بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
www.aecenar.com

IAP
INSTITUTE FOR ASTROPHYSICS

TEMO
Lebanon
منصات للإتصالات
platforms for communication

TEMO-LEB AIRSHIP REPORT 2017

Initial Document: 18.02.2017

Last update:

Tuesday, November 28, 2017

Editor: Samir Mourad

With Contributions of

Souha Bakri (Aerodynamic Investigation),

Amena Shaker (Actuator System) and

Abdullah Mourad (Prototype Construction)

Content

1 تحليل متطلبات المنظومة (System Requirements Analysis)

1.1 نشر اولي للمشروع في 18.2.2017

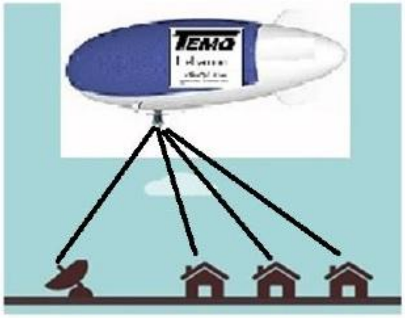
Initial Project (published 18.2.2017, talked to investors)

بسم الله الرحمن الرحيم

TEMO
Lebanon
منصات للإتصالات
platforms for communication

Qalamoun-COM_Mintad 2017

نظام لتوزيع انترنت للقلمون والجوار



كلفة المنظومة (بالون واحد زائد ايليكترونيك التحكم ومنظومة الاتصالات)	90.000$
كلفة التشغيل سنوياً	
كلفة التشغيل (للمراقبة شخص في كل دوام، 3 دوامات = 3 اشخاص)، 1200$ للشخص الواحد شهريا	$36,000
تكاليف تصليح (سنويا)	$14,000
الربح سنوا (مدخول ناقص تكاليف التشغيل والتصليح)	
سعر الانترنت للمستخدم: 20$ في الشهر ، 1000 مستخدم -> المدخول سنويا $240,000	
الربح سنويا $190,000	

1.1.1 حساب التكلفة (Calculation)

The concept is to take a fast internet bundel from OGERO and to distribute it.

من OGERO		عدد المستهلكين الاجمالي	معدل الاستهلاك الشهري [GB]
الرسم الشهري لـ100 GB (ل.ل)		3000	20
LBP 100.000	ADSL More than 8Mbps		
			عدد المستهلكين تسعهم الـpackage من OGERO
			5

بيع الخدمة للمستهلك (ل.ل.)
LBP 30.000

الربح علي الـpackage
LBP 50.000

الربح الاجمالي في الشهر
LBP 30.000.000

الربح السنوي ($)
$240.000

الربح هنا هو الدخل السنوي لمشروع المنطاد

1.1.2 لقاء مع الاستاذ باسل الايوبي، مدير OGERO في 19.2.2017 في مسجد القبيسي

نتيجة:

- الدولة اللبنانية اصبحت لا تعطي رخص لشركات خاصة لبث الانترنت. ولكن عن طريق الجامعة ممكن ان شاء الله.
- ما تفعله google هو ان يكون لديها مناطيد لبث الانترنت من فوق 20 كم وهذا خارج الاجواء الدولة التي تحت هذا المنطاد واصبحت اخواء دولية مثل البحر البعيد عن الشاطيء.

1.2 متطلبات المنظومة(System Requirements)

[Sys 10]

المنطاد يجب ان يكون

أ – في علو 2 كم

ب – في علو 20 كم (اي خارج نطاق اجواء الدولة البنانية)

[Sys 20]

جسم المنطاد مثبت بأضلع

1.3 تصميم وتصنيع المنطاد (TEMOLeb-Mintad/Mechanics)

TEMOLeb-Mintad/Mechanics: Construction and Manufactoring of Airship

Master Thesises

Title	**Keywords, additional information**	**Preferred Faculty/ Student Profile**	**Project**
Conctruction of a solar powered high altitude airship	Mechanics, FEM analysis, airship, photovoltaics	Energetics	TEMOLeb-Mintad
Aerodynamic investigation for high-altitude airship	Aerodynamics analysis, airship	Energetics	TEMOLeb-Mintad
Mechanical constructing and testing of an actuator system for a high-altitude	CAD, actuator system, airship	Energetics	TEMOLeb-Mintad

1.4 ايلكترونيك في المنطاد (TEMOLeb-Mintad/Electronics)

Master Thesises

Title	**Keywords, additional information**	**Preferred Faculty/ Student Profile**	**Project**
Telemetry system for a high-altitude airship	Remote control, automotive control, sensor integration	Electronics/Control	TEMOLeb-Mintad
Satellite based internet communication through a high-altitude platform	Satellite communication, transponder, antenna control	Telecommunication/ Electronics	TEMOLeb-Mintad

2 Basics

2.1 History of airships

In 1782, Joseph Montgolfier and his brother Etienne had the idea of using the smoke of a fire to overcome gravity. They developed the first balloon, called hot air balloon, using warm air to inflate a sphere of paper. They thus realized the first unmanned flight. Shortly afterwards, Pilâtre de Rozier and the Marquis d'Arlandes set up the first flight inhabited by man. However, the balloon remained uncontrollable in front of the winds and the ballooners therefore sought as early as 1784 to control and direct it. Some people tried to use rudders and oars, such as sailors, but without much success. The spherical shape of the balloons was soon called into question, and in the summer of 1784 the first elongated envelope was created. However, the large dimensions of aircraft remain problematic vis-a-vis the winds; the existing engines at the time were not powerful enough to counter the winds. It was thus necessary to wait until 1852 for Henri Giffard to cover a distance of 27 kilometers while controlling his aircraft (***Figure 1:*** *The first steam dirigible, built in 1852 by Henri Giffard.*).

The feat is recognized but it cannot manage to counter the effects of the wind. Despite this unprecedented performance, Henri Gifford's aircraft is not recognized as dirigible, and it was not until 1884 to see the first airship deserve its title.

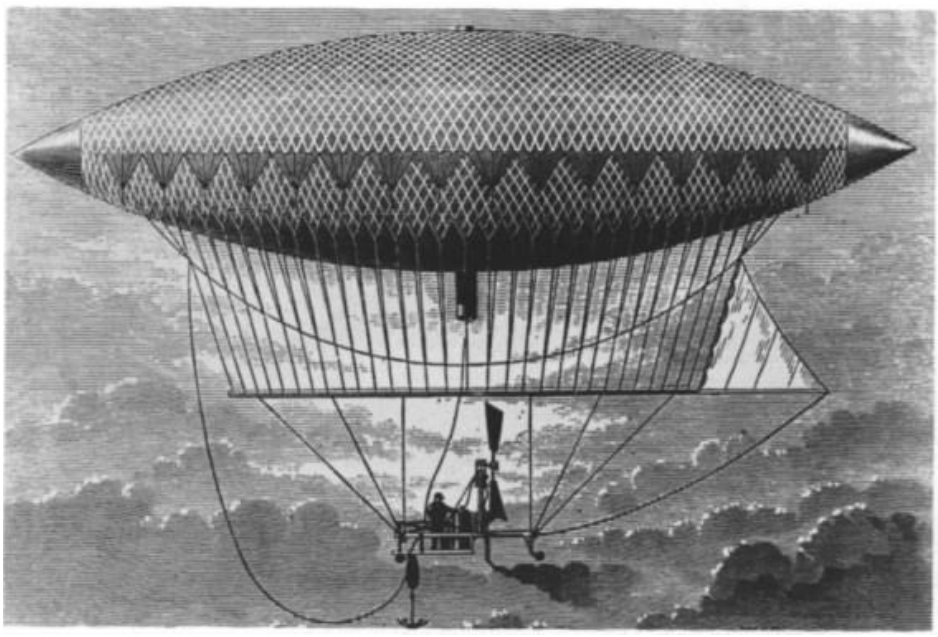


Figure 1: The first steam dirigible, built in 1852 by Henri Giffard.

After the example of Henri Giffard, many aeronauts embarked on the conquest of the perfect maneuverability of the balloons. For example, the engineer Henri Dupuy de Lôme and the Tissandier brothers who, in the years 1871 to 1874, brought many solutions to this problem.

Despite the innovations brought by these aeronauts, it was not until August 9, 1884 to see the realization of Man's dream of tame the winds. Charles Renard and Arthur Krebs carry out on board the "La France" (***Figure 2***: *France - First airship of the world, in Villacoublay in 1885.* aerostat what is considered the first airship flight. They make a 23-minute flight over the forest of Meudon, with the particularity of returning to their point of departure (closed circuit) thus proving the "steerability" of their aircraft.

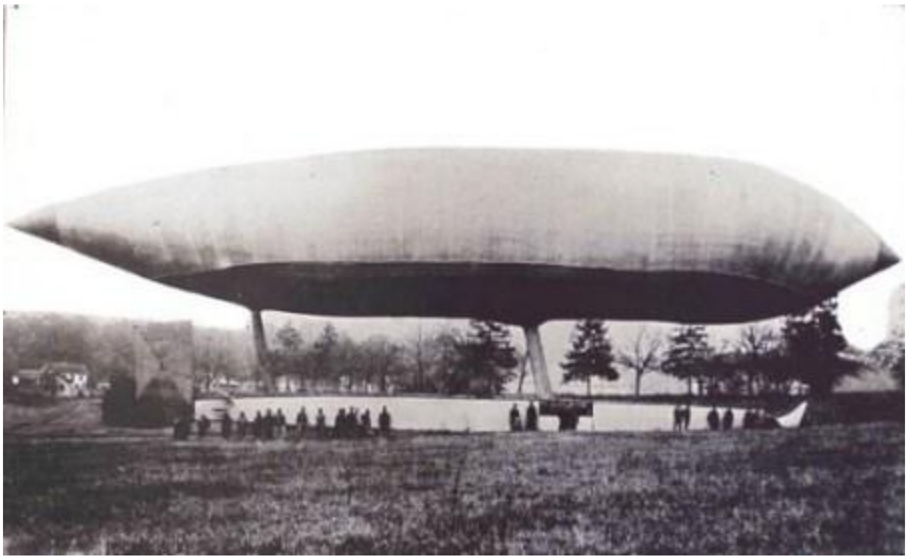


Figure 2: France - First airship of the world, in Villacoublay in 1885.

Beginning in 1898, Santos Dumont, a Brazilian by birth and French by adoption, developed many aircrafts, most of them airships. Several models stand out. From "n ° 6" in 1901, to "la Baladeuse" (***Figure 3***: *Santos Dumont at the controls of his dirigible No. 6: Brasil, October 19, 1901.* from the year 1903 to "No. 6" in 1901.

Figure 3: Santos Dumont at the controls of his dirigible No. 6: Brasil, October 19, 1901.

In the tradition of Santos Dumont, the Lebaudy appeared in 1902 and marked the birth of a new type of dirigibles: the "semi-rigides". The Lebaudy brothers developed a rigid hull on which the nacelle and the propulsion systems are fixed. The envelope, however, remains completely flexible.

On the German side, what became the world's largest airship company was born in 1898: Count Ferdinand Von Zeppelin deposited in 1895 a patent showing the basis of what will be the model of the Zeppelins for nearly a year century and constitutes a real break in the history of the airship: the rigid aluminum dirigible was born.

In parallel to the development of Zeppelin, the world's first airline was founded in 1909. During its five years of service, the DELAG transported some 33,000 passengers, its fleet of airships traveling 170,000 km in just over 3,000 flight hours. During those 1600 flights, no victim was to be deplored.

In 1908, Henry Deutsch de la Meurthe founded Astra and produced two flexible airships. Two years later, Leonardo Torres joins the adventure and created the series of Astra-

Torres "AT", flexible dirigibles having the peculiarity to propose for the first time a so-called "trilobée" envelope. In 1910, the Clément Bayard-II crossed the sleeve for 390 km in 6 hrs at a speed of 65 km/h.

At the announcement of the entry into the war, the European countries requisitioned their respective dirigibles. In France, the airships of companies Zodiac, Astra and Clément Bayard were used for surveillance and bombing.

At the same time, the SPIESS (***Figure 4****: The Spiess, first and only rigid dirigible of French construction.*, developed in 1913 by the company Zodiac and Joseph Spiess, was produced in the Paris suburbs. It is the first and for the moment unique rigid dirigible of French construction. It is also the largest, with its 140m long and has the distinction of being composed of wooden beams.

The role of small, flexible dirigibles in maritime surveillance and anti-submarine struggle, particularly within the French and English navies, can also be mentioned.

On the German side, three companies built a large number of dirigibles: Zeppelin built nearly 67 rigid dirigibles, Parseval constructed about twenty flexible dirigibles and Schütte-Lanz also produced about 20 rigid wooden dirigibles.

During this short period, there were many developments, both in design and production and in the exploitation of airships. These intense innovations led to a race to record.

Figure 4: The Spiess, first and only rigid dirigible of French construction.

At the end of the First World War, the technologies developed made it possible to establish new standards; the interest of airships has been demonstrated and new perspectives were emerging. Each country now wanted to own the largest, and most powerful airship in support of its supremacy. Major programs were emerging:

As early as 1918, the United Kingdom began to conquer the air with its "R" series. In 1919, the R34 thus ensured the first air crossing of the Atlantic in less than 8 days of flight.

In France, the Dixmude (former Zeppelin LZ114) was ceded to the army as a war damage in 1920 but crashed in 1923.

In Italy, Umberto Nobile developed the Norge, a semi-rigid airship of 106 meters in length and departed with Amundsen to conquer the North Pole (***Figure 5**: The Norge conquered the North Pole in 1926.* in 1926, reached it and flied over it on 12 May 1926. Two years later, Nobile returned towards the North Pole on the Italia dirigible, slightly longer than the Norge, but crashed on the way back. Nobile and some men survived for almost 7 weeks on the pack ice before being rescued.

Figure 5: The Norge conquered the North Pole in 1926.

In the United States, the United States, together with Zeppelin, developed several very large dirigibles, such as the first American rigid ZR-1 Shenandoah, which took off in 1923, the ZR-3 Los Angeles (1924) sisterships "USS Akron (1931-1933), and USS Macon (1933) (***Figure 6**: One of the two largest US airships: the USS Macon, in 1935.* . These last two airships were the largest and most powerful American airships, true aircraft carriers flying, carrying up to 5 Sparrowhawk fighter jettisons and recoverable in flight.

Figure 6: One of the two largest US airships: the USS Macon, in 1935.

In Germany, Count Ferdinand Von Zeppelin, relayed by Dr. Eckener, still developed new airships, increasingly bigger and more efficient. Let us note the magnificent Graf Zeppelin I (LZ127) which, with its 236 meters in length, crossed the Atlantic more than 150 times from 1928 to 1940 and signed a round the world in 12 days.

The dirigibles thus dominated the heavens. This impressive aircraft became an industrial flagship, military or even a means of propaganda in some countries. It became media and famous; a real communication tool. Unfortunately, a series of accidents permanently damaged the image of the airship.

It is indeed impossible to speak of the Zeppelins without mentioning the well-known LZ129-Hindenburg, the largest of the dirigibles (245m long) which enjoyed a short career between March 1936 and May 6, 1937, crushed upon its arrival in the US, causing the death of 35 people among the 97 on board.

Although highly publicized and considered the most serious airship accident, it is not the most deadly. Nevertheless, this crash marks the spirits durably.

Indeed, like any development of an innovative product, that of the airship has not escaped a period of maturity which has resulted in a wave of accidents and more or less serious incidents. Thus, in 1920 alone, the USS-Roma crashed, causing the death of 34 people. That of Diksmuide causes the death of 52 people. Finally the one of the R38 bore 44 families. Then, on October 1, 1929, the British rigid dirigible R101 crashed in France near Beauvais causing the death of 48 people including the British Minister of Transport. This accident marks the end of British rigid dirigibles.

On the American side, the crash of the USS Akron in 1931, causing the death of 73 people, marks the spirits and that of the Hindenburg, the largest of the airships and true flagship of the German firm Zeppelin (***Figure 7:*** *One of the largest German airships: the Graf Zeppelin I.*, definitely signs the stop of the developments of the great dirigibles.

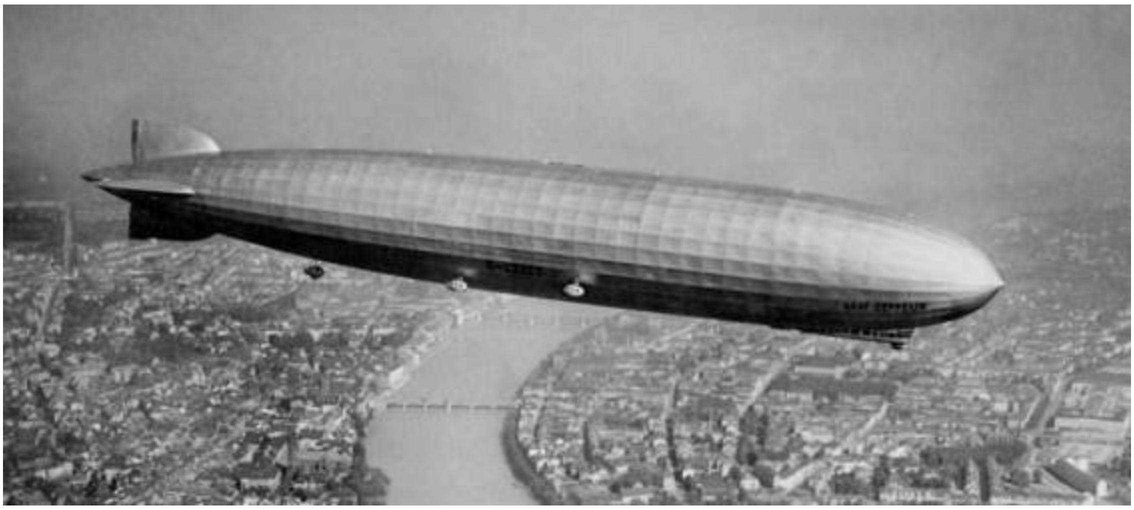


Figure 7: One of the largest German airships: the Graf Zeppelin I.

This series of accidents, however, is not the only cause of the decline of the dirigibles. Indeed, the development of new aircraft, such as planes, helicopters, rockets and even space conquest gradually concentrate all efforts, budgets and fantasies.

Thus, during the Second World War, airships were gradually abandoned to the profits of planes, faster and more discreet, even though small, captive, flexible airships were used to protect the battalions during landings.

Nevertheless, the US Navy continues to develop airships in large quantities to constitute an armada of patrollers-escorts for Navy ships. These dirigibles are flexible, of relatively small size, but are produced in very large quantities.

After the Second World War, priority was not given to spending on the development of new aircraft. In addition, aircraft played a key role in the fall of the Nazi regime. The dirigibles, considered too dangerous and without real commercial or military interest, are gradually abandoned.

We note, however, the development of the American firm Goodyear, which continued to innovate and produce flexible airships: in 1954, the ZPG-2W beats the record of endurance of a flight with 11 days and more than 15,000 km on the meter. In 1958, Goodyear built the largest flexible airship (129m long!). Note that Goodyear still exists today and has just relaunched the historical collaboration that links it to Zeppelin by taking possession of the latest version of the Zeppelin NT (ZLT-101).

However, the return of airships from the 1960s remained very limited, and limited to flexible dirigibles, the aircraft then presenting no real economic interest.

Beginning in the 2000s, the airship regained favorable winds; with many projects coming to light all over the world. The renaissance of Zeppelin, with its NT07 "New Technology" (***Figure 8:*** *The Zeppelin "New Technology", in flight for a decade.* produced in 5 copies for civil applications of tourism and scientific missions, and of which a new version has just been certified and delivered to Goodyear.

Figure 8: The Zeppelin "New Technology", in flight for a decade.

At the same time, the year 2000 marked the arrival of a new market, that of heavy hauliers, like the gigantic German CargoLifter project, abandoned in 2005, for technical reasons. On the American side, the DARPA-funded Multi-intelligence Vehicle Long-Endurance Multi-Vehicle project has created several projects: Northrop Grumman and Hybrid Air Vehicles have teamed up to develop the Airlander, prototype made its first flight in 2012 and is expected to return soon; Aeroscraft produced and stolen its Pelican, which is now dismantled for lack of funds; and Lockheed Martin developed the P-791, a capability demonstrator, whose development now allows him to embark on a new, civilian, heavy-duty 20T load carrying program, the LMH-1.

However, no heavy-lift carrier project has yet taken off for the time being.

We will further develop the current projects in a forthcoming article devoted entirely to today's airships.

Finally, the airship enjoyed a period of splendor following a rapid development, setting it up as a true pioneer of the aeronautical world. The economic reality, the lack of technological maturity and the appearance of the heaviest air, however, have gradually erased the blimp of the collective imagination. Like its history, the airship enjoys a controversial notoriety, between fear and dreams. Today, this mythical aircraft is a great absentee of the very varied aviation sector, and it is a shame. [1]: http://www.portail-aviation.com/2015/07/dossier-dirigeable-episode-1-lhistoire-des-dirigeables-pionniers-de-laeronautique.html

2.2 Evolution of airship

Since the past ages, the high ambition of human promotes him to fly. The science of aviation has developed gradually.

2.2.1 Hot air balloons

The first attempt was based on heating of the air without a motor. The balloon consisted of the envelope, a burner and the gondola.

Figure 9: First ever of hot air balloon

The hot air balloons adopted two principles to work:

- **The principle of cold and of hot air**

The air is composed of the invisible particles: "molecules". When the air is cold, the molecules approach together and take a small volume comparing to the case of hot air where the molecules move away from each other and the volume is larger.

For this reason, the mass of hot air is lighter than cold air. When the molecules of air contained in the envelope is heated, the air in the balloon becomes lighter than the air in the atmosphere, allowing the balloon to lift.

In order to descend the balloon, the air in the envelope must be cooled and it is also possible to open the valve located at the top of the balloon. In this way, the cold air replaces the hot, and the mass of interior air increases. Consequently, the balloon can descent. [1]

- **Principle of Archimedes**

When a body is immersed in a fluid (gas or liquid), it is held up by a force equal to the weight of the displaced fluid.

In order to lift an airship, the bouncy force must be larger than the weight of the displaced air.

Figure 10: Hot air balloons

The manufacturing of hot air balloon has developed and the design of his envelope, his burner and his gondola work out big success.

- **Development of envelope**

By time, the fabrication methods used to produce balloons have changed. The aim was to achieve the following characteristics:

- Flexibility
- Resistance
- Tightness: It is necessary to achieve this characteristic because the gas lighter than air as helium has small molecules which can leak out of the balloon. So to be able to undergo long flights, the balloon cover needs a very good seal.

a. "Baudruche"(Type of tissue)

The "Baudruche" is a membrane made from the intestine of beef and mutton. This tissue is very light and waterproof but it has low durability and high cost.

b. Cotton or Silk

Cotton or silk can provide the mechanical strength. They coated with rubber or vanish to ensure the tightness.

c. Polyamide(Nylon) and Polyester

The polyamide (Nylon) and Polyester have used a lot in this days because they have a light weight and good resistance. They are coated with polyurethane or silicone for protection to the ultraviolet rays. [2]

- **Development of burner**

The burner is the engine of the hot air balloons. It heats and propels the air in the envelope and contributes to lift the balloon.

In the first time, the damp straw and wood were used as fuel in the burner. After that, the coal and the oil derivatives were used.

The current balloons used the propane in the burner. In the basket, many cylinders contain propane. It is highly compressed in canisters and it is entered into the burner in liquid form.

When the burner is started up, the flame burns, the propane heats and transforms from a liquid to a gas. The gas makes for a more powerful flame and an overall more efficient fuel consumption. [3]

- **Development of gondola**

Originally, the gondola or the basket was made of "Wicker" (material was used at the time especially to make baskets).

Since that time, the materials have evolved. "Rattan" is also a material which used after, his advantage is more solid and less susceptible to external elements but that is heavier than "Wicker".

Both of materials still used, they have more advantages: solidity, lightness and flexibility. [2]

The modern materials used to made baskets are from "Kooboo" and "Palambang" cane. There are many characteristics: sturdy, flexible and relativity light weight. The cane is very strong even more than aluminum or some composite plastics. [2]

2.2.2 Dirigible or Airship

The dirigible is newer than hot air balloon. It contains gas which is lighter than air, this gas is used instead of hot air. Three types of airship existed and they developed gradually:

1. Non-rigid airship(blimp):

It is composed of ballonets, rudders (for directions), elevator flaps, gondola and a small engine.

Figure 11: Blimp (Non rigid airship)

This type developed and had an amelioration, it is named:

2. Semi-rigid airship:

The improvement of this dirigible: instead of the ballonets, it used gas bags, and it used big engine and a keel.

