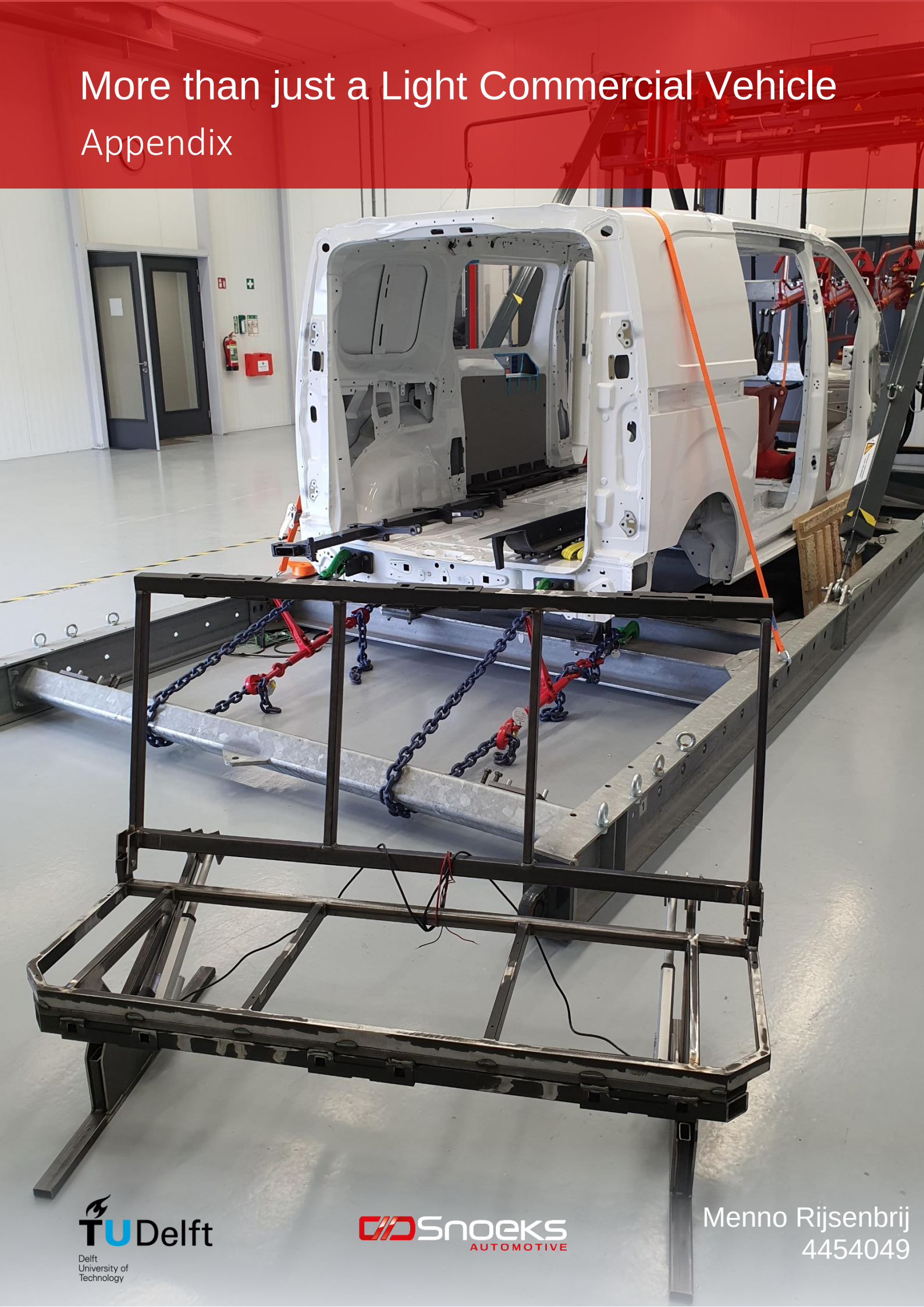
More than just a Light Commercial Vehicle

Appendix



TU Delft
Delft University of Technology

Snoeks AUTOMOTIVE

Menno Rijsenbrij
4454049

Contents

Appendix A, Original Project Brief

5598

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name	Rijsenbrij
initials	M.L. given name Menno
student number	4454049
street & no.	E. du Perronlaan 836
zipcode & city	2624NG
country	Netherlands
phone	0623467088
email	mennorijsenbrij@live.nl

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ☐ DfI ☐ SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ☐ Honours Programme Master

specialisation / annotation: ☐ Medisign ☐ Tech. in Sustainable Design ☐ Entrepeneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	Ir. R.J.H.G. van Heur	dept. / section:	AED
** mentor	Ir. S.G. van de Geer	dept. / section:	DA
2nd mentor	Kenny Smit		
	organisation: Snoeks Automotive		
	city: Nieuw-Vennep	country:	Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

TU Delft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Ir. R.J.H.G. van Heur date 02 - 03 - 2022 signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

List of electives obtained before the third semester without approval of the BoE

(X) YES all 1st year master courses passed

( ) NO missing 1st year master courses are:

name K. Veldman date 15 - 3 - 2022 signature

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (V) APPROVED ( ) NOT APPROVED

Procedure: (V) APPROVED ( ) NOT APPROVED

comments

name Monique von Morgen date 29/3/2022 signature MvM

Personal Project Brief - IDE Master Graduation

TU Delft

More then just a Light Commercial Vehicle — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 28 - 02 - 2022 — 22 - 07 - 2022 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

In the past few years, the transportation industry has seen many developments. Technology is getting more advanced and vehicles have become more than just a way of transportation.
Customers get a larger choice in the customization of the vehicles, and modularity is becoming a key element.
The RV industry has been growing for a while now, but in the past few years this growth became enormous.
In 2021, RV shipments increased by 40% compared to 2020 (RVIA, 2021).

Snoeks Automotive is the leading partner for car manufacturers to extend their product range in Light Commercial Vehicles (LCV's) by supplying them with innovative modification concepts. With over 80.000 converted vehicles a year, Snoeks Automotive is an expert in creating modular modifications for LCV's.

Snoeks Automotive currently markets its crew cap mostly for business, but why would you only use the LCV for work when it can also function as a large car with 7 seats and big cargo space?

With the current RV trends and the expertise of Snoeks Automotive, an interesting opportunity can be found. Currently, RV's are always a separate vehicle that is used for leisure purposes only. The opportunity here is to combine work and leisure into one LCV. For my Graduation Project, I would like to develop a modular RV LCV concept that Snoeks Automotive could create for their customers. A van that can be used for business purposes, but also for their preferred leisure activities like camping for a weekend.

The limitations are mostly found in the usage and proportions of the vehicle. As the LCV will mostly be used for business purposes, the RV features should not be an obstacle in this process. This means that elements should either be modular, convertible or consume a small amount of space while continuing to meet all safety regulations.

Money is also a possible limitation as the market viability for an LCV with both business and recreational purposes is still unsure. Therefore, a large increase in price could be a high risk.

As Snoeks Automotive ships its modules to the factories of their clients, the dimensions of the product could also be a limiting factor.

Finally, human ergonomics will play an important role in this project. as the space in an LCV is limited, the ergonomics of the user will be an important factor to take into account. The user should be comfortable and the concept should be easy to understand, accessible and safe.

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: Placing modular modifications in LCV's

image / figure 2: Testing their modifications at Snoeks Innovation Center

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The idea of an RV / LCV hybrid is an interesting market opportunity but comes with two big problems; space & usage. We are dealing with a relatively small van, in which people and products are often transported.

The LCV's in which Snoeks creates modifications are limited in their size and dimensions. It can be difficult to combine this with recreational usage, as can be found in an RV. To use this LCV for leisure activities as well, the tiny space should be used efficiently. The modules/interior should be as small or modular as possible and storage options must be explored.

The second problem lies within the usage. The LCV's are mainly used for business purposes.

There are different users that also use the LCV voor a different purpose like shipping products or containing their tools. What they have in common is that it can be difficult to optimize/empty their LCV to take it out for leisure activity. This transformation needs to be taken into account in the solution space.

Due to the limited time of this project, the scope will be limited to the interior of one specific vehicle or an in-depth optimization of a specific part.

Advance material research, detailed safety regulations, optional IoT integration and advanced circularity/sustainability research will be left out of the scope.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

I will develop an interior design concept for an LCV so that it is suitable for preferred leisure activities without reducing the efficiency of its regular (commercial) usage. The product should provide users with a smooth transition between work and leisure-related usage.

The product I aim to deliver will be physical model to illustrate/prove (parts of) the concept, as well as a CAD modeled product.

Depending on the research this can result in 3 possible scenarios

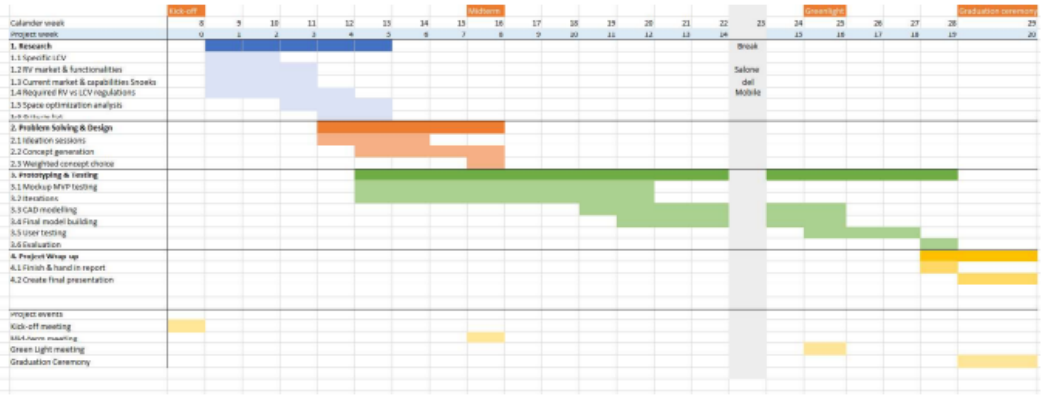
- A complete interior design of the entire LCV, with recommendations on what to elaborate on after the project.
- A basic space-efficient interior design with an in-depth optimization focus on a specific part.
- An Introduction plan with several interior design stages for the upcoming years, with a focus on the first stage.

The scenario will be chosen after the research phase with the criteria in mind. Possible concepts will be generated for this chosen scenario, after which one concept will be chosen during the midterm.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 28 - 2 - 2022 22 - 7 - 2022 end date



Initials & Name M.L. Rijsenbrij Student number 4454049

Title of Project More then just a Light Commercial Vehicle

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I have always had a passion for product, furniture and interior design. During my master, I noticed that my technical knowledge grew, but the feeling for aesthetics was missing. In group projects, I would often create the CAD models, but the design drawings and embodiment design were mostly done by others. To improve this I decided to do a full semester internship at a furniture design studio to learn more about design aesthetics.
Now I want to combine my technical background and passion into a final project in which I can work on a physical project.

Personal learning ambitions:

Design Aesthetics --> In this project I want to further develop my design aesthetics skills by paying attention to the looks and feel of a product and making sure that the final result is an aesthetically pleasing and coherent design.

Embodiment manufacturing --> I want to gain knowledge about product manufacturing and research how my concept could/should be manufactured in a way that is cost-efficient and matches with the companies current manufacturing capabilities.

Physical prototyping skills --> I see myself as a hands-on designer. Rather than researching everything, I prefer to get my hands dirty and try things out myself. In this project, I hope to develop several prototypes that I can use to test my concepts and make meaningful iterations.

Improve visual presentation (in terms of design drawings, CAD, physical prototypes and optional VR Sketching) --> I often have a lot of design ideas in my head, but find it difficult to express exactly what I mean. To convince a future client, company or team, I would like to strengthen my overall visualization skills so that I can present my work in a more effective way.

Interior Design --> I've always had an interest in Interior design, but missed this in my current education. I have tried to twist a few projects into creating an interior concept, but often couldn't express this as far as I would have liked. This graduation project like this feels like a great opportunity to integrate interior design within my Integrated Product Design degree.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Appendix B, Target Market

This appendix shows the elaborated research that was conducted towards the current market that Snoeks Automotive is operating in, as well as the RV and LCV market.

Snoeks Current market

Snoeks Automotive has a full focus on LCV's. They are mainly based in Europe, but now expanding in the USA as well. Snoeks makes most of their sales in France, followed by Belgium, the Netherlands, Germany, and the UK. (Snoeks, 2020)

To quote the statement on the Snoeks Automotive website: "Snoeks automotive is the leading partner for car manufacturers to extend their product range in LCV's by supplying them with innovative modification concepts, expanding the usability of vehicles and the applicability to different markets." Their focus is to create interior modifications like partition walls, crew-cabs, and the flex cabs.

They sell these modifications via three different sales channels: OEM [redacted], Dealer network [redacted] & After fit [redacted] In the past two years, the OEM sales have been rapidly increasing in percentage. [redacted] This can mostly be explained due to the Covid situation and the ongoing microchip shortage (SPG Global, 2022). Dealer networks barely got new vehicles, let alone ones they had to adapt. As the microchip shortage continues and as the Dealer network and After fit channels consist out of a much larger variety of vehicles with relatively small numbers of modifications, it is recommended to focus on the OEM market.

Snoeks Automotive biggest success is the Crew cab. The Crew cab is an additional backseat in the LCV with a separation wall behind the passengers. This way it is possible to transport up to seven people while maintaining enough space for cargo. There are several arguments why this product is as successful as it is. The first one being that this product comes with a big financial benefit. It allows consumers to use their commercial vehicle for private usage with their family, while still having the financial benefits of a commercial car. This is quite a large target group as 68% of the Dutch LCV users are sole traders or private limited companies (figure B.1). This also explains why the comfort edition was much more beloved in their most popular medium LCV in the past three years. [redacted]% of these crew cabs came as comfort and only [redacted]% came in the eco edition (Snoeks, 2022). This success could create a good business opportunity for the RV/LCV hybrid. By creating a Crew Camper, customers could still receive the financial benefits of a commercial car, transport up to seven people, and have the opportunity to use the vehicle for recreative purposes.

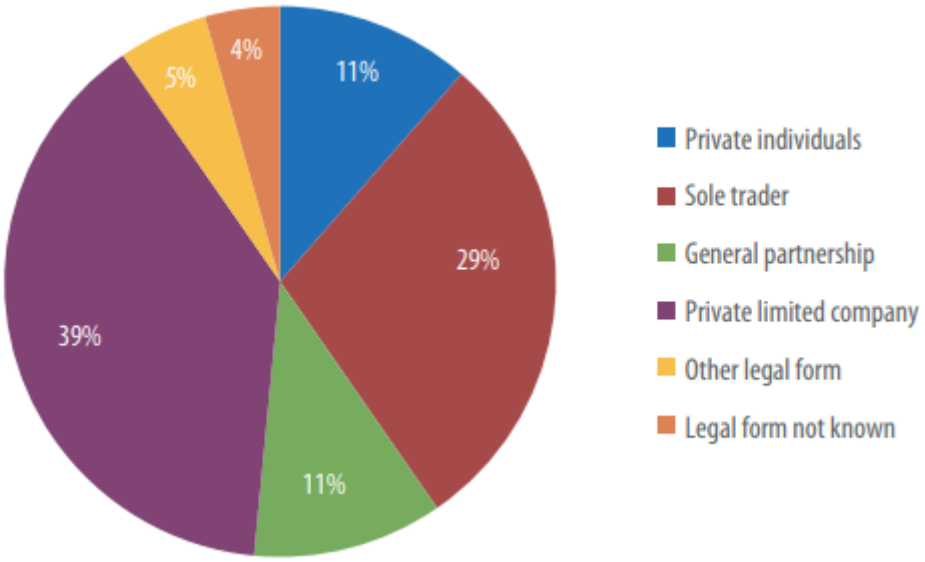


Figure B.1, Company form (Topsector Logistiek, 2017)

RV market

As this product will introduce a new concept, it is important to look at the potential market. This is a vehicle that could potentially replace RVs, as the product combines business and leisure activities, and it is no longer required to own a separate vehicle for this. A good start to look at the potential market is to compare the RV sales in Europe and their growth, as can be seen in figure B.2 (Civd, 2021). The demand for RV's could indicate a demand for a vehicle with optional leisure usage. Therefore, countries with high RV sales could potentially be a successful target market.

Germany is the European market leader in RV sales with 78.055 sales in 2020. An increase of 44,8% compared to their 2019 sales. On the second place is France with 24.961 sales and third is the UK with 12.613 sales. The Dutch RV market sold 2.099 vehicles in 2019 and 2.449 in 2020. This is about 1.5% of the European market. The rest of Europe has a combined amount of around 44k sales.

The US market will not directly be considered, as motorhomes are less popular there and Snoeks Automotive is not established in this market yet. More details can be found in Appendix D, US market.

It is recommended to put the main focus on the German, French and UK market as they have a combined market share of 72%.

County	2019	2020	Change %
Germany	53.922	78.055	+44,8
France	23.776	24.961	+5,0
UK	15.342	12.613	−4,4
Sweden	4.147	4.011	−3,3
Italy	6.092	6.515	+6,9
Switzerland	5.345	6.731	+25,9
Belgium	5.007	5.437	+8,6
Spain	5.977	6.149	+2,9
Norway	3.590	3.384	−5,7
Netherlands	2.099	2.449	+16,7
Other	2.105	2.529	+20,1
Total	132.496	160.026	+20,8

Figure B.2, European RV sales growth (Civd, 2021)

LCV market

The next thing that should be analysed is the actual LCV market. As the vehicle will mainly be used for commercial purposes, it is important to focus on a market where LCVs are doing well.

When looking at the LCV market in 2019, France was found in the number one position with 450k newly registered vehicles in 2019. Followed by the UK at 367k, and Germany with 328k. Spain follows with 210k and Italy with 179k. (ACEA, 2021)

For the total amount of LCV's driving within each country, France is still on first place with over six million registered LCV's. Followed by the UK (4.53 mil), Italy (4.17 mil), Spain (3.78 mil) and Germany (3.28 mil).

When analysing these total amounts, Italy and Spain do stand above Germany, but it is important to look at the age of the vehicles as well. In Italy, 2.67 mil LCVs are over ten years old. In Spain this is 2.40 mil. When comparing this to Germany (953k), The German market still seems to be a better choice to focus on (figure B.3).

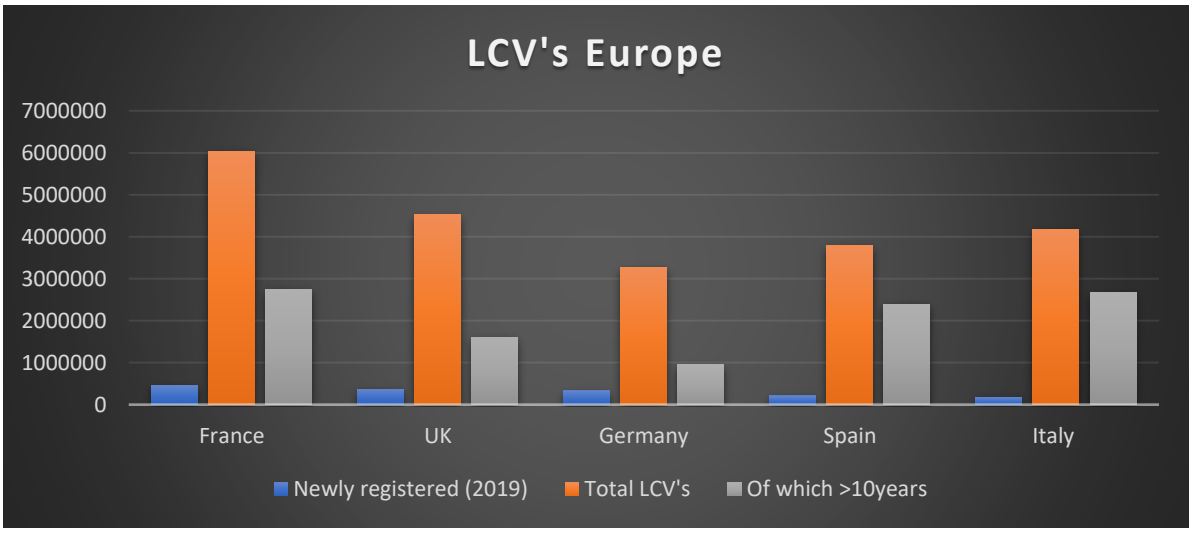


Figure B.3, LCV registrations in Europe (ACEA, 2021)

Appendix C, Fiscal Regulations EU *(Confidential)*

Appendix D, US Market

To find out whether the US market could be interesting, the general RV statistics will be analysed. As can be seen in figure D.1, US RV shipments reached 600k in 2021. This is an increase of 39.5% compared to 2020 (RVIA, 2021). This seems like an interesting market, but it is important to note that towables are significantly more successful than motorhomes in the US (see figure D.2). Out of the 600k shipments, only 56.212 motorhomes have been sold.

In Europe on the other hand, the motorhome market is growing rapidly (ECF, 2022) and significantly more popular than towable RV's as can be seen in figure D.3.

In conclusion, The US market should not be the first place to focus on, but with the growth in LCV's in could be interesting to see if the concept could still be implemented in this market in a later stage.

For now, the main focus should be on the German, French and UK market as they have a combined market share of 72%.

