RECONNAISSANCE AND OBSERVATION-PURPOSE SOLAR AUTONOMOUS AIRSHIP DESING

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ABSTRACT

The purpose of Reconnaissance and Observation-Purpose Solar autonomous airship project, is that several studies made Unmanned Aerial Vehicles (UAV) on in recent years to gain an alternative perspective and to benefit from advantages of provided by solar energy such as the environmental compatibility and sustainability.

The purpose of the use of unmanned aerial vehicles is to make difficult duties instead of peoples. Zeppelins are vehicles that can hang in the air for a long time with low energy needs. In this study, airship autonomous systems are intended for use to do duty that contrary to human physiology (dirty, boring, dangerous). Using the airship for reconnaissance and observation purposes are considered. Added via module data and image transmission will be performed on simultaneously. The zeppelin is designed autonomous because of difficulty in controlling the observations in wide area. Autonomous systems will reduce the workload spent. In an alternative energy source, solar energy has no limits, no cost and environment friendly. Tasks without the need for fuel in the long-term mission will provide complete.

Key Words: Zeppelin, Solar Power, Autonomous, Reconnaissance, Observation, Airship.

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1. INTRODUCTION

The airship is one of the earliest flight vehicles. The first reasonably well controlled airship flewin1852, achieving a speed around10 km/h [1]. The first golden age of airships began with the launch of the Luft Schiff Zeppelin LZ1 in 1900, lasting about 40 years in World War 1. Germany, the United States, England, and Italy designed and manufactured many airships for military and civilian uses. The zeppelin airships manufactured by Germany were the most famous, total 119 between 1900 and 1938. Some of these airships were used as bombers during World War 1 by the German Army. Some of these rigid, hydrogen-filled zeppelins routinely cruised above 6 kilometers, high enough to avoid allied interceptors and anti-aircraft artillery [2].

Lighter-than-air vehicles, popularly known as airships or dirigibles, started with hot air balloons and evolved to lifting gas filled, tethered and un-tethered aerostats, airships, and novel buoyancy air vehicles in step with the advancement of new materials and technologies. In this paper, the word airship is used to denote all the air displacement vehicles that obtain buoyancy from the difference between the weight of the inflation gas within their hulls and the weight of the ambient atmosphere their bodies displace. This classification includes all airship-type vehicles with control and propulsion systems: traditional airships, unconventional airships, non-rigid, semi-rigid, and rigid airships, hybrid airships, heavy-lift air vehicles, high altitude airships, buoyancy assisted lift air vehicles, etc. Balloons and aerostats are not included in this catalogue because they do not have powered means of propulsion. Airships can be classified based on hull configuration (non-rigid, semi-rigid, and rigid), the way of producing vertical force (lighter-than-air, heavier-than-air, and hybrid), and payload capability (heavy-lift and medium-lift). The payload of traditional buoyancy air vehicles is usually less than 30 tons, while heavy-lift air vehicles can reach as high as 500 tons. Airships can also be divided into conventional types and unconventional types [3].

In recent years there have been many studies on the airship. Some of these are a literature review of airship modeling [4], a review of airship structural research and development [5], the future of air transport powered with hydrogen [6].

The main purpose of the Reconnaissance and Observation-Purpose Solar Autonomous airship Project is develop and design zeppelin that can fly at low altitude and transferring data (speed, altitude, picture and video of the area) by telemetry system. Zeppelin will fly autonomously on selected area to complete its task. In additionally flight time will have been increase by gaining electrical energy from solar panels. This Project may lead civil and military aviation branch by developments in the future.

2. CONCEPT DESIGN

2.1. The Weight Estimate

The net weight calculate of the concept design is very difficult. Thus at this stage the estimated weight calculation is done for each part as shown on Table 1.

Component	**Weight (gram)**
Body	
Body	7000
Gondola and Thrust Systems	
Gondola (Balsa)	500
3*ESC	400
Battery (engine)	3000
Servos	25
2* Engine axle	30
3* Engine	1200
Camera and Payload	
Camera and Receiver	58
Battery(Camera)	130
Solar panel	2700
MPPT Regulator	256
Control System	
2* Xbee Pro S2B	15
Battery(Control System)	130
Ardunio mega	47
Ultrasonic altimeter	25
Accelerometer	16
TOTAL	**15532**

Table 1: Weight Estimate.

2.2. Gas Constituting The Lift

According to Archimedes law; air density to the density of the force required gas hovering and expressed depending on the volume airship;

$F_{lift} = (\rho_{air} - \rho_{gases}) * g * V$ [7] (1)

Gas	Formula	Molecular weight	Destiny(kg\m^3)
Ammonia	NH_3	17.031	0.717
Helium	He	4.02	0.1664
Hydrogen	H_2	2.016	0.0899
Methane	CH_4	16.043	0.668

Table 2: Gas Constituting [8].

As seen in Table 5 gives the maximum lifting of hydrogen. However, helium is preferred in blimps after the disaster as a result of the explosion of the hydrogen 1930s.

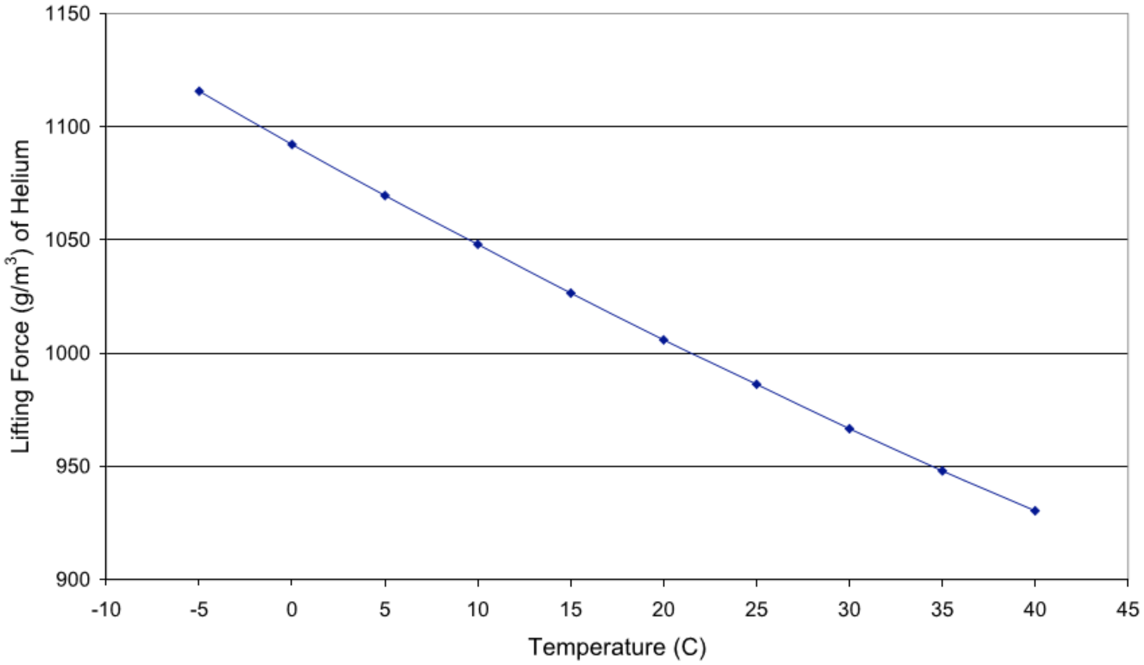


Figure 1: Temperature- Helium of Lift Force.