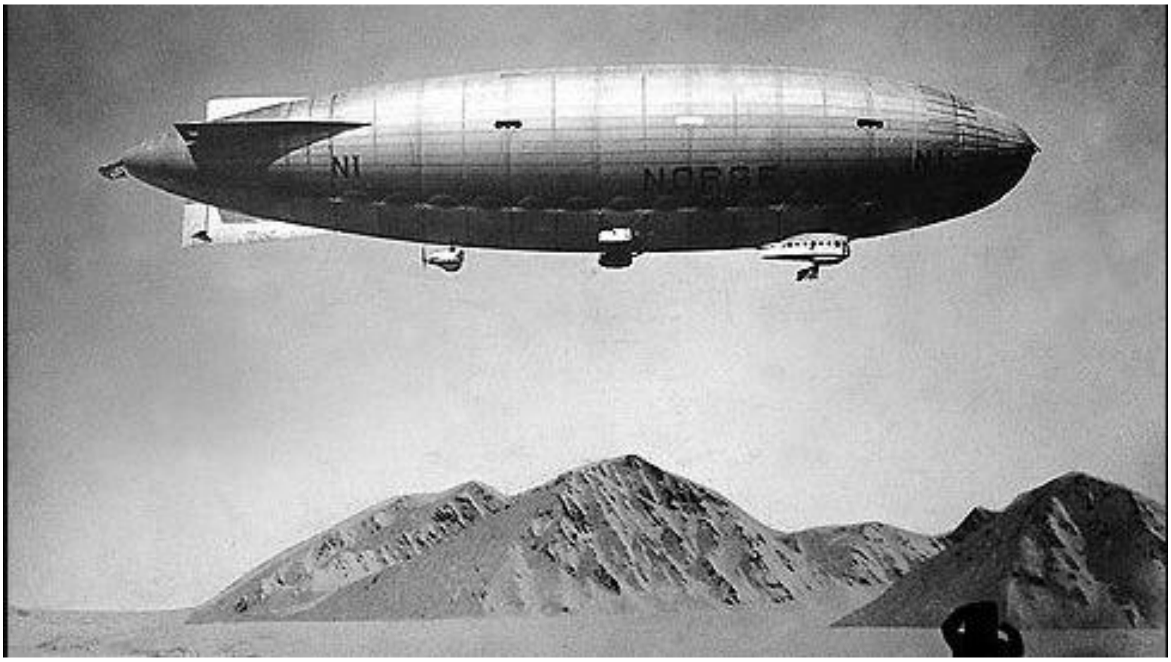


Figure 12: Semi-rigid airship

3. Rigid airship: More than the previous type, it had a rigid structure.

Figure 13: The Graf Zeppelin LZ-127 the most successful rigid airship

2.3 Evolution of the airship industry

In 1784, Jean-Baptiste Meusnier suggested a design for an airship of ellipsoid form. This design consisted from: rudder, elevator and three large aircrews without lightweight powerful engine.

In 1852, Henri Giffard succeeded to apply steam-engine technology to airships. With a single propeller driven by a three horsepower engine, his airship flew 17 miles. [4]

In 1872, Paul Haenlein was powered an aircraft by an internal combustion engine, the first attempt was used such an engine to power an airship. [5]

In 1900, the Zeppelin airships became the most famous dirigible. During World War I, the Germany army was used some of these airships as bombers.

In 1920s and 1930s, the United States and the Britain also were made airships, mostly imitating the original Zeppelin design. [5]

2.4 The end of airship

Series of accidents were happened and ended the golden age of airship. In particularly, the Hindenburg disaster at Lakehurst, New Jersey, 6 May 1937.The burn of this airship named" LZ 129 Hindenburg" was filled hydrogen ,killing 36 persons and becoming the most well-known and widely remembered airships disasters of all time. The public's confidence in capacities of airships was shattered.

The development and application of airplanes has declined also the use of airships. The century of airship finished and start new future of aircraft. [6]

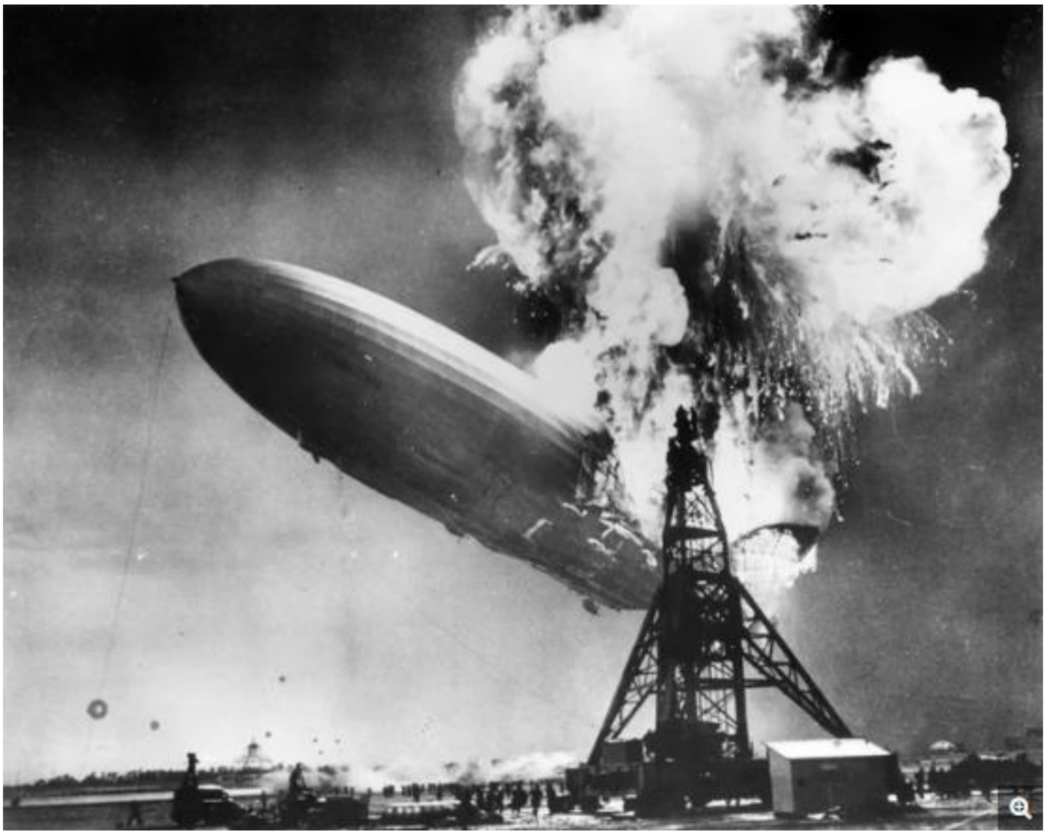


Figure 14: The Hindenburg disaster

2.5 Return of airship

After a pause of about hundred years, the airship returned to life at the end of the twentieth century. Thus the hobby of the airship has aroused the curiosity of many, and has opened up new horizons for this invention to move from sport to a means that allows man to leave the Earth and seek other uses, especially in the science field, such as surveillance and telecommunication.

If we have a traffic jam, we can use the airship as a solution to detect the main point of traffic, using the new technology people receive messages to avoid the busy roads. Consequently, people save their time.

In the far forests, if we have fire or natural disasters, we can use the airship to detect these actions as a satellite.

Also, the airships can used for tourism, they are very attractive means for transport.

Our study concerns to create a design of a rigid airship, its application will be in the field of telecommunications. Indeed, the problem of internet weakness and its high price will be solved by such a project whose objective is to distribute Internet in the far regions without having to install a complete network. Hence the objective of this thesis is to design a rigid airship which can reach a high altitude. To appropriate this design, we need to do a study of aerostatic of airship, to draw the design on "FreeCAD" and to study the all parts of this dirigible.

2.6 Archimedes principle

The main source of lift in an airship is the bouncy force or the static lift. The bouncy force is based on Archimedes principle: if a body is immersed in a fluid, in this case the fluid is the air, it experiences a force proportional to the volume of the displaced air in the opposite direction of its weight. When the density of the gas contained in the airship is less than the air, that force is substantial.

2.7 Types of airships

2.7.1 Non-rigid Airship

The non-rigid airship named also "blimp" maintains his shape and his structural integrity using higher internal pressure from its lifting gases. [4]

When the airship ascends, the lifting gas expands and when it descends, the lifting gas contracts. Then, the envelope would lose shape and become unmanageable. That is happening because this type of airship doesn't contain a framework.

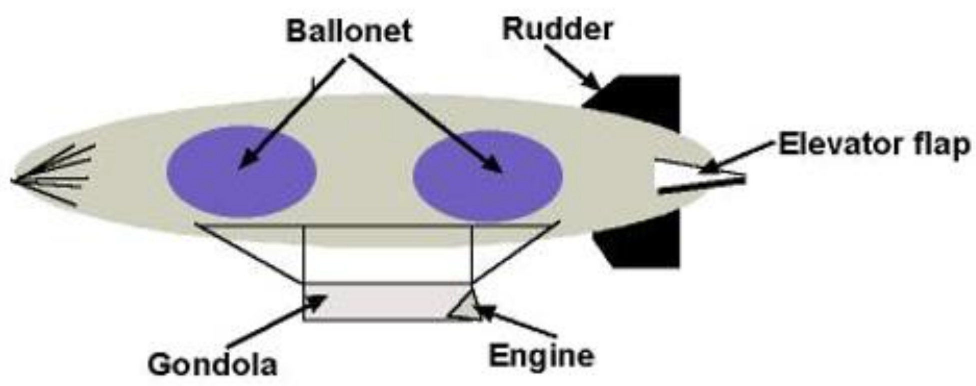


Figure 15: Parts of non-rigid airship

Figure 16: Blimp during filling gas

The development of aeronautic science was emerged a new type of airship:

2.7.2 Semi-rigid airship

Semi-rigid airships are similar to blimps in that they have no internal frame to support their envelopes. They do have, however, rigid objects on them that give them some backbone. A stiff keel runs along the length of the airship for distributing weight and attaching fins and engines. The keel also provides structural integrity during flight maneuvering. Similar to non-rigid airships, the shape of the hull is maintained largely by an overpressure of the lifting gas. Light framework at the nose and the tail may also contribute to the hull's outer shape. [4]

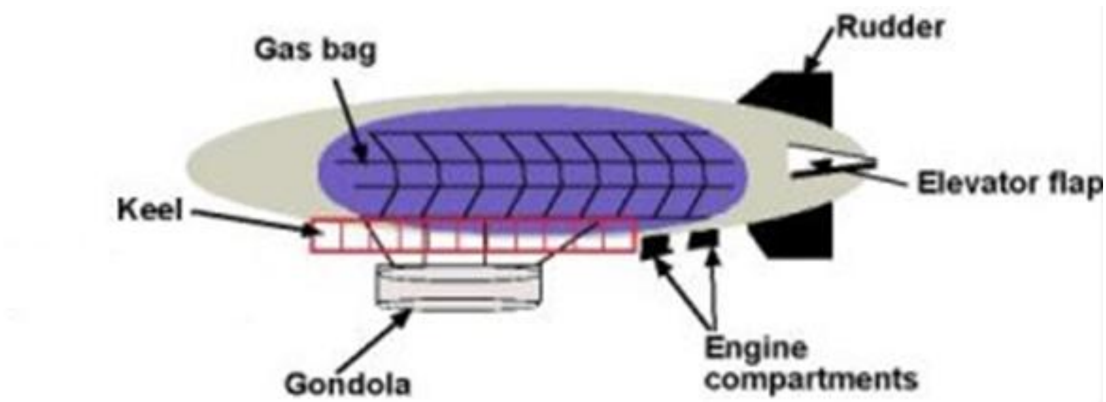


Figure 17: Parts of semi rigid airship

2.7.3 Rigid Airship

Semi-rigid and non-rigid airships maintain their shapes by the internal pressure of lifting gases. But rigid airship is different, it has an internal structure framework which it gives their shape form. It has an outer envelope to recover the framework.

Rigid airships have be built by a size larger than semi-rigid and non-rigid airships because there are no possibility of kinking in the hull due from aerodynamic forces and moments. Multiple gas bags containing the lifting gases are filled inside the internal framework of dirigible.

Splitting the gas in multiple bags instead using a single large bag is more safety and minimizes to happening a catastrophe. [4]

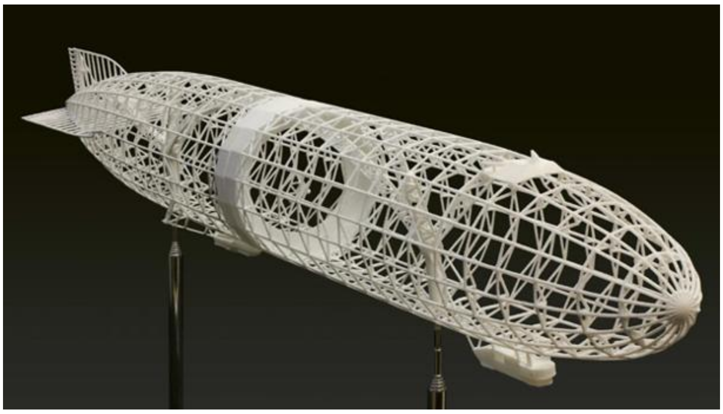


Figure 18: The internal framework of rigid airship

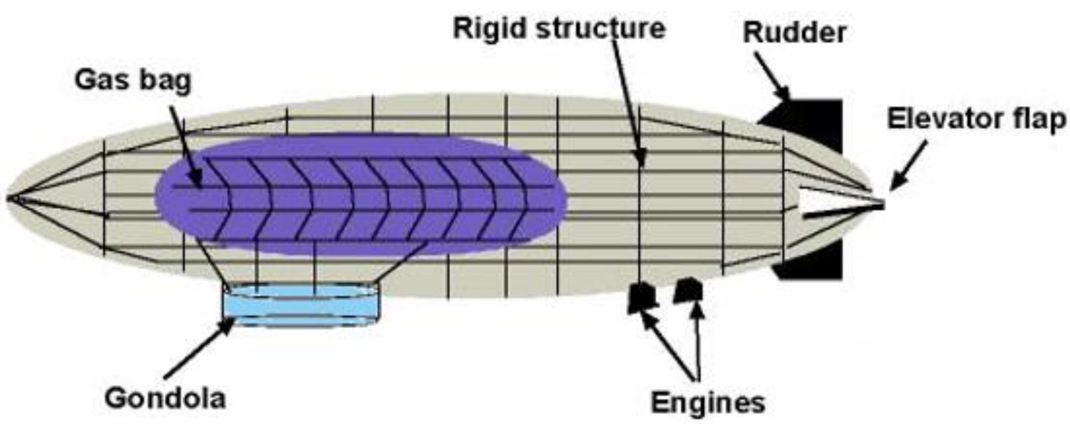


Figure 19: Parts of rigid airship

2.8 How do rigid airship work?

In order to rigid airships get off the ground, fly and descend, different gases are used by rigid airships. Today, to rise the lighter-than-air craft, the helium gas is used instead to hydrogen. Helium is more expensive than hydrogen, but it was adopted because it has more properties. It is inflammable contrary the hydrogen which causes the infamous Hindenburg accident.

The airships, filled by Helium, load ballonets (tanks of air). When the pilot opens the valves of air, a positive bouncy is created, and consequently the dirigible elevates because air is heavier than helium.

The pilot controls the airship in flight by rudders and elevators, when it becomes in the sky, like a submarine under water. The rudders are used to steer the airship and the elevators are used to ascend and descend and throttling the engine to angle it into the wind. The engine provides forward and reserve thrust.

The air pressure outside the lighter-than-air craft deceases, at higher altitudes, consequently the helium in the gasbags expands. The pilot pumps air into ballonets in order to maintain pressure.

To descend the airship, this technique is also employed, the ballonets are filled by air. The air is heavier than Helium. That is created a negatively buoyant and therefore sinks lower in the sky or bring it in to land. [7]

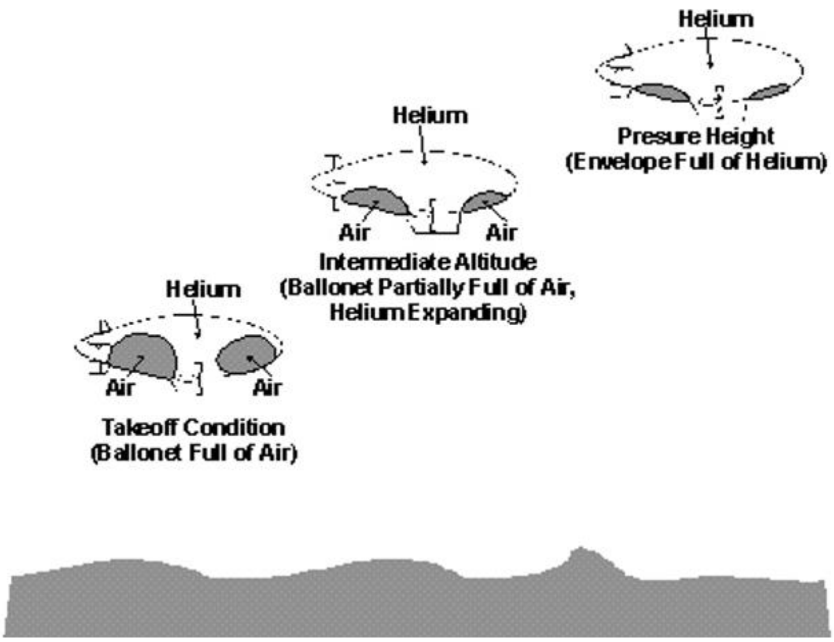


Figure 20: Airship principle of operation

2.9 Why do we use Helium not Hydrogen?

The performance of Helium in airship is better than hydrogen. In order to inflate an airship, the use of Helium instead of hydrogen reduces the cruising range from 30 to 40 % and reduces the total lift from 10 to 15 %. This is a disadvantage for Helium but it be can justified. Helium has absolute safety against the risks of fire that is expected with hydrogen. In the United States, Helium finds in large quantities. It is very expensive, but the price is significantly lowered, because the quantities of production have increased.

- Characteristics of hydrogen and Helium:
- Hydrogen
  - Lightest element in the earth
  - Inexpensively
  - Easily to obtain
  - Flammable. For this disadvantage, it is unacceptable for manned airship operations.
- Helium
  - Scarce
  - Expensive
  - Non-flammable. This advantage makes it the only practical lifting gas for manned airship operations. [8]

2.10 Control of airships

The Control of the airship differs from the aircraft's one. It can be divided into two categories. While the control of airplanes is performed by one pilot; in airships two pilots are utilized, one for direction, one for altitude.

Both pilots must recognize the flight pattern of each and constantly alert each other to mutual assistance; to give an effective performance. The pilot should organize the route to meet the needs of the situation. There are too many coordination cases, but capable pilots have little difficulty in achieving the expected results.

Directional: as indicated in the previous paragraph, the pilot is responsible for monitoring the course of the airship in a horizontal plane. On flights throughout the country, his problem is solved with regard to the course required by the mission of the dirigible. Once the course is established, the dirigible will hold its own. But when it is affected by external powers such as gusts, the rudder must work in the opposite direction to overcome it. While flying in a very stormy air, it is impossible to prevent lace, but a good pilot can prevent the amplitude of oscillations from exceeding a few degrees. Then, as the storms also strike on both sides, the average direction of the dirigible will be the desired direction.
It is essential that the pilot has a clear conception of the reaction to control the rudder of the airship at the turn. When you need to move to the right, for example, the rudder is placed to the right. Immediate effect of this rotation is to produce a force to the left acting on the right side of the rudder. This force to the left has a dual effect. In the first place, it gives a moment around the center of gravity inclined to turn the nose to the right. In the second place, it moves the whole airship to the left. When the airship moves to the left, and the nose turns to the right, both motions combine to make the air fall to the left of the envelope and to turn the nose still further to the right.
Once this has been done during a period, the pressure on the left side of the nose becomes equal to that on the right side of the rudder and the resulting total pressure is zero, but as the force is applied to the front, there is a moment of rotation that tends to continue twisting to the right.
As the motion goes further, the force on the left side of the envelope becomes larger than the force on the right side of the rudder, and there is a gravitational force to the right of the skill to begin to scroll to the right. If you leave the rudder hard or if it is rotated to neutral, this turning to the right will continue, to check the cycle, it is necessary to put the rudder on the left side of the envelope.
The shift radius is controlled by instantaneous damping on the envelope, which is more important for the rate of high-speed propagation than those with a low ratio. This should be one of the main concerns of the driver whenever he controls a new type of airship to identify himself with his turn circle. Otherwise, he may try to maneuver when the space limit is insufficient.

The first effect on the rudder mode on the right is to move the airship slightly to the left so that if the airship was stolen near the right side of the wall or any other obstruction, it would not be wise to put the rudder On the right to move to the right and away from the obstacle because the immediate action for such work would be to pay the airship in the wall.

Sometimes, when flying through foggy weather, an obstacle will suddenly loom up in front of the airship. So the pilot must first put the rudder to disperse the nose of the airship and then completely reverse the rudder in order to miss the obstacle. [2]

2.11 What's an actuator?

The actuator is a component of the device responsible for the transmission or control of a mechanism or system, for example by running (opening or closing) a valve; in simple terms, it is an "engine".

The control signal and the source of energy are required for the operator (Figure1) principal of work of actuator.).Relatively, it is a low power same as electrical voltage, or pneumatic or hydraulic push, or maybe human force. The principal source of power furnished can be electrical current, hydraulic liquid press, or aerial compression. After receiving the control signal, a mechanical movement appear from the operator by converting her energy. [1]: http://www.portail-aviation.com/2015/07/dossier-dirigeable-episode-1-lhistoire-des-dirigeables-pionniers-de-laeronautique.html

[2]:https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/airship_aerodynamics.pdf

[3]: https://en.wikipedia.org/wiki/Actuator

Actuators are usually consumed by factories or industrial usage and can be utilized in devices like engines, pumps, switches and vans.

This motion can be in almost any form, such as blocking, clamping or output. Actuators are usually used in manufacturing or industrial applications and can be used in devices such as motors, pumps, switches and valves. [[4]: https://www.quora.com/What-is-an-actuator

A simple scheme (***Figure 21:*** *principal of work of actuator.*[4]: https://www.quora.com/What-is-an-actuator can explain the principal of work of actuator:

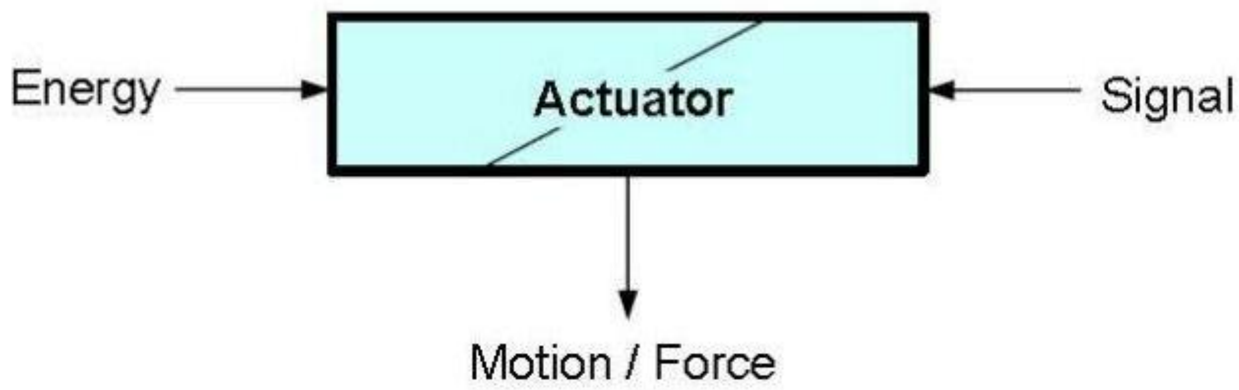


Figure 21: principal of work of actuator.[4]: *https://www.quora.com/What-is-an-actuator*

2.12 Types of actuators

Many types of actuators for controlling motion such as speed control, torque or positional accuracy exist:

- **Air Motors (pneumatic)**
- **Hydraulic Motors**
- **Clutch/Brake**
- **Stepper Motors**
- **AC Induction Motors**
- **Servomotors** [5]: http://www.baldor.com/Shared/manuals/1205-394.pdf

2.12.1 Air Motors

A pneumatic engine is a kind of mechanical motor that use pressed air to make motion. His principal based on transforming pressed air power into mechanical action either over straight or rotary movement. Many kinds (***Figure 22****: axial piston, radial piston, and rotary vane air motors.* [7]:http://www.bluetools.com/Air-Tools-Motors/c88_50/index.htmlof air engine exists like axial piston, radial piston or rotary vane motor. A diaphragm or piston motor, can create the linear motion while the rotary motion is provided by a type air engine, air piston engine, and wind turbine or gear type motor.

