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ABSTRACT

Having a camper vehicle is synonymous with traveling in complete freedom, without timetables, defined plans, without having to depend on a place to stay to sleep, where to eat... in short, it is a mobile cabin that allows you to travel to wherever you want with all the basic needs covered.

However, and despite the multitude of models and different options that are currently on the market, there is no solution that is 100% effective in all the requirements that a product of these characteristics should fulfill. The models that have all the services on board are large, difficult to drive and maneuver. On the other hand, the models that are more manageable, as is logical, are smaller and do not have all the services and comforts that greater volume vehicles have.

The aim of the project is to from the conception of the space and from the furniture design, develop an interior design, which allows to satisfy the maximum number of needs that user may demand from this type of product. Making the most of the space and the possibilities of the vehicle. In other words, try to optimize to the maximum and equalize to the minimum the "volume and maneuverability / equipment" ratio.

The present memory part from the analysis of the current market context and explains the different types of vehicles that this offers. List and study the different needs to which these types of vehicle would have to donate response according to the target user. Based on this, and in compliance with the regulations, a selection of materials and elements that meet the main ranges, the specifications described is made, and a description of the generic reform procedure is prepared that serves as a model for different similar camperization projects.

The current state of the art in terms of commercialization is studied, and the solution is developed. The space is conceptualized and optimized, various dimensional sketches of utilization and interior distribution are drawn up in Autocad. Furniture is designed, construction plans are extracted and a final 3D assembly of the solution integrated in the vehicle it is done by SolidWorks.

Finally, a budget is drawn up, the economic viability of the project and its environmental impact are studied, and the future considerations that can be taken into account are described.

Keywords (10 maximum):

vehicle	camperization	maneuverability	equipment
furniture	space	interior	camper
modular			

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GLOSSARY OF SIGNS, SYMBOLS, ABBREVIATIONS, ACRONYMS AND TERMS

Camper vehicle: Self-propelled vehicle that serves both to sleep and to travel. The fundamental difference with motorhomes is based on the fact that they have been conditioned from an original vehicle, customizing the interior depending on the purpose for which it will be used.

Camperitization: process that consists of modifying the interior of a vehicle to adapt it to a camper van.

INTRODUCTION

Having a camperized vehicle means being able to travel freely and without timetables, being able to choose to stay in one place or another without the condition of having to find a place to sleep or a place to eat. Finally, it allows the user to be in a specific place without the need for any infrastructure or service or inhabited place with the comforts and basic needs covered.

As a student of the industrial design and product development engineering degree and at the same time a mountain, nature and outdoor sports lover I saw the need to conceive what the camper would be like that I personally would like have, which camper vehicle would meet my needs starting from: which model on the market would be the most suitable in terms of dimensions, what equipment should it have, what layout and interior design should it have and how should the furniture be like.

To date I have not found yet a model on the market that met all the requirements I would like to see covered. Therefore, the motivation of this work is to see if there is a possibility that starting from an existing vehicle model on the market, with its spatial dimensions, and from an optimal design of both the space and the furniture can meet all the needs of the user that will be exposed next, or on the other hand, it is impossible.

This report presents a linear development structure. It will be based on the analysis of the current market context and the different types of camperized vehicles that exist on the market will be explained. Next, we will proceed to the study of the user and the analysis of the needs he may require. At the end of this point, the choice of the chosen vehicle will be justified.

The next point will be the analysis of the market, different alternatives will be seen, and within them, the different models. At this point we will enter to the technical part of the project. The bases and regulations to which the present work will have to adhere will be established. A search and selection of materials and elements will be carried out that will satisfy the needs previously stated and that will form part of the final solution proposal.

Once chosen, the description of the reform that will be carried out on the vehicle chosen will be described in a generic way, making it possible to extrapolate it to other models with similar characteristics.

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Next, we will move on to the final phase of the project, which will consist to find a solution in the form of interior space conception and design and furniture design that allow, through the use of materials and the incorporation of the chosen elements, to satisfy as much as possible the needs on which the work will be based.

The present project will be concluded with the preparation of a budget, a study of economic viability and environmental impact and the incorporation of specifications to the work in order to be able to carry it out in the future.

Since as an industrial design engineer I am not endowed with collegiate attributions, the work will focus on the basis of design. This work is not a homologation project, therefore, the data and description of the chosen vehicle model, the characteristics of the vehicle before and after the reform, the relevant mass calculations, or the regulatory homologation format project are not considered on this work.

1. OBJECTIVES

The aim of this project is to design the interior space of a camper van. It will be based on a conventional van model, intended for the transport of goods (industrial vehicle) or mixed, which is currently found on the market. This will be adapted and reconditioned into a vehicle suitable for home, in other words, a camper vehicle.

The purpose of this work is to achieve a design of the interior space from the conception, optimization of the same and design of furniture that satisfies the needs of the user to which we want to respond, complying with the camperization regulations valid for this type of vehicles.

Next, the 10 proposed steps that will be carried out in order to develop the project are listed. These points are considered as objectives to be met.

1. Definition of the current context.

The current context of the health of the sector, growth prospects and different types of families of camper vehicles and motorhomes that are on the market will be analysed. Current and potential customer will be studied.

2. Study of user needs.

A serie of needs will be delimited which will be tried to be answered in the final solution of the project, thus determining the scope of the present project. Once this point is reached, a first sketch will be made on how the interior space should be distributed.

3. Selection of alternatives.

A study of the market for camper vans will be carried out, of the different families grouped by their dimensions, of the different brands and of the different models, as well as of the dimensional characteristics of each one in order to find the most suitable model that better fit the design needs of this project.

4. Choice of elements and materials that will make up the design.

The elements and materials that will comprise the project will be justified.

5. Reform's description

The process to be followed for the camping of the chosen vehicle will be detailed point

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by point.

6. Interior design and furniture design.

A search will be made of the current state of the art for interior space designs and conceptions. Of a modular nature, each of the furniture modules will be designed in the way that best suits the needs of the project and the distribution and conception of the final space will be carried out.

7. The relevant future work considerations will be established if applicable.

8. A budget will be drawn up.

9. The economic viability of the project will be studied, as well as its environmental impact.

10. Relevant conclusions will be drawn from the overall project.

2. CONTEXT

Today, society in general is experiencing an important change in mentality. More and more there is a tendency to want to leave urban spaces and cities and "escape" to nature or the rural environment. This process, also remarkably accelerated by the COVID19 pandemic, with mobility restrictions and the difficulty of carrying out cross-border trips, added to the rise of "outdoor" sports and the desire to adopt by certain groups of population certain models and lifestyles that for different factors have become fashionable, has meant a boom in camper vehicles and especially camper vans.

2.1 DEFINITION

"Camper" comes from the term "campista".

A camper van is a self-propelled vehicle that serves both sleeping and traveling purposes. The fundamental difference with traditional motorhomes is based on the fact that the campers have been conditioned from the original vehicle that was initially not conditioned for housing, this has subsequently been adapted by customizing the interior depending on the purpose to which it will be allocated in order to satisfy the user's needs to the maximum extent.

The motorhome, on the other hand, tends to be a larger vehicle than a camper and aims to be more comfortable, it is conceived as a structure designed as a home that is later mounted on the body of a vehicle. Consequently, it is less maneuverable and entails a higher economic cost.

Its origin goes back to the middle of the last century, when the "hippie" movement began in the sixties and contact with nature and the ability to camp freely became fashionable.

2.2 CURRENT MARKET

The current market for both camper vans and conventional motorhomes despite the stagnation this year due to the crisis of lack of components, inflation and the loss of purchasing power of families, is marked by the last years for exponential growth.

It is a fashion market. Clearly favored and accompanied by the "boom" of "outdoor" sports, people's need to "escape" from the cities and "low cost" trips/holidays.

Currently have much more in demand than supply, with high prices and with an upward trend. More and more vehicle manufacturers are betting on bringing their own model to market.

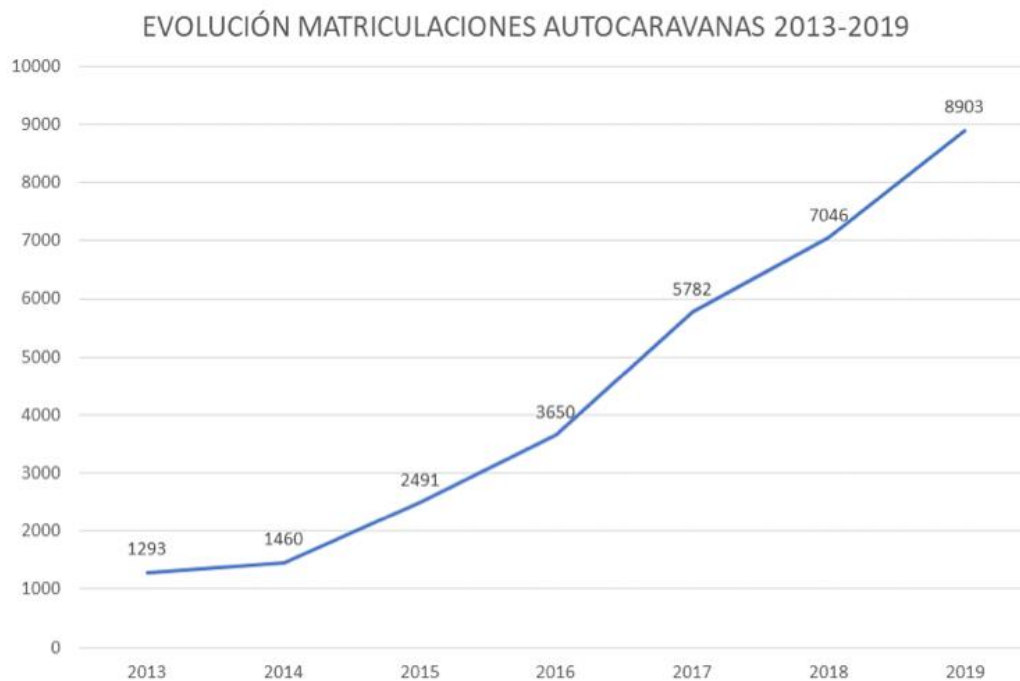


Figure 1. Evolution of motorhome registrations in Spain ("aseicar.org").

According to ASEICAR (Asociación española de la industria i comercio del caravaning) in 2019, the mobile fleet in Spain went from 250,000 vehicles to more than 300,000 between caravans (230,000), motorhomes (60,000) and campers (10,000). Also in 2020, and for the second year in a row, Spain was the country where caravaning grew proportionally, becoming the most sought after holiday leisure offer in contact with nature.

2.2 TYPES OF MOTORHOMES

According to the legislation, the motorhome is intended only for the transport of people and never for the transport of goods. To be able to drive motorhomes weighing more than 3,500 kg, you must have a type C driving license. For this reason, the empty weight of motorhomes usually ranges between 2,500 kg and 2,800 kg, never exceeding 3,500 kg in order not to have to use a type C driver's license. The dimensions of motorhomes usually range between 5 and 7 meters in length, 2.15 and 2.25 meters in width and 2.80 and 3.15 meters in height.

Currently on the market, we find four types known as profiled, integral, capucine and campers.

2.3.1 PROFILED

It has good aerodynamics, which means that fuel consumption is not excessive, and it has a generous space for storage. Its use is recommended for 2-4 people who make long and continuous journeys. It is very similar to the Capuxine, although above the cabin instead of having a bedroom it has a wardrobe, this makes its height lower, which makes its driving more manageable



Figure 2. Challenger 398 xl special edition: 7,4 m, central bed, 4 places
 (“www.autocaravanas.es”).

2.3.2 CAPUCINE

It is the most well known type of motorhome. Its main feature is that it adds a space above the driver's cabin, as a bedroom, which expands its capacity, being perfect for four, five or even six people.



Figure 3. Capucine (“www.autocaravanas.es”).

2.2.3 INTEGRAL

It is the most aerodynamic motorhome model. It has the most spacious cabin that allows 2-4 people to travel comfortably. They are the high and medium ranges of firms specializing in motorhomes, although they are increasingly being manufactured for all types of public, which has made them more accessible.



Figure 4. Integral (“www.autocaravanas.es”).

2.3.4 CAMPER

They are vans adapted as motorhomes. It is among the options mentioned above, the relatively most affordable in terms of acquisition cost. They are also the most manageable and perfect for any type of terrain. Its interior is ideal for one or two people to travel comfortably, although there are models that can accommodate up to four people in full.



Figura 5. Camper (“www.autocaravanas.es”).

3. STUDY OF USER NEEDS

It is been taken as a user prototype a couple, young, who like to travel under the camper van concept, who like nature and who practice outdoor sports.

This last aspect, the fact of practicing outdoor sports both in the mountains and on the coast means having to maneuver in demanding places with limited space, such as tracks and mountain roads. Therefore, we start from this first premise when it comes to the dimensional dimensions of the vehicle.

This vehicle must be able to allow the user to stay autonomously in natural places without "relatively" nearby human infrastructure. Therefore, users will need to have:

- A place to sleep and rest protected from the outside elements.
- A place where you can do a minimum of indoor living in case of adverse weather conditions outside or simply be able to stay indoors. Therefore, the vehicle will have to allow itself to be upright within its interior.
- The user must be able to cook and store food.
- The user must be able to shower and go to the toilet (indoors).
- Energy self-sufficiency must be available.
- A comfortable temperature must be guaranteed inside the passenger compartment.
- There must be enough space to store luggage and material.

3.1 NEEDS TO FULLFILL

The essential specifications to consider for the design are:

- Housing for 2/4 people.
- Energy autonomy: solar panel installation, inverter, batteries and connection to external network.
- 4 windows.
- Bedroom: 2 double beds.
- Kitchen: Counter surface, 1 stove, Fridge, drawers...
- Storage area.
- Living room.
- Couch for 2 people.
- Free space that connects the front of the van to the back door.
- Table with 4 chairs.
- Bathroom: WC, shower.
- Stationary heating.
- Interior space intended for the accommodation of 2 bicycles.
- Ability to stand up.

The NOT essential specifications to take into account for the design are:

- Oven.
- Tv

The vehicle model chosen must be able to accommodate a design that satisfies all the previous mandatory compliance points. In addition, in order to guarantee the maximum possible versatility, the vehicle must have sufficiently small external dimensions so as not to excessively hinder maneuverability and driving in demanding situations such as:

- Driving on mountain roads and forest tracks (fixed).
- Driving through narrow streets in towns and cities.
- Enter underground car parks.

3.2 CHOSEN VEHICLE JUSTIFICATION

Taking into account the user needs described above, the vehicle on which this work is based is reaffirmed by the camper van.

The advantages offered by this type of vehicle compared to conventional vehicles and even to their sisters motorhomes are clear and obvious:

1. Manageability. Although campers generally have less space inside than motorhomes and therefore have fewer amenities, one of their main advantages is that, being more compact, they are much more manageable and manoeuvrable.

While it is very difficult to conceive of a motorhome as a utilitarian vehicle for 'day-to-day' use, due to the obvious problems of consumption, difficulty in maneuvering inside cities, parking, etc., this is not the case with camper vans.

In addition, as already mentioned, due to their smaller size, they also allow passage through areas that are more difficult to access, such as: forest tracks, narrow roads, places with difficult maneuverability.

2. They go more unnoticed. They usually do not incorporate any external signs that show that their interior equipment allows overnight stays. Therefore, they offer a much higher freedom of movement than motorhomes. Allowing camping practically where the user wants.

Sleeping in a vehicle is a prohibited practice in many municipalities in our country (Spain), except in specially designated places (camping areas, or campsites).

This advantage makes camper vans very popular among outdoor enthusiasts since, by going unnoticed, they allow you to camp in many more places and park in many urban centers where you could not with a motorhome.

3. Allow to live there. Inside it is adapted to be able to meet the minimum requirements so that it can be inhabited for a more or less long period of time, making it an almost perfect alternative for short weekend trips and holidays without hotels or conventional places to stay overnight.

4. SELECTION OF THE ALTERNATIVES

4.1 ORIGIN OF THE CAMPER VANS

The origin of camper vans is due to the German automotive brand Volkswagen, with the launch of the Volkswagen Bulli on the market. The birth of this van dates back to 1947, when a Dutchman named Ben Pon who was engaged in importing vehicles of this brand had a moment of enlightenment on his way to the Volkswagen plant in Wolfsburg. It was then that Ben Pon came across a vehicle that caught his attention, this vehicle was an artisanal transformation of a tourist car intended to transport parts inside the factory. Based on this idea he drew the sketch of the Type 1, this sketch really pleased Volkswagen and in 1948 it began to manufacture the first prototypes.



Figure 6. Volkswagen Type 1

In 1950, Volkswagen moved the production of the Type 2, also known, to Hanover as "Bulli". However, in 1951 an English officer stationed in Germany was the forerunner of transforming the vehicle into a passenger compartment giving it a different character, personal and traveller. Westphalia was the company that carried out this transformation, thanks to the creation of the camping box. That these were drop-down boxes that gave way to beds, sofas and tables among others, making the van more livable.



Figura 7. Volkswagen Type 2

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Little by little, the sales of this model increased until it became a real icon of non-conformism in the 60s, being key to the hippie era.

Years later, the spirit of freedom and adventure with which this model was created, has continued to be preserved in the following generations until reaching the current T6 model.



Figura 8. Volkswagen T6

4.2 TYPES OF CAMPER VANS

Currently on the market there is a wide variety of models and variants of campervans, as many as types of vans that exist, since any can be used as a basis for a camperization. Each model has its advantages and disadvantages, so you must choose the vehicle that best suits the needs required by the user.

There are four main types of vehicle, depending on their size and volume:

- Small camper vans or mini camper vans (S).
- Medium camper vans (M).
- Large or large-volume camper vans (L).
- Extra Large Camper vans (XL)

In this section, each type of vehicle will be analyzed, citing its advantages and disadvantages, which will serve to end up choosing the model that best meets the needs for the project.

4.2.1 SMALL CAMPER VANS OR MINI CAMPERS

As for the reality of small camper vans, we find that most of them are handmade campers. The goal is to achieve a vehicle that fulfills basic housing functions for short trips. The space is very limited and it has to be used to the maximum. There is the possibility of installing modules that move to the outside of the van, such as the kitchen or shower, and it is possible to adapt a retractable roof or tents to the roof of the vehicle.

Mini campers are perfect for driving and parking easily in any city, with very little consumption and for an affordable price. They allow traveling and sleeping in them, but other activities such as cooking or showering must be done outside the van. A compact motorhome is ideal for a single person or couples who regularly take short breaks and prefer the versatility of a vehicle that can also be used around town.

It is the group of camper vehicles of smaller size and volume. They are perfect vans for people who want to use them as their main vehicle, with which they can go to work and who also want to use them for short trips, such as a weekend. In addition, due to their small size and height, they are the model of camper vans that consume the least fuel, with consumption similar to that of any car.

Another of the advantages they have is their mobility and ability to adapt, since it is possible to camp almost anywhere and spend the night without attracting attention. However, the storage capacity and comfort available in this type of van is quite limited. In general, these types of vans are designed solely for sleeping. The rest of the activities of daily life, such as cooking, must be done outside.

The main equipment and facilities of these minivans are usually the basic elements for camping, such as a bed that can be converted into a couch, or vice versa, and a space intended for storage, such as drawers and chests of drawers.

There is no possibility of an indoor shower or toilet.

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Small Campers	
Advantages	Disadvantages
Very manageable and manoeuvrable	Reduced space
A large investment is not necessary	Low load capacity
Low consumption	Scarce equipment. There is no kitchen or shower inside
Discreet, they allow you to spend the night without attracting attention	Impossibility to stand up inside

Table 1. Small camper vans advantages and disadvantages.

Brands and models of vans most used for this type of mini-camping, most common:

Small vans:

Model	Large (mm)	Height(mm)	Wide (mm)
Citroen Berlingo	4.403	1.880	1.848
Dacia Dokker	4.363	1.804	1.751
Fiat Doblo	4.406	1.845	1.832
Ford Tourneo Connect	4.425	1.819	1.835
Mercedes Citan	4.321	1.809	1.829
Nissan e-NV200	4.560	1.858	1.755
Opel Combo	4.753	1.796	1.848
Opel Combo Life	4.403	1.841	1.848
Peugeot Rifter	4.403	1.820	1.848
Renault Kangoo	4.486	1.838	1.919
Toyota Proace City Verso	4.403	1.880	1.848
Volkswagen Caddy	4.500	1.832	1.855

Table 2. Small vans comparative dimension table.

4.2.2 MEDIUM CAMPER VANS

This type of van is an intermediate step between the Mini Campers and the Large Volume. They still retain great mobility (most of them enter any parking lot), but they already have more space. For this reason, medium campers can only be used occasionally as a daily vehicle.

The consumption of these vans is relatively not usually excessively high, around 7-8 litres/100km. Being bigger and consequently offering more camping possibilities, they give the option of taking longer trips with them, thinking about getaways of even one or two weeks.

The main disadvantage of this type of van is the impossibility of being upright. However, this problem can be solved by installing a liftable roof. Depending on the model and interior layout, in these medium-sized vans it is already possible to install elements such as kitchen, toilet, refrigerators, swivel seats, water tanks, dining table, ceiling installation... apart from the elements basics already mentioned in small campers.

The most difficult facilities to find in these vans are all those related to the interior bathroom, such as the shower or the toilet.

Usually, the camperization of this type of van is intended for the use of two people, so they are the right type for traveling as a couple. Even so, there are cases in which the number of users can be adapted and increased up to 4.

Here are the main pros and cons of mid-sized camper vans:

Medium campers	
Advantages	Disadvantages
Manageable and manoeuvrable, easy to park.	Higher price (especially for new or already converted vans)
More space and more services (toilet, kitchen...)	Low load capacity
Low/medium consumption	They continue to offer little space for more than 2 people or very long trips
Discreet, they allow you to spend the night without attracting attention	Option to be standing only with a liftable or raised roof

Table 3. Medium camper vans advantages and disadvantages.

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The vans in this category that are most often used for a camper project are:

Medium vans:

Model	Large (mm)	Height(mm)	Wide (mm)
Citroën Jumpy	4.959	1.940	1.920
Citroën Jumpy Furgon	5.309	1.940	1.920
Fiat Talent	5.248	1.953	1.391
Ford Transit Van	5.340	2039	1.986
Hyundai H-1	5.150	1.925	1.920
Mercedes Vito	5.140	1.974	1.928
Nissan NV300	5.080	1.963	1.956
Opel Vivaro	4.999	1.971	1.956
Peugeot Expert	5.308	1.945	1.920
Renault Trafic Furgon	5.399	1.967	1.956
Toyota Proace Verso	5.309	1.899	1.920
Volkswagen Transporter Furgon	5.290	1.969	1.904

Table 4. Medium vans comparative dimension table.

4.2.3 LARGE VOLUME CAMPER VANS

They are the vans of the largest dimensions, therefore, they fit many more items that provide similar comforts that we would have in a home. They already grant the possibility of having several rooms, such as: bedroom, living room, kitchen, bathroom... In addition, they already offer the possibility of being able to move and stand.