The advantage of the closed chamber test phase to test our zeppelin our future on Table 1 at 20 ° C for the lifting force of the helium will create 1010 g \ m^3 was adopted.

2.3. Take-off

During take-off weight and drag of the airship must defeat towards below. If the engine is not enough lift force from the gas fails to provide thrust. Therefore, it is necessary supply thrust engines in the upward direction. Calculated from Newton's second law that required thrust movement.

W= Lift
$m*g = Lift_{helyum} + Lift_{motor}$ (2)

Our Zeppelin mass is approximately 15532 grams. The volume of our Zeppelins 9,750 m^3 and 1 m^3 of helium creates lift force 1010 grams. The lift force must come from our engine 55.7649 N.

2.4. Cruise

Cruise stage is needed in both the vertical and the horizontal direction thrust (Figure 2). Thrust necessary cruise mode is the same as in the vertical direction. Again making the cylinder approaches the horizontal direction into the drag coefficient Cd =0.38 can say. The slow flight conditions taken into consideration during the horizontal movement of the gondola drag is negligible because it is very small compared to the body.

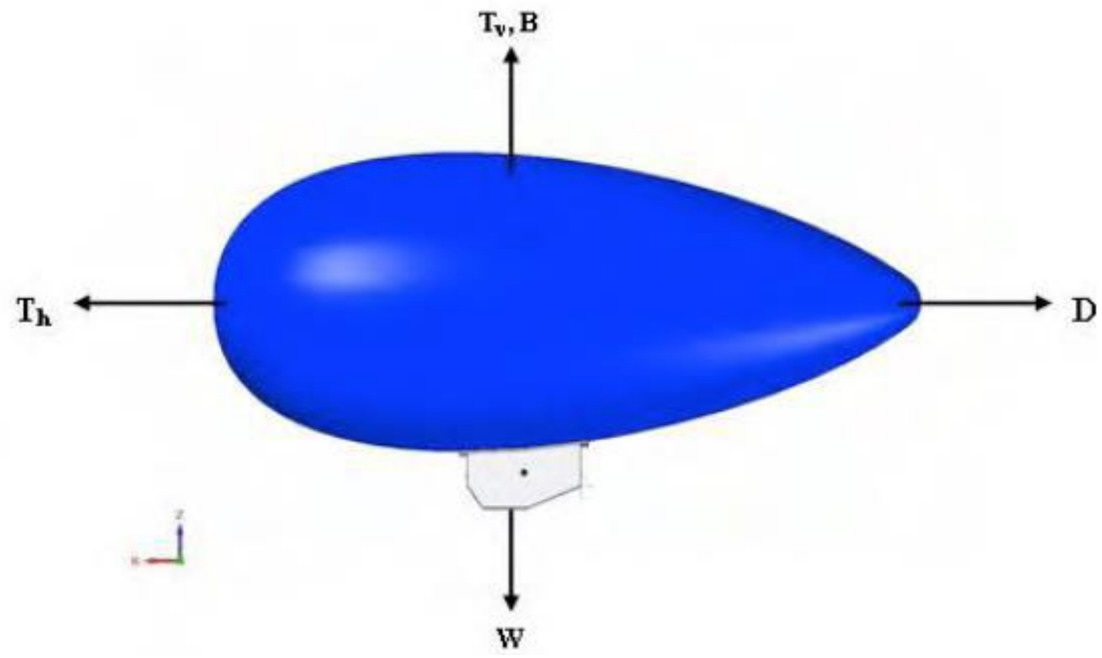


Figure 2: Forces Acting On The Zeppelin.

2.5. Propulsion System Arrangement

We have set design Airship engine placement is as shown in Figure 3. Airship Design will occur on maneuvers and drag forces are considered to be realized.

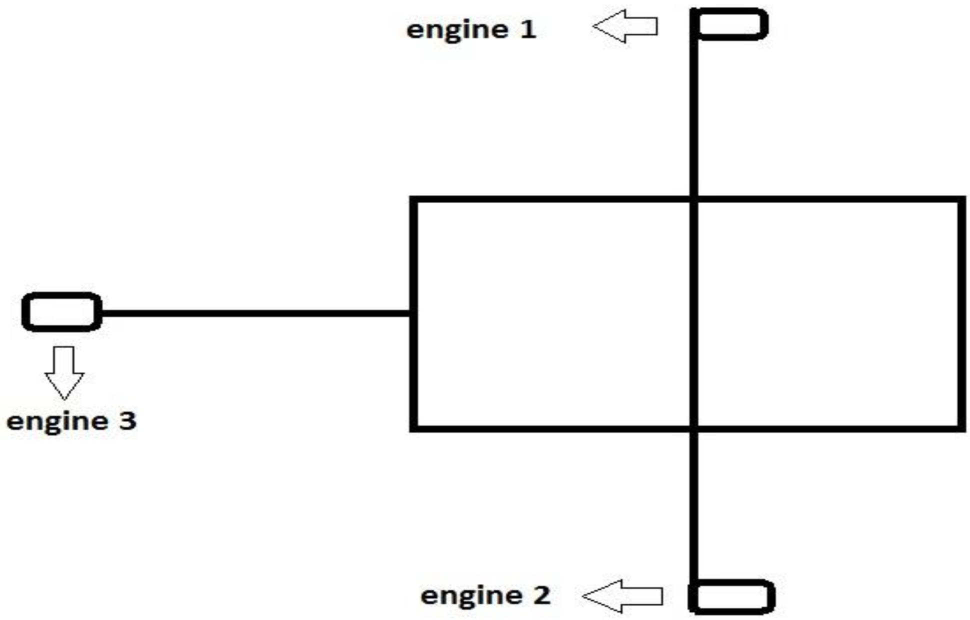


Figure 3: Engine Placement Design.