The manufacture of hand tools are using this motor vastly and successfully, also it was utilized in a constant area of industrial usages. Continuous efforts are being made to develop their apply in the transport industry.[6]: https://en.wikipedia.org/wiki/Pneumatic_motor

Figure 22: axial piston, radial piston, and rotary vane air motors. [7]:*http://www.bluetools.com/Air-Tools-Motors/c88_50/index.html*

2.12.2 Clutch/Brake:

Electromagnetic clutch or brake (***Figure 23:*** *electromagnetic clutch/brakes.*[9]: http://www.warnerelectric.com acts electrically but it transfer the torque mechanically. Defined by a device coupling a rotating shaft and a load. The separation of the pregnancy leads to stopping the movement of the shaft.[8]: http://www.machinedesign.com/archive/basics-electromagnetic-clutches-and-brakes

Figure 23: electromagnetic clutch/brakes.[9]*: http://www.warnerelectric.com*

2.12.3 Stepping Motors:

Stepper motors existing in a variety shape and size (***Figure 24:*** *variety shape of stepper motor.* [10]: https://learn.adafruit.com/all-about-stepper-motors/what-is-a-stepper-motorare a special type of DC motors that move in discrete steps. It consist of many coils arranged into groups called "phases". Activate each stage in sequence, the engine will spin, one step at a time. The principal of this electromechanical device is to converts one digital pulse into a specific rotational movement or displacement.[10]: https://learn.adafruit.com/all-about-stepper-motors/what-is-a-stepper-motor

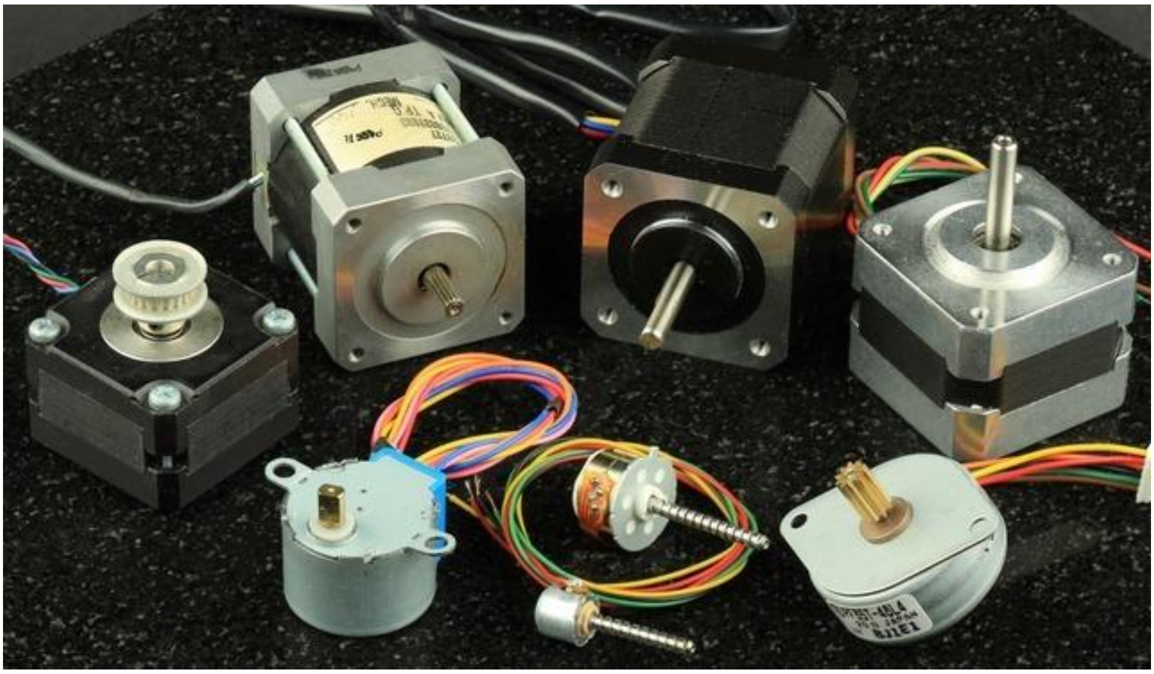


Figure 24: variety shape of stepper motor. [10]: *https://learn.adafruit.com/all-about-stepper-motors/what-is-a-stepper-motor*

2.12.4 AC Induction Motors

The AC induction motor is the electric engine in which the electric current in the rotor is needed for the production of torque obtained by the electromagnetic induction of the magnetic domain of the static coil. The induction motor can be made accordingly without electrical connections to the rotor.

This kind of engine widely utilized for constant speed requirements. Three-phase induction motors (**Fehler! Verweisquelle konnte nicht gefunden werden.** are vastly utilized in industrial drives because they are rugged, reliable and economical. Single-phase induction motors are widely used for small loads, such as household appliances like fans.[11]: https://en.wikipedia.org/wiki/Induction_motor

Figure 25: three phase AC motor. *Fehler! Verweisquelle konnte nicht gefunden werden.*

2.12.5 Hydraulic motors:

Hydraulic motor principal based on pressurized oil. A mechanical actuator that converts hydraulic pressure and flow into torque and angular displacement (rotation). Higher pressure results in higher torque (i.e. brute force).

winches and crane drives, wheel motors for military vehicles, self-driven cranes, excavators, conveyor and feeder drives, mixer and agitator drives, roll mills, drum drives for digesters, trommels and kilns, shredders for cars, tires, cable and general garbage, drilling rigs, trench cutters, high-powered lawn trimmers, and plastic injection machines utilize hydraulic motor presently.

We count many kinds of hydraulics like gear motor, vane motor, and axial piston motor (**Fehler! Verweisquelle konnte nicht gefunden werden.** … [13]: https://en.wikipedia.org/wiki/Hydraulic_motor

Figure 26: Axial piston hydraulic motor. [9]: *http://www.warnerelectric.com*

[10]: https://learn.adafruit.com/all-about-stepper-motors/what-is-a-stepper-motor

[11]: https://en.wikipedia.org/wiki/Induction_motor

[12]: http://electronicsforu.com/buyers-guides/selecting-electric-motor-drive-system

[13]: https://en.wikipedia.org/wiki/Hydraulic_motor

[14]: http://www.directindustry.com/prod/hydro-leduc/product-7677-1287099.html

2.12.6 Servomotors

Servo motor is a standalone electric device with feedback, which can push or rotate parts of a machine with great accuracy. It can rotate an object at certain specific angles or distance. It is made only from a simple engine that operates through a servo mechanism. Servo motor can be DC or AC powered. In a small and light weight packages we can find a very high torque servo motor (**Fehler! Verweisquelle konnte nicht gefunden werden.**.Because of these features they are used to control movement in a variety of electromechanical industries, such as robots, CNC, toy cars, and in space. [15]: https://circuitdigest.com/article/servo-motor-basics

Figure 27: generic high torque servo.[16]*: https://www.sparkfun.com/products/11965*

2.13 Technology comparisons

Our study was based on two important types that can be used in aerospace. Hydraulic and servo motor.

The effectivness of electro-hydraulic motor surround aerospace industry usage. As indicated in (***Figure 28****: comparison between electro-hydraulic; electro-mechanical; and electro-pneumatic actuator.* **;** the performance of electro-hydraulic actuator is higher than electro-mechanical and electro pneumatic. That's because electro-hydraulic systems have been designed and sophisticated to achieve every manifested mission. [17]: https://www.iei.liu.se/flumes/tmhp51/filearchive/coursematerial/1.105708/HydServoSystems_part1.pdf

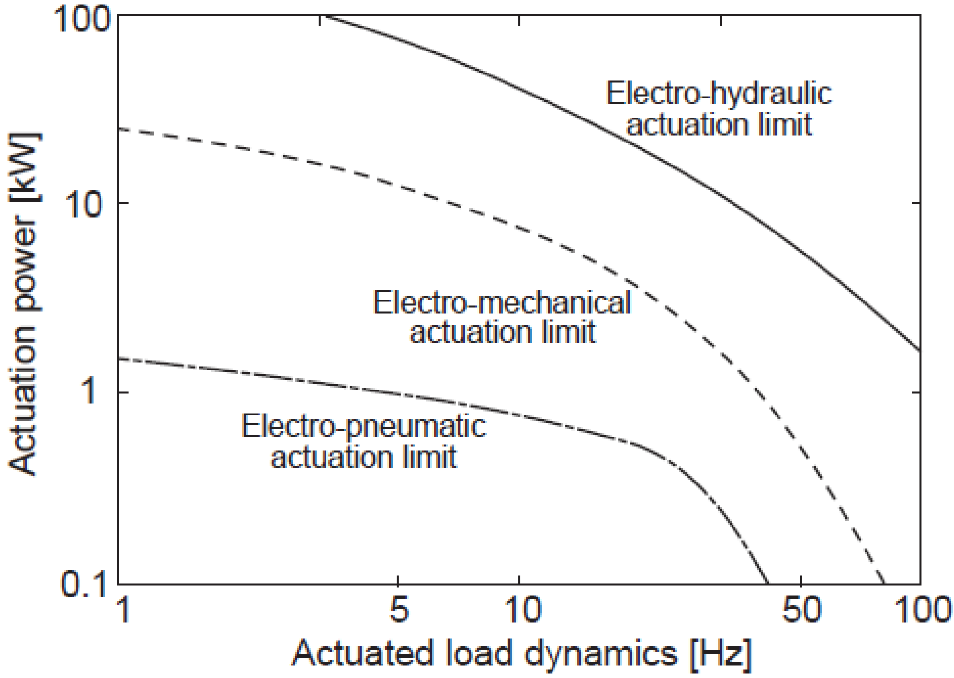


Figure 28: comparison between electro-hydraulic; electro-mechanical; and electro-pneumatic actuator. [17]: *https://www.iei.liu.se/flumes/tmhp51/filearchive/coursematerial/1.105708/HydServoSystems_part1.pdf*

2.14 First actuator chosen: hydraulic actuator

2.14.1 Applications of Hydraulic Motors

Operation of wing trailing edge flaps and leading edge slats are the most common application of hydraulic motors in aerospace vehicles. In these applications, a hydraulic motor push the flutter or slice via a torque tube that work over the trailing edge or leading edge. Gearboxes (90 degree, bevel and offset gear arrangements) connect the torque tube along the trailing edge or leading edge. Other applications for hydraulic motors are folding wing control, cargo doors and ramps and landing gear. Motors are ordinarily high speed with low torque that are geared down to provide a lower speed and higher torque.

This is why we decided to use it in the airship to control its direction, especially since the outer shape of the airship is very similar to aircraft's one. **Fehler! Verweisquelle konnte nicht gefunden werden.**

2.14.2 Types of hydraulic motors

We distinguish three kinds of hydraulic engines that are presently utilized; gear, vane and piston motors—with a variety of styles available among them. In addition, several other varieties exist that are less commonly used, gerotor or gerolor are including (orbital or roller star) motors.

Hydraulic motors can be either fixed- or variable-displacement, and work uni-directionally or bi-directionally. While a constant input flow is provided, Fixed-displacement motors drive a load at a constant speed. Variable-displacement engines can offer varying flow rates by changing the displacement. Fixed-displacement motors provide constant torque; variable-displacement designs provide variable torque and speed.

The three different kinds of engines have different characteristics. Gear motors work best at medium pressures and flows, and are usually the lowest cost. Medium pressure ratings and high flows, with a mid-range cost Vane motors, were offered on the other hand. At the most expensive end, piston motors offer the highest flow, pressure and efficiency ratings. In the following; a detailed explanation about the three common types already cited.

2.14.2.1 Gear motor

Gear engines(***Figure 29**: external gear motor.* focus on two gears, one being the driven gear—which is joined to the output shaft—and the idler gear. Their work is simple: High-pressure oil is ported into one side of the gears, where it flows around the gears and housing, to the outlet port and pressed out of the motor. Meshing of the gears is a bi-product of high-pressure inlet flow acting on the gear teeth. What actually prevents fluid from leaking from the low pressure (outlet) side to high pressure (inlet) side is the pressure differential. With gear motors, you must be concerned with leakage from the inlet to outlet, which decrease engine capacity and fabricate temperature as well.

In addition to their low cost, gear engines do not drop out as fast or simply as other methods, because the gears wear down the covering and bushings before a tragic deficiency can happen.

Figure 29: external gear motor. [19]: *www.mobilehydraulictips.com/hydraulic-motors/*

2.14.2.2 Vane Motor

Vanes motor (***Figure 30:*** *vane motor*. slide in and out, run by the eccentric bore at the medium-pressure and cost range. The movement of the compressed fluid makes an unbalanced force, which in turn forces the rotor to turn in one direction.

Figure 30: vane motor. [19]*: www.mobilehydraulictips.com/hydraulic-motors/*

2.14.2.3 Piston type motor

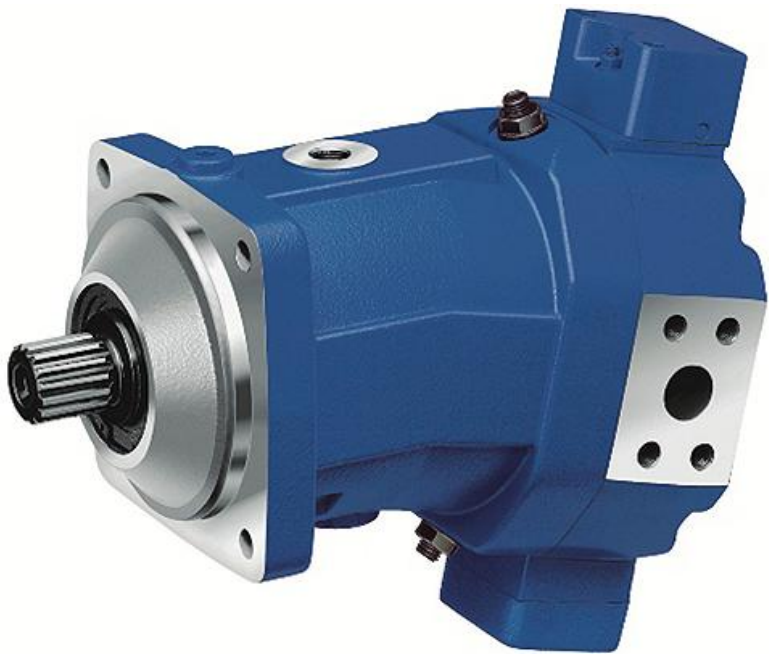


Figure 31: Variable, axial piston motor, with the bent-axis design. [19]*: www.mobilehydraulictips.com/hydraulic-motors/*

Many sorts of piston motor exists such as including radial (***Figure 32:*** *Radial piston motor.*), axial (***Figure 31****: Variable, axial piston motor, with the bent-axis design.* , and others. In the first type; pistons are characterized by its perpendicular configuration to the crankshaft's axis.when the latter enter in rotation motion; pressuriezed fluid makes pistons in a lineary action. The second type; is characterized by his number of pistons coordinated in an orbicular modelinside a cover; which in rotation around its axis by a shaft that is in line with the pumping pistons. We identify two designs of axial piston motors ; swashplate and bent axis types. In Swashplate designs the pistons and drive shaft are arranged in parallel. In the next one , the pistons are sloped to the main drive shaft.

Among the lower models used two designs, roller star motors is characterized by a low friction, high efficiency and high start-up torque than gyrator designs. They also provide, low-speed operation and offer longer life with less wear on the rollers. Running and present extended life through low endurance on the pulleys. Gyrators furnish continued fluid-tight sealing over their soft operation. [19]: www.mobilehydraulictips.com/hydraulic-motors/

Figure 32: Radial piston motor. [19]*: www.mobilehydraulictips.com/hydraulic-motors/*

2.14.3 Details about axial piston hydraulic motor:

A pivotal piston engine is like to an axial piston pump and is the most functional common engine frequently utilized in aerospace, consequent to high power to weight ratio. A schematic of an axial piston engine is shown in Figure 8. As can be seen in the figure, the axial piston pump is similar to a piston pump, excluding that the swashplate (plateau oscillant) corner is presently constant (i.e., there is no compensator and control piston). The entry part of the engine is the high pressure side and the way out is low pressure. The push distinction causes the pump to rotate. Since the swashplate is constant, quickness of this engine is controlled by either controlling entry pressure (Δp across the motor) or the flow rate. Also, such as pumps, hydraulic engines resort to own 9 pistons, or probably 7 (more pistons raise extraction and for this reason increase output torque). Piston motors extend the top sealing for high input pressures and work best in high torque, low speed purposes. They have the best sealing and will be the most effective. An axial piston engine with a constant swashplate is unidirectional (rotate in 1 direction only). To be bi-directional, the swashplate would require to be changeable status. Finally, piston motors will own a case drain line to allow piston drain to spout to return. [20]:

2.14.4 Motor Installation Considerations:

The most important parameters for the installation of any motor are listed below.

Dimensions – global dimensions for the motor are intended to establish the desired setup volume.

Interfaces – interfaces contain piping connections and places on the motor, as well as assembly handle and output shaft site.

Weight – weight of the motor, which is commonly provided as a dried weight. When full of with fluid, weight will be higher.

Noise – Motors turn on at high velocity and produce racket. A specialization for extreme noise level should be considered for motor installations.

Attachments – way of connexion of the motor to the airframe affects constructional stiffness of the motor and also noise transition into the airframe.

Motor/Shaft Alignment – put the motor and shaft on one line; needs to hold to tight tolerances. Considerations are tolerance stickups, relative motion between motor and shaft, possible angular displacements on installations, spline teeth dimensions, etc. incorrect alignment can cause exaggerated vibration (leading to premature failure), or failure of the motor seals.

Splines – Usually some grease is applied to the splines to reduce wear. Selection of lubrication should include temperature, corrosion inhibiting and acceptable life of the grease before collapse take place.

Torque Requirements – we should consider start-up and running torque.First one is higher than second. Start-up torque accelerates the mass of the motor and load, leading to temporary high stresses within the mounting hardware and motor.Obviously, the speed of the motor must match the manufacturer's recommended speed for actuation device. A gear arrangement may be used, if in demand.

Axial and Radial Shaft Load Capability – Be sure that the motor shaft and splines are designed specifically to sustain to the loads that motor will confront during its all life. Inlet and outlet fittings must be matched to the motor.

Direction of Rotation – We distinguish two types of motors about direction: uni-directional or bi-directional. So a bi-directional pump is to be used in aerospace application. Clearly, the control valve position must be matched to the suit direction of rotation. [21]:

2.15 Second actuator chosen: servo actuator

2.15.1 Reason for choose of servo actuator:

Servomotors are not so old; they can therefore be integrated into various applications. Despite their small dimensions; they offer a hard rap and a very good energy yield. With these specifications; their uses extend into the field of toy automobiles; robots, radio control aircraft; as well as in industry such as robotics; pharmacy; etc. [22]: http://www.jameco.com/jameco/workshop/howitworks/how-servo-motors-work.html

They are also used in powerful heavy sailing boats. The servos are rated for speed and torque. Although these motors exist in different sizes but their patterns are similar. These small motors are extremely powerful compared to their size; and their feed for a load is suitable. For this; generally a servo loaded by a small element is a well valued energy. [23]

So that all we came to mention leads to replace the hydraulics with the servo because "it has some characteristics of the aircraft and some other of robots. Also, the lightness of its weight and strength that is good, in addition to the light exchange of energy make it overcome the hydraulic and replace it in this Type of applications.

2.15.2 General information about servo:

A servomotor is a type of motor that incorporates in the same housing the mechanics (DC motor) and the simplified control electronics, generally servo-controlled in position with a limit of 180 degree angle travel, but also available in continuous rotation .

Its advantage is the ease of control by an external digital signal and the high gearing that the gears integrated in its housing allow.

these motors are usually used to move pieces (sails, capstans, drifts, control surfaces, flaps) of models, boats or planes, and are recognizable thanks to their standardized box, rectangular and black.

They are therefore used as actuators or for the motorization of small robots, possibly by modifying their mechanics so that they rotate continuously, thus eliminating the servo-control in position. [24]: http://www.pobot.org/+-servomoteur-+.html?lang=fr

Usually; servo motors comes with arms (metals or plastic) that is connected to the object required to move (see figure below to the right).

Servo have 3 wires:

Black wire: GND (ground); RED wire: +5v; Colored wire: control signal (***Figure 33:*** *scheme for the three wire of servo.*).

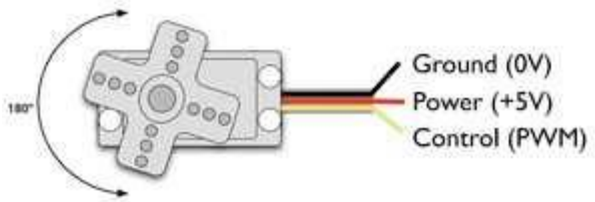


Figure 33: scheme for the three wire of servo. [25]*: https://www.scribd.com/document/99583469/Introduction-to-Servo-Motors-Arduino*

The third pin accepts the control signal which is a pulse-width modulation (PWM) signal. It can be easily produced by all micro- controllers and an Arduino board. This accepts the signal from your controller that tells it what angle to turn to. The control signal is fairly simple compared to that of a stepper motor. It is just a pulse of varying lengths. The length of the pulse corresponds to the angle the motor turns to.

The pulse width sent to servo ranges as follows:

Minimum: 1 millisecond ---> Corresponds to 0 rotation angle.

Maximum: 2 millisecond ---> Corresponds to 180 rotation angle.

Any length of pulse in between will rotate the servo shaft to its corresponding angle. For example, 1.5 ms pulse corresponds to rotation angle of 90 degree (***Figure 34:*** *scheme explaining the pulse width and its corresponding angle.*).

This is will explained in figure below. [25]: https://www.scribd.com/document/99583469/Introduction-to-Servo-Motors-Arduino

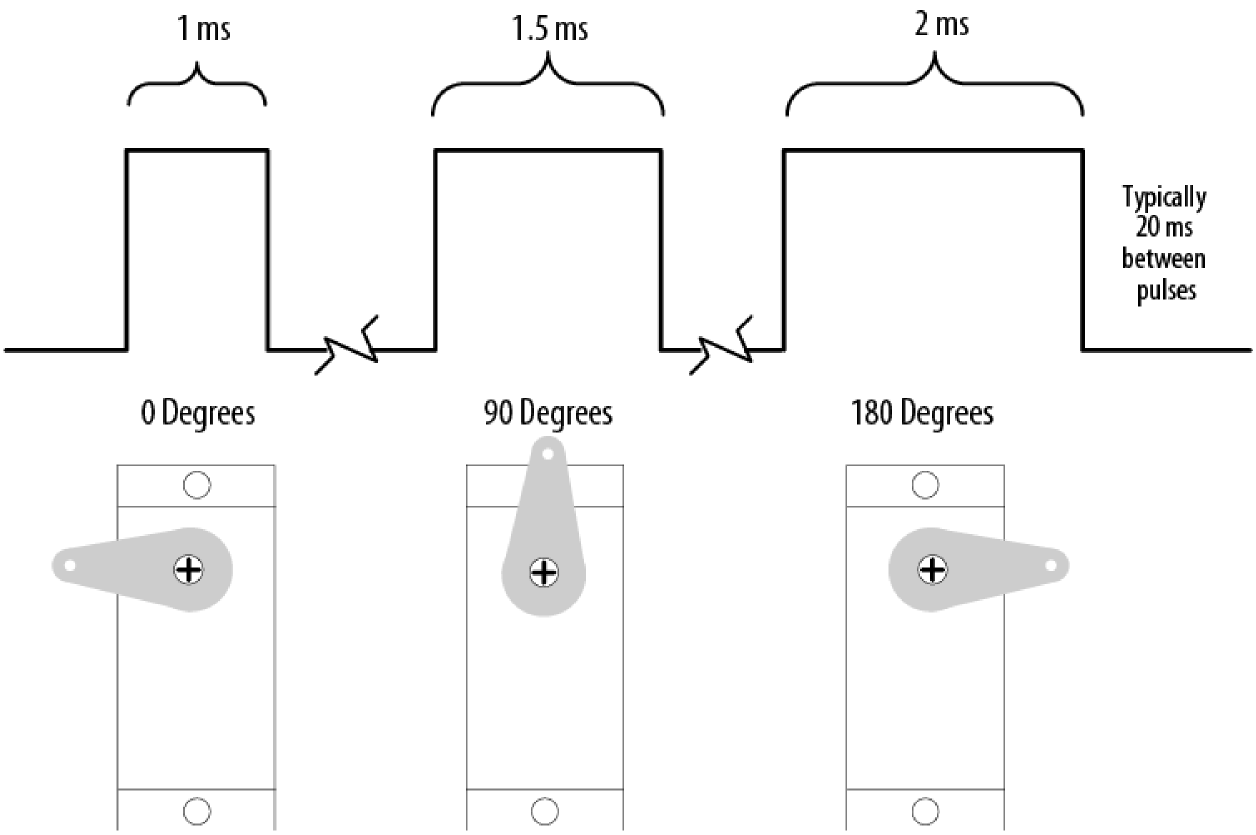


Figure 34: scheme explaining the pulse width and its corresponding angle. [25]: *https://www.scribd.com/document/99583469/Introduction-to-Servo-Motors-Arduino*

2.15.3 Types of servo motors

There are three Main Types of servo motors which are:

Positional Rotation Servo: (***Figure 35:*** *positional rotation servo.*

This variety rotates within a 180° range. It's not designed to turn beyond its preset limits. Useful for limited-range applications like moving levers or steering linkages.

Figure 35: positional rotation servo. [26]:

Continuous Rotation Servo: (*__Figure 36:__ continuous rotation servo.*

While levers are often used on standard servos, wheels and gears become more useful with this style, which can turn in any direction independently and continuously.

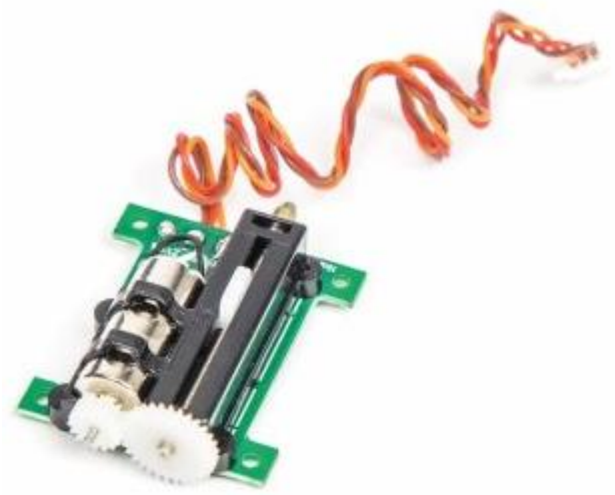


Figure 36: continuous rotation servo. [26]:

Linear Servo: **Fehler! Verweisquelle konnte nicht gefunden werden.**(*__Figure 37:__ Spectrum Mini servo linear servo Gear box material.*

This type offers more gears than the positional rotation servo, but is otherwise very similar. It uses a rack and pinion mechanism to change the output back and forth instead of circularly. This servo is rare, but can be found in larger hobby planes and robots. [26]:

Figure 37: Spectrum Mini servo linear servo Gear box material. [26].