December 2021 RV Wholesale Shipment Summary

	DEC 2020	DEC 2021	Change Over Last Year	YTD 2020	YTD 2021	Change Year To Date
Towables						
Travel Trailers (ALL)	28,047	28,550	1.8%	298,478	423,775	42.0%
Travel Trailers - Fifth Wheel	7,670	7,213	-6.0%	81,508	107,566	32.0%
Folding Camping Trailers	516	652	26.4%	6,255	7,885	26.1%
Truck Campers	271	493	81.9%	3,372	4,802	42.4%
All Towable RVs	**36,504**	**36,908**	**1.1%**	**389,613**	**544,028**	**39.6%**
Motorhomes						
Conventional (Type A)	1,062	901	-15.2%	11,892	15,350	29.1%
Van Campers (Type B)	796	912	14.6%	7,222	13,827	91.5%
Mini (Type C)	2,020	1,626	-19.5%	21,685	27,035	24.7%
All Motorhomes	**3,878**	**3,439**	**-11.3%**	**40,799**	**56,212**	**37.8%**
Total RV Shipments	**40,382**	**40,347**	**-0.1%**	**430,412**	**600,240**	**39.5%**

Figure D.1, RV shipments 2020-2021 (RVIA, 2021)

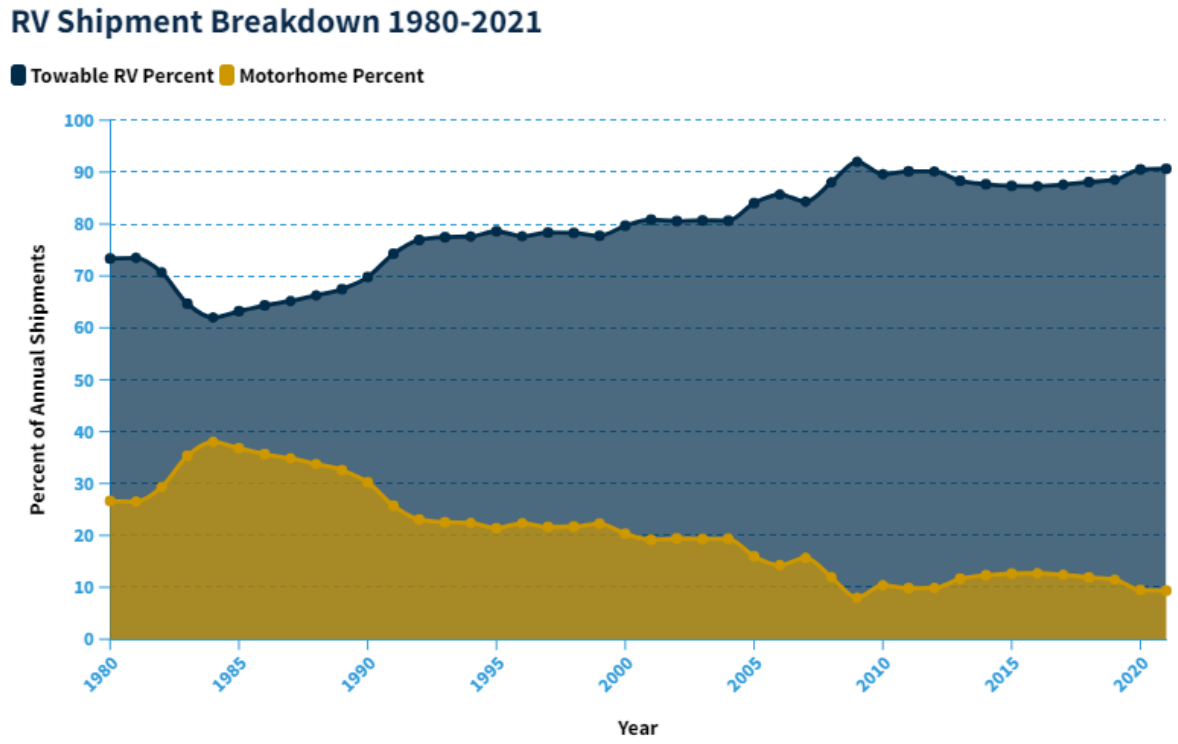


Figure D.2, RV Shipment Towable vs Motorhome US (RVIA, 2021)

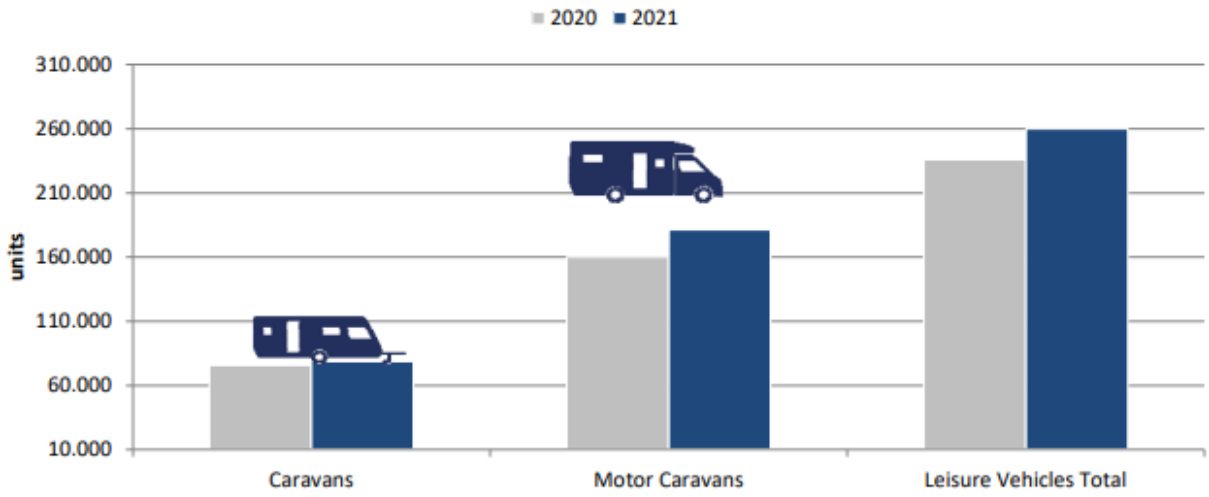


Figure D.3, RV Shipment Towable vs Motorhome EU (ECF, 2022)

Appendix E, RV or LCV

The registration type of the vehicle plays an important role in its success. How will this vehicle be placed on the market? The vehicle can be registered as either an RV (Recreational Vehicle) or LCV (Light Commercial Vehicle). The registration for one of these types comes with several regulations and benefits that need to be compared.

Registration regulations

It is important to meet the fiscal regulations for either an RV or an LCV, in order to apply for a commercial licence (grey licence plate) or an RV licence. These licences have certain benefits that make the vehicle desirable by the consumer. There are fiscal and safety regulations for each license. As the fiscal regulations are of large influence for the consumers' willingness to pay, these will be assessed first. The safety regulations will be implemented as criteria in de ideation phase.

For LCV's there are some standard fiscal regulations in Europe for the loading area and the rear door dimensions. On top of that, some countries have their own regulations, as can be seen in Appendix FIXME 1. The fiscal regulations for a Dutch LCV are significantly stricter than the rules for LCVs in other European countries. One significant regulation is that the partition wall (a wall that separates the passengers from the loading space) should be inseparably connected to the vehicle body. This would mean that the only way to get from the front side of the vehicle to the backside would be to go outside. The vehicle will be permanently divided in two halves, which is quite an undesirable feature.

To register the vehicle as an RV, different regulations apply. In order to register as an RV in the Netherlands, the fiscal rules (Belastingdienst, 2022) consist out of:

- Minimal two fixed seats
- Fixed table (may be foldable)
- Sleeping arrangements for minimal two persons (180x110cm or 2x 180x60cm)
- Minimal two fixed closable storage facilities
- Fixed kitchen block with 60cm high worktop with a build-in water supply, sink, tap & drain)
- Build in cooking facility for inside usage (microwave is allowed)

These regulations are similar in Germany (autozeitung, 2022), France (Journal officiel de l'Union européenne, 2007) and the UK (Gov.UK, 2022).

Registration benefits

Now that the regulations are clear, the benefits will be compared. For this the Dutch market wat analysed first as this is one of the biggest current markets for Snoeks and the regulations are quite straightforward.

A Dutch RV licence comes with a 75% reduction on the road taxes (Belastingdienst, 2022), and insurance can be significantly cheaper. The biggest problem here is that BPM (Private Vehicle and motorcycle tax) needs to be paid, which is 37,7% of the net list price including additional options/accessories (Belastingdienst, 2022).

A Dutch LCV has higher road taxes, and the insurance is more expensive, but due to its commercial registration, no BPM needs to be paid. Within Dutch regulations, registering the vehicle as an LCV is significantly more advantageous for the customer.

These Tax regulations and benefits are different for each country in Europe, as could be seen in Appendix C, Fiscal regulations. ACEA (European Automobile Manufacturers Association) brings out a yearly Tax Guide for each country. This guide was used to check the regulations for the most promising marketplaces (Germany, France, and the UK). These countries do not have significant BMP differences, but the VAT is mostly deductible and other significant tax benefits for commercial licence plates can be found (ACEA, 2021). It is therefore advisable to design and register the LCV/RV hybrid for an LCV licence. The fiscal and safety regulation that come with this LCV licence will be considered during the Ideation phase.

Appendix F, Specific LCV

Due to the limited time of this project, the scope for this concept have been limited to the interior of one specific vehicle. This appendix shows that analysis that was used to determine which vehicle to start with. First the category was determined, after which a specific model was chosen.

LCV category

LCV's can be categorized in three types: F1 (compact van), K1 (medium van) and K2/3 (large van).

According to the marketing division at Snoeks Automotive, the F1 type is often used by freelancers. They are used to transport a small amount of cargo. The K1 type is often used by smaller business owners which use the car for both commercial and private usage. The K2/K3 type is mostly used by fleet owners. They are specifically designed for commercial purposes and are too large for normal everyday usage. In Figure F.1, the number of registered vehicles per type in the Netherlands can be found. As can be seen the medium segment is the most popular group with around 400.000 active vans registered. The compact van (also known as two-seater) is the second largest group with around 316.000 vehicles. (RDW, 2017)

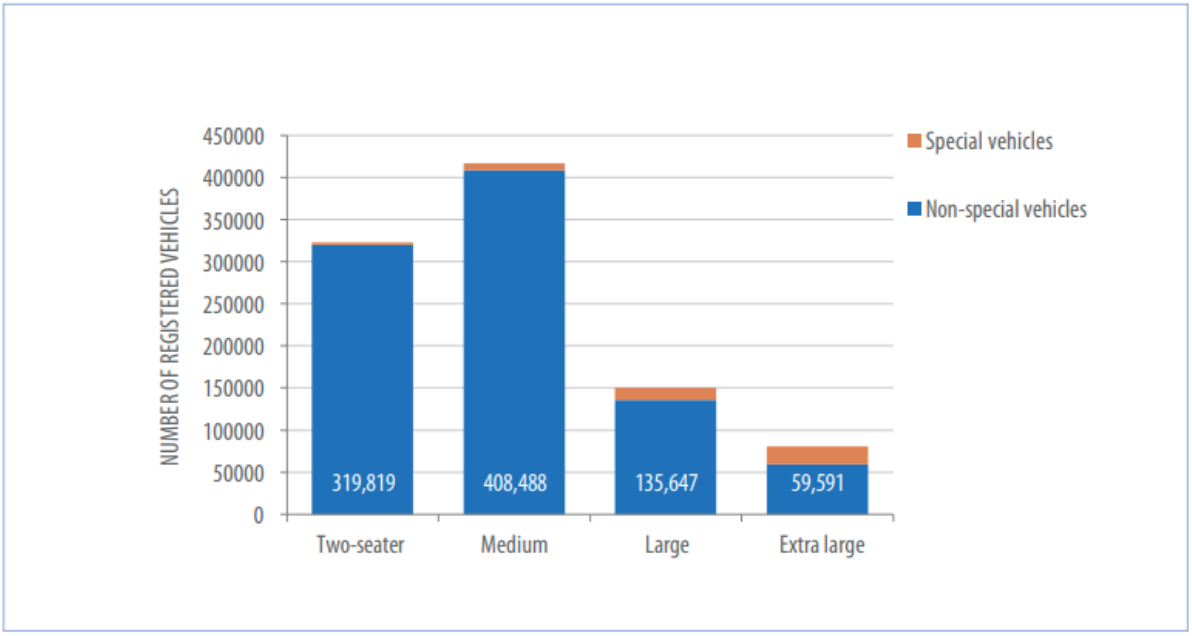


Figure F.1, Registered LCVs by size (Topsector Logistiek, 2017)

The K1 medium van is also the most popular LCV for Snoeks Automotives crew cab. Annual sales numbers show that an average of 94% of the crew cabs have been built into this segment in the past three years (Snoeks, 2022). For the smaller segment (F1), only 34 crew cabs were built in in the past three years. This is because the vehicle is simply too small and building in a crew cab leaves almost no cargo space. The commercial vehicle license plate cannot be obtained as the minimal required cargo space is not met. As this segment is not quite suitable for crew cabs, let alone create a sleeping place, it will not be further considered.

The larger segment (K2/3) could well be used for an RV/LCV hybrid. The RV market in this segment is already booming. On the websites of the most popular RV brands that build these Class B campervans (Businessinsider, 2019), K2/3 sized campervans can almost exclusively be found. This does not come as a surprise as most campers are quite large, as their sole purpose it to function as an RV and deliver a comfortable experience. The vehicle is however not practical for daily usage. The dimensions are not ideal for driving through the city and depending on the size of the vehicle, several regulations make it difficult to park the vehicle in residential areas (Businessvans, 2019). In the Netherlands for example, it is illegal to park your van in a residential area of it is longer than six meters or higher than 2.4 meters (AVP, 2019).

This vehicle is often used for large fleet organisations. They are used to quickly transport a large number of supplies and/or employees from or to the work floor and often stay on company property. These vehicles are suitable for crew cabs, but far less popular then the previously mentioned K1 segment.

Based on a list with requirements and aspirations (Appendix G), a Harris Profile has been created to determine the right LCV category to focus on. The results can be seen in figure F.2.

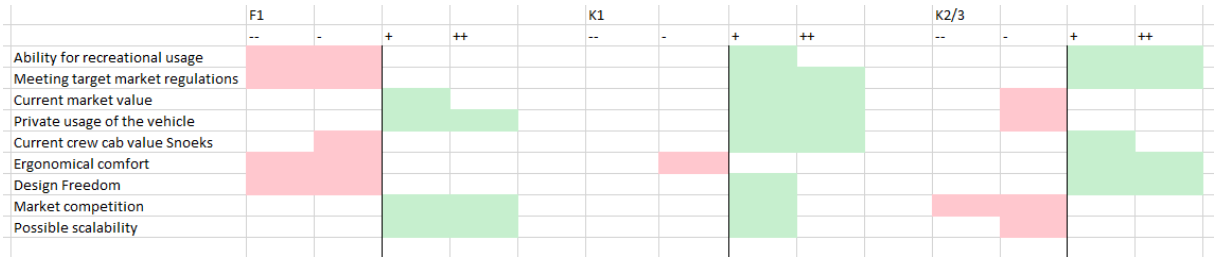


Figure F.2, Harris Profile analysis for LCV category

For this project the K1 class seems ideal. This vehicle has the biggest market value, highest viability based on the potential customers and fits well with Snoeks current market.

The biggest weak point here is ergonomic comfort. This should be optimised as well as possible in the ideation and design phase.

Specific LCV platform

After the medium segment was chosen, a specific model was selected to place this product on the market and to prove the concept.

It is important to note that many LCVs are built on the same platform. As an example, the K0 platform is used for the Citroen Jumpy, Opel/Vauxhall Vivaro, Peugeot Expert and Toyota Proace. An overview of this can be found in figure F.3.

As a certain design for a specific platform can be used for several types/brands that er build upon that platform, this paper will mostly refer to platform codes rather than specific brands or vehicles.

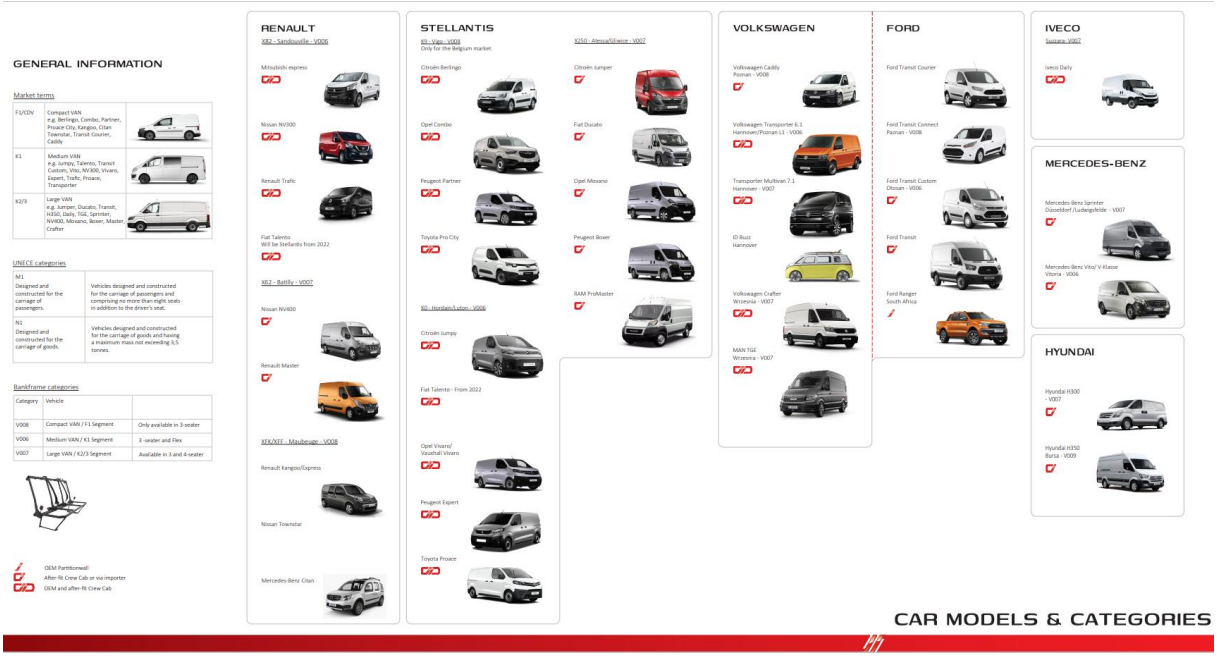


Figure F.3, Overview of platform types (Snoeks, 2021)

The most successful crew cabs for Snoeks Automotive can be found in the X82, K0 & T6 (Snoeks, 2022). The most popular medium LCVs in Europe in 2021 are the Ford Transit Custom (Custom), Volkswagen Transporter (T6) and Vauxhall Vivaro (K0). (Parkers, 2022)

These four Platforms will be analysed on Pros and cons, as can be seen in figure F.4.

In theory, all of these vehicles could be used to develop the RV/LCV hybrid. A “body in white” (the metal platform around which the LCV is build) could be used for any of these vehicles to do some physical testing.

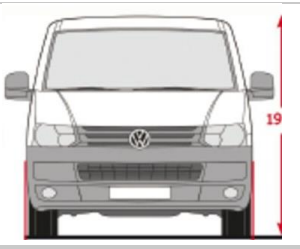
			
X82	K0	T6	Custom
Renault Trafic Mitsubishi Express Nissan NV 300 Fiat Talento (<2021)	Citroen Jumpy Opel/Vauxhall Vivaro Peugeot Expert Toyota Proace Fiat Talento (2022)	VW Transporter	Ford Transit Custom
Trafic 12k sales in 2021	Vivaro 3rd bestseller at 16k sales in 2021	2nd Bestseller EU with 20K sales in 2021	Bestseller EU with 50K sales in 2021
[redacted]	[redacted]	[redacted]	[redacted]
Largest volume	Smallest volume	In between K0 and X82	In between K0 and X82
4139 sales in NL 2020	6746 sales in NL 2020	4644 sales in NL 2020	4109 sales in NL 2020
[redacted]	[redacted]	[redacted]	[redacted]
Loses Fiat Talento	Fiat Talento moves to this platform	Will merge with Ford Custom into a new platform	Will merge with VW Transporter into a new platform

Figure F.4 Comparison of the most successful K1 medium LCV's

Each model has certain benefits, pros, and cons. The X82 has the biggest volume and a mostly rectangular shape, which could be beneficial for certain mechanisms. The T6 is the 2nd bestseller in the EU and Snoeks Automotive already makes crew cabs at OEM level here. The Custom is the EU bestseller, but currently Snoeks Automotive only creates about 200 crew cabs a year within its dealer network and after fit.

There is currently news that could have an enormous impact on the market. Ford and Volkswagen are going to collaborate to create a new version of the Ford Transit Custom and VW transporter, as seen in figure F.5 (Volkswagen, 2020). To put this in perspective, the number one and two in the medium LCV segment are going to develop a new platform, as can be seen in figure Fixme. It is expected that there is a large market potential to develop a concept that could be applied to this model and is ready by launch.

As Volkswagen is currently also the first and only OEM to produce their own RV version within their factory, this could be a way to still place the RV/LCV hybrid directly on the market via OEM.

Figure F.5 New Ford and Volkswagen 1 Ton-Cargo Van (Autocar, 2020)

As the new platform is still under construction and there are large confidentiality issues for this design, it is decided to create a solution for the K0 for proof of concept. This is ideal during this research, as the K0 platform can also be used for physical prototyping and testing. In a later stage, a roadworthy vehicle will also be made available for the creation of a final proof of concept model.

The K0 is the best-selling current platform on the European market and within Snoeks Automotives sales. Developing an RV/LCV Hybrid for this platform could still be an interesting market opportunity as there are many different car manufacturing brands that could be approached with this concept idea.

The k0 is in every dimension slightly smaller than the new Ford/VW platform. If the proof of concept is successful for this platform, it is likely that the solution could also be applied for the new platform as the size restrictions are less extreme. The ability to apply this concept in different vehicles within the same segment (K1 medium LCV's) is high on the aspirations list.

Appendix G, Requirements & Aspirations Harris Profile

To decide which category LCV should be focussed on for the first RV / LCV hybrid, a list of requirements & aspirations has been created. These requirements and aspirations are based on the previous research regarding the target market, regulations, LCV types and the problem definition.

Requirement

Ability for recreational usage

The most important criteria is that the vehicle should at least have the ability to be used as a recreational vehicle. As for some vehicles it is physically impossible to offer somewhat comfortable sleeping spaces, it would be unusable as an RV/LCV hybrid.

Aspirations

Current market value

The product needs to be viable. This means that there should be a market for this segment that is potentially large enough to create a profit. For this the deviation between classes is compared.

Private usage of the vehicle

This concept is beneficial for consumers that also use this vehicle for private usage. If the vehicle is purely used for commercial purposes, improving recreational options in this vehicle is not viable.

Current crew cab value Snoeks

Snoeks is an established company in Europe with an expertise in the crew cab. As this concept builds on to this function, it is desirable to focus on the market in which this function is already successful and where they already have the technical experience.

Ergonomic comfort

A certain level of comfort is expected when using a vehicle for recreational purposes. The vehicle should offer a comfortable experience during both recreative and commercial usage.

Design Freedom

To create a concept like this, it is desirable to work with a certain amount of design freedom. This is highly dependent on the interior volume/working area. The larger the area, the larger the design freedom to create ideal solutions while still complying to fiscal regulations.

Market competition

Although this concept has the USP of recreational usage with a grey licence plate, it is still important to look at the competition. If there are many alternatives in a certain category, this could lower the chances of the product being successful.

Possible scalability

If the concept turns out to be profitable, it is desirable that it could be scaled into different segments. It is expected that solutions that work in a smaller vehicle could easily be scaled into a larger vehicle, where solutions in large vehicle could be harder to adapt to a more restricted space.

Appendix H, LCV Height and Length.

LCV's can come in different lengths and heights, depending on the type and brand. In figure H.1 an example can be seen for different lengths and height. An L1H1 means that the van comes in its smallest length and height. Lengths can go up to L4, where heights can go up to H3.

