

Interior Design of a Camper Van

Joaquim Samsó Cuevas

Final Project for Graduation – Grau en Enginyeria de Disseny Industrial i Desenvolupament del Producte

Abstract

Having a camper vehicle is synonymous with traveling in complete freedom, it allows you to travel to wherever you want with all the basic needs covered.

This project develop, from the conception of the space and furniture design, an interior design of a camper van, which allows to satisfy the maximum number of needs that user may demand from this type of product.

Based on the current market, the current state of interior van designs and the materials and elements that a product like that should to locate, 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. A budget, economic feasibility and environmental impact of the final solution is also considered.

1. Introduction

A camper vehicle is a 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.

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 has, what layout and interior design should it has 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.

This report presents a linear development structure. It starts at point 2. Context where the current context of the market in Spain will be studied from an economic point of view and a search will be made of the motorhomes currently on the market in order to locate the camper vehicles.

Next, section 3. Study of user needs proceeds to analyse the different needs that the target user can ask for a product like this. At the end of this point, the choice of the chosen vehicle will be justified. In section 4. Selection of the alternatives, a search is made for the different types and models of camper vans, focused mainly on dimensions.

In the following point 5. Regulation, we enter the technical part of the project and establish the regulations that the product must comply with. In the two consecutive sections, point 6. Materials selection and point 7. Elements selection, the research and selection of the different materials and elements that will make up the solution based on the discussed prerequisites is done and then, it is elaborated in section 8 Description of the reform, in generic form a description of the reform that will be made to the chosen vehicle, which allows it to be extrapolated to other models with similar characteristics.

In the final phase of the project, in point 9. State of art, a search is made for existing designs on the market and in point 10. Design of the solution, a solution based on the conception, distribution and optimization of the space is found interior available and the design of the corresponding furniture that makes it possible.

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.

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.

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 favoured 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.

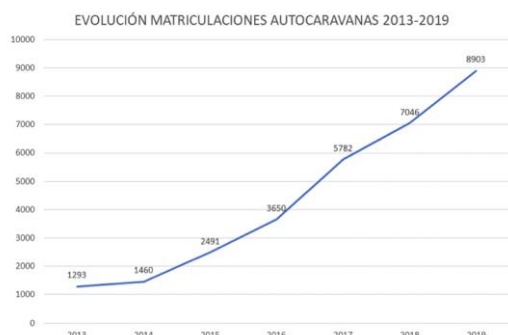


Fig. 1. ^[1]Evolution of motorhome registrations in Spain ("aseicar.org").

We find four types known as profiled, integral, capucine and campers.

3. Study of user needs

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

This last aspect, the fact of practicing outdoor sports both in the mountains and on the coast means having to manoeuvre 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:

- 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.
- Oven.

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 manoeuvrability 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.

4. Selection of the alternatives

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

A medium camper van has been chosen,

5. Regulation

^[2]Manual de Reformas de Vehículos Revisión 7

6. Material selection

Wood striping:

Brushed fir slats 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.

Thermal insulation:

Giving importance to the fire resistance factor and taking into account the good thermal insulation capabilities, ^[3]Kaimann's Kaiflex ST sheets are chosen, with a thermal conductivity of 0.033 W/m·K at 0 °C.

Panelled and furniture:

For the panelling and for the manufacture of the furniture, plywood is the chosen one. It offers 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 bathroom module, fiberglass will also be used for the shower tray and waterproofing vinyl for the coating and insulation.

7. Elements selection

Raised roof:

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.

Seats:

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 and some rear seats with the possibility of transforming into a bed for two people.

Stationary heater / water heater system combined system:

The van 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. To solve this, it has been decided to install a dual heating/water heater system. 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.

Electrical installation:

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

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.

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 efficiency of 90%.
 Necessary DC power to transform to AC = 332 / 0.90 = 368,89 [W h /d]

Battery charger amperage = 29,29 A

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. It is decided to carry out the installation to provide the van with 1 day of total autonomy (without the option of recharging). To perform the calculation, a discharge depth of 50% and a system loss coefficient of 1.15 are taken into account.