3 Aerodynamic investigation of a high altitude airship

In this chapter, we speak of the aerostatic of airships which is based on the bouncy force. We also talk about the variation of the density, the pressure and the temperature as a function of the altitude. This variation is plotting on the "MATLAB" software. Then, we study the influence of these parameters on the airship.

In this chapter too, we suggested a design of "TEMO-Leb airship" draws on "FreeCAD" (FreeCAD is a software similar to AutoCAD, but it is more complicated and needs more time to do drawing by comparing the AutoCAD. Despite this disadvantage, we obtain the same quality.)

In this chapter, the necessary calculation is made to determine whether the "TEMO-Leb airship" is able to reach the desired altitude. We talk about the problems that confront us and prevents us from applying this theoretical study.

Next, we propose a new conception which has considered as a solution. This design which has a new dimensions, will rise to a lower altitude. It calls "Low altitude test TEMO-Leb Airship". We expect its implementation.

3.1 Aerostatic of airship

To define the buoyant lift capability and to determine the maximum attainable altitude by the airship, it is necessary to calculate the volume of the hull.

Depending on aerostatic principles, we obtain some relations between mass, volume and gas densities.

3.1.1 Bouncy force

The bouncy force (F) generated by an airship is equal to the weight of the displaced air subtracting the weight of the lifting gas (Helium). Noting the volume of displaced air is equal to the volume occupied by the helium.

$$F=V_N*(\rho_{A0}-\rho_{He0})*g \qquad \text{Eq.1}$$

V_N: The net volume of displaced air.

ρ_{A0}: The density of air at sea level.

ρ_{He0}: The density of Helium at sea level.

g: The acceleration of gravity.

The amount of lift available to counteract the weight of the airship structure and payload is represented by the bouncy force F.

3.1.2 The relation between altitude and density

The density varies with altitude. The relation is inversely proportional: when the altitude increases, in opposition, the density decreases.

The conventional state of atmosphere is defined by equations of International Standard Atmosphere (ISA). The equation below is suitable until an altitude of 11 000 m:

$$\rho_H/\rho_0 = [1-(H/44\,300)]^{4.256} \qquad \text{Eq.2} \quad [9]$$

ρ_H : Density of the air as a function of altitude (kg/m^3).

ρ_0 : Density of the air as a function of altitude (kg/m^3) at sea level, ρ_0=1.205 kg/m^3.

H: Altitude (m).

MATLAB is used plotting the variation of density as a function of altitude using Eq.2. This program allows matrix manipulation, plotting of data and functions, creation of user interfaces, implementation of algorithms and interfacing with programs written in others languages, including **"C"** , **"C++"** , **"Fortran"** , **"Java"** and **"Python".**

- ✓ Writing the code in **"MATLAB":**

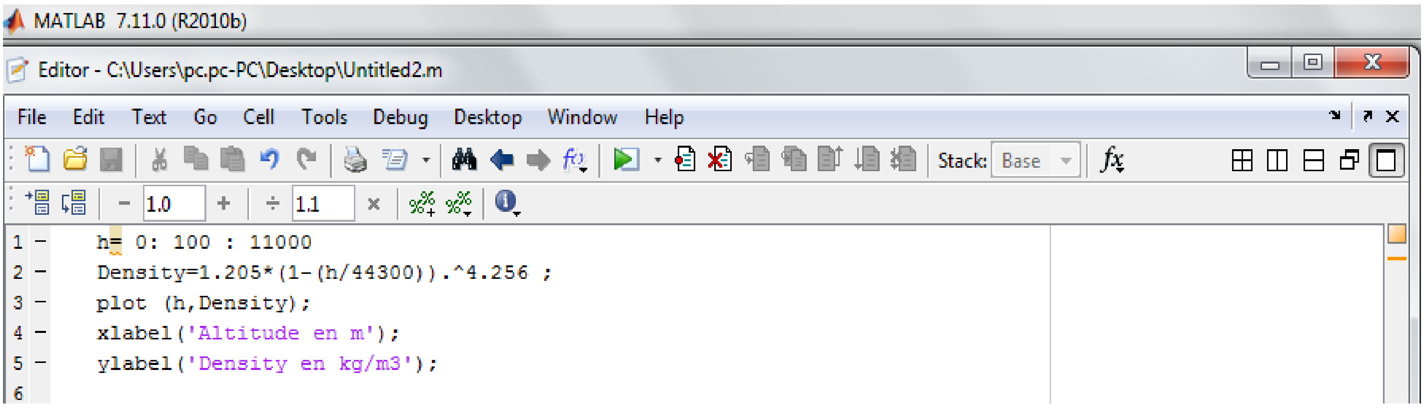


Figure 38: code of Eq.2 in MATLAB

Results and plotting of this function is shown in the next chapter.

3.1.3 The relation between altitude and pressure

The atmospheric pressure decreases rapidly with the altitude. The conventional state of atmosphere is defined by equations of International Standard Atmosphere (ISA). The equation below is available till altitude of 11 000 m:

$$P/P_0 = [1-(H/44\,300)]^{5.256} \qquad \text{Eq.3} \quad [9]$$

P : Pressure of the air as a function of altitude (Pa).

P_0 : Pressure of the air as a function of altitude (Pa) at sea level, P_0=101 325 Pa.

H: Altitude (m).

MATLAB is used for plotting the variation of pressure as a function of altitude using the equation "Eq.3".

✓ Writing the code in **"MATLAB":**

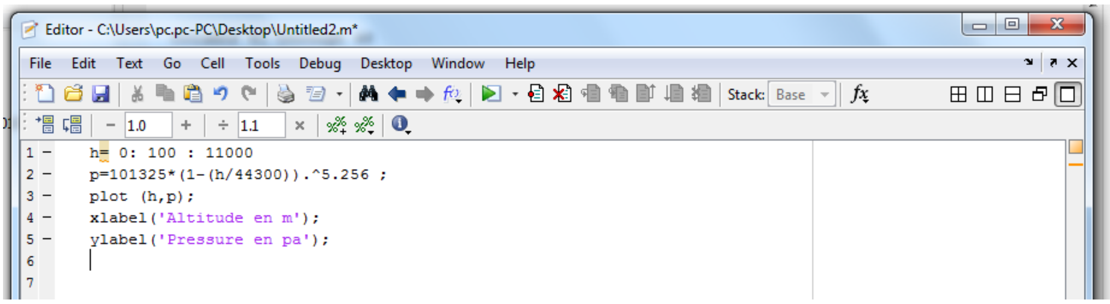


Figure 39: code of Eq.3 in MATLAB

Results and plotting of this function in the next chapter.

3.1.4 The relation between altitude and temperature

The temperature decreases with the altitude. The conventional state of atmosphere is defined by equations of International Standard Atmosphere (ISA). The equation below is available till altitude of 11 000 m:

$$T_H = T_0 - 0.0065*H \qquad \text{Eq.4} \qquad [9]$$

T_H : Temperature as a function of altitude (°c).

T_0 : Temperature as a function of altitude (°c) at sea level, T_0=15°c.

H: Altitude (m).

MATLAB is used for plotting the variation of pressure as a function of altitude using the equation "Eq.4".

✓ Writing the code in **"MATLAB":**

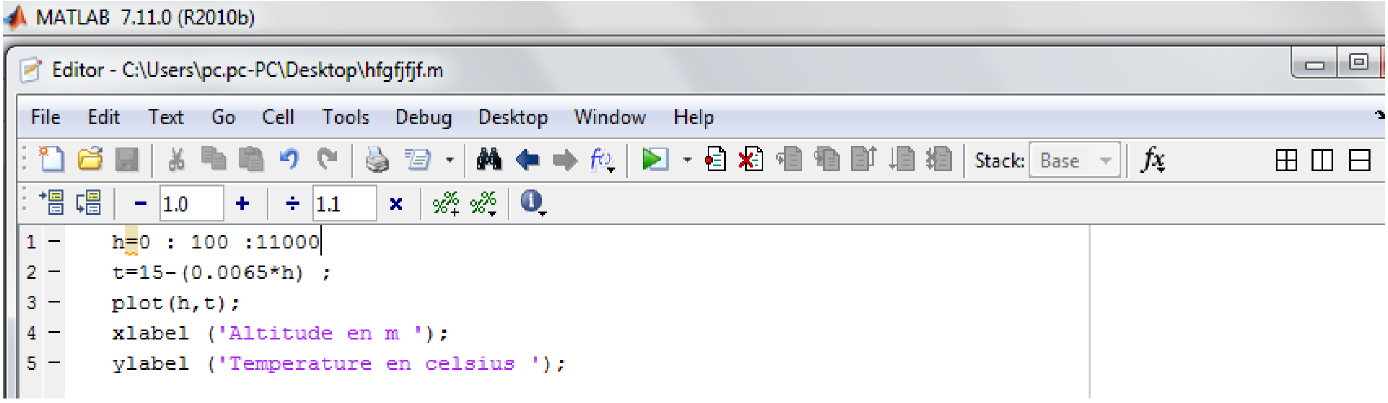


Figure 40: code of Eq.4 in MATLAB

The results and plotting of this function in the next chapter.

3.1.5 Pressure Altitude

It is necessary to define the term **"Pressure Altitude"**. At this point, the net volume is maximum "Vmax" and no further expansion of the lifting gas volume is possible.

3.1.6 Influence of pressure, temperature, density and volume on the airship during its rise

a) Under "Pressure Altitude"

Supposing both gases, air and Helium have the same temperature and pressure, but their densities change with altitude.

A slight pressure differential is necessary, but this difference is very small. For the purposes of this analysis, it is considered null.

When the airship rises, the density of Helium decreases along with the atmospheric density. We know the relationship between density, mass and volume:

$$\rho = m/V \qquad \text{Eq.5}$$

Therefore, since the mass of the Helium remains fixed, the volume V_N must increase. In order to regulate the internal pressure, two ballonets contain air are located inside the hull which expand and contract. By this way, the variation in internal lifting gas volume is achieved.

At the sea level, assume that is the airship's launch altitude, the value of density is maximum. Also, the volume of ballonets expand to maximum while the net volume is minimum.

When the airship begins to rise, the ambient density and pressure both decrease, and air is automatically ejected from the ballonets to match the falling pressure.

At a given point, the ballonets must be empty completely. At this point, the volume of the lifting gas can't expand. The value of the net volume now is maximum "V_{max}".

By summarizing, under the point **"Pressure Altitude"**, we have:

- The differential of pressure between lifting gas and atmosphere is null: ΔP=0.
- The differential of temperature between lifting gas and atmosphere is null: ΔT=0.
- The density of lifting gas and atmosphere decrease, this variation affects an increase of net volume. The equation Eq.5 is available up to the **"Pressure Altitude"**.

b) Above "Pressure Altitude"

When the airship continue to rise, the density of lifting gas and atmosphere also continue to decrease, but the volume of lifting gas remains constant.

The differential of pressure now isn't null, it starts to increase. An overpressure is created, and consequently the differential of pressure will increase so a rupture will be exist in the exterior structure of airship. The equation Eq.5 becomes unavailable.

3.1.7 Sizing the airship hull

To reach the Equilibrium, the bouncy force must be equal the weight of the airship structure (framework, external fabric and gasbags) and payload (propeller, control system…).

The weight is equal:

$$P= (m_s+m_p)*g \qquad \text{Eq.6}$$

P: The weight of the structure and payload (N/Kg).

m_s: The mass of structure (kg).

m_p: The mass of payload (kg).

g: The acceleration of gravity (N/Kg).

When the airship rise, up to the pressure altitude, the net lift remains constant, because the atmospheric density changes at the same rate as the density of the lifting gas.

The density ratio is equal to:

$$\sigma=\rho_A/\rho_{A0}= \rho_{He}/\rho_{He0} \qquad \text{Eq.7}$$

σ: The density ratio.

ρ_A: The atmospheric density at a given altitude.

ρ_{A0}: The atmospheric density at the sea level.

ρ_{He}: The density of Helium at a given altitude.

ρ_{He0}: The density of Helium at the sea level.

At a given altitude, the Eq.1 will be:

$$F=V_N * \sigma * (\rho_{A0}-\rho_{He0}) * g \quad \text{Eq.8}$$

At the equilibrium and the point **"Pressure Altitude"** ($V_N=V_{max}$), we have:

$$\text{Eq.6} = \text{Eq.8}$$

$$(m_s+m_p)*g= V_{max} * \sigma * (\rho_{A0}-\rho_{He0}) * g$$

$$V_{max}= (m_s+m_p)/ \sigma * (\rho_{A0}-\rho_{He0}) \quad \text{Eq.9}$$

The equation "Eq.9" gives us the maximum volume of the airship hull which is needed to rise the airship. This volume is based upon the ratio of the density which is varied with altitude, mass of the structure and payload.

The mass of structure includes the mass of the gasbags, the mass of the airship framework and the mass of the envelope or the external skin.

3.2 TEMO-Leb Airship

In this project, we suggest an airship called "**TEMO-Leb Airship"**. This airship will distribute Internet between Turkish and Lebanon, at altitude 7 km.

The new idea in this project is that the size of "**TEMO-Leb Airship"** is smaller than other airships which take off at a high altitude.

The "**TEMO-Leb Airship"** dimensions: it length equal to twenty meters and a diameter equal to four meters.

A theoretical study is needed to calculate the volume required for "**TEMO-Leb Airship"** to reach an altitude of 7 km.

a) First, it is important to calculate the volume of the airship based on the proposed dimensions.
b) Secondly, it must be calculate V_{max}.
c) Thirdly, it must be investigated whether this airship is available to reach the altitude 7 km with these dimensions. This is discussed in the next chapter.

To get V_{max}, it is necessary to calculate the mass of structure includes the mass of framework, the mass of external fabric and the mass of the gasbags. It must be know the mass of payload.

Step a) is described in section 3.2.1. Step b) is described in section 3.2.2.

The airship is like an ellipse, so the volume is equal to:

$$V_{TEMOLeb\ Airship} = 4/3*\pi*(L/2)*(D/2)\ \hat{}2$$

$V_{TEMOLeb\ Airship}$: The volume of the airship (m^3).

L: The length of the airship (m).

D: The diameter of the airship (m).

$$V_{TEMOLeb\ Airship} = 4/3*\pi*(20/2)*(4/2)\ \hat{}2 = 167.55\ m^3.$$

We draw this airship having this dimensions using a free 3D modeling software named **"FreeCAD".** This program is oriented towards product design and mechanical engineering. It also targets towards architecture or other branches of engineering.

3.2.1 Design of "TEMO-Leb Airship"

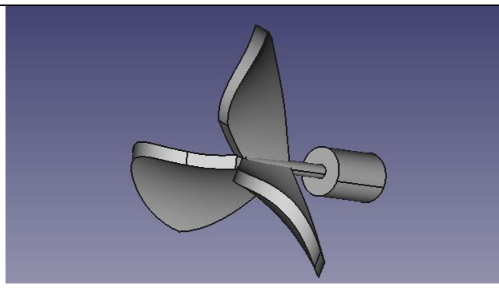
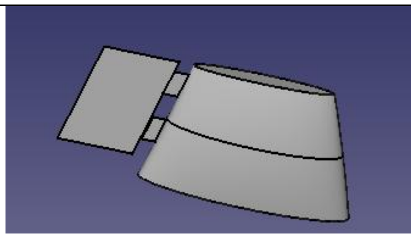
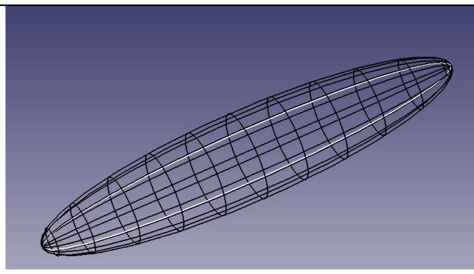
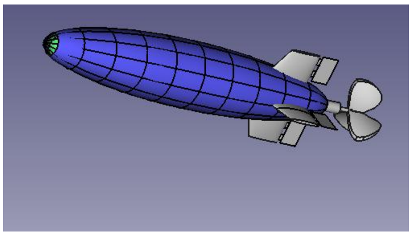
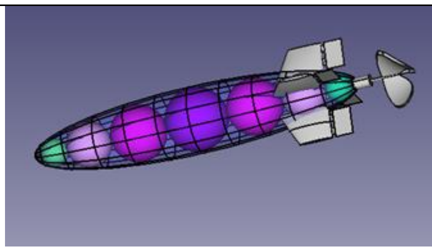
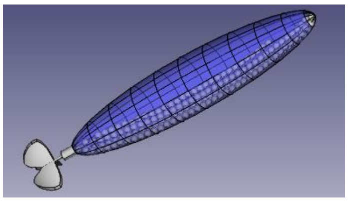
Part and details	Date and Data	Design
Propeller	May/2017 Propeller.Design.FCStd	
Rudder and Elevator	May/2017 Rudder.Elevator.FCStd	
Frame of Airship L=20 m D=4m	April/2017 Frame.of.Airship.FCStd	
Outer Shell of the Airship	April/2017 Outer.Shell.of.airship.FCStd	
Airship with the internal gasbags	April/2017 Airship.with.the.internal.gasbags.FCSt	
Airship With Balloons	29/May/2017 070617_Airship_Gazbags(Balloons).FCS	

Table 1: All Parts and design of Airship

- **Propeller**

In order to displace the dirigible, we use the propeller. It transmit power by converting the rotational motion and it provides the main thrust. The propeller is also used to provide various speed.

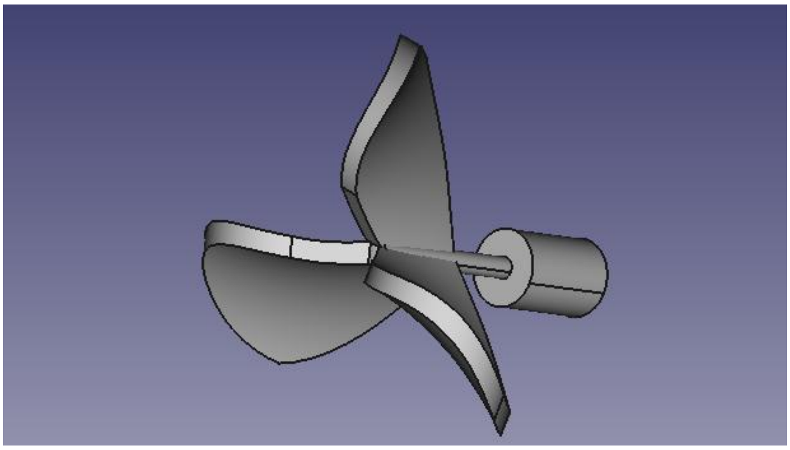


Figure 41: The propeller model drawn with FreeCAD

- **Rudder and Elevator**

To control an airship, we need many instruments, among them: rudders and elevators.

- The rudder is the part of airship which rotates and help to turn right or left.
- The elevator is like the rudder but it leads the dirigible to rise or descend.

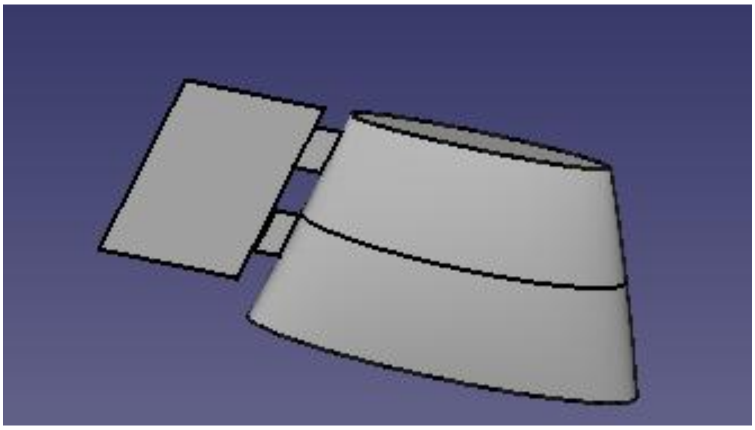


Figure 42: The rudder and the elevator models drawn with FreeCAD

➢ **Frame of the airship**

The frame is the body of airship, it gives its shapes. Which is main characteristic of rigid airship

It has formed by:

- Six ellipses: The length of the major axis is 20 m and the length of the minor axis is 4 m.

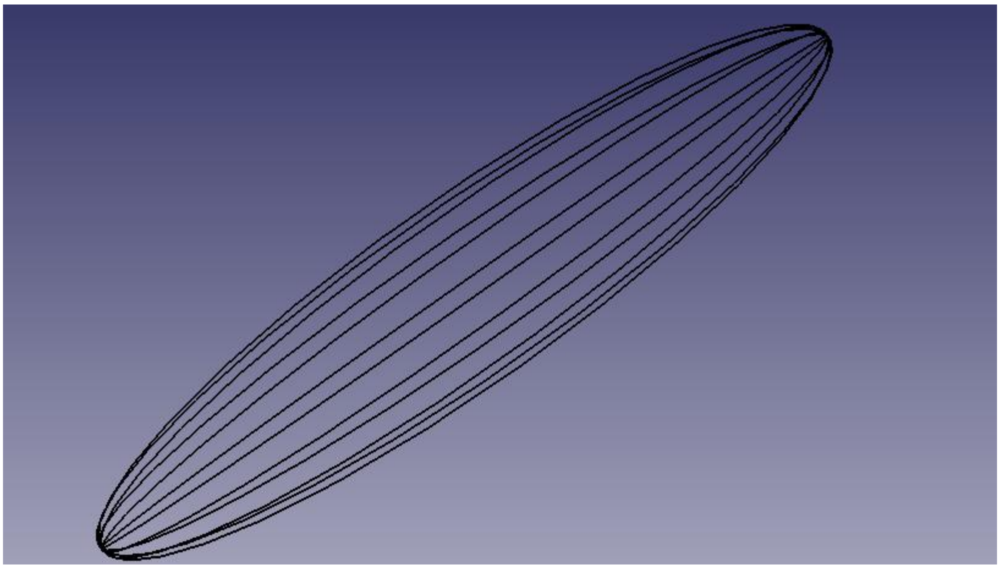


Figure 43: Ellipses of airship are drawn using FreeCAD

- 11 circles: This airship have 11 circles, four of them are symmetrical. Theirs dimensions are given in the table below.

Circle	Radius(m)
Circle 1	2
Circle 2	1.96
Circle 3	1.83
Circle 4	1.56
Circle 5	1.19
Circle 6	0.43
Circle 7	0.66

Table 2: Radius of Circles of the airship

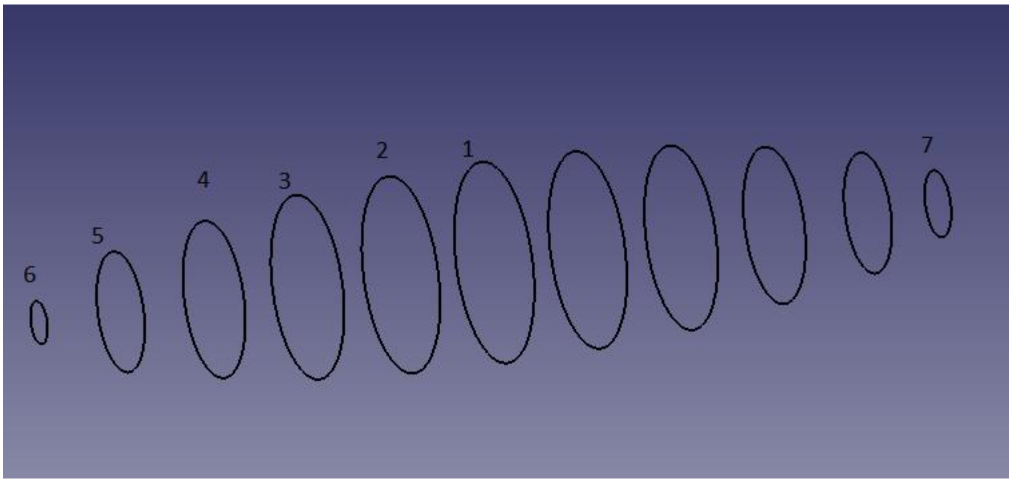


Figure 44: Circles of airship are drawn using FreeCAD

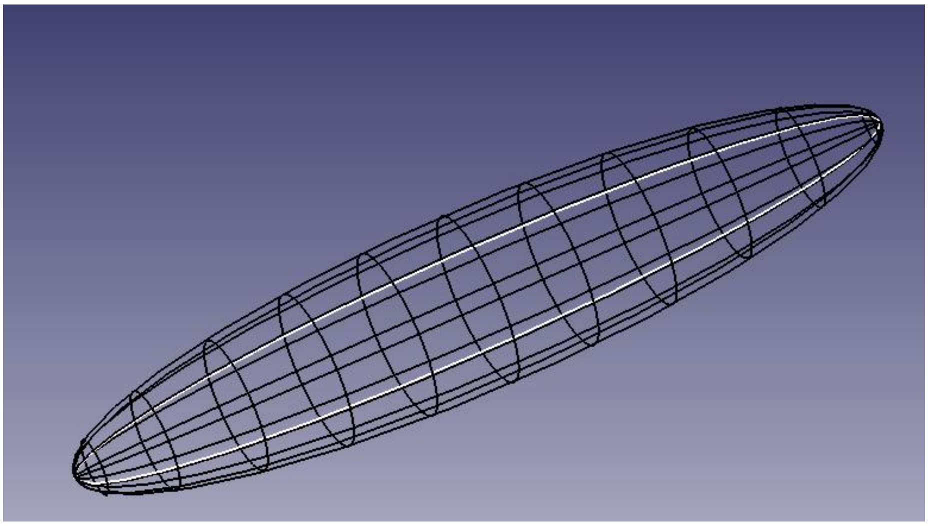


Figure 45: The framework of airship model drawn with FreeCAD

- **Outer shell of the airship**

The outer shell must be light. It covers the whole airship.