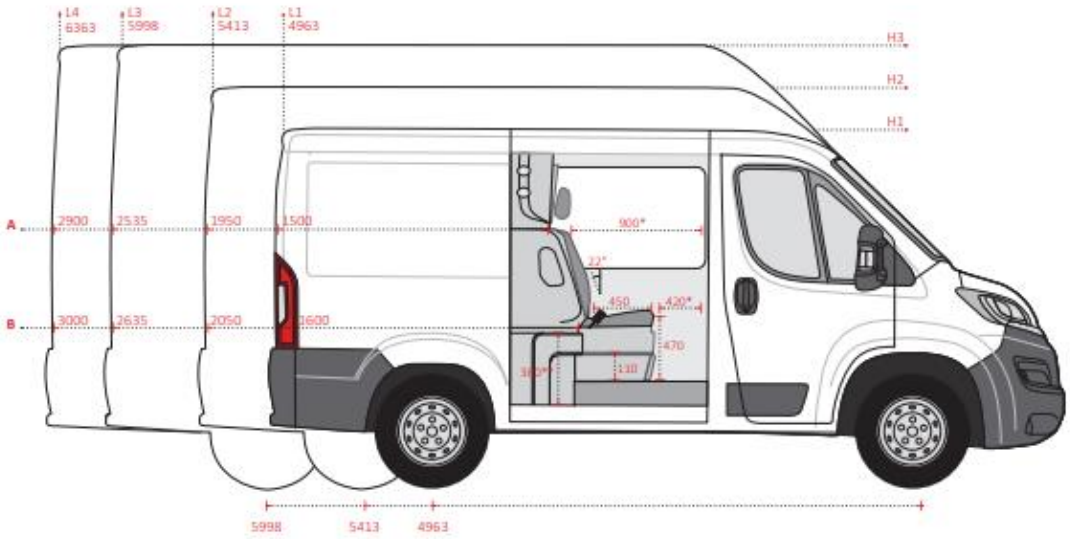


Figure H.1 Different lengths and Heights of an LCV (Snoeks, n.d.)

For the K0 platform (figure H.2), there are no different heights available. This is often the case within the medium LCV segment. The K0 generally comes in three lengths: compact, standard, and long. The compact version is an adapted car base with reduced door sizes. This version will not be considered as it is physically impossible to fulfil the fiscal regulations for the chosen target markets and there is no room for a comfortable sleeping space (like the F1 segment). The two lengths that remain are the L2 and L3. The L3 could create a larger recreative space, where the L2 might be more comfortable for driving through the streets. For the X82 platform, the long version is more popular at 60% of the sales (Snoeks, 2021). Ideally the solution should be appliable at the smaller L2 base, so it could fit in both lengths with possible extra features in the longer L3 version.

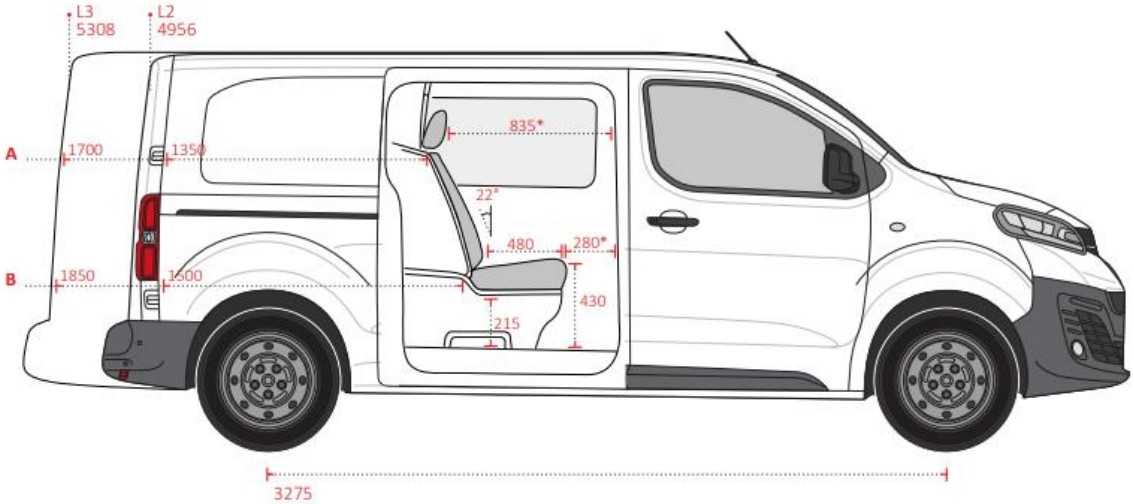


Figure H.2 Different lengths of the K0 platform (Snoeks, n.d.)

Appendix I, Target Group

As direct contact with the Target Group was not possible during this project, The paper of Topsector Logistiek was used to gain insights about this group. The most important statistics are found in this Appendix

The Dutch LCVs are divided into categories (by SBI-1 coding) as can be seen in figure I.1. Here it can be seen that the construction and trade section cover almost half of the Dutch LCV market.

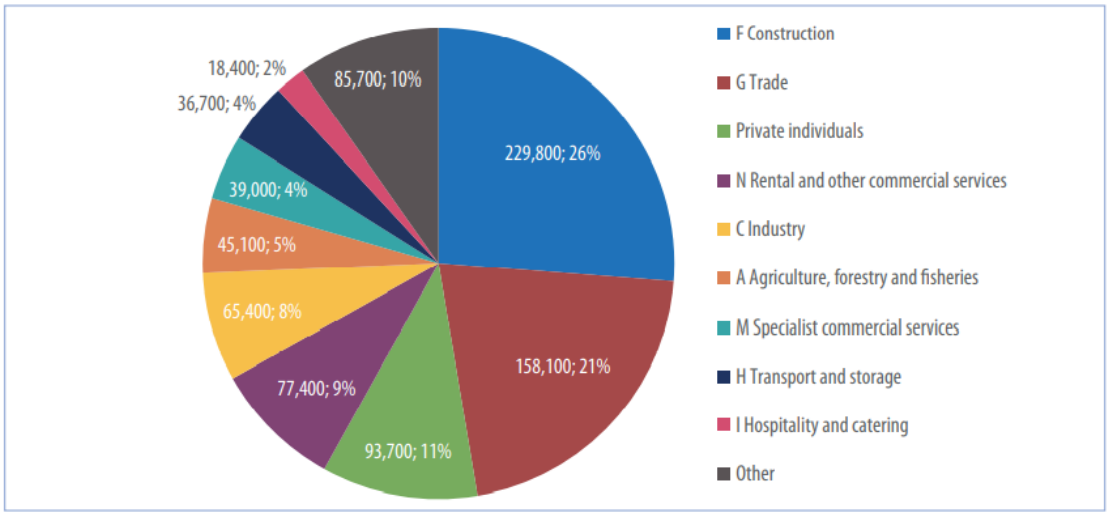


Figure I.1, Company categories by SBI-1 coding (Topsector Logistiek, 2017)

The largest group 'construction' can be subdivided into the many different professions as can be seen in figure I.2.

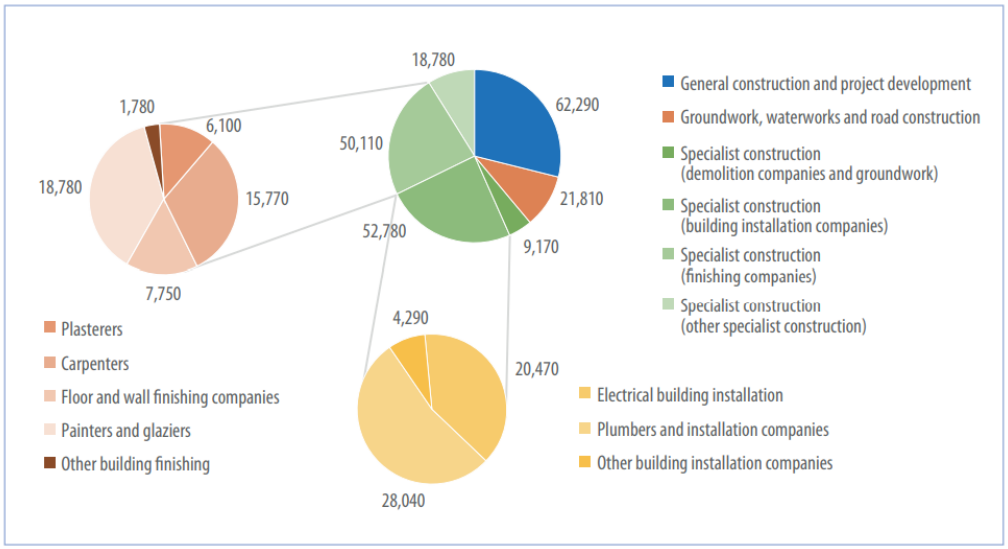


Figure I.2, Distribution of LCVs within the Construction sector (Topsector Logistiek, 2017)

Over 40% of the entire 'construction' group LCV's is owned by sole traders (figure I.3). This percentage is larger than the general self-employed percentage (35%) and can be explained by the relatively high number of 211.000 self-employed people working in construction (CBS, 2015).

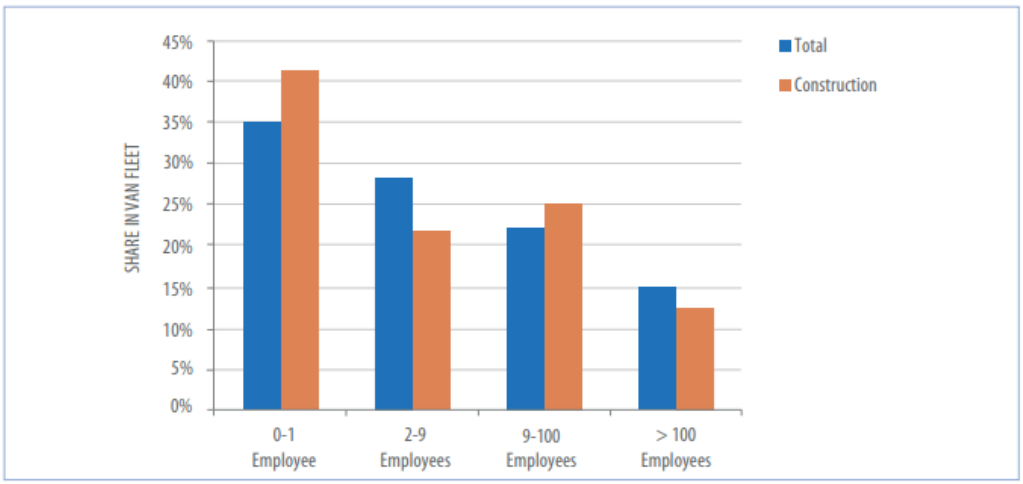


Figure I.3, Company size deviation (Topsector Logistiek, 2017)

As most of the customers for the K1 crew cab chooses for the comfort edition rather than the eco version, it can be assumed that this vehicle is also used for private usage. This makes sense as it is also one of the main benefits of the Snoeks Crew cab; the possibility to transport up to seven people while still owning a grey license plate.

Especially for self-employed people (35% of all LCV owners), this is a logical conclusion. They use the vehicle on their own for commercial usage but use the crew cab to seat their friends or family during private use. As the entire idea of this product is that it is not a purpose-built vehicle but a vehicle that can be used for both recreative and commercial purposes, it must at least provide the same basic features, like offering seating places for at least five people.

As the crew cab is installed, it is expected that the vehicle should be usable for more than two people. It is also unrealistic for an LCV in this segment to require it to support up to six people. It is desirable that the LCV could offer a recreational experience for at least four people. This could also be in a form of partial support, where the vehicle could transport a larger group but only offer sleeping spaces for two people.

Because of the large division in the Target Group, the focus will be placed on creating a product that is the most beneficial for most users. This can be achieved by creating a basic version with certain “must have” functionalities and allowing users to adapt the vehicle to their personal preference.

The personalisation could party be implemented in the form of trim levels, or by collaborating with other companies.

It is also optional to only offer the base product and let users decide what else they want to do with the interior of the LCV.

Appendix J: Space Optimization

This analysis is mainly based on similarities and insights that were found when analysing multiple pictures of truck interiors, boat interiors, tiny houses, and RV's. A small collage has been created with some of these main features and space optimization ideas, as can be seen in figure J.1.

The main takeaways from this analysis are the following:

Foldaway and Stowaway

Usable space is often not usable all the time. A table can be very convenient, but when it is not used, it is a large, unusable element within your limited space. Foldaway or Stowaway furniture could be a solution to temporally use convenient functions, while they can be stored away when they are not used.

Storage

Overhead cabins, gear hammocks, cargo nets, drawers and gaps, any available empty space is often transformed into some kind of storage facility. Storage remains one of the most important aspects when providing a space to live in. Apart from a large, general storage space, smaller spaces could be useful to store small items or provide quick access to certain items.

Light

In any tiny living space, there is always enough light to be found. There should be enough light inside the space during the evenings or to live within the compact space during bad weather. Reading lights are often implemented closely to the sleeping space. There are often windows to allow daylight to enter the space. At the same time there are curtains to be able to block the light to allow users to sleep.

Food

There is often some kind of cooking facility installed. Most of the time there is an integrated fridge and microwave or a small stove to be found within the confined space, so users can spend a longer time inside and can prepare meals.

Power

There are always multiple power sockets available to charge a phone or use entertainment systems like a small tv or radio. The ability to have power within reach seems desirable.

Basic seat/bed and table

In every analysis there was always a bed / seating place and a small table to use. Often the bed and seat are combined in a sleeping couch. The table can often be folded/stored away when it is not used.

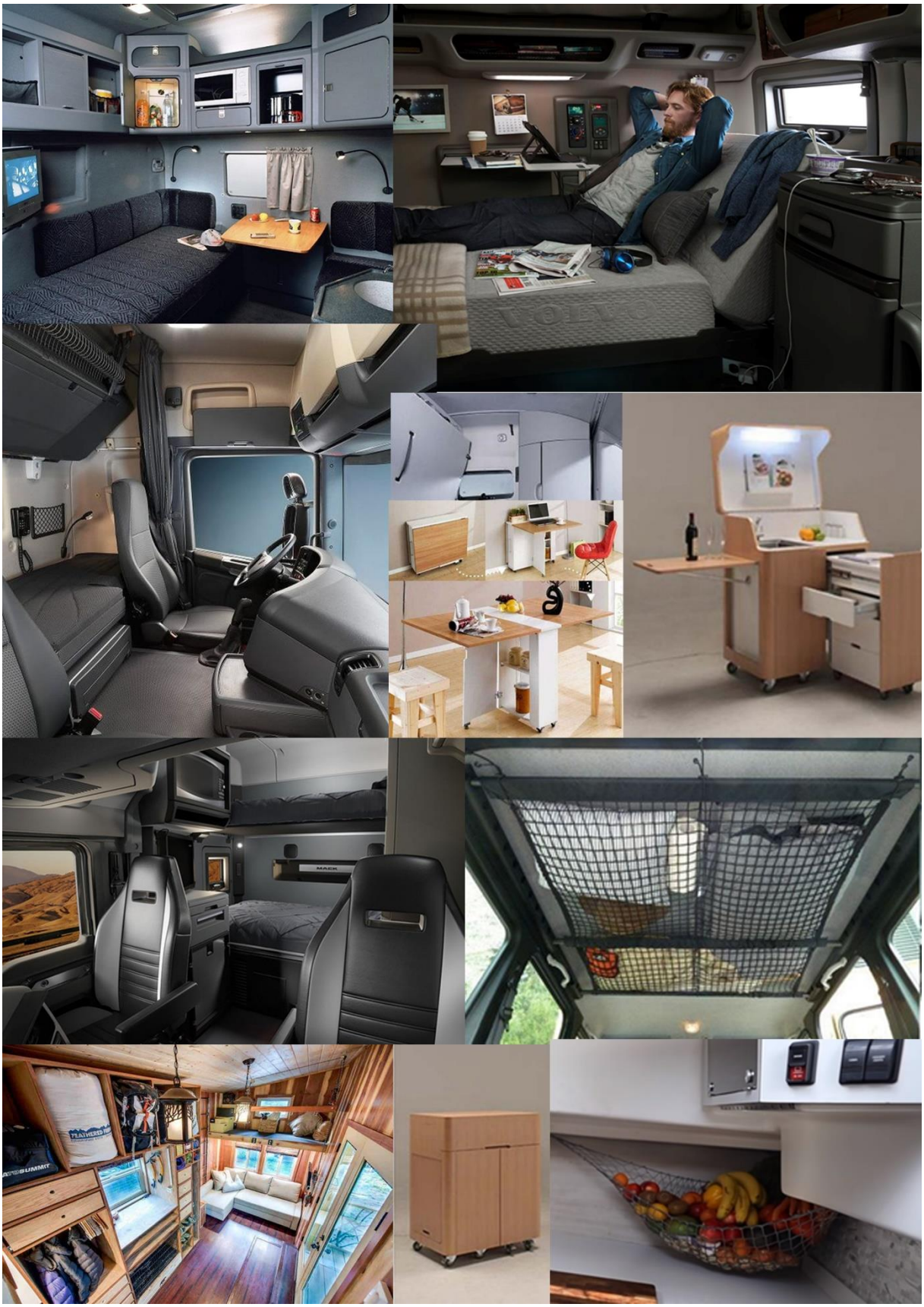


Figure J.1, Space optimization analysis

Layering

To get some design inspiration for space optimization, tiny houses have also been analysed. This analysis proved unsuccessful in terms of space optimization. Apart from the main takeaway to use the entirety of the height from a wall for storage space (figure J.2), no insights were found that could be applied on this RV/LCV hybrid. Tiny houses are simply too large compared with medium LCV's and the space optimization solutions are not applicable. What was found however is an approach for the interior design of a tiny house. This approach could be applied within the concept.

Figure J.2, Optimal usage of height in a confined space (Inhabitad, n.d)

When it comes to the interior design of tiny houses, layering could add dept and character to the overall design of a room (Spaceoptimized, 2018). There are different components that should be considered to create a balanced design. These components are Wall coverings, flooring, pieces of furniture, textures, lighting, wall decors and decorative items.

Looking at the interior design of an LCV, these layers could also be applied to create a coherent design. The slogan of Snoeks is "merged perfection." They create and interior design that merges perfectly with the existing design of the company. Layering could be a helpful step in the aesthetics of the RV/LCV hybrid.

Starting by matching the colours and coverings of the existing interior design of the vehicle. Then a type of flooring can be chosen that matches with the interior colours and is fit for its regular commercial usage. The furniture can be designed in a way to provide optimal comfort for transportation and an at least somewhat comfortable sleeping space. Textures can be a match or an addition to the current interior, potentially with some contrasting colours to make the vehicle stand out more. It should be noted that the interior should have a commercial look and feel, as it needs to be seen as a commercial vehicle in order to get the proper LCV registration. Lighting can be added to provide both a comfortable workspace and a cosier light for recreational purposes. Finally, some slightly decorative additions could be considered that are fit for both commercial and private usage.

Appendix K: RV Functionalities

According to several salesman at the Camper Expo in Houten, the demand for small campervans has been rising, especially in the age category of 25-35. This can be mostly explained by the dimensions of the vehicle. General RV customers are often a bit older and prefer luxury and comfort in the vehicle. They often choose for larger RVs, where the smaller campervans are more in demand by people that are still young and vital and prefer mobility over comfort. The following analysis on functional elements within the campervan will be based on personal findings during a visit at the Camper Expo and commentary by salesman and camper converters at the event.

General layout of large and small campervans.

An example for a common layout in larger campervans can be seen in figure K.1. In this segment, the layout is often relatively similar to large RV's. As this segment is high enough to stand in the vehicle, there is often a shower included in the van. There is a small corridor going through the entire van, connecting a main sleeping area, shower, and main seating area. This seating area can sometimes be converted in an additional bed depending on the size of the RV. The sleeping area could consist out of two single beds or one double bed. Often there is a large storage space underneath this sleeping area.

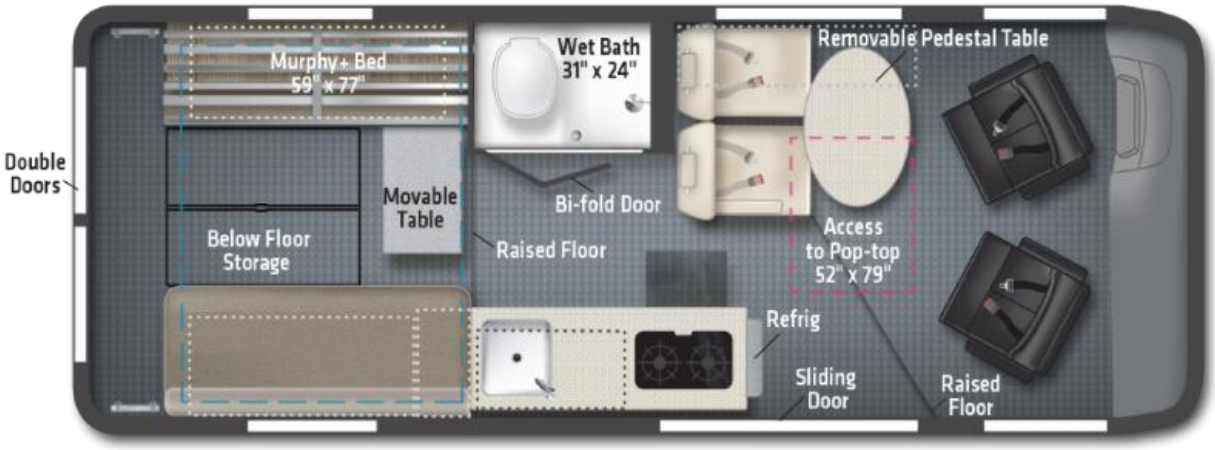


Figure K.1, Layout of a larger campervan (RV OWNER HQ, n.d.)

For large RV's there are tons of different layouts / floorplans available, as can be seen in figure K.2. For the smaller campervans, this layout is much more limited, as a single bed almost fills the entire LCV. Therefore, the interior layout of large RV's will not be analysed any further. The focus of this research will be on the chosen medium K1 campervans and functionalities that apply in this segment.

Figure K.2, There are many different floorplans for large RVs (EuroCampingCars, 2020)

The most traditional and common setup for small campervans has the backseats (that can turn into a bed) located on one side, with storage space and a small kitchen on the opposite side of the single sliding door (figure K.3). This setup was used for most of the campervans that were found during the RV Expo. It also appears to be the most famous design for self-converted LCV's. This layout will be referred to as the side kitchen layout (figure K.4).

Figure K.3, bed with a small kitchen on the opposite side of the sliding door

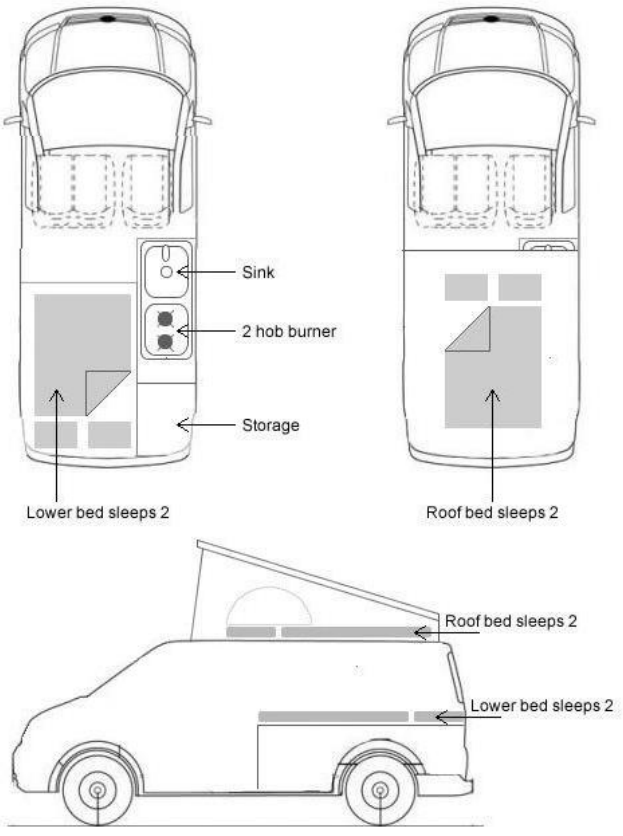


Figure K.4, Basic side kitchen layout

Alternatively, The Ford Transit Custom Nugget and some other RV interiors have the kitchen placed in the back, and the bed in front (figure K.5). This layout will be referred to as the back kitchen layout. In this layout, general usage is less practical as storage space is limited. The side kitchen layout is now often also used as a private car, where this back kitchen layout is used mostly for recreational activities.