Auxiliary battery capacity = 2 x (Amper x hour / day demanded) x days of autonomy x coef. losses

To cover this consumption without any external element, a 250Ah battery is chosen. The power sources for the auxiliary battery will be:

- The van alternator with an automatic relay.
- Photovoltaic panel : We want the solar panel to perform well on cold and cloudy winter days in the mountains. The panels tend to work at 70%. To select the plate, the daily energy that will be required is calculated:

(W panel / 12V) x efficiency x hours of sunshine = W demanded / 12V

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. For the regulator calculation, the power of the solar panel is divided by the battery voltage. 250W / 12V=20,83A. A 20A regulator is chosen.

The calculations are presented in the Annexes: *Electrical installation calculation.*

Water circuit installation:

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 grey water tank where the waste from the shower and the sink will be dumped. 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.

Gas installation:

The gas installation follows the ^[4]R.D. 919/2006 approving the Technical Regulation for the distribution and use of gaseous fuels.

Lighting:

12V led lighting will be installed for the interior lighting of the vehicle.

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

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 cancelling their anchors, are removed.

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 grey water tank pipe. 1 cut on the driver's side to fill the sanitary water tank. 1 cut at the bottom for gas outlet.

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.

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

Assemblies performed:

Raised roof: 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.

Seats: Decrease in the number of seats, installation of swivel bases on the seats of the pilot and co-pilot, installation seat/folding bed rear two-seat, lower drawer unit.

Stationary heater / water heater combined system: 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.

Wood striping: The interior of the passenger compartment (floor, sides and ceiling) will be levelled with the aim of levelling the surface. They will be arranged parallel to the longitudinal axis of the vehicle on the surfaces of the load area. Thus, a fixed structure is created that serves as a base for placing the insulation, walls, ceiling and floor.

Thermal insulation: Plates with a thickness of 10 and 20 mm have been selected. Aluminium tape will be used to seal and join plates and fire resistant polyurethane foam to fill voids.

Panelled: 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 lifetable roof, wiring, lights and sockets.

Electrical installation:

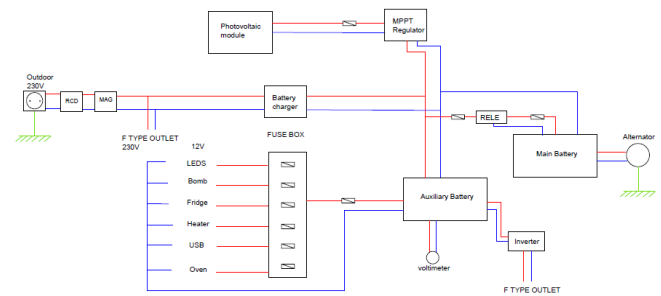


Fig. 13. Electrical installation scheme.

Water circuit installation:

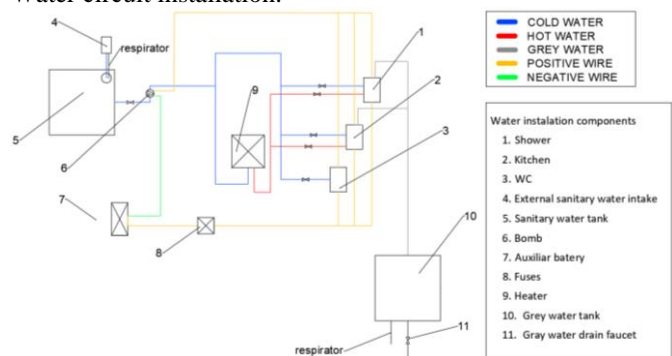


Fig. 13. Hydraulic installation scheme.

Gas installation:

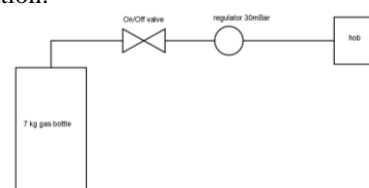


Fig. 14. Gas installation scheme.

Bathroom: 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 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 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.