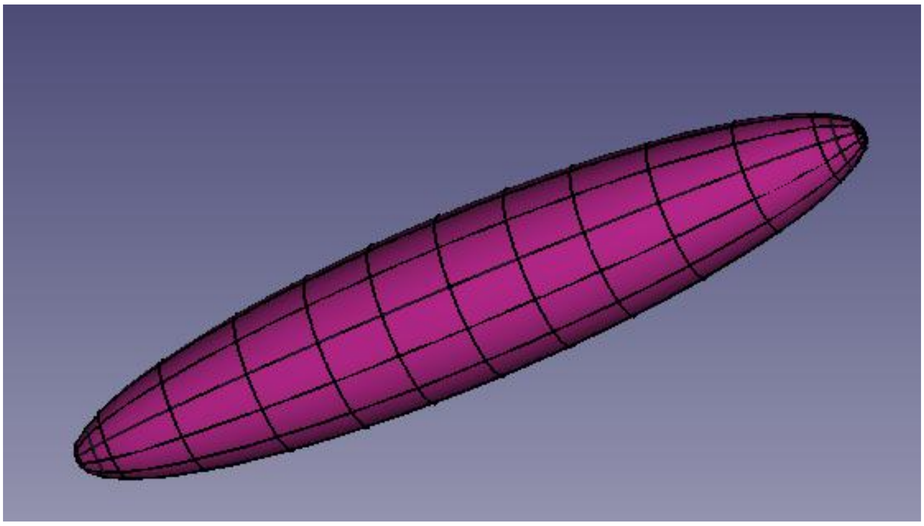


Figure 46: The hull of the airship designed with FreeCAD

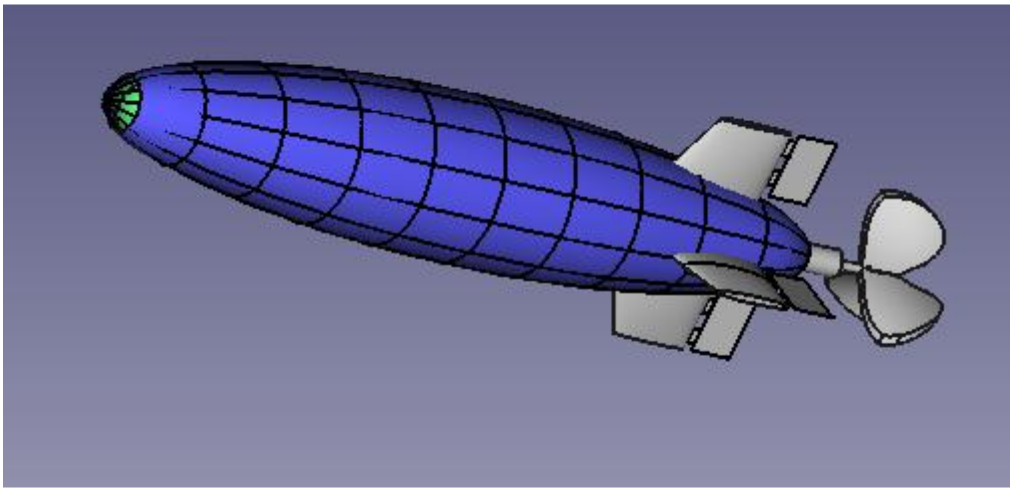


Figure 47: The envelope of airship model drawn with FreeCAD

- **Airship with the internal gasbags**

The internal gasbags contain the lifting gas and are designed with different dimensions.

The gas used is Helium and should choose carefully the envelope of gasbags. We know the atom of Helium is very small so it should not leak from the envelope. It gives greater durability of the airship to stay at the desired altitude.

This airship have 7 bags, three of them are symmetrical. Theirs dimensions are given in the table below.

Bag	Radius(m)
Bag 1	1.9
Bag 2	1.7
Bag 3	1.35
Bag 4	0.83

Table 3: Radius of Bags of the airship

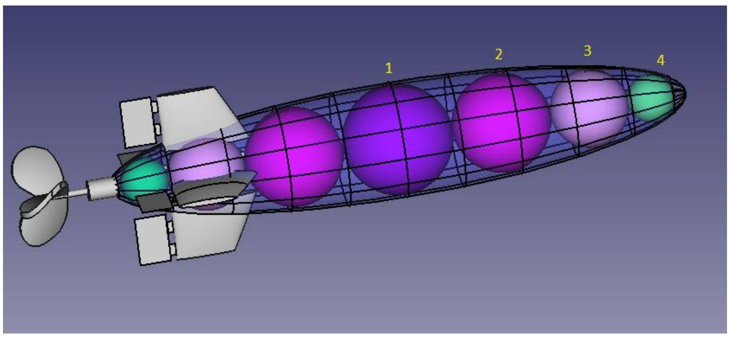


Figure 48: The internal gasbags of the airship

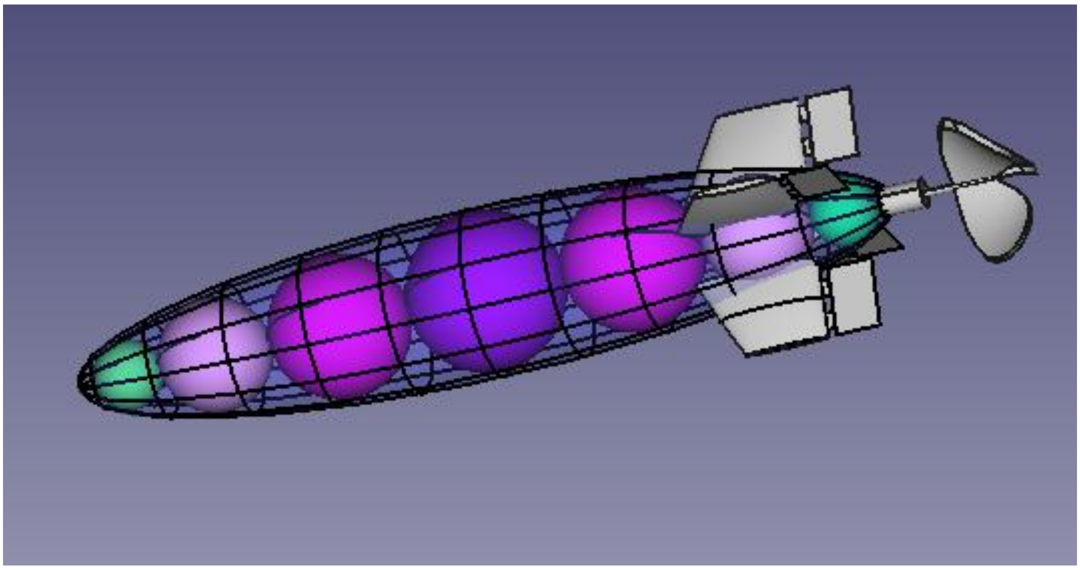


Figure 49: The internal gasbags of airship model draw with FreeCAD

- **Airship with balloons**

After a search in the Lebanese market done to find gasbags with the chosen dimensions, we did not find our requests. That's why we decided to use balloons having a 0.5 m of diameter instead of gasbags.

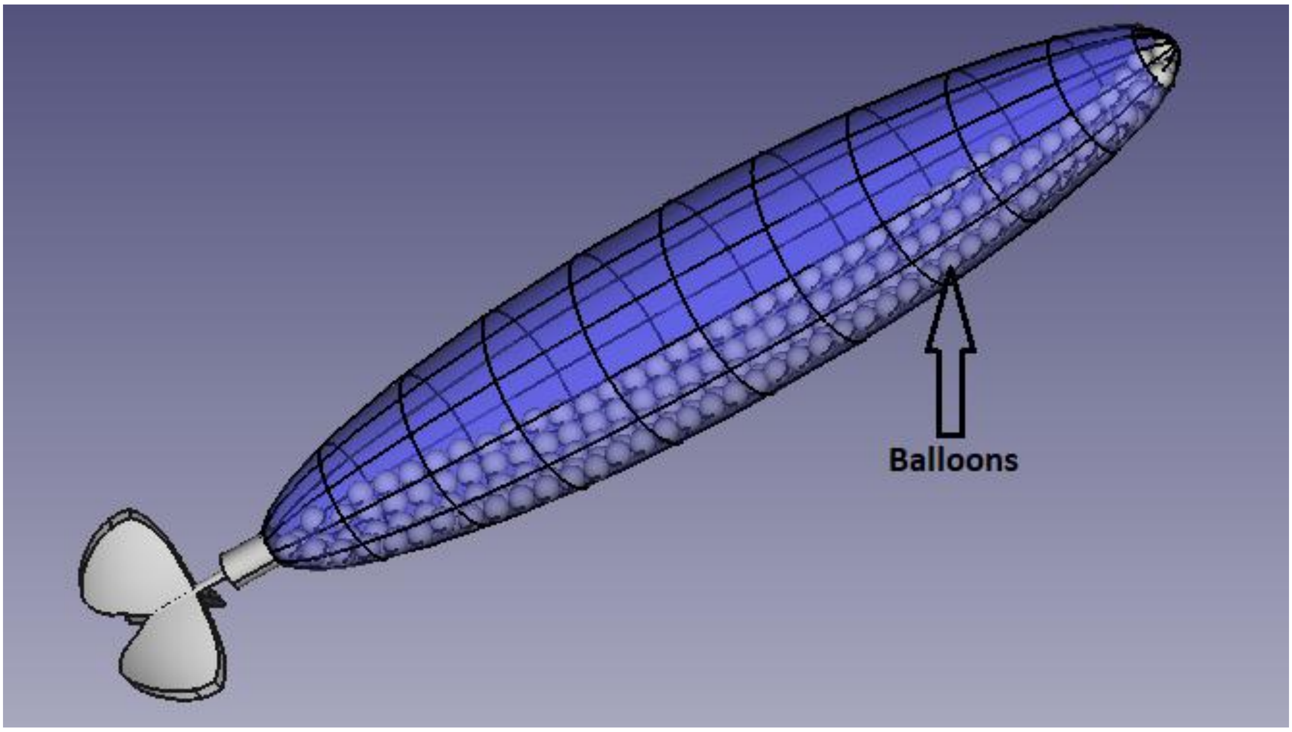


Figure 50: The airship with balloons model draws with FreeCAD

3.2.2 Mass of framework

To obtain the mass of framework, we need to choose the suitable material and to know its characteristics and its density. Then, we calculate the volume of the framework and finally, we use equation Eq.5.

Plexiglas is the suitable material to construct the airship framework. On the Internet, there are many choices. We choose Plexiglas stick, plastic, having a circular section of diameter 6 mm and a length of 1m. [10]

It has also many characteristics:

1. Good mechanical strength
2. Good shock resistance
3. Good dielectric properties
4. Minimal absorption of humidity
5. UV resistance
6. Density= 1180 kg/m^3
7. Elongation at rupture= 4%
8. Compressive strength= 118 N/mm^2
9. Elasticity module= 3140 N/ mm^2
10. Specific Heat= 0.35 cal/g°C
11. Coefficient of linear expansion= 6.8*10^-5 (1/°c)
12. Resistance to cold temperature > -40°C

Figure 51: Stick of Plexiglas

Now, we know the characteristic of Plexiglas, so we can calculate the mass of framework. At the beginning, the volume of the frame must be calculated.

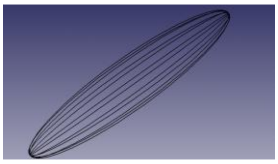
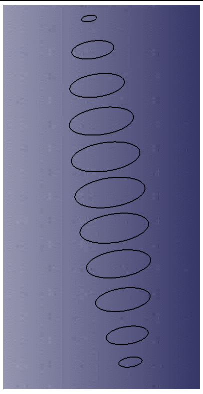
Plexiglas (Material of Structure)			
Volume of structure of ellipses (cm^3)	Ellipse 1	1281	
	Total (6 Ellipses)	7686	
Volume of structure of circles(cm^3)	Circle 1	355	
	Circle 2	76	
	Circle 3	118	
	Circle 4	213	
	Circle 5	213	
	Circle 6	277	
	Circle 7	277	
	Circle 8	326	
	Circle 9	326	
	Circle 10	348	
	Circle 11	348	
	Total	2877	

*Table 4: The volume of frame made of **Plexiglas** in cm3*

Volume of ellipse is calculated by this equation:

$$V_{ellipse} = 2 \cdot \pi \cdot ((((\frac{L}{2})^2 + (\frac{D}{2})^2)/2)^{0.5}) \cdot \pi \cdot S^2 \qquad \text{Eq.A}$$

Volume of circle is calculated by this equation:

$$Vcircle = 2 \cdot \pi \cdot (\frac{D}{2}) \cdot \pi \cdot S^2 \qquad \text{Eq.B}$$

S: Demi-Section of circle and ellipse manufactured by Plexiglas.

Using Eq.5, we obtain the mass of frame made of **Plexiglas**:

Total volume of frame : Volume of ellipses + Volume of circles	0.01 m^3
Density of Plexiglas	1180 kg/m^3
Mass of Plexiglas	12.47 kg

*Table 5: Mass of **Plexiglas***

3.2.3 Mass of gasbags

We need a specific material when we use Helium. The newly developed envelope is made of high-strength, tear-resistant multi-layer laminates. Even a lighting impact cannot significantly after the flight characteristics. The envelope has a slight overpressure of 5 mbar.

The materials used for this envelope:

- Outer Layer: “Teldar”. It is a film which has a protection from UV rays.
- Intercellular Layer: “Polyester fabric”. It has a snag resistant.
- Internal Layer: “Polyurethane”. It has many characteristic: weldable and waterproof. [11]

This envelope has a density equal to 0.25 kg/m^2 and a force tearing equal to 285 N/cm.

Now, we know the characteristic of the envelope, so we can calculate the mass of gasbags. At the beginning, the surface of the gasbags must be calculated. Eq.5 is not suitable because when we study the tissues, we need to use the surface instead the volume. We calculate the mass using this equation:

$$\text{Surface density } \varrho' = m/S \qquad \text{Eq.5'}$$

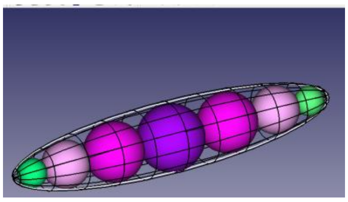
Material of Gasbags			
Surface of Gasbags(m^2)	Bag 1	45.36	
	Bag 2	36.32	
	Bag 3	36.32	
	Bag 4	22.90	
	Bag 5	22.90	
	Bag 6	8.66	
	Bag 7	8.66	
	Total	181.12	

Table 6: The surface of gas bags en m2

The surface of gasbags is calculated by this equation:

$$S \text{ sphere} = 4*\pi*(D/2)\ \hat{}2$$

Total surface of gasbags:	181.12 m^2
Surface Density	0.25 kg/m^2
Mass of gasbags	45.28 kg

Table 7: Mass of gasbags

3.2.4 Mass of external fabric

The tissue used for the external fabric is different from the one that is used in the bags. The envelope of the bags does not leak gas and this is not the status of the outer shell. So another type of tissue is used "Cotton Fabric "has a density of 0.075 kg/m^2.

Surface of external shell	251.33 m^2
Density	0.075 kg/m^2
Mass of external fabric	18.85 kg

Table 8: Mass of external fabric

This theoretical study is difficult to implement now, because, in this project, we want to elevate the airship at high altitude, given that we have become large-scale.

The approval of the Lebanese government must be taken, and it will take a long time. Moreover, the difficult circumstances encountered by neighboring regional states may hinder such approval.

As the aim of the project is to revive the science of airships, we decide to set up a small airship at low altitude, with some modifications to the theoretical study, due to the unavailability of airship manufacturers in the Lebanese market.

3.3 Low altitude test TEMO-Leb Airship

3.3.1 New design with new dimensions of the Low altitude test TEMO-Leb Airship

The new design of the Low altitude test TEMO-Leb Airship has the following dimensions which elevates at a low altitudes. This airship is actually under construction.

Diameter= 1.2 m;

Length= 6.4577 m

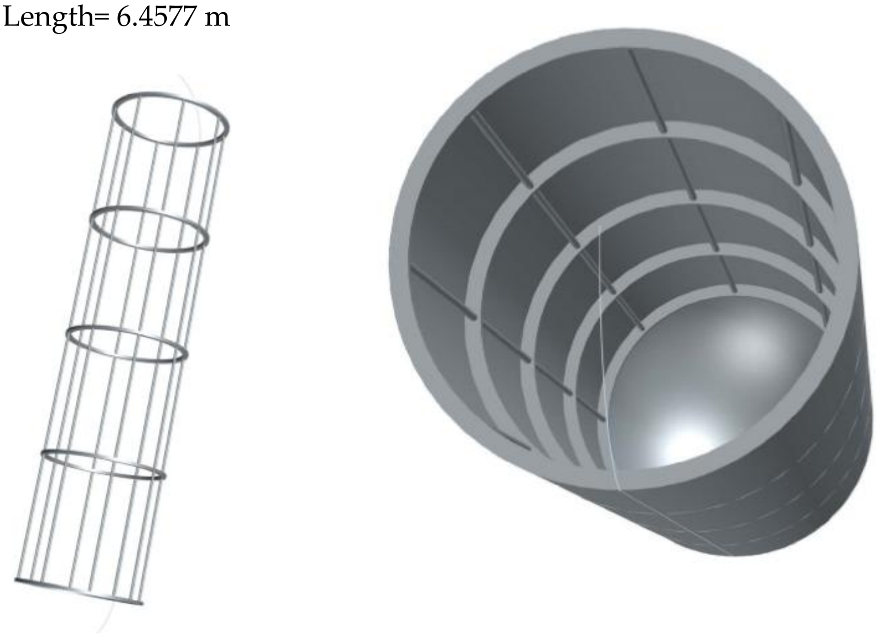


Figure 52: The framework of airship model draws with AutoCAD

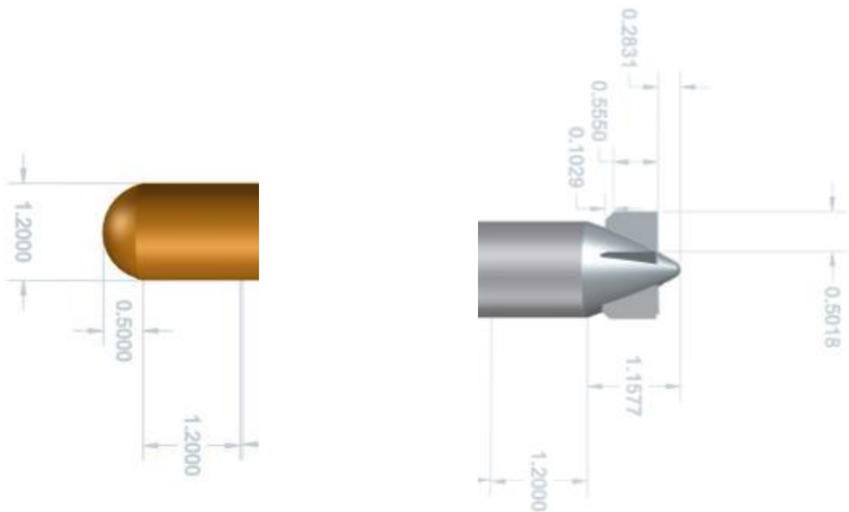


Figure 53: The new design of airship draws with AutoCAD

3.3.2 Materials of the test device for the Low altitude test TEMO-Leb Airship in Lebanese market

1) Balloons filled with Helium

The gasbags are replaced by the balloons, having 1.5 m as a diameter. It is important to know the mass hold by the balloons and the pressure of Helium contained into the balloon. To obtain these parameters, we want to perform this calculation:

Firstly, we calculate the volume of balloon:

$$V_{Balloon} = 4/3*\pi*(D/2)\ \hat{}3 = 4/3*\pi*(1.5/2)\ \hat{}3 = 1.77\ m^3$$

We know the density of Helium at 20°C: ρ_{He}= 0.178 kg/m^3 [14]

By applying Eq.5, we obtain the mass theirs hold by the balloons:

$$m_{\text{hold by 1 balloon}} = (\rho_{air} - \rho_{He})*\ V_{Balloon} = ((1,2041 - 0.178)*1.77\ )kg = 1.8\ kg$$

$$m_{\text{hold by balloons}} = 4*1,8\ kg = 7.2\ kg$$

The pressure of Helium into the balloon can be calculate by using the equation:

$$P*V= (m/M)*R*T \qquad \text{Eq.10}$$

P: Pressure of Helium into the balloon (Pa)

V: Volume of balloon (m^3)

m: Mass of balloon (kg)

M: Molar mass of Helium (kg/m^3)

R: The universal gas constant = 8.314 JK^{-1}mol^{-1}

T: The absolute Temperature of Helium (k)

To obtain the mass, we use Eq.5:

$$\rho=m/V;\ m=0.178*1.77=0.3\ kg/m^3$$

The pressure is:

$$P= ((m/M)*R*T)/V=((0.3/4)*8.314*293.15)/1.77=108457.6\ Pa=1.07\ atm$$

ρ: Density of Helium at 20°c=0.178 kg/m^3

2) Plexiglas

The framework of airship is manufactured by empty tubes of Plexiglas. The section of tube is equal: 6 mm. The mass of framework must be lower than the mass hold by the balloons, in order to rise the airship.

To ensure this calculations, we have to wait for the implementation.

3) External envelope

For the external envelope, a very light type of fabric must be used, because Plexiglas and the balloons cannot sustain an excess weight.

3.4 Results of theoretical study

3.4.1 Results of "MATLAB"

We use **"MATLAB"** for plotting the variation of density, pressure and temperature as a function of altitude. The results can be found below:

1) Variation of the density with altitude

✓ Plotting the function:

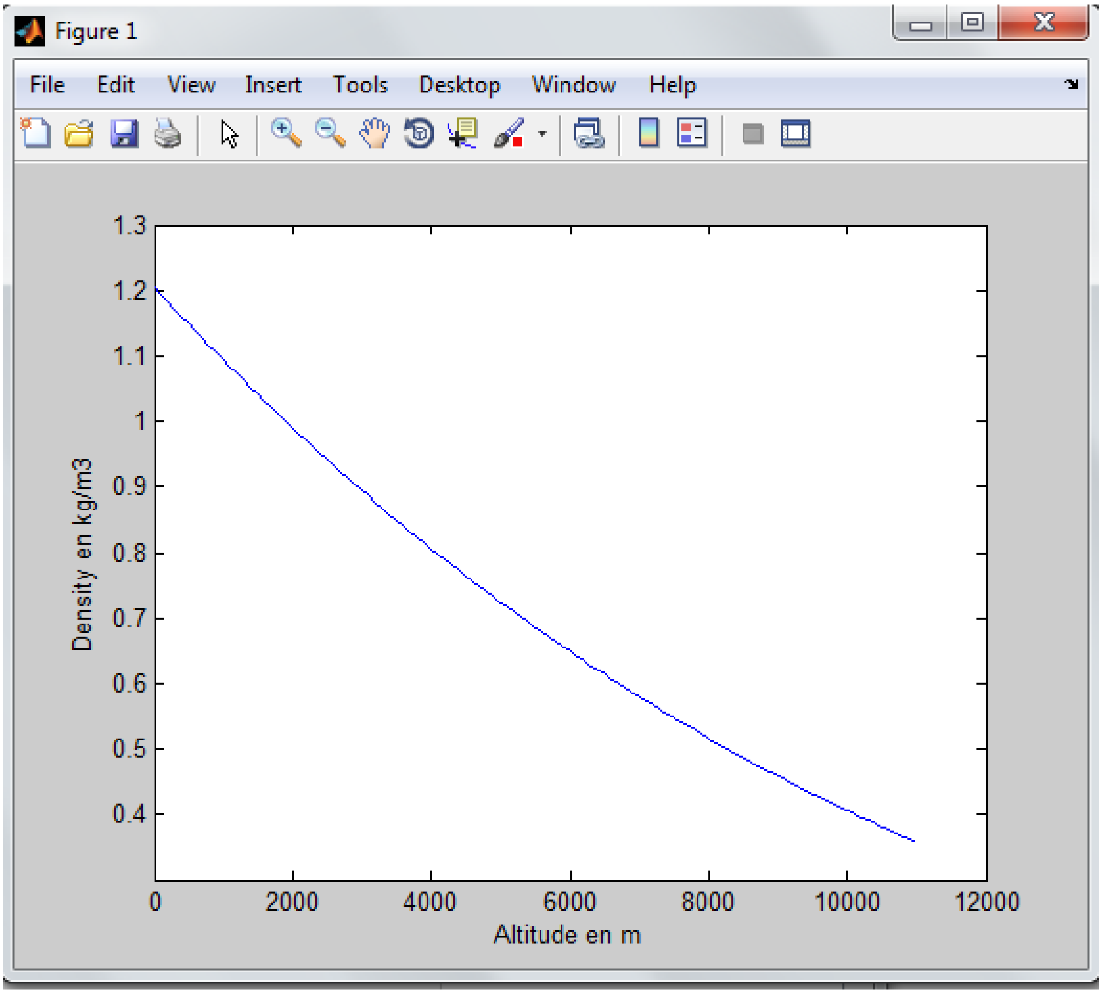


Figure 54: Variation of density (kg/m3) with altitude (m).

