing cover film	600X1000 mm polyster	1		
16	**Landing Gear**	FK Filament - Black Strong Pla Filament 250 Gr.	landing gear manufacturing	Diameter: 1.75mm (Tolerance +-5%)	1		
		4mm screw	landing gear link	steel	1