HOW TO CONVERT A VAN INTO A CAMPER

Juan Manuel Pineda Gonzalez

Abstract

Recently younger generations are looking for cheaper ways to travel and live great experiences, this is why a camper has become an attractive option.

Currently there are discussions regarding if to buy a camper is more advantageous than to do it by yourself. For which it is necessary to analyse both options to choose one according the study performed.
All the necessary steps for the study have been detailed below.

Steps to follow until to convert into a van:
1. To choose a Van.
    a. To choose a Van model through value engineering.

2. To design the camper interior.
    a. Internal isolation.
    b. Electrical system.
        i. To connect a solar panel.
        ii. To connect a secondary battery.
    c. Water system.
    d. Gas system.
    e. Interior organization
        i. Furnishing
        ii. Appliance location

3. Price comparison between buying a camper or doing it.

Introduction

The van is a commercial vehicle used to transport goods or groups of people. They have an orthogonal and roofed cargo area at the back. The tailgate is always two-leaf horizontally opening.

The size of the vans is very varied, because they have been adapted to the wide variety of needs that exist. In general, vans can be identified through alphanumeric codes that will determine the size of the van.

In relation to the lengths there are the codes L1, L2, L3 and L4. These codes are not standardized, so each brand can offer a different length for each one. The meaning is as follows:

- L1: short length
- L2: medium length
- L3: long length
- L4: extra-long length or maximum length

For the roof we find the codes H1, H2 and H3. This second batch of codes refers exclusively to the height of the ceiling, and has the following meaning:

- H1: standard roof
- H2: high roof
- H3: super high roof

Project description

The project deals about all the necessary steps to convert a van in a campervan and compare the result with a campervan already done it. This requires a thorough analysis about the model chosen in order to define the reforms to do and the dimensions available to build in it.

REF.	Objetive	L1H1	L2H1	L2H2	L3H2	L3H3	L4H2	L4H3	Weighting coefficient
1	Cost (k€)	0	0,05	0,1	0,15	0,2	0,3	0,35	10
2	Weight (T)	0,012	0,009	0,009	0,0045	0,0045	0	0	5
3	Exterior length (m)	0	0,045	0,045	0,1035	0,1035	0,14	0,14	10
4	Exterior height (m)	0	0	0,0268	0,0268	0,0506	0,0268	0,0506	10
5	Interior length (m)	0,42	0,285	0,285	0,1095	0,1095	0	0	30
6	Interior height (m)	0,1518	0,1518	0,0708	0,0708	0	0,0708	0	30
7	Consumption (L)	0	0	0	0,06	0,06	0,09	0,09	15
	Total	0,5838	0,5408	0,5366	0,5251	0,5281	0,6276	0,6306	

Table 1. *Analysis engineering model van.*

The campervan will be equipped with the same comfort that a home, this means that it will have a bathroom, a bed and a kitchen, where these facility could be modified according the type of travel, since it will have a guide for allowing to move the facility.

This project takes advantage of solar energy to generate electricity inside the van, furthermore, the campervan will have a water tank to shower and clean and will have gas tank to cock and to heat water.

To define the current that through by the cables will be used the watt's law.

$$I = P/V \qquad (1)$$

Structure calculations are done with the formulas of resistance of materials.

The formula will depends of the effort apply in the structure, it could be bending stress, shear resistance, etc…

Targets and Methodology

One objective is made a welcoming ambience in the van, to get that, the insulation for noise, temperature and humidity is needed and some guides are used to move the furniture, creating the perfect atmosphere for different trips. Furthermore, some modification in exterior of the van have been done (windows, skylights), all this modification should be homologated at ITV. According the regulation all the furniture should be fixed at four points at least, and also the total weight should not exceed the maximum tare recommended by the manufacturer.