2.6. Body Design

To determine the size of the body, you need to determine the body volume and we need the necessary buoyancy. This iterative numerical analysis determines the weight and buoyancy are used should be calculated. As a first step, the total weight of all components should be calculated. The feasibility study is made known on this account during the total weight. The equations used to be able to hang in the air [9] I found it necessary to eliminate the movement of the volume of helium.

Surface area of ellipsoid:

$$SA \approx 2\pi\left(\frac{a^p b^p + a^p c^p + c^p b^p}{3}\right)^{1/p}$$ [9] (3)

Volume of elipsoid:

$$V = \frac{4}{3}\pi abc$$ [10] (4)

V: Volume
SA: Surface area
a, b, c: Body dimensions
P: 1,6

a = 2.35 m

$b = 1$ m
$c = 1.05$ m

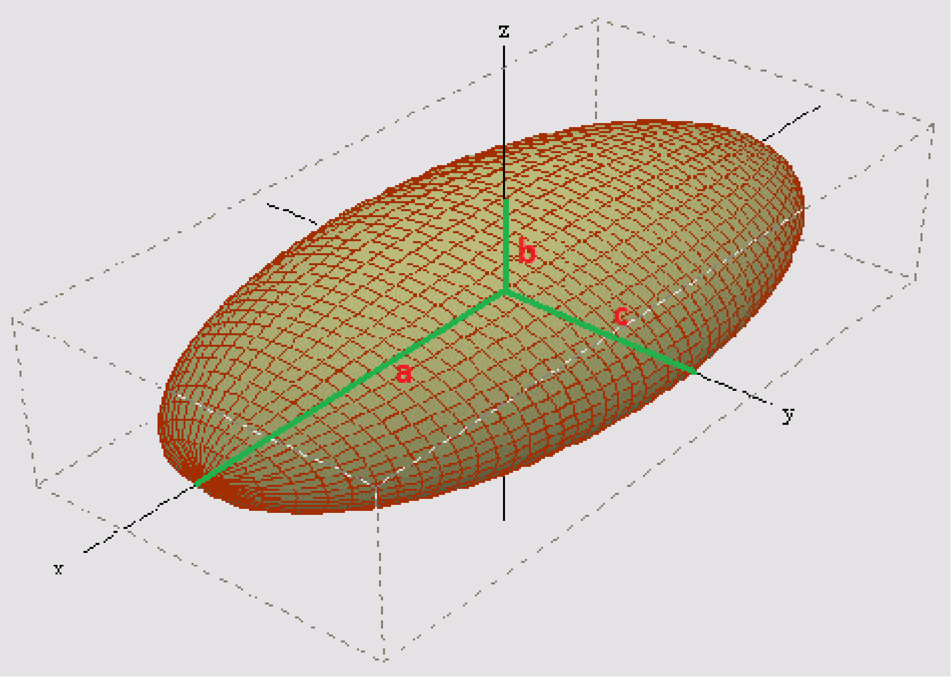


Figure 4: The Airship Directions And Elliptic Airship.

2.6.1. Buoyancy Calculation

1 m^3 of helium under normal conditions (15 °C) buoyancy created;

$F_{lift} = (\rho_{air} - \rho_{helium}) * g * V$ (5)
$F_{lift} = (1.2929 - 0.1787) * 9.81 * 1$
$F_{lift} = 10.9303$ N
$F_{lift} = 1114$ grams
1 m^3 of the mass of the helium;
M helium = $I * V * \rho_{helium}$
M helium = $0.1787 * 1$

MA = 178.7 grams of helium calculated. However, temperature can be calculated to be greater than the buoyancy of the movement of gas from the Figure 1.

2.6.2. Weight Calculation

X-gram will fill the helium airship body mass and volume must be able to remove their bodies. Here is 1 m^3 volume helium with a temperature of 20 degrees formed by the lifting force of 1010 grams and 178.7 grams of helium is known that 1 m^3. Hence, if we need is called helium volume X;

Zeppelin's volume 9.75 m^3
$R = 9.75 * 1010 + 2F_{engine}$ $(15.532 + 9.75 * 178.7)$
$R =$ *7426,825* grams F_{engine}

2.6.3. Thrust In The Vertical Direction

Flight altitude of 10 meters accepts this altitude is considered as the starting time of 20 seconds;

$a = h / t_{flight}$
a = 10/202
$a = 0{,}025\ m / s^2$ as it has.

The friction force during the rise;

$D = 1 /2 * \rho * V^2 * A * CD$ (6)
$A = (c + b) * 2 = 2{:}05 * 4.7 = 9635\ m^2$

Written with an average speed of 0.5 V and ρ is received instead of sea level;

D = 0.5 * 1,225 * 0.52 * 9,635 * 1.15 = 1.696 N

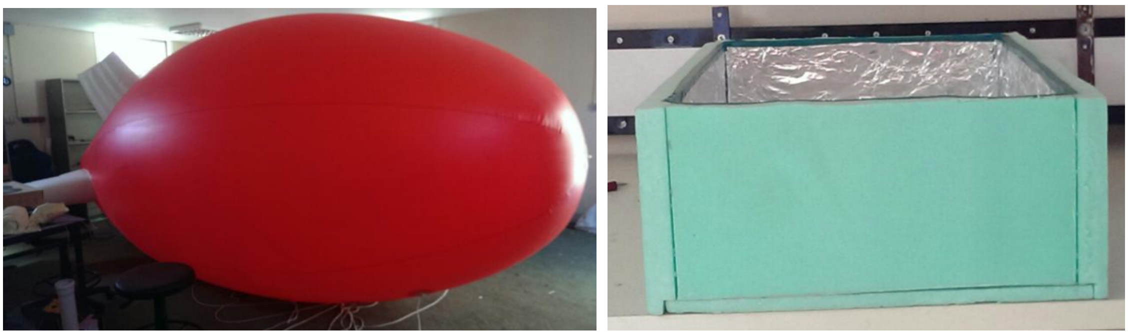
Thrust Friction = M * A + D;
T = 15,532 * 0,025 + 1.696 = 2.0843 N is located in.

When it is written in grams;
T = 2.0843 / 9.81 * 1000 = 212,466 grams;

When the safety factor of 1.2;
T = 1.2 * 212 466 = found as 254.9602 grams.

2.6.4. Gondola Manufacturing

Gondola, are made of hard foam reinforced with carbon fiber rods (Figure 5). The inner part for resistance to heat is covered with aluminum foil. Gondola is connected to the body with ropes.



(a) (b)

Figure 5. Gondola Manufacturing (a. Zeppelin, b. Gondola)

2.6.5. Velocıty and Drag

Airship speed and drift condition is shown in Figure 6. As seen here, the speed increases, drag increases also. These calculations were based on 50 feet altitude and 1,224 g/cm^3 density.