This layout is better suited to have the pop-top roof (A roof that can be folded upwards to create room to stand or sleep, as also seen in figure K.4. This will be further discussed later in this Appendix) located with the high end in the rear. The rooftop bed can be accessed from the rear end of the vehicle without walking over any other beds.

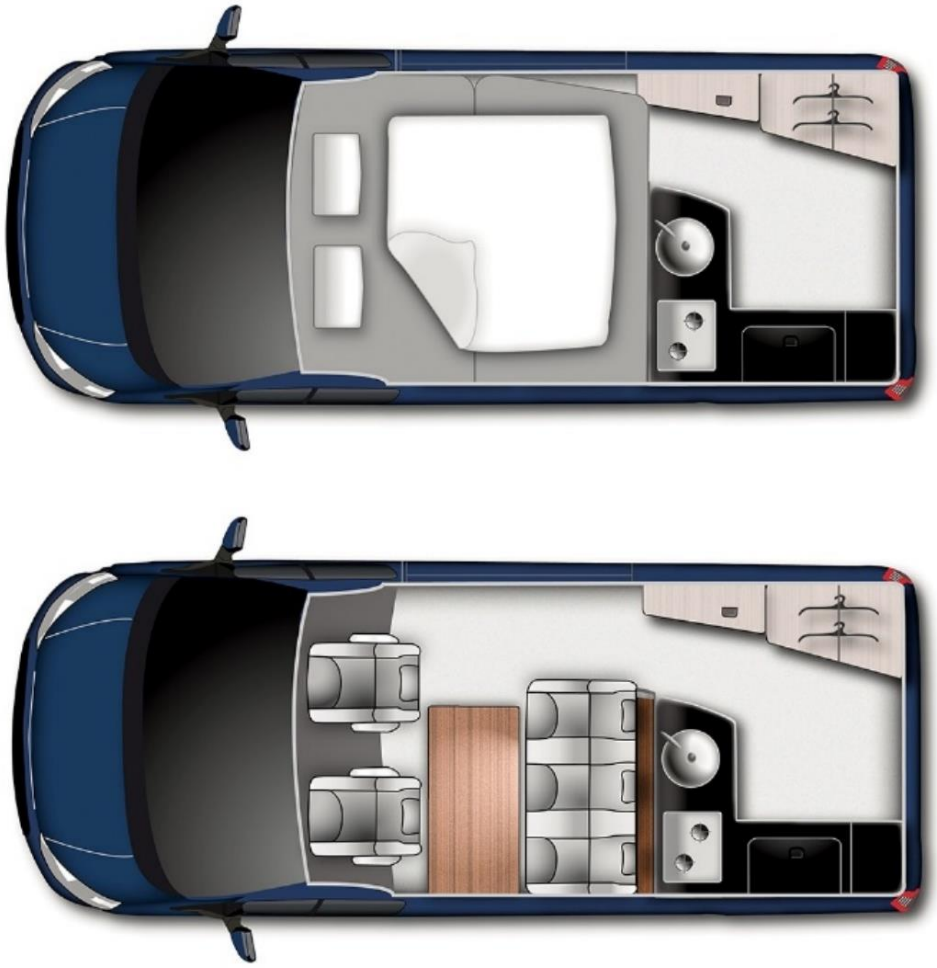


Figure K.5, Ford Nugget campervan layout

For this concept, the general commercial usage remains the most important. Therefore, the storage space at the rear end of the vehicle should be as optimal as possible. Preferably with no fixed structures that could intervene with regular commercial usage. It is also desirable to use the full width of the vehicle for seating as the vehicle will be used much more frequently for transporting people then for recreational usage. Creating a corridor between the second-row seat and the back of the van is convenient for recreational purposes, but for regular business it creates a less comfortable seating area without many benefits.

Seating and Sleeping

Sitting and sleeping is without a doubt the most important aspect of the RV interior. The seating arrangement should be logical and comfortable. Rotating chairs are very common within the RV interior to involve these seats with the rest of the rest of the interior make optimal usage of the space. The second seating row is often used to transform into a bed. It is important that both the seating and sleeping function offer a comfortable experience. It should allow passengers to travel long distances at daytime and offer good night's rest during the night (figure K.6).

Figure K.6 Ford Nugget in seating and sleeping position

Transforming the seat into a bed can be done in different ways. The most common way is by lowering the backrest and adding a pillow at the back of the van (figure K.7).

Figure K.7 folded backseats with additional pillow at the back

Other versions: often with a rail in the floor, have an additional cushion at the back of the backrest that can fold down (as can be seen in figure K.8).

Figure K.8 The foldable cushion is attached to the back of the backrest

The benefit of this configuration is that the entire backseat can slide to any desired place, and storage space could be adapted (figure K.9). This only applies when the seat is not folded out into a bed, as there is often a fixed location at which the bed should be placed.

Figure K.9 The backseat can slide over a rail

The system in figure K.10 is a little more complex. As the back cushion folds backwards, the seat completely rotates forwards on a hinge at the front, and the backrest folds forwards into the original seat's location.

Figure K.10 forwards folding backseat (Weekender Van Life, 2019)

With this system, the back of the backrest and the seat is used for the bed. The system is more complex and likely to be more expensive, but it allows different ergonomics to be used for the seat and the bed. The shape could be completely different to ensure optimal comfort.

Finally, there are also some more modular campervan concepts like Ventje (figure K.11). This allows more freedom in the way it is used, but the seats will not be approved for regular driving, so this concept could only be used for two people. The idea of the modular setup with different couch, bed or outdoor possibilities could however be interesting to consider during the ideation phase.

Figure K.11 Modular Ventje layout

Roof Pop-top

All medium campervans at the exhibition (as well as most DIY campervans) have Pop-tops installed. This is a mechanism that allows you to lift the roof of the vehicle up and transform it into a tent. The space that is created this way allows the user to stand in the vehicle. It allows daylight to shine through your campervan and gives a more spacious feeling. During the night, a platform can be lowered from the rooftop, and this can be used as an additional bed, as can be seen in figure K.12.

Figure K.12 Pop-top bed (Reisemobile Scholz, n.d.)

These Pop-tops come in many different sizes and orientations, as can be seen in figure Fixme. The most common pop-tops are diagonal, as there is one strong pivot point at the lower part that functions as a hinge. Several companies placed the high end of the rooftop tent at the rear, where others placed it at the front of the van. The direction is often influenced by the interior layout of the van. If the bed is located at the back of the van, the high part of the tent can mostly be found in the front, as this is an easier accessible place to enter the rooftop bed. Otherwise, it would be required to walk over the bed every time you want to enter the rooftop sleeping place. Therefore, the high part at the front of the vehicle is the most common layout.

Insulation & Heating

All vehicles at the expo had been isolated. Often there was an additional floor panel with insulation, and all the doors and structures have been filled with insulation. When the roof is closed, the heat can remain inside the vehicle quite well. When the rooftop is popped open, the rooftop tent could cause some issues as the fabric is very thin. Therefore, most RVs had an optional package to install a diesel-powered heater in the RV. The price for this addition ranged between 1200, - and 1400, -

Within RV's there are two types of heating that could be installed.

The most commonly used addition is a diesel-powered air heater. The heater is installed under the LCV and directly connected to the fuel tank. The outlet is placed under the passenger seat, as can be seen in figure K.13. Compact diesel-powered air heater will consume around 0.1 litres of diesel fuel per hour. As a small van does not require continuous heating, the campervan could be warmed up for a day with about one litre of diesel fuel.

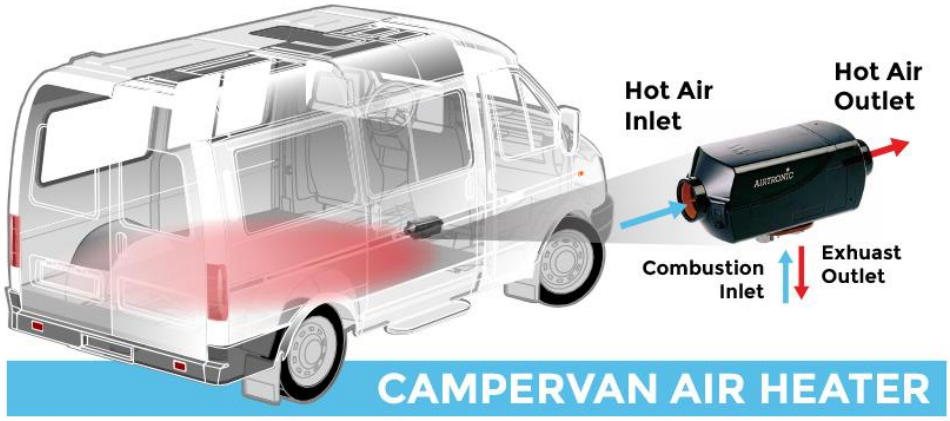


Figure K.13 Diesel powered air heater (ParkedInParadise, n.d.)

An alternative option is a combined Hob & Heater. This is a hotplate that can be used for cooking your meals, but with the lid closed turns into a heater, consuming around 0,09 litres of diesel fuel per hour. An example of this is the XC Duo (figure K.14). This product costs around 2000, - euros.

Figure K.14 heating system Wallas XC Duo (Wallas, n.d.)

This heating package is often a possible addition. It should be noted that this feature is not really required if the campervan is only used during high season. If it is only on rare occasions that the van is used for recreative / sleeping purposes, a simple electric heater can also be used to warm up the vehicle.

Cooking Facilities

Practically every RV in the expo had a build in cooking facility.

These cooking facilities come in several different forms and sizes. The main forms are the side kitchen and the rear kitchen. The rear kitchen can often be used from outside, as it often comes as a slide out drawer.

There are multiple versions of extendable drawers that can be installed at the back of the van. These extendable kitchens can come in many different sizes, as can be seen in figure K.15.

Figure K.15 possible cooking installations at the rear or the van

The side kitchens are located inside of the van, often on the opposite side of the sliding door. This kitchen is often found with two stoves and a lid to cover it up. With the lid on the side of the van can be used as a small countertop, although there is often an option to attach a side table next to the kitchen. This is also more convenient for cutting and preparing the food, after which is it used as the dining table. Examples of the side kitchen can be seen in figure K.16.

Figure K.16 possible cooking installations at the side of the van

Water supply

Often a sink can be found inside the van. The fountain is often foldable, and the sink can be closed with a countertop that could be used as side table (figure K.17). There is often a container for both clean and wastewater located in a small storage space underneath the sink.

Some RVs also have a water outlet on the outside of the van for cleaning or potential showering.

Figure K.17 A sink in the side kitchen layout (Goboony, 2020)

Power outlets

Consumers want to be able to use power within the vehicle. Charge their phones, turn on some lights, etc. Therefore, there are often several power sockets and USB ports installed throughout the campervan. When arriving at a campground, the RV is often connected to the power grid (figure K.18).

Figure K.18 Connecting to the campground power grid

According to multiple salesmen at the Expo, there is a large request for internal power, to allow off the grid camping. Customers do not want to be dependent on a specific campground with power supply. Therefore, additional batteries can now be placed under front seat. This is often installed under the rotating platform (figure K.19) and can also be applied for a double seat.

Figure K.19 Placement of the batteries

Storage

An important aspect that should not be forgotten is storge. Especially in tiny spaces, room to store your personal products, clothing and utilities is very important. Some concepts really strive in this aspect. In figure K.20 a campervan can be found that could store up to ten shopping crates, four chairs and a toilet. Other campervans are not that ideal when it comes to storage options. In figure K.21, a concept can be found in which, when the bed is being used, barely any storage space remains. The backseat folds down, and the only remaining space is the small part underneath the bed, in which the entire sliding system and power cords are located. It would be impossible to store even one backpack here.

Figure K.20 Large storage compartment

Figure K.21 small storage compartment

In the side kitchen layout, there are often many smaller storage spaces at the side of the vehicle, as can be seen in figure fixme. This storage space is desirable, but not practical for commercial usage as the cabinets are fixed and the storage space is limited to specific dimensions.

Certain vehicles had large storage spaces and seemed ideal to go on a road trip, where other campervans seemed to have large design flaws where there was barely any storage space after the seats were converted to beds. The dimensions should also be considered.

As our concept will mainly be used for commercial purposes, the storage space is one of the most important things to consider. Even for recreational usage, there should be enough room for storage. This should be listed as one of the top aspirations during the ideation face.

Livingroom area

One thing that can be found in practically every RV is a place to sit with a small group, possibly around a table. This is the place to play games, eat a meal or sit down and relax if the user does not want to lay down on a bed yet. Possible Livingroom setup can be seen in figure K.22. These setups can be very small, but the possibility to sit down with a group is high in desirability.

Figure K.22 living areas inside the vehicle

The table that is used for this seating area can often slide in a rail on the side of the vehicle or on a kitchen module. It can be hidden on the side next to the bench, or in the door cover.

Potential additions

There are also possible additions that could be added to the vehicle in a later stage.

An Off-road tailgate tent (figure K.23) could be used to create a small addition to the space inside of the vehicle and could for example be used to get dressed more easily or cook outside of the vehicle when it's raining. It can also be used to store some cargo when the storage space gets limited in case the bench is folded out into a bed.

A fold-out awning (figure K.24) is a common addition to most campervans. It allows users to sit outside even during bad weather, or to be protected from excessive sunlight. Users could also use the awning to cook outside of the vehicle while maintaining a roof above their head.

Figure K.23 Tailgate tent (Reimo Pan, n.d.)

Figure K.24 Awning (Vanbreak, n.d.)

Railing and folding systems

All vehicles had some sort of railing/folding system to turn the seats into beds and to create an extra sleeping place in the rooftop tent. These systems can be seen in the figure K.25 and are taken into consideration during the ideation phase.

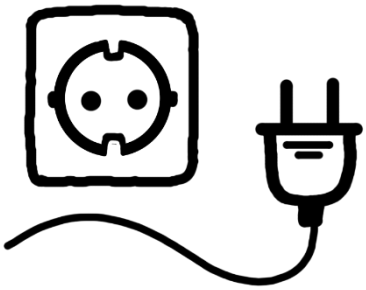
Figure K.25 Folding and railing systems at the camper expo

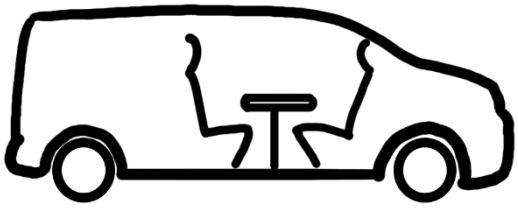
Appendix L, Additional Functionalities

The following functionalities are considered “nice to have” for an improved user experience.

Power outlets

Power outlets could allow passengers to charge their phones or use tools within their vehicle, which could reduce their dependency of other power supplies and could offer them a better user experience. Implementing power sockets is also important for recreational usage. It allows the user to use power without being dependant of a campground power grid. This can be used to have light and power in the vehicle when the engine is turned off and is an absolute should have when the vehicle is used for recreational activities.



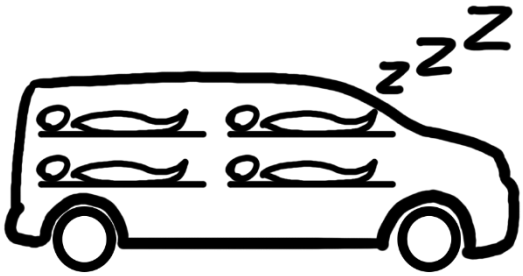


“Livingroom” area

A space where people can sit down at a table would greatly enhance the recreational experience. It offers users a place to sit and eat or play games, and a place to stay during bad weather instead of forcing them to lay in their bed.

Ability to stand

The possibility to stand in the vehicle creates much more ergonomic comfort for the users, especially if they intent to spend a longer period of time in the vehicle. It greatly enhances their overall recreative experience as the freedom to move around in the vehicle increases.



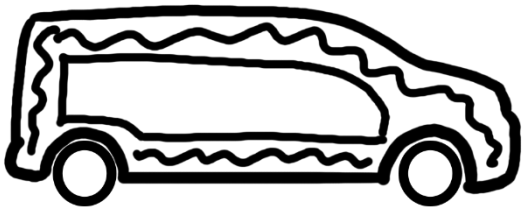
Sleeping space for three - four people

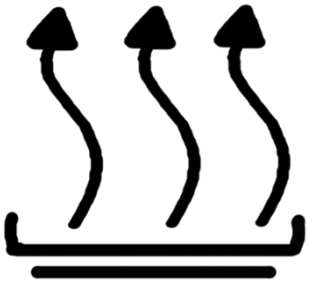
Almost every RV during the Camper Expo in Houten offered this feature, although this can be explained by that fact that the ability to stand is a requirement, so installing a pop-top for additional sleeping places is an easy choice. For the crew-camper, one of its main strengths compared to a regular LCV is the fact that it can transport more than two people. As 43.5% of the German short-term campers goes with a group size of three or four people (Westtoer, 2011), offering them a place to sleep inside the vehicle could increase the desirability.

The following functionalities are considered “could have” for a more personalized vehicle.

Insulation

Every campervan at the expo was fully insulated. This makes sense as a compact vehicle with thin, sheet metal walls like this easily loses its heat. As the vehicle now offers users a place to sleep, proper insulation could be included to make the sleeping experience more comfortable and keep possible heating costs at a minimum. As this vehicle is aimed for mostly commercial usage and it is unlikely to be used for camping in the winter, this should not be in the standard version.





Heating

Heating can be done is several ways, by fully integrating a diesel-powered heating system or by simply plugging in a small electric heater. The preferred option is dependent on the expected usage. How often does the customer plan to use the vehicle for recreational purposes and during which seasons? An integrated heating system could be a possible add-on for the customer to choose.

Cooking facilities

A fixed cooking facility is required for RV registration, but as the main purpose of this vehicle is commercial usage, this is not required. A fixed cooking facility could interfere with the regular commercial usage and is not recommended. It could however be implemented as a modular part, depending on whether the customer is interested in the ability to cook inside of the vehicle or not.

Water supply

Just like the cooking facility, water supply is required for a vehicle to be registered as an RV. As this is not the case for this vehicle, it should again be considered if a water supply is something you want to install. As the main purpose of this vehicle is commercial usage, a fixed water supply could again interfere with the regular commercial usage. It could however be implemented as a modular part, depending on whether the customer is interested in the ability to have running water within the vehicle or not.

Appendix M: Snoeks Capabilities

A short analysis of the current capabilities of Snoeks Automotive. These skills, production techniques and material knowledge will be taken into consideration during the conceptual phase. The project will however not be limited to these current production techniques.

Snoeks automotive is specialized in the interior design of LCV's, with a focus on Partition Walls, Crew cabs and Flex cabs. The strength of these concepts is mostly within the fiscal benefits. They allow customers to get large tax reductions on the vehicles while offering a good combination for commercial usage and possible private usage.

Snoeks Automotive has their own static testing facility. They are certified to do their safety testing internal.

Snoeks has their own distribution centre in Czech Republic. This is where they create complete packages that could be sent to their Dealer Network or After fit locations. These are certified locations that are allowed to build in Snoeks modules in existing LCV's.

Snoeks also has direct contact with certain OEM's. These sales are significantly higher, as the brands sell their products themselves and can build them in at factory level. It would be beneficial to place the concept in this OEM market as well, but for RV's this could be a difficult task, as most OEMs do not create their own RV versions. Volkswagen is currently the only OEM that makes their RV version of the VW California in their own factories.

Snoeks also has collaborative project with some OEMs, for which they create special editions of certain vehicles. For these products they can sometimes make some exterior adaptations as well, like the black rims and side-steps on the Ford Transit Custom Platinum Edition (figure M.1).

Figure M.1 Ford Transit Custom Platinum Edition (Autoweek, 2020)

Snoeks uses many different production techniques and has a scouring department that is continuously looking for new trends and innovations that could be applicable within their branch. Below is a list of production techniques they are currently applying

- TPO thermoforming (Flooring design)
- Thermoforming
- Injection Moulding
- Sheet metal bending
- Thermocompression
- EPP moulding
- Powder coating

The materials (figure M.2) that are often used with these production techniques are:

- ABS
- HI ABS (High Impact ABS)
- COMPAX (High performance composite made with PET)
- EPP (Expanded Polypropylene, looks like black Styrofoam)
- TPO (Thermoplastic polyolefin, Rubberlike properties)

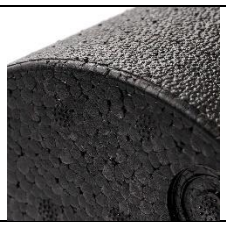
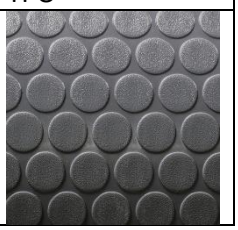
ABS	HI ABS	Compax	EPP	TPO
				

Figure M.2 The materials used in the production for Snoeks Automotive

Appendix N, Possible Idea Directions

In this appendix, the main idea directions that were generated (using the Morphological chart combinations as seen in figure N.1) are shortly explained with a few expected pros and cons.

The choosing process with the use of Harris Profiles was based on this level of idea development. There are still many uncertainties within these ideas, but they were expected to be elaborated enough to make a first rough estimation about the most viable idea directions. The chosen direction would have to be verified on the riskiest assumptions before it can turn into a concept.

