UNIVERSITAT POLITÈCNICA DE VALÈNCIA
CAMPUS D'ALCOI

Uniwersytet Technologiczno-Przyrodniczy
im. Jana i Jędrzeja Śniadeckich w Bydgoszczy


Polytechnic University of Valencia,

Alcoy Campus –

Uniwersytet Technologiczno-Przyrodniczy


Mechanical engineering and Industrial design engineering and product development

# STUDY AND DESIGN OF AN UNMANNED AERIAL VEHICLE


Author: Borrell Jornet, Jordi

Tutor: Pérez Fuster, Joaquín

Graphic and Design Department

Tutor: Szczutkowski, Marek

Mechanical Department


Bydgoszcz, Poland 11 June 2018

Abstract:

The objective of this Final Project is the study, design and construction of Unmanned Aerial Vehicles (UAV). A detailed analysis will be provided both internally and externally of the object of study in order to understand its functionality, generalities and applications. In addition, the "Initiation" and "Product and process design" phases will be carried out, describing the manufacturing processes by machinery and industrial plant applied to the current regulations. In this way you can obtain a manufacturing cost with which to make the project viable.

In the "Initiation" phase, the requirements and restrictions of designs according to the market, uses, user, processes, materials, safety regulations and other specific studies will be defined. In the "Product and process design" phase, viable solutions will be obtained specifying shapes and dimensions to accommodate the highest possible load.

If the time and magnitude of the work permit, the "Implementation" and "Operation" phases can be carried out.

In the "Implementation" phase, the intention is to build the prototypes by applying the methods and processes that are carried out in the manufacturing industry of this type of products. And, in the "Operation" phase, the product support documentation will be prepared, such as: the catalog, presentation videos and instruction manual.

If the "Implementation" phase fails for economic and time reasons, a scale prototype can be made in 3D printing.

Keywords:

Drone, application, design, UAV, mechanical, loads

Resumen:

El objetivo del presente Trabajo Fin de Grado consiste en el estudio, diseño y construcción de Vehículos Aéreos No Tripulados (VANT). Se proporcionará un análisis detallado tanto interno como externo del objeto de estudio con el fin de entender su funcionalidad, generalidades y aplicaciones. Además, se llevarán a cabo las fases de “Iniciación” y de “Diseño del producto y del proceso” describiendo los procesos de fabricación mediante maquinaria y planta industrial aplicadas a las normativas vigentes. De esta forma se podrá obtener un coste de fabricación con el que viabilizar el proyecto.

En la fase de “Iniciación” se definirán los requisitos y restricciones de los diseños acordes al mercado, usos, usuario, procesos, materiales, normativa de seguridad y otros estudios específicos. En la fase de “Diseño del producto y del proceso” se obtendrán soluciones viables especificando formas y dimensiones para albergar la mayor carga posible.

Si el tiempo y la magnitud de trabajo lo permite, se podrán llevar a cabo las fases de “Implementación” y de “Operación”.

En la fase de "Implementación" se pretende construir los prototipos aplicando los métodos y procesos que se realizan en la industria manufacturera de este tipo de productos. Y, en la fase de "Operación" se elaborará la documentación de soporte al producto como son: el catálogo, videos de presentación y manual de instrucciones.

Si la fase de "Implementación" falla por motivos económicos y de tiempo se podrá realizar un prototipo a escala en impresión 3D.

Palabras clave:

Dron, aplicación, diseño, VANT, mecánica, cargas

# Image Index

Table Index



Graph Index

# INTRODUCTION

Remotely Piloted Aircraft Systems have gained great significance due to their economic potential and practical applicability. These systems allow the operation of an aircraft without a pilot on board, and include the ground control station, the communications link and the aircraft. Current regulations restrict the operation of these aircraft to segregated airspace, so multiple studies and initiatives are being conducted to achieve their integration into shared or non-segregated airspace, to ensure their viability. Non segregated airspace has a clearly defined structure, procedures and information services which are known as Air Traffic Management. The main function of Air Traffic Management systems is to those services required for the safe operation of aircraft into shared airspace, so that the interaction of these new systems is paramount for the future development.

The possibility of transmitting images or data in real time to a base or terrestrial devices, or the increase of the load that can transfer them, has meant a great advance, since it has allowed incorporating a greater number of sensors that allow controlling agents of the flight, such as speedometers, gyroscopes or altimeters, or external agents such as gas concentrations, or the implementation of the LIDAR system, among others. Waking up the interest of a new civil industry dedicated exclusively to the manufacture and maintenance of these unmanned vehicles. Therefore, drones are used in multiple applications depending on the number of sensors they have incorporated. The simplest and cheapest aircraft have image stabilizers and optical cameras, to capture or record any image that is relevant, these are widely used in industries related to entertainment, while the most complex have countless sensors, cameras and communication systems, whose purpose is to perform a sweep of the environment that surrounds them, detecting and attacking any type of danger that may occur, these aircraft are widely used in the military field.

This project aims to show from 0 the design, operation and construction of a drone capable of being used for the taking of moving aerial images and the transport of heavy elements.

Among the main objectives, you can find:

-Normative: industrial ship, machine, object...

-Market study about the object

-Object design (SolidWorks)

  -Analysis of materials, forces and mechanical resistance of the object (Ansys)

  -Render (Keyshot)

-Design the plans of an industrial plant (Autocad)

  -Electrical parts, wiring, switches, emergency lights, fire extinguishers…

-Route of operators for the construction of the object

-Distribution of machinery in the industrial ship

-Production times, processes, budget and machinery controls

-3D printing (Slic3r, Netfabb)

**DESCRIPTIVE MEMORY**

**1.1 BACKGROUND**

The starting conditions are:

-The innovative design of a drone capable of carrying weight for use in messaging

-Mechanical elements and forces that can intervene.

-Normative of materials, machinery and plans

**1.2 OBJECT OF STUDY**

The purpose of this study is to describe the preliminary design and mechanical process by presenting the elements that will intervene in the project.

**1.3 PROJECT JUSTIFICATION**

Drones are an emerging technology that few people know. The purpose is to focus this novelty for the improvement of society, looking for different solutions and applications through the improvement of these objects.

**1.4 MARKET STUDY**

The object of market study is a drone.[1]

Companies are looking for new developments in this emerging field in terms of design and applications, so we will seek to find a quality solution in terms of the construction of the pieces that will compose the drone, always trying to enter a market gap where the differentiation is the main priority.

Magnitude and size of market:

Within the emerging market of this type of products we find two clearly differentiated sectors. On the one hand, there is the final consumer who uses the product for enjoyment through the recording images and control.

On the other hand, the most important courier companies want to be able to reach their consumers as soon as possible. In this way they look for legal means that allow them to use this type of objects for their benefit.

The drones are organized according to prices from the highest quality. Depending on the consumer's economy, the purchase range will increase or decrease the price. In the market, there are all kinds of price, so it focuses on a high quality area for the proposed drone. This happens because the consumer can acquire this product in the same way as companies.

The companies will obtain a quality product that satisfies their needs of transport of messaging service up to a maximum of 10 Kg and the consumers, in addition to being able to obtain this service; will also be able to use it for the recording of aerial images.

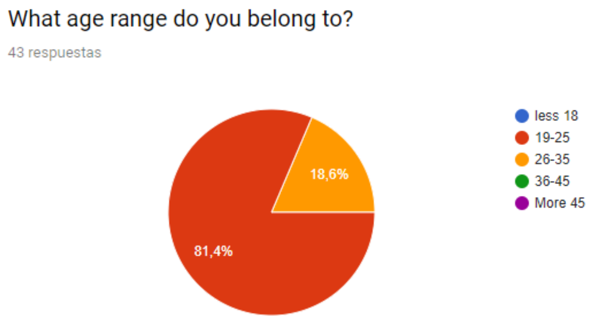
Then, the different results of the market study are shown in order to understand the main needs of consumers and their habits. In this way, it is possible to focus on a market segment to introduce the product.

The market study consists of a business initiative in order to get an idea about the commercial viability of an economic activity.

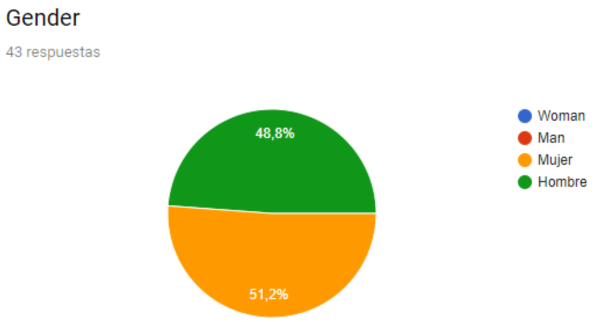
That is why it is intended to know by hand what are the thoughts, concerns and characteristics that society values in this type of objects.

In addition, it is important to know the buyer model by age, gender, range of money to be able to satisfy the most in-depth needs of final consumers.

A survey of 50 anonymous people has been carried out to Spanish people. The survey was done in March between $13^{th}$ – $20^{th}$ and passed on the internet. UPV has a platform for do surveys and people of all university can do it. This is why 50 people decide to fill it and know more about drones.



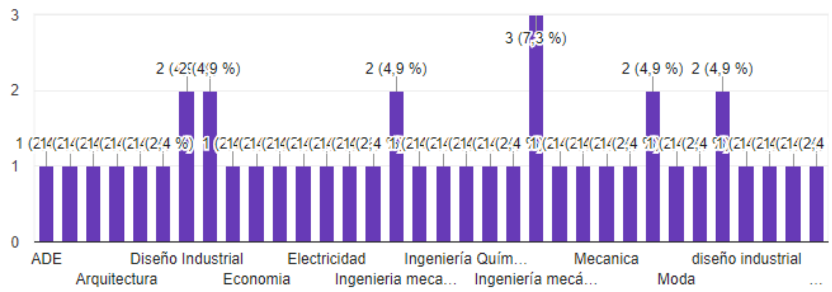

Graph 1: Age




Graph 2: Gender

Especiality

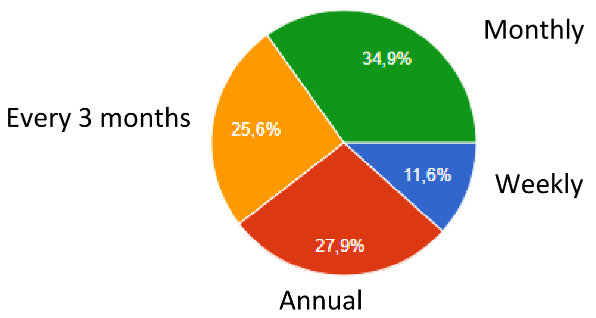
41 respuestas




Graph 3: Speciality

What is your purchase frequency online?

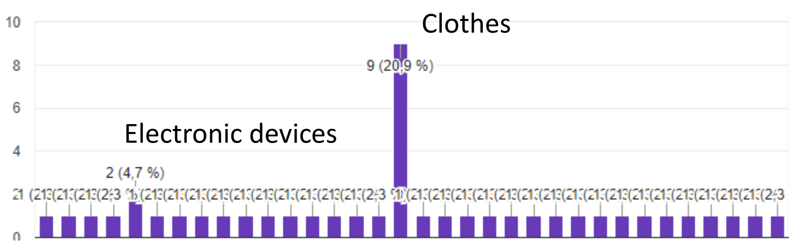
43 respuestas




Graph 4: Frequency

What do you usually buy online?

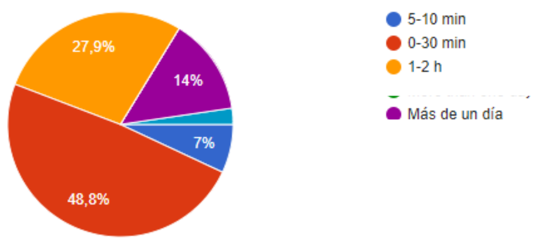
43 respuestas




Graph 5: purchases

How much time do you spend to make the purchase?

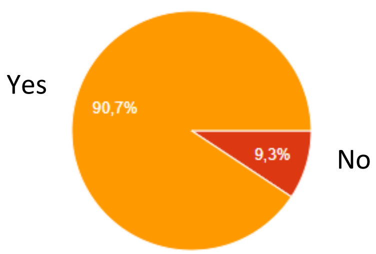
43 respuestas




Graph 6: time

Do you consider important the time from when the seller sends the product until you receive it?

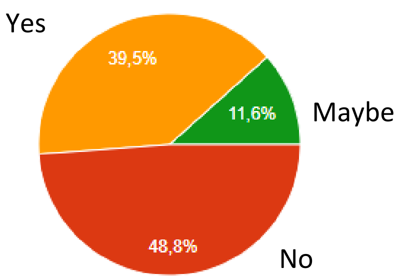
43 respuestas




Graph 7: Seller time

If Amazon could send your order faster using a drone, would you be willing to pay an extra shipping fee?

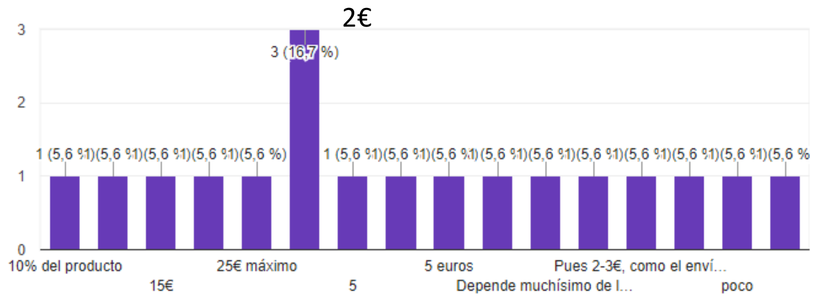
43 respuestas




Graph 8: Sending

If you chose yes, specify how much

18 respuestas




Graph 9: Additive

What do you think a drone is for?

43 respuestas

Diferentes usos, tanto laboral como de ocio

Para grabar videos

Para realizar fotografías, vídeos, transporte de paquetes de pequeño tamaño.

Seguridad, fotografía, expedición...

Para Poder grabar y transportar cosas pequeñas en rangos cortos

Para realizar grabaciones, fotografías...

Para muchas cosas, por ejemplo para realizar vídeos aéreos, para transportar objetos no muy pesados, etc...

Para hacer vídeos aéreos

Para hacer fotos desde el aire

Diversos usos: exploración de lugares peligrosos, mejora en empresas de transporte,topografía, fotografía...

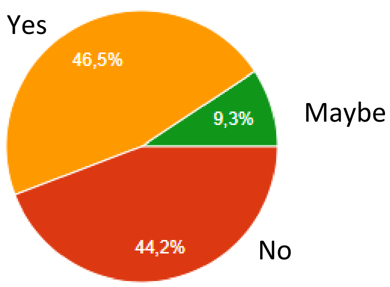
Tiene múltiples utilidades, transporte, vigilancia, rescates, agricultura...

Para vistas sobre el aire

Graph 10: Thought

Do you consider a drone dangerous?

43 respuestas




Graph 11: Danger

How do you think it could improve the safety of drones?

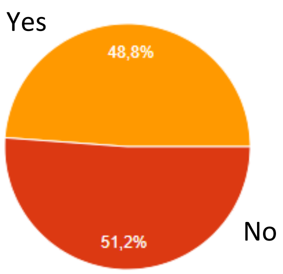
43 respuestas

- Mayor estabilidad y control durante el vuelo
- Incluyéndose un chip que informe de su localización
- Sistemas informáticos más seguros y restrictivos
- Haciendo que cada dron posea un GPS y tenerlo controlados así
- Incluyéndole un dispositivo localizador
- Centrarse en la mejora de la hélices
- Control de venta
- Sistemas de detección de personas para evitar choques
- Estructura
- De ninguna manera
- Protecciones en las hélices, emisión de sonido para avisar de su posición, detección de objetos para evitar colisiones, etc
- Tal vez que las hélices no sean tan filosas

Graph 12: Security

Have you ever thought about buying one?

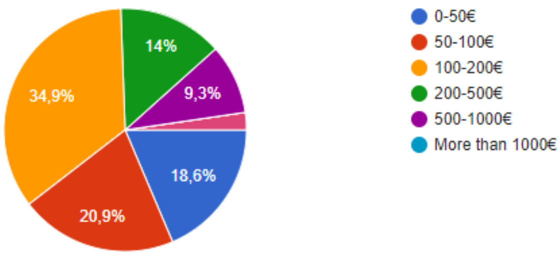
43 respuestas



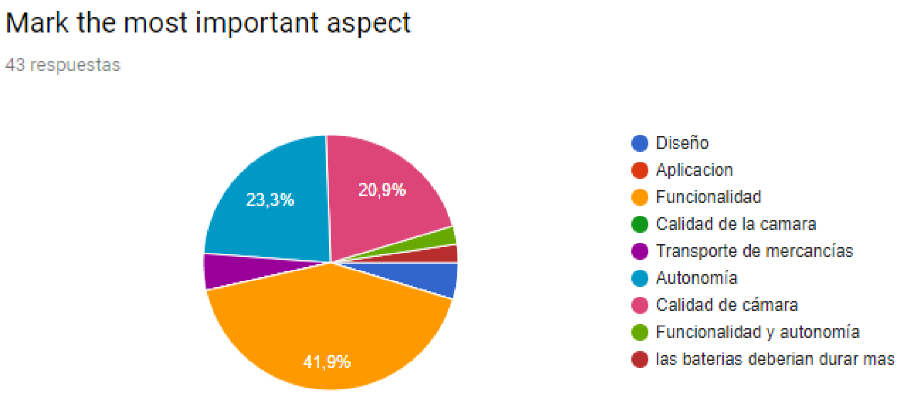

Graph 13: purchase of drone

If you had the possibility of buying one in which strip of money would you move?

43 respuestas




Graph 14: Possibility




Graph 15: Aspect

Conclusion:

Most people interested in drones are between 19 and 25 years old and have baccalaureate and university degrees.

The highest percentage of online purchases is monthly, highlighting the purchase of clothes and electronic devices, and spending an average of 30 minutes during the online purchase.

Almost 100% of the respondents believe that the shipping time of the online seller is important, so that a part of them would pay a supplement to receive faster products.

Regarding drones, many people agree that drones are used to record, transport objects, have fun and fly over difficult areas.

In turn, half of them think that a drone is dangerous and that they should improve certain parameters especially in autonomy, control and propellers.

There is a diversity in the range of opinions on how much to pay for a drone (€ 100-500) and on the most important aspect of a drone: Functionality and Autonomy.

## 1.5 DESIGN CONCEPT SELECTION

For this case, it will be based on a conceptual design that will penetrate directly into the appropriate segment of the market. If we wanted to obtain different solutions, we would use the Weighted Technical Value method.

Image 1: Design concept selection

## 1.6 ANALYSIS OF INTERNAL ELEMENTS [2]

-Frame or Chassis

It is the skeleton of the multirotor. It is the structure that gives it shape and where all the components of it must be housed for its correct operation: Motors, electronics, batteries, etc.

The materials used for the construction of the chassis, are closely related to the benefits to which the drone is destined (aluminium, carbon fibre, fiberglass, Kevlar, etc.) and closely related to the price.

Image 2: Frame

-Motors

They are the fundamental components to keep the multirotor in the air. The most common are the Brushless type electric that do not use brushes to make the change of polarity in the rotor. They stand out for the weight / power ratio.

Image 3: Motors

-Regulators

The speed regulators or ESC (Electronic Speed Control) are responsible for electronically providing the necessary revolutions to each motor / propeller individually at a given time to perform different movements (elevations, rotations, translations, acrobatics, etc.).


Image 4: Regulators

-Flight Controller or Control Unit

It is the brain of all Drone. Controls everything that happens in the Drone and is where they are connected almost all components of the Drone (regulators, sensors, etc).

Most common sensors:

Gyroscope. - Allows to have the drone level.

Accelerometer. - Measures variations of acceleration or speed.

Barometer. - Measures height variations, also called altimeters.

Compass. - Measure the orientation of the drone.

GPS. - Measure and place the drone in geographic coordinates. (GPS satellites network)

Image 5: Fly complements

-Propellers

They are manufactured in different sizes and materials, composed of nylon, carbon fibre, etc. They are responsible for, changing enough thrust for each pair of motors turning in the opposite direction.

Each helix is determined by two digits (50/30) where the first digit represents the length of the helix and the second digit the pich or helix pitch. Higher length of the thruster causes higher thrust and also the higher current count. So you have to use the propellers appropriate to any model.

Image 6: Propellers

-LIPO Batteries (Lithium Polymers)

Provide the necessary energy to operate the Drone. They are very heavy components so it is essential that they are able to have a good weight / capacity ratio to maximize the autonomy of the Drone's flight. The lithium polymer is due to its energy density, its low weight and its high discharge rate which is ideal for agile manoeuvres like those of a multirotor.

Image 7: Battery

-RC transmitter

The Issuer is the remote control of the drone and the one that establishes the communication between the pilot and the Drone in a bidirectional way: the pilot gives flight instructions to the drone and the drone gives relevant information about its status to the pilot, such as the state of the battery or your GPS position.

·Types of wireless communications.

A.M, FM, 2.4 Ghz. The 2.4 Ghz being the most frequent in aeromodelling because it ends with interference problems.

Wi-Fi: Bluetooth Used in Drones equipped with Wi-Fi or Bluetooth control for Tablet or Smartphone.

·Channels of the station:

Each of the channels manages a function of the Drone by electronic servos. Examples of channels are: the power channel, elevation channel, rudder channel, etc.

·Screen:

It shows all the relevant information about the status of the drone to the pilot: Battery consumption, position coordinates, status and quality of the signal, FPV, etc.

Image 8: RC transmiter

-FPV (First Person View)

The FPV is a system of transmission and reception of the video captured by the camera of the Drone, in real time. This way the pilot can see what the drone is "seeing". It is one of the most mentioned characteristics when choosing a drone or another.

Image 9: First person view

-Camera and Stabilizer

The structure of the drone have a camera installed (many are included) that depending on the power of the drone can be a small size GoPro to a professional type. The camera is installed in a stabilizer called Gimbal to prevent the movements of the multirotor flight from affecting the shots. These gimbal absorb the vibration of the motors and automatically correct the inclination of the camera so that it is always at the same angle with the ground. Depending on the quality of the station we can have a channel to move the Gimbal and position the camera.


Image 10: Camera

## 1.7 TECHNIC AND PHYSIC VIABILITY - MATERIALS

For the viability of this project, it is intended to fix the material to be used and its geometry.

In this way, you can obtain two viable ways to build the product.

- 3d print
- Plastic Injection

### 1.7.1 3D PRINT [3]

We will analyze the materials separately to see their conditions and characteristics, whether they are resistant to breakage or contamination.

ABS: It is a thermoplastic polymer, very impact resistant plastic, It is often called engineering plastic because its processing and processing is somewhat more complex than in common plastics. ABS is an example of a composite of materials that, with the union of their properties, seeks to be an alternative to the development of new materials.

The resistance of ABS to extreme temperatures, especially when they are below zero makes it an especially interesting material for cold environments, staying unchanged where others become brittle.

In addition, ABS absorbs little water and is easily coated with metal layers as it is very receptive to metal baths.

The ABS [4] is opaque and can be dark or ivory. It can be pigmented in most colors obtaining a good finish and is not toxic.

The ABS is more indicated when looking for strength in the result or when what is going to print will be exposed to extreme temperatures. It is available in a wider range of colors, especially because of its good tolerance to pigmentation itself, although its price is higher than the PLA.

| General properties | | | | |
|---|---|---|---|---|
| Density | 1,01e3 | - | 1,21e3 | kg/m^3 |
| Price | * 2,15 | - | 2,54 | EUR/kg |
| **Mechanical properties** | | | | |
| Young's modulus | 1,1 | - | 2,9 | GPa |
| Yield strength (elastic limit) | 18,5 | - | 51 | MPa |
| Tensile strength | 27,6 | - | 55,2 | MPa |
| Elongation | 1,5 | - | 100 | % strain |
| Hardness - Vickers | 5,6 | - | 15,3 | HV |
| Fatigue strength at 10^7 cycles | 11 | - | 22,1 | MPa |
| Fracture toughness | 1,19 | - | 4,29 | MPa.m^0.5 |
| **Thermal properties** | | | | |
| Maximum service temperature | 61,9 | - | 76,9 | °C |
| Thermal conductor or insulator? | Good insulator | | | |
| Thermal conductivity | 0,188 | - | 0,335 | W/m.°C |
| Specific heat capacity | 1,39e3 | - | 1,92e3 | J/kg.°C |
| Thermal expansion coefficient | 84,6 | - | 234 | µstrain/°C |
| **Electrical properties** | | | | |
| Electrical conductor or insulator? | Good insulator | | | |
| **Optical properties** | | | | |
| Transparency | Opaque | | | |

| Eco properties | | | | |
|---|---|---|---|---|
| Embodied energy, primary production | * 90,3 | - | 99,9 | MJ/kg |
| CO2 footprint, primary production | * 3,64 | - | 4,03 | kg/kg |
| Recycle | ✓ | | | |
| **Recycle mark** | 7 Other | | | |

Image 11: ABS properties

PLA: It is a thermoplastic polymer, permanent, biodegradable and odourless polymer.

It is clear and bright like polystyrene (used to make batteries and toys). Resistant to moisture and grease. It has taste and odor barrier characteristics similar to polyethylene terephthalate plastic, used for non-alcoholic beverages and for other non-food products.

The tensile strength and modulus of elasticity of PLA is also comparable to polyethylene. But it is more hydrophilic than polyethylene, it has a lower density. It is stable to U.V. light, resulting in fabrics that do not fade. Its flammability is too low.