Velocıty(m/s)	Velocıty (Knot)	Drag Force(Front Surface) (Newton)	Drag Force (Sıde Surface) (Newton)
1	1,943844494	0,7302384	1,7511768
2	3,887688988	2,9209536	7,0047072
3	5,831533482	6,5721456	15,7605912
4	7,775377976	11,6838144	28,0188288
5	9,719222471	18,25596	43,77942
6	11,66306696	26,2885824	63,0423648
7	13,60691146	35,7816816	85,8076632
8	15,55075595	46,7352576	112,0753152
9	17,49460045	59,1493104	141,8453208
10	19,43844494	73,02384	175,11768

Figure 6. Velocıty and Drag.

3. AUTONOMOUS SYSTEM DESIGN

Unmanned Aerial Vehicle system (Figure 7); it consists essentially of the aircraft and ground control stations. With using software where works in ground control stations, and through the ground data terminal so aircraft can make wireless connect with aircraft. Commands received by Air Data Terminal sends to Flight Control System and Duty Control Computer. As a result of this circumstance autonomous flight can happen. Unmanned Aerial Vehicle can controlled by RC in ground control station. Add to this, payloads that in need can control on ground control station.

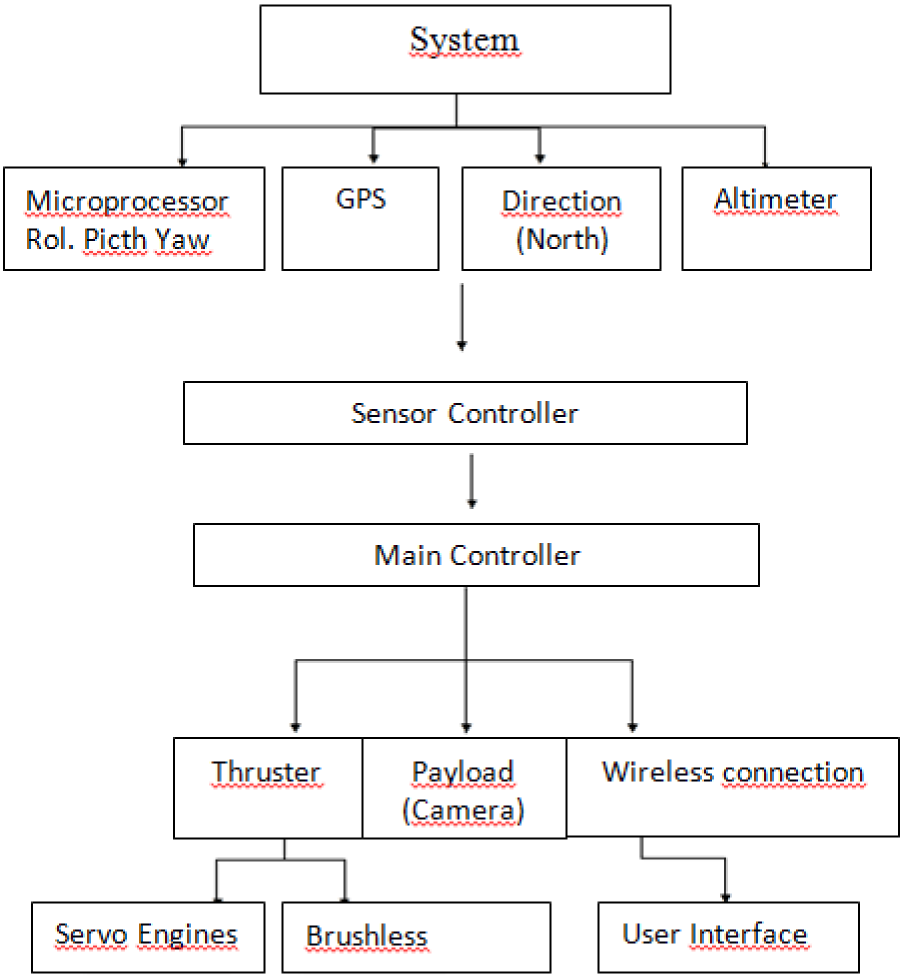


Figure 7: System Diagram.

3.1. System Design

3.1.1. Ground Control Station

Ground control station will have been used by operator and it include computer, Ground Data Terminal, RC (Figure 8.).

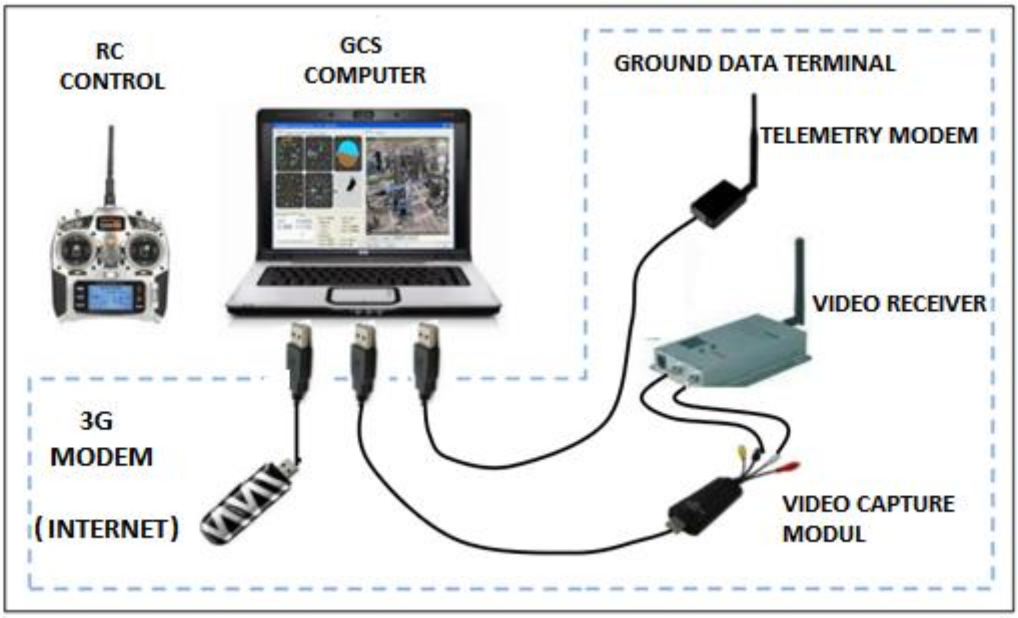


Figure 8: Ground Control Station.

3.1.2. Ground Control Station Software

Ardupilot 2.6 interface planned to use on this project but, other software has been search to against the nuisance which may happen. Sample flight plan is shown on Figure 9.