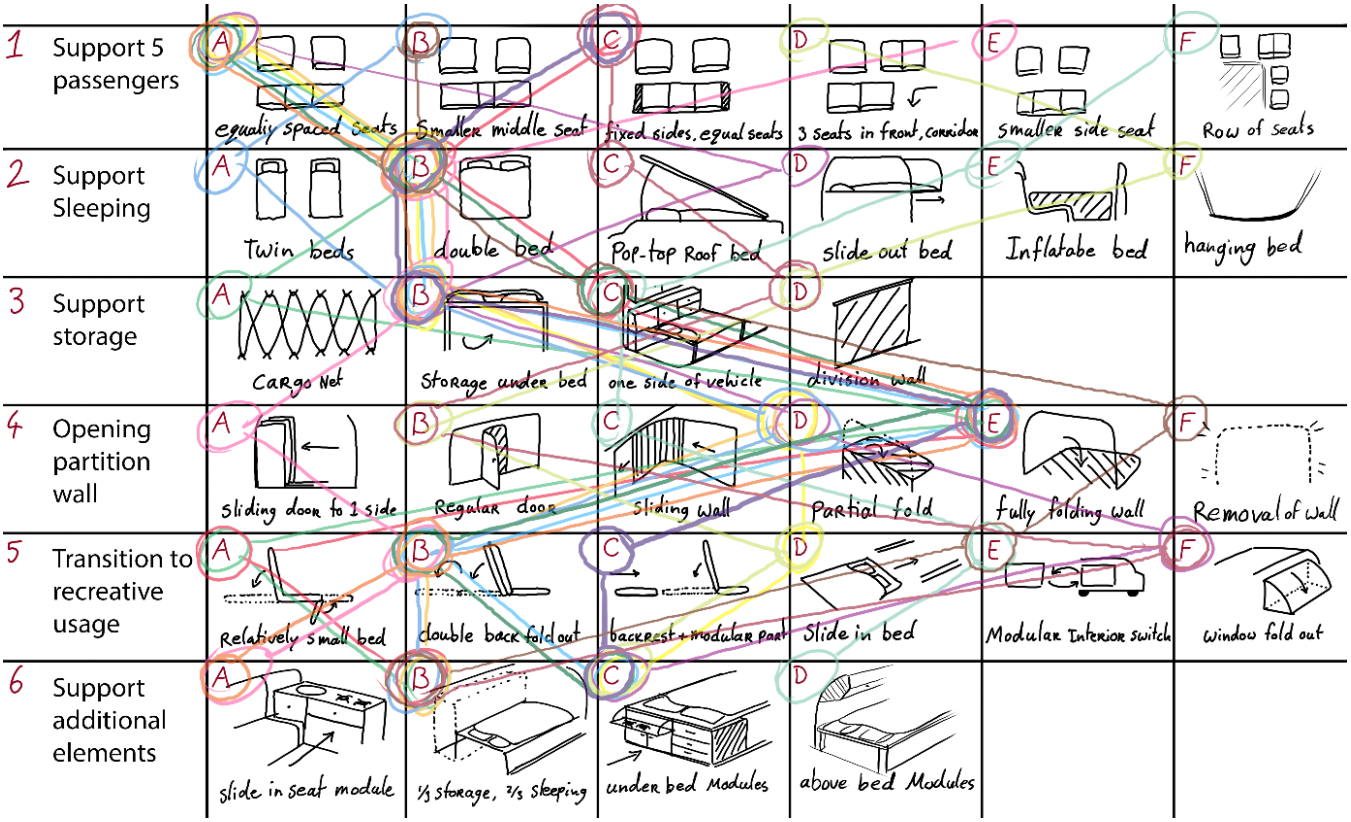


Figure N.1 Morphological chart with combination lines

Folding backseat

This idea direction (figure N.2) covers the basic idea of a backseat that can fold backwards into a bed. The sides of the bench frame remain in position to avoid any tapering of the bed and to create a strong construction so the partition wall could easily meet the ISO safety regulations.

Several versions of this foldable backseat are already in existence for the RV market, but not with within the commercial market with an integrated partition wall.

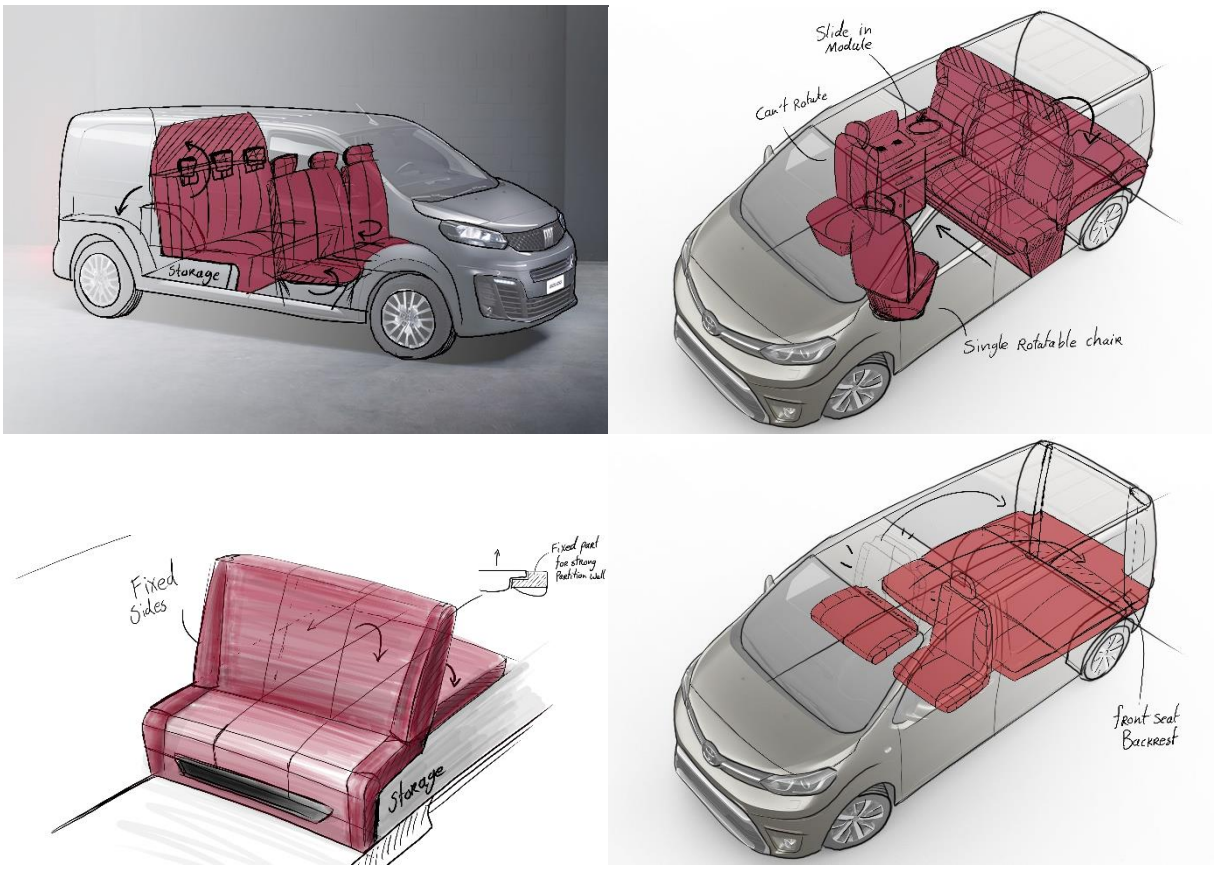


Figure N.2 Folding backseat idea

Pro's

No issues with tapering walls

A small storage frame could remain in place or be modularly replaced for additional modules like cooking facilities.

Con's

Slightly small bed

Not a lot of space for storage

Not a lot of space for modular components

Folding backseat partial

This idea direction (figure N.3) builds on the foldable backseat but allows users to choose whether to fold the entire bench or only 2/3rd. This way, they could choose to install additional modules or keep a fixed cargo storage on the side of the vehicle. The principle would work the same way as current car seats folding forwards in one large and one small part, but instead it would fold backwards and create a sleeping place.

It could approach a new target market for customers that have multi-day jobs or those who need to take a break during or after a long workday.

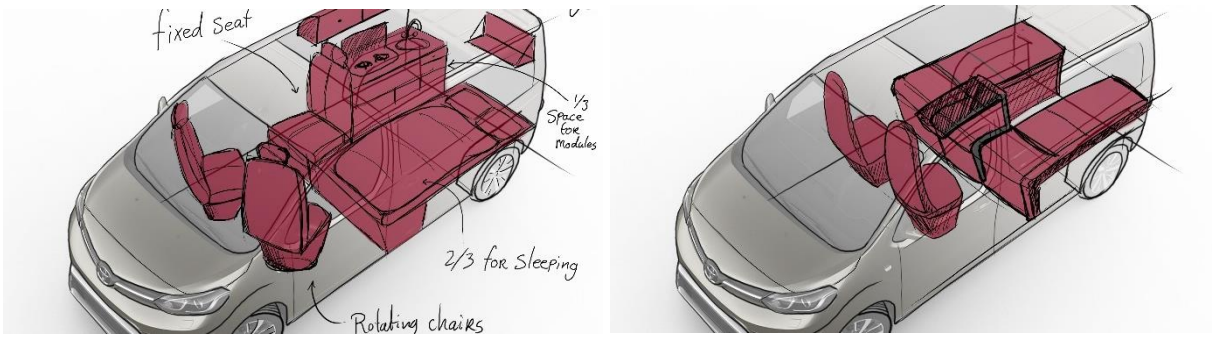


Figure N.3 Folding backseat partial idea

Pro's

Fast transition, some cargo can remain in place

Ability to add modules to the side or middle of the vehicle

Possibility to create two single beds

Con's

Relatively small storage space

Small bed(s) if partially folded.

Partial split requires additional safety measures to separate cargo from passengers.

Elevated folding backseat

This idea direction (figure N.4) builds on the foldable backseat idea direction, but with a higher base. This creates more space beneath the bed to allow more storage, and this system can be used to make it physically impossible to use the backseats without the partition wall.

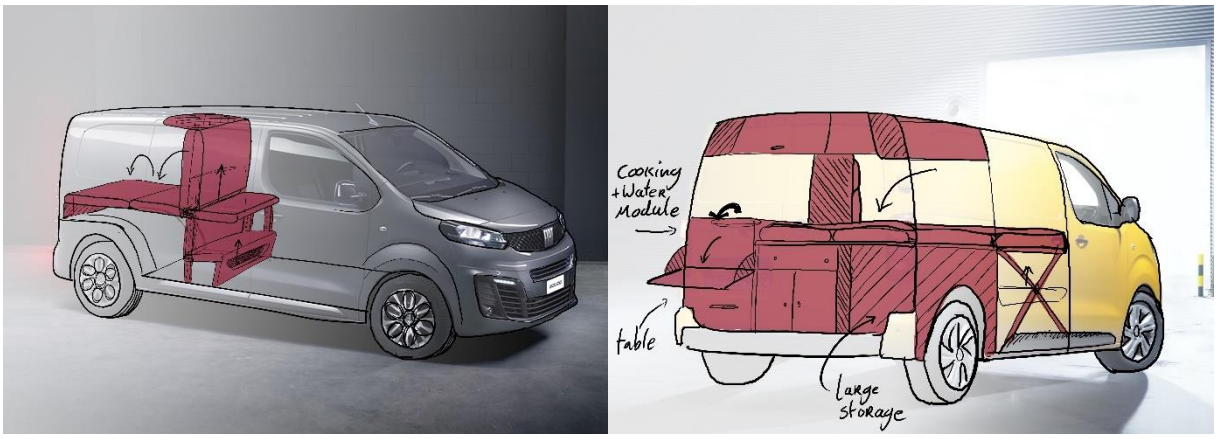


Figure N.4 Elevated folding backseat idea

Pro's

Relatively large storage space

Large space for rear modules

Commercial usage physically not possible without partition wall

Con's

Complex mechanism, which comes with a large amount of development cost

Low headspace above bed

Cannot sit in sleeping position

Flex cab +

This idea direction (figure N.5) has the same functionalities as the basic foldable backseats but has an additional feature that allows it to fold forward like the current flex cab. This feature allows users to have both an improved recreational and commercial experience, as the setup can be optimised for three different forms of usage: sleeping, seating & cargo transportation.

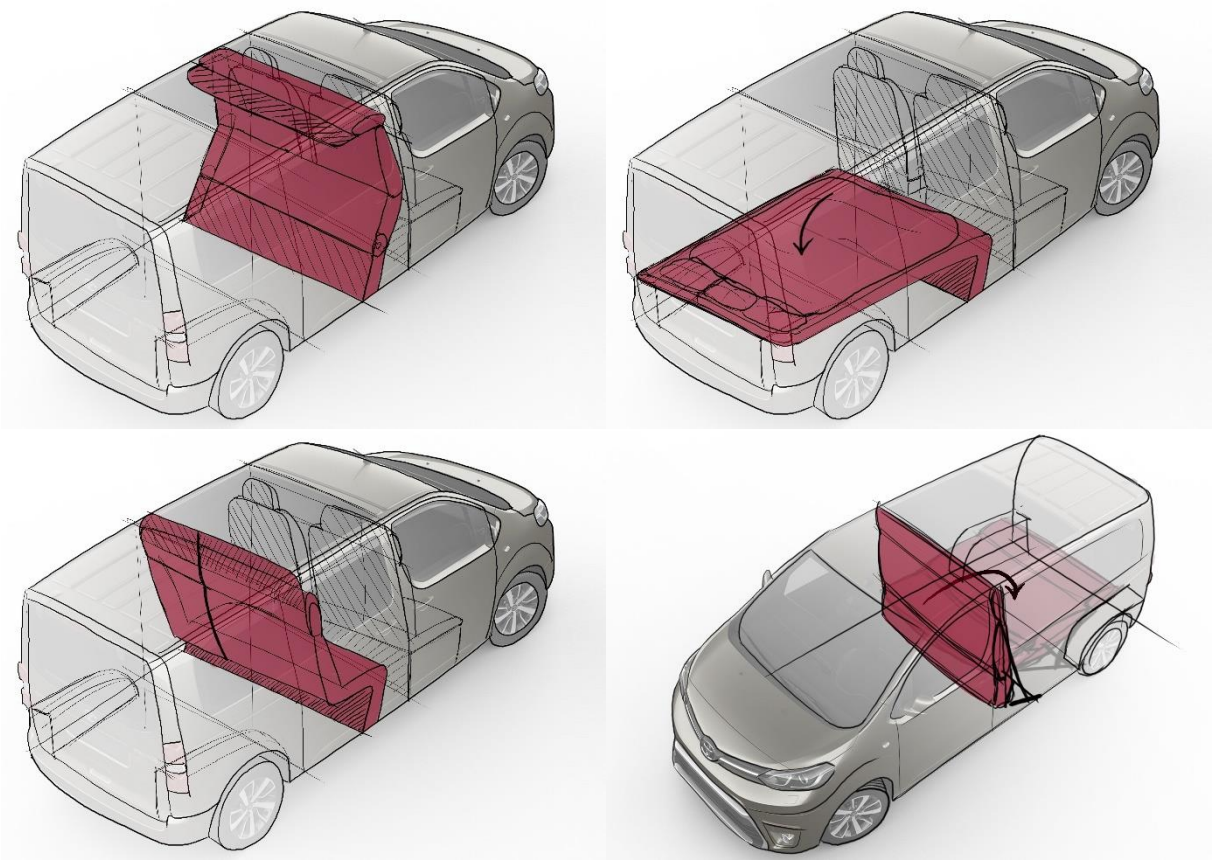


Figure N.5 Flex cab + idea

Pro's

Largest commercial cargo space available

Additional feature to existing product

Part of development can be integrated in regular flex cab

Con's

Complex system

Not a lot of space for additional modules

Flex cab + Partial

This idea direction (figure N.6) builds on the flex + idea direction. Rather than creating three separate positions (cargo transportation, seating & sleeping), this idea allows possible combinations. By dividing the flex cab in 1/3rd and 2/3rd, different types of usage are possible. A kitchen module could be installed behind the seat, allowing users to use a smaller bed with a kitchen on the side. This module could even be larger by sacrificing one seat an keeping it in the flexed position. The possible switches can also allow users to bring more cargo like bicycles without sacrificing all passenger seats.

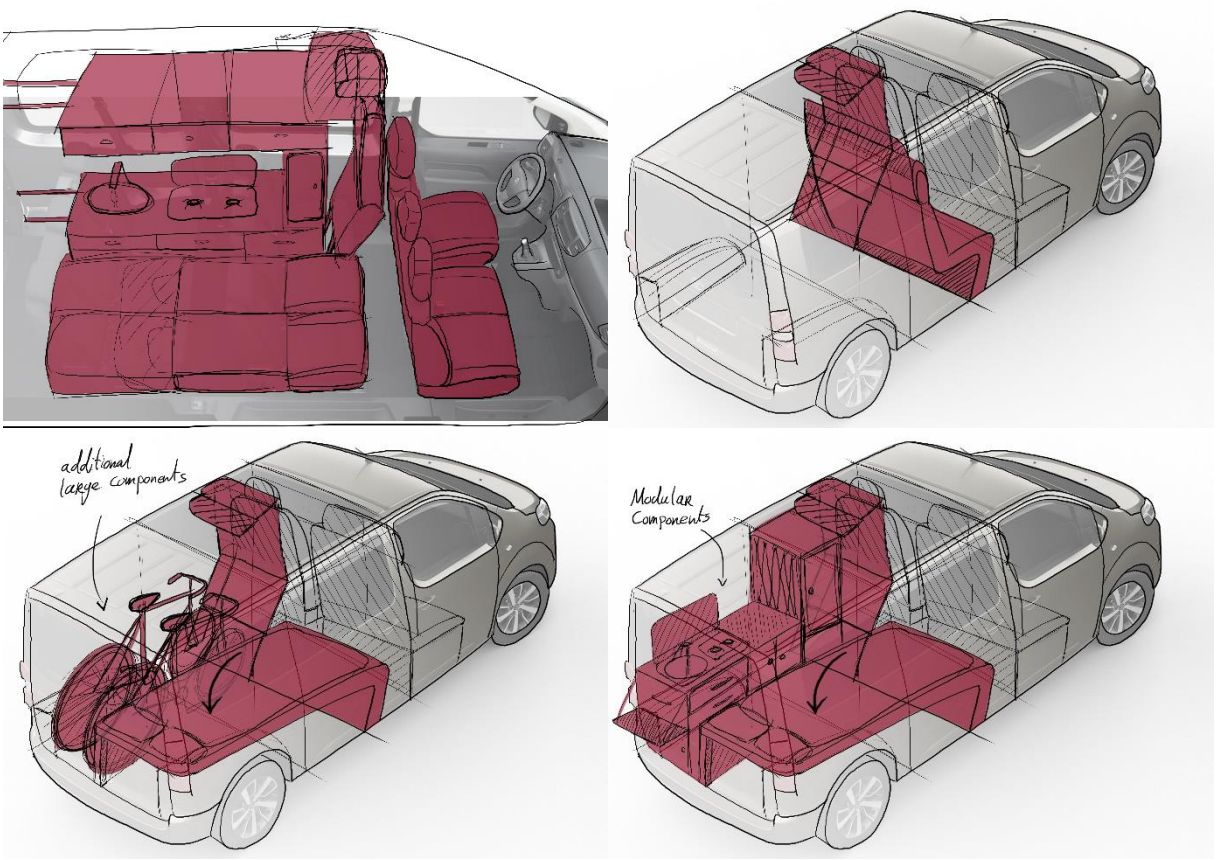


Figure N.6 Flex cab + partial idea

Pro's

Largest commercial cargo space

Optimal customer choice for type of usage

Possibility to add modules on the side of the vehicle

Con's

Additional complexity on top of flex +. Large amount of safety testing required

Partial split would make the system even more complex, and the bed will only fit one person comfortably. (<1000mm in width)

Partial split requires additional safety measures to separate cargo from passengers.

Retractable flatbed flex

This idea direction (figure N.7) comes from the idea to keep the bed as flat as possible. Think of a hammock, but applicable within a van and with a bit more comfort. When implemented in a flex cab, the space in the back of the vehicle should be large enough for a sleeping pace and no additional commercial space is wasted in the process.

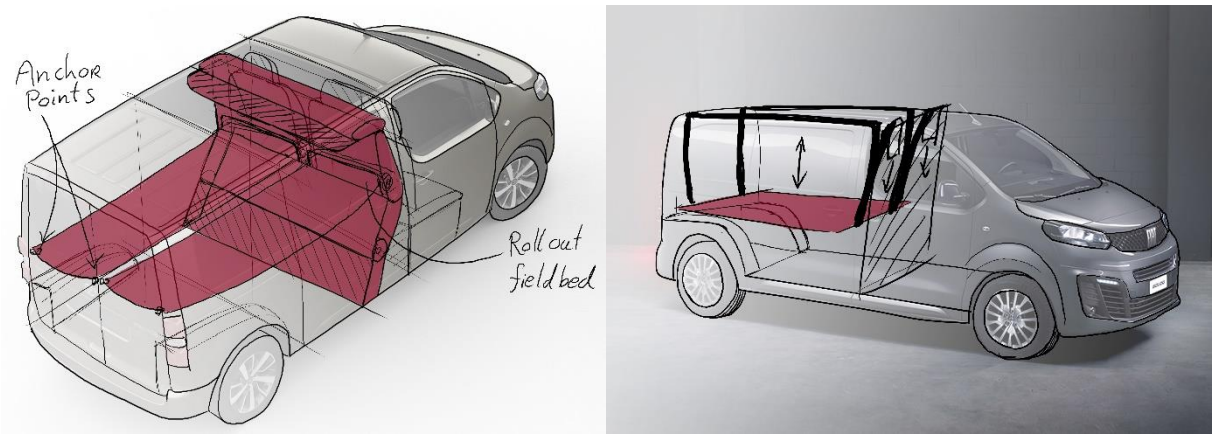


Figure N.7 Retractable flatbed flex idea

Pro's

Largest commercial cargo space

Additional feature to existing product

Flex cab system can remain the same

Fully retractable to the ceiling or in flex cab

Con's

Not very comfortable sleeping experience

Complete split between sleeping and "living" area

Accessible only by going outside

Additional system to implement for ceiling version

Pop-top fixed cargo

This idea direction (figure N.8) has a focus on keeping the interior of the vehicle unchanged. By adding a pop-top roof to the vehicle, users could sleep above their cargo in a clean and separated space. By adding a possible doorway in the partition wall, an internal connection between the passengers and cargo could be created. Users could install modules in the back or keep their cargo in position depending on their preferred usage.