The PLA can be formulated to be rigid or flexible and can be copolymerized with other materials. The PLA can be made with different mechanical characteristics depending on the manufacturing process followed.

**Propiedades generales**

| | | | | |
|---|---|---|---|---|
| Densidad | 1,24e3 | | | kg/m^3 |
| Precio | * 2,34 | - | 3,2 | EUR/kg |
| Fecha de primer uso ("-" significa AC) | 1993 | | | |

**Propiedades mecánicas**

| | | | | |
|---|---|---|---|---|
| Modulo de Young | 3,3 | - | 3,6 | GPa |
| Modulo a cortante | * 1,2 | - | 1,29 | GPa |
| Módulo en volumen | * 5,7 | - | 6,3 | GPa |
| Coeficiente de Poisson | * 0,38 | - | 0,4 | |
| Límite elástico | 55 | - | 72 | MPa |
| Resistencia a tracción | 47 | - | 70 | MPa |
| Resistencia a compresión | 66 | - | 86 | MPa |
| Elongación | 3 | - | 6 | % strain |
| Dureza-Vickers | * 17 | - | 22 | HV |
| Resistencia a fatiga para 10 ^ 7 ciclos | * 22,2 | - | 27,7 | MPa |
| Tenacidad a fractura | * 3 | - | 5 | MPa.m^0.5 |
| Coeficiente de pérdida mecánica (tan delta) | 0,06 | - | 0,09 | |

**Propiedades térmicas**

| | | | | |
|---|---|---|---|---|
| Punto de fusión | 145 | - | 177 | °C |
| Temperatura de vitrificación | 52 | - | 60 | °C |
| Máxima temperatura en servicio | * 45 | - | 55 | °C |
| Mínima temperatura en servicio | -20 | - | -10 | °C |
| ¿Conductor térmico o aislante? | Buen aislante | | | |

**Reciclado del material: energía, CO2 y fracción reciclable**

| | | | | |
|---|---|---|---|---|
| Reciclaje | ✓ | | | |
| Contenido en energía, reciclado | * 34,8 | - | 38,5 | MJ/kg |
| Huella de CO2, reciclado | * 2,74 | - | 3,02 | kg/kg |
| Fracción reciclable en suministro habitual | * 0,5 | - | 1 | % |
| Reciclado inferior | ✓ | | | |
| Combustión para recuperar energía | ✓ | | | |
| Calor neto de combustión | * 18,8 | - | 19,8 | MJ/kg |
| Combustión CO2 | * 1,79 | - | 1,88 | kg/kg |
| Vertedero | ✓ | | | |
| Biodegradable | ✓ | | | |
| Ratio de toxicidad | No toxico | | | |
| Fuente renovable | ✓ | | | |

NYLON: Polyamides, or also known as nylon, (PA) are semicrystalline polymers. There are two types. Polyamides structured from a single starting material and structured polyamides from 2 starting materials. The polyamides possess a magnificent picture of mechanical properties, a very high tenacity and excellent characteristics of sliding and resistance to wear. Its properties vary from hard and tenacious PA 66 to soft and flexible PA 12. Depending on the type of material, polyamides absorb different amounts of moisture, which are influenced by mechanical characteristics and dimensional accuracy.

In the manufacture of semi-finished products, extrusion and casting are distinguished. By means of the casting process it is possible to manufacture semi-finished polyamide products of larger dimensions and a higher degree of crystallization (greater mechanical resistance), which contain less internal stresses. On the contrary, the extrusion method allows to manufacture with lower costs.

Medium-high mechanical resistance, hardness, rigidity and toughness, a high mechanical damping capacity, good resistance to fatigue, excellent wear resistance, good sliding properties, in most cases, high moisture absorption, in most cases, reduced dimensional stability.

| Propiedades generales | | | | |
|---|---|---|---|---|
| Densidad | 1,12e3 | - | 1,14e3 | kg/m^3 |
| Precio | * 2,31 | - | 2,51 | EUR/kg |
| **Propiedades mecánicas** | | | | |
| Modulo de Young | 2,62 | - | 3,2 | GPa |
| Límite elástico | 50 | - | 94,8 | MPa |
| Resistencia a tracción | 90 | - | 165 | MPa |
| Elongación | 30 | - | 100 | % strain |
| Dureza-Vickers | 25,8 | - | 28,4 | HV |
| Resistencia a fatiga para 10 ^ 7 ciclos | * 36 | - | 66 | MPa |
| Tenacidad a fractura | * 2,22 | - | 5,62 | MPa.m^0.5 |
| **Propiedades térmicas** | | | | |
| Punto de fusión | 210 | - | 220 | °C |
| Máxima temperatura en servicio | 110 | - | 140 | °C |
| ¿Conductor térmico o aislante? | Buen aislante | | | |
| Conductividad térmica | 0,233 | - | 0,253 | W/m.°C |
| Calor específico | * 1,6e3 | - | 1,66e3 | J/kg.°C |
| Coeficiente de expansión térmica | 144 | - | 149 | µstrain/°C |
| **Propiedades eléctricas** | | | | |
| ¿Conductor eléctrico o aislante? | Buen aislante | | | |

| Ecopropiedades | | | | |
|---|---|---|---|---|
| Contenido en energía, producción primaria | * 115 | - | 127 | MJ/kg |
| Huella de CO2, producción primaria | * 7,58 | - | 8,38 | kg/kg |
| Reciclaje | ✓ | | | |
| **Marca de reciclaje** | | | | |

7 Other

Image 12: Naylon Properties

Conclusion: The main properties that we look for in the prototype is a high resistance to impacts and resistance to high temperatures that can take the electrical circuit so we opted for Nylon because it can absorb impacts and be rigid enough.

## 1.7.2 MATERIAL FOR INJECTION PROCESS

For the design and development of the drone, it is necessary to analyze materials for serial production, so different materials will be analyzed to see which would be ideal if we want to manufacture the drone by injection. The most used materials in the injection process are Polyethylene and Polypropylene, due to their fluidity and melting temperature, these two materials are suitable for the injection process.

Polypropylene (PP)[5]: provides precise control of its impact resistance. In its natural state it is a flammable material and degrades with sunlight, but through chemical processes we achieve stability and resistance to temperature and ultraviolet rays. Once this material is used, it can be reused, converting it into pellets and processing it again. It can be processed several times without losing its qualities so by combining unprocessed raw material with a percentage of the processed material we will reduce the CO2 emissions that are produced when manufacturing it.

| | | | | | |
|---|---|---|---|---|---|
| **Propiedades generales** | | | | | |
| Densidad | ⓘ | 890 | - | 910 | kg/m^3 |
| Precio | ⓘ | * 1,52 | - | 1,58 | EUR/kg |
| **Propiedades mecánicas** | | | | | |
| Modulo de Young | ⓘ | 0,896 | - | 1,55 | GPa |
| Límite elástico | ⓘ | 20,7 | - | 37,2 | MPa |
| Resistencia a tracción | ⓘ | 27,6 | - | 41,4 | MPa |
| Elongación | ⓘ | 100 | - | 600 | % strain |
| Dureza-Vickers | ⓘ | 6,2 | - | 11,2 | HV |
| Resistencia a fatiga para 10 ^ 7 ciclos | ⓘ | 11 | - | 16,6 | MPa |
| Tenacidad a fractura | ⓘ | 3 | - | 4,5 | MPa.m^0.5 |
| **Propiedades térmicas** | | | | | |
| Punto de fusión | ⓘ | 150 | - | 175 | °C |
| Máxima temperatura en servicio | ⓘ | 100 | - | 115 | °C |
| ¿Conductor térmico o aislante? | ⓘ | Buen aislante | | | |
| Conductividad térmica | ⓘ | 0,113 | - | 0,167 | W/m.°C |
| Calor específico | ⓘ | 1,87e3 | - | 1,96e3 | J/kg.°C |
| Coeficiente de expansión térmica | ⓘ | 122 | - | 180 | µstrain/°C |
| **Propiedades eléctricas** | | | | | |
| ¿Conductor eléctrico o aislante? | ⓘ | Buen aislante | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Ecopropiedades** | | | | | |
| Contenido en energía, producción primaria | ⓘ | * 75,7 | - | 83,7 | MJ/kg |
| Huella de CO2, producción primaria | ⓘ | * 2,96 | - | 3,27 | kg/kg |
| Reciclaje | ⓘ | ✓ | | | |
| **Marca de reciclaje** | ⓘ | | | | |

5 PP

Image 13: PP properties

Polyethylene (PE)[6]:  is one of the most popular plastics because of its low cost, versatility and simplicity in its production. In addition, its excellent thermal and chemical resistance and its high resistance to impact, make it suitable for a wide variety of applications, from materials for the manufacture of containers and packaging or pipes for water and gas, to coatings for cables and films for agriculture .

Polyethylene is a polymer obtained from the polymerization of ethylene, which is a molecule that comes from the petroleum naphtha fraction. There are two types of polyethylene: high density polyethylene and low density polyethylene. The main difference between them is that high density polyethylene is harder and more rigid than low density polyethylene, but at the same time it is less deformable. As with other thermoplastics, both have the advantage of being recyclable.

| | | | | | |
|---|---|---|---|---|---|
| **Propiedades generales** | | | | | |
| Densidad | ⓘ | 939 | - | 960 | kg/m^3 |
| Precio | ⓘ | * 1,44 | - | 1,48 | EUR/kg |
| **Propiedades mecánicas** | | | | | |
| Modulo de Young | ⓘ | 0,621 | - | 0,896 | GPa |
| Límite elástico | ⓘ | 17,9 | - | 29 | MPa |
| Resistencia a tracción | ⓘ | 20,7 | - | 44,8 | MPa |
| Elongación | ⓘ | 200 | - | 800 | % strain |
| Dureza-Vickers | ⓘ | 5,4 | - | 8,7 | HV |
| Resistencia a fatiga para 10 ^ 7 ciclos | ⓘ | 21 | - | 23 | MPa |
| Tenacidad a fractura | ⓘ | * 1,44 | - | 1,72 | MPa.m^0.5 |
| **Propiedades térmicas** | | | | | |
| Punto de fusión | ⓘ | 125 | - | 132 | °C |
| Máxima temperatura en servicio | ⓘ | * 90 | - | 110 | °C |
| ¿Conductor térmico o aislante? | ⓘ | Buen aislante | | | |
| Conductividad térmica | ⓘ | 0,403 | - | 0,435 | W/m.°C |
| Calor específico | ⓘ | * 1,81e3 | - | 1,88e3 | J/kg.°C |
| Coeficiente de expansión térmica | ⓘ | 126 | - | 198 | µstrain/°C |
| **Propiedades eléctricas** | | | | | |
| ¿Conductor eléctrico o aislante? | ⓘ | Buen aislante | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Ecopropiedades** | | | | | |
| Contenido en energía, producción primaria | ⓘ | * 77 | - | 85,1 | MJ/kg |
| Huella de CO2, producción primaria | ⓘ | * 2,64 | - | 2,92 | kg/kg |
| Reciclaje | ⓘ | ✓ | | | |
| **Marca de reciclaje** | ⓘ | | | | |

2 HDPE    4 LDPE

Image 14: PE properties

Conclusion: Once analyzed the two materials we must select the most suitable for the injection of our drone. Finally we opted for Polypropylene due to its mechanical characteristics such as tensile strength or compression, which are higher in this material. These characteristics are taken as a reference because if the drone suffers an accident the damage can be minimized.

## 1.8 ECONOMIC VIABILITY

PROTOTYPE[7]

As previously stated, two ways to enter the market are sought.

1.8.1 3d print:

To know the economic viability of the prototype, it is necessary to take into account the time of printing of each piece, the necessary material, the labor of the operator and the amortization of the machine.

- RAW MATERIAL: The cost of the raw material is 3.18 € / Kg of Nylon.

Upper Housing: 0.37 €

Lower Housing: 0.37 €

Propeller: 0.06 € (x4) = 0.24 €

Wing Support: 0.16 € (x4) = 0.64 €

Leg: 0.10 € (x4) = 0.40 €

- DRYING TIME: The nylon to be used needs a time of between 3 and 4 hours of drying before it can be used. This time causes the cost of the prototype to increase. +0.5€/h

- OPERATOR: An operator can be controlling several machines at the same time; due to cameras that record each machine and monitor it, or to sensors in the extruders the price can decrease per unit to 2€ / h.

- PRINTER: Ultimaker 3 Extended 3d Printer has a cost of € 3000 and its useful life is 3 years; every day can do work for 6 hours.

The cost of this printer is 1 €/ h which will increase to € 1.5 / h due to maintenance and wear costs. The final price of the prototype is found in section MEASUREMENTS AND BUDGET, where is the breakdown by elements.

1.8.2 Manufacture in series with labor.

Despite being a prototype, manufacturing costs are developed by injection to see the viability of our product. For its production in series, a series of factors must be calculated, such as raw material, molds, injection or assembly machines, among others. The cost will be made to manufacture 100,000 pieces. In this way we will obtain a certain demand that will enhance the continuation of mass production, or else it will show that the product has not been successful in the market.

-MOLD: Mold for upper casing, this mold will cost € 20,000 due to its dimensions and curved areas. - Mold for lower housing, € 30,000 as it has curved and round areas and houses the supports of the wings, so it increases the price in order to obtain a single joint piece.

-MANO DE OBRA: For the development of the prototype, you need operators that control machines for injection, cutting and bending of metallic elements. Each of them will have a price according to their range of knowledge as it is reflected in the BUDGET

-MATTER: The material used to make the drone will be Polypropylene, since it has sufficient strength and can be used in injection processes.

Its price will be 1.7 € kg of PP and each piece will have different weight.

- Upper housing 0.15 kg
- Lower housing 0.25 Kg
- Leg: 0.0525 Kg (x4) = 0.21 Kg
- Support Ala 0.03 Kg (x4) = 0.12Kg
- Propeller 0.005 Kg (x4) = 0.02Kg

Total = 0.750 Kg

-ELECTRONIC DEVICES: The electronic elements are acquired in large quantities so the price will decrease considerably.

Electronic set 8€

-WAREHOUSE FOR STOCK: The units manufactured must be stored while the product is marketed.

Costs of € 500 rent during one year.

-MARKETING: The client must know the object and want it to increase sales - Costs of € 10,000 in marketing campaign.

-DISTRIBUTION: Costs of € 10,000

## 1.9 INTERNAL NEWS

The main novelties that the drone will have will be the adaptation of solar panels connected to the internal battery cells. In this way the drone would have an average autonomy of 30-40 min to unlimited, since during the flight the battery would recharge. In addition, the implementation of more powerful engines will allow companies to send their products up to 10 kg. Thanks to these innovations, we look for a little used and booming market.

To calculate the appropriate batteries and motors for our drone model, we will need to calculate the thrust.[8]

Thrust = Aircraft weight x2 / 4 engines

Aircraft Weight:

-Engines and propellers: 500gr

-Frame: 750gr

-Battery: 400gr

-Flight controllers: 150gr

-Solar panels: 100gr

-Weight: 10.000gr max

Total: 11900gr

$$T = \frac{2W}{4} = \frac{2 \cdot 11900gr}{4} = 5950gr$$

Image 15: Drone position with package

Image 16: Drone position with package

In order to raise the drone we will need thrust motors between 5-10kg and Lipo 6-12 S batteries with a maximum capacity of 8300mhA that will be recharged during the flight.

To calculate the number of solar cells we need, we must investigate the average annual radiation of the place where they are going to be sold, that is, Spain.

Average annual radiation: 5,47 Kwh/$m^2$ [9]

Energy consumption: 22,2 Wh/day

$$Nº\ of\ sollar\ cells = \frac{diarly\ energy \cdot days\ in\ a\ week}{Annual\ radiation \cdot work \cdot power}$$

$$Nº\ of\ sollar\ cells = \frac{\frac{22{,}2Wh}{d} \cdot \frac{7}{7}}{5{,}47h \cdot 0{,}6 \cdot 16{,}6W} = 4{,}84$$

5 solar cells are needed to recharge the battery of the drone.

In this way, it is decided to place a sixth solar cell. This is because the power consumption is faster than the battery charge. 5+1= 6

In addition, analysing the market study an increase in the safety of drones it is demanded. That is why it is intended to install an internal parachute that is activated at the time of a possible collision. In this way the propellers would stop in order not to cause sharp damage and the parachute would serve as an element of safety against a possible fall.

Image 17: Drone position with parachute

## 1.10 PROJECT CONCEPT SELECTION:

The selection is given by the main prototype to be made, as previously stated.

The project will have an upper and lower housing adapted with the wing supports, made of polypropylene; aluminium legs and carbon fiber propellers.

## 1.11 STRUCTURAL ANALYSIS:

For this project, we are going to study the possibility of a drone can transport loads up to 10 Kg, to be able to perform a delivery service of packages to people in a more economic and efficient way.

The drone will be subjected to static structural forces: a maximum pressure of 10 Kg on its rear surface and fixed supports on the legs.

The distribution of forces will allow us to know to what extent the drone can carry a weight without breaking.

Through the ANSYS program, we will know the total deformation and the stresses that are generated in the structure, in this way it will be possible to verify if the materials of the structure support the weight, or otherwise break.

Materials: Aluminium (legs), Polypropylene (supports and upper and lower housing), carbon fiber (propellers)

| | Aluminium | Polypropylene | Carbon Fiber |
|---|---|---|---|
| **Density (kg*m^-3)** | 2698,4 | 900 | 1750 |
| **Young's modulus (Pa)** | 7e+10 | 1,3e+10 | 22e+10 |
| **Poisson's Ratio** | 0,34 | 0,43 | 0,25 |
| **Elastic Limit (MPa)** | 414 | 28,5 | 4000 |

Table 1: Material Properties

Aluminium:

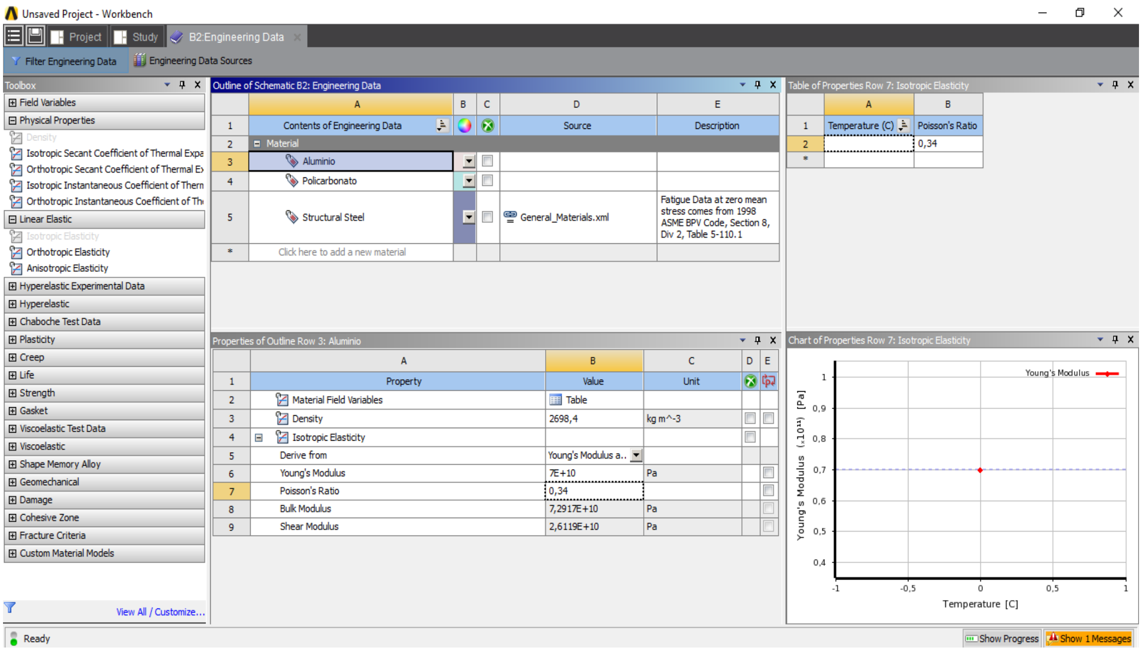



Image 18: Ansys Aluminium

## Carbon Fiber:

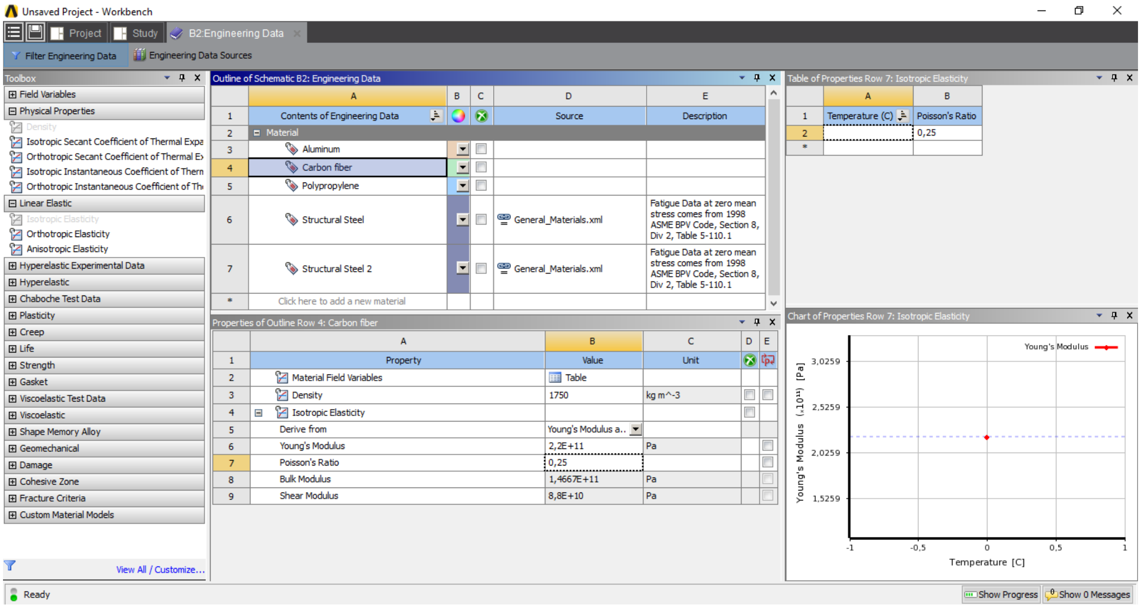



Image 19: Ansys Carbon fiber

## Polypropylene:

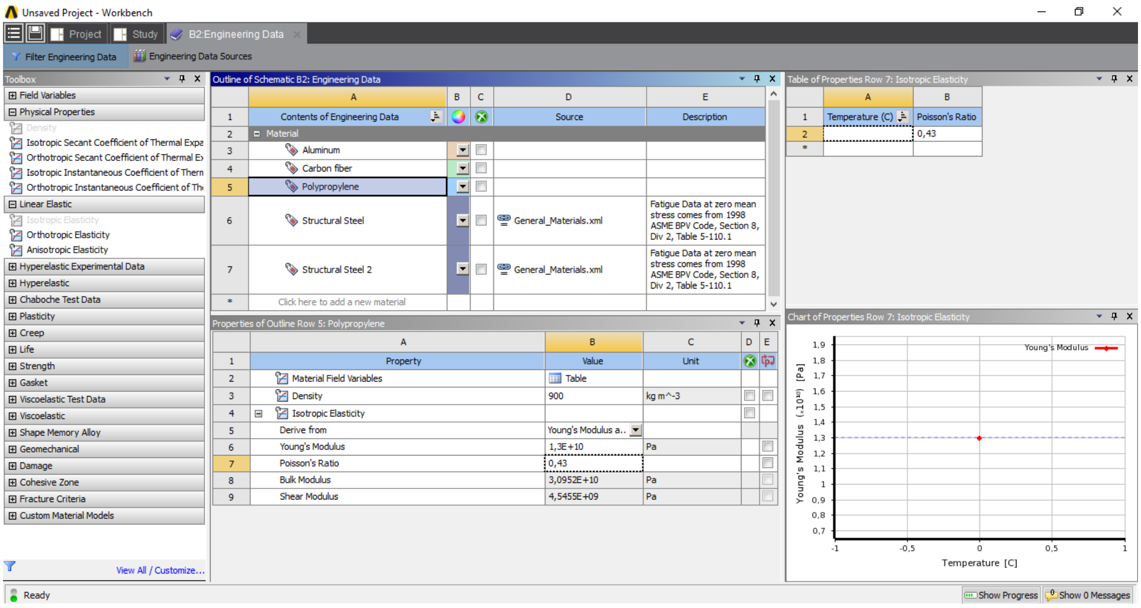



Image 20: Ansys Polypropilene

Static Pressure:

To apply the pressure, first calculate the force that will be exerted respect to the area involved.