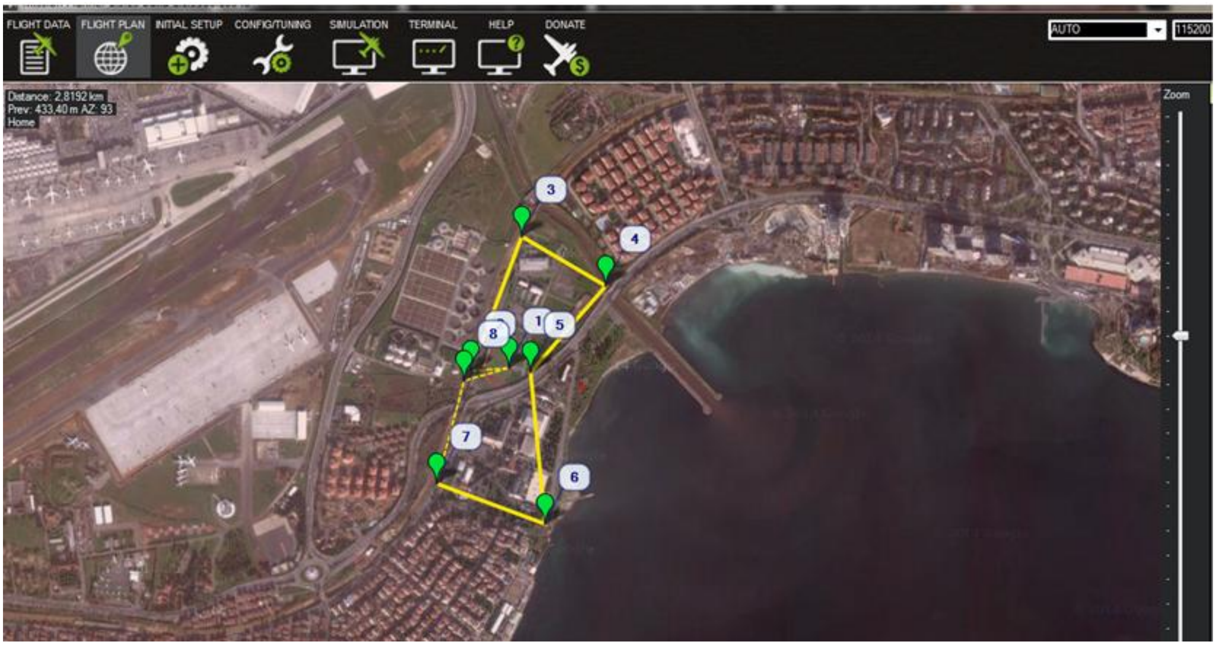


Figure 9: Sample of Flight Plan.

3.1.3. Ground Data Terminal

Aircraft and telemetry information exchange will enable by 3G Modem. USB port will create link between Ground Data Terminal and Ground control Station and data flow will be done by Ground control Station. Using a wireless modem and use the telemetry system capable whip antenna is thought to spread in all directions (Figure 10).

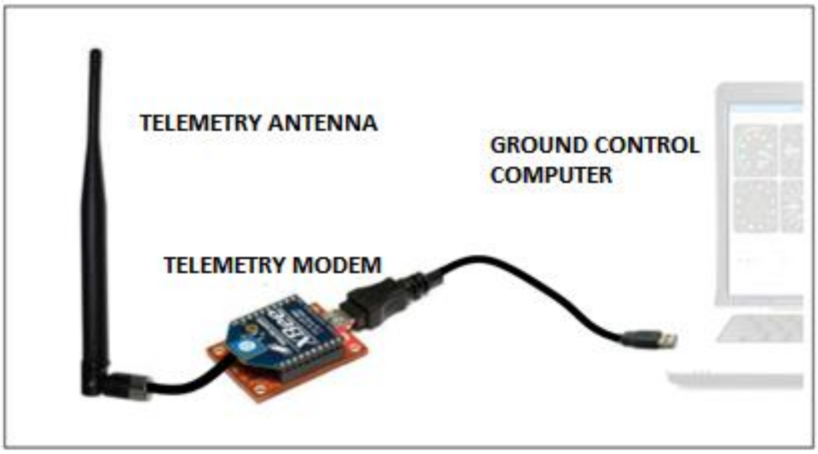


Figure 10: 3G Modem.

3.2. RC Control

That is planned that UAV in manual control mode, using the RC controls in order to ensure control of the airship (Figure 11).

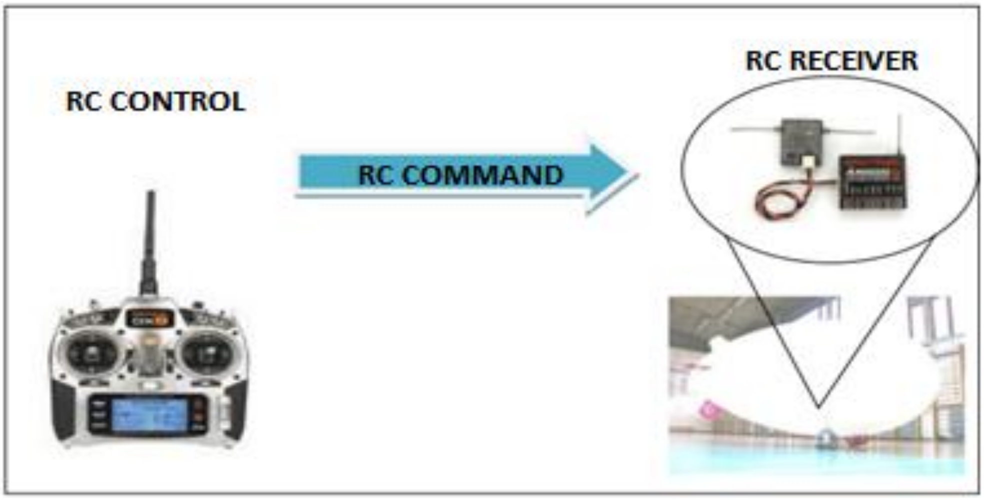


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Figure 11: RC Control System.

3.3. Flight Control System

Unmanned Aerial Vehicle, which will be designed to provide autonomous flight control and ArduPilot airship developed by the Arduino Mega Search 2.6 and users of these systems face, is used (Figure 12).

Micro-regulators and automated control system maintains control codes on the airship to the desired altitude and maintain pitching clicking and editing. Micro regulators pitching and the altitude sensor input value made up the difference between the desired thrust values. Asking altitude values are transferred to the editor via a computer in the station.