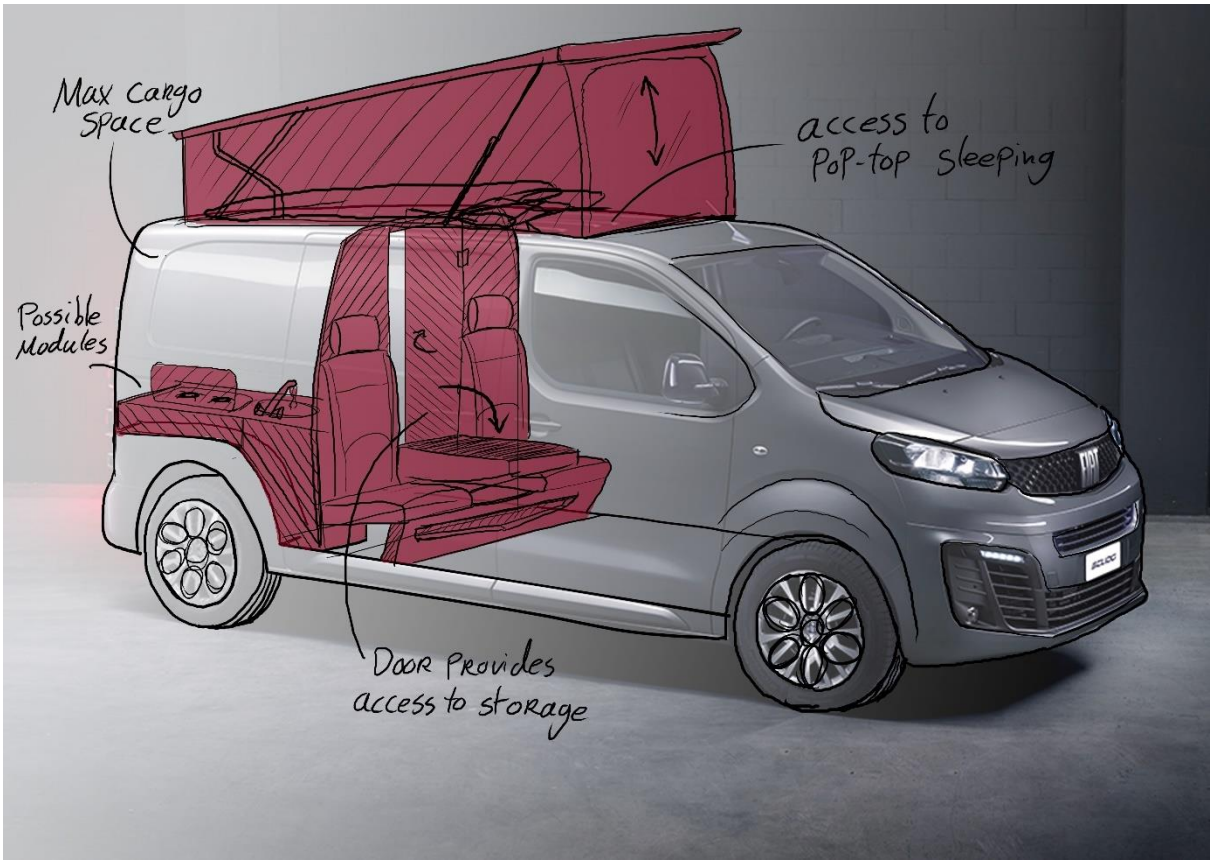


Figure N.8 Pop-top fixed cargo idea

Pro's

Cargo can remain in place

Maximal storage space

Possibility to stand in the vehicle

Access to storage from inside the vehicle

Con's

Loading on rooftop is no longer possible

Partition wall cannot be attached to rooftop

Clear split in vehicle with a narrow doorway in-between

Unlikely to be implemented by OEM's (With exception of VW)

Frame for additional mattress A

This idea direction (figure N.9) comes from the idea to keep the impact of the recreational possibilities to a bare minimum during commercial usage. The vehicle should only have an interior structure that could be used to place an externally saved matrass. This creates an optimal commercial usage and a possibly more comfortable sleeping experience but makes the switch between the types of usage more complex. The frame could be folded out from the sides or as a retractable construction in the bench frame.

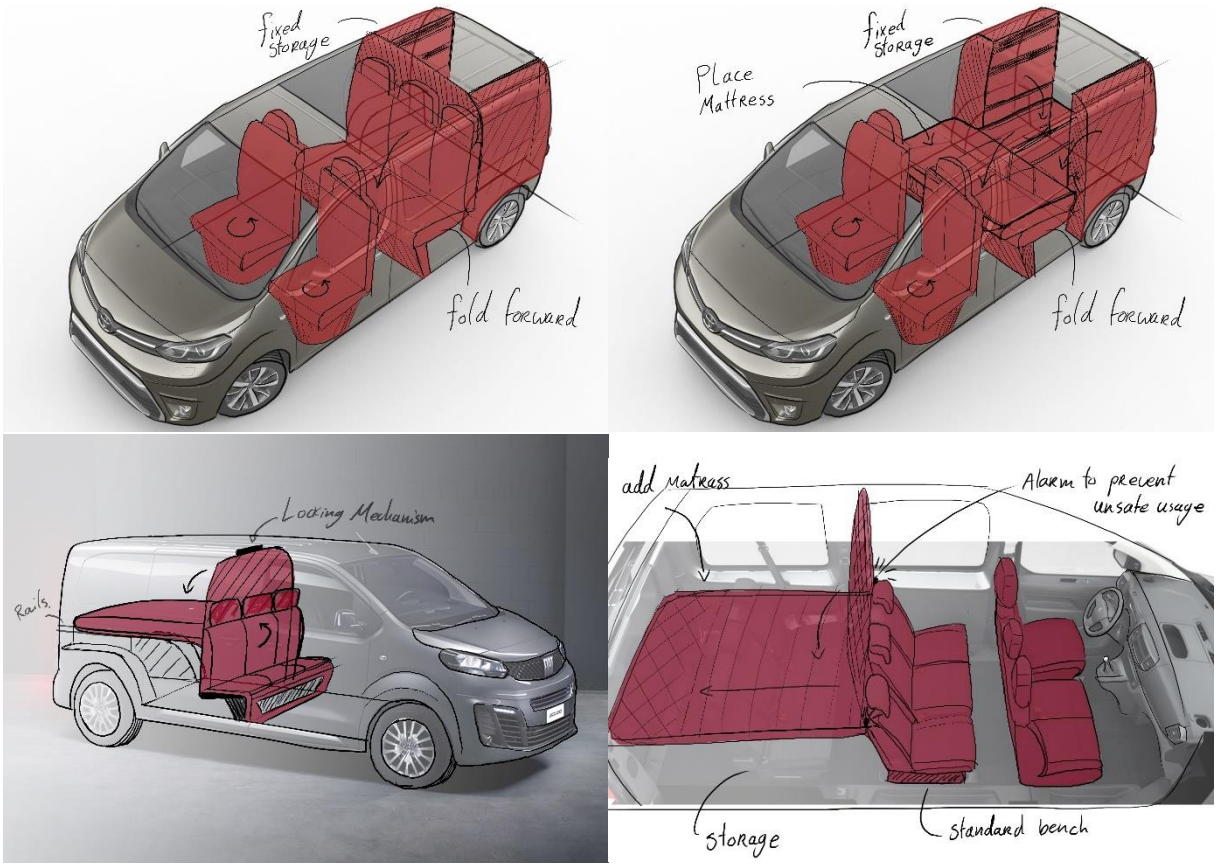


Figure N.9 Folding frame for additional mattress idea

Pro's

No issues with tapering walls

Some cargo can remain in place

Con's

Transition requires multiple steps

Requires external storage of mattress

Little headspace above the bed

Bed might be smaller between panels

Mattress is shaped differently

Rentable modules

This idea direction (figure N.10) is based on the idea that commercial and leisure activities are not often done simultaneously. Leisure activities like camping or hiking are often planned. For this idea, the entire module is being replaced with a complete RV module. This could be done in the form of a rental module, as the module will only be used a few times a year and several people with the same LCV platform could use the same module.

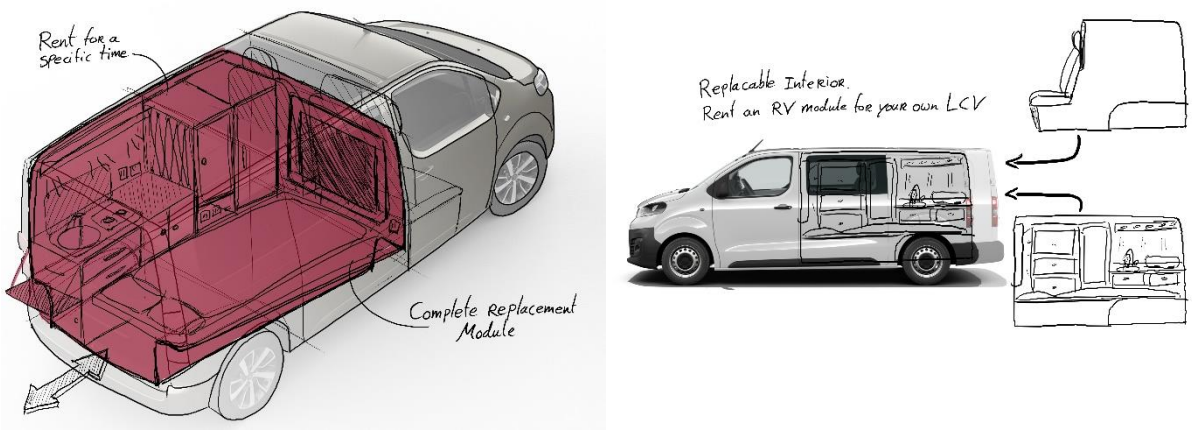


Figure N.10 rentable modules idea

Pro's

No interference with commercial usage

Luxury RV interior & experience

No personal storage required

Con's

3rd party required to rent out modules

Transition needs to be planned and done in specific locations

Vehicle needs to be completely empty before transition

Does not match with Snoeks current market (sales only)

Against regulations, Commercial registered LCVs would not be allowed to drive with this module.

Different cargo dimensions

This idea direction (figure N.11) is an out of the box idea that alters the current type of additional seat implementation. Rather than splitting the cargo area in the width, it could also be split in the length. This way it could still be possible to transport longer products or goods, and offer seating

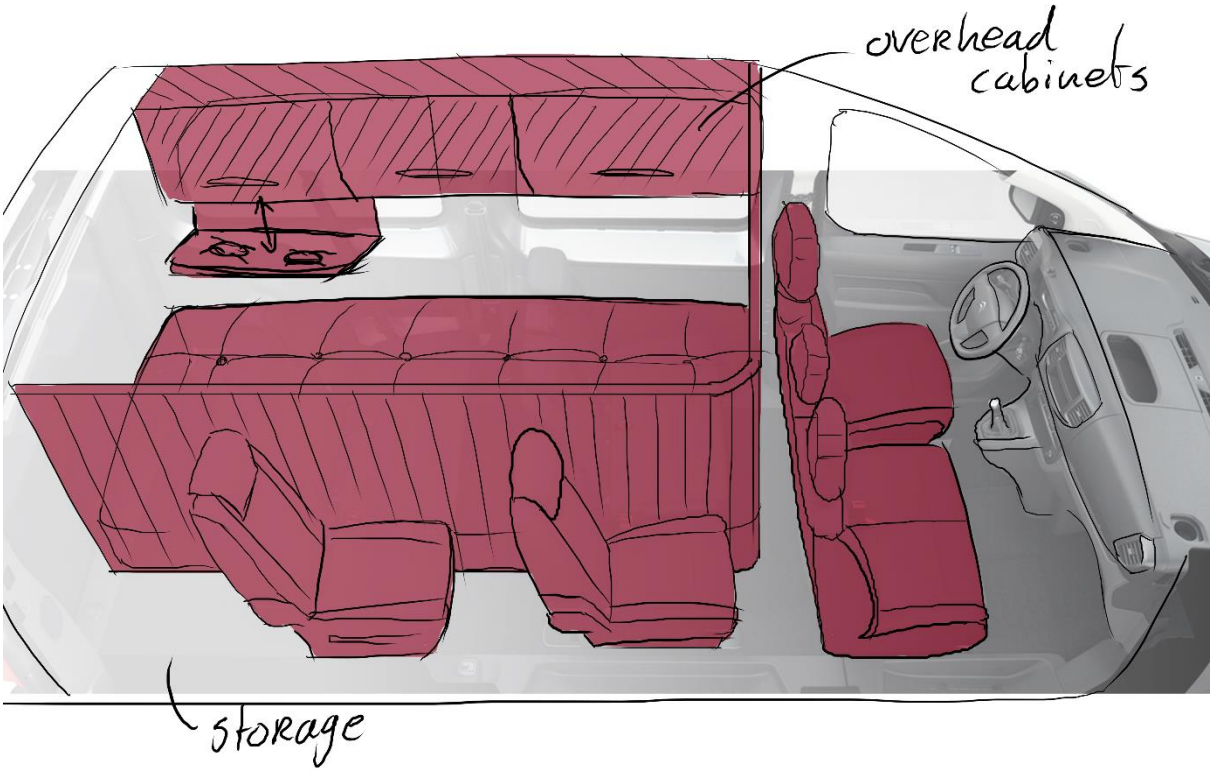


Figure N.11 Different cargo dimensions idea

Pro's

Full loading dept could target a new market

Bed can be placed without any transitions

Con's

Cramped seating positions

Max five chairs possible if three seats are installed in front

No "living room" area possible

Many uncertainties considering fiscal regulations

Extending windows A

This idea direction (figure N.12) is mainly based on using the exterior space as part of the sleeping area. Windows can fold/slide out and space is created for your feet. This way it is possible to sleep in the length or width direction without having to adapt the bench frame on the second row.

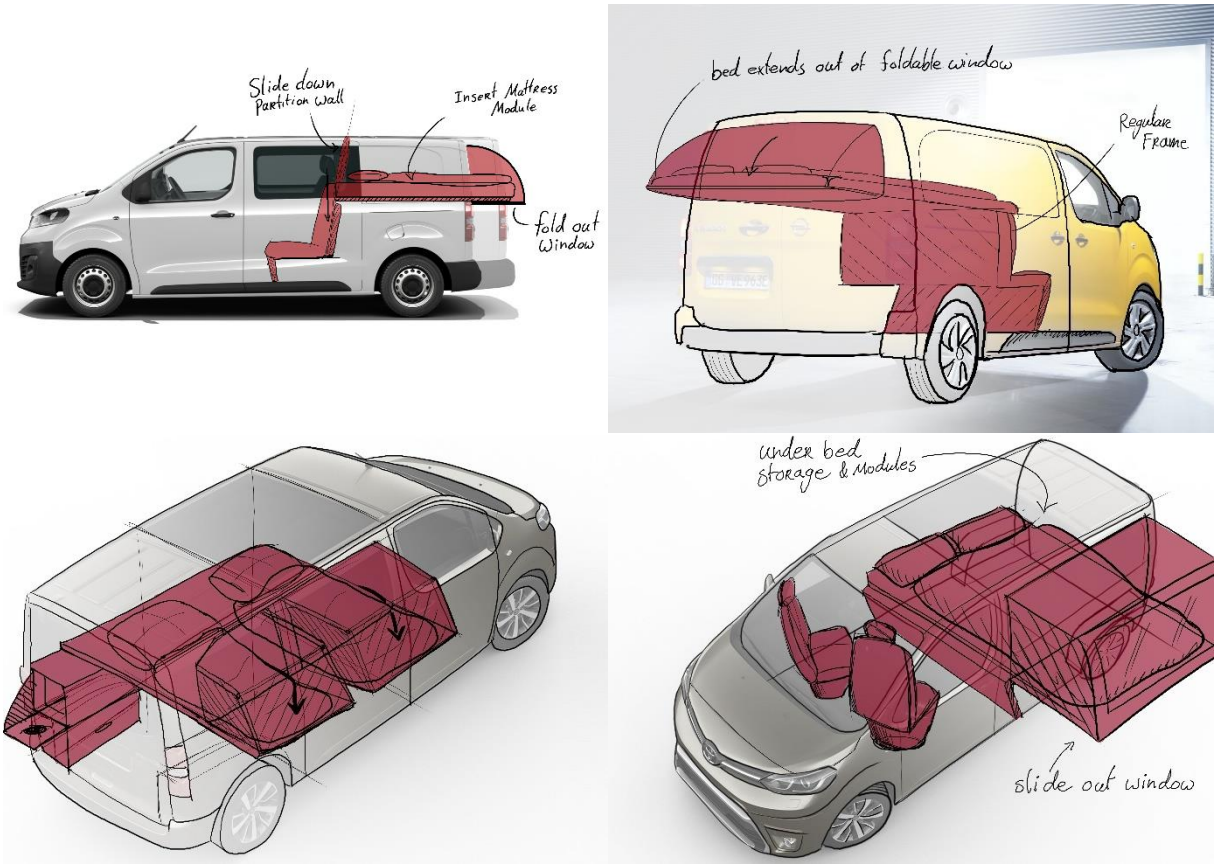


Figure N.12 Extending windows idea

Pro's

Bench frame can remain the same

Relatively large storage space

Sleeping in width direction creates an enlarged vehicle space

Enlarged vehicle space

Con's

Additional mattress required

Limited space above the bed

Door needs to go upwards for the length system to function

Appendix O, Idea Direction Harris Profiles

The 11 found idea directions have been analysed using a list of criteria's and ranked aspirations in order of importance. An overview can be seen in figure O.1. The ideas are individually scored on their expected outcome. Six of these ideas have been found to score the highest and have been further analysed and compared against each other. The pop-top idea was found to be a good addition to most of the concepts, rather than being a solution on its own. It has been taken as a possible recommendation to add as a trim level.

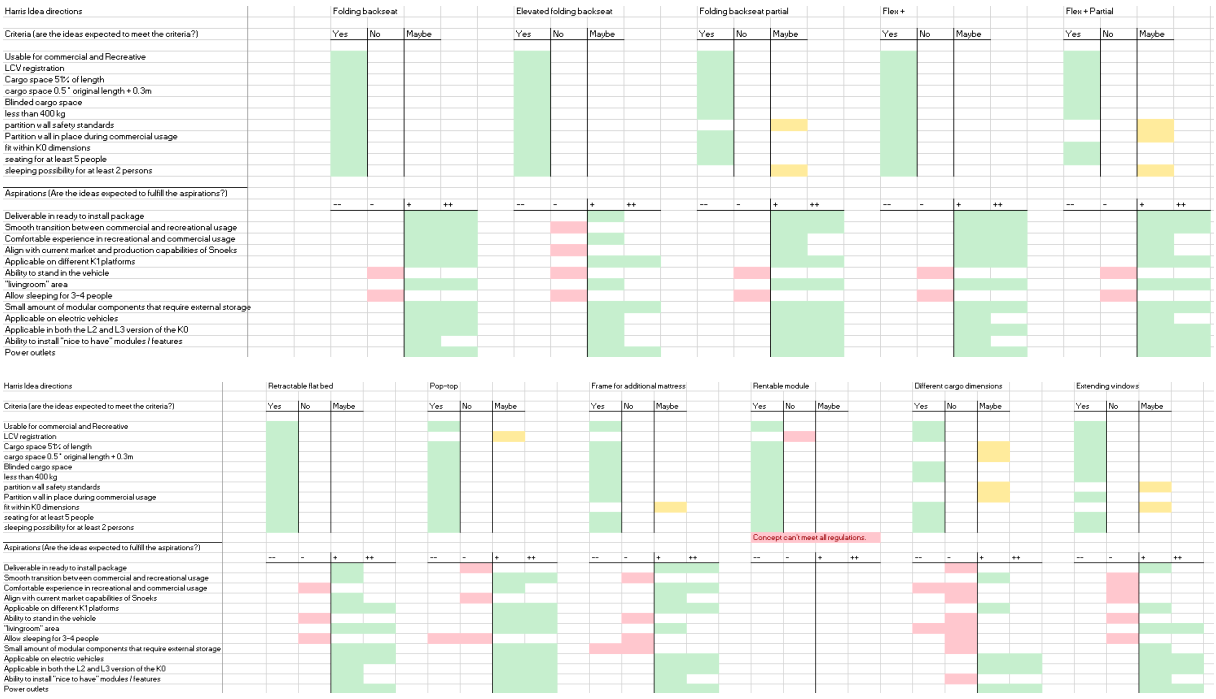


Figure O.1 Harris profile overview for all concept directions

In the figures O.2, O.3 and O.4 below, zoomed in versions of the criteria, aspirations and idea scores with the Harris Profiles can be found for improved readability.

	Harris Idea directions
	Criteria (are the ideas expected to meet the criteria?)
1	Usable for commercial and Recreative
2	LCV registration
3	Cargo space 51% of length
4	cargo space 0.5 * original length + 0.3m
5	Blinded cargo space
6	less than 400 kg
7	partition wall safety standards
8	Partition wall in place during commercial usage
9	fit within K0 dimensions
10	seating for at least 5 people
11	sleeping possibility for at least 2 persons
	Aspirations (Are the ideas expected to fulfill the aspirations?)
1	Deliverable in ready to install package
2	Smooth transition between commercial and recreational usage
3	Comfortable experience in recreational and commercial usage
4	Align with current market capabilities of Snoeks
5	Applicable on different K1 platforms
6	Ability to stand in the vehicle
7	"livingroom" area
8	Allow sleeping for 3-4 people
9	Small amount of modular components that require external storage
10	Applicable on electric vehicles
11	Applicable in both the L2 and L3 version of the K0
12	Ability to install "nice to have" modules / features
13	Power outlets