CARACTERÍSTICA	MASA (KG)
PMA	3000
PMA_A	2240
PMA_B	1800
TARA	2010
$TARA_A$	1200
$TARA_B$	810
CARGA ÚTIL (Q_U)	990
$TARA_A'$ (30º)	1049
$TARA_B'$ (30º)	961

Table 2. *Manufacturer's data.*

Three models have been proposed to different trips in this project:

- Design A: It has kitchen, bed, one hanging furniture and bathroom. Recommended for a long trip.
- Design B: It has sofa/bed, a cabinet, the kitchen and bathroom. Recommended for wild trips.
- Design C: It has a bunk, clothes cabinet, two seats, the kitchen and the bathroom. Recommended for friends trips.

As previously mentioned, the campervan has electricity thanks to solar panel. The solar panel charge the battery and then the battery feed the electric system. The electric system is formed for an inverter, a stationary heating, the lighting, a water pump and a refrigerator.

Once its defined the components involved at electric system, it is necessary to define the location of each one to calculate the length and the size of the cable. The size of the cable depends of the current that through for the cable, more current requires more cable size. Fuses are used to protect the connections, at the below table is defined the fuse required for each component.

Component	Consumption (A/hour)	Fuse
Refrigerator(12V)	3,75	20 A
Water pump (12V)	3,07	15 A
Lighting (12V)	1,00	5 A
Heating	2,08	20 A
Inversor de 12V a 220V	3,00	15 A
Regulator	3	15 A
Baterry	15	60 A

Table 3. *Fuses used.*

The water system of the camper has two tanks, one for clean water and another one for dirty water. To have hot water a boiler is used. The boiler also use gas and diesel.

For the gas system is needed respect some conditions:

1. It must be a watertight compartment with joints sealed with silicone or similar. The contour of the door must have a rubber to ensure sealing.

2. A ventilation grill to the outside must be made on the floor of the compartment. The opening must cover an area of at least 100cm2 (a square with a side of 10cm or a circumference of 17.8cm in diameter). If the sum of the capacity of the cylinders does not exceed 7kg, the ventilation gap may be smaller (minimum 20mm in diameter). The grid cannot be obstructed, so it is recommended to mount the cylinder on a base.

3. The tank must be in a vertical position with the valve up and attached to the vehicle by means of a double fixing system (upper and lower). The fastening system must be totally manual, it must not require tools to open or close.

4. There should be no electrical appliance inside the gas compartment.

5. The compartment door must save a jump of at least 5cm from the compartment level. If the door at floor level, it must install a wooden strip in front of the tank.

The diesel system is used to feed the boiler and the heating. The installation is done by a professional.

Once the system installation has been completed, it is time to panelling the walls, the roof and the floor, it is possible to use a different panel for each surface, being able to install a lighter material on the roof and at walls so that it affects less the stability of the vehicle. It is very important to completely cover the surfaces, without leaving any gap where a change in temperature can be caused and weaken the insulation.

In this campervan, it will use the pine tongue and groove for the roof and walls, for the floor it will use a vinyl.

The panels are installed on battens, the battens allow to panelling despite of the van ribs.

Once the panels are installed, it's time of putting the furniture. The difference of our project is that furniture is not fixed, that is, the location of each component can be

modified to please the user that providing many alternatives depending on the destination of the trip, to get that a guide will be used. It must take into account that the kitchen and bathroom areas are fixed, since they require a fixed installation (electrical, gas and water).

To define the guide used in campervan are studied two materials, the wood and the aluminium.

In a first step the material chosen is wooden guide, it is thermal insulator, but it is difficult to build due it is not on the market. To compare both materials is necessary create a prototype to see the disadvantages of the wooden guide.