This graph show the variation of the density as a function of altitude along 11 km. we notice that the density decreases with the increase of altitude.

2) Variation of pressure with altitude

✓ Plotting the function:

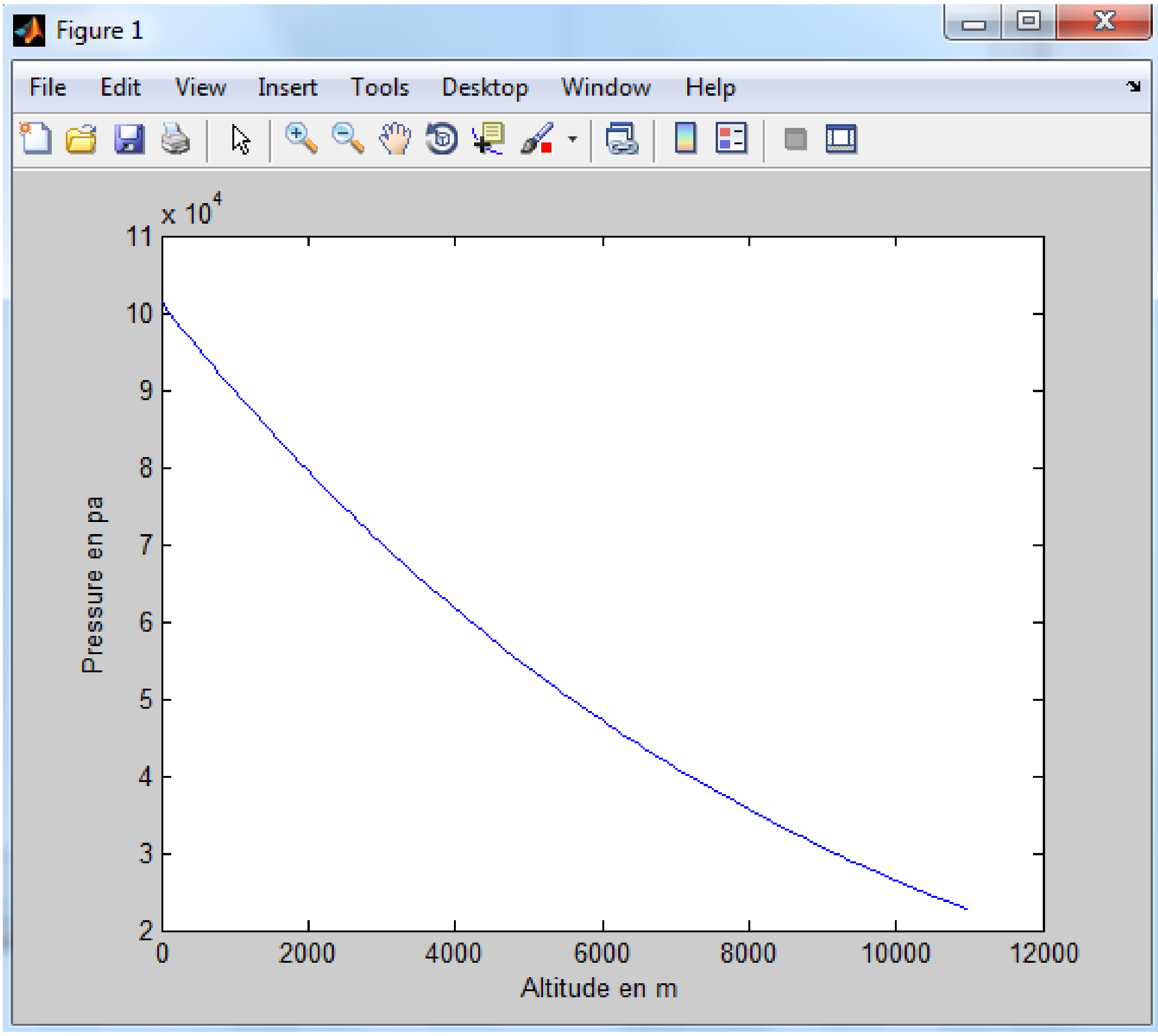


Figure 55: Variation of pressure (pa) with altitude (m) computed for 15°c and 0% relative humidity.

This graph show the variation of the pressure as a function of altitude along 11 km. we notice that the pressure decreases with the increase of altitude.

3) Variation of temperature with altitude

✓ Plotting the function:

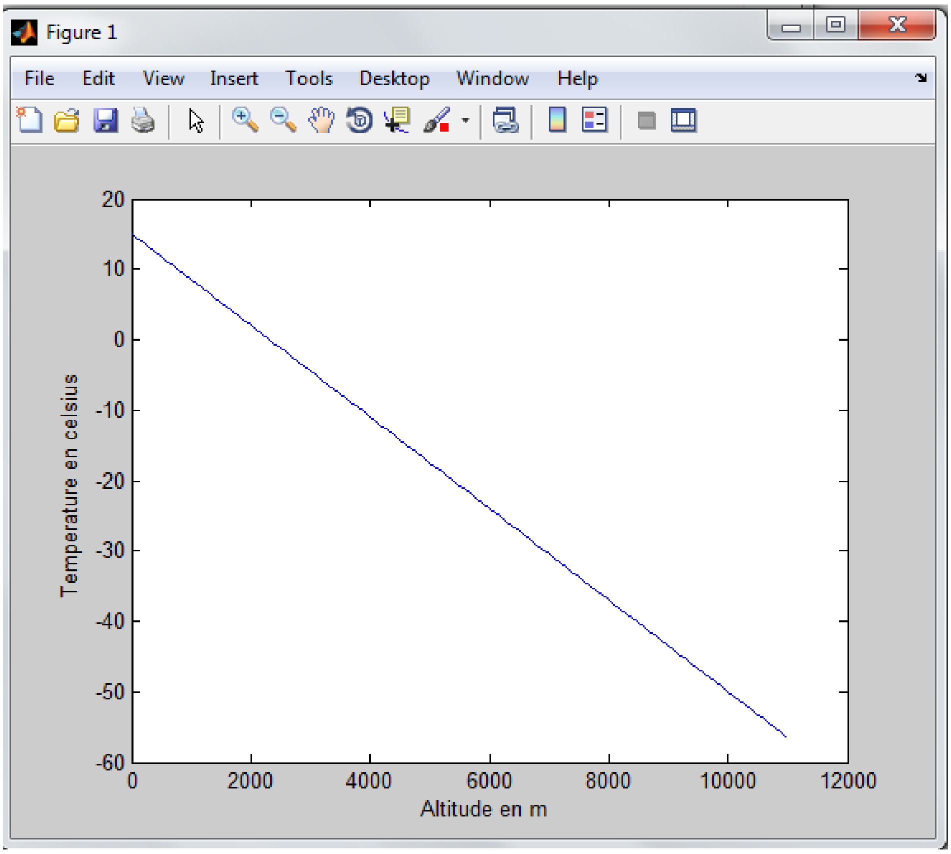


Figure 56: Variation of temperature (°C) with altitude (m).

This graph show the variation of the temperature as a function of altitude along 11 km. we notice that the temperature decreases with the increase of altitude.

4.1.2. V $_{\text{TEMOLeb Airship}}$ and the V_{max}

We will calculate the maximum volume of Helium contained in the gasbags, and we will check whether the airship able to reach the proposed height.

$$V_{max} = (m_s + m_p) / \sigma * (\rho_{A0} - \rho_{He0})$$

To obtain the mass of structure, it is necessary to add the mass of framework, the mass of gasbags and the mass of external fabric.

$$m_s = 76.6 \text{ kg}$$

It is assumed that the mass of payload:

$$m_p = 2 \text{ kg}$$

We have the density of air and Helium at 15°c and at sea level:

ρ_{A0}= 1.225 kg/m³; ρ_{He0}= 0.169 kg/m³

The density ratio "σ "is varied with altitude, depending on the below table, we calculate the ratio:

$$\sigma=\rho_A/\rho_{A0}$$

	0	100	200	300	400
-500	1.285	1.273	1.261	1.249	1.237
0	1.225	1.213	1.202	1.190	1.179
500	1.167	1.156	1.145	1.134	1.123
1000	1.112	1.101	1.090	1.079	1.069
1500	1.058	1.048	1.037	1.027	1.017
2000	1.007	0.996	0.986	0.977	0.967
2500	0.957	0.947	0.938	0.928	0.919
3000	0.909	0.900	0.891	0.881	0.872
3500	0.863	0.854	0.845	0.837	0.828
4000	0.819	0.811	0.802	0.794	0.785
4500	0.777	0.769	0.760	0.752	0.744
5000	0.736	0.728	0.720	0.713	0.705
5500	0.697	0.690	0.682	0.675	0.667
6000	0.660	0.652	0.645	0.638	0.631
6500	0.624	0.617	0.610	0.603	0.596
7000	0.590	0.583	0.576	0.570	0.563
7500	0.557	0.550	0.544	0.538	0.531
8000	0.525	0.519	0.513	0.507	0.501
8500	0.495	0.489	0.484	0.478	0.472
9000	0.466	0.461	0.455	0.450	0.444
9500	0.439	0.434	0.428	0.423	0.418
10000	0.413	0.408	0.403	0.398	0.393
10500	0.388	0.383	0.378	0.373	0.369
11000	0.364	0.359	0.355	0.350	0.346
11500	0.341	0.337	0.333	0.328	0.324
12000	0.320	0.316	0.311	0.307	0.303

Table 9: Variation of density of air with altitude

To obtain the density of atmosphere, we use table 9, when we want to obtain the density of 600 km, we see the column in the left: 500 and the line above 100 and we read the density 1.156 kg/m³.

Altitude (km)	$\sigma *(\rho_{A0}-\rho_{He0})$	V_{max} (m³)
H=0	1.056	74
H=1	0.959	82
H=2	0.868	91
H=3	0.784	100
H=4	0.706	111
H=5	0.634	124
H=6	0.569	138
H=7	0.508	155
H=8	0.461	170

Table 10: Variation of volume Helium as function of altitude

4.1.3. Positive results

From 0 km to 7 km, we are under the point **"Pressure Altitude"** (explain in Chapter 3).

Under this point, we have:

- The differential of pressure between lifting gas and atmosphere is null: $\Delta P=0$.
- The differential of temperature between lifting gas and atmosphere is null: $\Delta T=0$.
- The density of lifting gas and atmosphere decrease, this variation affects an increase of net volume. The equation Eq.5 is available up to the **"Pressure Altitude"**.

The variation of density and pressure is composed by the volume. When the density and the pressure decrease, the volume of gasbags increases.

At 7 km, this is the proposed altitude to elevate **TEMO-Leb airship**:

$$\mathbf{V_{TEMOLeb\ Airship} > V_{max}}$$

This is a **positive result**, it hasn't any danger to a rupture of airship. The volume of Helium in the gasbags is enough to rise **TEMO-Leb airship**, at **7 km.**

The airship cannot to rise at 8 km, because:

$$V_{TEMOLeb\ Airship} < V_{max}$$

We are now above the point **"Pressure Altitude"** (explain in Chapter 3).

When the airship continue to rise, the density of lifting gas and atmosphere also continue to decrease, but the volume of lifting gas remains constant.

The differential of pressure now isn't null, it starts to increase. The overpressure is created, and consequently, a rupture of the exterior structure of airship can be result if the differential becomes too great.

4 Actuator System of TEMOLeb-Mintad

4.1 Hydraulic actuator system

4.1.1 Work principal for hydraulic motor

In the figure below (***Figure 57:*** *simple work principal of hydraulic actuator.*; two cylinders are used; to understand the principle of hydraulic actuator operation. In fact; the section of the left cylinder is 1 square centimeter; and that of the right is 10 square centimeters. The two cylinders are filled by an incompressible fluid. If a pressure unit is applied to the left cylinder, which is used to push the pump; of 10 centimeters; the effect of this force on the right cylinder is to push the piston one centimeter with a unit force. Which implies that a unit of force applied on one side of the cylinder provides 10 units of this force on the other side. This relation results from the Pascal principle which shows us the proportionality between force and pressure:

$$P = \frac{F}{S}$$

This type of cylinder (or called a linear hydraulic motor) is useful in systems that require high strength but not much accuracy. For example, if you need a linear force to move a robot. The action of the hydraulic pressure on these actuators provides a reciprocating movement of the piston included in the cylinder. And since the load is attached to the piston, it will move in parallel with its motion. Even a rotating action can be created by transforming the hydraulic pressure.

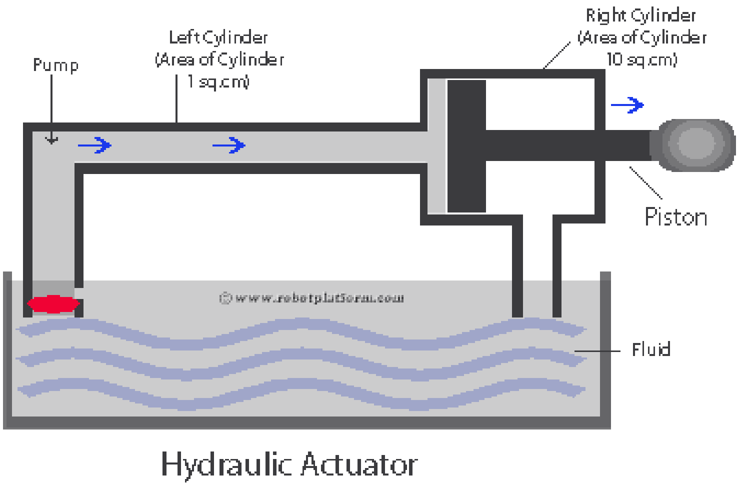
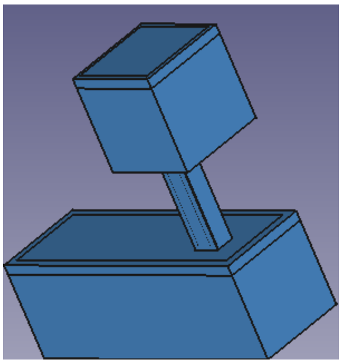
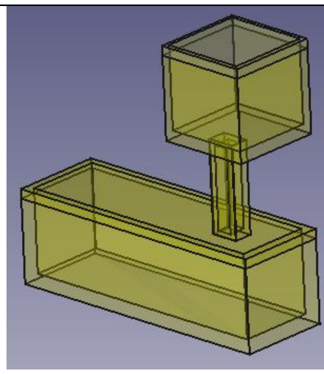
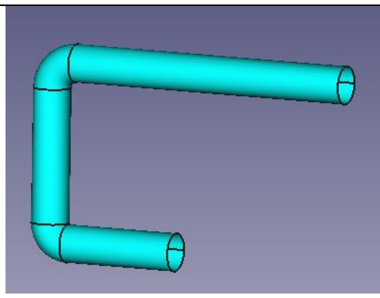
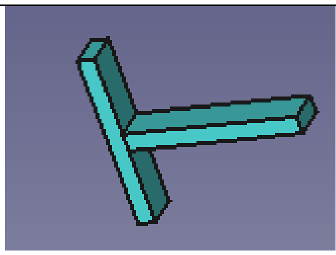


Figure 57: simple work principal of hydraulic actuator.

4.1.2 FreeCAD design proposal

Parts and details	Date and FreeCAD file	Screenshot
Oil tank	April /2017 oil_tank.FCStd	 
Pipes	April/2017 pipes.FCStd	
Piston	April/2017 piston.FCStd	

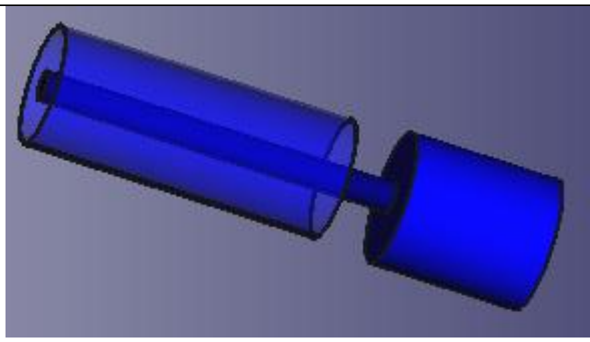
Pump Electric Motor	May/2017 pump_22 5 2017.FCStd	

Table 11: freecCAD design for each part of the proposal hydraulic actuator system.

The whole motor is drawed below:

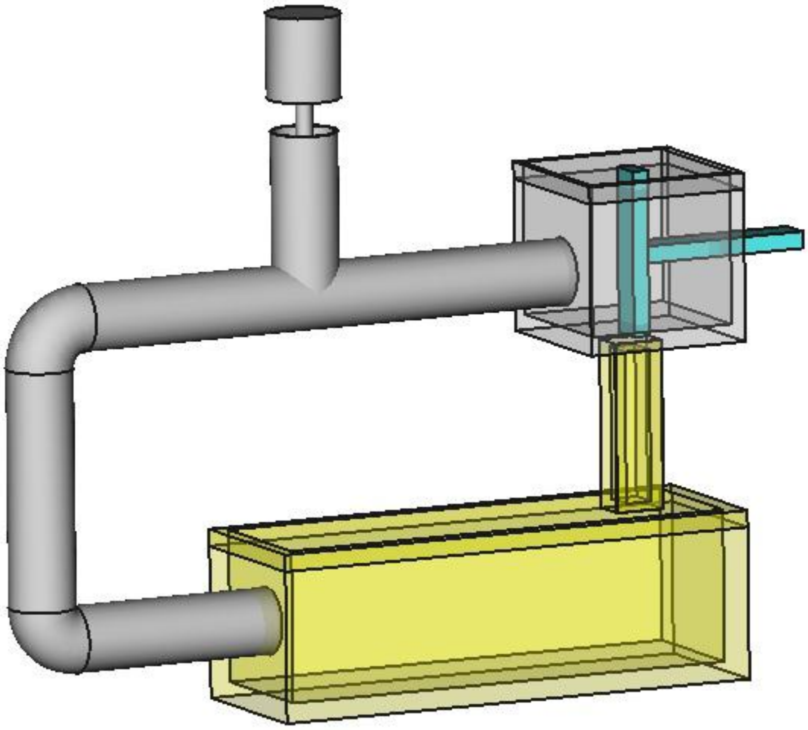
whole_hydraulic_motor_22_5_2017.FCStd	

Table 12: freeCAD model of whole actuator.

We later discovered that this type of actuator who drives the piston in one direction is not enough to move the rudder and elevator in two different directions, when the airships control system gives the command. And to do that, we need a system acting in both directions such as the "double acting cylinder". This last isn't a very easy system; a lot of problems we face if we are to manufacture this type… Even if we want to buy it.

4.2 Servo actuator system

4.2.1 Adopted Motor (*Figure 58: the servo motor which we buy.*

Figure 58: the servo motor which we buy.

4.2.2 Basic parts of the servo (*Figure 59: picture showing all interior parts for any servo (motor, gearbox, potentiometer, and control electronics).*

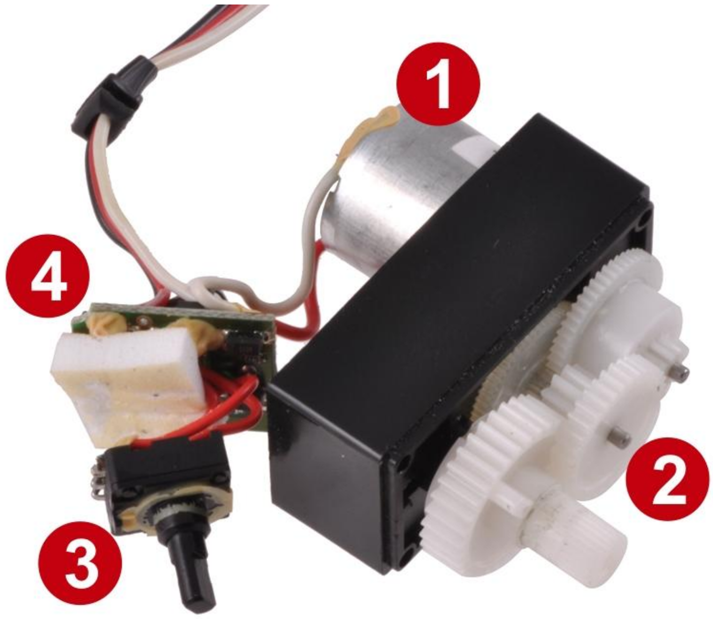


Figure 59: picture showing all interior parts for any servo (motor, gearbox, potentiometer, and control electronics).

1. Motor
2. Gearbox
3. Position sensor
4. Motor control electronics

4.2.3 Servo motor block diagram (*Figure 60: servo motor block diagram.*

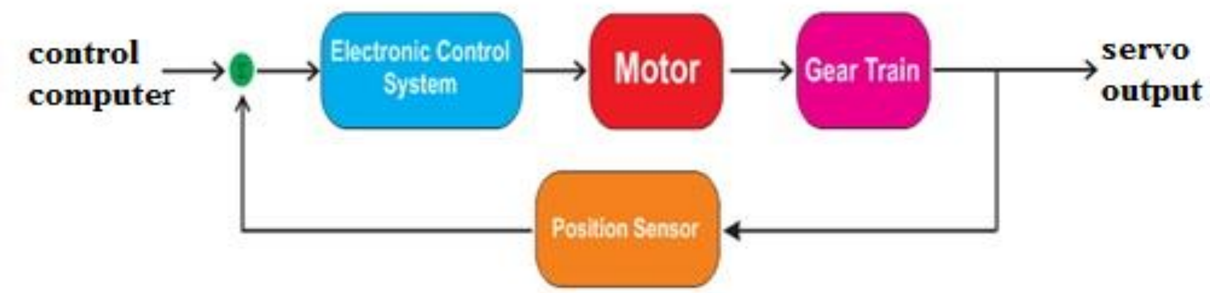


Figure 60: servo motor block diagram.

4.2.3.1 Control computer:

The mobile application used "BlunoBasicDemo"; send an electronic control signal containing the angle of each servo and the on or off for propeller.

4.2.3.2 Electronic control system:

It is an interconnection between 2 signals: input and output. A signal is transformed to another one using a process; in the objective to create motion, change a speed, etc. specifically, in our project we use the type called closed loop electronic control system. By correcting the error occurred; it helped us to main the system more stable and enhance its control. In the following a scheme (***Figure 61:*** *the concept of electronic control system.* is showed to explain this concept.

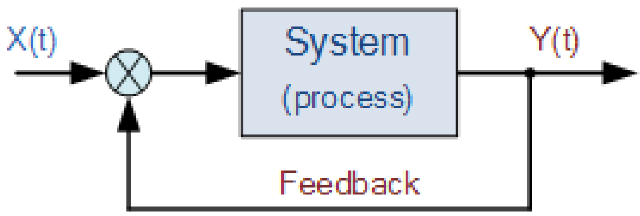


Figure 61: the concept of electronic control system.

4.2.3.3 Motor:

Inside the servo is a DC motor. This one will turn when receiving an electric signal from the control system.

4.2.3.4 Gear train:

An assembly of many gears; receive the rotation force from DC motor; and transform it into torque.

4.2.3.5 Position sensor:

Such as a potentiometer; which has to learn continuously the mechanical position of the shaft by changing the resistance of an interior resistor.

4.2.3.6 Servo output:

A PWM signal was sent to the motor, turn the shaft in the desired position. This can describe the output of a servo.

4.2.4 Design of servo actuator system (FreeCAD)

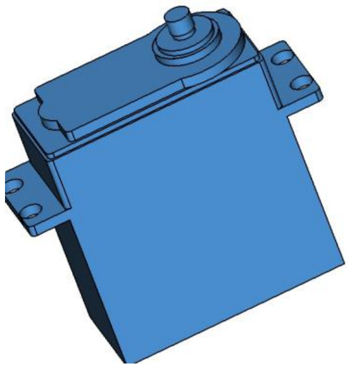
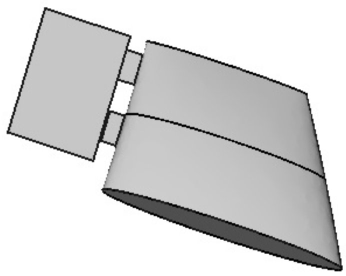
Parts and details	Date and FreeCAD file	Screenshot
Servo Motor	 servomotor.FCStd	
Rudder	 rudder.FCStd	

Table 13: freeCAD model of servo motor and the airship rudder.

4.2.5 Motor Controller and Interfaces

The work which is described in this section was done by CNCLab (see quotation in Appendix).

The mobile application named **"BlunoBasicDemo"** sends a command to the Bluetooth module taking place on the Arduino board. It passes through the motor drive then arrive to the servo actuator in the form of PWM signal which is responsible for rotating the servo in different angles.

4.2.5.1 Mobile App:

Figure 62: BlunoBasicDemo logo.