Pressure= Force/Area $\longrightarrow$ P= 10kg·10 N / 0,02034115 = 4916,18 Pa

Area= 20341,15 mm$^2$

As the pressure is distributed upwards, the negative sign must be added so that it is reflected that the weight that the drone will support will be in the direction of the -Y

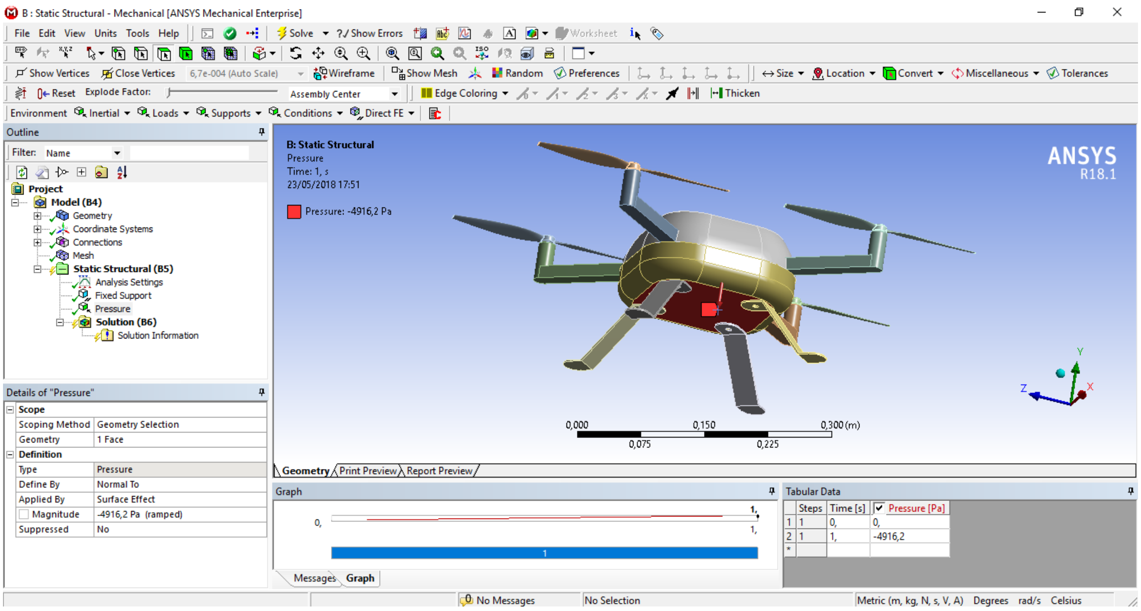



Image 21: Static preasure

For the solution, it is interesting to get the total deformation that the object is capable of supporting in order to check if the total deformation is higher than the elastic limit of the material. In this way, it is known if the material will break. In addition, the equivalent stress (von mises) is obtained to know which is the maximum tension that the material can support.

In order to Ansys calculate these parameters, we press the right button on Solution and Insert, and fix what we want to obtain. (Equivalent stress and Total Deformation)

Analysis of the results

Total deformation:

As we can see, the critical point of the structure is the center of the lower housing, since the weight that must be supported is concentrated on that point.

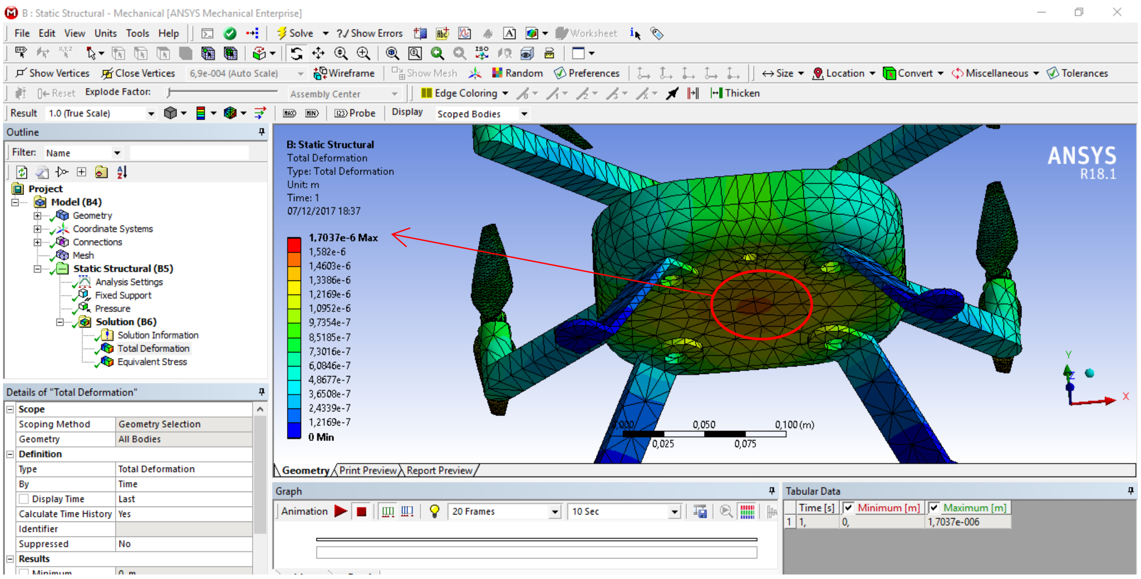
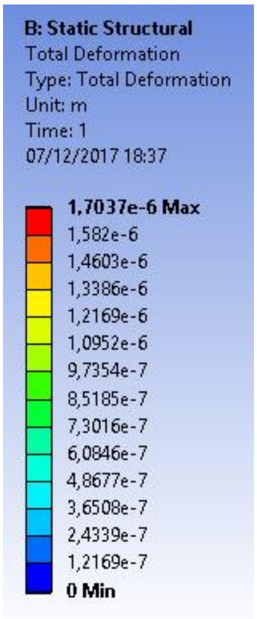



Image 22: Total deformation

The total deformation generated in that point is 1,7037e-6m = 0,0017 mm

The total deformation is minimal, it is negligible, this is because the section of the legs is very thick and how is a metallic material can withstand much more weight than has been proposed in the case.



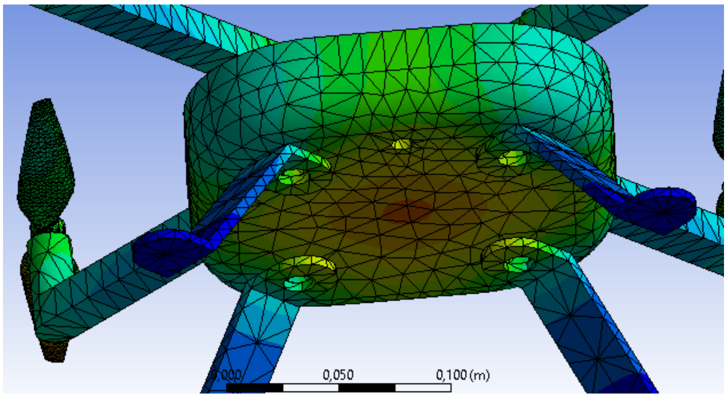



Image 23: Analysis deformation

Equivalent Stress (Von Mises):

The resulting tension of the material for the placed weight is minimal as well.

4,6861e5Pa = 0,46861 Mpa

Aluminium has an elastic limit of 414 MPa.

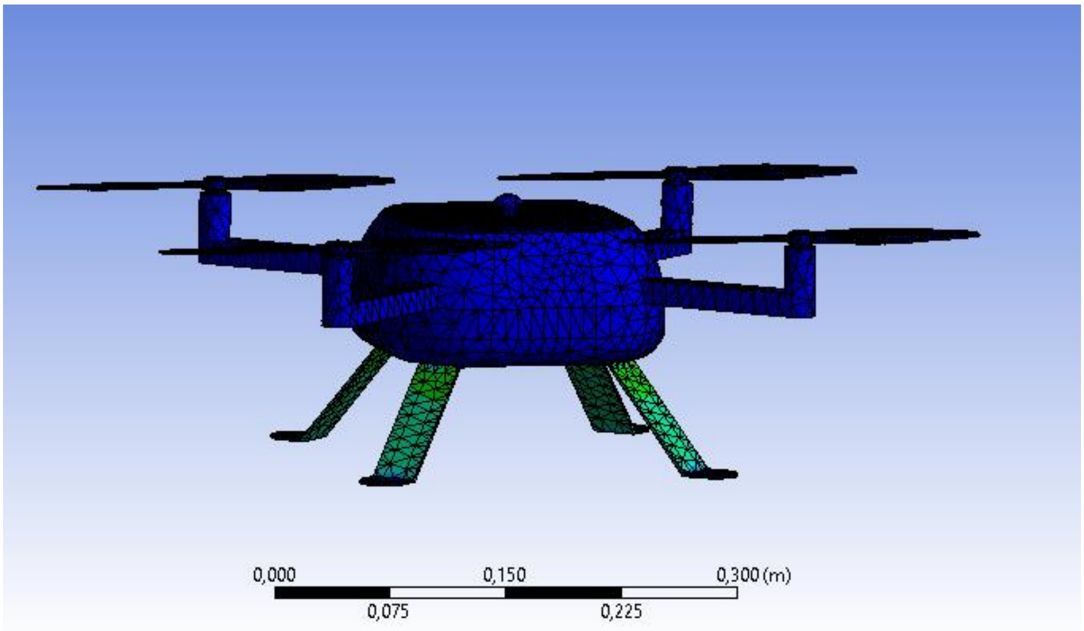



Image 24: Equivalent Stress Von Misses

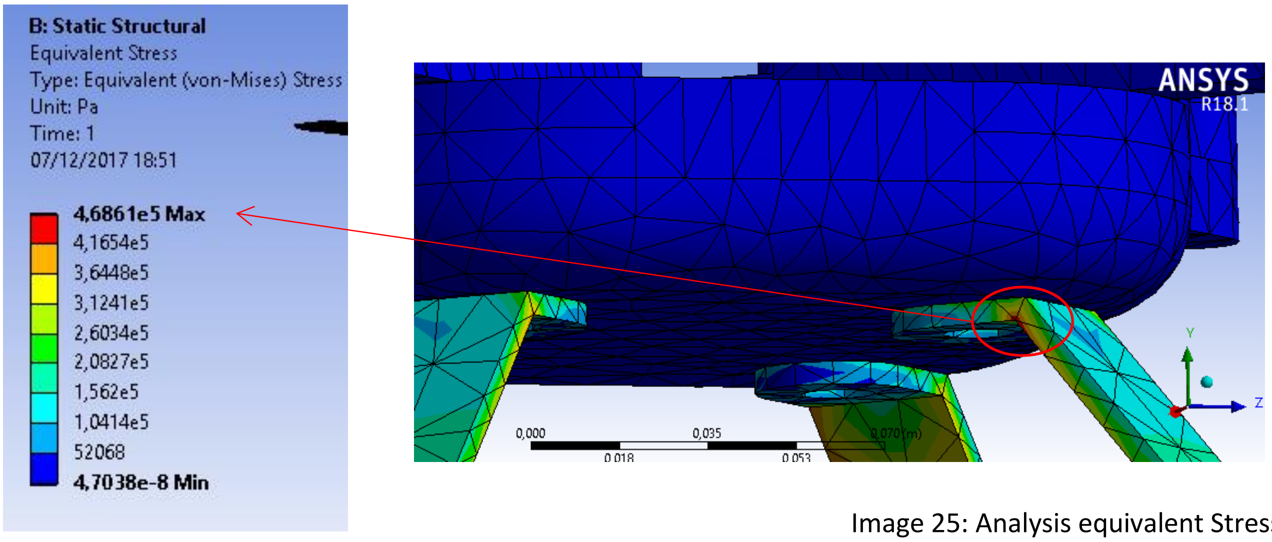



Image 25: Analysis equivalent Stress

The maximum tension is reflected in the lower edge of the leg, since it is the site that has the most tension. Even so, the tension is minimal and does not affect the structure.

Now each element will be checked separately to study how it would behave independently of the whole.

**Legs:** As described above, the total pressure that the legs must support is of 4916,18 Pa, as we are studying the behavior of one, we will divide the total pressure by 4, which is what each leg supports.

4916,18 Pa / 4 = 1229,045 Pa

Rest position without load:

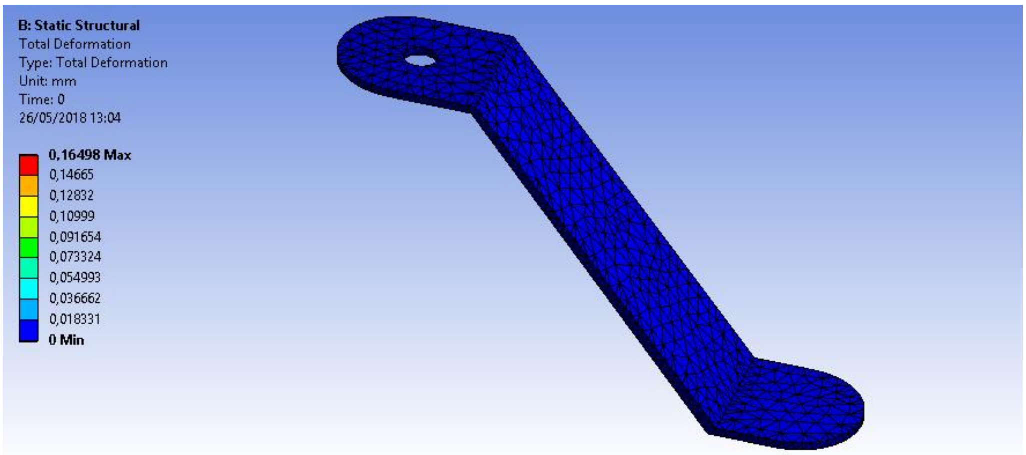



Image 26: Leg rest position

Position of tension with load:

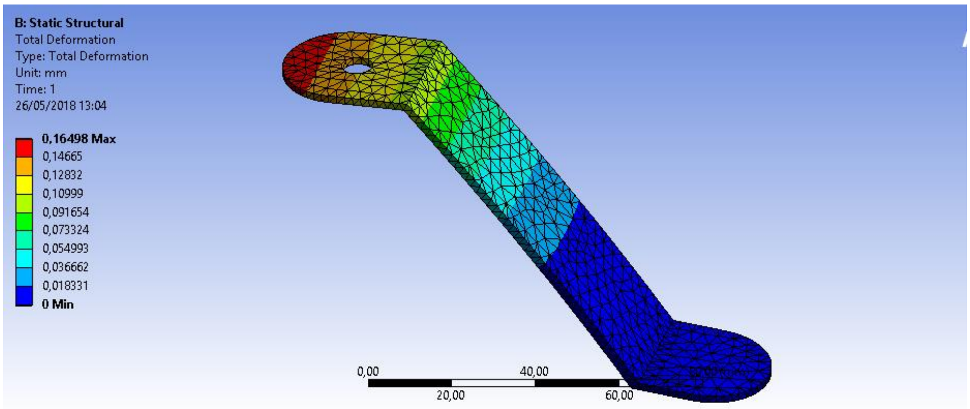



Image 27: Leg tensions with load

As can be seen, the upper zone of the leg is the one that suffers the most deformation due to the direct contact it suffers with a surface that supports the load. The maximum deformation is 0.165 mm, supporting 2.46 Mpa and the elastic limit of aluminum is 414 Mpa.

**Propeller:** The development of the helix is given by the air currents that originate during the flight. Next, the air cycle that the drone suffers during a normal flight is shown.

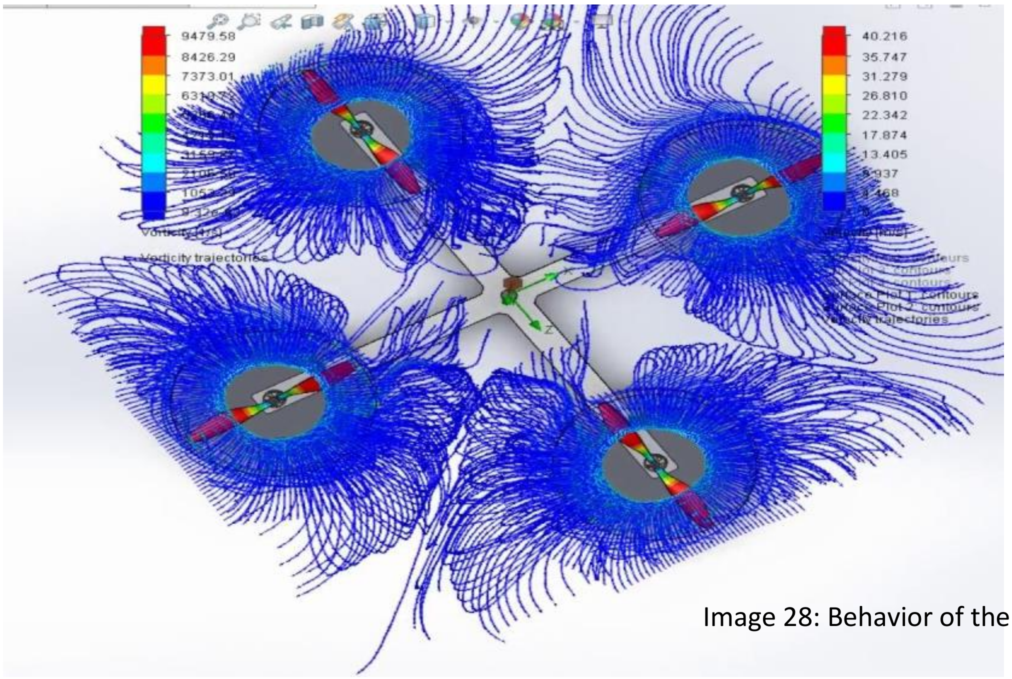



Image 28: Behavior of the propellers

For this, the lowest values of atmospheric pressure on the earth are used. This way the drone will be able to fly over anywhere. For this, pressures of 760 atm (mm of Hg) at sea level and 20º are calculated. The highest pressures are recorded at the ends and decrease as they approach the center point of the propeller.

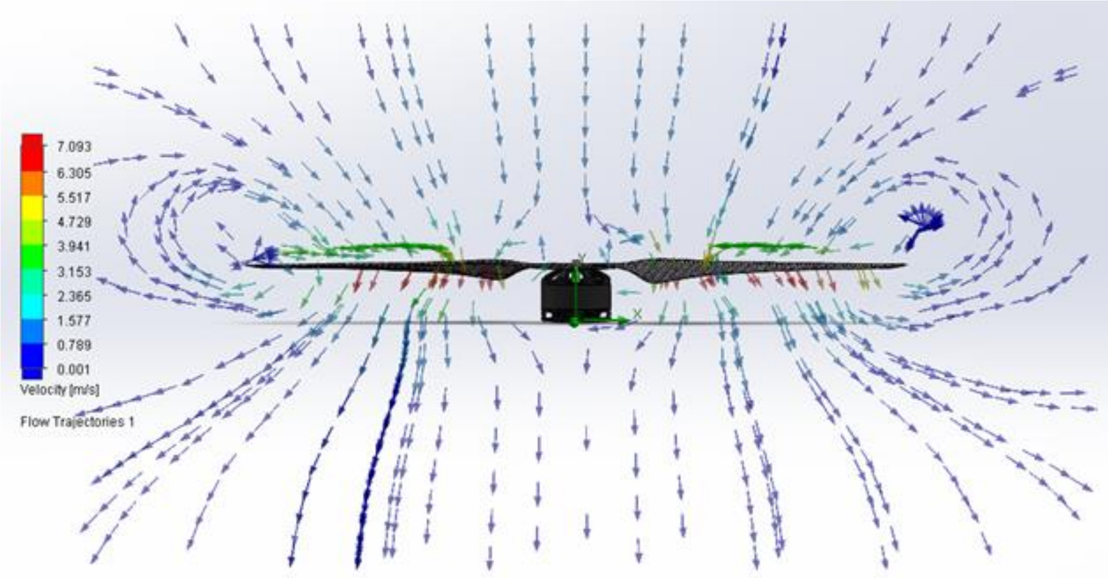



Image 29: Behavior of one propeller

**Wing support:** For this part it is important to know that the total pressure exerted will be the sum of the atmospheric pressure in the propellers and the weight of the propeller next to the engine.

Considering that the elastic limit of the Polypropylene is of 28 MPa, the pressure exerted on the supports is studied to know if the material will break or on the contrary sustain.

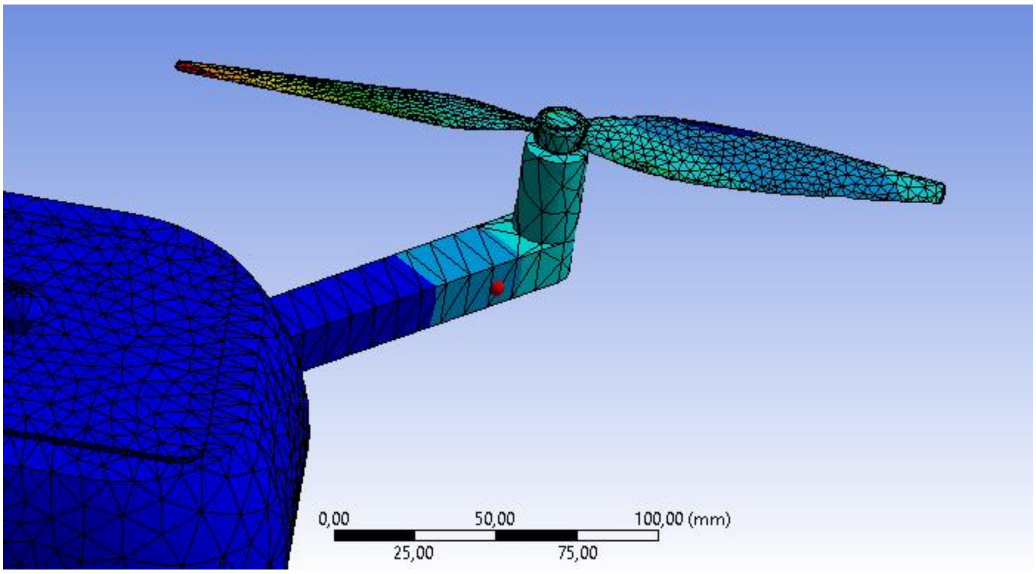



Image 30: Wing Support

The results obtained are:

The material will have a total deformation of 2 mm

The polypropylene will be able to withstand the stresses, since its elastic limit is 28 Mpa, and the tensions submitted are 15 Mpa

## 1.12 PRE-DIMENSIONING

The order of development and exposure of the previous dimensioning of the elements is carried out based on the priority criterion of the most related element. The relationships between elements are shown in the system diagram presented in APPENDIX 2.1.3

| MARK | DENOMINATION | TYPE | Nº RELATIONS | ORDER |
|---|---|---|---|---|
| **1.1.1** | LOWER HOUSING | MANUFACTURE | 4 | 1º |
| **3** | SCREW | NORMALIZED | 3 | 2º |
| **1.2** | LEG | MANUFACTURE | 3 | 3º |
| **2.1** | UPPER HOUSING | MANUFACTURE | 3 | 4º |
| **2.2** | SOLAR CELL | NORMALIZED | 2 | 5º |
| **2.3** | PIVOT | NORMALIZED | 2 | 6º |
| **4** | WASHER | NORMALIZED | 2 | 7º |
| **1.1.2** | PROPELLER | NORMALIZED | 1 | 8º |

Table 2: Pre-dimensioning

All type "A fabricate" elements are considered semi-finished, since they are made of aluminum sheet metal, like metal profile, which, after the sizing process, will be cut and in some cases, folded.

The normalization of the dimensions of the elements is done based on the standards, standard elements, tools and commercial elements that are described in the ANNEXES 2.2.1 to 2.2.7

## Element 1.1.1 Lower Housing

| Related elements | |
|---|---|
| **Mark** | **Noun** |
| **1.1.2** | PROPELLER |
| **1.2** | LEG |
| **2.1** | UPPER HOUSING |
| **3** | SCREW |

Table 3: Element 1.1.1 (Lower Housing)

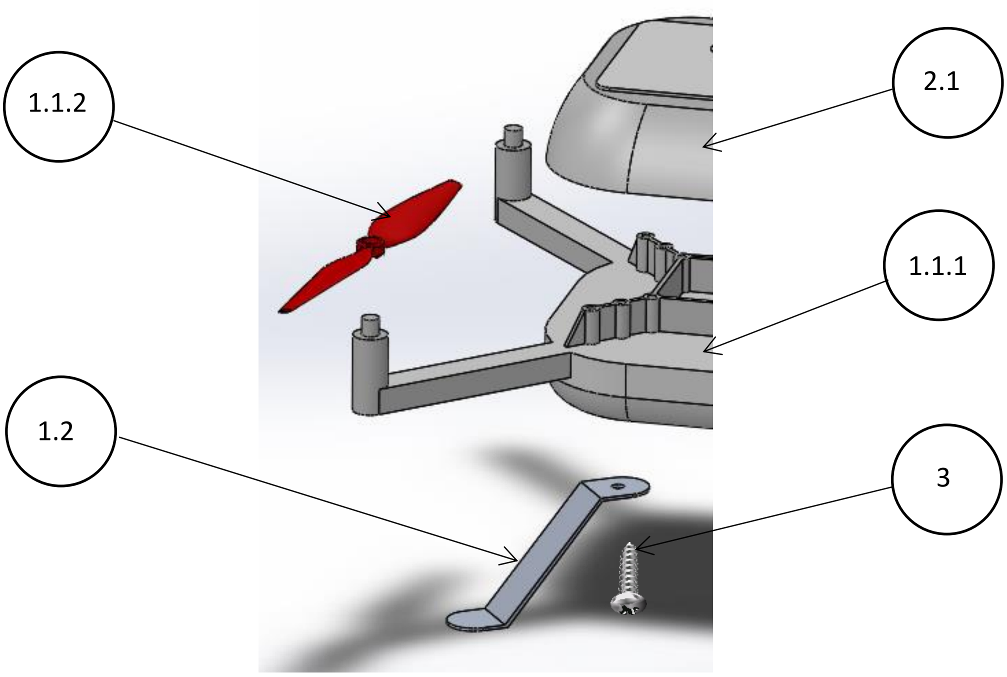



Image 31: Relations Element 1.1.1

| Normalized elements | | |
|---|---|---|
| **Mark** | **Noun** | **Catalogue** |
| **1.1.2** | PROPELLER | Carbon Fiber 240x8mm |
| **1.2** | LEG | Aluminum profiles 70x2mm |
| **2.1** | UPPER HOUSING | - |
| **3** | SCREW | Screws M7x20 |

Table 4: Normalized Elements 1.1.1 (Lower Housing)

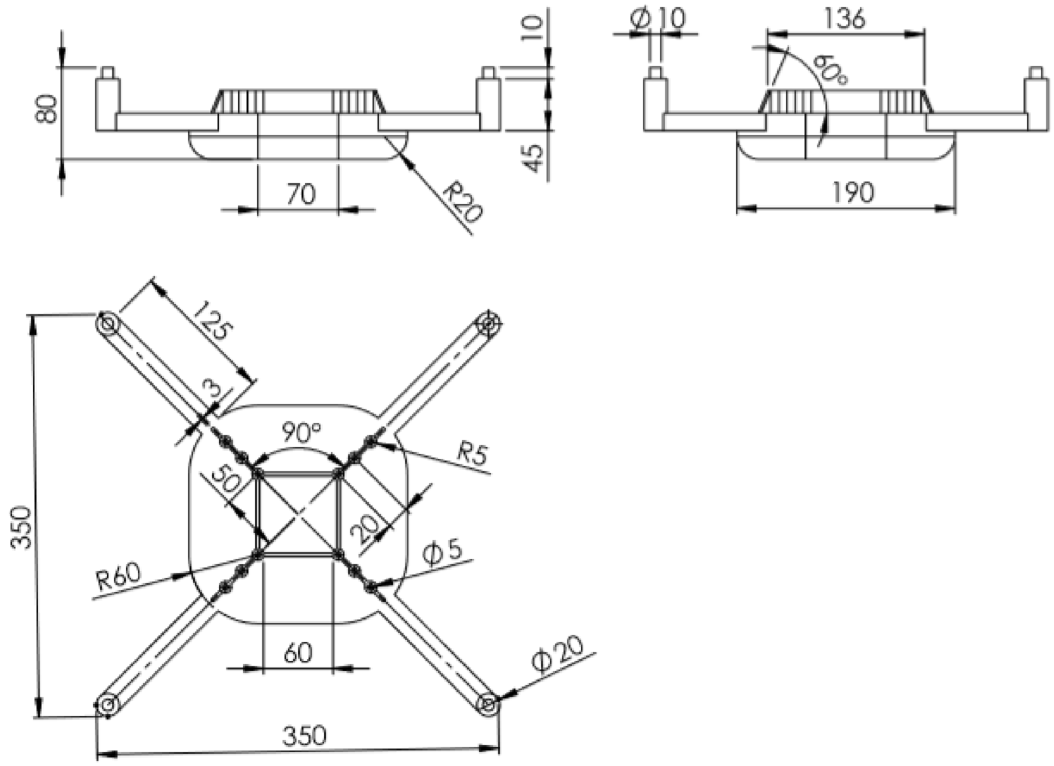



Image 32: Sub-set Plans 1.1.1

Support piece with hook that is shown resting on the legs and, in turn, holds the propellers at a balanced distance so that they can rotate. It is part of the subset 1.1 and is attached to the subset 2.1 by means of hooks.