They are the best option to transform into a passenger vehicle. A Large Volume van is the best equipped vehicle for long journeys. With the possibility of accommodating 4 or more people inside. As a counterpoint, the mobility of a large van can already be reduced depending on the circumstances, driving on some narrower roads or with more pronounced curves can become complicated.

In addition, these types of vans cannot enter almost any underground car park. In addition, due to the fact that the fuel consumption of these campers is around ten liters consumed every 100km.

Even so, these vans are among the most used for camper projects, their acquisition has

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grown significantly in recent years. This is also due to the wide variety of high volume vans that exist in the market. Within this large group, different sizes and heights can be defined, finding a wide range of combinations that offer many possibilities.

There are four varieties of length or battle, from L1 to L4 (L, length), and three varieties of height, from H1 to H3 (H, height). Based on these measurements, it is possible to combine them with each other to obtain vans of different volumes and sizes.

These are the measurements of the different heights and lengths for the large volume vans:

Height H	Large L
H1: 2,25 m	L1: 5 m
H2: 2,52 m	L2: 5,40 m
H3: 2,76 m	L3: 6 m
	L4: 6,40 m

Table 5. Large volume vans comparative dimension table.

There are up to eight possible combinations between the length and heights of the Large Volume vans, and they are as follows: L1H1 - L1H2 - L2H1 - L2H2 - L3H2 - L3H3 - L4H2 - L4H3.

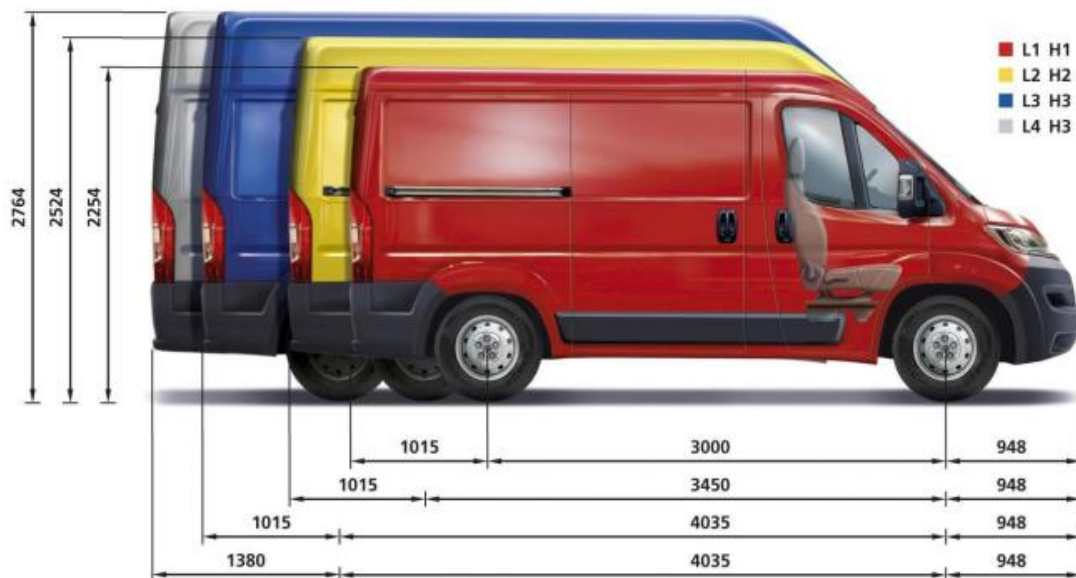


Table 6. Large volume vans dimensions (“campermania.es”).

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Here are the main advantages and disadvantages of Large Volume camper vans:

Large volume campers	
Advantages	Disadvantages
Long-term trips	Reduced mobility and handling
Complete equipment	Difficult parking
Comfort and great interior space	High fuel consumption
Much larger number of places	

Table 7. Large volume vans advantages and disadvantages.

There are so many large volume vans on the market, due to their multiple size combinations. In addition, they are the most used vans in the professional field for the transport of goods, which increases their supply and demand. The most used for camping projects are:

Large volume vans:

Model	Large (mm)	Height (mm)	Wide (mm)
Citroën Jumper	5.998	2.764	2.690
Fiat Ducato	5.998	2.764	2.690
Ford Transit Van	5.981	2.665	2.959
Mercedes Sprinter	5.267	2.356	2.175
Nissan NV400	6.225	2.749	2.470
Opel Movano	6.198	2.744	2.470
Peugeot e-Boxer	5.998	2.764	2.690

Table 8. Large Volume van comparative dimension table.

4.2.4 EXTRA LARGE CAMPER VANS

This group includes the largest types of vans on the market, including the largest combinations of the previous group, i.e. the longer and higher Large Volumes. These refer to the second group of large volume vans, with height H2-H3 combined with length L3-L4. As an example, the largest possible combination of the large volumes is shown:



Figure 9. L4H3 large volume van.

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This type of van has a large space for camping with all kinds of elements. They have enough room to carry out a complete equipment, without any exception, and without giving up comfort. They can count on all the rooms of a house such as kitchen, living-dining room, bedroom and bathroom, with all the necessary furniture and objects, and for that you don't have to give up comfort. Unlike L campers, they can increase the number of bedrooms or beds.

On the other hand, the large size of the van means a great decrease in the handling of the vehicle. The long battles of this type of camper make it difficult to access multiple places and streets where more complicated maneuvers are necessary. Access to underground car parks is also restricted, as well as several car parks made for cars.

A highlight of the XL campers is the length of trips that users can take. It is undoubtedly one of its best advantages, since in a camper van of these dimensions it is possible to make trips of any length. The equipment allows the user a permanent stay, without depending on any door-to-door needs. Of course, the equipment may include a bathroom with sink, shower and toilet. In addition, the number of places can be increased with regard to other large volumes, being usually campers designed for an occupation of four to six users, perfect for a large family. However, XL campers command the highest price in the camper van market due to their more comprehensive design and larger size. The reason for this is also its high fuel consumption, which can reach 12 or 14 liters per 100 kilometers.

In general, this type of camper is a good alternative for traveling with your own house, very close to the next level of vehicle-dwelling or motorhome, motorhomes. In terms of equipment and space, they are very similar, but a camper van also allows the user to design their own ideas and have that level of personal design that characterizes the camper world.

As noted above, XL camper vans encompass the largest of the Grand Volume vans, combining H2 and H3 heights with L3 and L4 heights. There are a total of 4 combinations, represented below:

Looking at the volumes, there are three possibilities, varying from 13 cubic meters to 17 cubic meters of space inside the van. The intermediate volume is 15 cubic meters, with two different possibilities of occupying it: the first consists of expanding the volume with height, in the L3H3 van; the second consists of carrying the volume along, with a L4H2.

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Summarizing, the characteristics of XL camper vans are very similar to those of L camper vans, as they belong to the same group of vans, the Large Volume vans. The difference lies in the increase in battles and heights. So, their advantages and disadvantages are the same, accentuated a little more.

The most common van models for XL campers also match those of L campers as they are Large Volume and only the measurements of the models vary.

The most used therefore are:

Model	Large (mm)	Height (mm)	Wide(mm)
Citroën Jumper	6.363	2.764	2.690
Fiat Ducato	6.363	2.764	2.690
Peugeot e-Boxer	6.363	2.764	2.690
Mercedes Sprinter	7.370	2.919	2.690
Iveco Daily	7.130/7.500	2.919	2.690
Ford Transit	6.704	2.781	2.690

Table 9. XL large volume van comparative dimension table.

5. REGULATION

The following regulations and rules will be taken into account in the design:

Interior conditioning.

- Royal Decree 2028/1986, of June 6, by which rules are issued for the application of certain EEC Directives, relating to the approval of types of motor vehicles, trailers and semi-trailers, as well as parts and components of the mentioned vehicles.
- Royal Decree 2822/1998, of 23 December, approving the General Vehicle Regulations.

Affected System	Reference
Resistance of the seats	74/408/CEE
Seat belt anchorages	76/115/CEE
Safety belts and systems of retention	77/541/CEE
Masses and dimensions (cars)	92/21/CEE
Mechanical resistance to the structure	Reglamento CEPE/ONU 66R
Radio interference (compatibility electromagnetic)	72/245/CEE
Indoor conditioning	74/60/CE
Headrest	78/932/CEE
Heating systems	2001/56/CE
General Regulations of Vehicles	2822/1998 (Anexo VI)
Locks and hinges	70/387/CEE
External exits	74/483/CEE
Flammability	95/28/CE

Table 10. Regulations (Royal Decree 2822/1998, of 23 December, approving the General Vehicle Regulations).

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Electrical installation.

- Regulation for low voltage.
 - ITC-BT-10 Previsió de càrregues per a subministraments a Baixa Tensió.
 - ITC-BT-21 Indoor or receiving facilities. Protective pipes and channels.
 - ITC-BT-22 Indoor or receiving facilities. Overcurrent protection.
 - ITC-BT-23 Indoor or receiving facilities. Protection against overvoltages.
 - ITC-BT-24 Indoor or receiving facilities. Protection against direct and indirect contact.
 - ITC-BT-27 Rooms with bathtub or shower.
 - ITC-BT-36 Very Low Voltage
 - ITC-BT-40 Low Voltage generating facilities.
 - ITC-BT-41 Electrical installations in caravans and caravan parks.

Gas installation.

- Royal Decree 919/2006, of 28 July, approving the Technical Regulations for the distribution and use of gaseous fuels and the complementary technical instructions ICG 01 to 11 thereof.

Homologation.

- Royal Decree 750/2010, of June 4, which regulates the approval procedures for motor vehicles and their trailers, self-propelled or towed machines, agricultural vehicles, as well as systems, parts and pieces of the aforementioned vehicles.
- Royal Decree 866/2010, of July 2, which regulates the processing of vehicle renovations.

6. MATERIALS SELECTION

6.1 WOOD STRIPING

Brushed fir slats will be used. This particular material is chosen for its characteristics as it is ideal for supports for cladding boards, roof and roof structures, manufacturing of walls, partitions and all types of enclosures, slats on ceilings and walls for chain link, door locks, etc.

Material	Characteristics
Brushed spruce slat	<ul style="list-style-type: none"> • APPLICATIONS: <ul style="list-style-type: none"> - Interior reinforced carpentry. - Laminated wood; Interior carpentry of coverings, friezes; hoops, pre-circles, moldings, plinths. - Containers and packaging. - Fir wood beams - Fir wood for construction • PHYSICAL PROPERTIES: <ul style="list-style-type: none"> - Apparent density at 12% humidity 490 kg/m³ - Light Wood • DIMENSIONAL STABILITY: <ul style="list-style-type: none"> - Coefficient of volumetric contraction 0.44% stable wood. - Ratio between contractions 2.1% very tending to praise. - Hardness (Chaláis-Meudon) 1.5 soft wood. • MECHANICAL PROPERTIES: <ul style="list-style-type: none"> - Static bending strength: 815 kg/cm² - Modulus of elasticity: 145,800 kg/cm² - Compression resistance: 418 kg/cm²

Table 11. Brushed spruce slat characteristics (“maderame.com”).

6.2 THERMAL INSULATION

6.2.1 OBJECTIVES OF INSULATION

Through thermal insulation we achieve:

- Avoid condensation:

This is caused by the temperature difference between the outside and the inside. Inside, the hot air that circulates very close to the sheet cools and the water vapor it contains condenses. Condensation can be a serious problem in the long term as the moisture will oxidize the veneer. The function of the insulator is not to allow steam to pass through it, so the veneer will always remain dry.

Another problem that can occur without a good insulator is that, on nights when the outside temperature is very cold (we are talking about negative temperatures) all the steam and water that can accumulate inside the sheet freezes and produce a freezing effect.

- Avoid getting cold:

One of the main points for thermally insulating the van is to not get cold on winter nights. With it, the internal heat is prevented from being conducted through the sheet to the outside.

- Avoid overheating:

The other aspect is to avoid being very hot on summer days, sheet metal being a conductor, it can heat up to very high temperatures, producing an oven effect, making it practically impossible to be in the inside the van.

- Consume less fuel:

By retaining more heat inside the van, there will be less demand on the stationary heating system, so there will be fuel savings.

- Reduction of CO2 emissions:

This point is closely linked to the previous one, which is that by using less fuel, CO2 emissions are reduced.

6.2.2 TYPES OF THERMAL INSULATION

Below are the main insulators that are usually installed in camper vans.

Reflective Insulators:

There are different types of reflective insulators, but the most common are those formed by layers of bubble plastic or polyethylene foam, separated by aluminum sheets. This type of insulators are more suitable for insulating the heat than the cold, but because their effectiveness was good, it is necessary to leave an air chamber between the sheet of the van and the insulator and another air chamber between the insulation and the coating that you put on, but it is not a viable option since it would complicate its installation quite a bit and in addition the loss of space would be considerable. Therefore, it is not advisable to install reflective insulation in a camper van.

Rockwool:

Rockwool is a great acoustic insulator, although it also has good properties as a thermal insulator, it is not the best. This insulator is made from fibers obtained from volcanic rocks. The good thing about this type of insulation is that it is very easy to install and adapts to the structure of the van. To be valid for camper installations this must have a vapor barrier, either aluminum or kraft paper. This can be a good option for not very cold areas. Therefore, due to the scope of this project, it is discarded.

Extruded polystyrene (XPS):

This insulator works very well to insulate from both heat and cold, and it also has a vapor barrier. The worst thing about this insulation is that it comes in rigid sheets, so it is very difficult to adapt it to the sheet metal of the van, in addition, it is flammable and produces very toxic gases. It could be a good option for the floor, as by putting a liner on top, it would spread the weight and not compress. Another negative aspect is that it is obtained from a petroleum derivative and the manufacturing process is highly polluting.

Expanded polystyrene (EPS):

It shares the same chemical composition as extruded polystyrene, as well as its advantages and disadvantages, but in this case expanded polystyrene does not work as well as a vapor barrier.

Geopanel:

It is an ecological thermal and acoustic insulating product and it comes from recycling which, at the same time, is between 85 and 100% recyclable. Easy handling.

Polyurethane foam:

Its basic composition is oil and sugar. There are different types of quality, and their chemical composition can vary, with open-cell polyurethane foam and closed-cell polyurethane foam. The first option is not at all recommended, since by not acting as a vapor barrier in the long run the veneer will oxidize.

Elastomeric foam (Kaiflex):

Self-extinguishing, does not spread fire. Its flexibility means that it adapts very well to any sheet geometry and is also self-adhesive, which considerably reduces installation time. It does not absorb water and the thickness varies between 10 and 30 mm. It is recommended to place 10mm on the floor and 20mm on the walls and ceiling. The price is higher than the previous insulations.

Insulating thermal conductivity 0 °C (λ) comparative:

Insulating	Thermal conductivity 0 °C (λ)
Reflective Insulators (Expanded Polyethylene)	0,045 W/m·K
Rock wool	0,038 W/m·K
Extruded Polystyrene (XPS)	0,034 W/m·K
Expanded Polystyrene (EPS)	0,038 W/m·K
Geopanel	0,034 W/m·K
Polyurethane foam	0,022 W/m·K
Elastomeric foam (Kaiflex)	0,033 W/m·K

Table 12. Insulating conductivities.

In addition to these values, factors such as ease of installation are also considered. Giving importance to the fire resistance factor and taking into account the good thermal insulation capabilities, Kaimann's Kaiflex ST sheets are chosen, with a thermal conductivity of 0.033 W/m·K at 0 °C. Also polyurethane foam will be used to fill voids. This must be resistant to fire, such as Sika Boom®-400 Fire^[1].

^[1] One-component polyurethane foam which complies with the highest fire resistance classification, class EI 240.

6.2.3 paneled and furniture

For the paneling and for the manufacture of the furniture, we will work with those materials that generally offer greater robustness, durability and lower density (a feature of great importance, so as not to overload the vehicle). Fire and moisture resistance criteria are also taken into account.

For the construction of the furniture, and other elements, wood is used in general, but more specifically plywood (material par excellence used in this type of reforms).

Plywood is boards made of thin sheets or layers of solid woods that are overlapped by sticking together firmly with synthetic resins. This is compact and resistant; it is very light and after the different treatments can provide other properties.

The table shows the comparison of the plywoods most used for this type of activity:

Type of Plywood	Density kg/m ³	Resistance classification	Durability	Fire resistance	Moisture resistance
Birch	650-700	High	Very high	No	No
Phenolic birch	650-700	High	Very high	No	Yes
Pine tree	+700	Very high	Very high	No	No
Poplar	400	Normal-low	High	No	No
Poplar HPL	400	Normal	High	No	No
Okume	440-490	Normal	High	No	No

Table 13. Plywood properties comparative.

The following plywoods are selected (according to our requirements):

Type of Plywood	Finished	Description
Phenonyl birch	phenolic	They are moisture-resistant plywood boards. Glue 3 is applied (exterior, according to UNE-EN-314-2)
	Non-slip phenolic	In addition to being resistant to moisture, a layer of varnish is applied to it which promotes non-slip.
Poplar		Poplar plywood is coated with a high pressure laminate (HPL) for added strength and stability.

Table 14. Selected plywood.

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None of the plywoods are fireproof (this will depend on the treatment they have). If this is the case, additional fire resistance can be achieved with the use of intumescent and flame retardant paints or varnishes according to the Fire Reaction Classification System UNE EN 13.501-1:07.

For the construction of the bathroom module, fiberglass will also be used for the manufacture of the shower tray and waterproofing vinyl for the coating and insulation of the bathroom. These two materials are used taking into account their ideal physical characteristics and their low cost and maintenance. In the same way, they adapt in a practical way to the requirements raised initially.

Material	Characteristics
Fiberglass	High strength, unalterable, tailored, anti-bacterial, anti-fungal, easy to clean, waterproof, UV resistance, requires knowledge to use the material.
Waterproofing vinyl	High strength, unalterable, tailored, anti-bacterial, anti-fungal, easy to clean, waterproof, UV/fade resistance, easy to use material.

Table 15. Bathroom materials.

7. ELEMENTS SELECTION

7.1 RAISED ROOF

For the requirements of the project, a liftable roof will be installed in order to give the user the option to stand up inside the passenger compartment with the vehicle parked. In addition to having an extra bedroom upstairs in case you want to use all the lower space to transport equipment or simply don't want to go through the process of assembling and disassembling the lower bed.

As it is a vehicle, the modifications that are carried out must comply with current regulations, making the relevant structural calculations and tests. Given the high cost that this entails, it is chosen to install ceilings that are previously approved. For the approval of this type of roof, the manufacturer includes a report which ensures that the technical characteristics of the vehicle are not changed.

The installation will be carried out in a specialized workshop where the instructions will be followed and the components included by the manufacturer will be used. The authorized workshop will provide a certificate of assembly as appropriate and its approval can proceed. (Raised roofs can only be fitted to the specific vehicle model for which they are designed.)

7.2 SEATS

Taking into account design needs, it is of great importance to provide the front seats with the ability to rotate on their vertical axis to be able to take advantage of the space where coexistence takes place optimally.

However, since it is a vehicle, the modifications that are carried out must comply with current regulations, making the relevant structural calculations and tests. Given the high cost that this entails, it is chosen to install bases on the seats that are previously approved.

The installation of swivel seats in the front seats will be carried out in strict compliance with the instructions provided by the product and recommended by the manufacturer. The manual will be followed at all times and you will not be able to replace any of the parts or fasteners unless expressly authorized in the manual provided.

7.2.1 SWIVEL BASES

Since one of the design requirements is to include space for two passengers in the rear compartment of the van, it is necessary to include a structure that meets all safety standards for passenger transportation.

That's why there are two possible ways. The first is the design and approval of an own structure. The second is the installation of a structure designed by a manufacturer, already approved.

Since the first way is long and expensive, as it requires structural calculations and relevant laboratory tests under competent certification, it will be obtained by the second way. There are not many models available on the market that meet the homologation requirements. After a search, these three were found:

- OKB structure.
- Structure AGUTI G2000.
- CTA structure.

Of these, the first is a structure that is anchored on aluminum rails. These rails are fixed on the chassis of the vehicle with a specific adhesive, after having properly treated the contact surface with a degreaser. The products that must be used are indicated in the assembly manual.

The other two fastening systems, both the AGUTI structure and the CTA, are fixed to the chassis by means of screws and require drilling. Because of this, they do not have the same flexibility in the placement of the seats with respect to the position and the installation is more complex. In addition, they do not have an Isofix system.

Although the AGUTI and CTA systems are cheaper, the OKB structure has better safety features and easier assembly. In addition, that the seats can be moved longitudinally is one of the intrinsic requirements of the project in order to have more space in the front or back area as appropriate and at the same time to transform the structure into a bed, it will be necessary to be able to move the structure.

For this reason, the OKB system mounted on aluminum rails is chosen. As indicated by the manufacturer in its assembly instructions, the contact surface between the rails and

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the chassis is treated with degreaser Sika Aktivator 205 or BETACLEAN 3350. After that, a primer Sika 206G+P or BETAPRIME 5061 or an adhesive will be used of SikaForce polyurethane or similar for fixing.

The structure of the seats, with the safety belts and the backrest incorporating the Isofix system will be mounted on these rails, as indicated in the manufacturer's instructions.

7.3 STATIONARY HEATER / WATER HEATER SYSTEM COMBINED SYSTEM

The chosen van, like a large number of vehicles, has a heating system that it works when the engine is started. While traveling there will be no problems, but these come at the time of making life and spending the night in the winter, since the engine should be kept on, so this leads to high fuel consumption and constant noise. To solve this, it has been decided to install a static heating system.

In this project, a dual heating/water heater system is chosen. In this way, the number of elements is minimized and space is optimized by grouping functions in a single device. The system will run on fuel from the van.

It will be installed outside as this way there will be less noise perception and there will be no risk to the health of the occupants in the hypothetical case of a gas leak inside the van

7.4 ELECTRICAL INSTALLATION

For the 12V electrical installation, an electrical bulletin is not required, even if the elements for approval are added. On the other hand, for the 230V installation, it will be necessary for a registered electrician to carry out an electrical report confirming that everything is suitable following the Low Voltage Electrotechnical Regulation, approved in Royal Decree 842/2002, and the CEPE/UN Regulation 100(R).

Knowing the appliances that you want to install, it proceed to calculate the consumption in Ampere x hour/day that are required per day in order to be able to select the solar panel, the auxiliary battery and dimensioning the entire electrical installation.

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Supply: The supply of the DC and AC circuits will be combined with the generation of Power through the solar panel and through the alternator.

There will also be an external 230V outlet that will feed the auxiliary battery and the 230V circuit through a battery charger.

Inverter: It is responsible for converting the DC stored in the batteries or produced by the photovoltaic panels into AC. To be able to use the household appliances you will need an inverter from 12V to 230V.

There are two types of inverters, pure sine wave and rectified wave inverters, the former are more expensive, but they work for all household appliances, so it will be the selected type. It must also be taken into account that the power of the inverter is equal to or greater than that of all the elements connected at the same time to the auxiliary battery.

The power of the inverter must always be higher than the power that we connect.

The vehicle has three different circuits, one at 12V and two more at 230V. The main circuit works at 12V and feeds a circuit with some 230V outlets through an inverter.