BlunoBasicDemo (***Figure* 62:** *BlunoBasicDemo logo.* is a basic Demo for Bluno including all the code and executable on Android, IOS and Android. You can easily develop your own with this Demo.

4.2.5.2 Bluetooth Module: (BLE Link -A Bluetooth 4.0 module for Arduino)

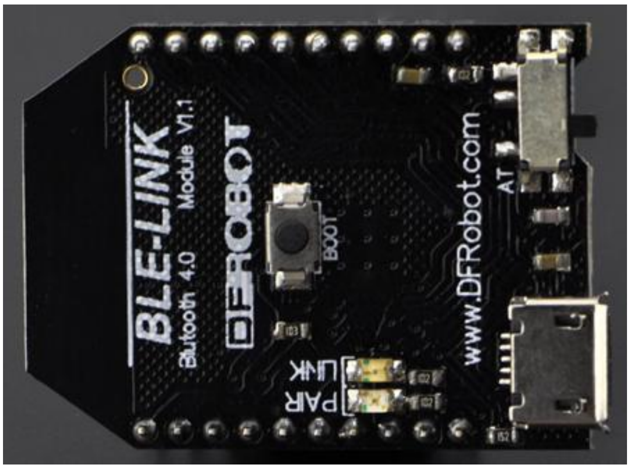


Figure 63: BLE Link -A Bluetooth 4.0 module for Arduino.

Description:

It is a peripheral that quickly connects the device to the mobile via BLE, using the XBEE model suitable for all XBEE screens. Many of the applications for Android and IOS systems are developed to be at the service of users who must use it to communicate between BLE and Arduino.

Specification:

Price: 23.95$

Mark: DFRobot

Serial number: WRL0024

Chip: TI CC2540>

Working voltage: +3.3DC

Power consumption: working 10.6 mA average, ready mode: 8.7 mA

Pin Layout: Compatible With XBEE pinout

Frequency: 2.4 GHz

Transfer rate: 1 Mbps

Modulation: GFSK, Bluetooth low power, V4.0

Sensitivity: -93dB

Operating temperature: - 40 → +85

Transmission distance: 60 m in free space

Size: 32mm * 22mm (1.26 * 0.87")

2.2.5.3. Arduino controller: Romeo V2-All in one Controller-motor drive built in

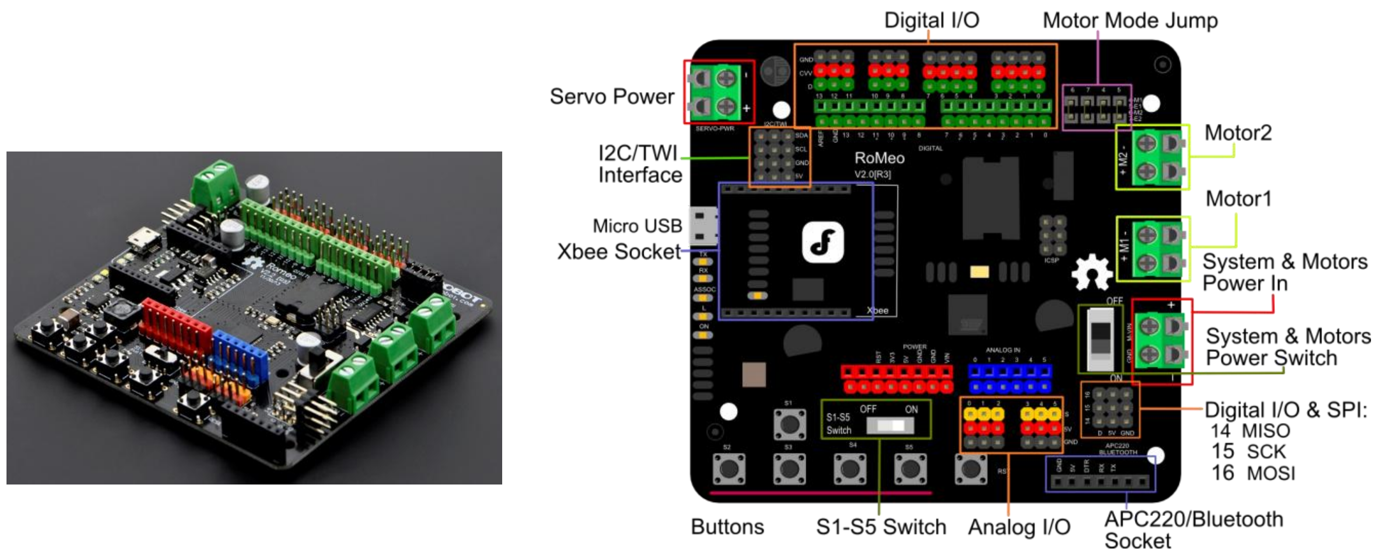


Figure 64: Romeo V2-All in one Controller-motor drive built in.

Description:

Romeo V2 [R3] (***Figure 64:*** *Romeo V2-All in one Controller-motor drive built in.*) is an All-in-One Arduino, microcontroller, made specifically for robotics applications. This type of Arduino based on the ATmega32u4 chip, can be programed fast via the Arduino IDE. Thanks to ATmega32u4 chip, the ease and the simplicity of RoMeo V2. Another application of Romeo V2 is that it can control a stepper motor.

Specification:

Price: 46.95 $

Mark: DFRobot

Serial number: DEV0005

DC Supply: USB Powered or External 6V ~ 23V DC

DC Output: 5V (2A) / 3.3V DC

Motor driver Continuous Output Current: 2A

Microcontroller: ATmega32u4

Bootloader: Arduino Leonardo

Compatible with the Arduino R3 pin mapping

Analog Inputs: A0-A5, A6 - A11 (on digital pins 4, 6, 8, 9, 10, and 12)

PWM: 3, 5, 6, 9, 10, 11, and 13. Provide 8-bit PWM output

5 key inputs for testing

Auto sensing/switching external power input

Serial Interface

TTL Level

USB

Support Male and Female Pin Header

Built-in XBEE socket

Integrated sockets for APC220 RF Module and DF-Bluetooth Module

Three I2C/TWI Interface Pin Sets (two 90°pin headers)

Two way Motor Driver with 2A maximum current

One Stepper Motor Drive with 2A maximum current

Size: 89 x 84 x 14mm

2.2.5.4. Motor drive: HR 2 channel dc motordrive dual h bridge stepmotor reversing PWM speed control mini L298N

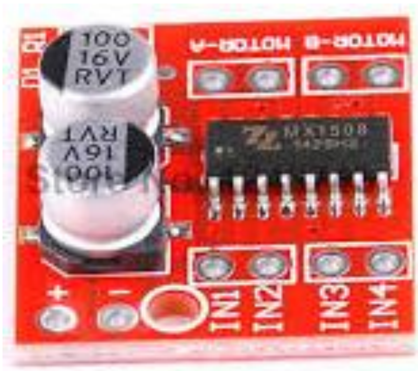


Figure 65: HR 2 channel dc motordrive dual h bridge stepmotor reversing PWM speed control mini L298N.

Description:

HR 2 motordrive (***Figure 65:*** *HR 2 channel dc motordrive dual h bridge stepmotor reversing PWM speed control mini L298N.* can be used in a device need a voltage between 2 and 10 v. with his 2 pin each to 1.5 A DC current ; it can manage the position and speed control.

Note that in this project motor drive is used only for DC motor which's responsable of propeller motion and speed (i.e. servo motor don't need motor drive, it will be directly connected to arduino).

Specification:

Price: 3.95$

Serial number: DRV0023

H bridge motor dual drive, and can drive two DC motor or 1 line 4 phase stepper motor;

The voltage of the power supply module 2V-10V;

The signal input voltage 1.8-7V;

Single channel current of 1.5A, peak current up to 2.5A, low standby current (less than 0.1uA);

The built-in common conduction circuit, the input end is suspended, the motor will not malfunction;

The built-in overheat protection circuit with hysteresis effect (TSD), there is no need to worry about motor stall;

Product size: 24.7*21*5mm (LxWxH), ultra-small size, suitable for assembly and vehicle;

Mounting whole diameter: 2 mm.

Weight: 5g

4.2.6 Power Management: Polymer Lithium Ion Battery - 1000mah 7.4v

Figure 66: Polymer Lithium Ion Battery - 1000mah 7.4v.

Description:

This LiPo (***Figure 66:*** *Polymer Lithium Ion Battery - 1000mah 7.4v.* is an excellent battery that can be used in any application; who need a little power supply has several punch as in robotics. Its low voltage and sufficient flow allows it to acquire many electronic and some small motors

The battery has two cells and produces 7.4 V to store 1000 mAh of charge. This type of batteries requires a specific charger.

Specification:

Price: 13.95$

Mark: SparkFun Electronics®

Serial number: PWR0024

7.4V 2-cell pack

1000mAh of charge

Discharge rate: 25C continuous

Charge plug: JST-XH

Discharge plug: JST-RCY

Dimensions: 70mm x 35mm x 18mm

Weight: 85g (2.99oz)

4.3 Software Development on Arduino side with the Arduino integrated development environment (IDE)

4.3.1 Architecture of the program on the Arduino

Arduino IDE is a software which can used to program Arduino board; with C or C++ languages; referring to its special programming rules. It supplies a software library from the Wiring project, which provides many common input and output procedures.

To well writing the code; two functions are required:

Setup (): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

Loop (): is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

Another functions furnishes by the internal libraries; are also used in this program: pinMode (), digitalWrite (), and delay ().

The program code is than converted into a text file; in hexadecimal encoding using a specific program; that is loaded into the Arduino board by a loader program in the board's firmware. So you will give short strokes at a click; and the program become uploaded.

4.3.2 Bluetooth_Blimp_Control: Code and explication

Bluetooth_Blimp_Control | Arduino 1.8.4

File Edit Sketch Tools Help

Bluetooth_Blimp_Control

```
#include <Servo.h> //include the library servo

Servo Servo1; //create 4 objects and rename each one
Servo Servo2;
Servo Servo3;
Servo Servo4;

#define MinAngle 45 //define the minimum and maximum angle for servo rotation
#define MaxAngle 135

#define DirPin 4 //choose 2 pin for the propeller direction and speed,pin 5 must be a PWM pin.
#define SpdPin 5

int S1Val = 90; // define the initial angle of each servo
int S2Val = 90;
int S3Val = 90;
int S4Val = 90;

int PMotor = 0; //0: off, 1: fwd, 2: bck
//the propeller is initially off mode.
String str = "";

void setup() // to apply all initial value on servos and propeller
{
  Serial.begin(9600); //serial1 is to make sure that all informations arrive write.
  Serial1.begin(9600); //serial is a connection between bluetooth and arduino.
//9600 is the boad rate: the speed of communication between the bluetooth and the arduuino.

  pinMode(DirPin, OUTPUT); // a function has 2 parameter(direction or speed) & (input or output)
  pinMode(SpdPin, OUTPUT);
```

Bluetooth_Blimp_Control | Arduino 1.8.4

File Edit Sketch Tools Help

Bluetooth_Blimp_Control

```
//  digitalWrite(DirPin, LOW);
  analogWrite(SpdPin, 0); // to be sure that the initial speed is zero.

  Servo1.attach(6); //to choose the servos pins between 14 pins in the arduino board; which must be PWM pin.
  Servo2.attach(9);
  Servo3.attach(10);
  Servo4.attach(11);

  Servo1.write(S1Val); //to give each servo his initial value.
  delay(100); /*a pause between the motion of each 2 servos(so as not be exposed to a shortage
  of electricity if the 4 servos start together)*/
  Servo2.write(S2Val);
  delay(100);
  Servo3.write(S3Val);
  delay(100);
  Servo4.write(S4Val);
}

void loop()
{
  if (Serial1.available())/*when an ordedr arrived to the bluetooth port this function become valid
  so the processor enter into it and start to performs all steps inside */
  {
      S1Val = Serial1.parseInt(); //parsint: whatever the value was it will be taked as an integer
      S2Val = Serial1.parseInt(); /*to check the value arrived from the bluetooth to serial1
      and send it to s1val(value for servo1)*/
      S3Val = Serial1.parseInt();
      S4Val = Serial1.parseInt();
      PMotor = Serial1.parseInt();
      MoveActuators();
```

Bluetooth_Blimp_Control | Arduino 1.8.4

File Edit Sketch Tools Help

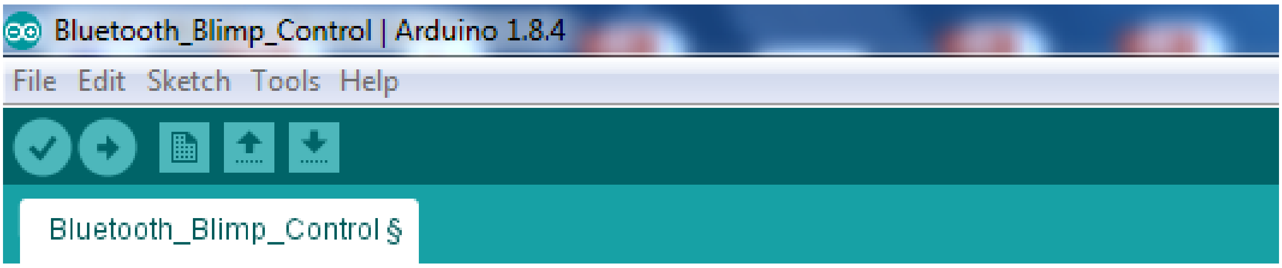
Bluetooth_Blimp_Control

```
  }
}

void MoveActuators()
{
  S1Val = constrain(S1Val, MinAngle, MaxAngle); /*define for each servo the minimum and maximum angle
  to do not take an angle out of this interval*/
  S2Val = constrain(S2Val, MinAngle, MaxAngle);
  S3Val = constrain(S3Val, MinAngle, MaxAngle);
  S4Val = constrain(S4Val, MinAngle, MaxAngle);

  Serial.print(" S1: "); //to print all result
  Serial.print(S1Val);
  Serial.print(" S2: ");
  Serial.print(S2Val);
  Serial.print(" S3: ");
  Serial.print(S3Val);
  Serial.print(" S4: ");
  Serial.print(S4Val);
  Serial.print(" PMotor: ");
  Serial.println(PMotor);

  Servo1.write(S1Val); // to apply all ordered values
  delay(500);
  Servo2.write(S2Val);
  delay(500);
  Servo3.write(S3Val);
  delay(500);
  Servo4.write(S4Val);
  delay(500);
```




```
  switch (PMotor)
  {
    case 0:
      // turn motor off
//      digitalWrite(DirPin, LOW);
      analogWrite(SpdPin, 0);
      break;
    case 1:
      // move motor cw (clock wise)
      digitalWrite(DirPin, LOW);
      analogWrite(SpdPin, 50);
      break;
    case 2:
      // move motor ccw (conter clock wise)
      digitalWrite(DirPin, HIGH);
      analogWrite(SpdPin, 50);
      break;
  }
}
```

Bluetooth_Blimp_Control.ino

4.4 Final assembly

Each part which was described and discussed in the previous chapter will be seen in this chapter in the final assembly; which contains: the programmed arduino,4 servos; bluetooth module;DC Motor; and the battery. All that we have mentioned appears in the following photo (***Figure 67:*** *the final assembly of servo actuator system and its interfaces.*).

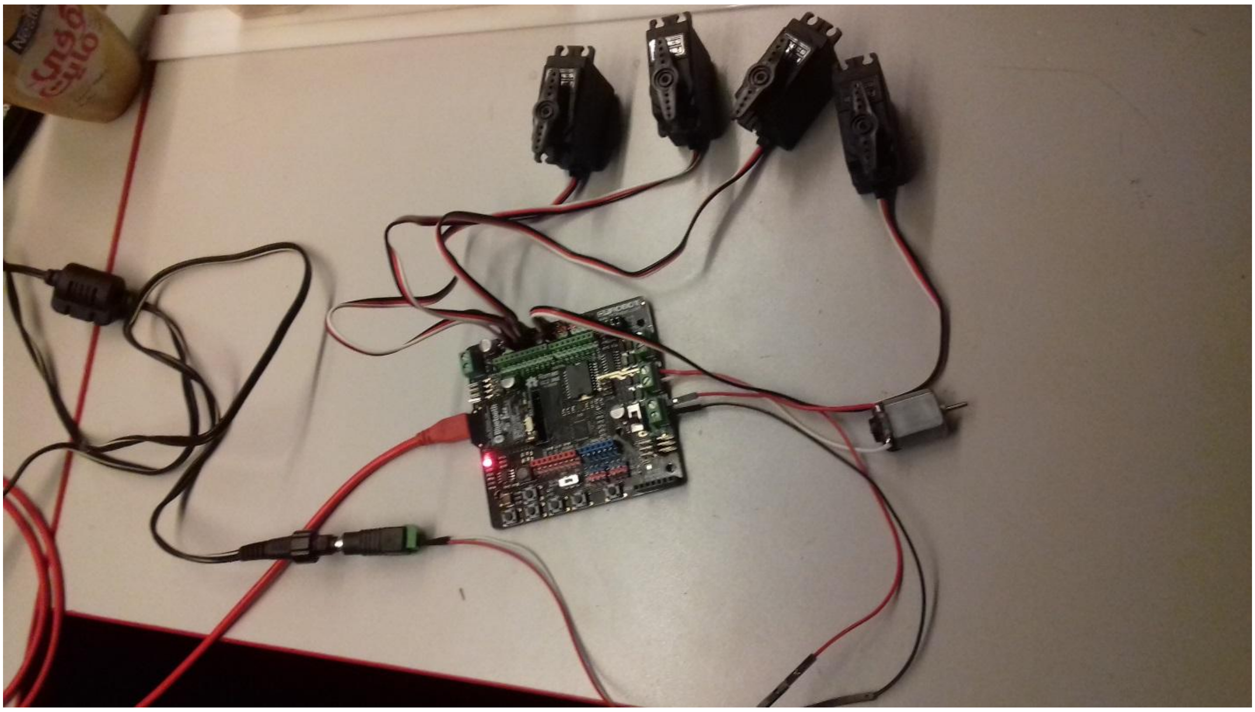
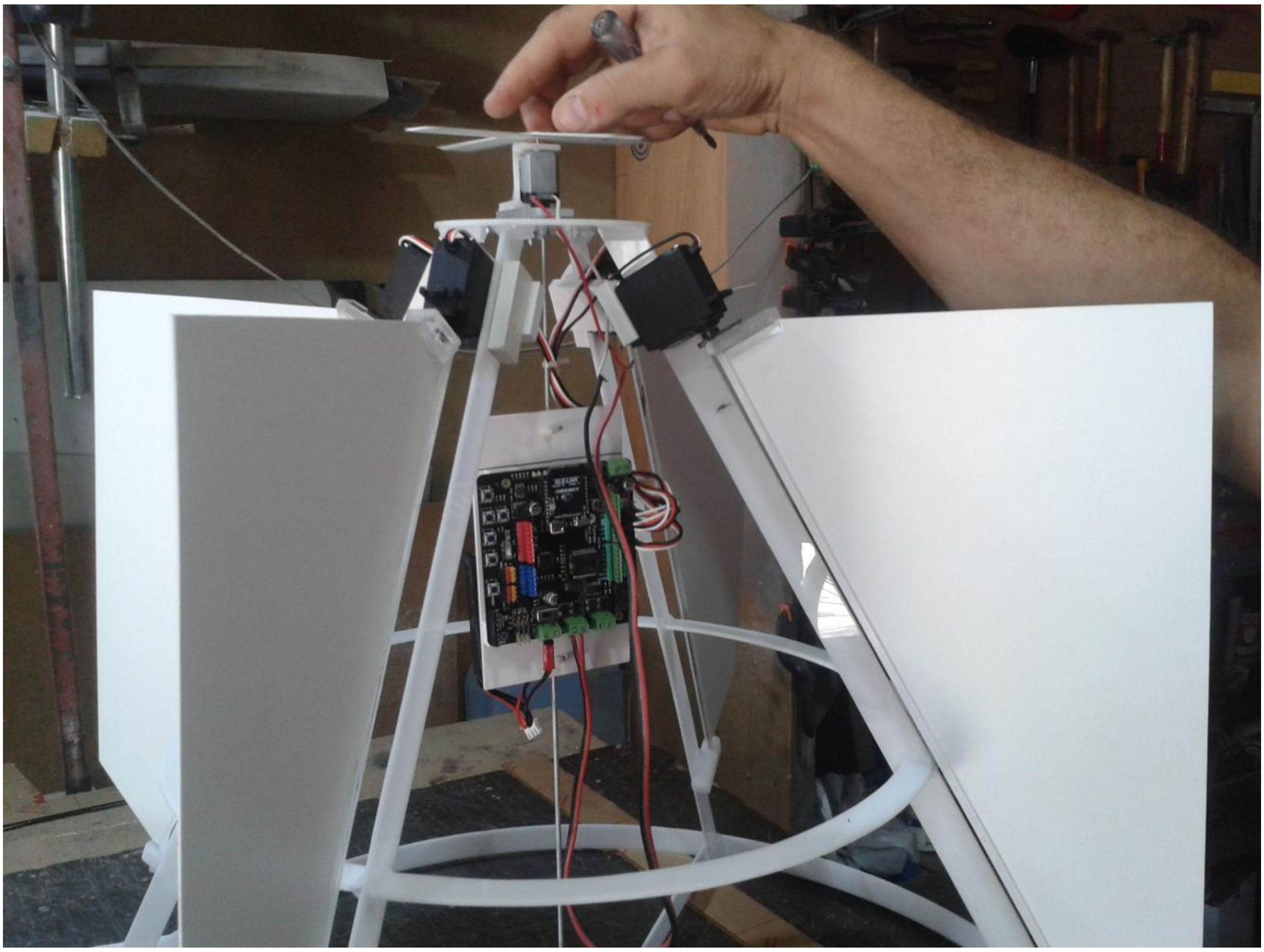


Figure 67: the final assembly of servo actuator system and its interfaces.

In effect the program already written will then uploaded to the arduino board. Once the upload finished; and the arduino supplied by the compatible power ; all servos turned to their intial position (90^0) as defined in the code.



4.5 Testing the integrated actuator

To test this assembly there are several steps to follow. First; make sure that all peripheral devices are well connected to the Arduino board; and the board is supplied by the compatible battery. The light seen on the Arduino confirms the arrival of current into the board. Then; verify the position of all servos on PWM pins (6, 9, 10, and 11) and the DC motor position. Later; start to connect your mobile Bluetooth to BLE link Bluetooth.

And now we start the control using the mobile application "BlunoBasicDemo". To do that you must enter 5 number between each 2 numbers a comma. The 4 first numbers will be the rotation angle of all 4 servos; which must be between the minimum (45^0) and the maximum ($135\ ^0$) angles. And the last number can be 0 (to turn off the propeller's motor) and 1 (to turn it on).