350 mm: General measures of the drone.

90º: Position of the wing supports.

20 mm: Distance between holes.

ø 10 mm: Hosting of the propellers

R 60 mm: Rounding the lower housing

45 mm: Height of the engines

125 mm: Length of the wing supports

## Element 1.1.2 Propeller

| Related elements | |
|---|---|
| **Mark** | **Noun** |
| **1.1.1** | LOWER HOUSING |

Table 5: Element 1.1.2 (Propeller)

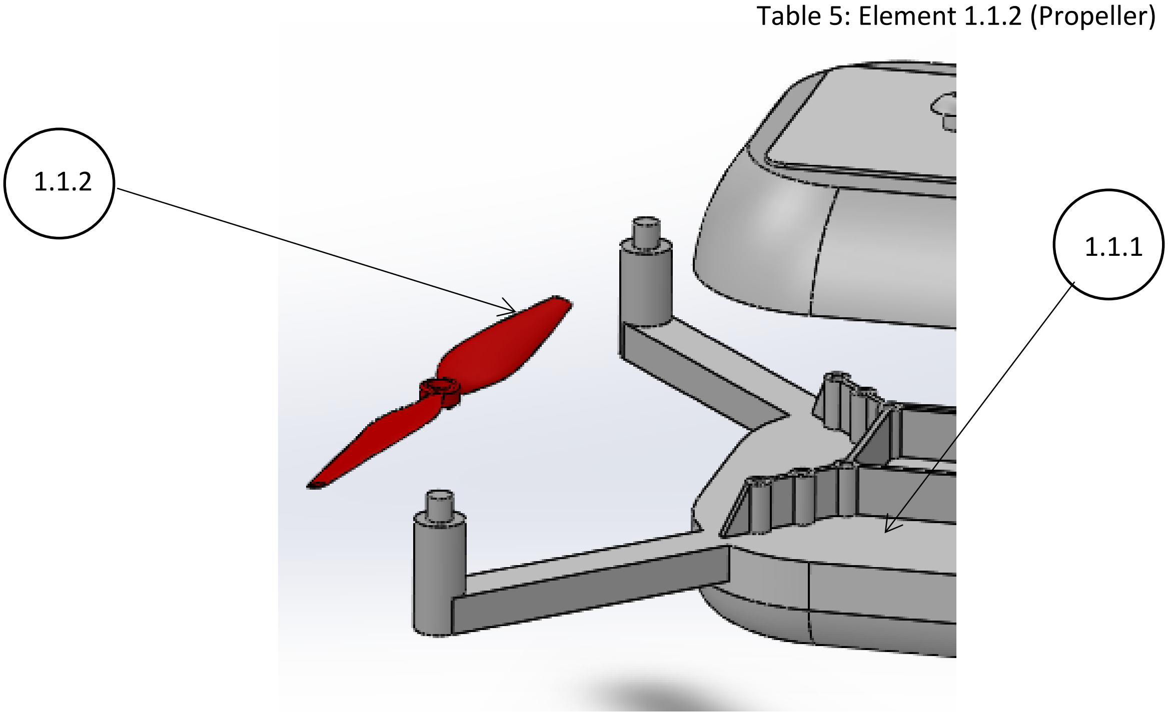



Image 33: Relations Element 1.1.2

| Normalized elements | | |
|---|---|---|
| **Mark** | **Noun** | **Catalogue** |
| **1.1.1** | LOWER HOUSING | - |

Table 6: Normalized Elements 1.1.2

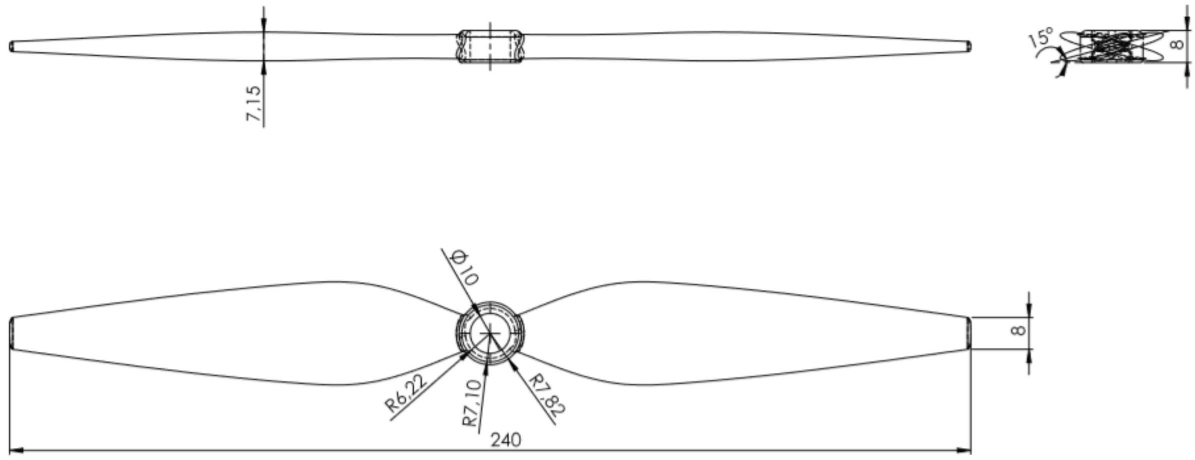



Image 34: Sub-set plans 1.1.2

Part of carbon fiber called helix, attached to the lower housing. It is part of the subset 1.1

240 mm: Total length of the propeller

8 mm: Total height of the propeller

15º: Torsion degree of the propeller

⦰ 10 mm: Hosting of the propellers

R 7,82: Circular rounding radius

## Element 1.2 Legs

| Related elements | |
|---|---|
| **Mark** | **Noun** |
| **1.1.1** | LOWER HOUSING |
| **3** | SCREW |
| **4** | WASHER |

Table 7: Element 1.2 (Legs)

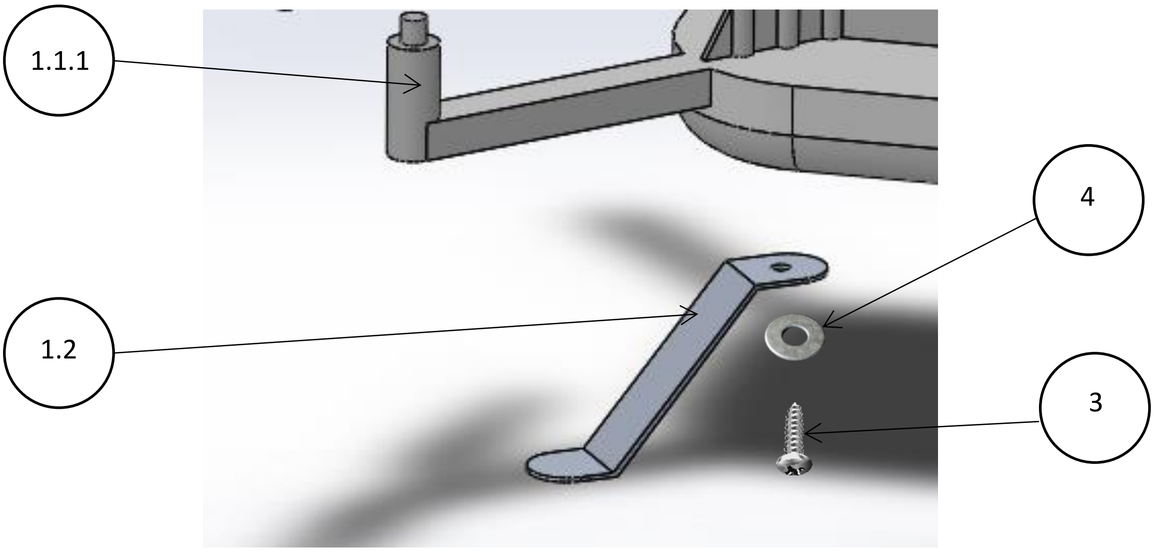



Image 35: Relations Element 1.2

| Normalized elements | | |
|---|---|---|
| **Mark** | **Noun** | **Catalogue** |
| **1.1.1** | LOWER HOUSING | - |
| **1.2** | LEG | Aluminum profiles 70x2 mm |
| **3** | SCREW | Screws M7x20 mm |
| **4** | WASHER | WASHERS M7x1,6 mm |

Table 8: Normaliced Elements 1.2

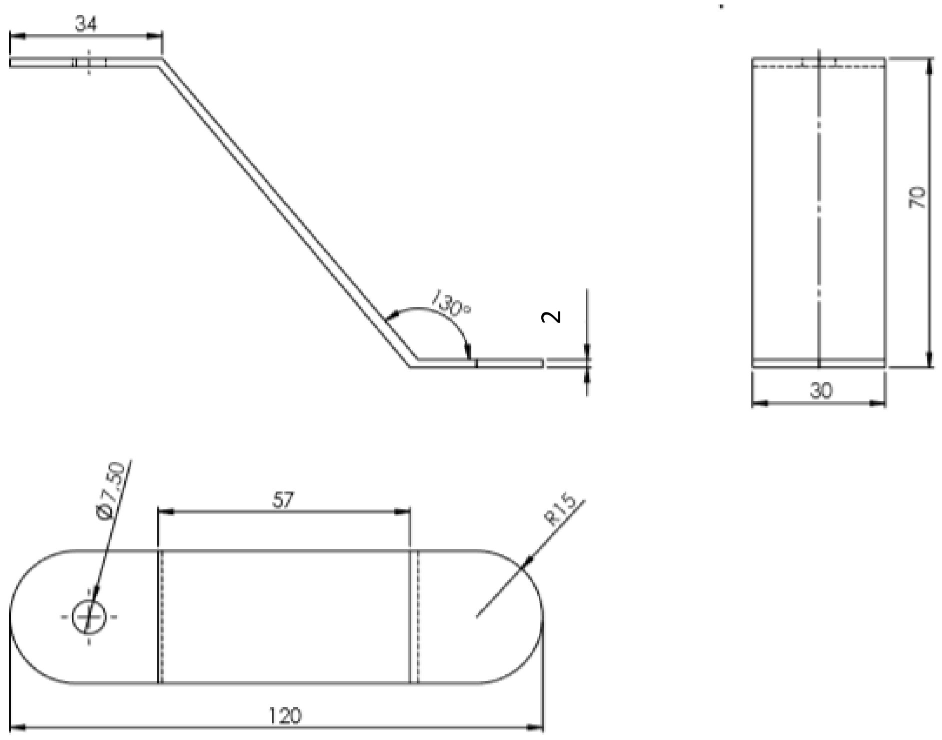



Image 36: Sub-set plans 1.2

Piece of ALUMINUM called leg, attached to the lower casing by means of screw (3) and washer (4). It is part of the subset 1.1. This piece is extracted from processes of cutting and bending sheet metal 70 x 2 mm.

70 mm: Total length of the propeller

30 mm: Total height of the propeller

ø 7,50 mm: Diameter for the through screw

130º: Leg inclination respect to the horizontal

2 mm: Width of the leg

## Element 2.1 Upper Housing

| Related elements | |
|---|---|
| **Mark** | **Noun** |
| **1.1.1** | LOWER HOUSING |
| **2.2** | SOLAR CELLS |
| **2.3** | PIVOT |

Table 9: Element 2.1 (Upper housing)

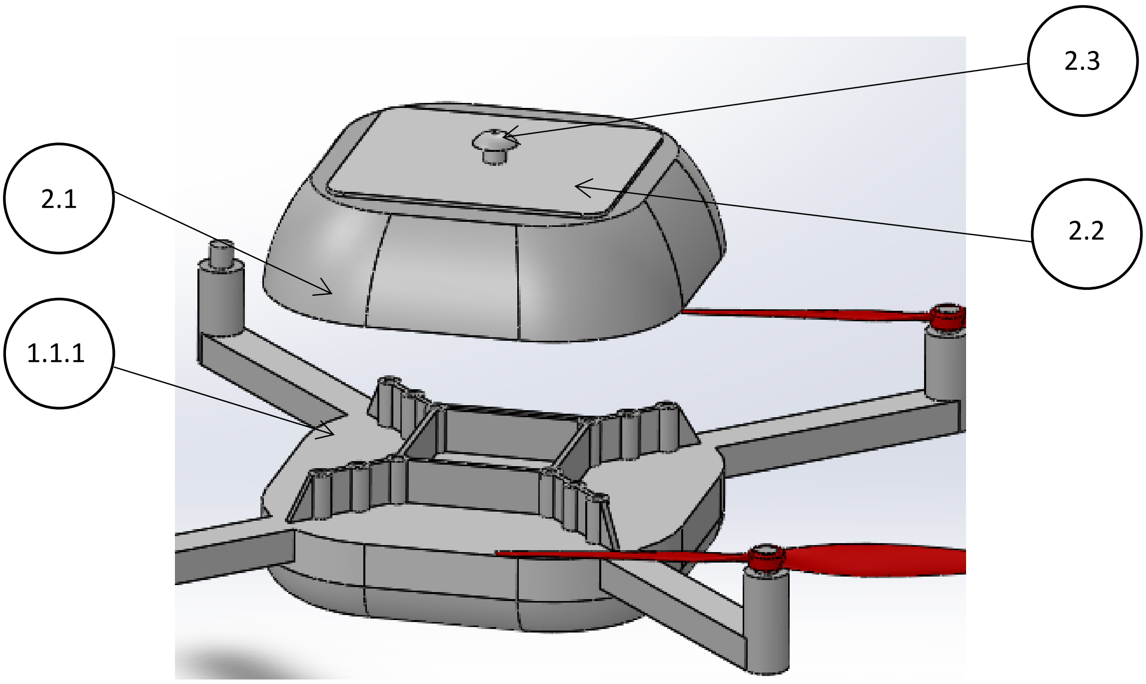



Image 37: Relations Element 2.1

| Normalized elements | | |
|---|---|---|
| **Mark** | **Noun** | **Catalogue** |
| **1.1.1** | LOWER HOUSING | - |
| **2.2** | SOLAR CELLS | CELLS 20x2 mm |
| **2.3** | PIVOT | P8xR10 mm |

Table 10: Normaliced Elemenst 2.1

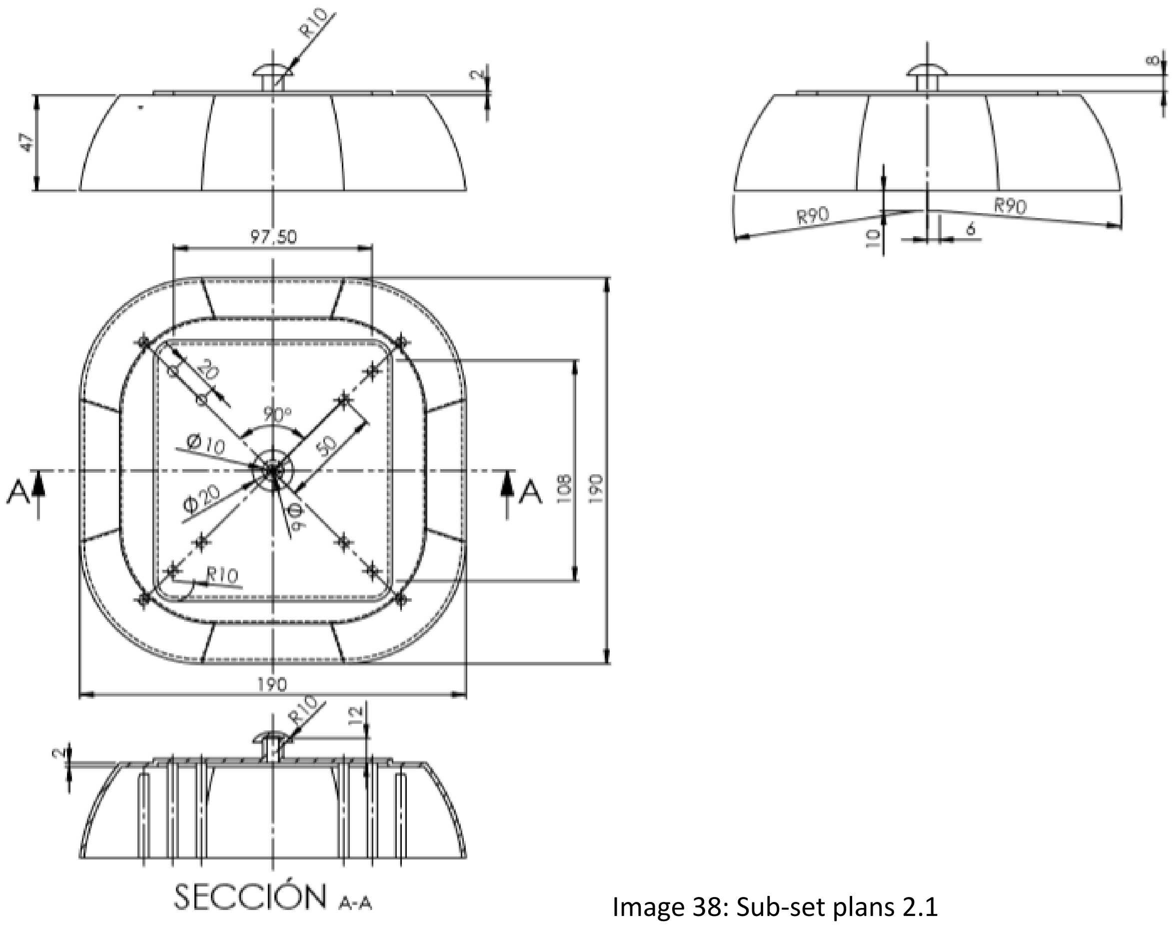



Image 38: Sub-set plans 2.1

Piece that collects the positioning of the holes in the lower casing, both joined by means of hooks. In addition, it serves as support for the solar cells (2.2) and the pivot of the parachute (2.3). It is part of the subset 2. In addition, it will be the site where all the drone's electronic systems are protected.

190 mm: Quadrangular width of the piece.

47 mm: Height of the upper casing

2 mm: Emptying the piece.

R90 mm: Rounding of surfaces

2 mm: Height of solar cells

20 mm: Step between outgoing

## 1.13 PROTOTYPE

This section is developed in a separate document.

## 1.14 CONCLUSIONS

After the previous dimensioning and the description of the prototyping carried out in a separate study, the design will be ready for the realization of tests and consequent readjustments both in dimensions and geometric shapes, for its improvement in resistance and manufacture. In addition a photo of the final prototype printed in 3D will be attached

## 1.9 INFORMATION SOURCES

The information that has been handled for the development of this study, classified according to its sources, is the following:

**Sources internal to the project:**

| **Source** | **Information** |
|---|---|
| Designer | Selected design |
| | Conceptual design |
| Developer | |
| | Initial conditions document |
| | Contract |

**Sources external to the project:**

| **SOURCE** | **INFORMATION** |
|---|---|
| Suppliers | Screw catalog |
| | Washer catalog |
| | Pivot catalog |
| | Catalog of solar cells |
| | Aluminium catalog |
| | Propellers catalog |

| | |
|---|---|
| **Administration** [11] | ISO 21895 section, which refers to the categories of unmanned aerial systems.<br><br>ISO 21384-2 Here the safety requirements of the design and manufacture of the UAS will be defined.<br><br>ISO 21384-3 will focus on establishing the security requirements for the UAS operation. |

# 2 ANNEXES

## 2.1 ANNEXES ON CONCEPTUAL DESIGN

### 2.1.1 PROPOSED DESIGNS

Image 39: Proposed designs

### 2.1.2 DISASSEMBLY SCHEME

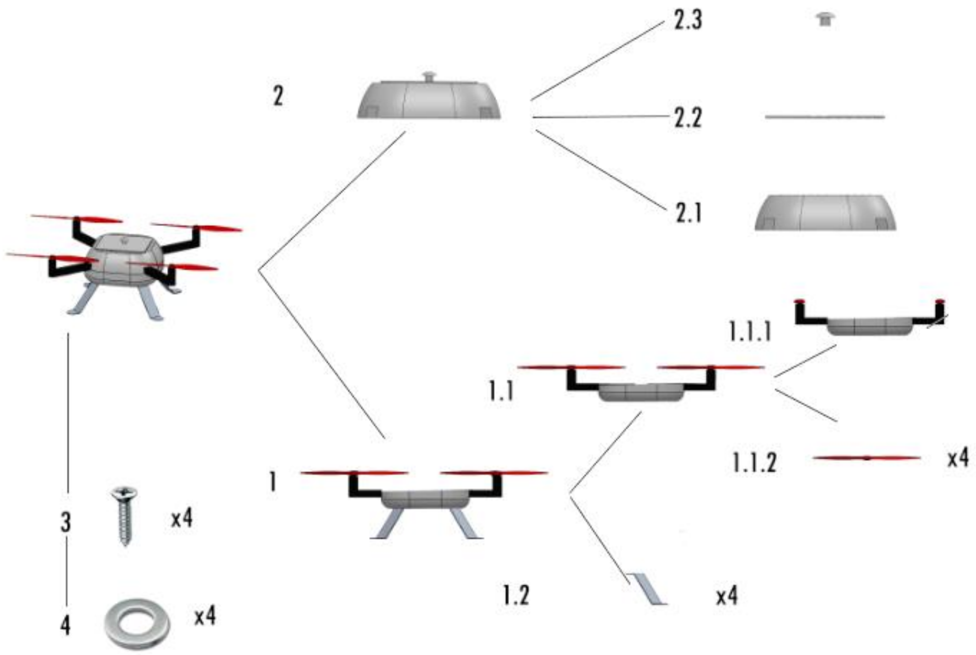



Image 40: Disassembly scheme

### 2.1.3 SYSTEMATIC DIAGRAM

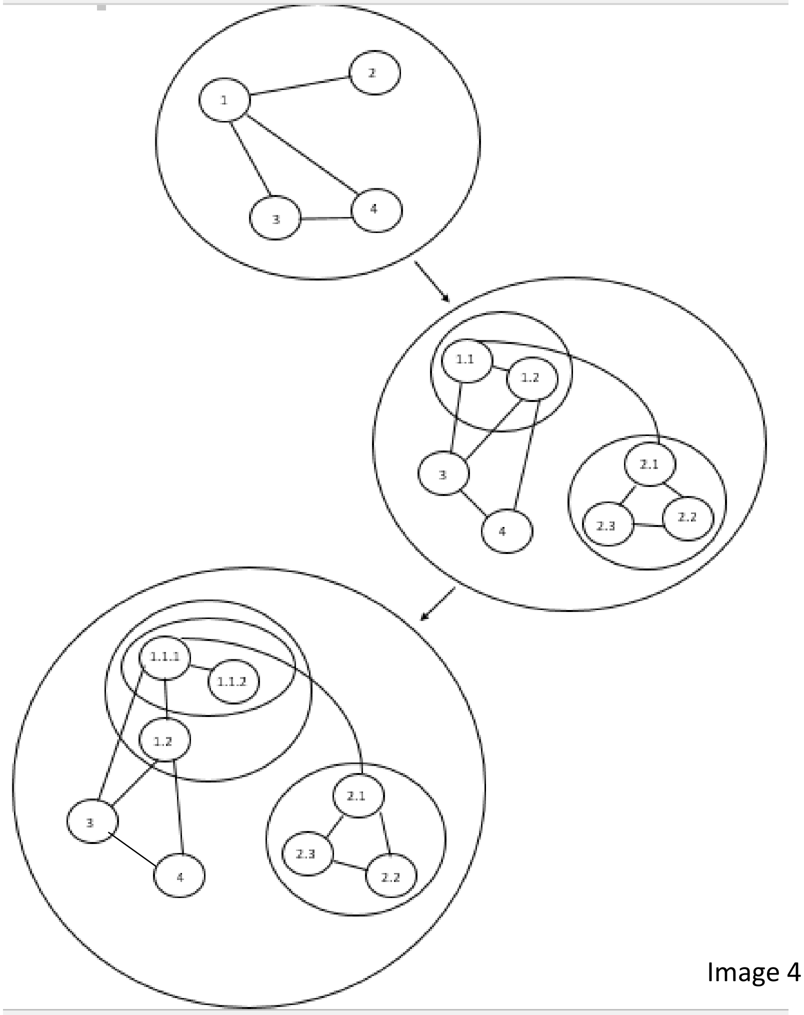



Image 41: Sistematic diagram

## 2.2 ANNEXES ON PREVIOUS DIMENSIONING

### 2.2.1 UNE NORMS OF APPLICATION [12]

ISO 21384-1

It is designed to establish the terminology and reference definitions for industry standards. This ISO also has another ISO 21895 section, which refers to the categories of unmanned aerial systems.