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 be located the tank of clean water and the gas installation.

Folding table: It 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.

Lighting: 6 additional points distributed throughout the living space.

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.

Trunk: 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.

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.

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.

Finished: It will be verified that all the corners and edges thereof have a radius of curvature greater than 5 mm.

9. State of art

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.
- 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.

10. Design of the solution

It has been shown that there is no medium van model that incorporates something as basic as an indoor shower, along with a toilet. There are also 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:

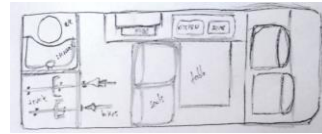


Fig. 26. Sketch 1.

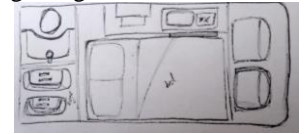


Fig. 27. Sketch 2.

Conception and distribution of the space: 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. 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, it having into account to have a bed inside. It has been considered a longitudinal dimension of 1.90m. The toilet will be added to this it has a length of 0.670m. To this, we add the 22mm x 2 width of the guides for the bulkhead and we get a length that the passenger compartment must be of 2.592m. Therefore, we will be guided by a longitudinal dimension of interior cargo space of: $1.90+0.670+(0.022 \times 2)=2.614\text{m}$. 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. We should work with a longitudinal load space dimension of: $1.9\text{m}+1.3\text{m}=3.2\text{m}$. 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: $1.2+0.41+0.009+(0.02 \times 2) (0.004 \times 2)=1.667\text{m}$.

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: *Table 57. Medium van dimensions.* *Table 58. Medium van dimensions filter 1.* According to the requirements, the chosen model is chosen, the Mercedes Vito Large.

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

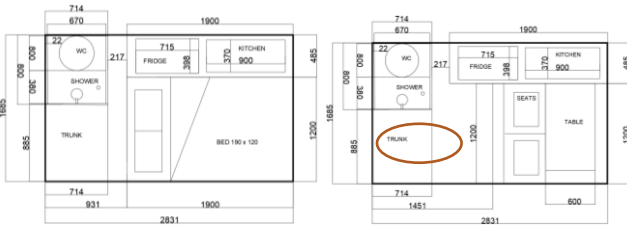


Fig. 34. Solution Space design 1. **Fig. 35.** Solution Space design 2.

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

Furniture design: Through the 3D modelling environment of SolidWorks, the different furniture that is proposed as a solution is modelled and its corresponding materials are associated with it. In the annexes section, the dimensional and construction drawings for each piece of furniture and element are found.

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.

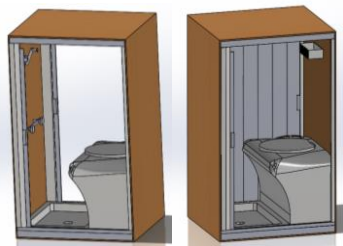


Fig. 36. Bathroom design.

Kitchen furniture: 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.



Fig. 37. Kitchen design.

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.

Folding table: The table can be moved longitudinally along the entire kitchen furniture 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.

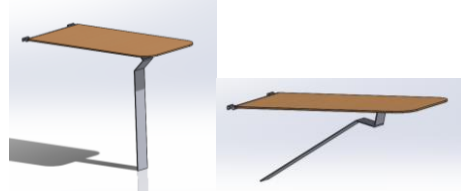


Fig. 38. Folding table design.

Lower furniture double seat: 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.

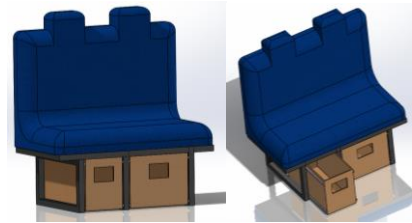


Fig. 39. Lower furniture double seat design.

Trunk: 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.



Fig. 40. Trunk design.

Cupboard: 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.



Fig. 41. Cupboard design.

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.