This process is illustrated in the following figure: (***Figure 68:*** *showing how to use BunoBasicDemo to give order to our system.*

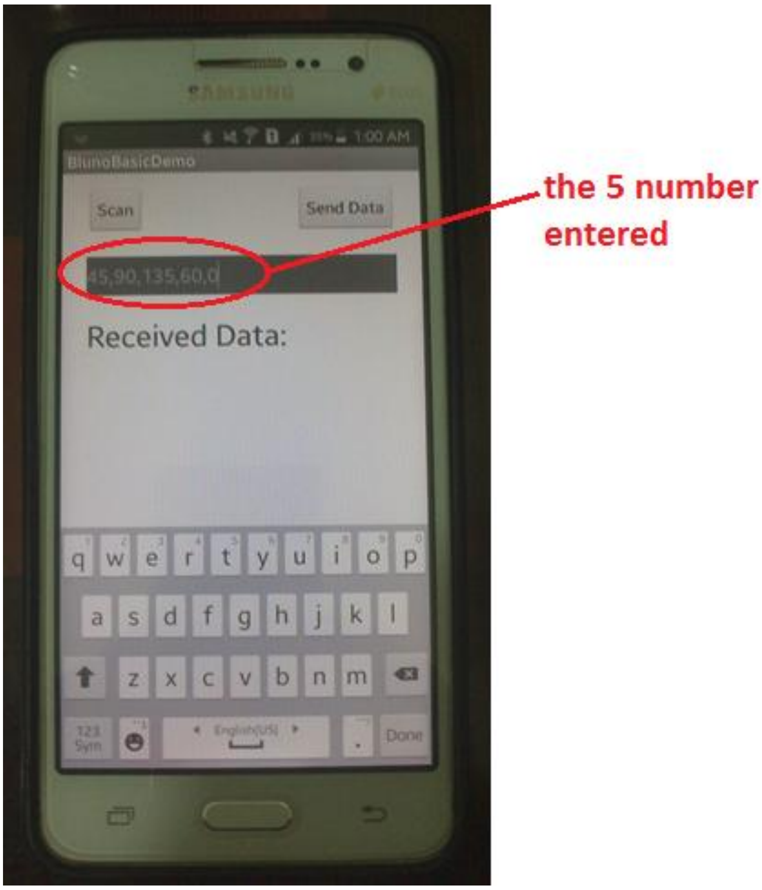
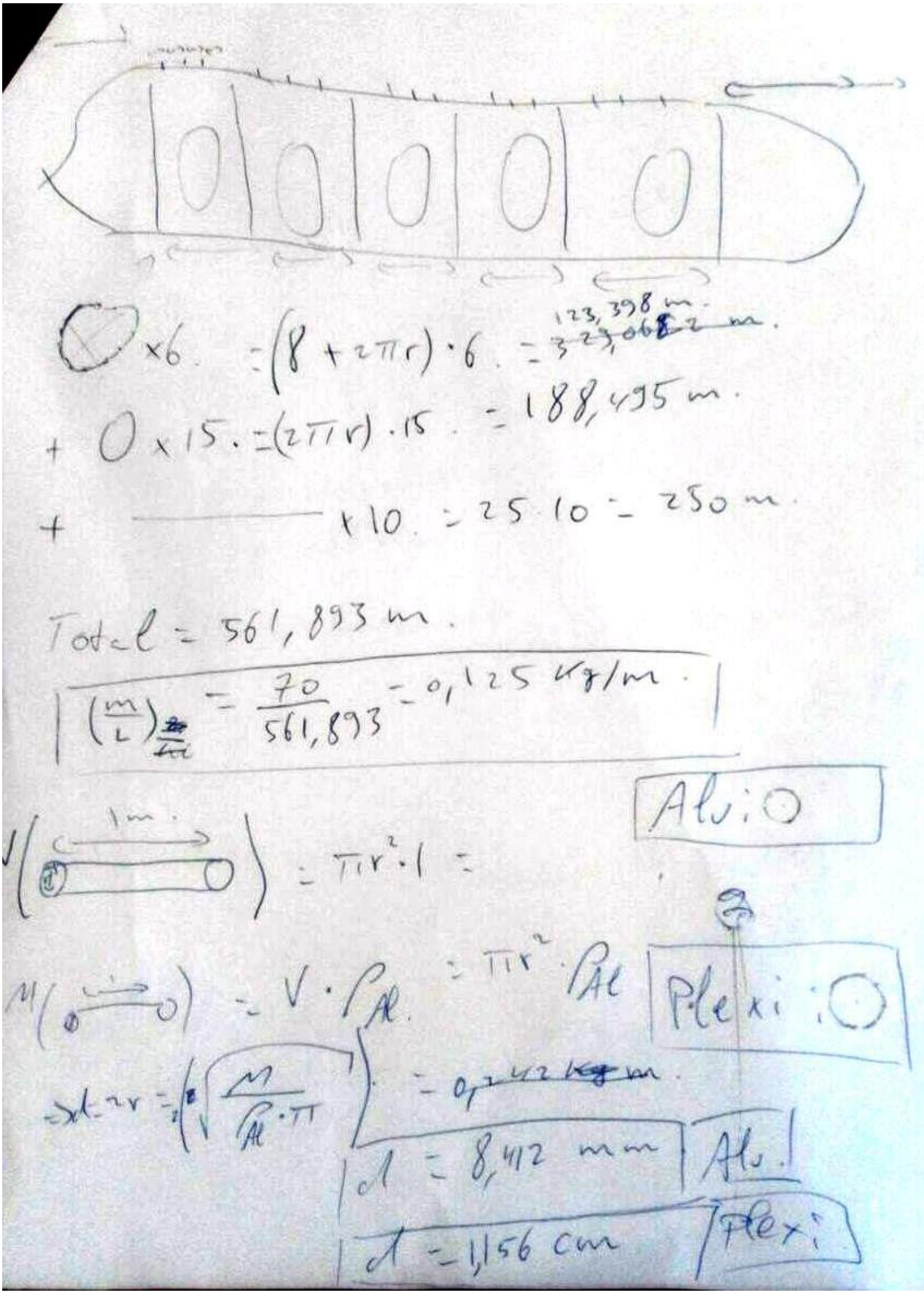


Figure 68: showing how to use BunoBasicDemo to give order to our system.

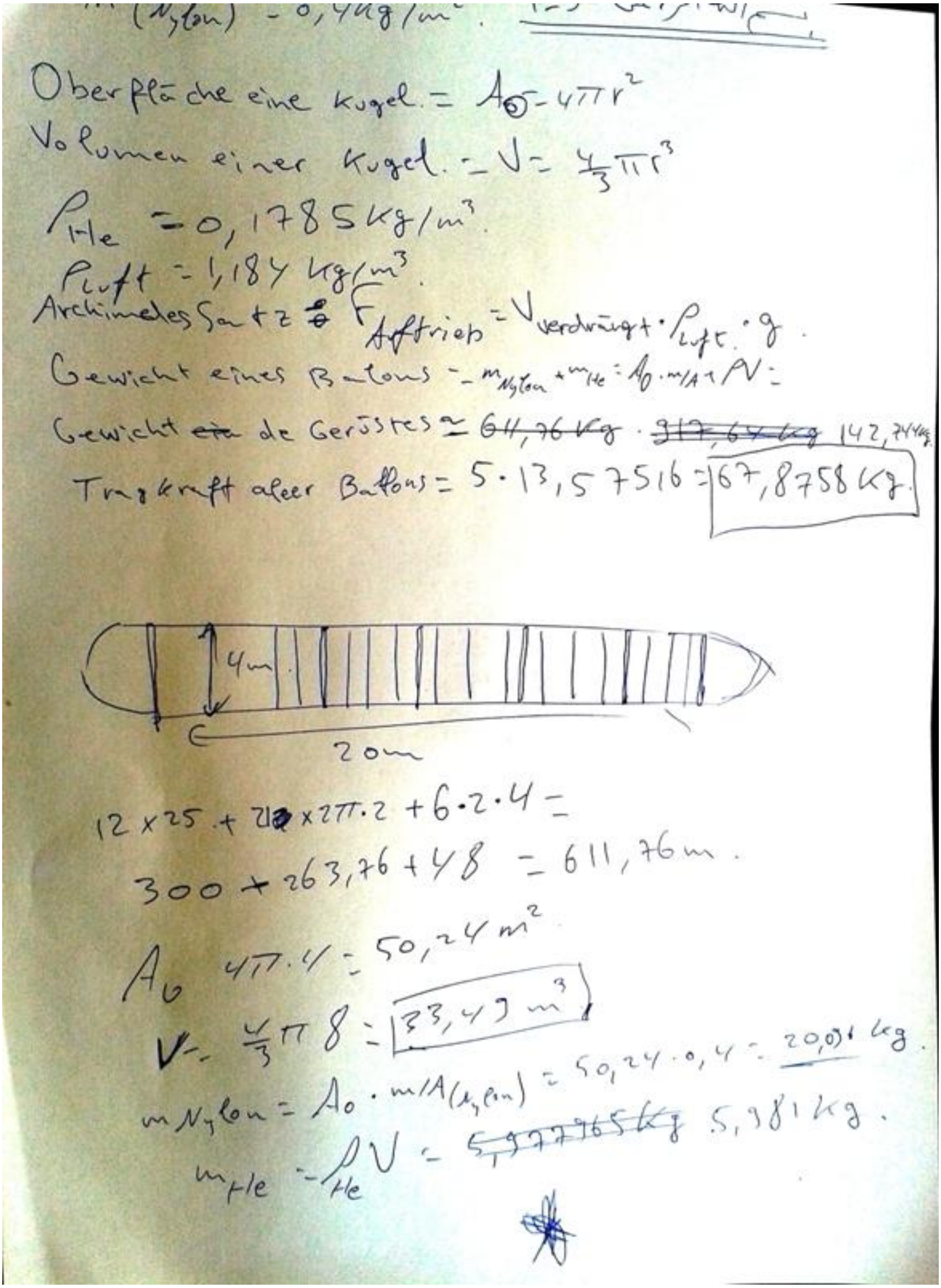
Each servo will turns in the required angle.

5 Prototype Construction

Alumininium Pipes for skelleton



×6 = (8 + 2πr)·6 = 123,398 m.
+ ×15 = (2πr)·15 = 188,495 m.
+ ×10 = 25·10 = 250 m.
Total l = 561,893 m.
(m/L) = 70 / 561,893 = 0,125 kg/m.
Alu:
1m.
V = πr²·l =
Plexi:
M = V·ρAl = πr²·ρAl
d = 8,412 mm
Alu!
d = 1,156 cm
Plexi



(Nylon) = 0,4 kg/m²

Oberfläche eine Kugel = $A_O = 4\pi r^2$

Volumen einer Kugel = $V = \frac{4}{3}\pi r^3$

$\rho_{He} = 0{,}1785\ kg/m^3$

$\rho_{Luft} = 1{,}184\ kg/m^3$

Archimedes Satz: $F_{Auftrieb} = V_{verdrängt} \cdot \rho_{Luft} \cdot g$

Gewicht eines Ballons = $m_{Nylon} + m_{He} = A_O \cdot m/A + \rho V$ =

Gewicht de Gerüstes ≈ 611,76 kg · ~~917,64 kg~~ 142,74 kg

Tragkraft aller Ballons = 5 · 13,57516 = 67,8758 kg

4m

20m

$12 \times 25 + 21 \times 2\pi \cdot 2 + 6 \cdot 2 \cdot 4 =$

$300 + 263{,}76 + 48 = 611{,}76\ m$

$A_O\ 4\pi \cdot 4 = 50{,}24\ m^2$

$V = \frac{4}{3}\pi\, 8 = 33{,}49\ m^3$

$m_{Nylon} = A_O \cdot m/A(Nylon) = 50{,}24 \cdot 0{,}4 = 20{,}096\ kg$

$m_{He} = \rho_{He} V =$ ~~5,97765 kg~~ 5,981 kg

$$V = \frac{4}{3}\pi r^3$$

$$\text{Mantelfläche} = A = 4\pi r^2$$

$$\text{Archimedes} = F_{Auftrieb} = V_{verdrängt} \cdot \rho_{Fluid} \cdot g$$

$$\rho_{plexi} = 1,19\ g/cm^3$$

$$\rho_H = 0,0899\ Kg/m^3$$

$$\rho_{He} = 0,1785\ Kg/m^3$$

$$\rho_{Alu} = 2,6989\ g/cm^3 = 2,6989\ \frac{10^{+3}\ Kg}{10^{-3}\ m^3}$$

$$\rho_{Luft} = 1,293\ Kg/m^3$$

$$\left(\frac{m}{A}\right)_{Nylon} = 400\ g/m^2.$$

$$V_{Balon} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (2)^3 = 33{,}510 \ m^3$$

$$(\text{Mäntelfläche})_{Balon} = 4\pi r^2 = 4\pi (2)^2 = 50{,}265 \ m^2$$

$$F_{Auftrieb} = V_{Balon} \cdot \rho_{Luft} \cdot g = 425{,}052 \ N.$$

$$m_{Balon} = m_{He} + m_{\text{~~Balon~~}nylon} =$$

$$= V_{Balon} \cdot \rho_{He} + \left(\frac{m}{A}\right)_{Nylon} \cdot (\text{Mantelfläche})_{Balon}.$$

$$= 33{,}510 \cdot 0{,}1785 + 0{,}4 \cdot 50{,}265$$

$$= 26{,}088 \ Kg.$$

$$(\text{mögliche getragene masse})_{Balon} = \frac{F_{Auftrieb}}{g} - m_{Balon}.$$

$$= 43{,}32843 - 26{,}088$$

$$= 17{,}240 \ Kg.$$

$$(\text{mögliche getragene masse})_{5\ Balons} = 17{,}240 \cdot 5.$$

$$= 86{,}202 \ Kg.$$

(Mögliche Nutzlast) $\approx$ 16,0[illegible] Kg

6 References

6.1 References for Chapters 1

[FatimaAlChaar 2015] Fatima Al Chaar, "Simulation of the meteorological satellite IAP-SAT", Master Thesis, AECENAR/LU, 2015, see www.aecenar.com/publications

6.2 References for Sections 2.1, 2.10-2.15 and Chapter 4

[1]: http://www.portail-aviation.com/2015/07/dossier-dirigeable-episode-1-lhistoire-des-dirigeables-pionniers-de-laeronautique.html

[2]:https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/airship_aerodynamics.pdf

[3]: https://en.wikipedia.org/wiki/Actuator

[4]: https://www.quora.com/What-is-an-actuator

[5]: http://www.baldor.com/Shared/manuals/1205-394.pdf

[6]: https://en.wikipedia.org/wiki/Pneumatic_motor

[7]:http://www.bluetools.com/Air-Tools-Motors/c88_50/index.html

[8]: http://www.machinedesign.com/archive/basics-electromagnetic-clutches-and-brakes

[9]: http://www.warnerelectric.com

[10]: https://learn.adafruit.com/all-about-stepper-motors/what-is-a-stepper-motor

[11]: https://en.wikipedia.org/wiki/Induction_motor

[12]: http://electronicsforu.com/buyers-guides/selecting-electric-motor-drive-system

[13]: https://en.wikipedia.org/wiki/Hydraulic_motor

[14]: http://www.directindustry.com/prod/hydro-leduc/product-7677-1287099.html

[15]: https://circuitdigest.com/article/servo-motor-basics

[16]: https://www.sparkfun.com/products/11965

[17]: https://www.iei.liu.se/flumes/tmhp51/filearchive/coursematerial/1.105708/HydServoSystems_part1.pdf

[18]: https://books.google.com.lb/books?id=cF7YBAAAQBAJ

[19]: www.mobilehydraulictips.com/hydraulic-motors/

[20]: http://www.supinfo.com/articles/single/296-qu-est-ce-qu-servomoteur

[21]: https://www.teamrobobox.fr/documentation/02_Le_moteur.pdf

[22]: http://www.jameco.com/jameco/workshop/howitworks/how-servo-motors-work.html

[23]: https://www.servocity.com/what-is-a-servo

[24]: http://www.pobot.org/+-servomoteur-+.html?lang=fr

[25]: https://www.scribd.com/document/99583469/Introduction-to-Servo-Motors-Arduino

[26]: https://makezine.com/2016/05/13/understanding-types-of-servo-motors-and-how-they-work/

6.3 References for Sections 2.2-2.9 and Chapter 3

[1] **Joseph Louis Lecornu, *La navigation aérienne: histoire documentaire et anecdotique***

[2] **La technique du ballon, G. Espitallier - 1907**

[3] **www.eballoon.org**

[4] **Frederick, Arthur, et al., *Airship saga: The history of airships seen through the eyes of the men who designed, built, and flew them*, 1982**

[5] **Griehl, Manfred and Joachim Dressel, *Zeppelin, The German Airship Story*, 1990**

[6] Archbold, Rich and Ken Marshall, *Hindenburg, an Illustrated History*

[7] **Althoff, William F., *USS Los Angeles: The Navy's Venerable Airship and Aviation Technology***

[8] Lutz, T. and Wagner, S., "Drag Reduction and Shape Optimization of Airship Bodies," Institute for Aerodynamics and Gas Dynamics, University of Stuttgart, AIAA, Germany, 1997.

[9] **Rehmet, M. A., Krplin, B., Epperlein, F., R.Kornmann, and Schubert, R., "Recent Developments on High Altitude Platforms**

[10] **www.plastiquesurmesure.com/materiaux-plastiques.html**

[11] www.carnetdevol.org/zeppelin/technique.html

Appendix A: Contact data of specialists (معلم), workers, ...

Specialist for / price	**Name**	**Address**	**Phone**
Aluminium, 80$/qm	عمر	بعبدة - عكار	70 140828
Electricity 25 USD/day	Abdullah (from Syria), brother of Ibrahim (Mustafa knows him)		
Sanitary 25 USD/day	Abdullah (from Syria), brother of Ibrahim (Mustafa knows him)		
Painting 25 USD/day	Abdullah and Ibrahim (from Syria) (Mustafa knows them)		
Bilat	Mustafa (from Halab)	Ras Nhache	76 493901
Welder / Metal working	Muhammad Qammah	Mina	70 339875
	Muhammad Akkumi	Biddawi	71669613
	Said Hussein, 25-45.000LL/day	Biddawi	06/383728 or 03/793802
Stainlessschweißer	Bilal Naouchi	bilalnaoushi@hotmail.com	03 446027
Wärme u. Kälte technik u.s.w.	Khidr Balita	Mina	03 232088

Appendix B: for Aerodynamic Investigation

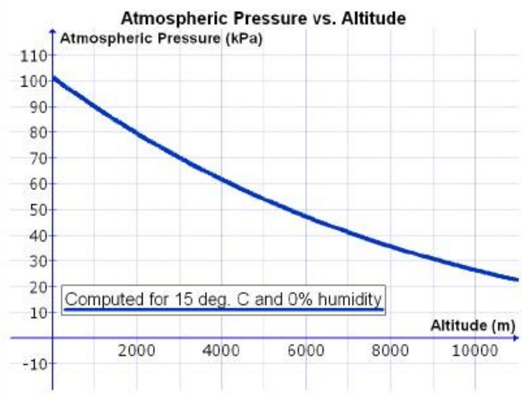
Initial Working packages

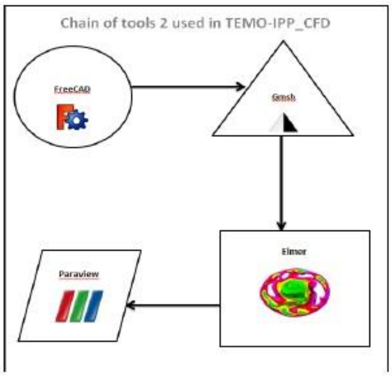
Ras Nhache, Batroun/Tripoli, 27.02.2017

There TEMOLebanon-Mintad project aims to offer internet access via a airship platform. There are the following Milestones for 2017/2018:

- Sep 2017: Low-altitude flying airship (1-3 km) for internet supply is in operation (above Qalamoun/Ras Nhache) (prototype is developed with some master thesis')
- 2018 High-altitude platform (20-22 km) for internet supply in cooperation with Turkey

Master Thesis: aerodynamic investigation of a solar powered high altitude airship





Tasks:

- Rough modeling of all parts of platform including internet communication payload
- Computing of total weight to required helium gas volume of lifting cells relation
- Specification of rough design parameters of airship (lenght, volume of lifting cells) and alttitude 1 (about 1-2 km) and altitude 2 (about 20 km)
- Animation (Film) of flights in the two operational altitudes

Contact:

Eng. Samir Mourad, Mob. +961 76 341526 (Lebanon), WhatsApp +49 178 7285578 (Mob. Germany)

Estimation for costs of logging sensors during flight

Haykalyeh Str Harba Bld Ground
Floor
Ras-Maska
Tripoli, Lebanon, 0000
Phone # 06412895
Web Site www.cnclablb.com

Estimate

Date	Estimate #
8/15/2017	E17-54

Name / Address	Ship To
Souha Bakri	

Customer Phone	P.O. No.	Price Level

Item	Description	Qty	Cost	Total
WRL0057	HR GY-NEO 6M V2 GPS module	1	27.95	27.95
INT0089	Micro SD Storage Board TF Card Reader Memory Shield	1	1.94	1.94
PWR0024	Polymer Lithium Ion Battery - 1000mah 7.4v	2	12.95	25.90
DEV0042	HR UNO R3 + USB Cable	1	12.95	12.95
PRT0005	Jumper Wires - Connected 6\" (M/F, 20 pack)	1	2.50	2.50
SEN0131	HR 3pin Button Key Switch Sensor Module	1	1.95	1.95
INT0030	Digital Red LED Light Module	1	2.99	2.99
			Total	$76.18

This quotation is valid for 30 days since issued

Customer Signature ______________________

Appendix C: for Actuator System

Initial Working packages

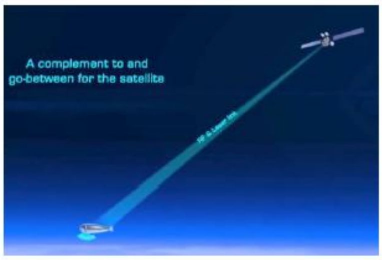
AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
www.aecenar.com

IAP INSTITUTE FOR ASTROPHYSICS

Ras Nhache, Batroun/Tripoli, 10.03.2017

The TEMOLebanon-Mintad project aims to offer internet access via a airship platform. There are the following Milestones for 2017/2018:

- Sep 2017: Low-altitude flying airship (1-3 km) for internet supply is in operation (above Qalamoun/Ras Nhache) (prototype is developed with some master thesis')
- 2018 High-altitude platform (20-22 km) for internet supply in cooperation with Turkey

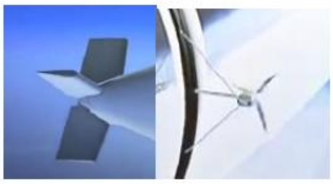


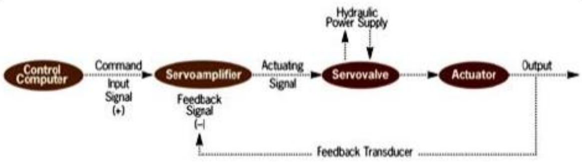
Master Thesis: Solar-power based actuator system for an airship

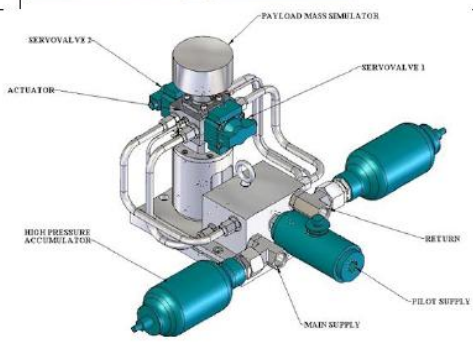
Energy Supply Generation System:

Solar plates -> Electrolyzer -> Hydrogene Gas tank -> Fuel Cells

Actuator System: Paddles, Propeller







Literature:

https://partners.ni.com/directory/solution/details.aspx?id=63&tab=overview

http://www.ideal-aerosmith.com/motion/model-hla-hp-hydraulic-linear-actuator-high-performance

https://partners.ni.com/directory/solution/details.aspx?id=63&tab=overview

Tasks:

- Detailed Modeling of elements Energy Supply Generation System and Actuator System with FreeCAD
- Contruction of a test system for Energy Supply Generation and Actuator System

Contact: Eng. Samir Mourad, Mob. +961 76 341526 (Lebanon), WhatsApp +49 178 7285578 (Mob. Germany)

Outworked by Amena Shaker

Quotation for Arduino based actuator system

All material and interfaces from: www.cnclablb.com

Invoice

Date	Invoice #
9/6/2017	I17-53

Bill To	Ship To
Dr. Samir Mourad	

P.O. Number	Terms	Ship	Via	Customer Price Level
		9/6/2017	Aramex	

Item Code	Description	Quantity	Price Each	Amount
ACT0057	HR Servo S3003	4	7.95	31.80
DEV0005	DFRduino Romeo V2 - motor drive built in	1	44.73	44.73
WRL0024	BLE Link Bluetooth Bee	1	23.95	23.95
PWR0024	Polymer Lithium Ion Battery - 1000mah 7.4v	1	13.95	13.95
ACT0059	HR DC toy motor 3V-6V	1	1.95	1.95
Consultancy	Consultancy Fees Hourly Rate	1	100.00	100.00
			Total	$216.38

Appendix D: For Prototype Construction

Initial Working Packages

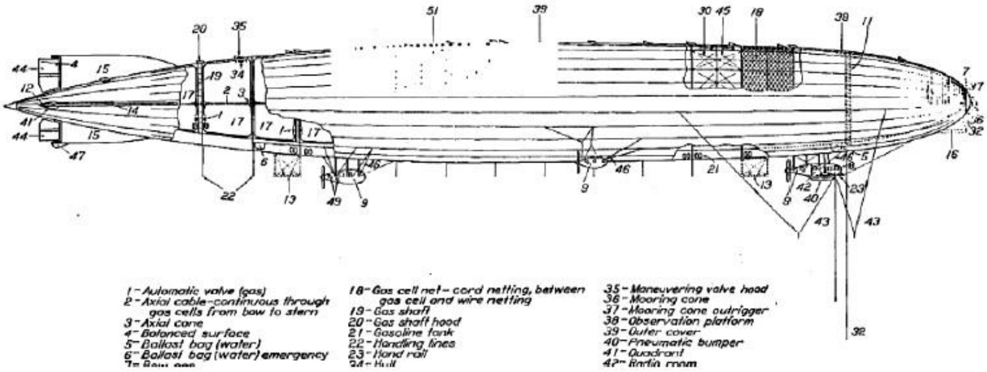
Ras Nhache, Batroun/Tripoli, 27.02.2017

There TEMOLebanon-Mintad project aims to offer internet access via a airship platform. There are the following Milestones for 2017/2018:

- Sep 2017: Low-altitude flying airship (1-3 km) for internet supply is in operation (above Qalamoun/Ras Nhache) (prototype is developed with some master thesis')
- 2018 High-altitude platform (20-22 km) for internet supply in cooperation with Turkey

Master Thesis: Construction, manufactoring and testing of a solar powered high altitude rigid airship

A rigid airship with a carrier frame formed of cross-ribs interconnected by long beams. A plurality of cross-ribs is interconnected by long beam sections interposed between neighboring cross-ribs. The so-formed carrier frame supports the lift producing carrier or lift gas cells and any other structural groups needed for the operation of the airship.



http://naca.central.cranfield.ac.uk/reports/1927/naca-report-240.pdf, p.73

Tasks:

- Construction of an airship based on patent, see https://www.google.com/patents/US5110070?hl=de&cl=en (
- Mounting a solar system
- Mounting actuator system (from other master thesis)
- Testing of airship at altitude of about 1 km

Contact:

Eng. Samir Mourad, Mob. +961 76 341526 (Lebanon), WhatsApp +49 178 7285578 (Mob. Germany)