The installation is designed to be energetically autonomous, obtaining the energy for charging the auxiliary battery both from the vehicle's own alternator when it is running or from the photovoltaic panel. However, the design is also equipped with an external 230V socket that feeds various 230V sockets and recharges the auxiliary battery using a battery charger.

In order to make an estimate of the expected power and thus be able to size the installation, all the powers of the different components to know the overall consumption of the electrical installation. A calculation of the estimated daily consumption will be made to install a battery that is suit those needs.

As aspects that should be taken into account. It should be taken into account that refrigerators only consume a third of the power, since that have rest states where no energy is consumed. For the calculation of the refrigerator, a daily use time of 8 hours is estimated.

The devices that will be connected to the 230V sockets can be, for example, a laptop or

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a mobile phone.

The following table shows the power of each component, its hours of operation and its daily consumption.

Estimated Loads:

DC circuits:

Elements	units	Power (W)	Estimated Power (W)	Intensity(A)	Voltage (V)	Hours of use/day	Ampere x hour/24h	Watt x hour/24h
Water bomb	1	40,80	40,80	3,40	12,00	0,50	1,70	20,40
LEDS	6	1,40	8,40	0,70	12,00	6,00	4,20	50,40
USB	2	20,00	40,00	3,33	12,00	2,00	6,67	80,00
Fridge	1	48,00	48,00	4,00	12,00	8,00	32,00	384,00
Heater	1	65,00	65,00	5,42	12,00	5,00	27,08	325,00
Oven	1	144,00	144,00	12,00	12,00	0,25	3,00	36,00
Inversor	1	368,89	368,89	30,74	12,00	-	30,74	368,89
Total			715,09	59,59			105,39	1264,69

Table 16. DC circuit calculation table.

AC circuit:

Elements	units	Power (W)	Estimated Power (W)	Intensity(A)	Voltage (V)	Hours of use/day	Ampere x hour/day	Watt x hour/day
F type outlet: ex: mobile	2	18,00	36,00	0,16	230,00	2,00	0,31	72,00
F type outlet: ex: laptop	1	65,00	65,00	0,28	230,00	4,00	1,13	260,00
Total			101,00	0,44			1,44	332,00

Table 17. AC circuit calculation table.

A 1000 W Inversor is chosen with an a efficiency of 90%.

Necessary DC power to transform to AC = $332 / 0.90 = 368,89$ [W h / d]

Battery charger amperage = 29,29 A

Total consumption:

Ampere h / day	Watt x hour/day
105,39	1264,69

Table 18. Total consumption calculation table.

Adding up the total consumption of the elements we obtain a result of 1264,69 Watt x hour/day. These results have been obtained taking into account the maximum consumption of all household appliances in winter since the consumption will vary quite a lot depending on whether it is summer or winter.

Battery.

Regarding the auxiliary battery, also known as secondary battery. Its function is to store energy and it is used when the vehicle is parked. It is necessary because, if the vehicle's main battery was used, the energy stored by it would be exhausted, making it impossible to start the engine again.

Having both batteries connected (auxiliary battery and main battery) this is charged by the alternator when the engine is on.

There are several types of battery on the market:

- **Acid:** It is the most common type of battery used in any vehicle and that is why they are the cheapest. It is not recommended to install them in camping processes since they emit gases harmful to health during the loading/unloading cycles. Also, they cannot be installed upside down and do not withstand long charge/discharge cycles.

- **Gel:** They are the best option for camperizing a vehicle, on the other hand, they are the most expensive on the market. It can be installed upside down, so it is possible to install it in small spaces. The high temperatures that can be generated inside the vehicle do not affect them. Another of its strong points is its durability. Instead, it is necessary to modify the charging system since the alternator gives us a voltage of 14.4V and this type of battery does not support voltages higher than 12V.

- **AGM:** Its price is between gel batteries and acid batteries. They do not give off any gases harmful to health and withstand charge/discharge cycles well. In addition, it withstands well the temperature changes that can occur inside the vehicle.

A AGM battery is chosen due Gel batteries have some problems if they are charged directly with the vehicle, since they do not support the 13.7 - 14V generated by the alternator, this reduces their useful life.

Auxiliary battery capacity:

With the total consumption calculated, it is decided to carry out the installation to provide the van with 1 day of total autonomy (without the option of recharging).

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It is recommended not to deep discharge the battery below 50%.

To perform the calculation, a discharge depth of 50% must be taken into account and a system loss coefficient of 1.15 will be taken into account.

Auxiliary battery capacity = $2 \times (\text{Amper} \times \text{hour} / \text{day demanded}) \times \text{days of autonomy} \times \text{coef. losses}$

Auxiliary battery capacity = $2 \times 105,39 \times 1 \times 1.15 = 242,40\text{Ah}$

To cover this consumption without any external element, **a 250Ah battery is chosen.**

The power sources for the auxiliary battery will be:

1. Alternator.

The main source of energy to charge the vehicle's batteries will be obtained from the vehicle's alternator when it is running. A relay will be installed so that it is only charged while the alternator is in operation, since otherwise the main battery would be discharged. An automatic relay has been chosen for this installation.

Relay: Once the secondary battery is chosen, it is necessary to choose which system will charge the batteries when the vehicle is in motion. The function of the relay is to enable or disable the flow of current to the batteries. When the alternator is in operation (vehicle running), the relay allows both batteries to be connected to proceed with charging. Instead, with the engine off, the relay closes the main battery current path and enables the auxiliary battery. If the auxiliary battery is discharged there is no problem as it is only used for the consumables equipped in the vehicle and does not influence when starting the engine.

There are two types of relay, manual and automatic:

Manual: It is the cheapest alternative, but the least suitable since its manual activation can generate major problems. To activate the relay, an electrical impulse is necessary to enable the connection of the batteries. It consists of four pins, two used for manual activation and the other two for the passage of electricity.

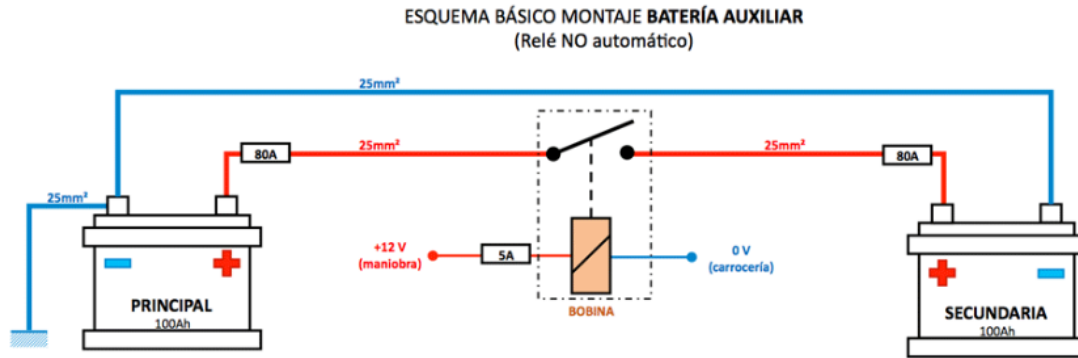


Figure 10. Non-automatic relay operation diagram (www.tierrasinsolitas.com).

Automatic: They are the most suitable to install, but it is the least economical alternative. These relays detect the input current, activate when the current exceeds a certain voltage and deactivate when it drops below this voltage. When the vehicle's alternator generates a voltage higher than the specified voltage, it allows current to flow. In contrast, when the motor is off, the voltage drops below the set voltage and turns off the relay.

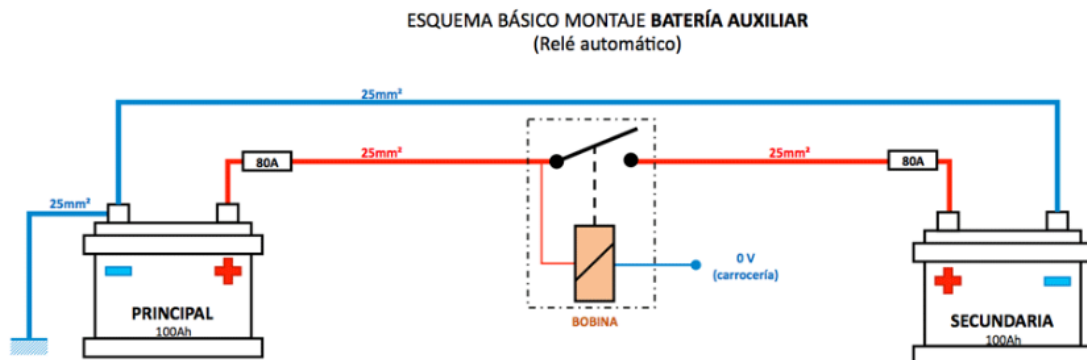


Figure 11. Automatic relay operation schematic table (www.tierrasinsolitas.com).

An automatic relay is chosen.

2. Solar panel.

Photovoltaic panels are divided into two groups according to the nominal voltage: 12V and 24V.

The 12V solar panels are built by 36 cells of 0.5V each. Since they are connected in series with each other, the voltages add up. At the output we obtain a V_{mp} (working voltage) of about 18V. On the other hand, 24V solar panels are made up of 72 cells of

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0.5V each. At the output we will have a working voltage (V_{mp}) of 36V.

Solar panels are monocrystalline or polycrystalline cells. Polycrystalline solar panels are ideal for warm climates. They perform better, absorb direct sunlight better and are less affected by heat. The cells are bluish in color and triangular in shape.

Conversely, monocrystalline perform better in cold and cloudy environments. They absorb radiation very well, but cannot withstand overheating. The performance of monocrystalline plates is greater than that of polycrystalline ones. The color of the cells is black and the corners are chamfered.

Solar panels are also classified between: rigid and semi-flexible.

- The rigid solar panels are mounted on a 3cm aluminum profile. As the name suggests, they cannot be bent and are relatively heavy. They need to be placed with brackets that raise the roof plate of our van so there is air flow and they don't get hot. They are quite a bit cheaper than the flexible ones.
- The semi-flexible solar panels have a thickness of about 2-4mm, are light (less than 2kg) and adapt to the curvature of the vehicle thanks to their flexibility. They can be attached directly to the ceiling, however it is recommended to place a cellular polycarbonate plate (between the ceiling and the plate) to improve cooling and therefore performance. They are more expensive than rigid solar panels.

Temperature is a factor that negatively influences solar panels. The higher the temperature of the solar panel, the less efficient it will be.

Depending on the geographical point that is decided. We want the solar panel to perform well on cold and cloudy winter days in the mountains.

A semi-flexible monocrystalline solar panel is chosen.

After calculating the consumption and choosing the battery, the solar panel is selected. It should be taken into account that the energy obtained from the solar panel will vary depending on the time and place and that its performance will not be optimal due to the fact that with the folded roof there is no inclination, in addition, the panels tend to work at 70% For this reason, the solar panel will be used to get the battery to discharge more slowly and not have to always depend on the external outlet or alternator.

To select the plate, the daily energy that will be required is calculated:

$(W \text{ panel} / 12V) \times \text{efficiency} \times \text{hours of sunshine} = W \text{ demanded} / 12V$

$(W \text{ panel} / 12) \times 0.7 \times 8 = 1264.69 / 12$

$W \text{ panel} = 225.83W$

A 250W semi-flexible monocrystalline solar panel is chosen.

In order to use the solar panel properly, it is necessary to regulate the energy that is obtained by means of a regulator and thus prevent the battery from being damaged.

Charge controllers are installed between the solar panel and the battery. They protect the batteries by supplying the necessary energy to charge them without damaging them.

They are classified into:

- **PWM regulator:** PWM (Pressure Wide Modulation) regulators work like a switch by equalizing the circuit voltage. They can only be used if the voltage of the solar panel is the same as that of the battery (it will not be possible to put a PWM regulator if the solar panel is 24V and the battery is 12V).
- **MPPT regulator:** MPPT (Maximum Power Point Tracker) regulators are able to isolate the solar panel voltage from the battery voltage, obtaining maximum performance thanks to the fact that they calculate the maximum power point taking into account the battery, solar radiation and the temperature. They are 15% to 30% more energy efficient than PWM regulators.

An MPPT regulator will be installed. This must be of the same amperage as the solar panel. For the regulator calculation, the power of the solar panel is divided by the battery voltage. With a 250W plate and the 12V battery the current will be $250W / 12V = 20,83A$.

A 20A regulator is chosen.

230 V external socket.

This installation will require additional approval. The socket will provide a voltage of 230V to AC circuit. This socket will feed the auxiliary battery through the battery charger and the independent 230V circuit.

A 30A battery charger is chosen.

Below are the calculations used to justify the sizing of the electrical installation.

Conductors:

They must have a sufficient cross-section to withstand the current flowing through them and not to cause excessive voltage drop, as indicated in different sections of the REBT.

A XLPE cable with Afumex insulation that is thermostable up to 90 °C will be used, with a flexible copper conductor. It is halogen free, it is not a flame propagator in case of fire, and it has a low or zero emission of smoke, toxic and corrosive gases. Designed according to UNE-EN 50525-3-41.

Polyethylene and PVC covered conductors cannot be used due to its content of halogen substances that are harmful to health in case of fire.

Calculation of the intensity:

To obtain the intensity that circulates through the direct current circuit, the expression is used:

$$I = P / V$$

Where:

I, Current intensity (ampere, A),

P, Power (watt, W),

V, Voltage (volt, V).

Calculation of voltage drop:

To calculate the cable sections, the following formula will be used, (which must be specified as most household appliances already indicate what the required section is).

DC circuit:

$$S = 2 \cdot L \cdot P \cdot \rho_{Cu} / V \cdot \Delta V \quad (\text{mm})$$

AC circuit:

$$S = 2 \cdot c \cdot L \cdot P \cdot \rho_{Cu} / V \cdot \Delta V \quad (\text{mm})$$

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Where:

L, is the length of the cable in meters,

I, Current intensity (amps, A),

P, Power (watts, W),

V, Voltage (volts, V).

ρ_{Cu} , the electrical conductivity constant of copper,

ΔV , the voltage drop for each appliance in %,

c, is the increase in internal resistance.

According to the UNE 20003 standard (UNE, 2000), for copper:

$$\rho_{CuT} = \rho_{20} \cdot (1 + \alpha_{20} \cdot (T - 20));$$

$$\rho_{CuT} = 0.01786 \cdot (1 + 0.00393 \cdot (T - 20));$$

$$\rho_{Cu20} = 0.01786$$

$$\rho_{Cu40} = 0.01860.$$

The limits of the voltage drop are defined in the ITC-BT-19 and establishes a maximum limit of 3% indoors. In other words, 0.36V DC and 6.9V AC.

Calculation of the voltage drop under operating conditions:

In operating conditions the temperature of the driver is increased. The driver's technical specifications indicate that the maximum operating temperature is 70°C. Therefore, the cable section will be calculated with a temperature:

$$T = T_0 + \Delta T_{\max} \cdot (I / I_{\max});$$

$$I_{\max} = \Delta T_{\max} \cdot I / T - T_0$$

Where:

T_0 , Reference temperature of the conductor (40°C).

ΔT_{\max} , Maximum conductor temperature (90°C) minus T_0 .

I, Calculation intensity (amps, A).

I_{\max} , Maximum permissible intensity.

Temperature:

It will be calculated according to the provisions of the UNE-20460-5-523 standard.

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The maximum operating temperatures according to the type of insulation are listed in table 52-A of the UNE-240-5-523 standard.

The reference ambient temperature will be:

- For cables buried directly in the ground or buried in ducts: 20 °C.

For the dimensioning of the circuit, use will be made of the following table of normalized sections:

Cable section (mm ²)	Iz, maximum intensity in pipe (A)
1.50	13
2.50	18
4	24
6	31
10	42
16	56
25	73
35	89
50	108
70	136

Table 19. Standard cable sections ("areatecnologia.com").

In the case of the wiring sections of the two batteries and the 230V external power outlet, as they are so short wired, small wiring sections appear. In this case, the criterion of maximum admissible current that the section must withstand prevails and it is dimensioned according to this criterion applying the table of sections and currents.

Short circuit current:

To calculate the short-circuit current we will use the formula:

$$I_{cc} = 0.8 \cdot V/R$$

Where:

- I_{cc} , Short-circuit current in the element to be calculated.
- V, Voltage (12V to DC and 230V AC)
- R, Resistance to the conductor between the element to be calculated and the power supply.

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The value of R is given by: $R=RLGA+RDI$

For this installation, the value of the resistor R will be 0 when there is no mains connection. If this connection exists, the supplier facility must meet all security requirements.

Therefore: $R = RDI = \rho \cdot L / S$

It will be considered that the driver is in the most unfavorable case of a temperature of 20°C.

Protections:

For the design of the fuses, ITC-BT-22 will be followed: protection against overcurrents.

At the origin of all circuits, a short-circuit protection device will be established whose breaking capacity will be in accordance with the short-circuit intensity that may occur at the point of its connection.

It is accepted, however, that in the case of circuits derived from a main circuit, each of these branch circuits has protection against overloads, while a single general device can ensure protection against short circuits for all branch circuits.

What this means is that the automatic main switch has a breaking capacity greater than the short-circuit current calculated at the point where it is installed, it is sufficient, it is not necessary for the fuses to have a breaking capacity greater than the I_{cc} , although it is recommended.

Calibrated fuses with adequate operating characteristics and automatic switches with an omnipolar breaking system (which breaks all the cables) are admitted as protection devices against short circuits.

For the choice of the driver, the intensity values will be taken into account, and it will satisfy:

$$I < I_z$$

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Where:

- I, Intensity expected.
- Iz, Permissible conductor current.

By restriction of the ITC-BT-41 unipolar cables with non-metallic conduit are used. Since the wiring passes through the gap between the bodywork and the plywood floor and this area is filled with thermal insulation, we will consider the A1 channeling method: Insulated conductors or unipolar cables in ducts embedded in thermally insulating walls. (UNE, 2014). In addition, the protective tubes, which will be bendable, must comply with the characteristics of the UE-EN 50086-2-2 standard, collected in the ITC-BT-2.

To protect the circuit against overloads, the following condition will be met:

$$I \leq I_n \leq I_z$$

This condition physically indicates that the fuse must pass the current necessary for the installation to operate according to the expected demand, but must not allow a current to be reached that deteriorates the cable, specifically, its insulation, which n 'is the weak part.

I: design current of the corresponding circuit.

I_n: nominal current of the fuse

I_z: maximum permissible current of the protected conductor

Standard fuse ratings

2	4	6	10	16	20	25	35
40	50	63	80	100	125	160	200
250	315	400	425	500	630	800	1000

Table 20. Standard fuse ratings (“riunet.upv.es”).

Mass contact:

As indicated by the ITC-BT-41 that refers to the UNE 20460-7-708 standard, modified by the UNE-HD 60364-7-708 (UNE, 2018), all the masses of electrical devices are connected.

The calculations are presented in the Annex: Calculations of the electrical installation.

7.5 WATER CIRCUIT INSTALLATION

No certificate or certificate is necessary for the water installation, although it is important to follow some guidelines:

- It is recommended to install the electrical installation of the tanks separately.
- The MMA^[2] of the vehicle will not be exceeded given the case that the tanks are completely full.

The inclusion of the gray water tank in residential vehicles and motorhomes is mandatory, as established by the DGT. In order to provide the vehicle with running water, a circuit will be installed that circulates it from a tank to the various projected taps. In addition, there will be a gray water tank where the waste from the shower and the sink will be dumped.

One of the main elements of the water installation are the 12V water pumps. These can be divided into three large groups: submersible, aerial and pressure.

The first ones have a low price, they are recommended for cold water installations and their flow is usually between 10 and 12 liters per minute, the second ones have similar characteristics to the previous ones, but they are installed outside the tank and it is necessary to use a non-return valve and the third ones, they are placed outside the tank and have a built-in pressure switch to activate the pump when the tap or shower is opened, the installation of a non-return valve is also necessary and are recommended for the installation of hot water.

Due to the requirement to have hot water for the shower, the project will have a pressure pump.

The water circuit will be boosted thanks to the pump that will be found next to the tank. This pump will raise water to the point required by the installation and will be operated through the kitchen and bathroom taps. For this reason, each faucet will incorporate a switch that starts the pump, activating the circulation of water.

^[2] The MMA (Maximum Authorized Mass) by regulation for a vehicle in circulation. Includes the weight of the vehicle, its equipment, its fuel, etc.

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One of the critical points regarding the installation of water, which must be approved, is the subsection of the tanks. This subsection must be strong. For this, a kit of adhesive and perforated tapes is used for specific fixation of tanks that are valid for both interior and exterior, as long as the location criteria are met so that it does not affect the vehicle's drive unit .

The kit of tapes for specific fixation of tanks, are regulated to support a mass of 150 kg at most. For the fixation of our tanks they are more than sufficient since the tank with the most mass is approximately 90kg.

7.6 GAS INSTALLATION

The gas installation follows the R.D. 919/2006 approving the Technical Regulation for the distribution and use of gaseous fuels, which specifically affects its instructions:

- ITC-ICG 10 LPG installations for domestic use in caravans and motorhomes: indicates the documentary requirements to approve the gas installation.
- UNE-EN 1949:2011 Specifications for the installations of LPG systems for domestic use in habitable recreational vehicles and for accommodation in other vehicles.

7.7 LIGHTING

12V led lighting will be installed for the interior lighting of the vehicle. The choice of this section was based on the price, the low consumption and energy efficiency of the LEDs, the lumens they provide and the useful life of the product

7.8 INTERNAL FIXATION SYSTEM FOR BICYCLES

It will be installed in the loading area of the trunk, on two rails, a fixing that can be adapted to the front fork of the bicycles.

8. REFORM'S DESCRIPTION

8.1 DISASSEMBLY PERFORMED

To carry out this reform, the double co-pilot seat and the set of second and third row seats, together with their safety belts and canceling their anchors, are removed.

The relevant cuts will be made in the sheet metal and in the bodywork to be able to pass the pipes and it will be removed from the roof of the vehicle following the instructions given by the manufacturer.

A total of 5 openings will be made in the van:

- The roof sheet will be cut for the subsequent installation of the retractable roof.
- 1 cut on the driver's side for the external electrical connection.
- 1 cut at the bottom for the gray water tank pipe.
- 1 cut on the driver's side to fill the sanitary water tank.
- 1 cut at the bottom for gas outlet.

8.2 VARIATIONS AND SUBSTITUTIONS

The reforms carried out on the vehicle are as follows:

- Reduction in the number of seats to two in the front and two in the second row.
- Incorporation of furniture in the luggage area, without affecting the structure of the vehicle.
- Water installation.
- Installation of a heater.
- Electrical installation.
- Gas installation.
- Installation of a solar panel on the roof of the vehicle.
- Installation of a retractable roof
- Increase in the lighting installation.
- Change of classification to unspecified tourism (1000)^[3].

These reforms involve the variation of the following exterior dimensions of the original vehicle: height.

^[3] tourism vehicle for private use.

8.3 USED MATERIALS

8.3.1 WOOD STRIPING

Reinforcement using beams to level the walls and make them more resistant. Slats of brushed spruce wood will be used due to their light weight and resistance to moisture.

This type of wood was chosen because it resists temperature changes and humidity very well, is light and is easy to screw and machine.