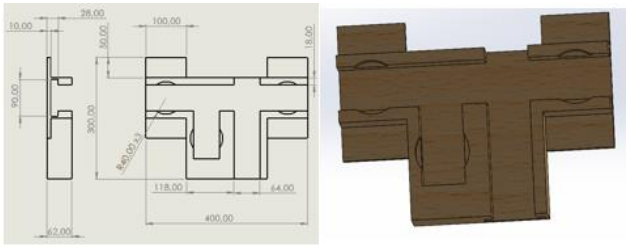


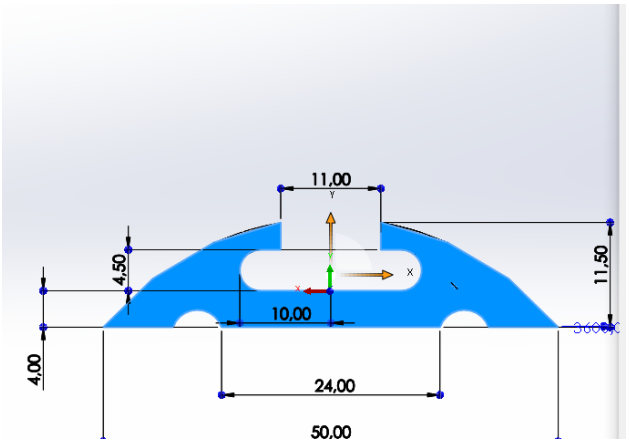
Figure 1. *Prototype wooden guide.*

The disadvantages are:

- The possibility of vertical movements is eliminated, it does not provide functionality and take up a lot of space.
- The material used is changed to aluminium, it is a lighter and easier to machine material.

Aluminium guide is in the market, so that is advantage and is resist hits and external damage.

Figure 2. *Aluminium guide.*



Las propiedades de sección de la cara seleccionada de guia

Área = 279.95 milímetros^2

Centro de gravedad con relación al origen del sistema de coordenadas de salida: (milímetros)
X = 0.00
Y = 3.98
Z = 3600.00

Momentos de inercia, del área, en el centro de gravedad: (milímetros ^ 4)

Lxx = 2305.87	Lxy = 0.00	Lxz = 0.00
Lyx = 0.00	Lyy = 48748.45	Lyz = 0.00
Lzx = 0.00	Lzy = 0.00	Lzz = 51054.33

Momento polar de inercia, del área, en el centro de gravedad = 51054.33 milímetros ^ 4

Ángulo entre ejes principales y ejes de pieza = 0.00 °

Momentos principales de inercia, del área, en el centro de gravedad: (milímetros ^ 4)
Ix = 2305.87
Iy = 48748.45

Momentos de inercia del área, en el sistema de coordenadas de salida: (milímetros ^ 4)

LXX = 3628142600.75	LXY = 0.00	LXZ = 0.00
LYX = 0.00	LYY = 3628184601.76	LYZ = 4014300.34
LZX = 0.00	LZY = 4014300.34	LZZ = 55495.89

Figure 3. *Guide area properties.*

The next step is determine the quantity of material to build the furniture, to define that has been created the following table:

Component	Material needed (m²)	Mat. board 1,20x0,60 (m)	Board needed plywood	Component weight (kg)	Cost (€)	Component weight /4 screws (kg/und)
Bed	6,6	0,72	9 + 1/4	61,975	323,75	15,49375
Kitchen	7,44	0,72	10 + 1/2	70,35	367,5	17,5875
Hanging forniture	4,86	0,72	6,75	45,225	236,25	11,30625
Clothes furniture	6,44	0,72	9	60,3	315	15,075
Bunk	3,36	0,72	4 + 3/4	31,825	166,25	7,95625
Seats	2	0,72	3	20,1	105	5,025
Sofa/bed	3,04	0,72	4 + 1/4	28,475	148,75	7,11875
Cabinet	2,36	0,72	3,5	23,45	122,5	5,8625
		Total	51	341,7	1785	

Table 4. *Quantity material and cost*

The last step is to compare the cost between converting a van in a campervan versus buying it ready. For this, all the associated cost to convert the van will be summed and compared with the market price of the same camper model.