ISO 21384-2

Here the safety requirements of the design and manufacture of the UAS will be defined

ISO 21384-3

Finally, ISO 213843 will focus on establishing the security requirements for the UAS operation.

No doubt the sector is crying out for an international regularization, so that all those who are operating in the sector of the Drone can speak a common language.

The current trend of the use of Drones and UAS suggests that we will soon have many necessary jobs. Every day that passes we have a new model in the market, and it seems that this trend will accelerate in the near future.

Likewise, we must bear in mind that the regulation of the sector will be key to the business development of the same. The rules will mark what can and can not be done with the drones, defining the working model that can be done with the drones.

UNE-EN ISO 7250-1 Definitions of the basic measurements of the human body for technological design.

UNE 82100-0 Magnitudes and units.

UNE-EN ISO 6410-1 Threads and threaded parts, part 1: general agreement. Part 3: simplified representation).

LIMITATION REGULATIONS:

PROPORTIONS IN ACCOMMODATIONS

- UNE 1121
- UNE 1032
- UNE1034
- UNE 1120
- UNE 1039
- UNE 1110
- UNE-EN ISO 6432
- UNE-EN ISO 7083

## 2.2.2 NORMALIZED ELEMENTS

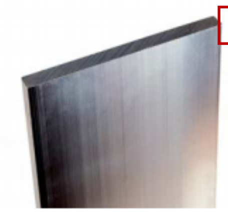
LEGS [13]: 70x2 mm

CATÁLOGO DE PERFILES NORMALIZADOS
ALUMINIUM STANDARD PROFILES

extrusax aluminium extrusion products

Normalizados pletinas
Extruded Flat Bars
Fecha de actualización 13/04/2017
Updated at 13/04/2017

| REF. | DESCRIPCIÓN mm | RADIO mm | PESO Kg/ml | PERIMETRO m2/ml |
|---|---|---|---|---|
| 5990 | 60 x 10 | 0.3 | 1.620 | 0.139 |
| 6777 | 60 x 15 | 0.5 | 2.439 | 0.149 |
| 6778 | 60 x 20 | 0.5 | 3.252 | 0.159 |
| 8350 | 60 x 30 | 2 | 4.852 | 0.177 |
| 9168 | 70 x 2 | 0.2 | 0.378 | 0.144 |
| 5617 | 70 x 3 | 0.5 | 0.567 | 0.145 |
| 6108 | 70 x 12 | 0.5 | 2.268 | 1.163 |
| 6779 | 80 x 15 | 0.5 | 3.252 | 0.189 |
| 6780 | 80 x 40 | 0.5 | 8.672 | 0.239 |
| 6781 | 80 x 60 | 0.5 | 13.008 | 0.279 |
| 6540 | 88 x 5 | 0.3 | 1.188 | 0.185 |
| 6110 | 90 x 8 | 0.3 | 1.944 | 0.196 |



Pletinas
Flat Bars

Image 42: metal catalog

SCREW [14]: M7 x 20

DIN 571
TORNILLO BARRAQUERO. ROSCA MADERA

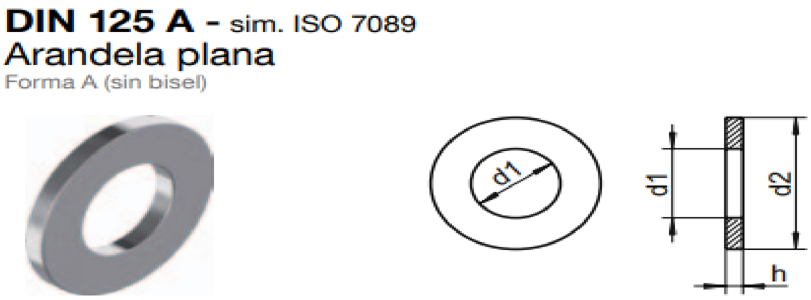

| d | 5 | 6 | 7 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|
| b | b ≥ 6 | | | | | | | |
| k | 3.5 | 4 | 5 | 5.5 | 7 | 8 | - | 10 |
| s | 8 | 10 | 12 | 13 | 17 | 19 | - | 24 |

Zincado.

| L | 5 | 6 | 7 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|
| 20 | 13012780 | 13012788 | - | - | - | - | - | - |
| 25 | 13012781 | 13012789 | - | 13012814 | - | - | - | - |
| 30 | 13012782 | 13012790 | 13012802 | 13012815 | 13012833 | - | - | - |
| 35 | 13012783 | 13012791 | 13012803 | 13012816 | 13012834 | - | - | - |
| 40 | 13012784 | 13012792 | 13012804 | 13012817 | 13012835 | - | - | - |
| 45 | 13012785 | 13012793 | 13012805 | 13012818 | 13012836 | - | - | - |
| 50 | 13012786 | 13012794 | 13012806 | 13012819 | 13012837 | 13012851 | - | - |

Image 43: Screw catalog

WASHER [14]: M7 x 1,6




| d1 | para | d2 | h | Grado | UV |
|---|---|---|---|---|---|
| 1,7 | M1,6 | 4,0 | 0,3 | | 1000 |
| 1,8 | M1,7 | 4,5 | 0,3 | | 1000 |
| 2,2 | M2 | 5,0 | 0,3 | | 1000 |
| 2,5 | M2,3 | 6,0 | 0,5 | | 1000 |
| 2,7 | M2,5 | 6,0 | 0,5 | | 1000 |
| 2,8 | M2,6 | 7,0 | 0,5 | | 1000 |
| 3,2 | M3 | 7,0 | 0,5 | | 1000 |
| 3,7 | M3,5 | 8,0 | 0,5 | | 1000 |
| 4,3 | M4 | 9,0 | 0,8 | | 1000 |
| 5,3 | M5 | 10,0 | 1,0 | | 1000 |
| 6,4 | M6 | 12,0 | 1,6 | | 1000 |
| 7,4 | M7 | 14,0 | 1,6 | | 1000 |
| 8,4 | M8 | 16,0 | 1,6 | | 1000 |
| 10,5 | M10 | 20,0 | 2,0 | | 500 |
| 13,0 | M12 | 24,0 | 2,5 | | 500 |
| 15,0 | M14 | 28,0 | 2,5 | | 200 |
| 17,0 | M16 | 30,0 | 3,0 | | 200 |
| 19,0 | M18 | 34,0 | 3,0 | | 200 |
| 21,0 | M20 | 37,0 | 3,0 | | 200 |
| 23,0 | M22 | 39,0 | 3,0 | | 100 |
| 25,0 | M24 | 44,0 | 4,0 | | 100 |

Image 44: Washer catalog

SOLAR CELLS [15]

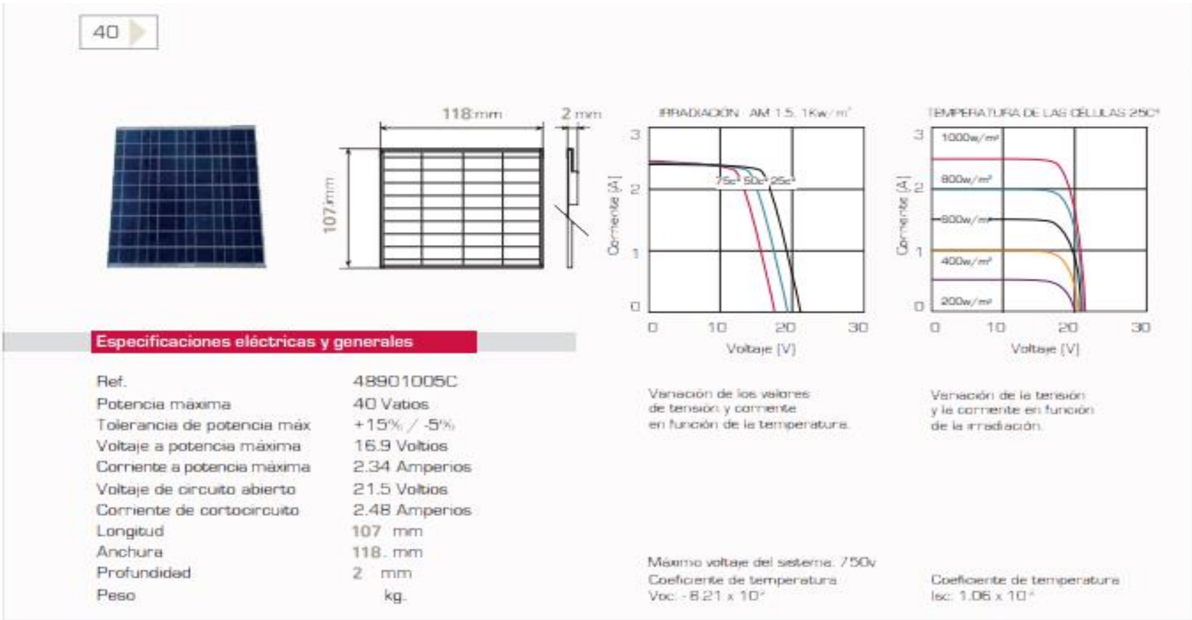



Image 45: Solar cells catalog

PROPELLER

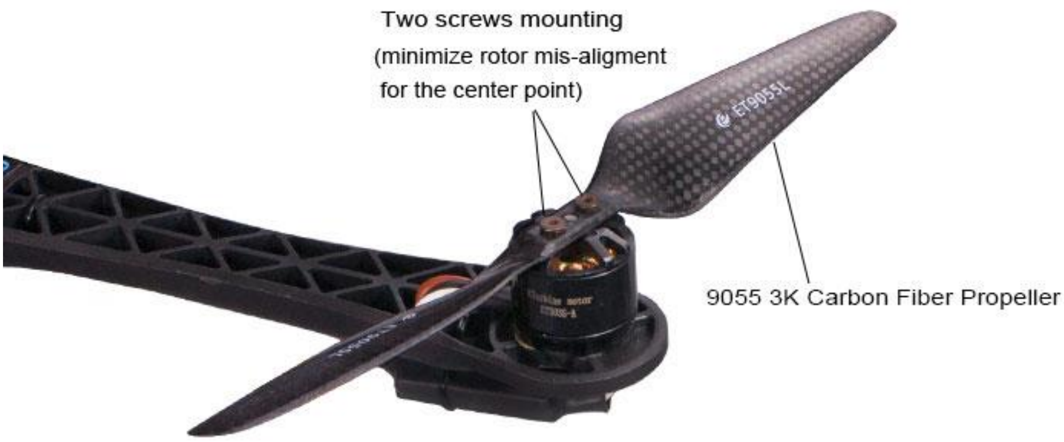



Image 46: Propeller catalog

PIVOT [16]

| VERS. | LTS | CIL | AÑO | USO | SIST. |
|---|---|---|---|---|---|
| - | 1.4 | L4 | 01-08 | NAC. | MPFI |
| SEDAN | 2.0 | L4 | 00 | NAC. | MPFI |
| CC | 2.0 | L4 | 01-06 | NAC. | MPFI |
| SW | 2.0 | L4 | 01-06 | NAC. | MPFI |
| SEDAN | 2.0 | L4 | 05-06 | NAC. | MPFI |
| - | 2.0 | L4 | 03-05 | NAC. | MPFI |
| - | 2.2 | L4 | 06-09 | NAC. | MPFI |
| - | 1.6 | L4 | 97 | IMP. | MPFI |

Image 47: Pivot catalog

## 2.3 MANUFACTURING TOOLS

-2.3.1 MACHINES FOR MANUFACTURING TOOLS

Manual lever shear FTX

Image 48: Shear Machine

The manual lever shear FTX is a guillotine table shear for the cutting of sheet steel width of bench up to 1050 mm and with cutting capacity up to 2 mm plate thickness. For cutting steel plates, aluminum, copper, etc. It is a robust and easy to use machine

Cutting thickness of 2 mm

Bed capacity 1,050 mm

Net / gross weight 235 kg

Dimensions with packaging (LxWxH) 1,550 × 1,000 × 5800 mm

Milling machine Skill 2.0

Image 49: Milling machine

1300 W milling machine for cutting, chamfering, grooving and grooving edges and profiles. Variable speed: 12,000-28,000 r.p.m. to work a wide range of materials with different types of strawberries. Dust extraction option. Adjustable ergonomic handle for perfect control.

-Product weight 2.3 Kg

-Dimensions of the product 34.7 x 7 x 22 cm

-Voltage 230 V

-Electric power 1300 w

-Amperage 5.41 A

-Components included Straight cutter; 2 6 & 8mm handles

Column drilling machine SNC 23 VM

Drill developed by Syderic. It comes with a SNT3 base and a coolant unit. Accessories such as 24 V illuminations and electrical systems are also included with the device. In addition, the drill press can choose between a 1PH or 3PH motor.


Image 50: Column Drilling

-Voltage: 400 V

-Rotation speed: Min .: 190 rpm
Max .: 5250 rpm

- Power: 1100 W, 520 W

- Depth of drill 140 mm

- No. speeds 12

- Speeds 72/2600 rpm

- Distance axis-column 3400 mm

- Distance axis-table 650 mm

- Distance axis-base 1200 mm

- Column diameter 130 mm

- Dimensions table 500X450 mm

- Dimensions base 400X410 mm

- Slots 2 in perpendicular

- Total height 2120 mm

Allrounder hybrid plastic injection molding machine


Image 51: Injection machine

The Allrounder 570 H high-performance hybrid has a clamping force of 2,000 kN and an injection unit of a size 800, and is equipped with a two-cavity mold.

A container made from PP, with a piece of 15.6 g in weight, will be manufactured in a work cycle of 3.5 seconds. The high performance machines of the Hidrive range offer maximum manufacturing capacity, as well as short work cycles and reduced energy consumption. Consequently, they are ideally suited for all types of wall applications.

WE67K80 / 3200 CNC bending press (DA52) electro hydraulic servo


Image 52: Press machine

- Aerodynamic lines design, high speed, high precision, high rigidity, CNC sheet metal press.

- Electro-hydraulic servo system, the complete loop controls the synchronization of the upper beam.

- Hydraulic compensation at the top of the working table and compensation of throat deformation, ensuring good strength and folding precision.

- Rear stop driven by AC digital servo motor, moved with the long-stroke screw ball, guided by linear guide way.

Control technology

Bench press synchronization adopts full servo electro-hydraulic loop control technology, the upper beam positioning signal is fed back by the raster (light rule) to the CNC system and the CNC system will check the opening size and synchronization valves, adjusting the amount of oil input, to perform the synchronization of movements of the upper beam (Y1, Y2), and keep the work table always in parallel situation. Following the situation of the metal sheet to be bent, the CNC system automatically controls the amount of working table compensation coronation to realize that the angle being bent of the work piece can maintain it along the full length of the workpiece. the piece.

## -TOOLS

Metric Drill [17] Bits 7 Diameter 7.50mm for metal

### TRS-HO-3D


● Legenda de ícones verifique pág. 4 | Leyenda de los iconos consulte pág. 4

Unid.:mm

| EDP No. | Dc | ℓ | L | Ds | Estoque Stock | Preço Precio |
|---|---|---|---|---|---|---|
| 48157050 | 5 | 25 | 80 | 6 | ● | R$ 755,12 |
| 8660510 | 5,1 | 26 | 82 | 6 | ※ | R$ 383,58 |
| 8660520 | 5,2 | 26 | 82 | 6 | ※ | R$ 383,58 |
| 8660530 | 5,3 | 27 | 82 | 6 | ※ | R$ 383,58 |
| 8660540 | 5,4 | 27 | 82 | 6 | ※ | R$ 383,58 |
| 8660550 | 5,5 | 28 | 82 | 6 | ● | R$ 383,58 |
| 48157555 | 5,55 | 28 | 82 | 6 | ※ | R$ 563,35 |
| 8660560 | 5,6 | 28 | 82 | 6 | ※ | R$ 542,74 |
| 8660570 | 5,7 | 29 | 82 | 6 | ※ | R$ 404,90 |
| 8660580 | 5,8 | 29 | 82 | 6 | ※ | R$ 404,90 |
| 8660590 | 5,9 | 30 | 82 | 6 | ※ | R$ 404,90 |
| 8660600 | 6 | 30 | 82 | 6 | ● | R$ 357,40 |
| 48157061 | 6,1 | 31 | 88 | 8 | ※ | R$ 840,76 |
| 48157062 | 6,2 | 31 | 88 | 8 | ※ | R$ 840,76 |
| 48157063 | 6,3 | 32 | 88 | 8 | ※ | R$ 840,76 |
| 48157064 | 6,4 | 32 | 88 | 8 | ※ | R$ 840,76 |
| 48157065 | 6,5 | 33 | 88 | 8 | ● | R$ 840,76 |
| 48157066 | 6,6 | 33 | 88 | 8 | ※ | R$ 887,98 |
| 48157067 | 6,7 | 34 | 88 | 8 | ※ | R$ 887,98 |
| 48157068 | 6,8 | 34 | 88 | 8 | ● | R$ 887,98 |
| 48157069 | 6,9 | 35 | 88 | 8 | ※ | R$ 887,98 |
| 48157070 | 7 | 35 | 88 | 8 | ● | R$ 887,98 |
| 8660710 | 7,1 | 36 | 94 | 8 | ※ | R$ 503,76 |
| 8660720 | 7,2 | 36 | 94 | 8 | ※ | R$ 503,76 |
| 8660730 | 7,3 | 37 | 94 | 8 | ※ | R$ 503,76 |
| 8660740 | 7,4 | 37 | 94 | 8 | ● | R$ 503,76 |
| 8660750 | 7,5 | 38 | 94 | 8 | ● | R$ 503,76 |
| 48157755 | 7,55 | 38 | 94 | 8 | ※ | R$ 913,41 |
| 8660760 | 7,6 | 38 | 94 | 8 | ※ | R$ 532,55 |
| 8660770 | 7,7 | 39 | 94 | 8 | ※ | R$ 532,55 |
| 8660780 | 7,8 | 39 | 94 | 8 | ※ | R$ 532,55 |
| 8660790 | 7,9 | 39 | 94 | 8 | ※ | R$ 532,55 |
| 8660800 | 8 | 40 | 94 | 8 | ● | R$ 470,03 |
| 48157081 | 8,1 | 41 | 101 | 10 | ※ | R$ 1.020,32 |
| 48157082 | 8,2 | 41 | 101 | 10 | ※ | R$ 1.020,32 |
| 48157083 | 8,3 | 42 | 101 | 10 | ※ | R$ 1.020,32 |

| EDP No. | Dc | ℓ | L | Ds | Estoque Stock | Preço Precio |
|---|---|---|---|---|---|---|
| 8660920 | 9,2 | 46 | 106 | 10 | ※ | R$ 641,94 |
| 8660930 | 9,3 | 47 | 106 | 10 | ● | R$ 641,94 |
| 8660940 | 9,4 | 47 | 106 | 10 | ● | R$ 641,94 |
| 8660950 | 9,5 | 48 | 106 | 10 | ● | R$ 641,94 |
| 48157955 | 9,55 | 48 | 106 | 10 | ※ | R$ 1.122,56 |
| 8660960 | 9,6 | 48 | 106 | 10 | ※ | R$ 696,72 |
| 8660970 | 9,7 | 49 | 106 | 10 | ※ | R$ 696,72 |
| 8660980 | 9,8 | 49 | 106 | 10 | ※ | R$ 696,72 |
| 8660990 | 9,9 | 50 | 106 | 10 | ※ | R$ 696,72 |
| 8661000 | 10 | 50 | 106 | 10 | ● | R$ 696,72 |
| 48157101 | 10,1 | 51 | 113 | 12 | ※ | R$ 1.194,18 |
| 48157102 | 10,2 | 51 | 113 | 12 | ※ | R$ 1.194,18 |
| 48157103 | 10,3 | 52 | 113 | 12 | ● | R$ 1.194,18 |
| 48157104 | 10,4 | 52 | 113 | 12 | ※ | R$ 1.194,18 |
| 48157105 | 10,5 | 53 | 113 | 12 | ● | R$ 1.194,18 |
| 48157106 | 10,6 | 53 | 113 | 12 | ※ | R$ 1.224,29 |
| 48157107 | 10,7 | 54 | 113 | 12 | ※ | R$ 1.224,29 |
| 48157108 | 10,8 | 54 | 113 | 12 | ● | R$ 1.224,29 |
| 48157109 | 10,9 | 55 | 113 | 12 | ※ | R$ 1.224,29 |
| 48157110 | 11 | 55 | 113 | 12 | ● | R$ 1.224,29 |
| 8661110 | 11,1 | 56 | 120 | 12 | ※ | R$ 804,94 |
| 8661120 | 11,2 | 56 | 120 | 12 | ● | R$ 804,94 |
| 8661130 | 11,3 | 57 | 120 | 12 | ● | R$ 804,94 |
| 8661140 | 11,4 | 57 | 120 | 12 | ● | R$ 804,94 |
| 8661150 | 11,5 | 58 | 120 | 12 | ● | R$ 804,94 |
| 8661160 | 11,6 | 58 | 120 | 12 | ※ | R$ 897,69 |
| 8661170 | 11,7 | 59 | 120 | 12 | ※ | R$ 897,69 |
| 8661180 | 11,8 | 59 | 120 | 12 | ※ | R$ 897,69 |
| 8661190 | 11,9 | 60 | 120 | 12 | ※ | R$ 897,69 |
| 8661200 | 12 | 60 | 120 | 12 | ● | R$ 792,35 |
| 48157125 | 12,5 | 63 | 128 | 14 | ● | R$ 1.377,39 |
| 48157130 | 13 | 65 | 128 | 14 | ※ | R$ 1.530,49 |
| 8661350 | 13,5 | 68 | 134 | 14 | ※ | R$ 1.194,84 |
| 8661400 | 14 | 70 | 134 | 14 | ※ | R$ 1.194,84 |
| 48157145 | 14,5 | 73 | 140 | 16 | ※ | R$ 1.673,21 |
| 48157150 | 15 | 75 | 140 | 16 | ※ | R$ 1.714,21 |

Image 53: Drill Catalog

The Ø 7.5 mm drill bit is used to generate the holes in SUBCONJUNTO 1.2 and can be assembled by screws (3) to the lower housing (1.1.1)

-2.3.2. MACHINE FOR PRINT 3D [20]

The Zortrax M200 Zortrax 3D printer is a plug & play printer that can print layers up to 25 microns with PLA, ABS or Nylon filaments. The printer includes the Z-Suite software and is compatible with Windows (XP / Vista / 7 +), Mac OS X and Linux. You can print objects with a maximum size of 205x205x190.


Image 54: 3D printer

Material (s): PLA, ABS, Special filaments

Technology: Deposition of molten material

Assembly: Plug & play

Size: 430x360x345

Weight (kg): 13.5

Diameter of the extruder (mm): 0.4

Thickness of the layer: 90

Speed (mm / s): -

Accuracy (mm): XY: 1.5 µm - Z: 1.25 µm

Strand size (mm): 1.75

Maximum production volume (mm): 200x200x185

Type of files: .stl, .obj

Software: Z-Suite

Connectivity: -

Operating systems: Windows (XP / Vista / 7 +), Mac OS X, Linux

Power: 100-240V ~ 2 amps 50-60 Hz

## 2.4 TOOLS FOR ASSEMBLY

Sergeant Leroy Merlin

Image 55: Seargeant

Special clamping and clamping tool for different jobs. 160 mm opening

-Tools and supplies

Kinpex jaws


Image 56: Kinpex jaws

-Chromed finish for better resistance to corrosion.

-Left to unlock with one hand.

- Screw to adjust the mouth and amount of pressure to exercise.

-Size of 180 mm.