The dimensions of these slats will be 20x10mm for the ceiling to lose the minimum height and 20x20mm for the walls.

Cuts will be made with a sufficient size so that the different ducts can pass in those places where necessary.

8.3.2 THERMAL INSULATION

The cargo space of the van will be insulated with thermal insulation Kaiflex ST from Kaimann, with a coefficient of thermal conductivity of 0.036 W/(m·K) at 20 °C and behavior against fire Class B. The sheets of insulation between the slats, taking into account the placement of the pipes.

Sheets of 10mm thickness will be used for the floor and 20mm for the walls and ceiling.

8.3.3 PANELED

The entire interior is covered with wooden panels. These panels make up the floor, walls and ceilings.

The following table shows the wood used for each part:

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Location	Material	Thickness (mm)	Characteristics
Floor	Plywood 100% treated birch Phenolic ^[4] and anti-slip.	9	Density 700 kg/m ³ . Material with grain load resistance. It has a phenolic treatment which makes it resistant to moisture, heat resistant, antiseptic and antibacterial. It is hygienic, rigid and water-repellent. Besides, it has a varnish treatment that promotes anti-slip. 
Walls	Birch plywood with Phenolic treatment.	4	Density 650 kg/m ³ . Material but with grain load resistance. It has phenolic treatment 
Ceiling	Poplar HPL plywood.	5	Density 400 kg/m ³ . Lighter material and it is also coated with a laminate of high pressure (HPL) for more resistance and stability, so it is a very light and resistant wood. 

Table 21. Wood used for the paneling.

^[4]Phenolic treatment means that during the manufacturing process the sheets have been glued with phenolic glues, which are resistant to moisture.

8.3.4 FURNITURE

Wood will mostly be used to make the furniture. The wood used will vary depending on the type of furniture and the characteristics it requires depending on the utility and function for which it is intended.

Next, a table of furniture materials is shown, specifying physical properties, thicknesses and in which furniture it will be used:

Material	Characteristics	Thickness (mm)	Moble
Birch plywood phenolic	Density 650 kg/m ³ . Wood with high mechanical strength and to the humidity	9	- Kitchen (kitchen counter) - Bathroom structure - Folding table - Bedroom furniture - Kitchen furniture - Wardrobe
Fir strip brushed	Solid wood, which provides a great stability for the use in structures.	44x20	- Basic structure of the kitchen - Base structure of the wardrobe - Double seat structure
Fiberglass	Material resistant to water, humidity, unalterable, antifungal, anticorrosive and putrefressible	To size 482x670	Shower tray (bathroom)
Vinyl waterproofing	Insulating in water, moisture, easy placement	-	Insulation for the bathroom module
Aluminum rectangular profile		To size 27x24x782	Bathroom structure
PVC runner door guide		590x16x18	Wardrobe door guide

Table 22. Furniture used wood.

In general, the materials used for furniture have properties of high resistance and light weight (low density). On the other hand, these must have contoured edges, in order to

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avoid possible injuries and safety closures on all doors or drawers to ensure that they do not open when the vehicle is in motion.

8.3.5 FIXATIONS ELEMENTS

The panels will be fixed to the structural reinforcements of the closed box using M6 screws type DIN 7505-B.M6 tipus DIN 7505-B.

Element	Dimensions	Function
Self-tapping screw of steel (cylindrical head pumped up)	30mm long and 6mm in diameter	Structure of the passenger compartment and fixing of furniture
Characteristics: - Screw for galvanized - Screw for wood. - Great durability.		

Table 23. M6 DIN 7505-B screw characteristics (“www.hispanox.com”).

Screws, reinforcement brackets, beam supports or slats will be used to fasten all the furniture. Sikaflex or a similar polymer with a resistance of 230 Kg/cm² will also be used for fixing the other elements.

Element	Dimensions	Function
Self-tapping screw of steel (countersunk head)	12 mm in length and 3,5mm in diameter	Construction of doors and drawers
Characteristics: Screw for galvanized - Screw for wood. - Great durability.		

Table 24. M6 DIN 7505-A screw characteristics (“www.hispanox.com”).

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Element	Dimensions	Function
Fixation bracket reinforced	70 x 70 x 2,5mm.	Furniture fastening
Characteristics: - Great load capacity.		

Table 25. 70x70x2.5mm square.


Element	Dimensions	Function
Fixation bracket reinforced	30 x 30 x 16mm.	Fastening furniture corners
Characteristics: - Union of elements - Fix items		

Table 26. 30x30x16mm square.

8.4 ASSEMBLIES PERFORMED

8.4.1 RAISED ROOF

The relevant roof model corresponding to the chosen vehicle will be installed as stated. The roof will have butterfly lock and opening systems that allow the roof to be locked easily and safely. Thanks to the scissor opening and the four pneumatic arms, it opens easily and quickly.


RAISING ROOF SCA Long battle
<ul style="list-style-type: none">- Front opening- Raised roof type- Closed vehicle roof height: 2065mm- Mattress thickness: 40mm- Bed type: aluminum slats with comfort mattress system- Rest area size: 1250 x 2000mm- Closure in the entrance area to the roof: YES- Locking mechanism: butterfly lock (southco)- Canvas type: standard and panoramic- Height of the scissors: 40mm- Roof with approval certificate


Table 27. Raised ceiling characteristics ("sca-iberica.es").

To carry out the installation, the roof of the vehicle will be cut following the dimensions indicated by the manufacturer and to prevent it from rusting, an antioxidant will be applied to the edges.

The next step will be to install the reinforcements provided by the manufacturer in order to guarantee the solidity of the structure. To attach these reinforcements, follow the manufacturer's instructions.

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Specified holes and screws cannot be changed. Once the resistance is guaranteed, the cover is installed and the lateral scissors that allow the roof to be raised and lowered. In this step it is very important to carry out the entire installation symmetrically so that there are no problems with movement.

Finally, the bed board fixed to the rear horizontal cross member and the anchors to prevent the roof from opening during journeys are installed.

8.4.2 SEATS

- **DECREASE IN THE NUMBER OF SEATS,**
- **INSTALLATION OF SWIVEL BASES ON THE SEATS OF THE PILOT AND COPILOT**
- **INSTALLATION SEAT/FOLDING BED REAR TWO-SEAT**
- **LOWER DRAWER UNIT**

The van has 3 front seats: a seat for the driver and another double seat for two co-pilots. The changes to be made in this case will be the following: Installation of an individual seat for co-pilot.

- Reduction in the number of places in the van by eliminating the two rows of three-seater rear seats by installing a folding two-seater seat that can be converted into a bed.
- Installation of swivel bases on the front seats.

In all three cases it will be necessary to make sure that the structures and seats are for the same make, model and year as our van and it will be necessary to have the technical data sheet for each structure and the certificate from the workshop ensuring that the installation is correct and safe in order to pass the ITV.

Rotating bases will be installed on the pilot and co-pilot seats to change the front fixed seats to rotating seats to be able to use these seats as part of the dining room and gain space. For the installation of the co-pilot seat, the seat anchors cannot be modified.

The bases chosen are of the **SCOPEMA** brand, approval number CE 19 Reconversion and approval of a residential vehicle e3*76/115*2005/41*1655*00 and references 0609100002/LG and 0609100002/LP for pilot and co-pilot .

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SCOPEMA ROTATING BASES	
<ul style="list-style-type: none">- European approval n°93SG0316-00.- Origin fixation points (for each model).- Stabilization with Teflon nipples.- 5 mm steel plates.- Easy unlocking.- Thickness: 23 mm (depending on the model).- Shift towards the rear: 60 to 140 mm (depending on the model).- Automatic lock in driving position.- Average inward displacement: 30 mm (off-center base).	

Table 28. Swivel bases characteristics ("scopema.com").

The installation of the swivel bases and the co-pilot seat will be done at the same time. The first step will be to unscrew the screws that fix the double seat to the ground and the belt sensor to be able to remove it. The co-pilot seat base will then be installed on the original anchors and secured with the original screws. Finally, the rotating bases will be installed.

The lever to turn, both in the case of the driver and the co-pilot, should be located next to the gearbox. The last step is to reattach the seat belt sensors to both seats.

With regard to the rear two-seater folding seat/bed installation. In order to incorporate the different furniture and elements of the camper in the back, proceed to the uninstallation of the sets of 3 seats in the second and third row, together with their safety belts and canceling- nor the anchors.

A passenger restraint structure is mounted in the intermediate area of the vehicle, behind the driver's seat, on the opposite side of the central access door and facing forward, as indicated in the plans of this project.

This fixing structure is mounted on aluminum rails which, at the same time, are fixed on the chassis of the van. For fixing the rails, the contact surface between them and the chassis must be treated beforehand with Sika Aktivator 205^[5] or similar degreaser. Then Sika 206G+P^[6] adhesive or similar will be used.

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Next, the installation of the folding rear two-seater seat for the transformation into a 1900x1200mm bed will proceed. **The model chosen is the Scopema Altair 2p 120 cm.**

SCOPEMA SEAT BED ALTAIR 2P 120 cm.	
<ul style="list-style-type: none">- Bed dimensions: 120 x 190 cm- Integrated type headrests.- 2 seats with 3-point belts.- For vehicles with category N1 and M1.- Fixing anchors on the chassis included.- Isofix.	

Table 29. Seat/bed characteristics (“scopema.com”).

This will incorporate a safety belt system for two people, guaranteeing the safety of passengers. In addition, they will have the Isofix system for the covers with the relevant approval and will be mounted in accordance with the manufacturer's instructions.

Once these reforms have been carried out, the number of seats in the reformed vehicle will be as follows: **number of seats: 4, two in the front and two in the second row.**

Finally, in the lower structure of the folding double seat, in order to take advantage of the space, a piece of furniture with a drawer will be mounted under each of the seats. The structure of these drawers will be made with wooden boards, fixed to the structure of the seats using 30x30 metal angles and M6 screws.

^[5] Solvent-based adhesion promoter for non-porous substrates.

^[6] Solvent-based pigmented primer for various substrates

8.4.3 STATIONARY HEATER / WATER HEATER COMBINED SYSTEM

A Webasto brand system has been selected for this project, specifically the Dual Top Evo 6 model, which has a power of up to 6kW. It is made in Europe and has the CE marking. Fuel consumption ranges between 0.19 and 0.66 litres/hour and electricity between 15 and 65W. It has a boiler with a capacity for 11L. A controller will also be installed to regulate the temperature.

Webasto Dual Top Evo 6

Integrated hot water and heating system.

- Can be installed inside and outside.
- The equipment quickly heats the passenger compartment and the 11L of the integrated water boiler, using the same diesel from the vehicle's fuel tank.
- Antifreeze system or automatic drainage of the water boiler from the same control panel.

- **Technical specifications:**

- Calorific Power (kW) 1.5 - 6.0.
- Type of Diesel Fuel.
- Fuel consumption (l/h) 0.19 - 0.66.
- Voltage (V) 12.
- Voltage range (V) 9 – 15.
- Power consumption (W) 15 – 65.
- Air flow (m³/h) 200.
- Boiler capacity (l) 11.
- Dimensions l x w x h (mm) 530 x 352 x 256.
- Weight (kg) 20.



Table 30. Dual heating system characteristics (“www.webasto.com”).

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The installation of the heating system will be carried out under the bottom of the vehicle, in the area of the rear seats. The holes will be made in the ground to fix the system and pass the air inlet, gas outlet and fuel pipes. Obtaining fuel from the tank will be done through a T system by splicing pipes. The last step of the installation will be to connect the heater to the auxiliary battery and install the control panel.

8.4.4 WOOD STRIPING

It should be taken into account that the Reforms Manual includes reforms that affect the interior conditioning of vehicles, as is the case here. In point 8.30 of the Reforms Manual it is specified that if the interior panels do not exceed 5% of the MMA they do not count as a reform. Point 8.31 deals with the installation and removal of fixed elements that affect the structure of the space intended for loading the vehicle.

The interior of the passenger compartment (floor, sides and ceiling) will be leveled with the aim of leveling the surface and improving the consistency of the subsequent panelling. They will be arranged parallel to the longitudinal axis of the vehicle on the surfaces of the load area (floor, walls and roof) and fixed with mounting adhesive for wood and metal: Pattex PL600^[7] or similar. Thus, a fixed structure is created that serves as a base for placing the insulation, walls, ceiling and floor.

8.4.5 THERMAL INSULATION

Kaiflex ST will be used to insulate the roof and walls. Plates with a thickness of 10 and 20 mm have been selected. Aluminum tape will be used to seal and join plates and fire resistant polyurethane foam to fill voids.

During the installation, any rust that may be present will be removed, an antioxidant will be applied and it will be thoroughly cleaned so that there are no problems when attaching the insulation.

Kaiflex panels will be cut to the shape of the walls, doors and ceiling, taking into account window and ceiling gaps. The case of the Kaiflex is self-adhesive, it sticks directly.

^[7] It is an extra-strong mounting adhesive with immediate grip.

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Insulation sheets will be placed between the slats, taking into account the placement of the pipes. The gaps in the beams will be filled with polyurethane foam and the joints between panels and holes will be sealed with aluminum tape.

8.4.6 PANELED

The entire interior of the loading area will be covered by wooden panels. The panels will be cut, both for the walls and the floor, adapting to the shapes of the van, taking into account the gaps in the windows, the liftable roof, wiring, lights and sockets. These panels make up the floor, walls and ceilings and are fixed to the structural reinforcements of the vehicle using M6 screws type DIN 7505-B.

They will also be screwed to the floor, the walls of the van and the walls that make up the bathroom compartment. An 800x716mm cabin, up to the ceiling, and built with two panels on the sides with a slatted frame at the front to reinforce and place the folding bulkhead.

To ensure that the wood is not damaged the interior walls are treated with several layers of marine varnish and two layers of waterproofing paint. All joints will be properly sealed with silicone to prevent leaks.

To finish the installation of the panels and with the aim of improving the aesthetics of the motorhome, self-adhesive vinyl will be placed on the exposed parts, which will also protect the wood.

8.4.7 ELECTRICAL INSTALLATION

An AGM battery will be installed. Both AGMs and gels withstand temperature changes and charge and discharge cycles well. Although the gel batteries have a longer life, an AGM is chosen since the gel batteries do not support loads higher than 12V (the vehicle's alternator, which will be a way to recharge, generates a constant voltage of between 14.2V and 14.4V depending on the model and engine revolutions).

The auxiliary battery selected is an AGM battery with a capacity of 250 Ah C100 and 12V of the brand Tensite.

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Auxiliary battery	
Brand	Tensite
Model	AGM 12V 250Ah
Type	AGM
Nominal voltage	12V
Capacity	250Ah
Number of items	2
CE MARKING:	yes
547 x 124 x 320 mm.	



Table 31. Auxiliary battery characteristics (“autosolar.es”).

Together with the battery, a 12V to 230V pure sine wave inverter will be installed, responsible for converting the direct current stored in the battery into alternating current.

Inverter	
Brand	Novopal
Model	DLCD2000PEU12
Type	Sinusoidal Pura
CE MARKING:	yes
Electrical power 1000 watts 32 x 16.5 x 10 cm. Voltage 12 Volts Total outlets 2 Input voltage 12 Volts Product weight 4.8 Kilograms Efficiency 90%	



Table 32. Inverter characteristics (www.amazon.es).

Both the 12V auxiliary battery and the current inverter will be located under the passenger seat fixed to the plywood using M4 screws and perforated metal tape.

A **relay** will be installed so that it is only charged while the alternator is in operation.

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Relay	
Brand	Victron Energy
Model	CYR010120011
CE MARKING:	yes
Cyrix-CT battery coupler, 12V / 24V. Continuous current: 120 at peak 300 A (5 seconds) on 13-13.8V (12V system) and 26-27.6V (24V system). Separation voltage: 11-12.8V (12V system) and 22-25.7V (24V system) with trend adjustment. Power consumption: 4Ma. Cable connection screws: M6 flat plug contacts (terminal 85 and terminal 86) Parallel switching option via button or switch	



Table 33. Relay characteristics (“www.victronenergy.com.es”).

The solar panel will be installed on the roof of the vehicle. This plate is fixed on the lifting roof using M04 screws. The solar panel is identified with the following characteristics:

Photovoltaic panel	
Brand	Plusenergy wccsolar
Model	B079WG1JMB
CE MARKING:	yes
Features 12V, 250W 1640 x 992 x 40mm, Weight: 6 Kg	



Table 34. Photovoltaic panel characteristics (“<https://www.wccsolar.net>”).

It is considered that the installation of the plate means a negligible increase in the height of the vehicle.

The photovoltaic panel will be accompanied by the installation of the following charge regulator in order to protect the battery by supplying the necessary energy to charge it without damaging it.

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MPPT regulator	
Brand	Victron Energy
Model	SCC075015060R
CE MARKING:	yes
SmartSolar MPPT 100/20 Charge Controller. 100V/20A. bluetooth H100 x W113 x D40mm	



Table 35. MPPT regulator characteristics (“www.victronenergy.com.es”).

The third battery power source will be from an external 230V outlet and through a 30A battery charger.

Battery charger	
Brand	Victron Energy
Model	Charger Blue Smart IP22
CE MARKING:	yes
<ul style="list-style-type: none"> - Internal Bluetooth compatible with the Victron Connect App. - Efficiency of 93% with stand-by consumption of 0.5W. - Selectable 3 maximum absorption voltages: Normal (14.4V), High (14.7V), Lithium (14.2V). - It can be used as a power supply. - Capacity for reconditioning and recovery of discharged batteries. - Led indicators of the charge stage. - Maximum load of 30A at 12V 235 x 108 x 65mm	



Table 36. Battery charger characteristics (www.victronenergy.com.es).

Protection elements:

An external 230V socket will be available to connect to the electricity network.

A Schneider Electric differential switch model A9R61240 In: 40A and 30mA sensitivity and a Schneider Electric bipolar 16A 6kA DomA62 magnetothermal will be installed both

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at the head of the installation in the 230V socket and in the alternating current circuit.

Diferencial switch	
Brand	Schneider
Model	A9R61240
CE MARKING:	yes
Characteristics: 2P 40A 30mA CLASS AIn: 40A ΔI : 30mA	



Table 37. Differential switch characteristics (“www.se.com”).

Magnetothermal	
Brand	Schneider
Model	DomA62
CE MARKING:	yes
Characteristics: Bipolar magnetothermal switch DomA62 16A 6kA In: 16A , Vn: 230V , PC: 6kA , Curve: C	



Table 38. Bipolar magnetothermal switch characteristics (“www.se.com”).

To complete the installation, a voltmeter to know the load level, a fuse box and wiring with the appropriate sections will be installed in the DC circuit.

All circuits will have an overcurrent protection device (fuses or magnetothermals) with omnipolar cut-off in accordance with the diagram.

Circuit	Fuses
LEDS	In: 10A ; Vn: 12V
Water Bomb	In: 10A ; Vn: 12V
Fridge	In: 20 A ; Vn: 12V
Heater	In: 40A ; Vn: 12V
USB	In: 10A ; Vn: 12V
Oven	In: 63A ; Vn: 12V
Photovoltaic module	In: 50A ; Vn: 12V
Main battery	In: 125A ; Vn: 12V
Auxiliary battery	In: 125A ; Vn: 12V
Fuse box	In: 50A ; Vn: 12V

Table 39. Fuses for each circuit.

Conductive elements.

A XLPE cable with Afumex insulation that is thermostable up to 90 °C will be used, with a flexible copper conductor.

They will have the section indicated in the annex: Calculations of the electrical installation.

Protection conductor.

As established in the General Installation Conditions of the ITC-BT-41, referring to the UNE 20460-7-708 standard, all the masses of the electrical devices and all the protection contacts of the sockets of current from the interior, they will be connected to the protective conductor of the caravan's power outlet.

The protective conductor will be a flexible unipolar cable with PVC insulation type H07V-K of 4mm² section.

Conductors.

The conductors of the different circuits will be channeled inside bendable or flexible PVC pipes with the characteristics indicated in Table 3 of the ITC-BT-21 of the REBT.

Separation of circuits.

The direct current (12V) and alternating current (230V) circuits will have independent channels, occurring at a physical separation.

Entrance.

The external power input will be through a UNE 60309-2 connector with 3 pins (2P+T). It will be covered with a safety cover and an identification plate with the nominal voltage, current and frequency values.

Finally, it will be verified that the installation corresponds to the scheme:

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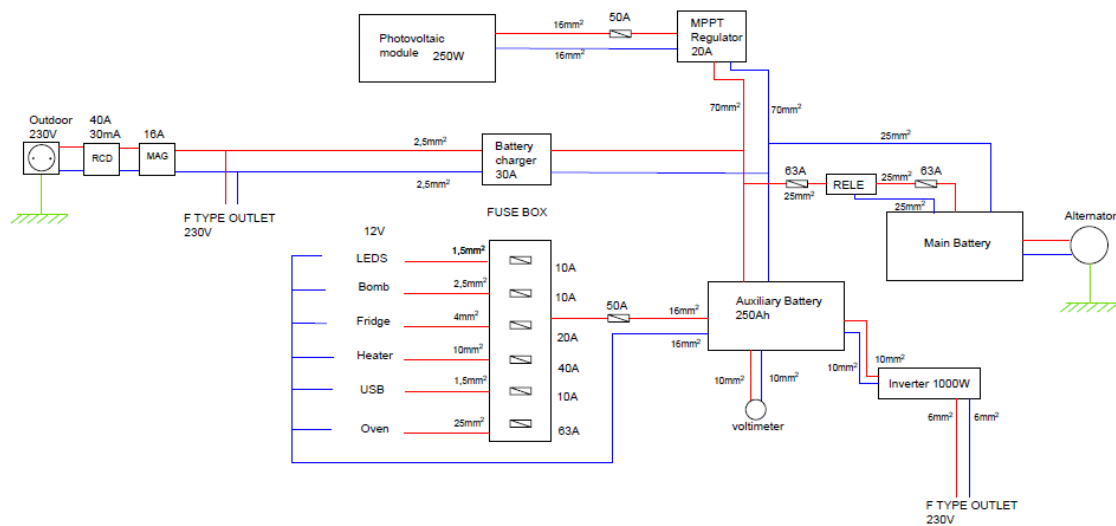


Figure 12. Electrical installation scheme.

8.4.8 WATER CIRCUIT INSTALLATION

An installation diagram will be designed in order to check the correct connection of all the elements and facilitate the whole process. To design the installation, different options have been studied and the ones that best suit what is desired have been chosen.

In order to have water in the vehicle, two tanks will be installed to store it, one for clean water, from which the water for the sink and shower will be obtained and one for water grey, intended for the installation's waste water. A tank with a capacity of 90L will be included to supply the motorhome. This can be accessed and filled from an opening with a safety cover on the right side of the vehicle. The opening or filling mouth must have an orifice through which the accumulated air inside the tank will escape while it is being filled.

The filling mouth must be attached and glued to the plate. A drill bit will be used to cut the sheet metal and the mouth will be attached using silicone, then an anti-rust layer will be applied.

Finally, the water spout will be connected to the tank using a 40mm hose (to fill) and a 10mm hose that will act as a breather.