One sensor is required for changes to take measurements during the flight. Two alternative sensor used to measure altitude. The first pressure sensor and the second ultrasonic sensor. Pressure sensor for pressure to change significantly in low flight altitude measurements not precise enough. Thus there is a need for an ultrasonic sensor to measure altitude. Ultrasonic sensor sends a signal to the ground. These signals hit the ground until you return to the time it can be calculated with the help of the current altitude auto control code.

A second sensor is required to control pitching clicking. It is available in two options. The first capacitance-based sensors, the second electrolytic sensor. Because that has the same features available in two sensor capacitance-based sensors to measure and control pitching. The duplex airship through this sensor is located on both sides of tension bands. Stress status signal is given to micro and pitching control is provided by the organizer.

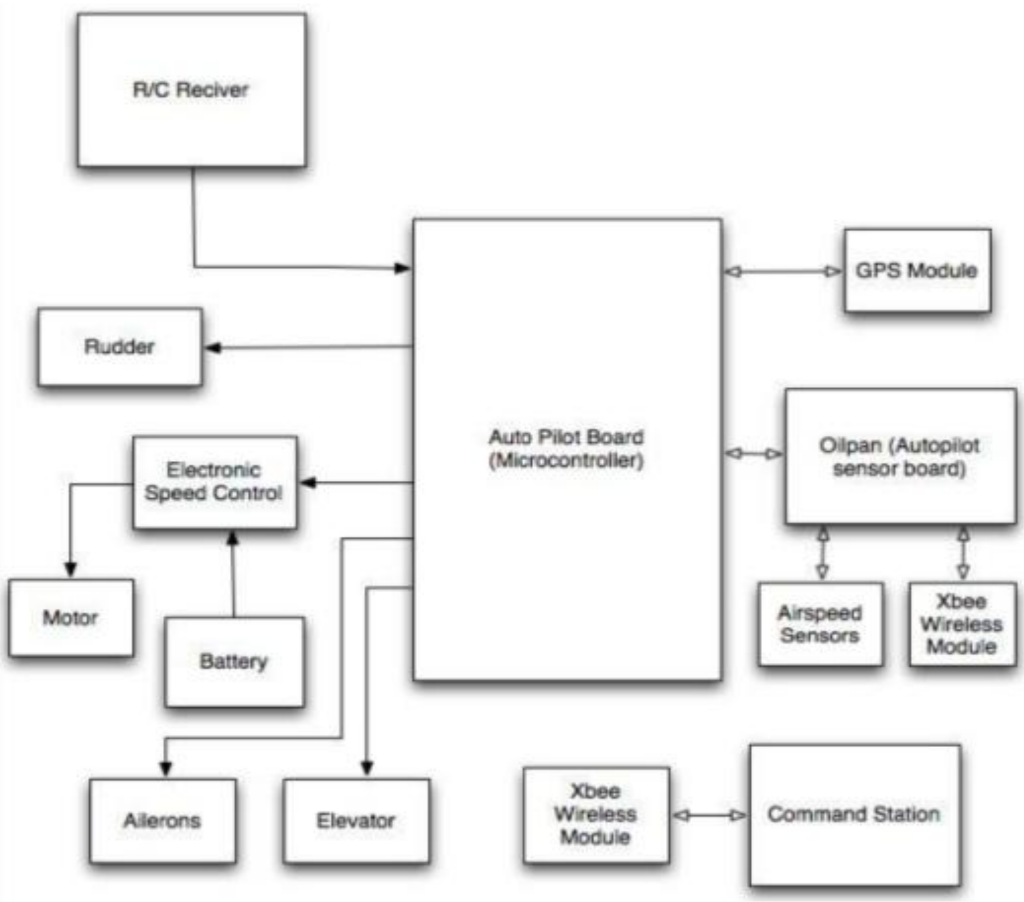

Figure 12: Flight Control System.

3.4. Air Data Terminal

Air Data Terminal consists of RC receiver and Telemetry Modem. RC commands from the controller as a single directional RC Receiver via Flight Control Unit delivered, with telemetry modems Ground Data Terminal and Air Data Terminals provided between the two-way communications (Figure 13).

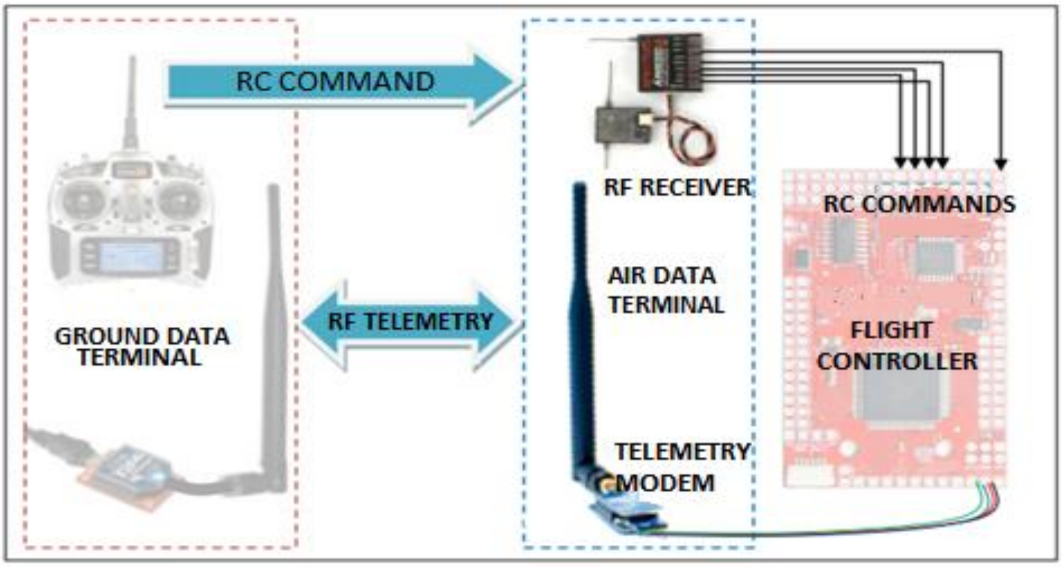

Figure 13: Air Data Terminal.

4. SOLAR PANEL INTEGRATION

4.1. Connection Plan

All connection plans showed on Figure 14. The energy where acquisition from solar cells, firstly regulate by regulator than transmit to battery. After all with this energy where stored in battery, will power to engines and other electrical tools.