STANLEY 1-65-412 [18] - Insulated screwdriver vde 1000v FatMax flat 4 x 100 mm


Image 57: Screw driver

Electrician's screwdriver with ergonomic, large-diameter bimetallic handle, which offers a high torsional capacity. Slim neck for fast rotation. The handle is molded directly on the steel rod. It can be hung thanks to its hole in the handle. Color code on the handle for identification of tip type. Industrial quality 1,000V a.c isolation. Individually tested standard EN60900: 2004. Protects from current up to 1,000V a.c. Protective polyamide insulating cover extremely resistant up to a temperature of -25ºC, which ensures resistance to corrosion and minimizes the risk of moisture absorption. SKU Tip width (mm) Blade length (mm) 65-410 2.5 50 65-411 3.5 75 65-412 4 100 65-413 5.5 150

Bed pressure screw

Universal jaws with rotating base

| MODELO | MU125 | MU150 | MU200 |
|---|---|---|---|
| CÓDIGO | 1000524 | 1000525 | 1000526 |
| ANCHO BOCA (MM) | 125 | 150 | 200 |
| ALTURA BOCA (MM) | 37 | 40 | 58 |
| APERTURA BOCA (MM) | 85 | 114 | 150 |
| LONGITUD TOTAL (MM) | 370 | 462 | 620 |
| ALTURA TOTAL (MM) | 128 | 145 | 202 |
| PESO (KG) | 17 | 28 | 58 |

Image 58: Bed pressure screw

The bench press screw serves to hold the parts in the drill and allow both a better grip and support, thus allowing the piece to be held does not oscillate or cause movement.

## 2.5 COMMERCIAL ELEMENTS FOR MANUFACTURING

SCREWS

Image 59: Screw box

PROPELLERS

Image 60: Propeller Box

WASHERS


Image 61: Washer Box

PLASTIC IN PELLETS for inyection

Image 62: Pellets Box

### 2.5.1 COMERCIAL ELEMENTS FOR PRINTING 3D

-Naylon [19]


Image 63: Naylon filaments

Diámetro: 1,75mm o 2,85 mm

Temperatura nozzle ideal (impresión): 230ºC

Rango de temperaturas de impresión: 228-235 ºC

Temperatura base impresión: No necesaria. (Recomendable a 45 ºC).

Cantidad Neta: 450gr (1lb)

Uso Alimentario: No Aprobado

Diámetro bobina: 200mm (Ø 1.75mm) / 130mm (Ø 3mm)

Ancho bobina: 50mm (Ø 1.75mm) / 70mm (Ø 3mm)

Diámetro agujero interior: 50mm (Ø 1.75mm) / 19mm (Ø 3mm)

-Carbon Fiber [21]

Image 64: Carbon Fiber filaments

The Filament 3d Special Carbon Fiber 1.75mm of Color Plus, with tolerances of diameter of ± 0,05mm or less, guarantee a constant supply and stable impressions, always.

## 3. Technical specifications

The following are the technical conditions necessary for the construction of the armchair prototype for each piece, subset and final assembly:

### Piece 1.1.1 (Lower Housing)

Starting material: Plastic pellets

| Operation | 1ª | Injection |
|---|---|---|
| -Machine | Plastic injection molding machine | |
| -Manufacturing | injection work can be carried out by an operator with a minimum category of "2rd Officer" | |
| -Media Assistant: | | |
| -Supplies | Mold | |
| -Tools | Not precise | |
| Development: | | |
| 1º- | Placement of the pellets in Plastic injection molding machine | |
| 2º- | Placement of the mold | |
| 3º- | Placement parameters in in Plastic injection molding machine | |
| 4º- | Start-up Plastic injection molding machine | |
| 5º- | Pick up the piece | |
| -Safety | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | |
| 1º- | Check the good condition of the machine | |
| 2º- | Check the good condition and placement of the mold | |
| 3º- | Check the parameters of the machine | |
| 4º- | Check the final dimensions of the piece | |
| -Tests | Every 100 units Resistance and hardness | |

Table 11: Lower Housing Injection

### Piece 1.2 (Legs)

Starting material: Aluminum sheet

| Operation | 1ª | Shear |
|---|---|---|
| -Machine | Manual lever shear | |
| -Manufacturing | Shear work can be carried out by an operator with a minimum category of "3rd Officer" | |
| -Media Assistant: | | |
| -Supplies | Not precise | |
| -Tools | Hooks | |
| Development: | | |
| 1º- | Placement of bar in the machine to the determined measure (150 mm). | |
| 2º- | Placement of the saw blade to a certain size (90 °). | |
| 3º- | Start-up of the machine | |
| 4º- | Cutting of the material in the given measurement (150 mm) | |
| -Safety | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | |
| 1º- | Check the good condition of the machine | |
| 2º- | Check the good condition and placement of the saw blade | |
| 3º- | Check the perpendicularity of the shear | |
| 4º- | Check the final dimensions of the piece | |
| -Tests | Not precise | |

| Operation | | 2ª | Edge rounding |
|---|---|---|---|
| -Machine | | Milling machine Skill 2.0 | |
| -Manufacturing | | Rounding work can be carried out by an operator with a minimum category of "3rd Officer" | |
| -Media Assistant: | | | |
| -Supplies | | Mills (5mm) | |
| -Tools | | Hooks | |
| Development: | | | |
| 1º- | Placement of bar in the machine to the determined measure | | |
| 2º- | Placement the parameters in the machine | | |
| 3º- | Start-up of the machine | | |
| 4º- | Cutting of the material in the given edge rounding | | |
| -Safety | | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | | |
| 1º- | Check the good condition of the machine | | |
| 2º- | Check the good condition and placement of the mills | | |
| 3º- | Check the perpendicularity of the shear | | |
| 4º- | Check the final dimensions of the piece | | |
| -Tests | | Not precise | |

Table 12: Aluminion Rounding

| Operation | | 3ª | Holey |
|---|---|---|---|
| -Machine | | Column drilling machine SNC 23 VM | |
| -Manufacturing | | Holey work can be carried out by an operator with a minimum category of "3rd Officer" | |
| -Media Assistant: | | | |
| -Supplies | | Bench pressure screw, flexometer | |
| -Tools | | Drill for metal Ø 7.5 mm | |
| Development: | | | |
| 1º- | Fixing of pressure screw in bedplate<br>Drilling hole. | | |
| 2º- | Placement of Ø 7.50 mm bit in the drill | | |
| 3º- | Mark centers of holes and punch before placing the piece in a pressure screw | | |
| 4º- | Placement of part in pressure screw in bench: it is seen the face of greater length and the mark of the hole of Ø 7.50 mm aligned with the bit. | | |
| 5º- | Drilling hole. | | |
| -Safety | | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | | |
| 1º- | Check the good condition of the machine | | |
| 2º- | Check the good condition and placement of the brench pressure screw | | |
| 3º- | Check the good condition and placement of the drill | | |
| 4º- | Check the final holes dimensions of the piece | | |
| -Tests | | Not precise | |

Table 13: Aluminium Holey

| Operation | 4ª | Curved |
|---|---|---|
| -Machine | WE67K80 / 3200 CNC bending press (DA52) electro hydraulic servo | |
| -Manufacturing | Curved work can be carried out by an operator with a minimum category of "$2^{rd}$ Officer" | |
| -Media Assistant: | | |
| -Supplies | Mold | |
| -Tools | Not precise | |
| Development: | | |
| 1º- | Fixing the mold in the curved | |
| 2º- | Placement of aluminium sheet | |
| 3º- | Placement the parameters in the machine | |
| 4º- | Curved by press | |
| 5º- | Piece extraction | |
| -Safety | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | |
| 1º- | Check the good condition of the machine | |
| 2º- | Check the good condition and placement of the press | |
| 3º- | Check the final curved dimensions of the piece | |
| -Tests | Not precise | |

Table 14: Aluminium curved

### Piece 2.1 (Upper Housing)

Starting material: Plastic pellets

| Operation | 1ª | Injection |
|---|---|---|
| -Machine | Plastic injection molding machine | |
| -Manufacturing | injection work can be carried out by an operator with a minimum category of "$2^{rd}$ Officer" | |
| -Media Assistant: | | |
| -Supplies | Mold | |
| -Tools | Not precise | |
| Development: | | |
| 1º- | Placement of the pellets in Plastic injection molding machine | |
| 2º- | Placement of the mold | |
| 3º- | Placement parameters in in Plastic injection molding machine | |
| 4º- | Start-up Plastic injection molding machine | |
| 5º- | Pick up the piece | |
| -Safety | Gloves, goggles, work clothes and safety shoes. | |
| -Controls | | |
| 1º- | Check the good condition of the machine | |
| 2º- | Check the good condition and placement of the mold | |
| 3º- | Check the parameters of the machine | |
| 4º- | Check the final dimensions of the piece | |
| -Tests | Every 100 units Resistance and hardness | |

Table 15: Upper Housing Injection

## 4. Measurements and budget

For the preparation of the chapter of MEASUREMENTS AND BUDGET information is required on the times of duration and cost of works, machinery and tooling

### ESTIMATED TIMES

According to the Technical Office of Methods and Times, the estimated time in each operation is as follows:

Operation: Metal sheet cutting = 0.10h

Operation: Embedding housing = 0.10h

Operation: Cutting leftovers = 0,10h

Operation: Perforated in sheet metal = 0,10h

Operation: End bend = 0.20h

Operation: Rounding of edges with cutter = 0.10h

Operation: Perforated in wood = 0,10h

Operation: Curved in metal = 0.10h

Operation: Plastic injection = 0.10h

Operation: Piece Assembly = 0.20h

### UNIT COSTS

According to the Commercial Department, the costs of labor and the prices of machinery and tools used, as well as their amortization or useful life, are the following:

### MATERIAL

Metal sheet Aluminum 70 x 70 x 2 mm = 1.2 kg / u = 5 €

Screw M7x20 = bag 250 units = 10.33 €

Washer M7 = bag 1000 units = € 5.70

Plastic in polypropylene pellets (part 1.1.1 and 2.1) = 1.5 € / Kg

Round stopper for parachute, order of 2000 units approx. € 0.20 / Ud

Solar cells, order of 1000 units, approx. € 7 / unit

**MACHINERY** (Estimate a use of 2000 h / year)

Shear = € 10,000. Amortization in 20 years.
Column drilling machine = € 1000. Amortization in 15 years. .
Manual portable milling machine = € 150. Amortization in 10 years.
Plastic injection machine = € 30000. Amortization in 10 years.
Curved press = € 4000. Amortization in 10 years.

**AUXILIARY MEANS**

Press trophy € 1000. Perform 1000 units
Drill 10 €. Life of 100h
Doubled die 200 €. Perform 1000 units
Bench pressure screw 500 €. Life of 20000 h
Concave radius router 15 €. Life of 100h
Molding to bend € 300. Perform 1000 units
Mold for injection (1.1.1) € 5000. Realize 4000 units
Mold for injection (2.1) 3000 €. Realize 4000 units

**MANUFACTURING**

Official 3rd = € 20 / h
Official 2nd = € 25 / h
Official 1st = € 30 / h

| WORK UNIT | MEASUREMENT | | DESCRIPTION | UNIT PRICE | AMOUNT (EUROS) | TOTAL (EUROS) |
|---|---|---|---|---|---|---|
| | QUANT. | Ud. | | | | |
| 1.1.1 | 1 | Ud. | Lower Housing | | | |
| | | | | | | |
| | | | **Material-** | | | |
| | 0,5 | Kg | **Plastic pellets** | 1,5 | 0,75 | |
| | | | | | | |
| | | | | | | |
| | | | Works of: Injection | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | Plastic injection machine | 1,5 | 0.15 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 2ª officer | 25 | 2,5 | |
| | | | **Auxiliary means-** | | | |
| | 0,1 | h | Supplies : Mold | 1,25 | 0,125 | |
| | | | Tools: Not precise | | | |
| | | | | | | 3,525€ |
| 1.2 | 4 | Ud. | Legs | | | |
| | | | | | | |
| | | | **Material-** | | | |
| | 0,21 | Kg | **Aluminium 70 x 70 x 2 mm** | 5 | 1,05 | |
| | | | | | | |
| | | | | | | |
| | | | Works of: SHEAR | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | | 0,25 | 0,025 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 3ª Officer | 20 | 2 | |
| | | | **Auxiliary means-** | | | |
| | | | Supplies : Not precise | | | |
| | | | Tools: Not precise | | | |
| | | | | | | |
| | | | Works of: EDGE SOFTENING | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | Manual portable milling machine | 0,0075 | 0,00075 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 2ª Officer | 25 | 2,5 | |
| | | | **Auxiliary means-** | | | |
| | 0,1 | h | Tools: concave radius cutter | 0,15 | 0,015 | |
| | | | Supplies: Not precise | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| UNIDAD DE OBRA | MEDICIÓN | | DESCRIPCIÓN | PRECIO UNITAR | IMPORTE (EUROS) | TOTAL (EUROS) |
|---|---|---|---|---|---|---|
| | CANT. | Ud. | | | | |
| | | | Works of: HOLDING | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | Column drilling machine | 0,034 | 0,0034 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 3ª Officer | 20 | 2 | |
| | | | **Auxiliary means-** | | | |
| | 0,1 | h | Tools: Metal Drill Ø7,5 mm | 0,1 | 0,01 | |
| | | | Supplies: Not precise | | | |
| | | | | | | |
| | | | Works of: CURVED | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | Curved Press | 0,2 | 0,02 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 2ª Officer | 25 | 2,5 | |
| | | | **Auxiliary means-** | | | |
| | 0,1 | h | Tools: Mold | 0,3 | 0,03 | |
| | | | Supplies: Not precise | | | |
| | | | | | | 10,15€ |
| | | | | | | |
| 2.1 | 1 | Ud. | Upper Housing | | | |
| | | | | | | |
| | | | **Material-** | | | |
| | 0,2 | Kg | **Plastic pellets** | 1,5 | 0,375 | |
| | | | | | | |
| | | | | | | |
| | | | Works of: Injection | | | |
| | | | **Machinerie-** | | | |
| | 0,1 | h | Plastic injection machine | 1,5 | 0,15 | |
| | | | **Workforce-** | | | |
| | 0,1 | h | 2ª officer | 25 | 2,5 | |
| | | | **Auxiliary means-** | | | |
| | 0,1 | h | Supplies : Mold | 0,75 | 0,075 | |
| | | | Tools: Not precise | | | 3,1€ |
| | | | | | | |
| 1.1.2 | 4 | Ud. | Propeller | 0,06 | | 0,24€ |
| | | | | | | |
| 3 | 4 | Ud. | Tornillo | 0,08845 | | 0,35€ |
| | | | | | | |
| 4 | 4 | Ud. | Arandelas | 0,0087 | | 0,035€ |
| | | | | | | 17,4€ |

Table 16: Lower Housing Injection

## 5. Activity planning

Next, a planning of the activities for the construction of a DRONE with its corresponding PERT diagram.

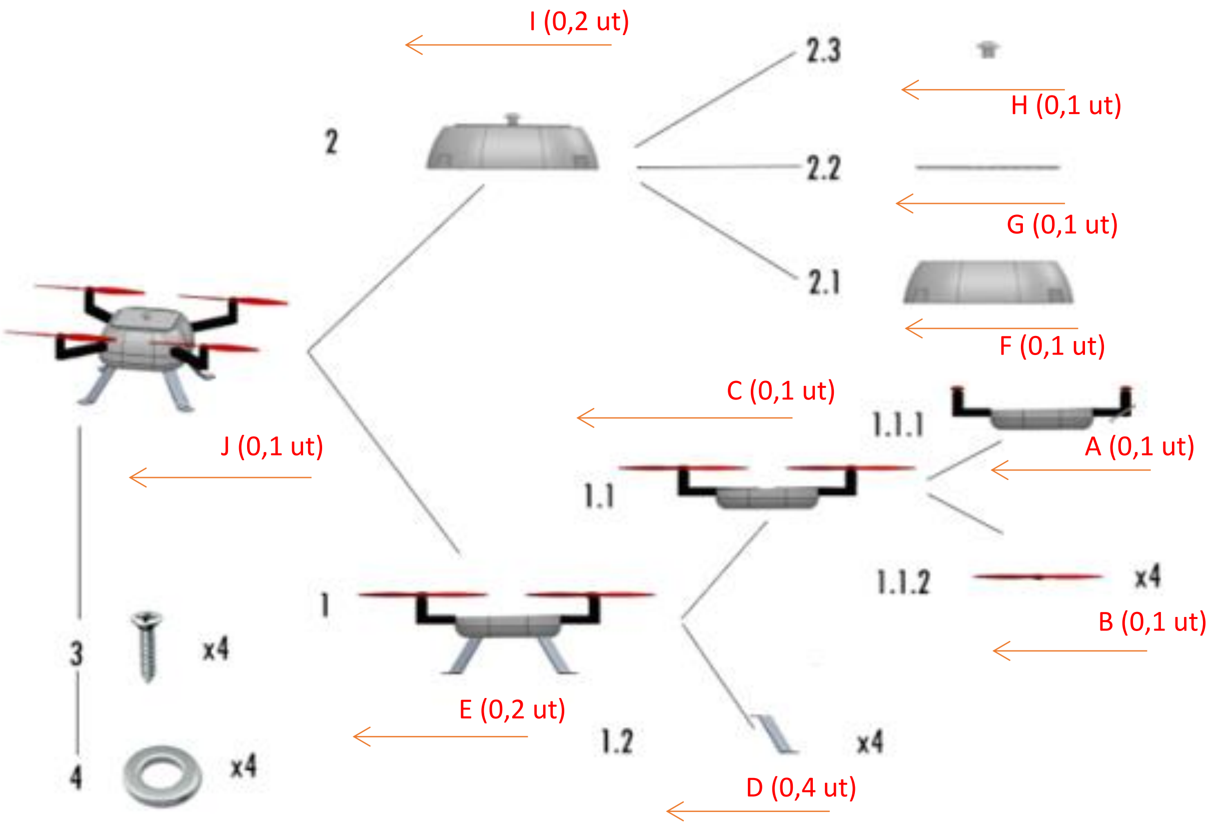



Image 65: Activity Planning

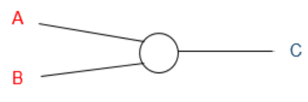
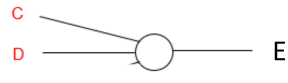
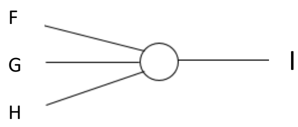
| TABLE OF ACTIVITIES FOR THE MANUFACTURE AND ASSEMBLY OF: DRONE | | | | | | |
|---|---|---|---|---|---|---|
| ELEMENT OR SUBSET | ACTIVITY DESIGNATION | | DURATION | PREVIOUS ACTIVITIES | ACTIVITIES IMMEDIATELY PREVIOUS | PARTIAL GRAF |
| 1.1.1 | INJECTION | A1 | 0,10 | - | - | - |
| 1.1.2 | (ASK FOR SUPPLY) | B | - | - | - | - |
| SUB-SET 1.1 | ASSEMBLY | C | 0,10 | A-B | A-B |  |
| 1.2 | SHEAR<br>ROUNDING<br>HOLEY<br>CURVED | D1<br>D2<br>D3<br>D4 | 0,10<br>0,10<br>0,10<br>0,10 | - | - | - |
| SUB-SET 1 | ASSEMBLY (SCREW) | E | 0,20 | A-B | C-D-E |  |
| 2.1 | INJECTION | F | 0,10 | - | - | - |
| 2.2 | (ASK FOR SUPPLY) | G | - | - | - | - |
| 2.3 | (ASK FOR SUPPLY) | H | - | - | - | - |
| SUB-SET 2 | ASSEMBLY | I1 | 0.20 | H-I-J | H-I-J |  |
| SET | USER ASSEMBLY | J | 0,10 | - | - | - |