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EXTERNAL FILLING JACK		
Brand	Fiamma	
Model	65156.10	
External water intake, with mouth and cap. With set of keys.		

Table 40. External filling outlet characteristics (“www.fiamma.it”).


CLEAN WATER DEPOSIT		
Brand	Gumer Camper Accessories	
Model/Capacity	90L	
Dimensions	400 x 310 x 800mm.	

Table 41. Clean water tank characteristics (“gumercamperaccessorios.com”).

The motorhome has a gray water tank with a capacity of 40L and dimensions 990x400x100mm. This tank is located at the bottom of the vehicle.



GRAY WATER DEPOSIT		
Brand	Gadi Camper	
Model/Capacity	40L	
Dimensions	990 x 400 x 100mm.	

Table 42. Grey water tank characteristics (“gadicamper.com”).

Waste gray water will be deposited in the tank installed under the vehicle through the action of gravity itself. This will have a pipe installed, oriented towards the back, which will end in a key that allows the emptying of the tank in the places enabled for this purpose.

The pump will be placed outside the tank, it will also install a non-return valve:

HYDRAULIC PUMP		
Brand	Fiamma	
Model	Aqua 8	
Type	non submersible	
Potència requerida	18W	
Capacity	10L/min	
Homologation	yes	
Power: 12v.		
Consumption 3.4 A		

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Output at 0 bar: 10 l/m Noise: 65/70 dB Weight: 1.5kg Maximum height of water rise 3 meters.	
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Table 43. Hydraulic pump characteristics ("www.fiamma.it").

For the circuit, a 10mm reinforced water hose will be used in three colors, blue, red and gray to indicate the type of water and facilitate installation. Two 10mm T connections will be used with the corresponding keys (to purge the circuit). And 8-16mm stainless metal clamps are used to fix the connections.

For the connection of each element, the manuals for each component of the installation are followed.

The tanks will be fixed according to the manual provided along with the fixing tapes.

The water installation consists of a simple design circuit, where the main elements are the sanitary and gray water tanks, pump and all the demand points of the circuit. In addition, it has a heater to supply it with hot water.

The placement of the different elements of the installation is established in the "Water installation plan".

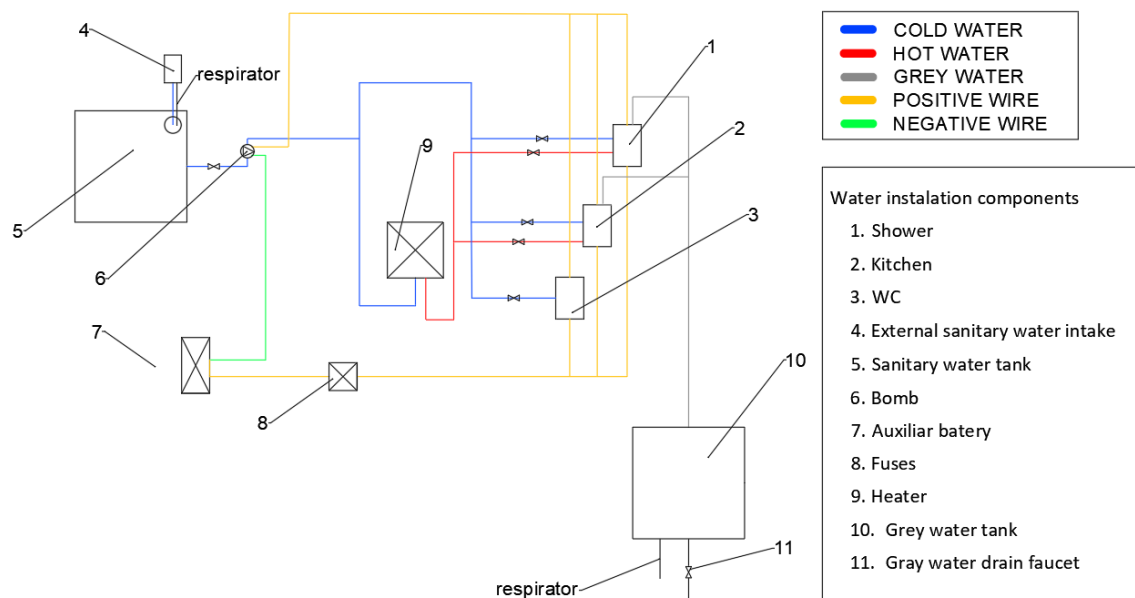


Figure 13. Hydraulic installation scheme.

8.4.9 GAS INSTALLATION

The gas installation will be carried out by an authorized installer, following the locations of the components according to the "Gas Installation" plan.

In order to minimize the installation and the number of cuts in the sheet metal and openings from the outside, an installation with bottles of up to 16 kg maximum is chosen. In this way we have internal access to the bottles. The regulations allow you to have up to two, but due to space issues we will only have one of 7kg.

These will be located inside the kitchen furniture, at most two bottles with a maximum combined capacity (between the two bottles) of 16 kg.

KIT GLP A4 MOTORHOME 1 BOTTLE 20 L MULTIVALVE	
Temperature range	-40 to +65 °
Kg Gas	7kg
Homologation	yes
Kit with 1 bottle of 24.4L. With specific Level Indicator for Motorhomes and Campers composed of 1 Refillable 24.4L. Bottle height: 58.3cm Diameter: 31cm	




Table 44. LPG pump kit ("www.masquecamper.com").

For the construction of the housing of the bottle in the furniture, the following considerations will be met:

- The furniture will be completely isolated. To achieve this, the furniture will be sealed with silicone or similar. In the case of the door, a rubber band or edging will be placed around it to achieve the seal.
- The door must be 50 mm above the floor of the accommodation. In other words, the door cannot be flush with the ground.
- The cylinders will always go in a vertical position, with the valve upwards. To hold them, a fixing device will be mounted that holds the cylinders at the top and another at the bottom. This clamping device must be opened and closed manually, never with tools.

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- There shall be no element that obstructs access and handling of valves, regulators, etc.
- There will be no electrical devices inside the compartment.
- A breather will be installed on the ground that connects directly to the outside of a minimum of 10,000 mm², that is, a square hole of 100×100 mm or round of Ø178 mm. This, in no case will be obstructed.


VENTILATION GRILLE		
Brand	Fepre	
Model	Varnished aluminum ventilation grid. 10x10x0,8mm.	
Reference	12323605	
Homologation	yes	

Table 45. Ventilation grille (“www.fepre.com”).

The installer of the LPG system will have to issue one establishing compliance with the EN 1949 Standard by carrying out tests to verify that the installation, materials and equipment meet the resistance and tightness requirements. All supply pipes will be permanently identified, when connected to the regulation system, with a label indicating the service pressure in mBar.

The installation will incorporate a 30 mBar pressure regulating valve:


30 mBar PRESSURE REGULATOR VALVE		
Brand	Truma	
Model	MonoControl CS	
Reference	5616140	
Homologation	yes	
Input connection type: External thread M20 x 1.5. Output connection type: Terminal for 8mm hose, Terminal for 10mm hose. Type of gas: Butane, Propane. Gas pressure: 30 mBar. Dimensions (H x W x D) 512 x 670 x 400mm		

Table 46. Regulating valve 30mBar (“www.truma.com”).

The tubes will be made of copper according to the EN 1057 Standard and will have the

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indicated thickness of 8mm. The maximum distance from the cylinder's flexible tube to the fixed installation will be 400mm.

The connection to the household appliances will be made by means of rigid screw connection systems (not welds). When connecting two elements, kitchen and oven, it is necessary to install with a fixed pipe. The diameter of this must be between 6 and 12 mm and copper. The fixings will be every 500mm at most. The pipes must run parallel to the electrical wiring separated by at least 30mm.

At intersections with electrical wiring, the separation distance will be at least 1cm. The electrical wiring must be protected with a channel or corrugated pipe.

There will be a general shut-off valve and one for each appliance or device connected to the installation. Always installed on the fixed part, not on the flexible tube.


SHUT-OFF VALVE		
Brand	Truma	
Model	Straight 8 mm gas cutting key	
Reference	110910	
Homologation	yes	

Table 47. Cutoff valve ("www.truma.com").

The installation will be carried out based on the following scheme:

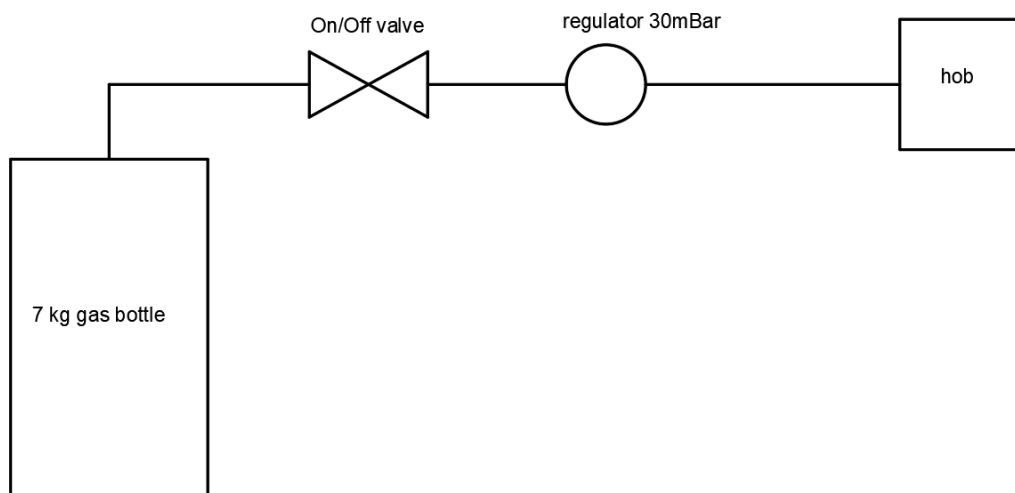


Figure 14. Gas installation scheme.

8.4.10 BATHROOM

There will be a room that will house a chemical toilet and shower. This will have a rectangular prismatic structure, fixed to the ceiling and floor. It will rise from the floor 9mm so that a base is built for the shower tray.

The shower tray will be custom made using fiberglass (reinforced with polyester and epoxy resins to give more resistance). Later, the walls inside the bathroom will be covered with waterproofing vinyl (with a wooden finish), leaving openings for the water intakes of the shower and the WC. Finally, a wooden structure will be placed on the ground, which will be previously treated, which will serve as an anti-slip zone. All joints will be sealed with transparent SikaFlex^[8] for bathroom.

It will have two entrances, one from the inside of the vehicle and the other from the outside. These will consist of a custom-made horizontal roll-up screen of 809 x 1382mm. This will be mounted on two guides:

Bottom guide: 23 x 22 x 782mm.

Top guide: 40 x 22 x 782mm.

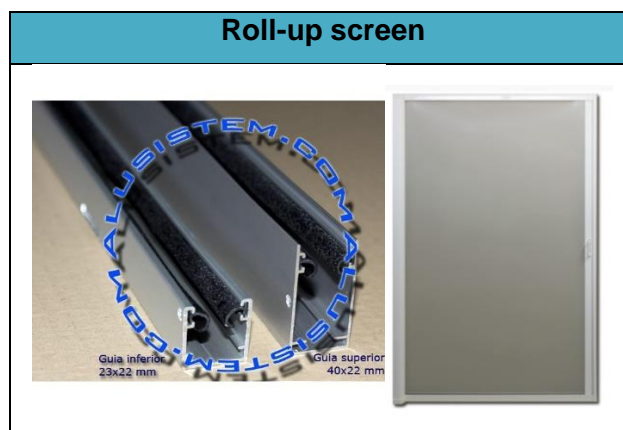


Table 48. Roll-up screen (“www.alusistem.com”).

The chemical WC will have a removable black water tank with a capacity of 19,3L and accessible from the outside through a sealed cover that includes a safety lock. It will also include a pump that will be connected to the water circuit to facilitate evacuation to the tank.

^[8] Clear Adhesive and Sealant.

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The toilet model chosen will be the Thetford C403L. It is a cassette toilet, which incorporates its own bench and waste cassette. It does not have its own water tank, so it must be connected to the caravan's water supply.


CHEMICAL WC		
Brand	THETFORD	
Model	C403-L - Left (C400 Series)	
Reference	51679SP	
Homologation	yes	
Dimensions 512 x 670 x 400mm		

Table 49. Chemical toilet characteristics table ("www.thetford-europe.com").

The water discharge is done thanks to an electronic button, therefore, it will also have to be connected to the camper's electricity supply. An advanced level indicator screen shows waste tank levels.

The shower set made of ABS with chrome finish to attach to the water tap. The connection is female and will include the bracket and screws for installation.


SHOWER		
Brand	IDROSPANIA	
Model	White 120 cm.	

Table 50. Shower characteristics table ("idrospania.es").

8.4.11 KITCHEN FURNITURE

Longitudinally on the front left side of the area intended for loading, a table furniture is incorporated with a kitchen with two stoves, sink, drawers, cabinets and lower cavities where a refrigerator, and an oven. It will also located the tank of clean water and the gas installation.

The piece of furniture, with dimensions of 1566 x 509 x 850mm and manufactured with

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the indicated wooden board, is fixed to the floor and to the side of the monocoque by means of metal brackets of 70 x 700mm and M6 screws type DIN 7505B.

When it matches the left rear wheel, it will be fit.

Its elements are:

KITCHEN	
Brand	Dometic
Model	HSG 2370 L
Operation	Gas
Homologation	yes
Two-burner hob and sink with glass cover, 900 x 370 x 152mm	




Table 51. Kitchen characteristics table ("www.dometic.com").

OVEN	
Brand	Dometic
Model	OG 2000
Operation	Gas
Certificates: CE	yes
Integrated gas oven. Oven volume: 20L. 310 x 530 x 410mm. Net weight: 13.2 kg. Input voltage (DC): 12V. Nominal input current: 12A. Kitchen gas consumption: 87.00 g/h. Grill gas consumption: 116.00 g/h.	




Table 52. Oven characteristics ("www.dometic.com").

FAUCET	
Brand	Dometic
Model	Tap AC 539
Reference	9102300076
Chrome faucet with single lever. Maximum water pressure: 1,5 bar.	




Table 53. Faucet characteristics ("www.dometic.com").

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Located inside a furniture receptacle that will prevent it from moving freely. The refrigerator is fixed to the internal faces of the same.


REFRIGERATOR	
Brand	Dometic
Model	Dometic CFF 45
Certificates: CE	yes
<ul style="list-style-type: none"> - Compressor powered at 12/24 V DC and 100-240V AC - Cooling technology: Compressor - Type of insulation: Polyurethane - Fridge or freezer function - Useful capacity 38 L - Gross volume 44 L - Internal height 1.5 L bottles - Input voltage (AC; [V] 100-240 V - Input voltage (DC) 12/24 V - Input frequency 50/60 Hz - Average energy consumption in AC (EN62552) 0.23 kWh / 24h - EU energy classification (1060/2010 / EC) A + - Climate class (EN62552) N/T - External measures 59x39.8x47.5 cm approx. - Weight 18.6 Kg approx. 	
	

Table 54. Refrigerator characteristics (“www.dometic.com”).

The drawers and cupboards will incorporate guides for the opening of 500mm and a safety closing system so that they do not open while driving.


SECURITY CLOSURES	
Brand	Reimo
Model	Türschloss 55x59mm Matt Chrom Türstärke 12-18mm
Certificats: CE	yes
36x59mm.	
	

Table 55. Safety closure characteristics (“www.reimo.com”).

8.4.12 FOLDING TABLE

The furniture described above will also incorporate a folding table that will be located between the front seats and the two-seater seat. This will be arranged in its functional position (extended, forming a table) when the vehicle is parked and folded when not. The table is fixed on one side of the kitchen furniture, to the guide that will allow it to be moved longitudinally. The joints will be stainless steel.

The dimensions are 1040 x 530mm.

8.4.13 LIGHTNING

An extension of the interior light installation that was already incorporated in the original vehicle is carried out, installing several additional points distributed throughout the living space; all with 12V/1.4W LED lamps.


IL·LUMINACIÓ (x6u)	
Brand	Dometic
Model	L100RM
Certificates: CE	yes
Voltage: 12V DC. Input current: 1,4W. Dimensions: Ø 53mm x 22mm.	
	

Table 56. LED lights characteristics (“www.dometic.com”).

8.4.14 LOWER FURNITURE DOUBLE SEAT

After incorporating the safety structure for the double seats, a piece of furniture will be built with two drawers guided by 2 double guides. Giving the structure a finished look and at the same time taking advantage of the lower space for storage.

The piece of furniture will in no way harm the safety of the passengers, fixing it to the structure without altering it and rounding the protruding corners.

8.4.15 TRUNK

A piece of furniture will be built that separates the back of the vehicle delimited on one side by the side and on the other by the toilet room in two heights.

Bicycles will be placed below, if applicable, and suitcases and luggage above.

8.4.16 CUPBOARD

A high cupboard with two shelves closed by two doors with a security closing system will be built, fastened by means of planks to the wall above the kitchen furniture.

8.4.17 INTERNAL FIXATION SYSTEM FOR BICYCLES

Two rails identical to those of the seats will be included in the place indicated in the rear area of the passenger compartment, corresponding to the storage area, where a bicycle fixing system will be fixed.

INTERNAL FIXING SYSTEM FOR BICYCLES (x2u)	
Brand	EASY IN
Model	Portabicicletes per a Maletor
Certificates: CE	yes
Portable bicycle front fork support fixed clamp quick release. 165x59x40mm.	

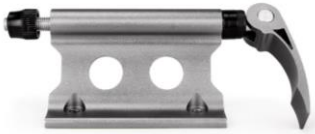


Table 57. Bicycle fixing characteristics (“www.easyin.shop”).

8.4.18 FINISHED

In the finishing phase of the work, the surface is polished, doors and drawers are adjusted, protective paints and varnishes are applied to the wooden elements, and all possible edges are removed cutting elements of the furniture, by polishing or mounting protective mouldings.

With regard to the finishes of the elements located inside the vehicle, it will be verified that all the corners and edges thereof have a radius of curvature greater than 5 mm.

9. STATE OF ART

In this section, a search for interior designs and the different options and possibilities currently available on the market based on project requirements is made.

Each camperization is different and personalized, and depends on each user. Because of this, a large number of different camper projects can be made for the same size and same model of van.

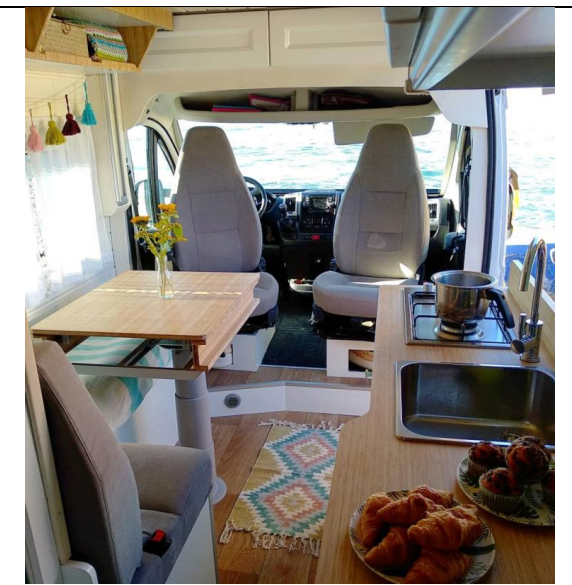
First, a search is made for "handmade" designs, they do not necessarily correspond to medium-sized vans which are, as already mentioned, the ones chosen in the present project. The following images are only descriptive in order to be able to observe different options and possibilities that can be adopted in the final solution of the project.

Various custom designs (handcrafted)



Interior Design Of A Camper Van

Joaquim Samsó Cuevas



Interior Design Of A Camper Van Joaquim Samsó Cuevas



Figure 15. Personalized interior designs.

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Next, a specific search for interior designs of medium-sized vans, which is the subject of this work, is carried out.

Several of the most significant designs marketed by the **Cultura Camper** company for medium vans are studied.

Volkswagen T6 with retractable roof



Equipment:

- Atlas Camper retractable roof
- Planar 2D stationary heating
- Scopema driver and co-pilot rotating bases
- Bed seat

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

- Refrigerator integrated in the furniture
- Clean water tanks 57L
- Waste water tank 27L
- Large capacity rear storage
- External socket 220 with battery charger
- 350W domestic inverter
- Solar panel 150w with MPPT 20A regulator
- CBE switchboard LED lighting divided into two environments
- Auxiliary battery Veclhine 115Ah

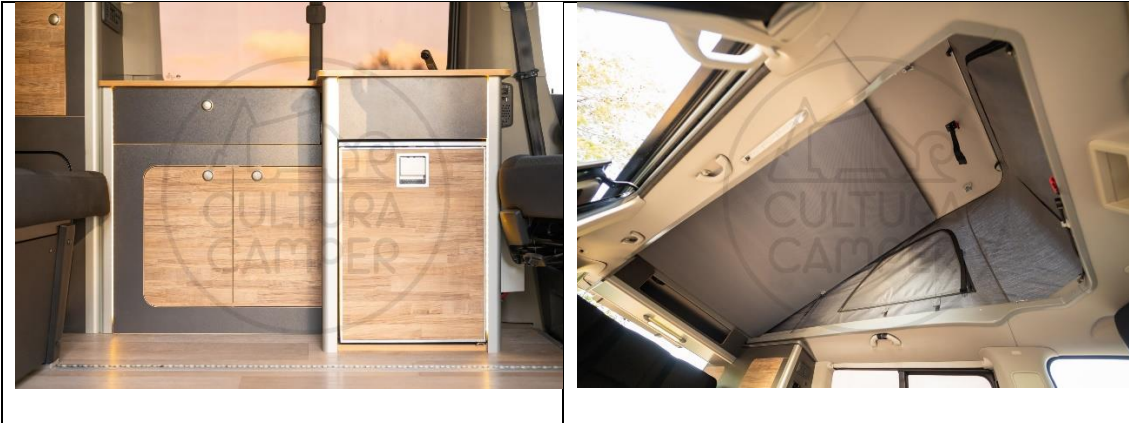
Figure 16. Volkswagen T6 design (“www.culturacamper.com”).

Volkswagen Caravelle T6



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Joaquim Samsó Cuevas



Equipment:

- Atlas Camper retractable roof
- Planar 2D stationary heating
- Scopema driver and co-pilot rotating bases
- Bed seat
- Refrigerator integrated in the furniture
- Clean water tanks 57L
- Waste water tank 27L
- Large capacity rear storage
- Fiamma F45 awning with guide
- 350W dometic inverter
- 150W solar panel with MPPT 20a regulator
- CBE switchboard LED lighting divided into two environments
- Auxiliary battery Veclhine 115Ah

Figure 17. Volkswagen T6 Caravelle desing (“www.culturacamper.com”).

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Citroën jumper L1H1



Equipment:

- Sink and two interior stoves
- Indoor and outdoor shower
- Stationary heating
- Compressor fridge
- Solar panel
- 90L clean water tank
- Waste water tank 45L

Figure 18. Citroën Jumper design (“www.culturacamper.com”).