Figure O.2 Zoomed in version of the Criteria and aspirations

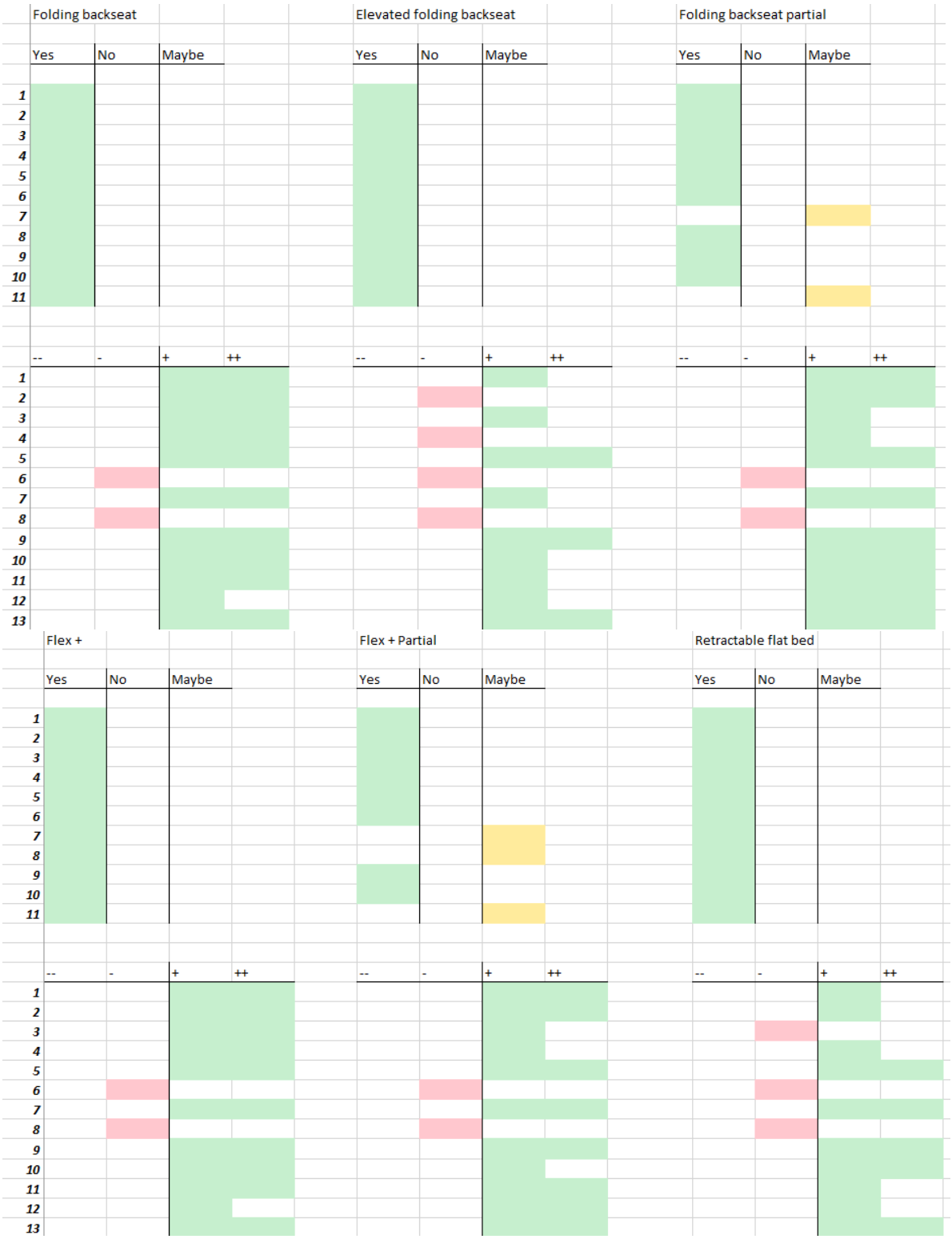


Figure O.3 Zoomed in version of the 11 idea directions - A

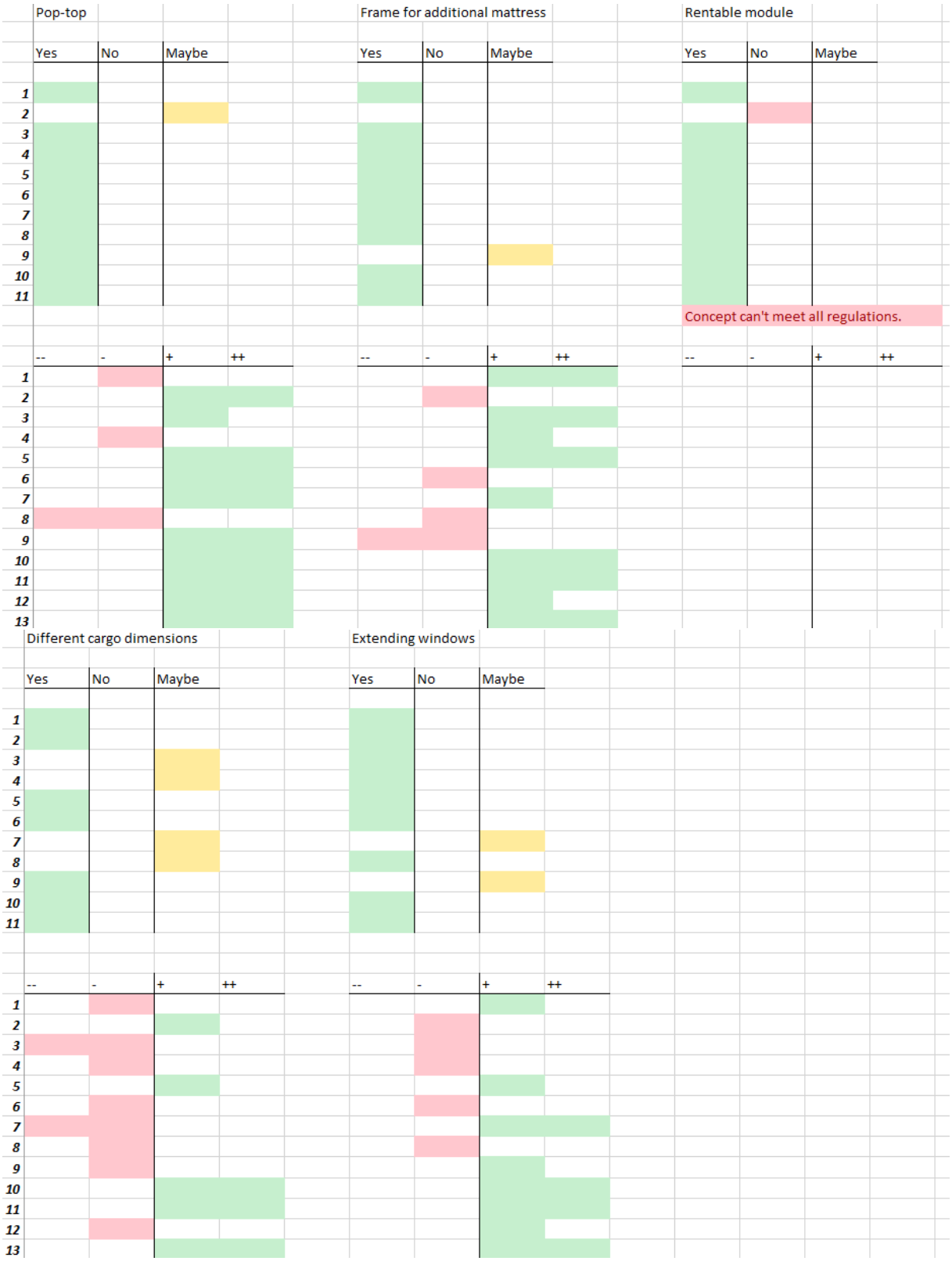


Figure O.4 Zoomed in version of the 11 idea directions - B

The six best idea directions have been compared to each other. These results can be found in a row in figure O.5. As can be seen, the first four concepts score significantly better than the last two. The four best ideas will be further compared using a different method to determine the most viable idea direction to pursuit.

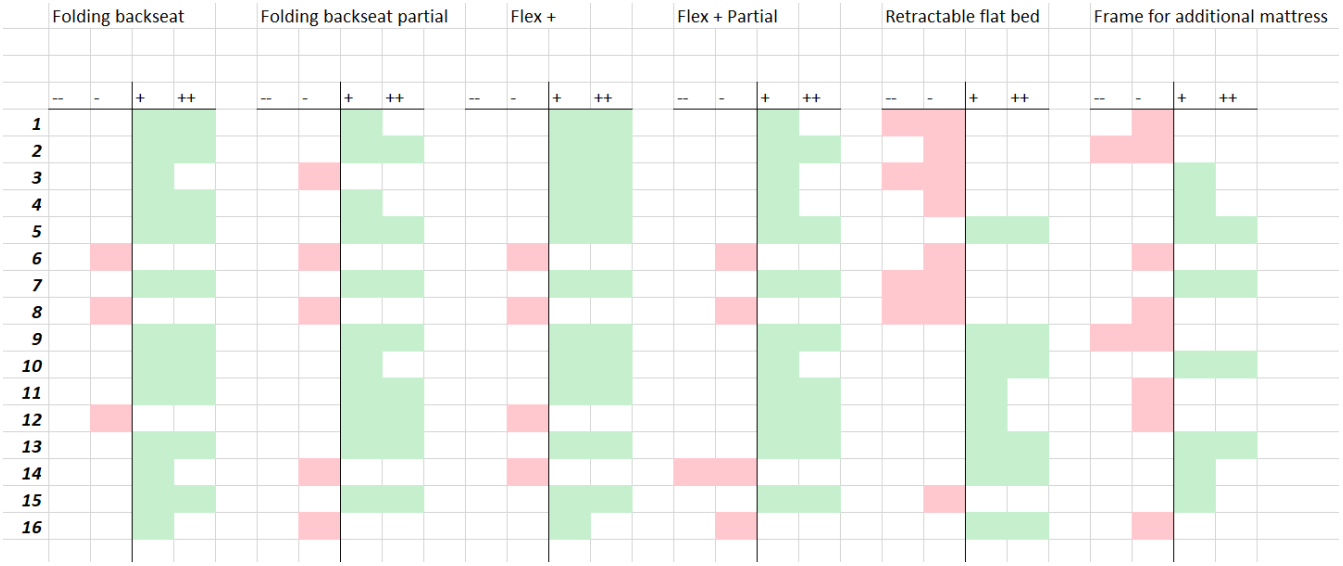


Figure O.5 Harris Profile comparison of the six best idea directions

Appendix P, Length Configuration

In this chapter several possible configurations are reviewed. A short explanation will be provided for each configuration to explain why this configuration would or would not work and what possible additions or complexities these would bring.

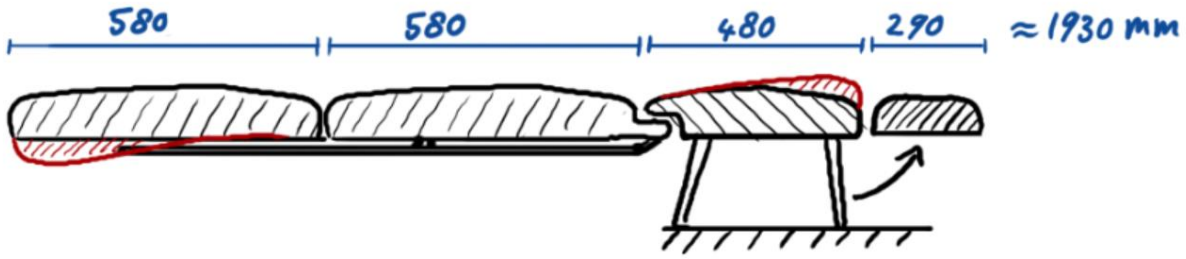


Figure P.1 Length configuration one

This configuration (figure P.1) is based on a double back that folds backwards, and an additional element that folds from under the seat. This could work in a regular crew-cab, but with the added flex cab functionality, there is no space for an addition module underneath the seat.

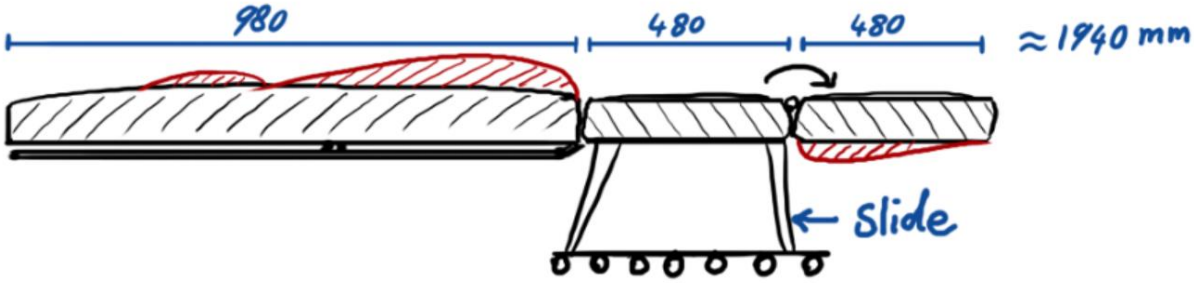


Figure P.2 Length configuration two

This configuration (figure P.2) is based on a double seat and an extended back frame up to the roof. This configuration would work in a regular crew-cab, but with the flex configuration, the entire backrest could not be folded forwards and this configuration could not be made. Another disadvantage is that the seating and sleeping side of the backrest are the same, so a complex bolster solution had to be implemented, or the seat must be made flat.

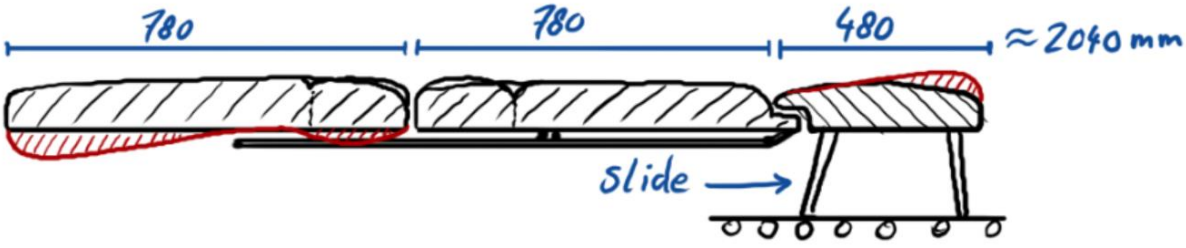


Figure P.3 Length configuration three

This configuration (figure P.3) is based on a double backrest with integrated headrest. Apart from the need to install a sliding rail to fit in the L2 version of the K0 and some complexity for the bending angle or the headrest, this idea still seems quite feasible.

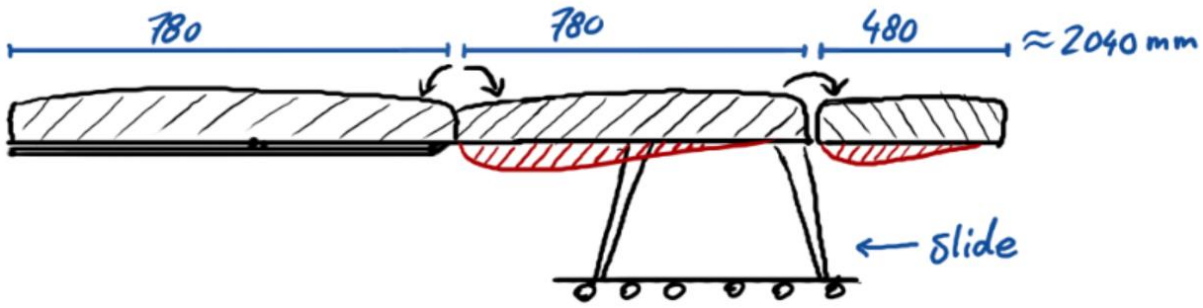


Figure P.4 Length configuration four

This configuration (figure P.4) was thought of to prevent a sliding rail, but it would still be required to move the seat backwards to fit the flipping seat. The benefit of this idea is that every part of the seat can be flipped, and all bolsters could be hidden, yet with a complex rotating system.

The main issue that was found in this and the previous configuration is that the seatbelt for the middle passenger seat could not be installed on the bench frame (see Appendix Fixme). A two-point seatbelt could solve this issue It is also an allowed option and could be considered if the forces prove to be too high, as this type of seatbelt lowers the tension on the bench frame with ISO tests. The seatbelt is however not perceived to hold up to the Snoeks standard, therefore this configuration is no longer considered.

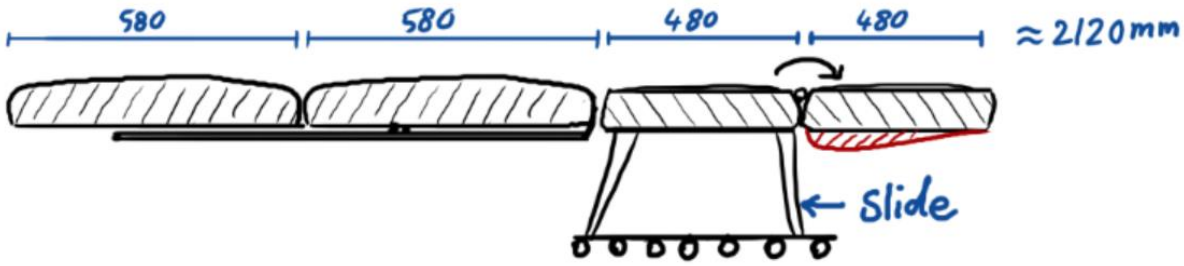


Figure P.5 Length configuration five

This configuration (figure P.5) uses both a double back and a double seat. The main issue that was found in this configuration was that splitting the seat results in a low bed height. This would cause the backrest to interfere with the wheelbase. The only solution to solve this is to make the bed smaller, which is undesirable and gives problems with the maximum gap size between the body and the bench frame.

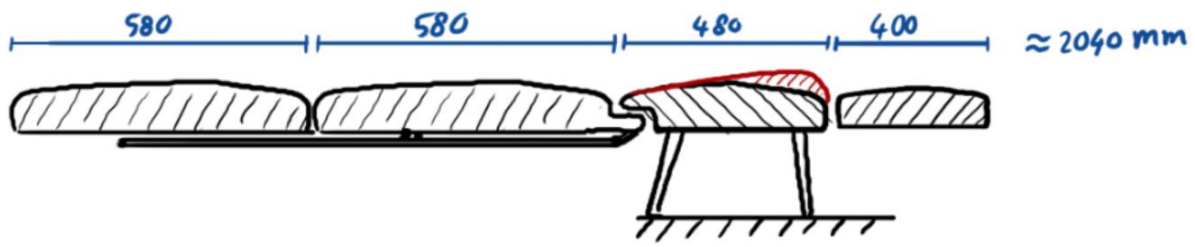


Figure P.6 Length configuration seven

This configuration (figure P.6) is based on the idea of adding an additional module together with a double back. It was found that the headrests could be replaced with this single module, and a comparable configuration could be created. The 400mm version was only achievable in the crew cab version. For a flex concept, the optional additional height was a bit less.

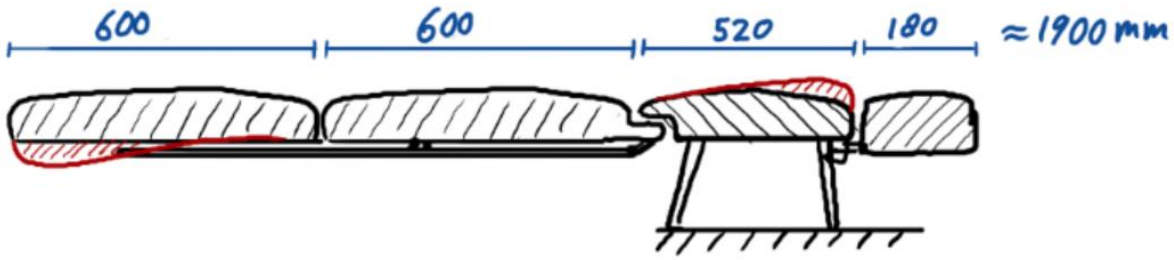


Figure P.7 Length configuration eight

The chosen configuration (figure P.7) uses a double back with a slightly longer backrest and seat as the double back overlaps. The headrest module is created in a size that fits within the flexed forward position. The total achievable length is now 190cm. This is sufficient for the set criteria, but if preferred, the configuration allows a user to move the headrest out a little bit and extend the bed. The gap that is created by doing so is positioned at a place that usually doesn't require any support, as can be seen in figure P.8.

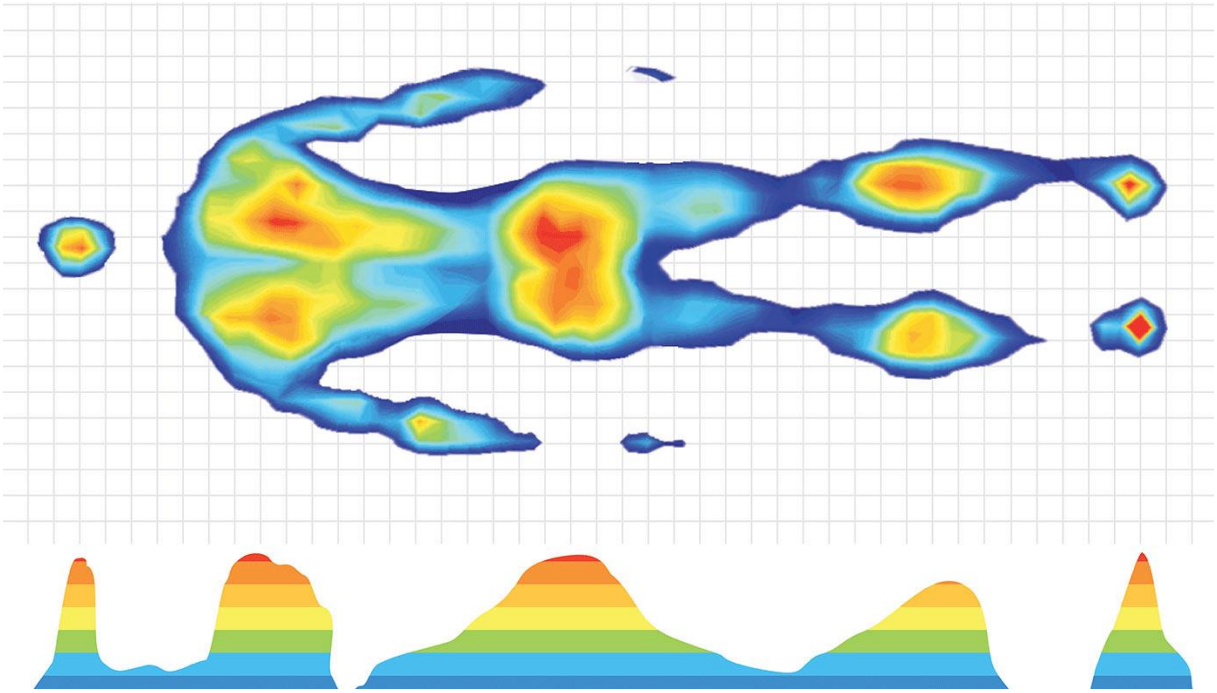


Figure P.8 Pressure measurements in sleeping position (Kloss furniture, n.d.)

Appendix Q, Bolster Comfort

To find out how comfort can be achieved for both seating and sleeping, more analyses have been done by visiting Pop-top campers and Kampeercentrum De Jong to see how they achieve comfort in RV's. In figure Q.1 can be seen that most RV seats are completely flat, as the same surface is used for sleeping and this is the main priority for an RV. In the designer's personal opinion, the seats were not that comfortable at all. The experts walking around in these locations also confirmed that most customers buy an additional topper mattress to increase sleeping comfort.

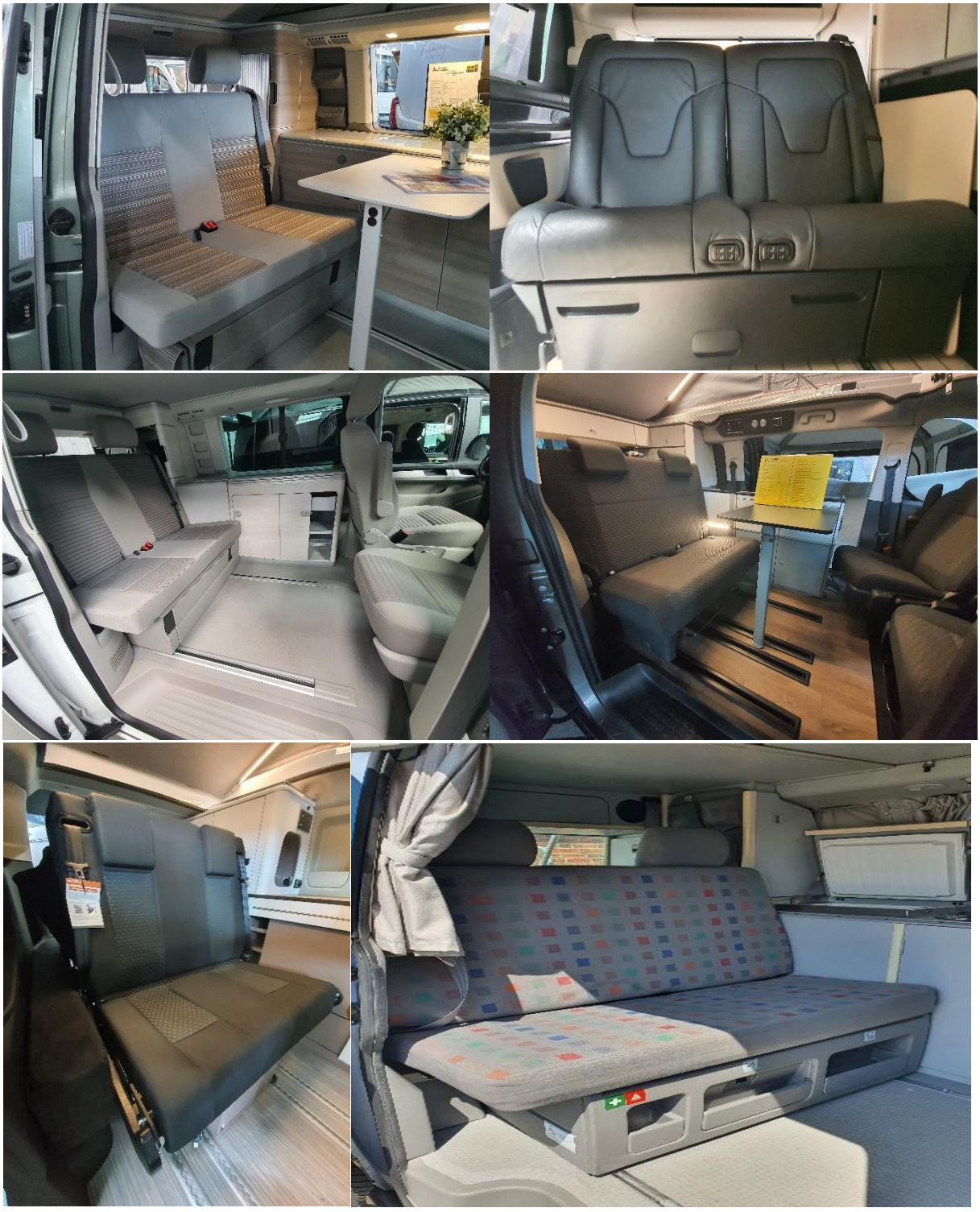


Figure Q.1 The seats in most campervans are almost flat

As the main priority for this product is the seating comfort, a solution should be found to create the optimal shape for both the seating and sleeping functionality. In figure Q.2 a few feasible options can be seen for these bolsters. These options will shortly be reviewed.