Results

To calculate the bolts that should anchor the furniture and the guide, it is carried out with the following steps:

1. List the amount of furniture for the design with the highest load.
2. Determine if the load on the axes in plane and at 30º exceed the PMA.
3. If the design is valid, the diameter of the bolt that is most in demand is calculated even in critical braking situation:
    a. Initial speed: 100 km/h (maximum speed allowed for these vehicle)
    b. Safety coefficient: 0.5
    c. DGT safety distance: 100 m -> 50 m (with safety factor)

Component	Component weight (kg)	Component weight /4 screws (kg/und)	Design	Deceleration (m/s^2)	Fbraking (N)	Fweight (N)	Ftotal (N)	Ftotal/screw (N/und)
Bed	61,975	15,49375	A	-100	-6197,5	0	6197,5	1549,375
Kitchen	70,35	17,5875	A, B, C	-100	-7035	0	7035	1758,75
Hanging forniture	45,225	11,30625	A	-100	-4522,5	443,205	4544,165151	1136,041288
Clothes furniture	60,3	15,075	C	-100	-6030	0	6030	1507,5
Bunk	31,825	7,95625	C	-100	-3182,5	0	3182,5	795,625
Seats	20,1	5,025	A, C	-100	-2010	0	2010	502,5
Sofa/bed	28,475	7,11875	B	-100	-2847,5	0	2847,5	711,875
Cabinet	23,45	5,8625	B	-100	-2345	0	2345	586,25
Poti	11,725	2,93125	A, B, C	-100	-1172,5	0	1172,5	293,125

Table 5. *Component forces.*

Design A is the loudest proposed design, so it is taken as reference to calculate the bolts and the load on the axes.

To define the load on axes is done the diagram of load forces (figure 4)

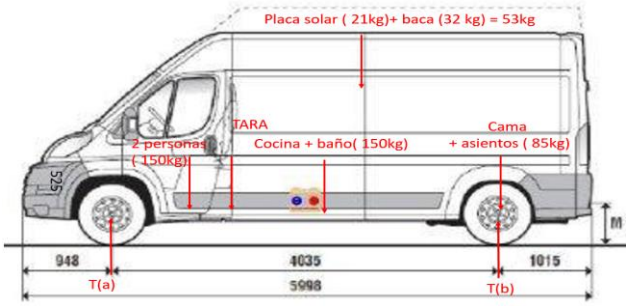


Figure 4. *Diagram load forces.*

It's calculated the force applied in each axle.

T(a) = 1462.8 kg
T(b) = 985.2 kg

To define the load on axes inclined 30º is done the diagram of load forces (figure 5)

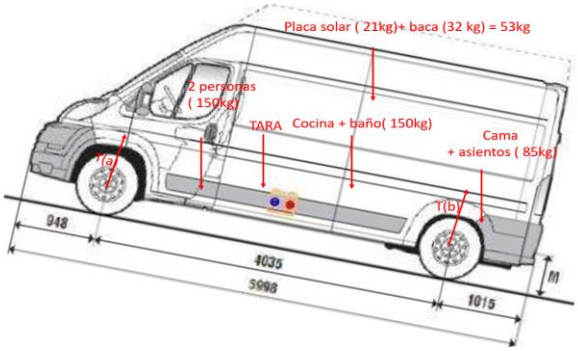


Figure 5. *Diagram load forces inclined 30º.*

It's calculated the force applied in each axle.

T(a) = 1054.2 kg
T(b) = 1393 kg

Axle loads do not exceed the PMA provided by the manufacturer (table 2), so it can be said that this design is valid for our van, the axles should not be modified and the braking system is effective for this design.

To calculate the force supported by the bolt, it's necessary to know the force of each component. From the table 5, we extract the corresponding data for each chosen design.

Once the force of each component is known, its can define the required type of bolt with the below formula:

$F = \frac{0.6 * f_{ub} * A}{\gamma_{Mb}}$ → γ_{Mb} is 1.25 for bolt joint.

From the formula, it's calculated F, that data is the resistance force of the proposed bolt.