Table 17: Activity Table

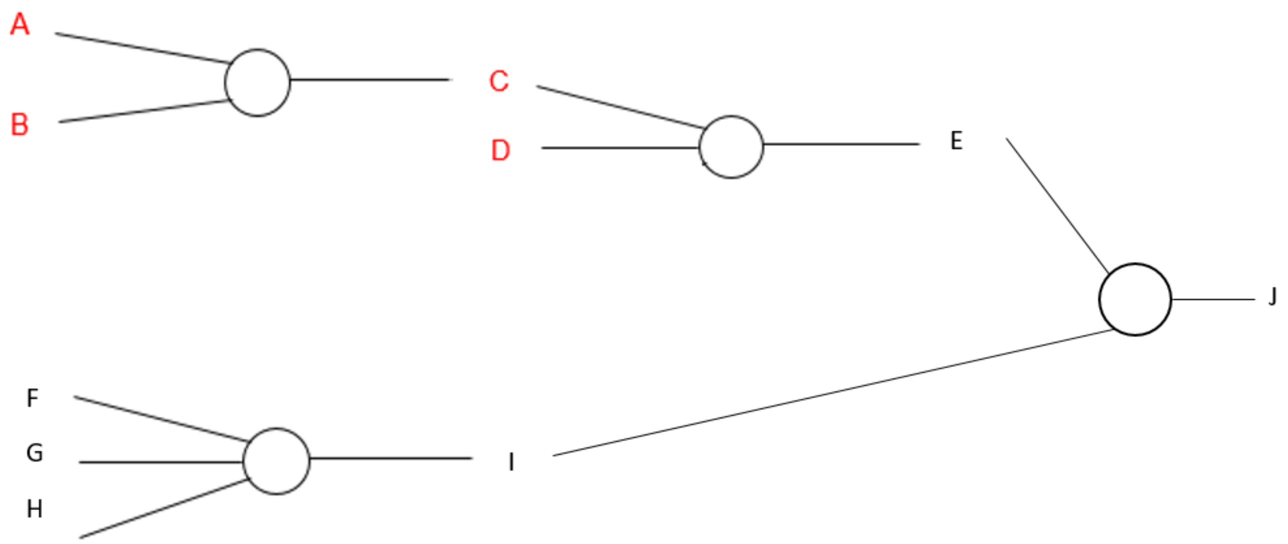



Image 66: Activity diagram

GRAFO SKETCH COMPLETE WITH TIME OF ACTIVITIES

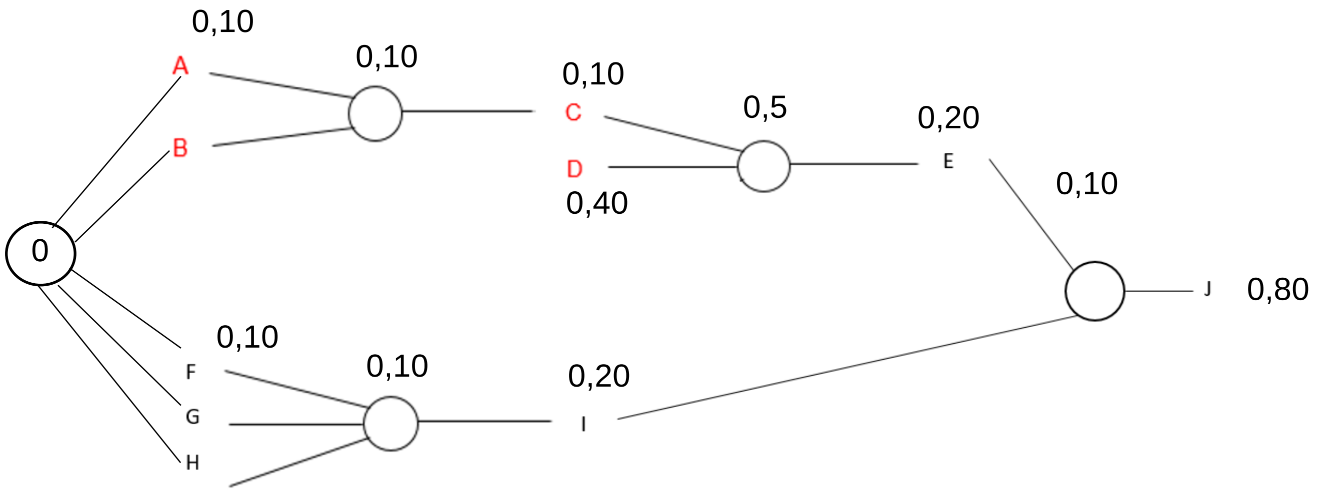



Image 67: Activity Plan with times

INITIAL PERT WITH NUMBER OF OPERATORS

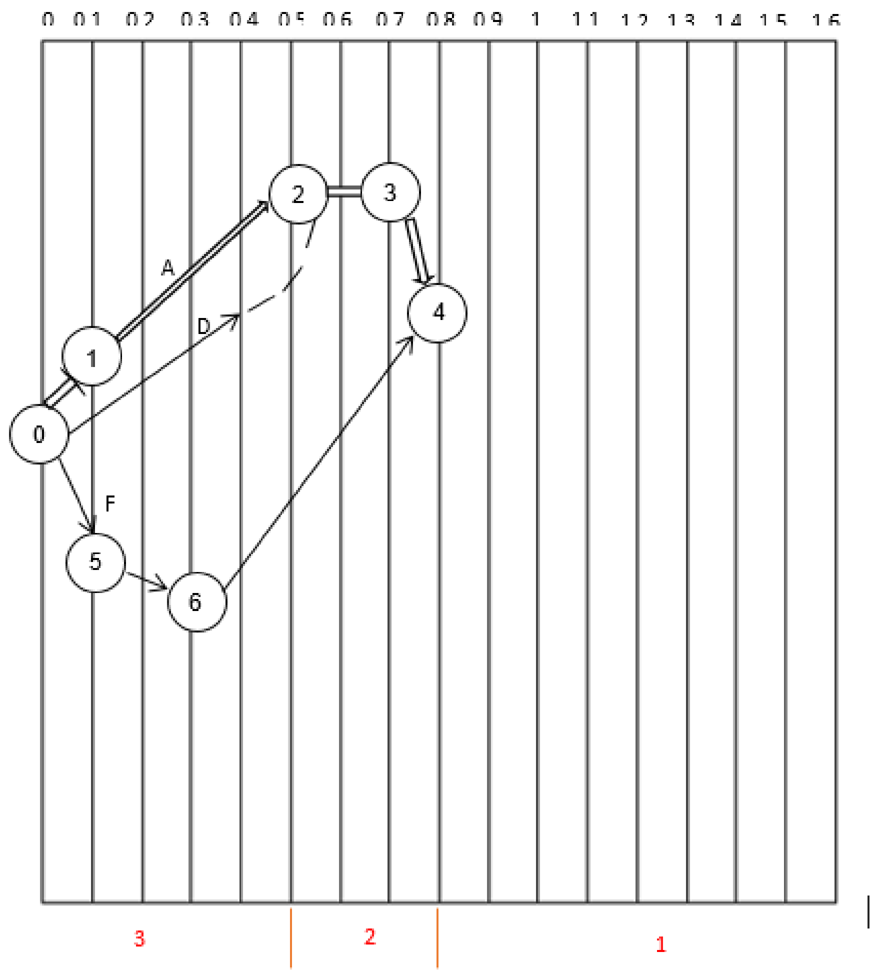



Table 18: Initial Pert

## INITIAL PERT WITH ADJUSTMENT OF NUMBER OF OPERATORS

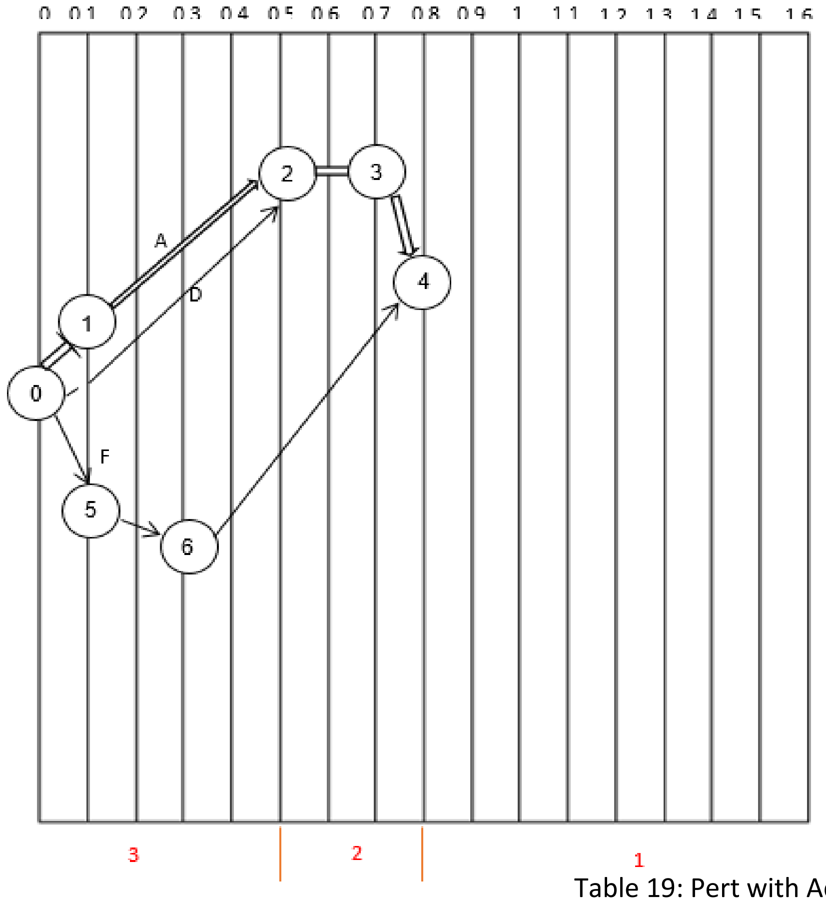



Table 19: Pert with Adjustment

## DECOMPOSITION OF DETAILED ACTIVITIES

| ACTIVITIES AND MATERIAL RESOURCES | | | |
|---|---|---|---|
| ACTIVITY | | MACHINE | TIME |
| INJECTION | A1 | INJECTION MACHINE | 0,10 |
| ASSEMBLY PROPELLERS (SUB-SET 1.1) | C1 | HOOK | 0,20 |
| SHEAR<br>ROUNDING<br>HOLEY<br>CURVED | D1<br>D2<br>D3<br>D4 | SHEAR<br>MILLING MACHINE<br>COLUMN DRILLING<br>PRESS | 0,10<br>0,10<br>0,10<br>0,10 |
| ASSEMBLY LEGS (SUB-SET 1) | E1 | SCREW | 0,20 |
| INJECTION | F1 | INJECTION MACHINE | 0,10 |
| ASSEMBLY HOUSINGS (SUB-SET 1) | I | HOOK | 0,20 |
| USER ASSEMBLY | J | TOOLS | 0,10 |

Table 20: Descomposition of activities

# 6. DEFINITION PLANS

## 6.1 JOINT PLANS

Plans of set, in orthogonal projection, with marks of elements, general dimensions and list of elements

## 6.2 SUBCONJUNT PLANS

Drawings of all subsets with functional dimension.

## 6.3 EXPLODED PLANS

Drawings of all the component elements with functional dimension.

## 6.4 PLANT DISTRIBUTION

In these planes the route of the operator that makes the elements (1.1.1, 1.2 and 2.1) in the industrial warehouse will be shown

## 6.5 LUMINARY PLANT DISTRIBUTION

Next, the electrical system of the ship is developed to check its installation.

## 6.6 EMERGENCY PLANT DISTRIBUTION

Finally, a safety set is designed to avoid accidents inside the ship itself.

Bibliography

https://www.ebsco.com/drone [1]

http://droneymas.es/partes-de-un-drone/ [2]

http://www.eis.uva.es/~biopolimeros/alberto/pla.htm [3]

https://www.impresoras3d.com/el-material-de-impresion-abs-y-sus-caracteristicas/ [4]

https://www.impresoras3d.com/filamento-pla-consejos-caracteristicas-y-mucho-mas/ [5]

http://www.petroquim.cl/que-es-el-polipropileno/ [6]

http://blogs.repsol.com/innovacion/polietileno-un-plastico-muy-resistente-con-gran-variedad-de-aplicaciones/ [7]

https://uadedrones.wordpress.com/2015/09/22/simulacin-de-empuje-de-la-hlice-con-cfd/ [8]

http://noticiasdelaciencia.com/not/12949/actuaciones-en-vuelo-de-drones/ [9]

http://www.profesorenlinea.cl/fisica/PresionAtmosferica.htm [10]

http://www.aenor.es/aenor/actualidad/actualidad/noticias.asp?campo=1&codigo=44924 [11]

http://fpvmax.com/2017/04/10/normas-iso-drones/ [12]

http://www.extrusax.com/imagenes/descargas/es/12/STANDARD%20PROFILES%20-%20PERFILES%20NORMALIZADOS.pdf [13]

http://www.echebarriasuministros.com/images/catalogo/13-tornilleria-y-remaches.pdf [14]

file:///C:/Users/Jordi/Desktop/TECHNO-SUN-catalogo-productos-energia-solar.pdf [15]

https://kem.com.mx/kem_txt_src.php?input_txt_src=capuchones&btn_txt_src [16]

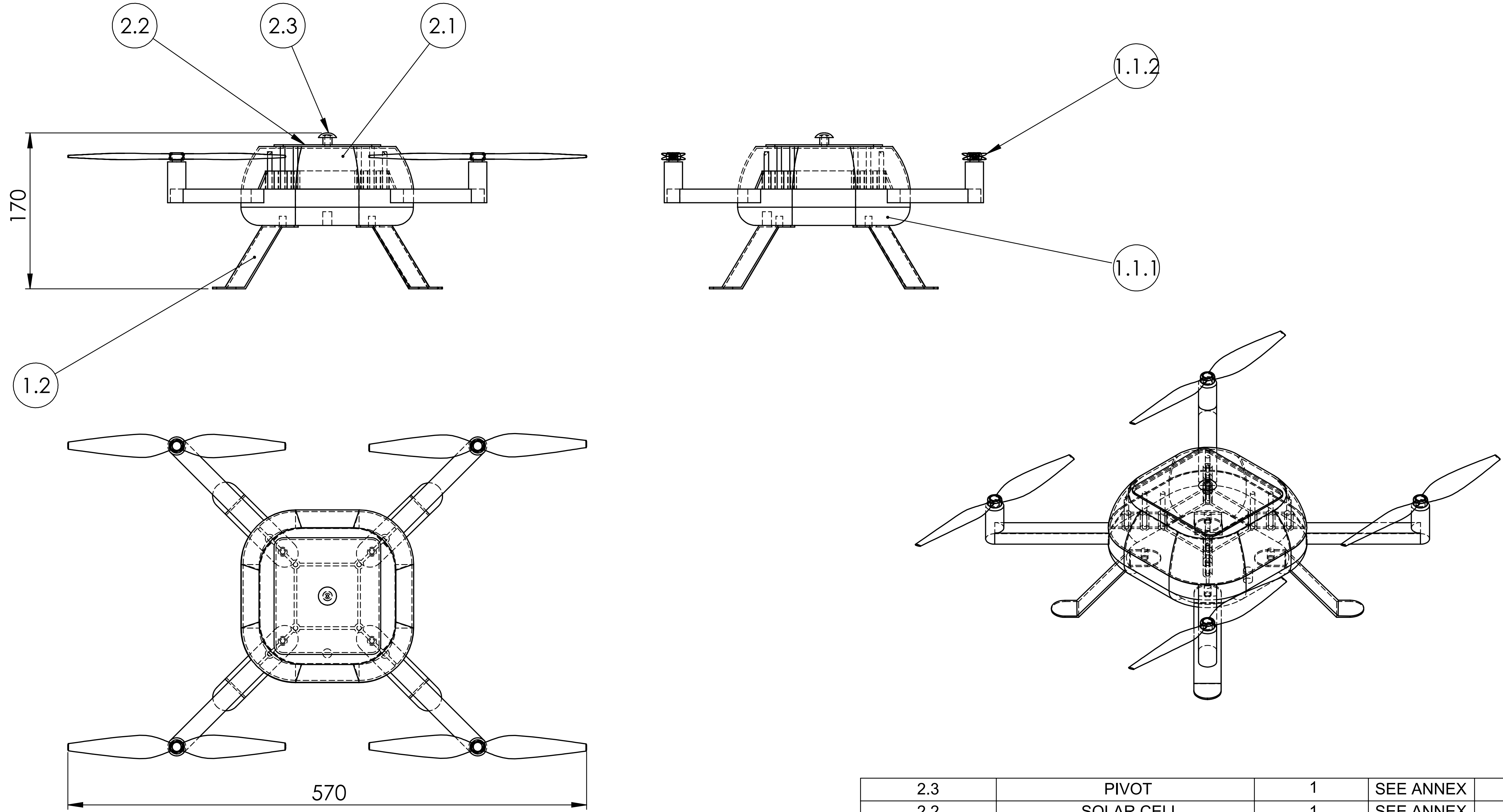
http://www.osg.com.br/v4/fotos/download/Cat_Brocas_Low2014.pdf [17]

https://www.amazon.es/STANLEY-1-65-412-Destornillador-aislado-FatMax/dp/B001E4IIPK/ref=sr_1_50?s=tools&ie=UTF8&qid=1528282582&sr=1-50 [18]

https://filament2print.com/es/nylons/641-nylon-taulman-230.html [19]

https://www.3dnatives.com/es/3D-compare/imprimante/zortrax-m200 [20]

https://www.colorplus3d.com/producto/filamento-3d-especial-fibra-de-carbono/ [21]




| | | | | |
|---|---|---|---|---|
| 2.3 | PIVOT | 1 | SEE ANNEX | POPLYPROPILENE |
| 2.2 | SOLAR CELL | 1 | SEE ANNEX | - |
| 2.1 | UPPER HOUSING | 1 | SEE ANNEX | POPLYPROPILENE |
| 1.2 | LEG | 4 | SEE ANNEX | ALUMINIUM |
| 1.1.2 | PROPELLER | 4 | SEE ANNEX | CARBON FIBER |
| 1.1.1 | LOWER HOUSING | 1 | SEE ANNEX | POPLYPROPILENE |
| MARK | DESIGNATION | QUANTITY | REFERENCE | MATERIAL |

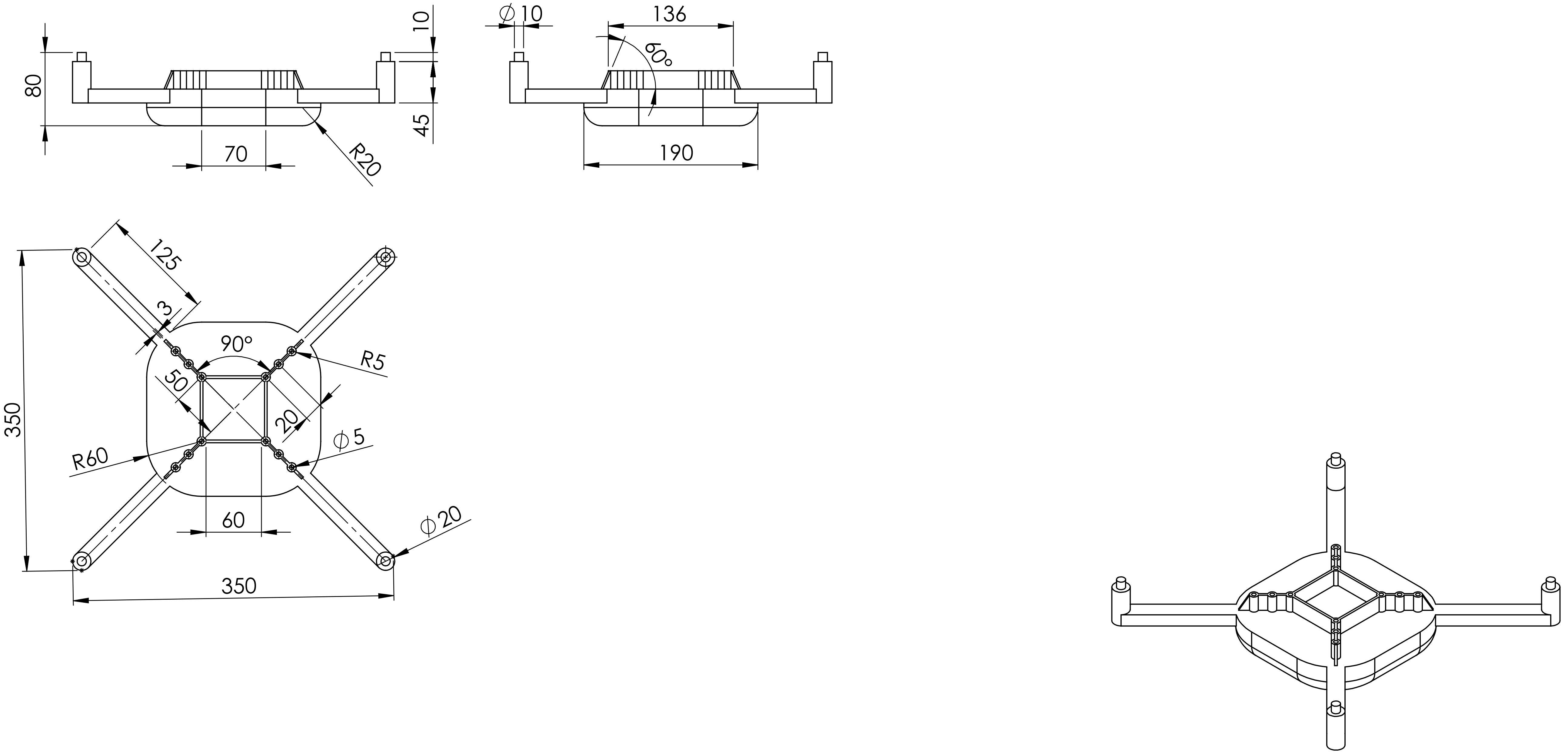
UNIVERSITAT POLITÈCNICA
DE VALENCIA
CAMPUS DE ALCOI
Uniwersytet Technologiczno-Przyrodniczy

HEADER: DRONE SET

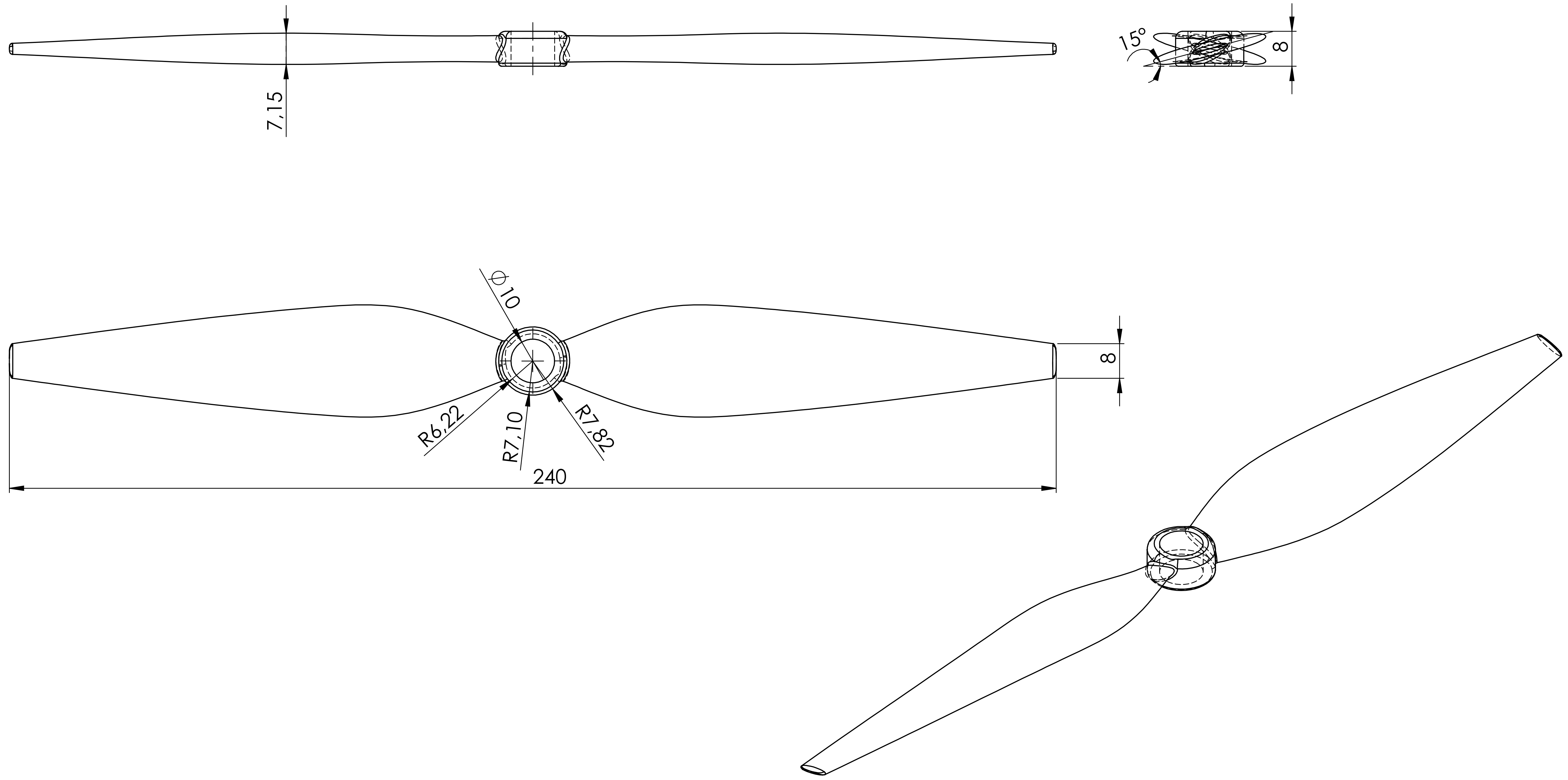
WORK HEADER:

DRON DEVELOPMENT

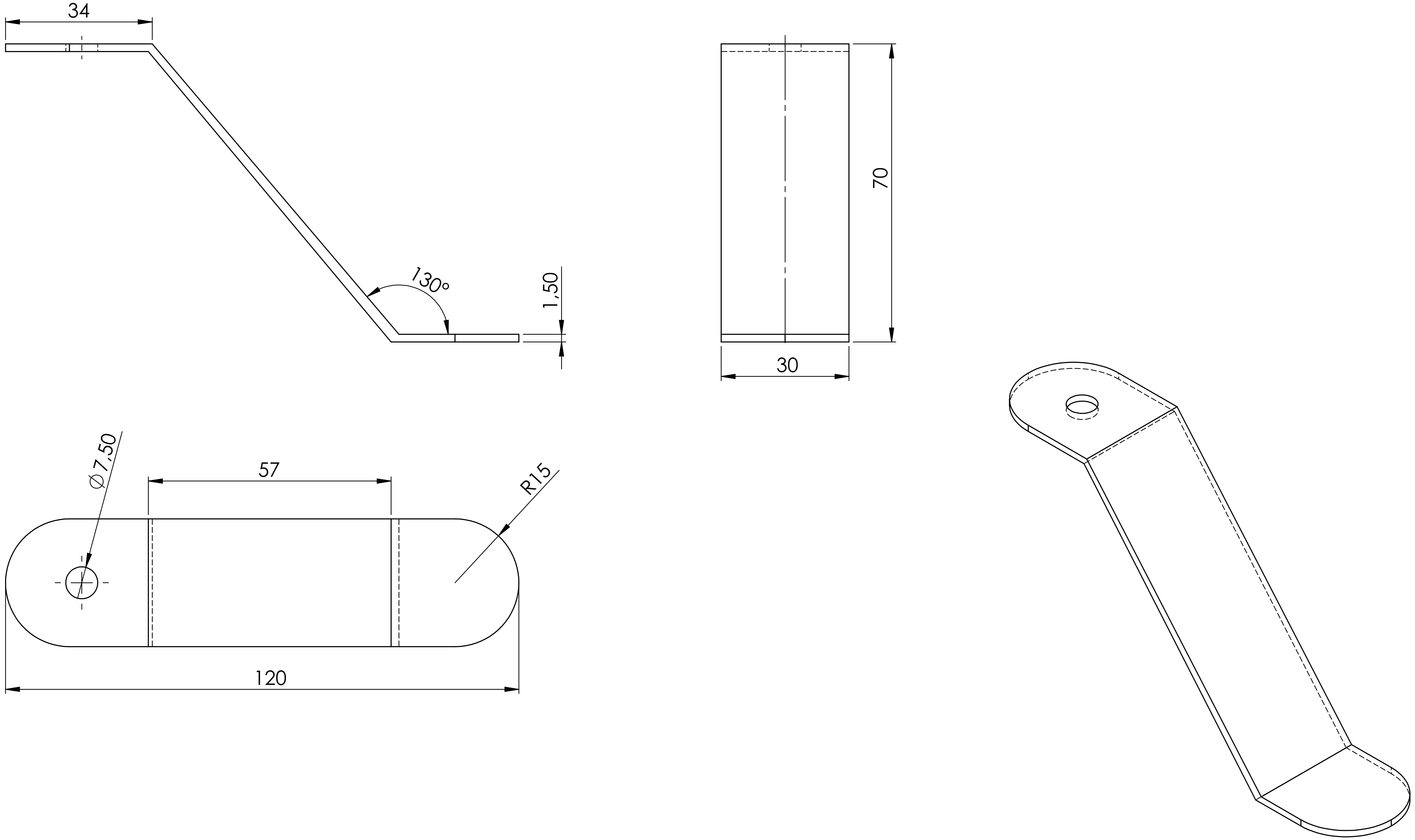
| | | | |
|---|---|---|---|
| Reviewed by: | Unit: mm | 1st SURNAME: BORRELL | DATE: |
| | SCALE 1:5 | 2nd SURNAME: JORNET | 15/06/2018 |
| | | Name: Jordi | |
| Note: | | Degree: Industrial design engineering | |