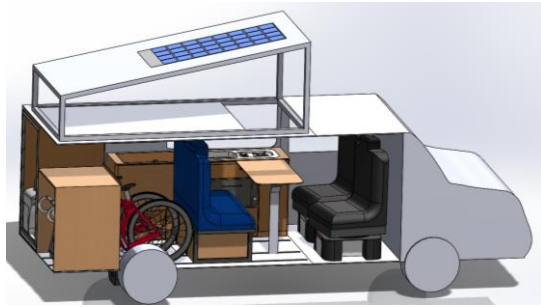


Fig. 42. Solution view 1.

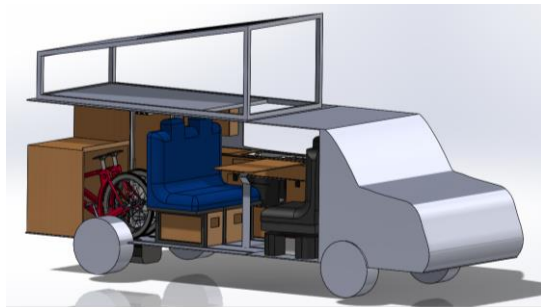


Fig. 43. Solution view 2.

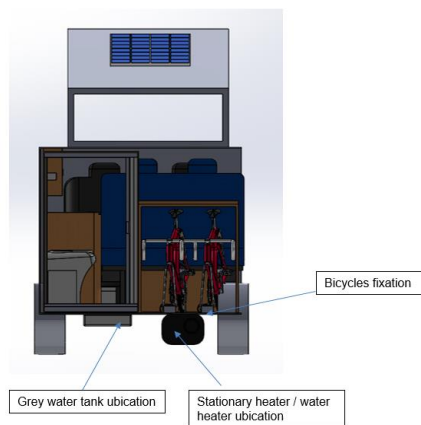


Fig. 44. Solution view 3.

- Inner bed unfolded/seats down:

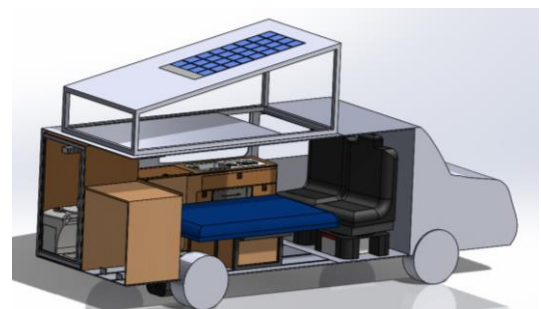


Fig. 45. Solution view 4.

11. Budget

Total cost of the project	eur	Total cost of the product	eur
Computer resources	123,61	Materials/Elements	61908,27
Human resources	30240,00	IVA 21%	13000,74
Materials/Elements	61908,27	Total (eur)	74909,01
Total	92271,88		
IVA 21%	19377,10		
Total (eur)	111648,98		

12. Environmental impact

Except for the insulation material, all of the other materials used are wood. Once the useful life of the van is over, it is easy to extract for recycling or even, thanks to the modularity of the design, reuse them in another camperization project.

13. Future considerations

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

14. Conclusions

Totally accomplished objectives:

- Cabin where you can sleep and rest protected from the outside elements.
- Cabin where you can do a minimum of indoor life (possibility of standing up inside).
- Housing for 2/4 people
- Energy autonomy
- 4 windows
- Bedroom: 2 double beds
- Kitchen
- Storage area
- 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

Partially accomplished objectives:

- Circulate through narrow streets of towns.

Not accomplished objectives:

- Enter underground car parks.

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.

References

- [1] ASEICAR (2020). Evolution of motorhome registrations in Spain ("aseicar.org").
- [2] Manual Reformas Vehículos Revisión Séptima (2022), pp 6-8, 115-183, 198-212
- [3] Kaimann. (2023) <https://www.kaimann.com/es/productos/refrigeracion-aire-acondicionado-ventilacion/kaiflex-st>
- [4] Royal Decree 919/2006, of July 28, which approves the Technical Regulation for the distribution and use of gaseous fuels and its complementary technical instructions ICG 01 to 11.