<u>Furniture anchor fixed to battens</u>

Maximum force supported by a bolt: 1758.75N.
Bolt proposed: DIN-7981 HC ST 4.8.
F = 3648.06N → Safety coefficient = 2.

<u>Movable furniture anchor by guide</u>

Maximum force supported by a bolt: 1549.4N.
Bolt proposed: DIN-912 5.6.
F = 4109.9N → Safety coefficient = 2.5.

<u>Anchor guide to the battens</u>

Maximum force supported by a bolt: 1025.9N.
Bolt proposed: DIN-7981 HC ST 4.8.
F = 3648.06N → Safety coefficient = 3.5.

Once defined the bolts used in the project, resistance material of a guide is calculated in order to ensure the structure.

<u>Guide resistance</u>

The material of the guide according to the manufacturer is Aluminium 6061 T6, the tempered form T6 indicates a resistance to fatigue of 290MPa, yield strength of 241MPa. It can withstand a maximum elongation of 10%. Aluminium is a ductile material, it means fracture resistance correspond to 1.5-2 safety coefficient.

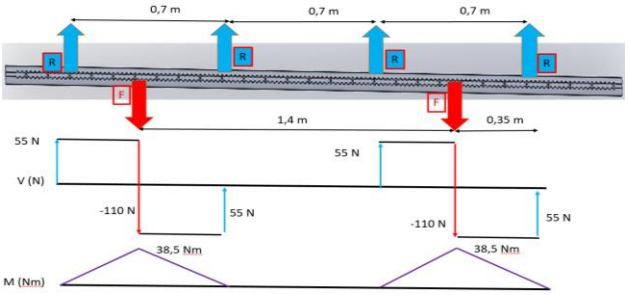


Figure 6. Free body diagram.

To define the material resistance of the guide, flexural strength and shear resistance are calculated to below:

$$\sigma = M * \frac{z}{ly} = 110 * \frac{700}{4} * \frac{25}{48748.45} = 9.87\ MPa$$
$$\sigma\ material = 241\ MPa \rightarrow Safety\ coefficient = 24.$$

$$\tau = F * \frac{z_1 * A_1}{b * ly} = \frac{110}{2} * \frac{12 * 279.95}{2 * 4 * 48748.45} = 0.473\ MPa$$
$$\tau\ material = \frac{241}{2} = 120.5\ MPa \rightarrow Safety\ coeffient = 254.$$
$$y_{max} = \frac{FL^3}{48EI} = \frac{110 * 700^3}{48 * 7.1 * 10^7 * 48748.45} = 0.00023mm$$

The elongation does not exceed 10%.
The material will resist the proposed design.

Finally, all the cost are listed to compare with the market price of the campervan model.

Item	Total	Price(€)
Van	Total item	23000
Exterior modification	Total item	1056
Insulation and paneling	Total item	769,4
Electrical system	Total item	2288
Water system	Total item	406
Gasoil system	Total item	800
Furniture	Total item	1846,25
	Total	30165,7

Table 6. *Items cost.*

Activity	Working time (hours)	Cost (€/hour)	Price (€)
Technical project			400
Certificate of conformity			100
Workshop certificate			150
End of work certificate			100
ITV			60
DGT			170
Workforce	80	20	1600
Total			2580

Table 7. *Professional fees.*

Total cost is 30165.7 + 2580 = 32745.65 € to buy the van and convert it in campervan.

Buying a Citroen Jumper already converted costs 52,000€, so we save 19,254€.

Conclusions

The results of the shear strengths calculated in the previous section confirm that the proposed designs can be made. It just has to take into account not to exceed the PMA of the vehicle, which in this case it is 3000kg.

The latest proposed design of the guides provides a more pleasant aesthetic, is cheaper to obtain and is also more functional.

The price comparison shows that it is cheaper to make a camper van than to buy it made, a very favourable point to making it yourself is that you know the exact location of each component, in case of a failure you can solve it, instead if you have bought the campervan already done where just the manufacture could solve it. In both ways the quality and the guarantee of the campervan are assured.