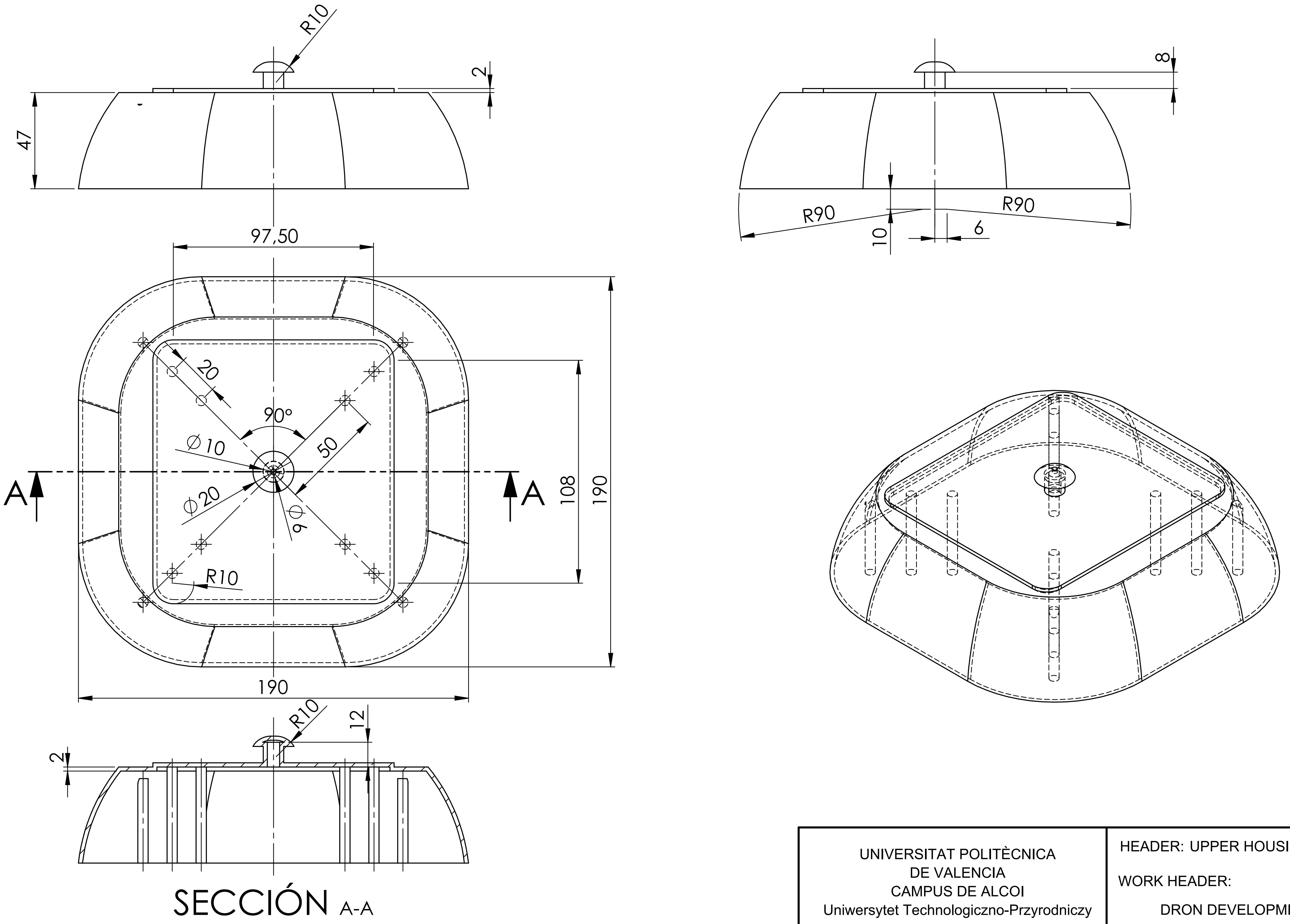

| | | | | |
|---|---|---|---|---|
| UNIVERSITAT POLITÈCNICA DE VALENCIA CAMPUS DE ALCOI Uniwersytet Technologiczno-Przyrodniczy | | HEADER: LOWER HOUSING PLANS<br>WORK HEADER:<br>DRON DEVELOPMENT | | |
| Reviewed by: | Unit: mm | 1st SURNAME: BORRELL | | DATE: |
| | SCALE<br>1:5 | 2nd SURNAME: JORNET | | 15/06/2018 |
| | | Name: Jordi | | |
| Note: | | Degree: | Industrial design engineering | |



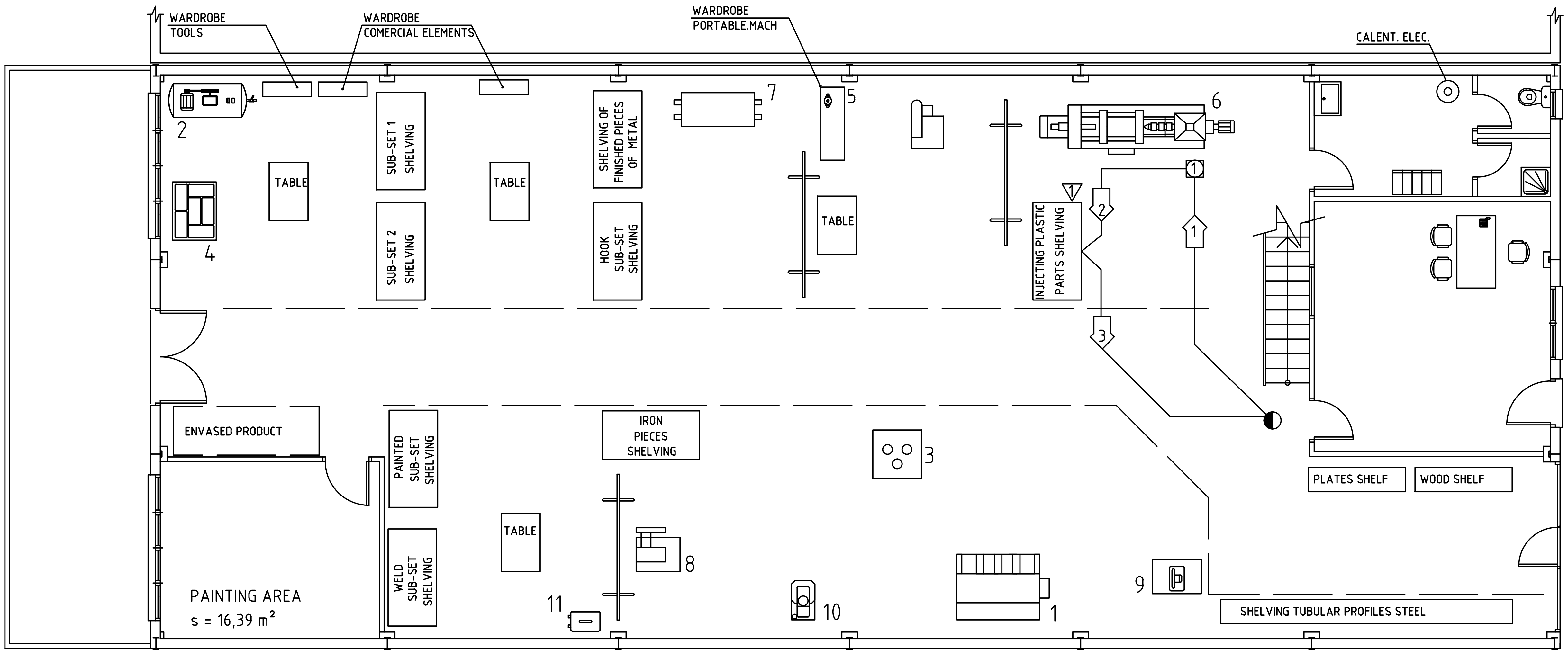

| | | | | |
|---|---|---|---|---|
| UNIVERSITAT POLITÈCNICA<br>DE VALENCIA<br>CAMPUS DE ALCOI<br>Uniwersytet Technologiczno-Przyrodniczy | | HEADER: LOWER HOUSING PLANS<br>WORK HEADER:<br>DRON DEVELOPMENT | | |
| Reviewed by: | Unit: mm | 1st SURNAME: BORRELL | | DATE: |
| | SCALE<br>1:2 | 2nd SURNAME: JORNET | | 15/06/2018 |
| | | Name: Jordi | | |
| Note: | | Degree: | Industrial design engineering | |

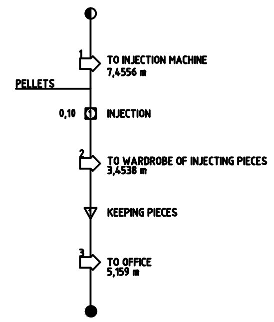



| | | | |
|---|---|---|---|
| UNIVERSITAT POLITÈCNICA DE VALENCIA<br>CAMPUS DE ALCOI<br>Uniwersytet Technologiczno-Przyrodniczy | | HEADER: LEG PLANS<br>WORK HEADER:<br>DRON DEVELOPMENT | |
| Reviewed by: | Unit: mm | 1st SURNAME: BORRELL | DATE: |
| | SCALE<br>1:1 | 2nd SURNAME: JORNET | 15/06/2018 |
| | | Name: Jordi | |
| Note: | | Degree: Industrial design engineering | |




| | | | |
|---|---|---|---|
| UNIVERSITAT POLITÈCNICA DE VALENCIA<br>CAMPUS DE ALCOI<br>Uniwersytet Technologiczno-Przyrodniczy | | HEADER: UPPER HOUSING PLANS<br>WORK HEADER:<br>DRON DEVELOPMENT | |
| Reviewed by: | Unit: mm | 1st SURNAME: BORRELL | DATE: |
| | SCALE<br>1:2 | 2nd SURNAME: JORNET | 15/06/2018 |
| | | Name: Jordi | |
| Note: | | Degree: Industrial design engineering | |




| Nº | MACHINE |
|---|---|
| 11 | Cutting machine with table |
| 10 | Column Drilling |
| 9 | Band Saw |
| 8 | Mechanic Press 60 t |
| 7 | Curved Press |
| 6 | Inyplast |
| 5 | Manual portable Milling |
| 4 | Welding equipment |
| 3 | Pibe curved |
| 2 | Compressor |
| 1 | Shear |

TITLE OF THE WORK:

OPERATOR'S PATH 1.1.1 & 2.1 PIECES

TITLE OF THE DRAW: PLANT DISTRIBUTION

REVISION Nº:

DATE:

DATE:

FORMAT:

UNITY: mm

SCALE 1:100

PROPERTY:

JORDI BORRELL JORNET

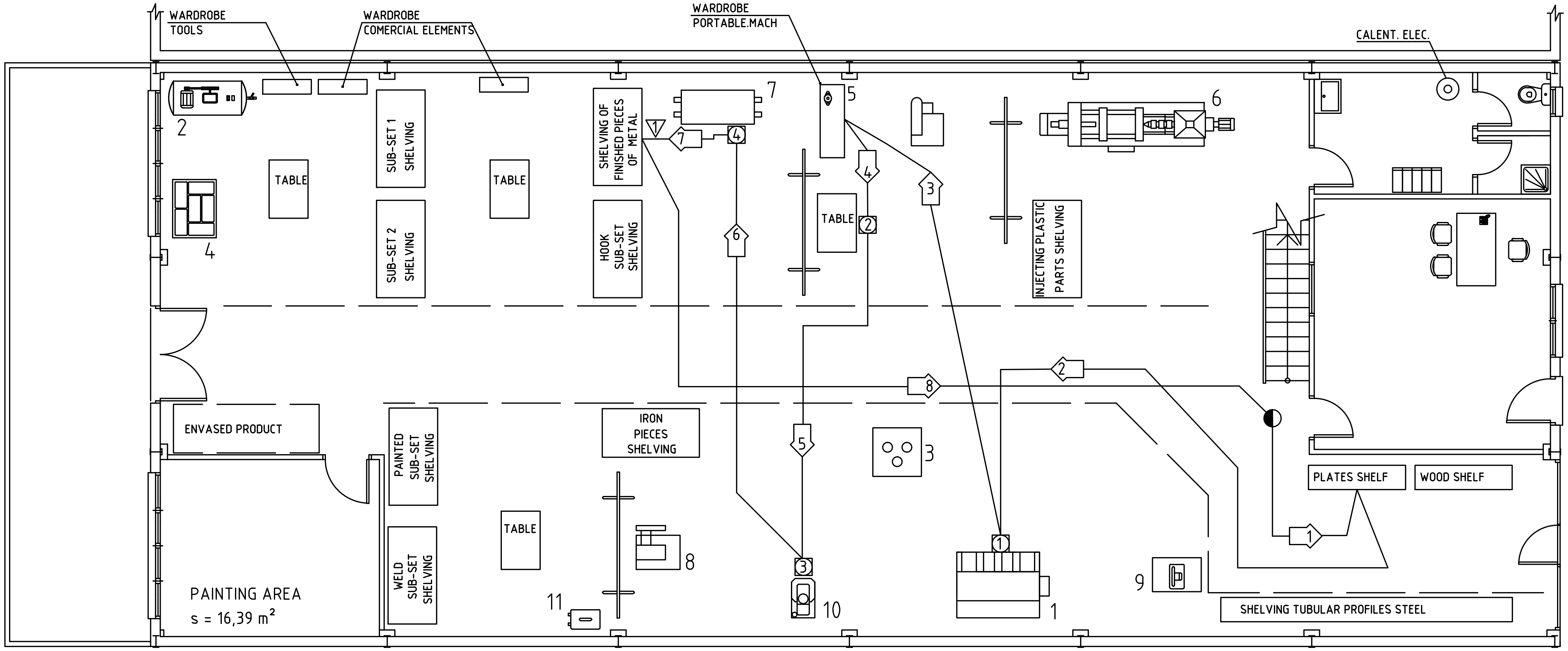
Made by:

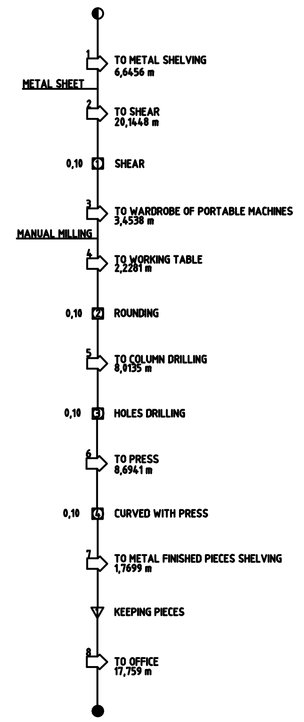
Nº de registry:

PAPER:

REVISION:

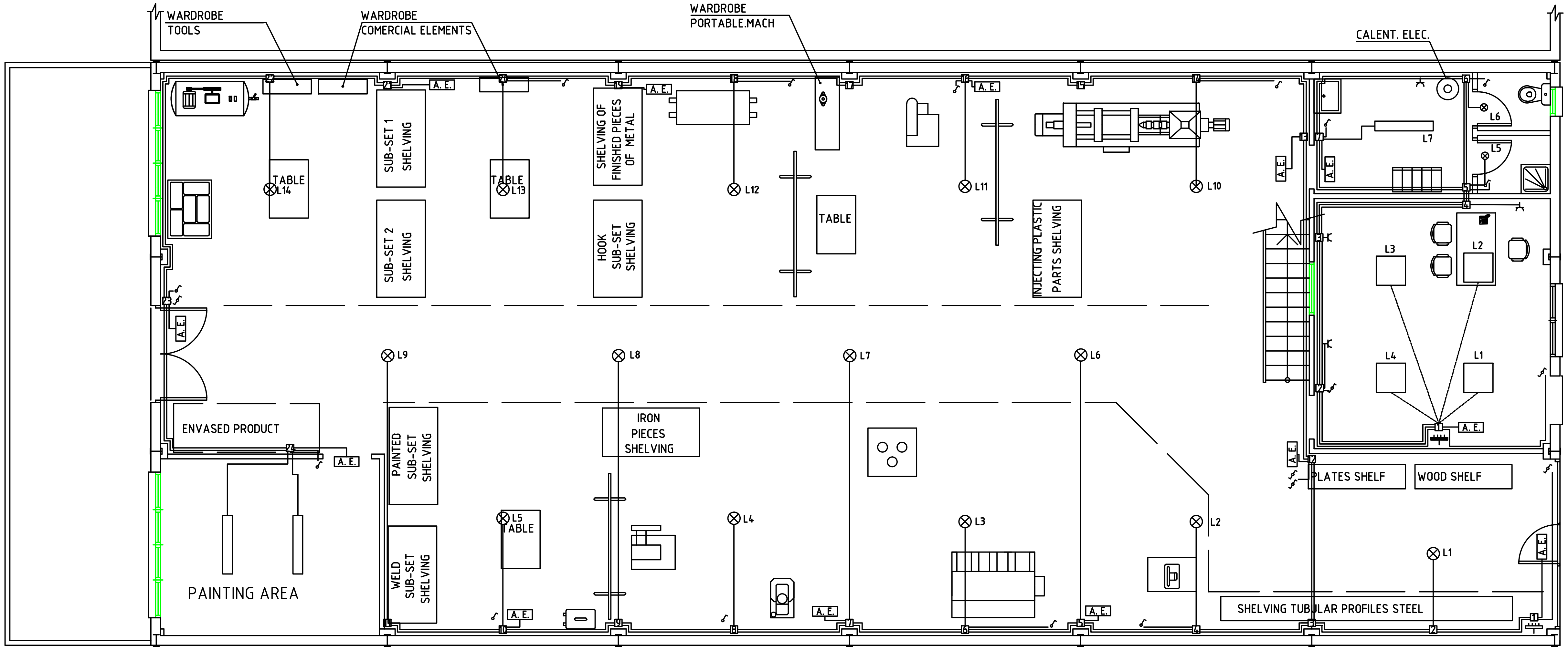
A3




| Nº | MACHINE |
|---|---|
| 11 | Cutting machine with table |
| 10 | Column Drilling |
| 9 | Band Saw |
| 8 | Mechanic Press 60 t |
| 7 | Curved Press |
| 6 | Inyplast |
| 5 | Manual portable Milling |
| 4 | Welding equipment |
| 3 | Pibe curved |
| 2 | Compressor |
| 1 | Shear |

| | | |
|---|---|---|
| | | TITLE OF THE WORK: OPERATOR'S PATH 1.2 PIECE |
| | | TITLE OF THE DRAW: PLANT DISTRIBUTION |
| REVISION Nº: | UNITY: mm | PROPERTY: JORDI BORRELL JORNET |
| DATE: | SCALE 1:100 | Nº de registry: |
| DATE: | | PAPER: |
| FORMAT: | | Made by: |
| | | REVISION: A3 |




## Legend of symbols of electricity

| | |
|---|---|
| | GENERAL SQUARE |
| A.E. | EMERGEN. LIGHTING |
| | LUMINARY HG 125W |
| | LUMINARY PL 60W |
| | PLUG IEB-10/16A |
| | SWITCH Unip. 48U |
| | COMMUTE IEB-49 |
| | INVESTOR |
| | LUMINARY FLO. F4x18 |
| | LUMINARY FLO. F2x36 |
| | JUNCTION BOX 45C2 |

TITLE OF THE WORK:

LUMINARY SYSTEM

TITLE OF THE DRAW: PLANT DISTRIBUTION

REVISION Nº:

DATE:

DATE:

FORMAT:

UNITY: mm

SCALE
1:100

PROPERTY:

JORDI BORRELL JORNET

Made by:

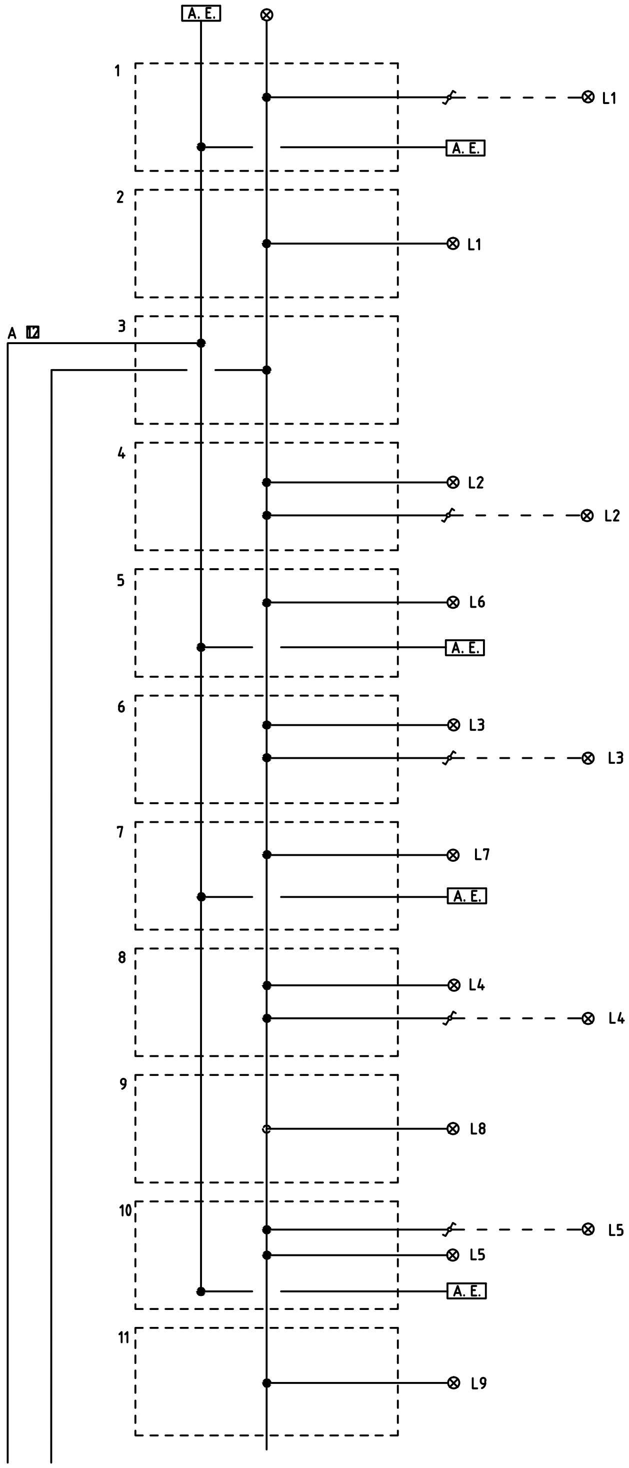
Nº de registry:

PAPER:

REVISION:

A3

1 2 3 4




| Legend of symbols of electricity | |
|---|---|
| | GENERAL SQUARE |
| A. E. | EMERGEN. LIGHTING |
| | LUMINARY HG 125W |
| | LUMINARY PL 60W |
| | PLUG IEB-10/16A |
| | SWITCH Unip. 48U |
| | COMMUTE IEB-49 |
| | INVESTOR |
| | LUMINARY FLO. F4x18 |
| | LUMINARY FLO. F2x36 |
| | JUNCTION BOX 45C2 |

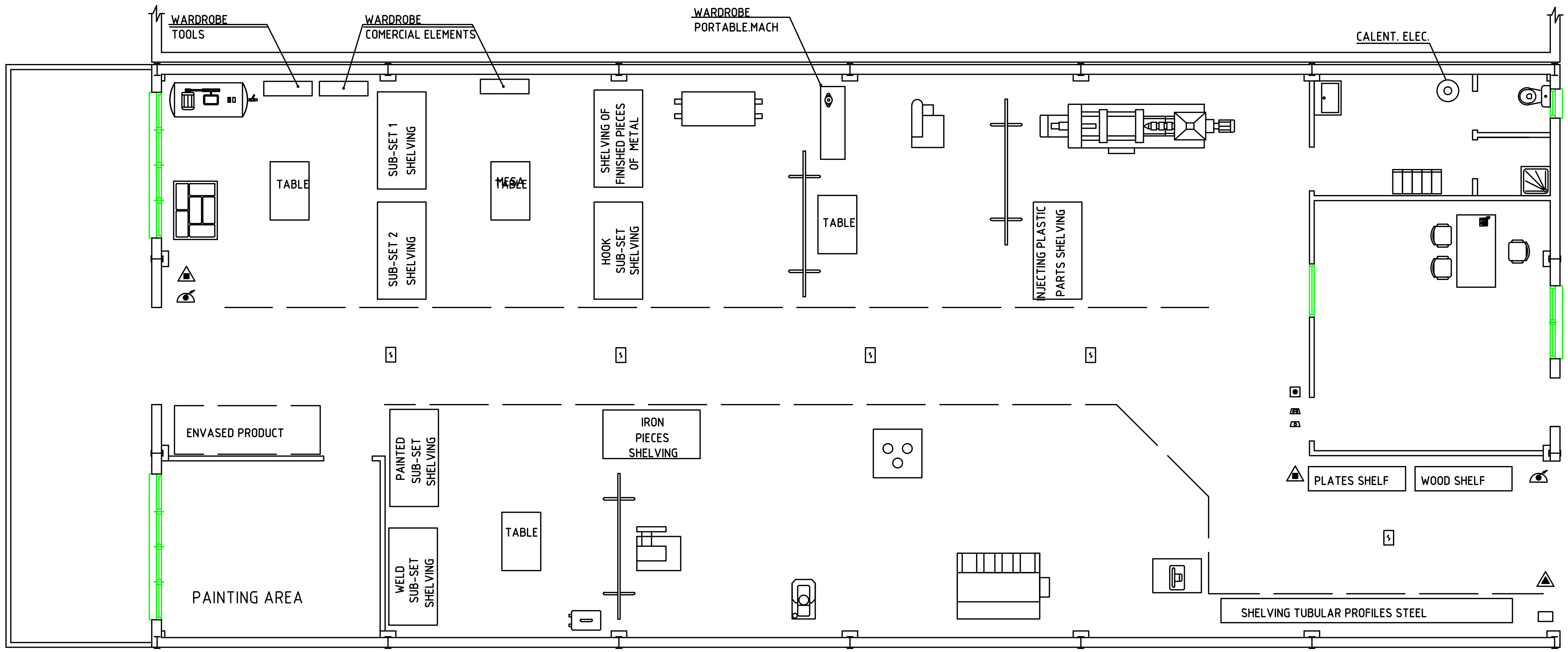
A B C D

TITLE OF THE WORK:

LUMINARY SYSTEM

TITLE OF THE DRAW: PLANT DISTRIBUTION

| | | | |
|---|---|---|---|
| REVISION Nº: | UNITY: mm | PROPERTY: | Nº de registry: |
| DATE: | SCALE 1:100 | JORDI BORRELL JORNET | |
| DATE: | | | PAPER: |
| FORMAT: | | Made by: | REVISION: |




| Legend Security Fire |
|---|
| SMOKE DETECTOR |
| CONTROL SQUARE |
| ACOUSTIC WARNING |
| OPTICAL ADVISOR |
| MANUAL PUSHBUTTON |
| COZ EXTINGUISHER |
| EXTINTO ABC POWDER |
| FIRE HYDRANT |

TITLE OF THE WORK:

EMERGENCY SYSTEM

TITLE OF THE DRAW: PLANT DISTRIBUTION

| | | | |
|---|---|---|---|
| REVISION Nº: | UNITY: mm | PROPERTY: | Nº de registry: |
| DATE: | SCALE 1:100 | JORDI BORRELL JORNET | |
| DATE: | | | PAPER: |
| FORMAT: | | Made by: | REVISION: |