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Ford transit Custom



Equipment:

- Auxiliary battery
- 12V electrical installation
- Stationary heating
- Solar system 150W
- 32L compressor fridge
- Two large storage trunks
- Clean and dirty water system
- Outdoor shower

Figure 19. Ford Transit Custom design (“www.culturacamper.com”).

Interior Design Of A Camper Van

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VW Caravelle T6



Equipment:

- Auxiliary battery
- 12V electrical installation
- Solar system 150W
- Compressor fridge 49L
- Two large storage trunks
- Clean and dirty water system
- Outdoor shower
- Specific internal anchorage for bicycles

Figure 20. Volkswagen T6 Caravelle design _2 ("www.culturacamper.com").

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Ford Transit Custom



Equipment:

- Auxiliary battery
- 12V electrical installation
- Stationary heating
- Solar system 150W
- 32L compressor fridge
- Two large storage trunks
- Clean and dirty water system
- Outdoor shower
- Fiamma F45 awning with guide

Figure 21. Ford Transit Custom design_2 ("www.culturacamper.com").

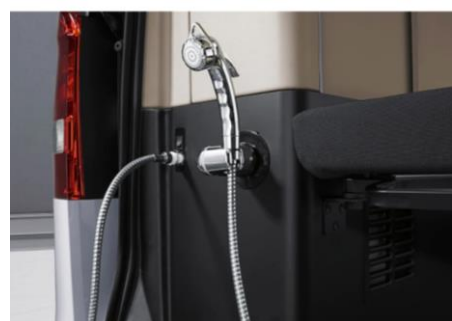
Interior Design Of A Camper Van

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Finally, research is done on the designs marketed as series by the vehicle brands.

The equipment is as described by the manufacturers:

Mercedes Marco Polo



Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Equipment:

- Raised roof with roof bed
- Wardrobe module with kitchen and table
- Floor covering in yacht floor effect
- Additional hot air heating with independent heating function
- 38L potable water tank
- 40L waste water tank
- Camping table and 2 chairs
- 2-seat bench as a comfort bunk
- External shower
- Kitchen

Figure 22. Mercedes Marco Polo (“www.mercedes-benz.es”).

Volkswagen California Ocean



Interior Design Of A Camper Van

Joaquim Samsó Cuevas



Equipment:

- Wardrobes
- Swivel seat, with lumbar support, in the 1st row of seats (no height adjustment)
- 2-seater bench/camper bed movable and folding for 2-seater bed, in the 3rd row of seats
- Roof bed (approx. 2000 x 1200mm)
- Indoor and outdoor camping table (in the sliding door) and 2 folding chairs (in the back door)
- Compressor refrigerator "Waeco" 42L
- Bed extension with mattress (Beach: bed extension incl. two storage compartments)
- Openable storage net to climb onto the roof bed, 2nd bench drawer instead of long cargo hatch.
- 2 additional batteries, maintenance free (1 additional battery with separator relay)
- 2 12 volt sockets on the instrument panel
- 2 USB interfaces (type C) on the instrument panel
- 420 A battery (75 Ah)

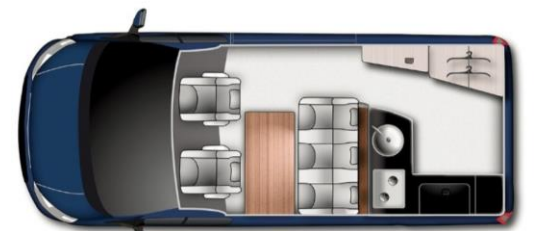
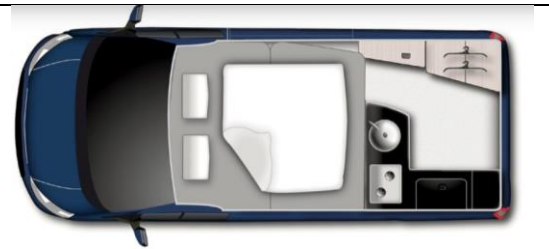
Interior Design Of A Camper Van

Joaquim Samsó Cuevas

- Independent heating for cabin cond. and charging area with remote control and heater. i add fuel driven
- 12V service voltage and 230V socket in the frame of the driver's seat.
- 230V socket with charging function for vehicle batteries and 230V socket in the passenger compartment

Figure 23. Volkswagen Californi Ocean (“www.volkswagen-comerciales.es”).

Ford Nugget



Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Equipment:

- Programmable stationary heating
- Raised roof with double bed
- Double bed seat with large capacity trunk
- External input of 220V
- Compressor refrigerator
- Two burner kitchen
- Sink
- Very spacious wardrobes.
- Outdoor shower

Figure 24. Ford Nugget (“www.ford.es”).

Ford Nugget Plus



Interior Design Of A Camper Van

Joaquim Samsó Cuevas



Equipment:

- Programmable stationary heating
- Raised roof with double bed
- Double bed seat with large capacity trunk
- External input of 220V
- Compressor refrigerator
- Two-burner propane gas stove
- Very spacious wardrobes.
- Outdoor shower
- Chemical toilet

Figure 25. Ford Nugget Plus (“www.ford.es”).

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Ratings:

Having carried out the camperization study for different models of medium-sized vans, both for companies dedicated to the sector and for the vehicle brands themselves, a series of similarities and similar patterns of design, distribution of elements and rooms can be seen:

- The bedroom is located at the back of the van, oriented along the passenger compartment.
- The kitchen is located to one side, usually that of the pilot's seat, but there are also designs where it is located on the side of the door or in the rear area.
- The dining room, next to the approved seats for travel, is located on the side front left of the passenger compartment.
- Very few designs have a WC and an indoor shower.
- The pilot and co-pilot seats usually have a swivel base so they can be used in the dining room.
- The homologated rear seats can be converted into beds for an additional sleeping place.
- In terms of storage, the trunk is the main space, located under the bedroom. To this are added different wardrobes located, mainly, above the dining room and kitchen, and drawers located in the kitchen.

The features described above are the most significant of the camper projects on the market.

As is logical, sometimes they differ from each other, and more significantly as increase or decrease van size. But in general, in a big way most appreciate a clear main line of design with very similar solutions.

10. DESIGN OF THE SOLUTION

This section corresponds to the objective of the work itself, which defines the "creation of a modular interior design that satisfies as many of the aforementioned needs as possible.

Once the different camperizations existing in the current market have been studied, the objective is to create a design that can respond and cover a greater number of needs than existing solutions.

The conclusions obtained in the previous point "State of the art" show a common design line for most camper projects. This design solution correctly responds to the need of users to travel to their own habitable cell with practically everything necessary to develop their stay in it.

However, it has been found that there is no medium van model that incorporates something as basic as an indoor shower, along with a toilet. There are also virtually none that incorporate any indoor bike transport system.

Therefore, it can be seen that there is no design on the market that satisfies all the basic needs, as well as the more specific ones already described.

Main features of the new camping design:

- Modular: modular equipment, each module will have its function.
- Versatile: same camping system, different needs to cover.
- Optimum: maximum use of the elements and the available space, using only what is necessary.

For this reason, this work will propose a camper design that contemplates the following requirements already mentioned in the "Study of user needs" section.

Interior Design Of A Camper Van
Joaquim Samsó Cuevas

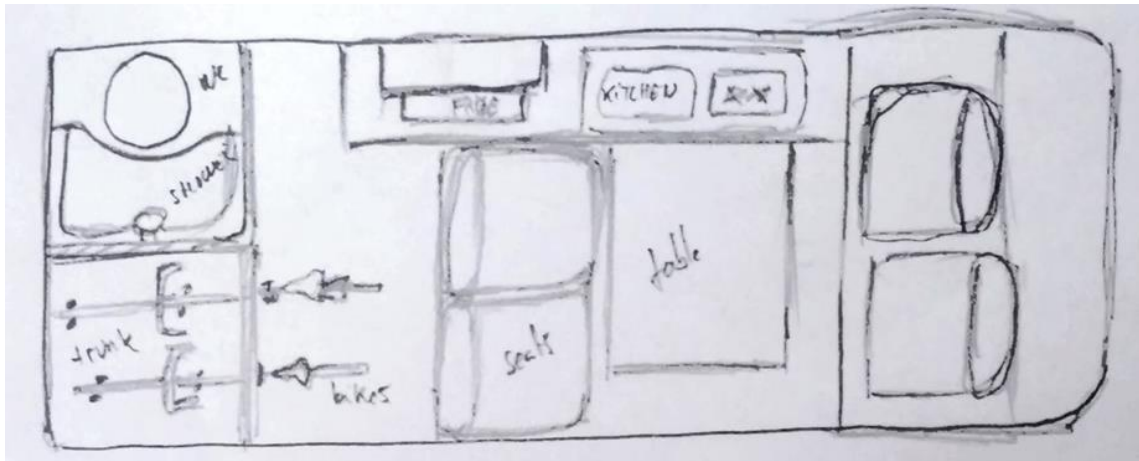


Figure 26. Sketch 1.

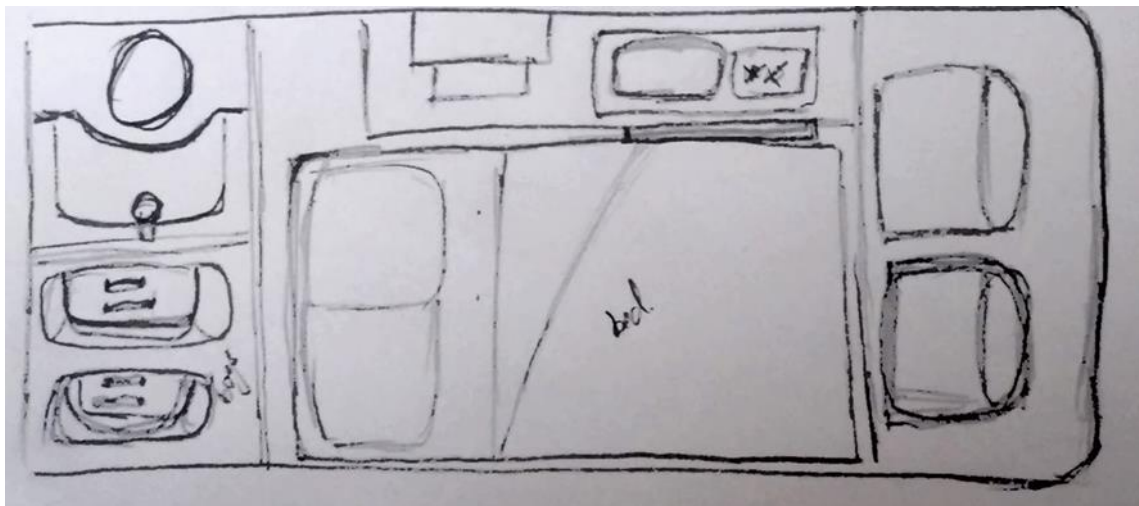


Figure 27. Sketch 2.

10.1 CONCEPTION AND DISTRIBUTION OF THE SPACE

Possible distributions:

Sketch 1: Layout with the WC/shower at the front and the bed at the back.

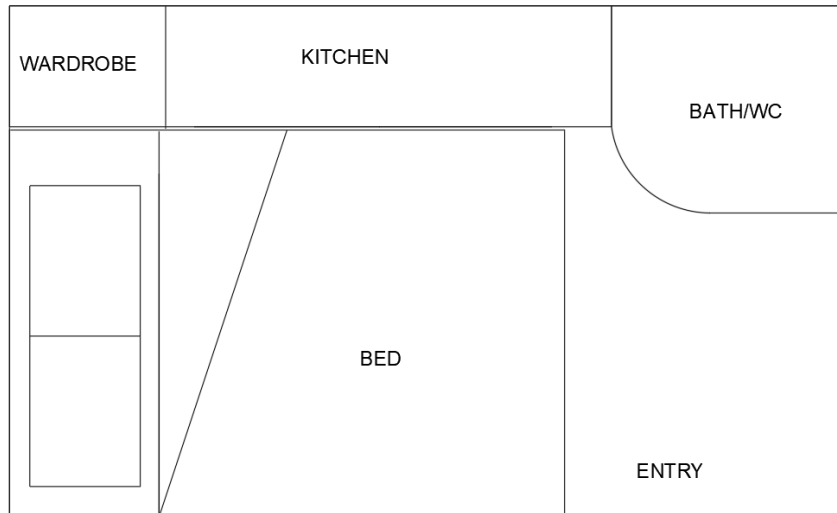


Figure 28. Distribution 1.

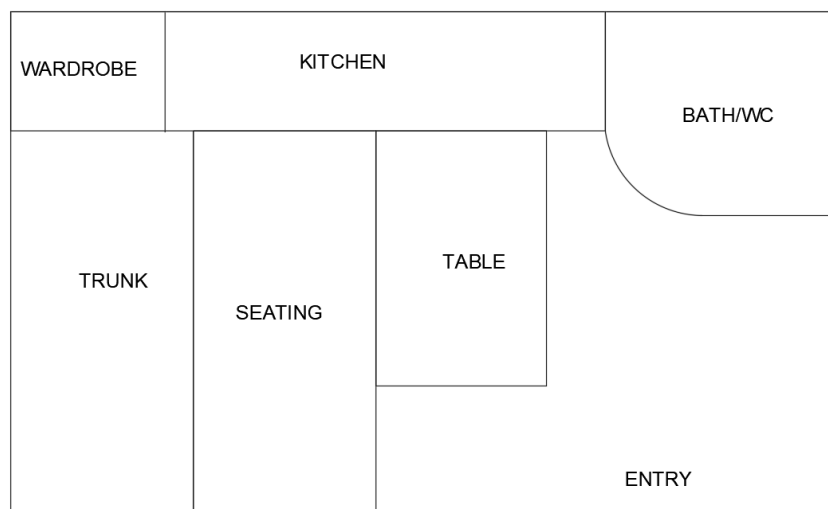


Figure 29. Distribution 1_2.

With this distribution we have accessibility to the toilet from the inside. However, we will lose useful dining/living room space, the two front seats cannot be used as they are far from the table.

We also don't have a clear space to fix the bikes since the free space is right in front of the entrance. In addition, the height of the trunk is lost, you can only have objects stored under the bed.

Interior Design Of A Camper Van

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Sketch 2: Layout with the WC/shower at the back and the bed at the front.

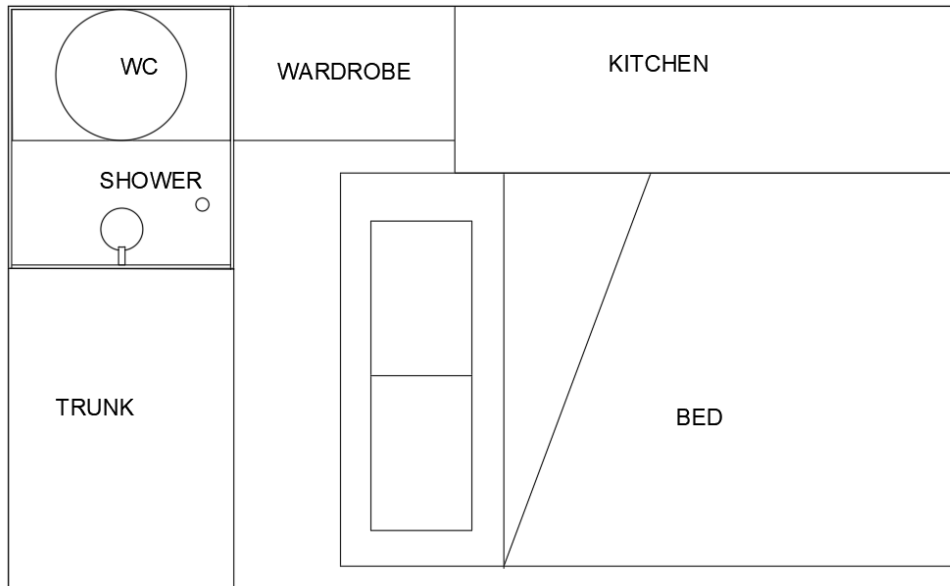


Figure 30. Distribution 2.

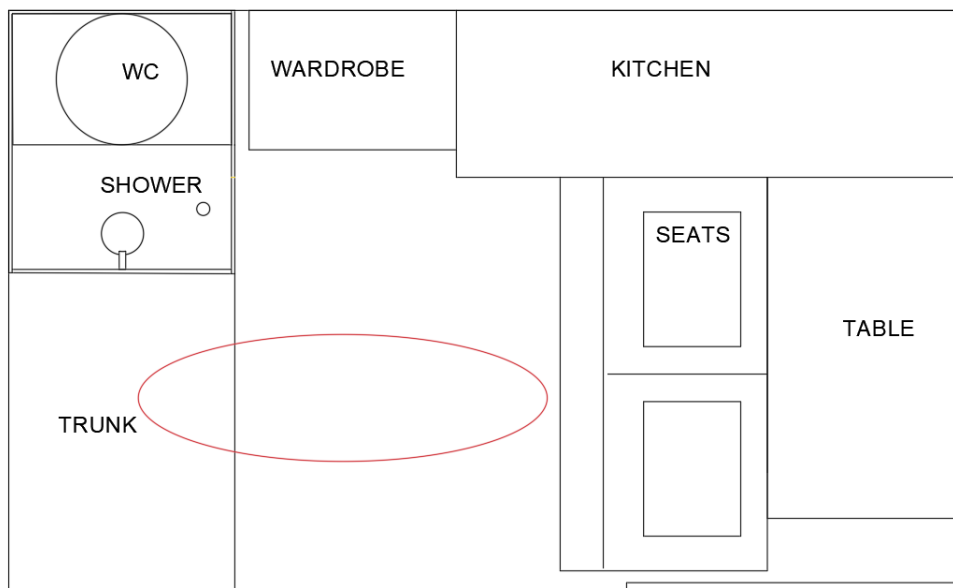


Figure 31. Distribution 2_2.

In this arrangement, with the seats placed as far as possible in the front, we gain a lot of trunk space, enough to accommodate two bicycles. On the contrary, the seats block the way for circulation inside the passenger compartment, leaving only the option of accessing the toilet with the seats folded down in bed position and crawling over it.

Considering the two distribution proposals, each with its pros and cons, the second option is chosen since it is considered to be the one that best meets the requirements.

Interior Design Of A Camper Van

Joaquim Samsó Cuevas

Design limiting conditions.

- The minimum dimensions of a garage space are 4.50 meters long, 2.20 meters wide and 2 meters high.

The standard ones are usually 5 meters long, 2.30 wide and 2m high, therefore, exceeding these dimensions, the van does not guarantee that we will be able to enter all the car parks.

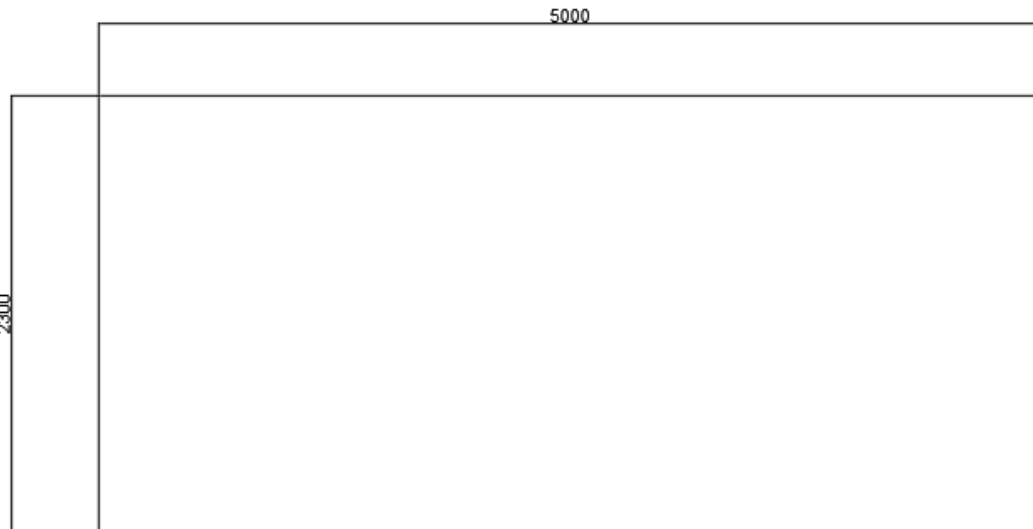


Figure 32. Limiting dimensions.

As a reference to choose the appropriate van model, we are guided by the most restrictive interior dimensions that we cannot lower.

Longitudinal.

To establish this measure, take into account:

To have a bed inside (without taking into account the retractable roof) we will consider a longitudinal dimension of 1.90m. The toilet will be added to this. The Thetford toilet has a length of 0.670m. To this, we add the 22mm x 2 width of the guides for the bulkhead.

Therefore, we will be guided by a longitudinal dimension of interior cargo space of:

$$1.90 + 0.670 + (0.022 \times 2) = 2.614\text{m.}$$

Interior Design Of A Camper Van

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If, in addition, we want to have the capacity to store two bicycles, we will have to have an empty space of additional length. Considering the length of a bicycle without the front wheel, we need 1.3m of space between the back of the folded bed and the trunk door.

Therefore, we should work with a longitudinal load space dimension of:

$$1.9\text{m} + 1.3\text{m} = 3.2\text{m}.$$



Figure 33. Fork-end rear wheel dimension (“www.canyon.com”).

Therefore, we can no longer work with this quota as we would not comply with the dimensional restrictions set by a medium van and we would have to adopt a large volume van.

However, if you do not sleep in the lower bed when transporting bicycles and do not fold down the seats, then it is possible to transport bicycles.

Transversal

The minimum width dimensions for a bed for two people are 1.2m. If we also want to have kitchen furniture, with the oven model chosen as an element requiring more depth, we will need 410mm minimum depth of furniture, in to which we will add the 9mm thickness of the wooden panel at the bottom of the furniture. In addition, the insulation thickness of the two walls (20mm x 2) and the thickness of the 4mm x 2 panels are taken into account.

Therefore, we will have an interior width dimension of the cargo compartment of the van of:

$$1.2 + 0.41 + 0.009 + (0.02 \times 2) + (0.004 \times 2) = 1.667\text{m}.$$

10.2 CHOSEN VAN JUSTIFICATION

The range of dimensions available to choose a model is:

Longitudinal: inside: >2,614mm, outside: <5000mm.

Transversal: inside: >1,667mm, outside: <2300mm.

Outside height: <2000mm.