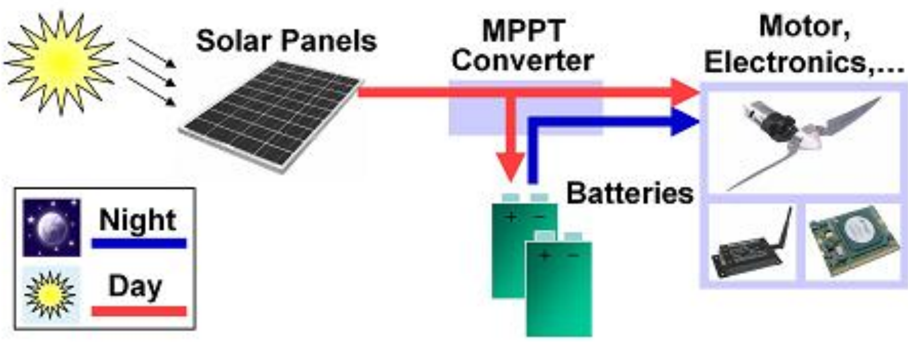

Figure 14: Solar Cells Connections Plan To The Airship.

4.2. Selections

4.2.1. Selection of Regulator

In this system MPPT (maximum power point tracker) will use as a regulator (Figure 15). A MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries. These are sometimes called "power point trackers" for short - not to be confused with panel trackers, which are a solar panel mount that follows, or tracks, the sun.

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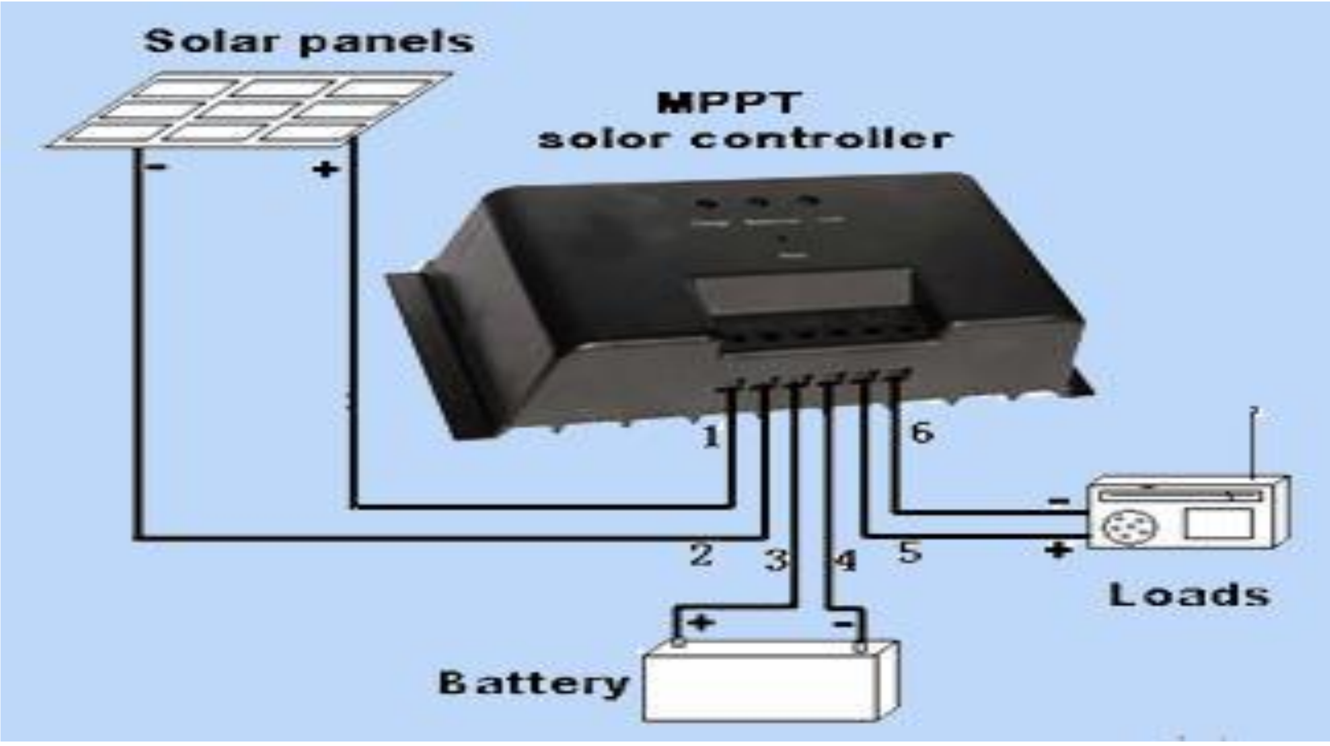

Figure 15: Circuit Diagram MPPT.

4.2.2. Selection of Solar Panels

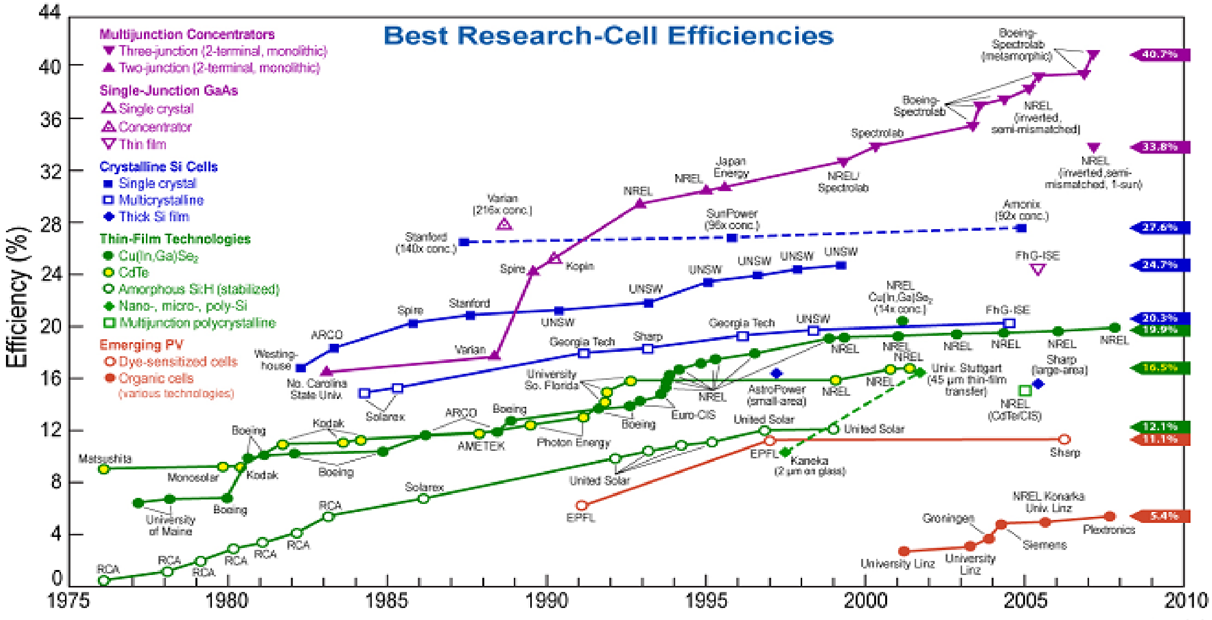

Figure 16: Efficiency of Solar Panels [11].