A filter/discard is made using the following tables:

Model	Large (mm)	Height (mm)	Wide (mm)	Interior large (mm)	Interior height (mm)	Interior wide (mm)
Citroën Jumpy Talla M	4.959	1.940	1.920	2.512	1.397	1.636
Citroën Jumpy Talla XL	5.309	1.940	1.920	2.862	1.397	1.636
Fiat Scudo Furgón M	4.610	1.890	-	-	1.390	-
Fiat Scudo Furgón L	4.960	1.890	-	-	1.390	-
Fiat Scudo Furgón XL	5.310	1.940	-	-	1.390	-
Ford Transit L1H1 Van	4.973	1.925	2.272	2.554	1.406	1.775
Ford Transit L1H1 Van Doble	4.973	1.925	2.272	2.554	1.406	1.775
Ford Transit L1H1 Mixta	4.973	2.060	2.272	2.554	1.382	1.775
Ford Transit L1H1 Kombi	4.973	2.060	2.272	2.554	1.382	1.775
Ford Transit L2H1 Van	5.340	1922	2.272	2.921	1.406	1.775
Ford Transit L2H1 Van Doble	5.340	2039	2.272	2.921	1.406	1.775
Ford Transit L2H1 Mixta	5.340	1.922	2.272	2.921	1.382	1.382
Ford Transit L2H1 Kombi	5.340	2.039	2.272	2.921	1.382	1.382
Mercedes Vito Compacta	4.895	1.910	2060	2.586	1.391	1.685
Mercedes Vito Larga	5.140	1.906	2060	2.831	1.392	1.685
Mercedes Vito Extra Larga	5.370	1.907	2060	3.061	1.391	1.685
Opel Vivaro Standard	4782	1890	1904	2400	1268	1668
Opel Vivaro Largo	5182	1958	1904	2800	1387	1690
Peugeot Expert Compact	4606	1890	2204	3320	1390	1620
Peugeot Expert Standard	4956	1890	2204	3670	1390	1620
Peugeot Expert Long	5308	1890	2204	4020	1390	1620
Renault Trafic Furgon Compact	5080	1971	2283	3750	1387	1268

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Renault Trafic Furgon Large	5480	1971	2283	4150	1387	1268
Toyota Proace Verso Compact	4609	1890	1920	2925	1385	1610
Toyota Proace Verso Standard	4959	1890	1920	3275	1385	1610
Toyota Proace Verso Large	5309	1890	1920	3275	1385	1610
Volkswagen Transporter Furgon Short	4904	1990	1904	2572	1410	1700
Volkswagen Transporter Furgón Large	5304	1990	1904	2975	1410	1700

Table 58. Medium van dimensions.

In this first selection, it can be seen that no current model meets the required dimensions, therefore, a choice is made again by discarding the exterior longitudinal dimension, since the interior equipment prevails and this cannot be modified.

The models that comply with the new restrictions are:

Model	Large (mm)	Height (mm)	Wide (mm)	Interior large (mm)	Interior height (mm)	Interior wide (mm)
Ford Transit L2H1 Van	5.340	1922	2.272	2.921	1.406	1.775
Mercedes Vito Larga	5.140	1.906	2060	2.831	1.392	1.685
Mercedes Vito Extra Larga	5.370	1.907	2060	3.061	1.391	1.685
Opel Vivaro Largo	5182	1958	1904	2800	1387	1690
Volkswagen Transporter Furgón Large	5304	1990	1904	2975	1410	1700

Table 59. Medium van dimensions filter 1.

Finally, according to the requirement of maximum possible manoeuvrability, the model with the longest exterior length is chosen, which is the Mercedes Vito Larga.

Model	Large (mm)	Height (mm)	Wide (mm)	Interior large (mm)	Interior height (mm)	Interior wide (mm)
Mercedes Vito Large	5.140	1.906	2060	2.831	1.392	1.685

Table 60. Mercedes Vito Large.

The Mercedes Vito Large Tourer is chosen, as it is the model that already incorporates windows from the factory.

10.3 SPACE DESIGN

Interior space with bed (seats down). There is not enough trunk space for the two bikes.

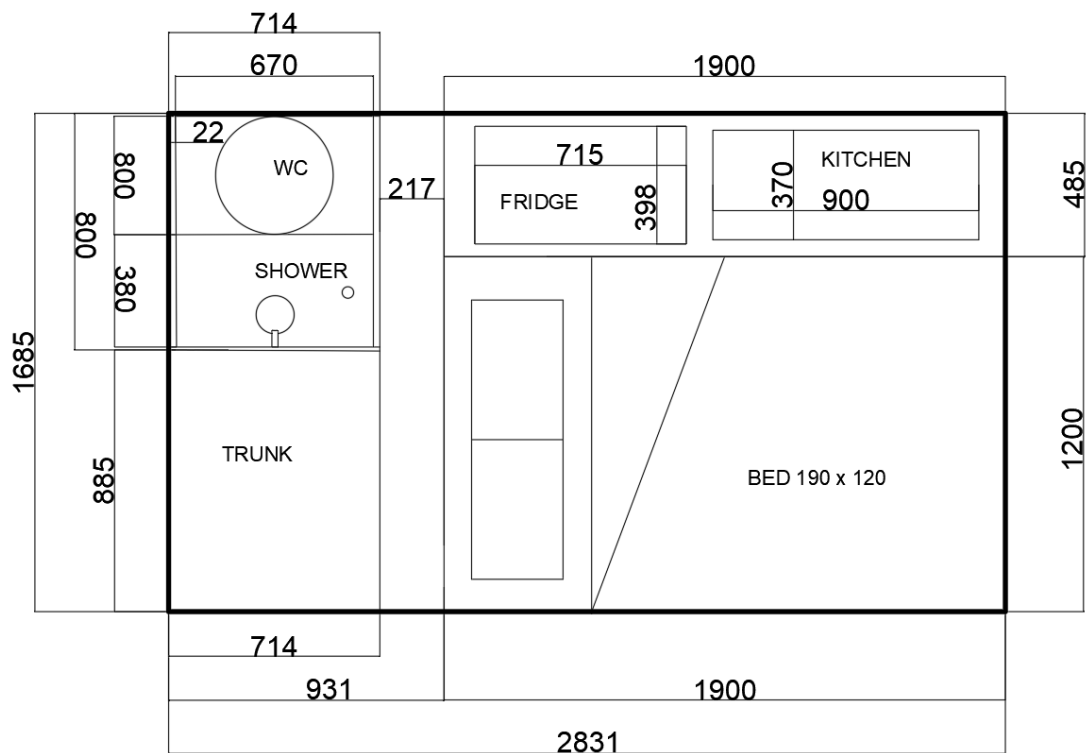


Figure 34. Solution Space design 1.

Interior space with seats and rear space, we see how it has a trunk space of 1,451mm, enough to accommodate two bicycles.

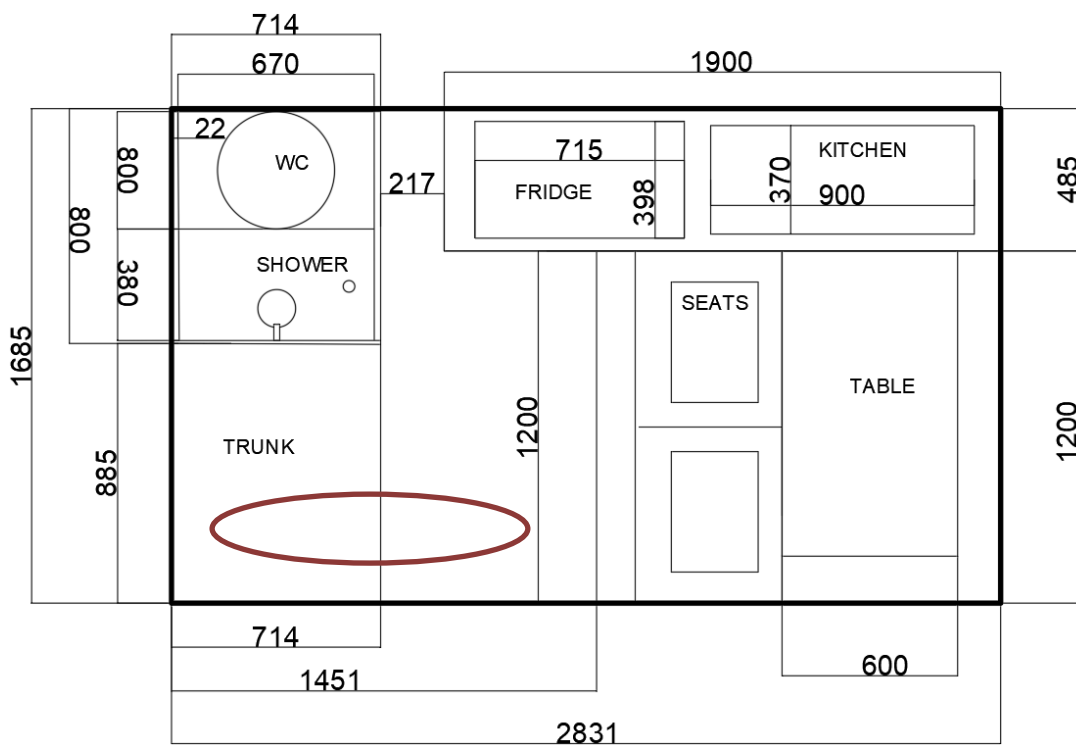


Figure 35. Solution Space design 2.

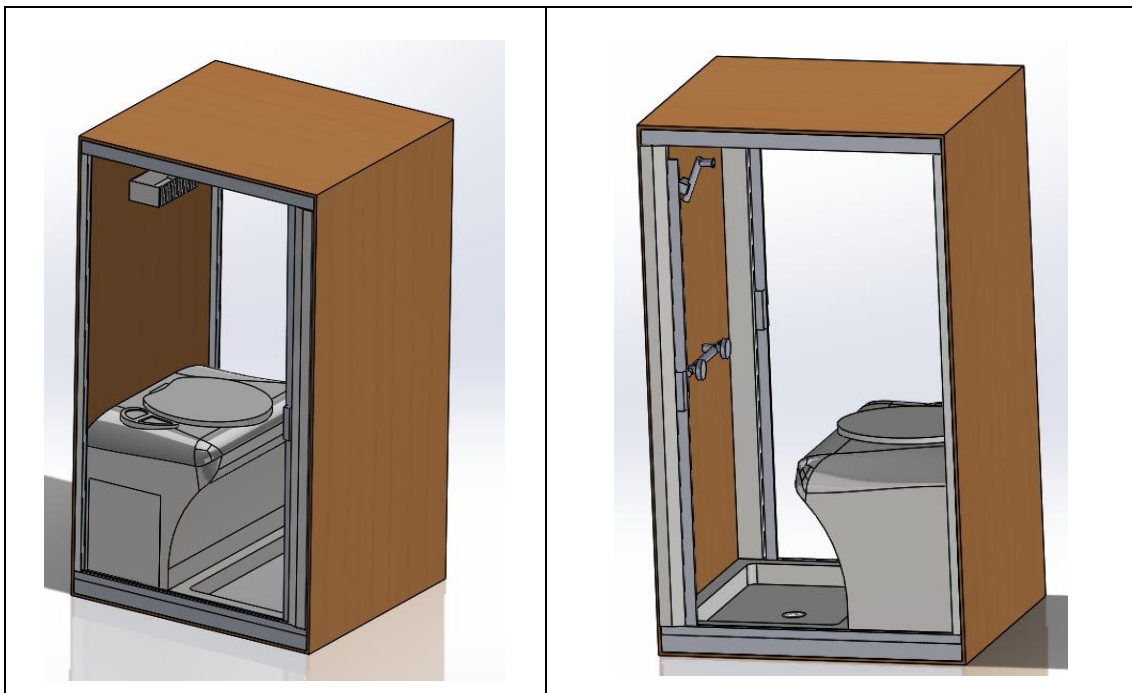
10.4 FURNITURE DESIGN

Through the 3D modeling environment of SolidWorks, the different furniture that is proposed as a solution is modeled and its corresponding materials are associated with it.

In the annexe section, the dimensional and construction drawings for each piece of furniture and element are found.

10.4.1 BATHROOM

It is a room equipped with a toilet and a shower that can be accessed both from the inside and outside of the vehicle and which is closed by means of two running screens.



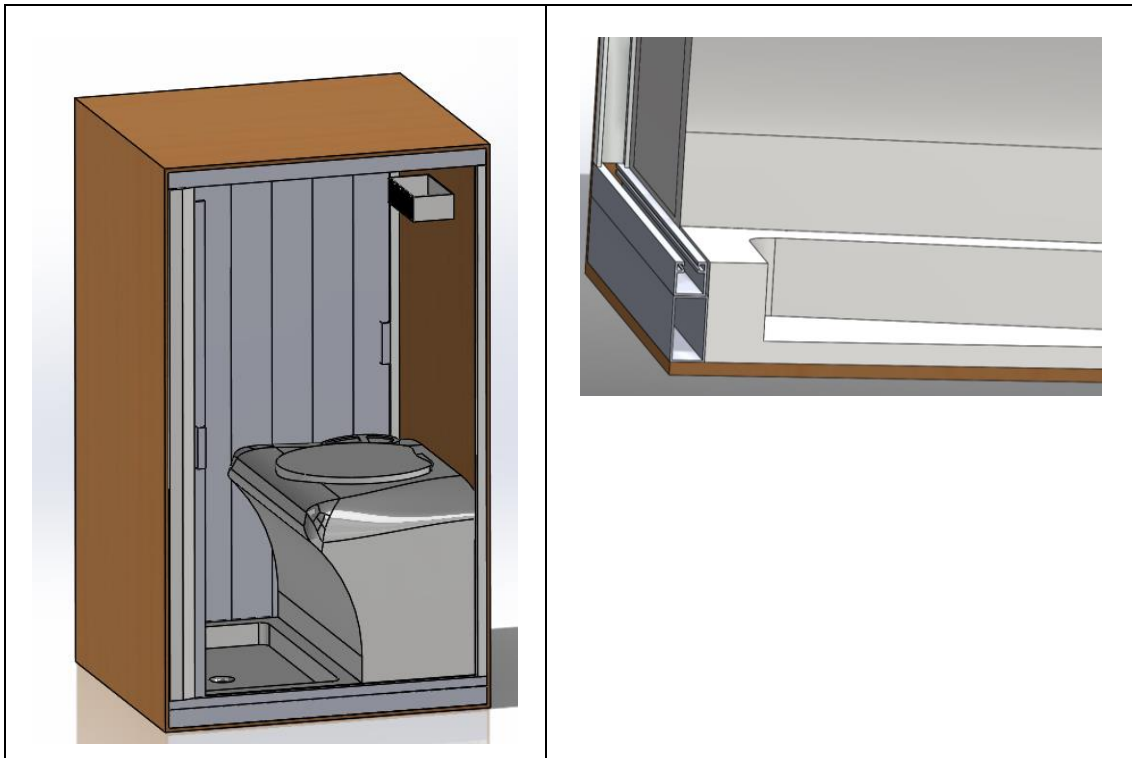
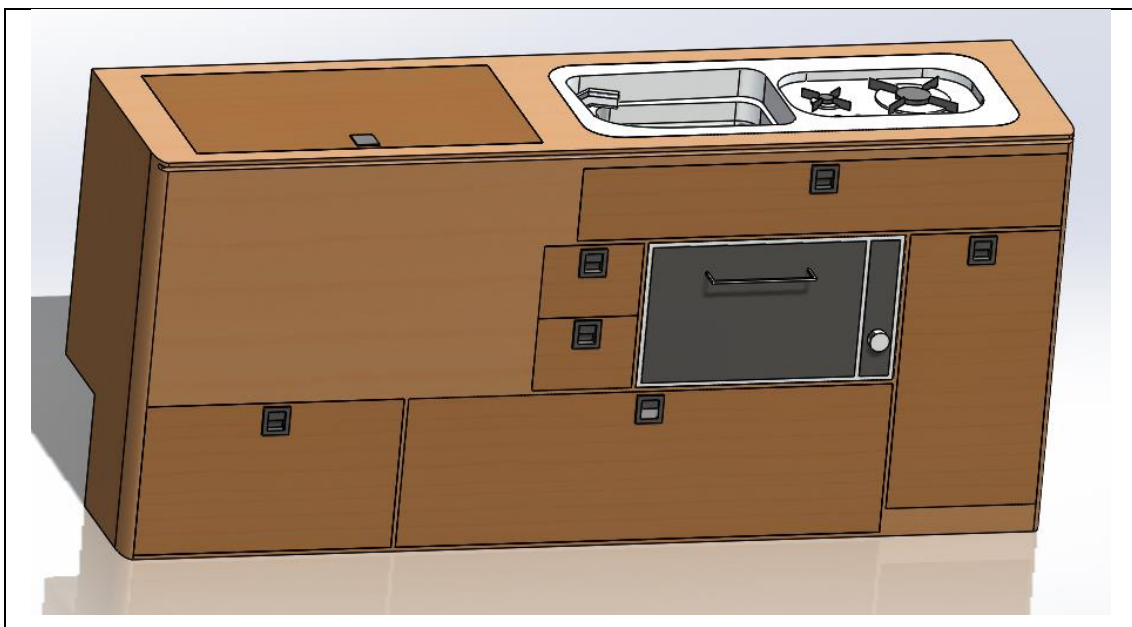


Figure 36. Bathroom design.

10.4.2 KITCHEN FURNITURE



Interior Design Of A Camper Van

Joaquim Samsó Cuevas



Figure 37. Kitchen design.

It consists of a piece of furniture that contains the kitchen, fridge, oven, cylinder and gas installation, sanitary water tank and pumping system. It also has two drawers and a compartment for storing utensils, each and every one of them with a safety lock to prevent them from opening while driving.

The gas compartment is closed with respect to the interior of the passenger compartment and opened through a grill that faces the outside. The door is 50mm above the floor of the accommodation.

10.4.3 FOLDING TABLE

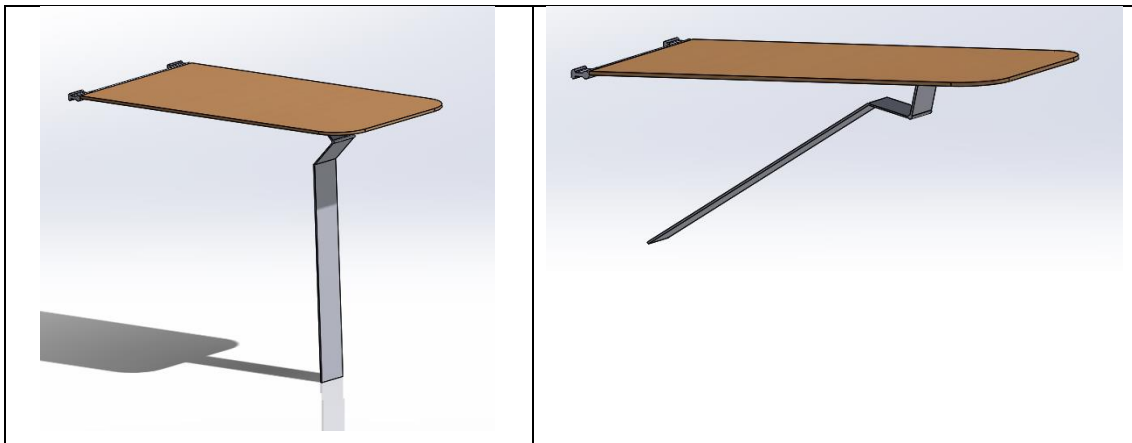


Figure 38. Folding table design.

The table can be moved longitudinally along the entire kitchen furniture by means of a guide and thanks to the articulation of the leg it is possible to fold it either to fit the inner bed or simply to have more free space.

10.4.4 LOWER FURNITURE DOUBLE SEAT

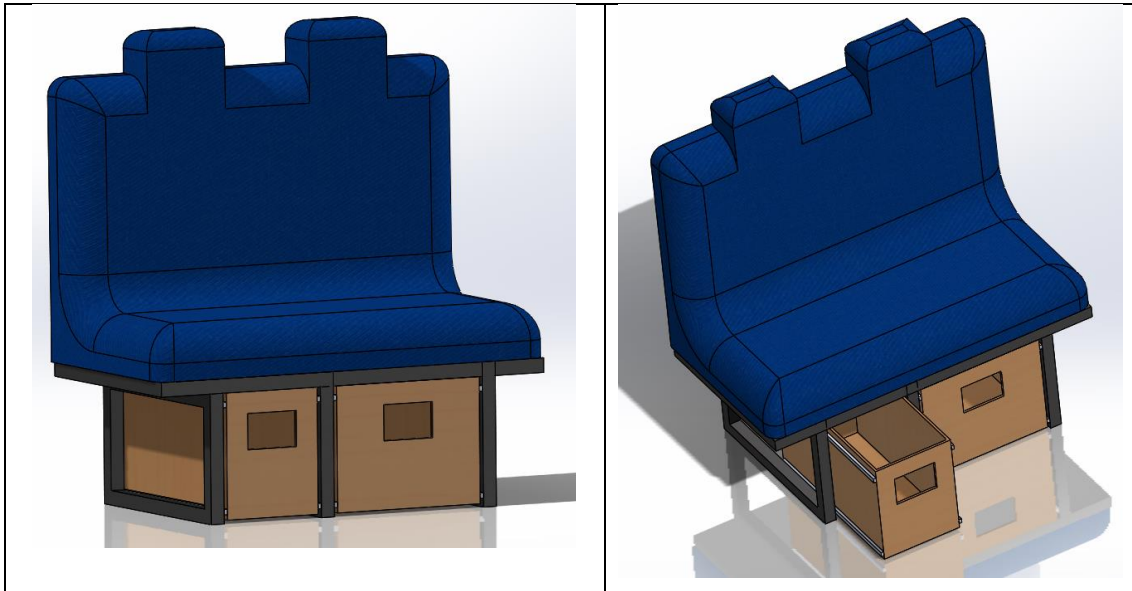


Figure 39. Lower furniture double seat design.

System of two drawers that take advantage of the standardized structure of the seats to anchor and make it possible to take advantage of the space left under them.

10.4.5 TRUNK

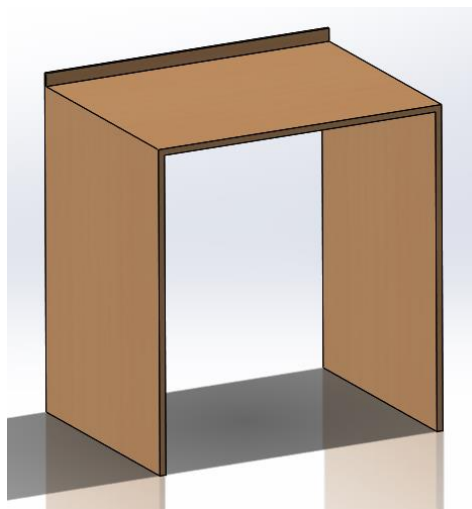


Figure 40. Trunk design.

The trunk structure divides the space into two floors. Above it is possible to place the luggage while below in addition to luggage it can be accommodate two bicycles.

10.4.6 CUPBOARD

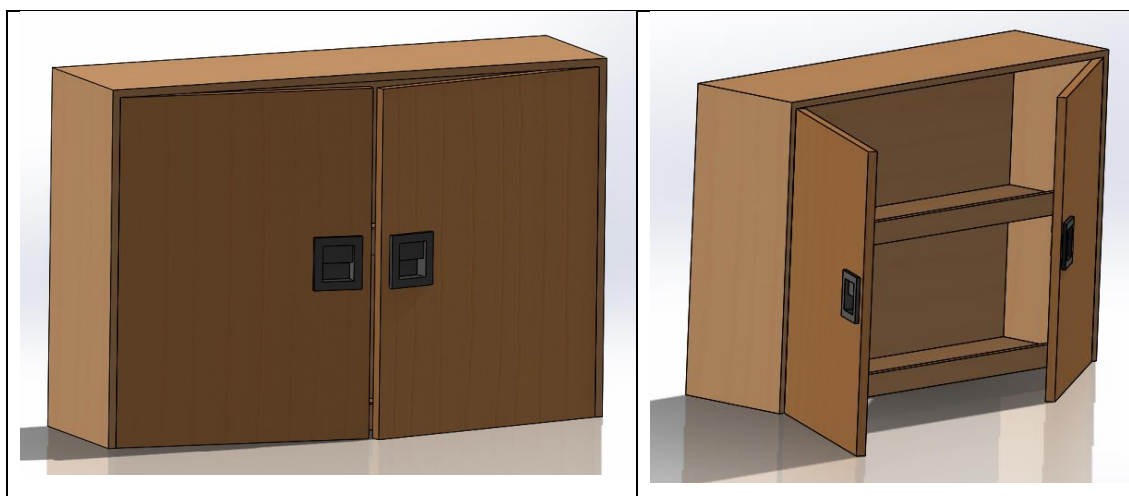


Figure 41. Cupboard design.

Cupboard that is located above the kitchen on the side of the window. It has two compartments with a bar that prevents objects from falling and two doors with safety locks.

10.5 SOLUTION

Using the SolidWorks assembly environment, the final solution is conceived. All the furniture and elements that make up the camperization project are assembled and properly installed in the cargo compartment of the vehicle.

In this way, the image of the final finished solution is given by some points of view:

- Folded inner bed/seats in sitting position.

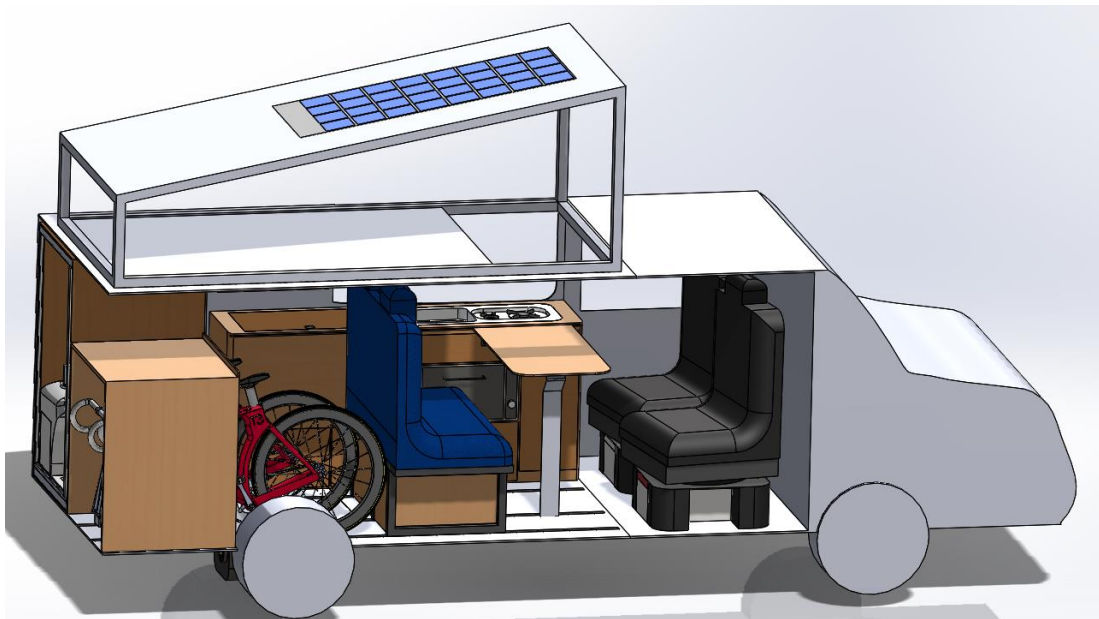


Figure 42. Solution view 1.

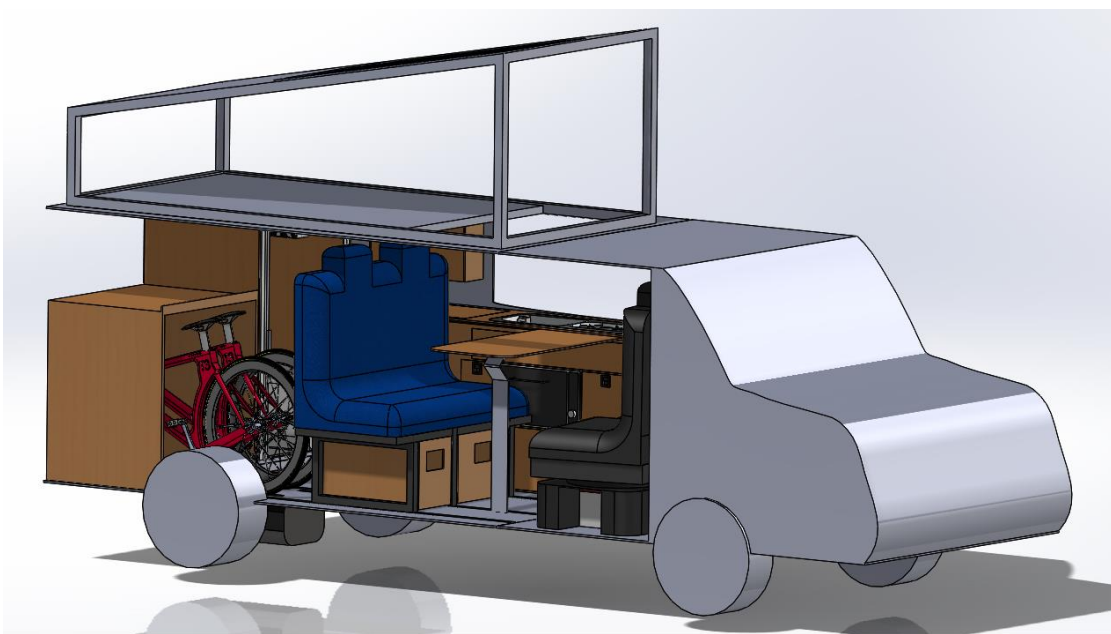


Figure 43. Solution view 2.

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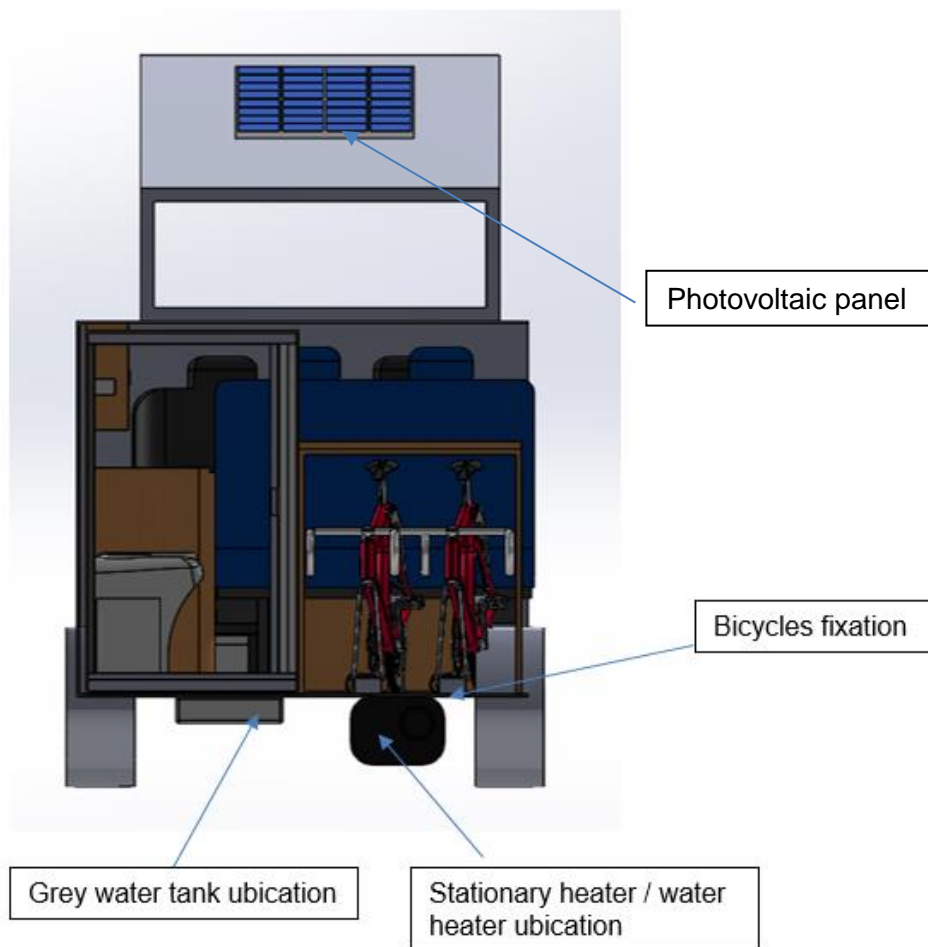


Figure 44. Solution view 3.

- Inner bed unfolded/seats down:

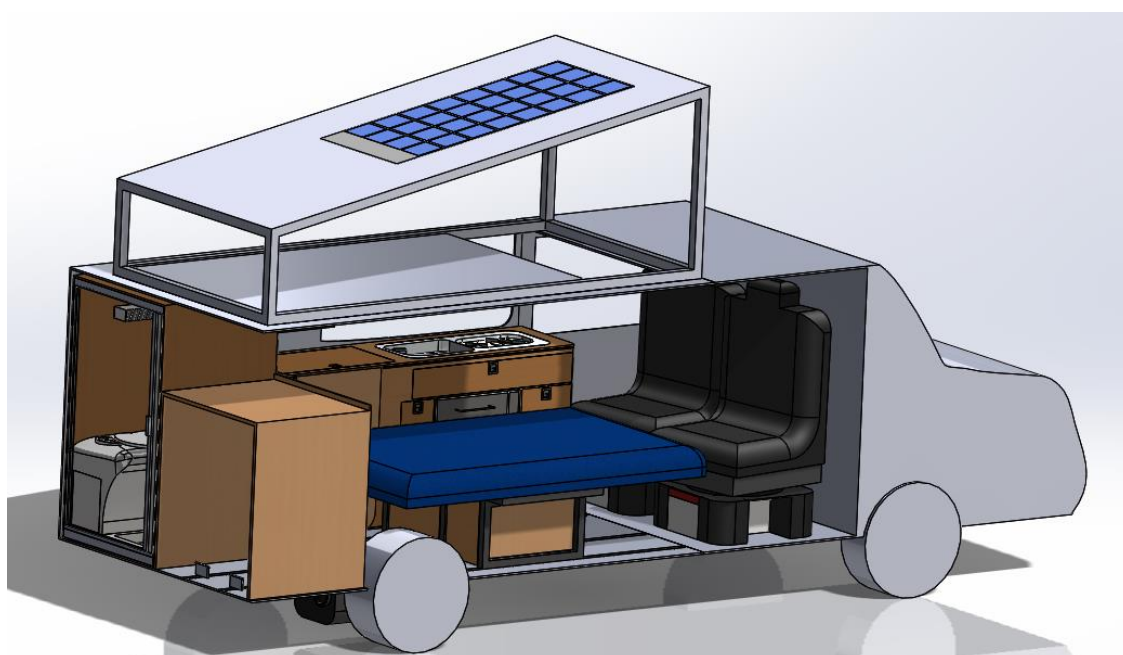


Figure 45. Solution view 4.

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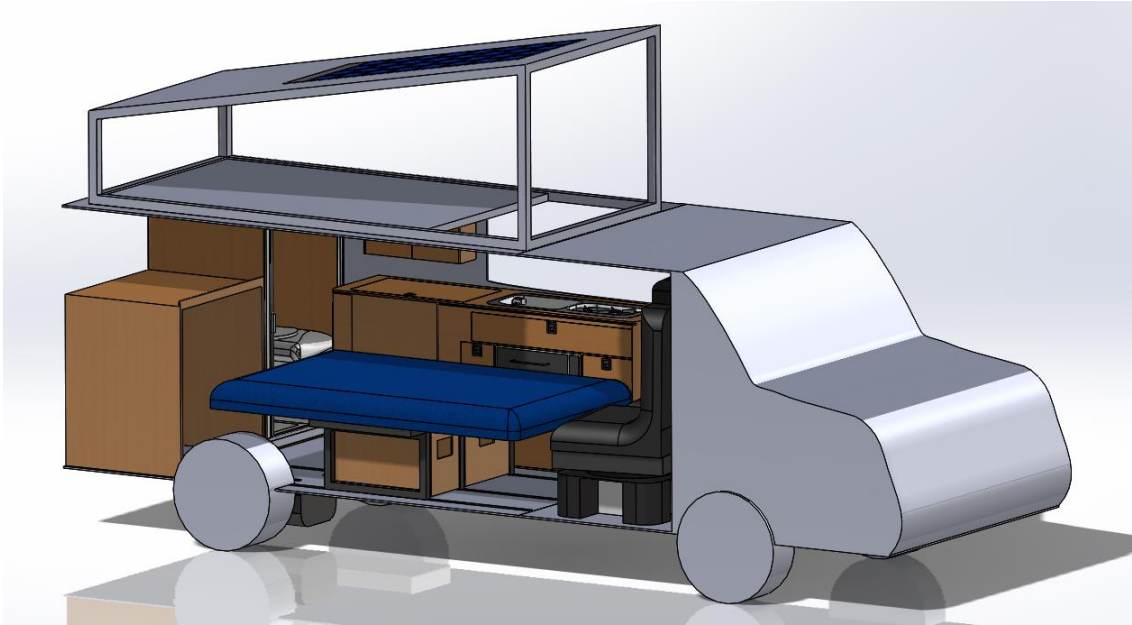


Figure 46. Solution view 5.



Figure 47. Solution view 6.

11. BUDGET AND ECONOMIC FEASIBILITY

The economic study is divided into two subsections. First of all, the budget is considered with all the expenses included regarding the realization and elaboration of the present report and study. then it is drawn up regarding the materials and elements required for the project.

Ambit	Material/Element	Price per unit./m	Units/m/m^2	TOTAL (eur)
	Mercedes Vito Large Base 114 CDI		1,00	44224,29
TRACE	Brushed spruce slat 20x10mm	1,90	25,00	47,50
	Brushed spruce slat 20x20mm	2,75	25,00	68,75
THERMAL INSULATION	Kaiflex ST 10mm	14,85	1,00	14,85
	Kaiflex ST 20mm	24,90	2,00	49,80
PANELED/FURNITURE	Birch plywood with phenolic treatment and anti-slip 9mm	58,41	6,00	350,46
	Birch plywood with 4mm phenolic treatment	54,99	14,00	769,86
	HPL poplar plywood 5mm	69,95	2,00	139,90
	Brushed spruce slat 44x22mm	4,25	8,00	34,00
	Fiberglass 482x670mm	4,92	0,32	1,59
	Waterproofing vinyl	20,50	2,00	41,00
RAISABLE CEILING	SCA long battle	3964,00	1,00	3964,00
SEATS	Scopema swivel bases	210,83	2,00	421,66
	Scopema altair 2P 120cm	2855,00	1,00	2855,00
STATIONARY HEATER	Webasto dual top evo 6	1850,00	1,00	1850,00
ELECTRIAL INSTALLATION	Tensite AGM 12V 250Ah	391,02	1,00	391,02
	Novopal 2000W	176,99	1,00	176,99
	Victron Energy Cyrix-ct	49,50	1,00	49,50
	Plusenergy wccsolar	531,00	1,00	531,00
	Victron Energy MPPT 100/20	134,00	1,00	134,00
	Schneider A9R61240	43,67	2,00	87,34
	Schneider DomA62	15,58	2,00	31,16
WATER INSTALLATION	Fiamma filler nozzle	9,00	1,00	9,00
	Gumer camper 90L	119,00	1,00	119,00
	Gadi camper 40L	78,40	1,00	78,40
	Fiamma Aqua 8	79,90	1,00	79,90
GAS INSTALLATION	Kit GLP A4	525,00	1,00	525,00
	Fepre 10x10x0,8mm	1,49	1,00	1,49
	Truma Mono control CSv30 mBar	119,52	1,00	119,52
	Truma gas key	15,90	1,00	15,90
BATHROOM	Bulkhead	267,65	2,00	535,30
	Thetford C403-L	569,00	1,00	569,00
	Idrospania 120cm	33,99	1,00	33,99
KITCHEN	Dometic HSG 2370 L	642,00	1,00	642,00
	Dometic OG 2000	1059,00	1,00	1059,00
	Dometic Tap AC 539	90,00	1,00	90,00
	Dometic CFF 45	699,00	1,00	699,00
	Reimo Türschloss 55x59mm	12,95	9,00	116,55
	Dometic L100RM	29,75	10,00	297,50
BICYCLES FIXATION	Easy in	35,55	2,00	71,10
TOTAL COST				61295,32
OTHER MATERIALS	1%			612,95
PRODUCT PRICE				61908,27

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Computer resources	Cost (eur)	Use (months)	Useful life (years)	Useful life (months)	Amortization (eur)	Total (eur)
MSI	2000	5	10	120	83,33	83,33
Solidworks Student	0	5	1	12	0,00	0,00
Autocad Student	0	5	1	12	0,00	0,00
Microsoft Office Pack Pro	580	5	6	72	40,28	40,28
TOTAL						123,61

Human resources	Preu (eur)/h	Quantity (hours)	Total (eur)
Engineering research	36	320	11520
Calculations	36	200	7200
Engineering - 3D design	36	160	5760
Engineering - drafting	36	160	5760
TOTAL		840	30240

Total cost of the project	eur
Computer resources	123,61
Human resources	30240,00
Materials/Elements	61908,27
Total	92271,88
IVA 21%	19377,10
Total (eur)	111648,98

Total cost of the product	eur
Materials/Elements	61908,27
IVA 21%	13000,74
Total (eur)	74909,01

Regarding the economic viability of the project, we take as a reference the value of the equivalent camperized model of the Mercedes brand, it is the Marco Polo model.

We are talking about a starting price for the basic model of this product of 59,585eur and it goes up to 78.648,00eur.

The cost of the project, taking into account only the product and without IVA, is 61.908,27eur.

There is a difference between the market model base price and the current project of 2323,27eur. Due this calculus are approximate, we can considerar this increase negligible.

It should be borne in mind that the item with a higher cost is the acquisition of the vehicle. In the project, has been considered the price of a first-hand vehicle, therefore, if it were

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considered to carry out the project with a second-hand vehicle, the final cost would be significantly reduced.

It is also considered that the product created is far from the 78.648,00eur that the high-end model of the brand is worth and, nevertheless, enjoys the same functionalities and satisfies all the needs that the latter satisfies and more, thanks to the added value that has been granted in terms of potential needs to which it responds.

It can be considered that the project is viable since the costs and the sale price are similar to the commercial ones.

12. ENVIROMENTAL IMPACT

Except for the insulation material, practically all of the other material used is wood from sustainable felling.

Once the useful life of the van is over, it is easy to extract the materials for recycling or even, thanks to the modular nature of the design, reuse them in another camperization project. Except for the insulation, which is difficult to remove as it is attached to the walls.

13. FUTURE CONSIDERATIONS

The design project is awaiting approval by a colegied mechanical engineer.

In terms of design, more equipment can be added, such as having a television inside.

14. CONCLUSIONS

In the present project, an interior design has been conceived both in terms of the distribution and conception of the space as well as the design of the furniture. The objective of the project was to design the interior space of a camper van based on a conventional van model, intended for the transport of goods (industrial vehicle) or mixed, that was currently on the market, readapting and conditioning it in a vehicle suitable for housing.

Based on this design of the interior space, the conception and optimization of it and the furniture design, the solution had to respond and solve the needs of the target user to which we wanted to respond, fulfilling the camperization regulations currently in force for this type of vehicle.

The current sector context, growth prospects and different types of camper and motorhome vehicle families found on the market and their current and potential customers have been analysed. From here, a series of needs have been identified, which have been answered practically in their entirety.

The target user was a young couple, who like to travel under the camper van concept, who like nature and who practice outdoor sports.

The fact of practicing outdoor sports both in the mountains and on the coast meant having to maneuver in demanding places with limited space, such as tracks and mountain roads. So, we start from this first premise when it comes to the dimensional dimensions of the vehicle.

In addition, this vehicle had to be able to allow the user to stay autonomously in natural places without "relatively" nearby human infrastructure.

Therefore, users needed to have:

- a place to sleep and rest protected from the outside elements;
- a place where they could do a minimum of indoor living in case of adverse weather conditions outside or simply, be able to stay indoors;
- be able to cook and store food;
- be able to have a shower and go to the toilet;
- be energetic self-sufficiency;

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- a comfortable temperature inside the passenger compartment.
- enough space to store luggage and material. These was the user needs to be satisfied.

A study has been carried out of the market of camper vans, of the different families grouped by their dimensions, of the different brands and of the different models, as well as of the dimensional characteristics of each one in order to find the most suitable model that better fit the design needs of this project. The model turned out to be the Mercedes Vito Large Tourer.

A search has been made for both the most suitable and best materials and elements on the market in order to give the best possible response to the requirements, without taking into account any economic aspect. The process of generic reform and camperization of the vehicle has been described by which can be extrapolated to any other vehicle project. Therefore, a pattern project has been created in order to be able to do more similar types of camping.

In the final phase of the project, a search for the current state of the art in terms of designs and conceptions of the interior space was made, and the solution was developed using the Autocad and SolidWorks software.

With the first aim of conceiving and optimizing the space, dimensional sketches of useful space available for design have been drawn up by Autocad software, as well as various possible interior distributions of the elements. Subsequently, with the 3D environment of SolidWorks, the various furniture elements have been designed and modulated, the dimensional and constructive 2D sketches of them have been extracted, and the 3D assembly of the entire final set of the solution integrated within the living room has been done.

Below is the summary table of the final state of: objectives met, not met or partially met, by the projected solution:

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OBJECTIVES	COMPLIMENT
Cabin where you can sleep and rest protected from the outside elements	
Cabin where you can do a minimum of indoor life in case of adverse external weather conditions or simply, be able to stay inside (possibility of standing up inside).	
Housing for 2/4 people	
Energy autonomy	
4 windows	
Bedroom: 2 double beds	
Kitchen	
Storage area	
Living room	
Couch for 2 persons	
Clear space connecting the front of the van to the rear door.	
Table with 4 chairs	
Bathroom with toilet and shower	
Oven	
Stationary heating	
Driving on mountain roads and forest tracks (fixed)	
Circulate through narrow streets of towns and cities	
Enter underground car parks.	

Table 61. Achieved objectives.

Finally, a budget has been drawn up on the hypothetical costs of carrying out the project, its economic viability has been studied, its environmental impact and a series of future considerations have been described, one of which and the most important is the to carry out the technical approval project of the present work by a mechanical engineer to be able to materially realize and commercialize the project.

AGREEMENTS

I want to express my deepest gratitude to all the people who have me accompanied throughout my studies at the Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú.

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Rules and laws referenced in section nº5 of the project: Regulation.

ANNEXES

- 1- Dimensional and construction drawings
- 2- Electrical installation calculation
- 3- Data sheets
- 4- Regulation and normative.