Solar panels have not technology to fly our airship for 24 hours. Therefore solar panels just will increase to flight time. Increase in efficiency over the years is seen on Figure 16. Our panels features showed at down:

Product Advantages

Bendable up to 20 degrees and it is flexible.

It consists of polycrystalline cells and it is high efficiency panels.

Base surface is aluminum structure.
Panels can easily mounted.

Electrical Features

Efficiency	:%22.5
Power	: 150 Watt
Max. Power Current	: 7,91 A
Max. Power Voltage	: 18, 97 Volt
Open Circuit Voltage	: 8,54 A
Weight	: 4500 g

4.2.3. Selection of Engines

Generally propellers or ducted fan motor in airship operation provide propulsion in horizontal direction. Steerable propulsion is used in making sharp turns and descents. It is varied by changing the direction of rotation of the propeller rotation and thrust is generated in the opposite direction [12].

Time for filling the answer is a command is issued when the reaction is rapid feature. Propeller engines and ducted fan engines can answer in short time such as 1-2 seconds.so, these reasons and because of zeppelin's weight, AXI 5320\06 (Figure 17) named propeller engine selected.

Features of AXI 5320\06

No. of cells	6 Li-Poly
RPM/V	370 RMP/V
Max. efficiency	93%
Max. efficiency current	25 - 55 A (>85%)
No load current / 10 V	1,4 A
Current capacity	78 A/20 s
Internal Resistance	23 mohm
Dimensions (diameter. x lenght)	63x54 mm
Shaft diameter	8 mm
Weight with cables	495 g

[13]

Figure 17: AXI 5320\06 Propeller Engine.

5. CALCULATIONS OF SOLAR ENERGY INTEGRATION

This part is determined to have the volume specified 10.75 cubic meters made design result dirigible remain in the air with a constant speed V time prior to when no solar cell then the airship flight time of the solar cell is calculated for the case of using the solar cell how much increase.

5.1. The Situation That The Solar Panels Not Being Used

Here is battery first before we choose the engine running again before we choose how long airship can fly in the air at a constant speed V is calculated [14]. The selected engine (AXI 5320\06) maximum current drawn, from battery is 15 A. 4 engines used and fitted on the gondola. Engines, where fitting at the airship's sideways provide to pitching motion and flying at V speed level while the front and rear motors to provide the movement of the vertical airship landing. Airship's engine will not used at maximum power. They only used at normal power. So, first engines current drawn approximately is 10 A and other engines current drawn is 3 A. As a result all current drawn is;

10 A+10 A+ 3 A + 3 A = 26 A = 26000 mA.

In this case flight time, which just taking energy from battery is;

41000 / 60 = 433,3333 mAh.

Battery capacity is 1800 mAh;

1800 mAh / 433,333 mAh = 4,1538 mins.

5.2. The Situation That The Solar Panels Being Used

5.2.1 For Using 2 Solar Panels

Firstly we find the battery charging time of solar panels.

All energy that we can earn in a hour from panels is 200 Wh.

We have to unmount system losses to all energy. Because all electrical energy where came from panels, can't store. Some part of power is turning to heat and in the same time solar panels may can't work full output. For this reason to get more realistic result, total power is multiplied by 0.85.

In this case total power;

200W * 0,85 = 170 Wh.

Battery capacity;

3.9 A * 20 V = 78 Wh.

For 3 battery;

78*3 = 234 Wh.

Solar panels charging time of the full battery;

234 Wh / 170 Wh = 1,376 hours = 82,58 minutes.

Just battery can provide 11.25 minute flight time. If airship fly with solar panels system, solar panels charge battery in full flight time (11.25 minutes). In 82,58 minute solar panels can charge full and in 11.25 minutes battery's % 13.6 part can charge.

The increasing flight time with extra electrical power where came from solar panels;

(13,62* 11,25) / 100 = 1,532 minutes = 91,95 seconds.

In this case total flight time;

11,25 + 1,532 = 12,782 minutes.

5.2.2 For Using 1 solar panel

Firstly we find the battery charging time of solar panels.

All energy that we can earn in a hour from panel is 100 Wh.

We have to unmount system losses to all energy. Because all electrical energy where came from panels, can't store. Some part of power is turning to heat and in the same time solar panels may can't work full output. For this reason to get more realistic result, total power is multiplied by 0.85.

In this case total power;

100W * 0,85 = 85 Wh.

Battery capacity;

3.9 A * 20 V = 78 Wh.

For 3 battery;

78*3=234 Wh

Solar panel charging time of the full battery;

234 Wh / 85 Wh = 2,751 hour = 165,06 minutes.

Just battery can provide 11.25 minutes flight time. If airship fly with solar panels system, solar panels charge battery in full flight time (11.25 minutes) .In 165,06 minutes solar panels can charge full and in 11.25 minutes battery's % 6,81 part can charge.

The increasing flight time with extra electrical power where came from solar panels;

(6,81* 11,25) / 100 = 0,7661 minute = 45,96 seconds.

In this case total flight time;

11,25 + 0,7661 = 12,061 minutes.

In the end of the calculations, results showed on Table 3.

Airship's flight time (minute)	
The situation that the solar panels not being used	11,25
The situation that the one solar panel being used	12,061
The situation that the two solar panels being used	12,782

Table 3: Airship Flight Time (minute).

6. CONCLUSIONS

Reconnaissance and observation-purpose solar autonomous airship designed theoretically in this project. Project has finished production but don't begin flight test because of limited budget and time. In the calculations of the airship, it was seen with solar energy can increase flight time. If this project develop, zeppelins will complete their task with more efficient than planes and unmanned aerial aircraft.

Today, unmanned aerial vehicles used in the airborne surveillance system is working on fuel. This means more weight and it limited payloads capacity. Therefore, these systems can't stay long time in air and their risk of failure is higher than zeppelins because of their complex mechanical structure. Also, these systems need to have a certain speed to stay airborne mold so hanging on the same point can't long observation. Besides the results of the use of fuel gases give great damage to the environment and atmosphere.

The main purpose of Reconnaissance and Observation-Purpose Solar Autonomous Airship Design is develop new area in aviation industry where unmanned aerial aircraft inadequate to tasks. In this project attention is drawn to limitless and cost-free solar energy. In the future nonrenewable energy sources will vanish and it will show importance of this project. So, in future there will be many innovations in civil and military aviation.

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