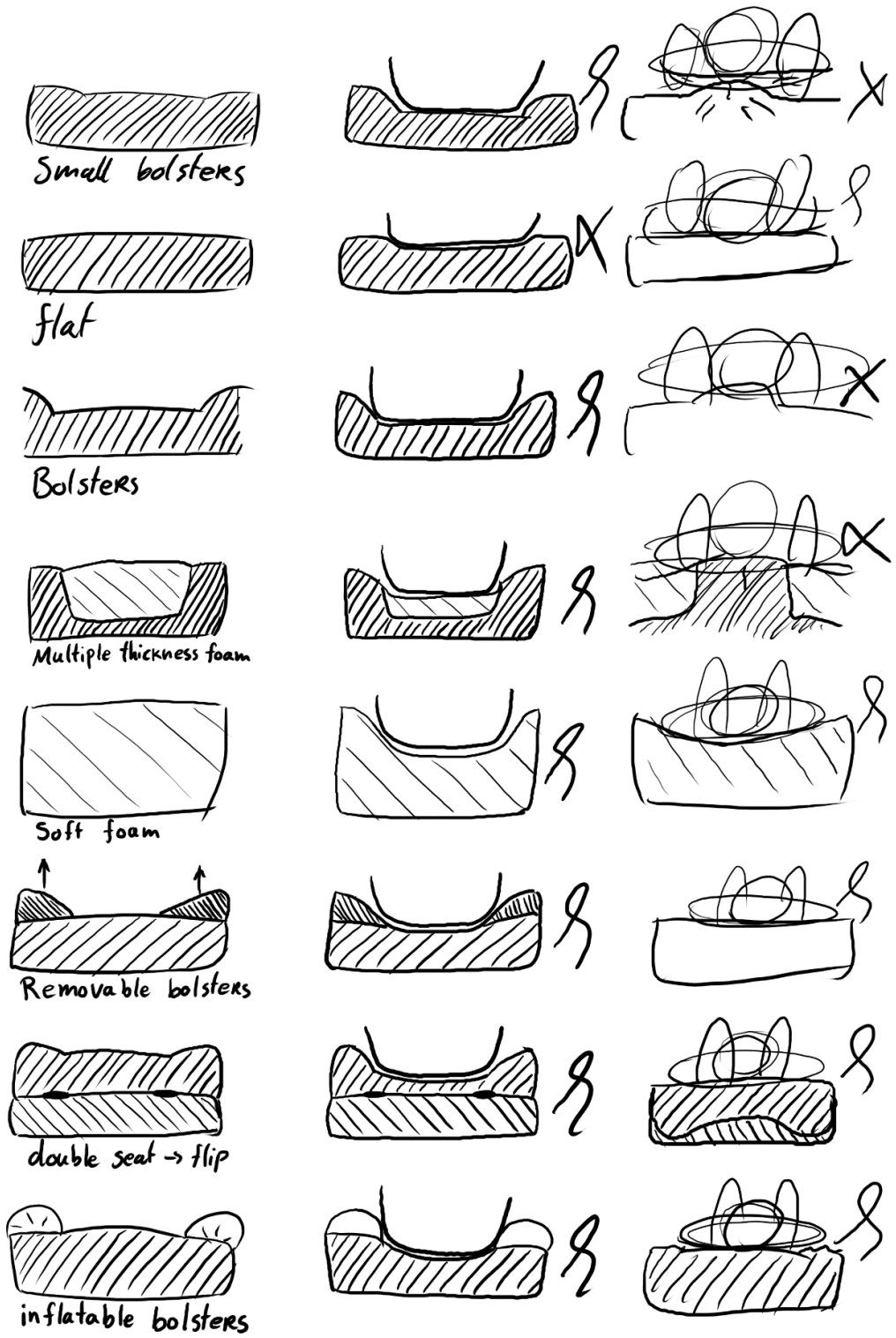


Figure Q.2 Possible bolster solutions

Smaller bolster could be a solution but can still create an uncomfortable situation to sleep on. It could however be considered to create small bolsters in the seating area if people would only place their feet there, or their head on top of a pillow.

A flat surface is not recommended as it simply does not provide the desired support during its commercial usage.

Large bolster would create an uncomfortable sleeping experience, except if the number of seats on the bench are reduced to two seats. This would however contradict with other aspirations, so this is not ideal.

Multiple thickness foam could be used to create certain shapes, and as the pressure of sleeping is much lower than sitting, the intensity at which the bolsters would be felt would be less. Apart from that the user would still feel a clear difference within the sleeping surface.

Soft foam could solve the issue, but this would create a backrest that would be too thick, especially with double components. This would result in less commercial cargo space and disturbing aesthetics.

A backrest that can be flipped 180 degrees could be a solution where there are bolsters to support the seating functionality and a flat surface for sleeping. The required frame could however cause some complexity within the configuration.

Removable bolsters are a possibility, although this could potentially be lost or result in a more complex system as for how to attach/detach them.

Inflatable bolsters (figure Q.3) are a potential solution, and this concept has been applied in the new Mercedes Marco Polo (Mercedes, 2022). This could however result in additional costs and complexity as well, and the durability cannot be guaranteed for long term usage.

Figure Q.3 The inflatable bolsters in the Mercedes Marco Polo

To fully hide all bolsters, every seat should be flipped. This results in a complex folding system, and as the distance between the backrow seat and the front row is less than 40cm. The transition to flip the seat forwards is not possible without implementing a sliding rail or permanently moving the seat backwards. This would affect the commercial usage as it reduces the loading area in both the seating and the flex position.

Even if this is done, other problems would occur. A full bed length cannot be created with only a double back and a seat that folds forward. This would result in a length of around 170cm. Ideally the seat is split into two pieces as well, but this creates an issue with the wheelbase as this would lower the seat height. The backrest would have to match this height to create a flat surface, and this would cause the frame to collide with the wheelbase, unless the bed width is made smaller than the wheelbase and the underneath storage would be decreased. Even if this is done properly, the partition wall would have to be split to fit beneath the wheelbase, causing several other issues.

To prevent all these issues, the seat will be kept in position. This means that the sitting side will be the same as the sleeping side, and bolsters will have to be reduced to offer a comfortable sleeping experience. It also means that an additional part is required to achieve the desired length.

Appendix R, Seatbelt Safety Configuration

The chosen configuration uses a double back in order to achieve a comfortable bed length. The seatbelt configuration causes an issue here. As the double backrest has a cushion that needs to fold over, the seatbelt is blocking this possibility as they will need to be attached to the back of the frame and block the folding motion, as seen in figure fixme. For the outer seatbelts, this issue can easily be covered by leaving the very sides of the backrest in place and only folding the inner part, as seen in figure R.1. The light blue area will fold over, and the side bolsters remain in place. The middle seatbelt still causes a problem at this stage.

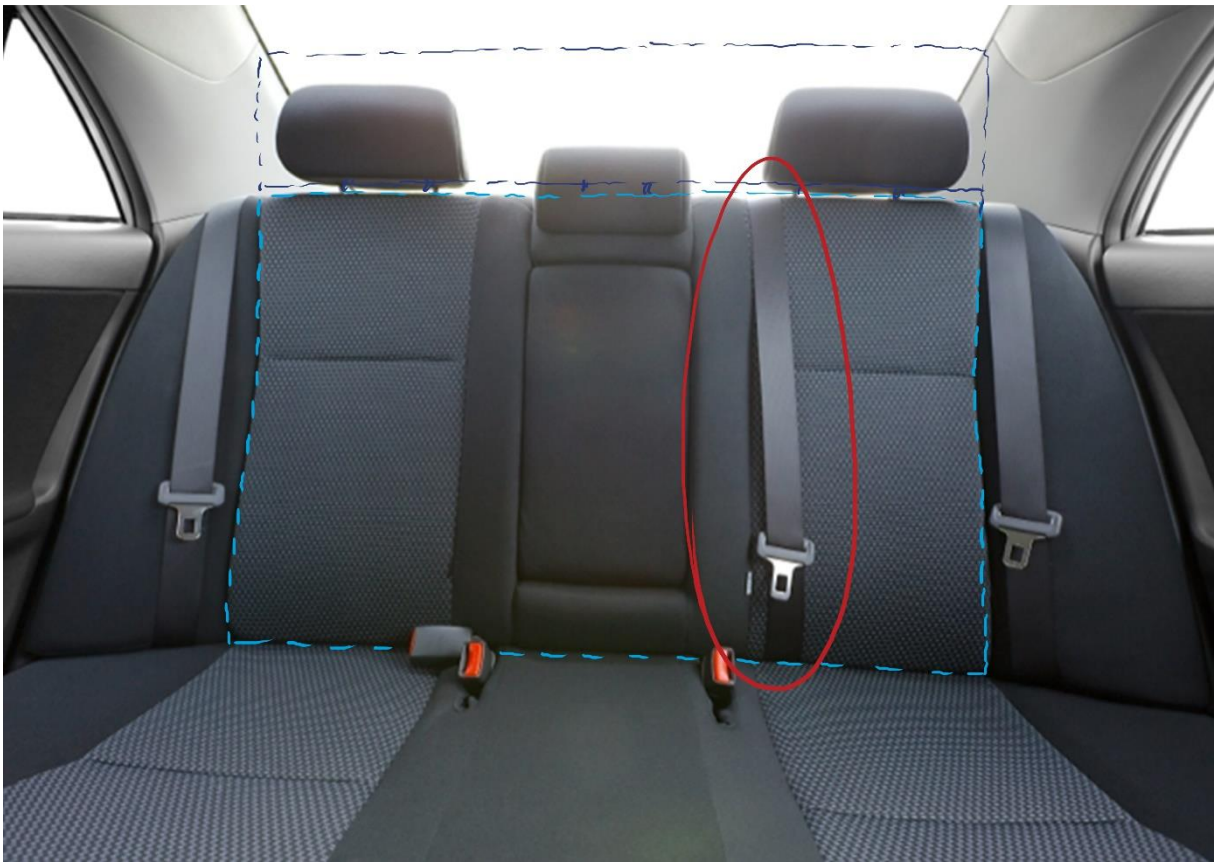


Figure R.1 The middle seat blocks the possible folding of a double backrest

After careful consideration of the safety regulations, it was found that back passenger seats on the sides must have 3-point safety-belts, whereas the middle seat is allowed to have a two-point lap belt as well (ECE, 2016). This was confirmed by homologation as well.

This means that the middle seatbelt does not have to interfere with the folding of the double backseat, eliminating this issue.

It was however found that this seatbelt is considered less safe and is currently not used by Snoeks. Snoeks wants to remain their high standards and have 3-point anchor seatbelts. To solve the issue, a double buckle is placed on top of the middle seat (figure R.2). This prevents any folding issues and still provides the proper safety standards.

Figure R.2 The chosen seatbelt solution in order to fold the double backrest

The Safety-belt Regulation ECE article can be found in figure R.3.

Safety-belt installation showing the belt types and retractor types *Minimum requirements for safety-belts and Retractors*

Vehicle category	*Forward facing seating positions*		*Rearward-facing seating positions*		*Side-facing seating position*	
Outboard seating positions			*Centre seating position*			
Front	*Other than front*		*Front*		*Other than front*	
M1	Ar4m	Ar4m	Ar4m	Ar4m	B, Br3, Br4m	-
M2 < 3.5 t	Ar4m, Ar4Nm	Ar4m, Ar4Nm	Ar4m, Ar4Nm	Ar4m, Ar4Nm	Br3, Br4m, Br4Nm	-
M2 > 3.5 t	Br3, Br4m, Br4Nm, or Ar4m or Ar4Nm ●	Br3, Br4m, Br4Nm, or Ar4m or Ar4Nm ●	Br3, Br4m, Br4Nm or Ar4m or Ar4Nm ●	Br3, Br4m, Br4Nm or Ar4m or Ar4Nm ●	Br3, Br4m, Br4Nm	-
M3	Br3, Br4m, Br4Nm, or Ar4m or Ar4Nm ● See para. 8.1.7. for conditions when a lap belt is permitted	Br3, Br4m, Br4Nm, or Ar4m or Ar4Nm ● See para. 8.1.7. for conditions when a lap belt is permitted	Br3, Br4m, Br4Nm or Ar4m or Ar4Nm ● See para. 8.1.7. for conditions when a lap belt is permitted	Br3, Br4m, Br4Nm or Ar4m or Ar4Nm ● See para. 8.1.7. for conditions when a lap belt is permitted	Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm
N1	Ar4m, Ar4Nm	Ar4m, Ar4Nm, Br4m, Br4Nm Ø	B, Br3, Br4m, Br4Nm or A, Ar4m, Ar4Nm* [1]	B, Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm	-
Para. 8.1.2.1. lap belt permitted if seat is inboard of a passageway			Para. 8.1.6. lap belt permitted if the windscreen is not in the reference zone			
N2	Br3, Br4m, Br4Nm orAr4m, Ar4Nm* Para. 8.1.6. lap belt permitted if the windscreen is outside the reference zone and for the driver's seat	B, Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm, or A, Ar4m, Ar4Nm* Para. 8.1.6. lap belt permitted if the windscreen is not in the reference zone	B, Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm	-
N3	Br3, Br4m, Br4Nm orAr4m, Ar4Nm* Para. 8.1.6. lap belt permitted if the windscreen is outside the reference zone and for the driver's seat	B, Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm, or A, Ar4m, Ar4Nm* Para. 8.1.6. lap belt permitted if the windscreen is not in the reference zone	B, Br3, Br4m, Br4Nm	B, Br3, Br4m, Br4Nm	-
A: three-point (lap and diagonal) belt 3: automatically locking retractor	B: 2-point (lap) belt 4: emergency locking retractor		r: retractor N: higher response threshold		m: emergency locking retractor with multiple sensitivity	
*: Refers to para. 8.1.6. of this Regulation [2]	Ø: Refers to para. 8.1.2.1. of this Regulation		●: refers to para. 8.1.7. of this Regulation[2]		(see UN Regulation No. 16, paras. 2.14.3. and 2.14.5.)	

[1] Erratum to Supplement 12 to the 04 series of amendments, applicable "*ab initio*."
[2] Erratum to Revision 4, applicable "*ab initio*."
Note: In all cases all S-type belts may be fitted in place of all possible A or B type belts, provided their anchorages comply with UN Regulation No. 14.
Where a harness belt has been approved as a S-type belt according to this Regulation, using the lap belt strap, the shoulder belt straps and possibly one or more retractors, one or two additional crotch straps including their attachments for their anchorages may be provided by the manufacturer/applicant. These additional anchorages need not meet the requirements of UN Regulation No. 14 (Erratum to Supplement 14 to the 04 series of amendments, applicable "*ab initio*.")."

"8.1.2.1. However, for outboard seating positions, other than front, of vehicles of the category N1 shown in Annex 16 and marked with the symbol Ø, the installation of a lap belt of type Br4m or Br4Nm is allowed, where there exists a passage between a seat and the nearest side wall of the vehicle intended to permit access of passengers to other parts of the vehicle. A space between a seat and the side wall is considered as a passage, if the distance between that side wall, with all doors closed, and a vertical longitudinal plane passing through the centre line of the seat concerned – measured at the R-point position and perpendicularly to the median longitudinal plane of the vehicle – is more than 500 mm."

Figure R.3 Seatbelt regulation Article by ECE (Snoeks Automotive, n.d.)

Appendix S, Determining Rotation Points

The difficulty behind determining the rotation points is found within the constraints. There should be three positions in which the seat can be place; Flexed forward, seating position, and sleeping position. To get from seating to sleeping, it is desirable to keep the angle of the back rod fixed as was found before using an older prototype. The backrest should be positioned at an angle of around 19 degrees in seating position and 90 degrees in sleeping position. (Figure S.1)

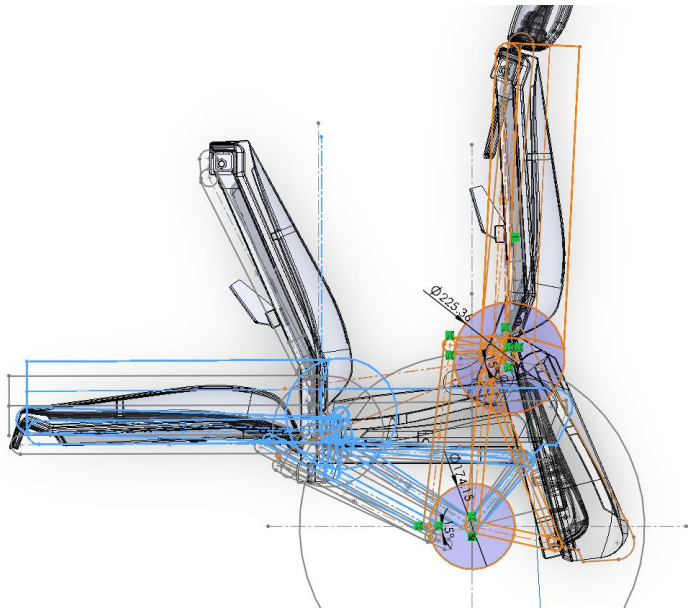


Figure S.1 The positioning and rotation points of the product

Several limitations played an important role in the positioning of these points.

These limitations are:

- A minimum height of the flat surface in sleeping position (to fit between the wheelbase),
- A flexed forward position that does not surpass the “dead point” (As pulling the flexed mechanism back after that can be difficult for actuators or gas springs).
- The 19-degree angled backrest with a slightly inclining seat,
- A pullback system that matches with the dimensions of available actuators
- A limited distance between seat and backrest in the flat position (to prevent an uncomfortable gap)
- The height difference between the flat backrest and seat should be minimal to prevent a different foam thickness or an even thicker backrest.

The actuator should be able to move the rotation point in a linear direction to achieve these angles. As most actuators have an initial length that is often around 105mm longer than the shaft length, the rotation points should also follow the following formula measured from the base rotation point:

(Base rotation point + minimum rotation point - 105mm) > (maximum rotation point - minimum rotation point) < 150mm (Maximum usable actuator extension length within the given dimensions).

The result of this plot can be seen in figure S.2. The actuator can achieve the minimum and maximum position within the given constraints, creating the correct angles of the backrest.

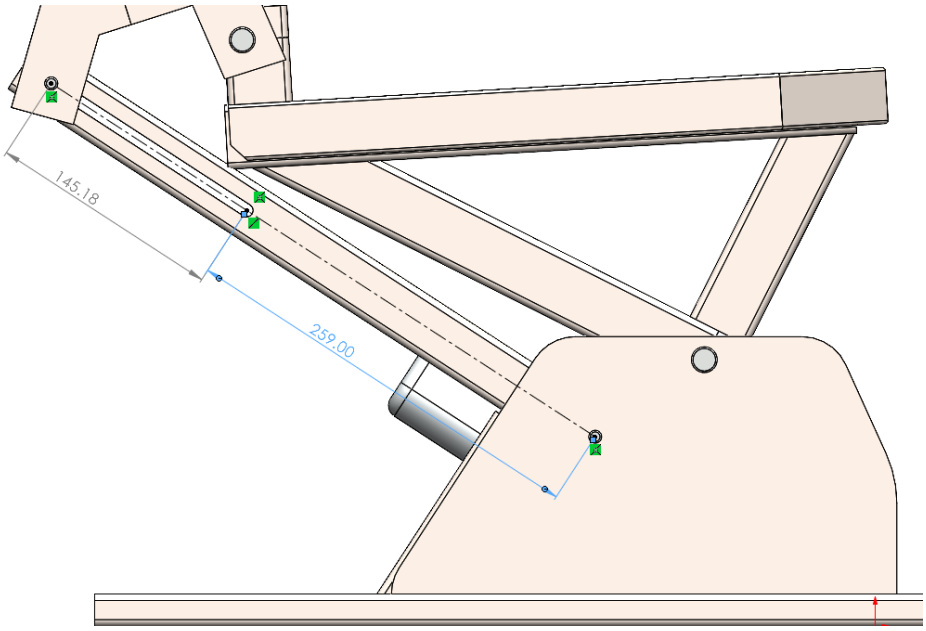


Figure S.2 The plotted rotation points for chosen actuator (see also Appendix U)

3D print prototype proof of concept rotation mechanism

To assess if these rotation points are accurate and if the construction seems sturdy enough, a two-dimensional 1:2 scaled model was 3D printed to check the functionalities. The back rod was created with a slot that covers the potential range of the actuator. The three positions that could be achieved this way can be found in figure S.3.

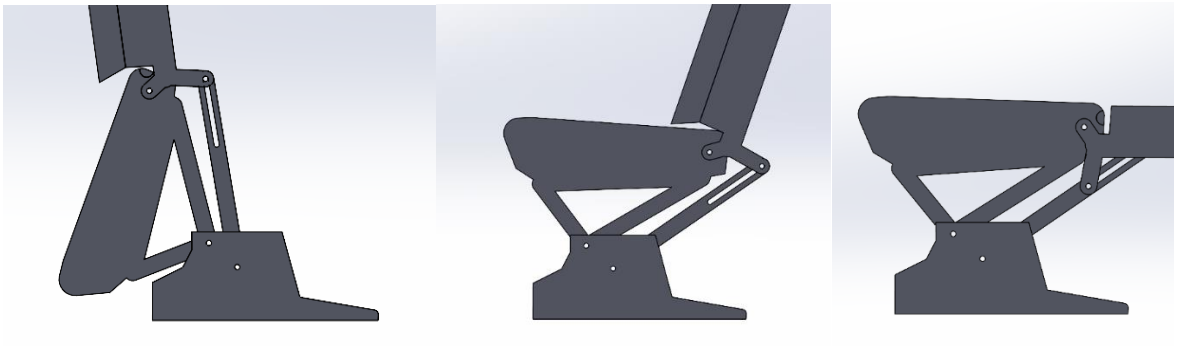


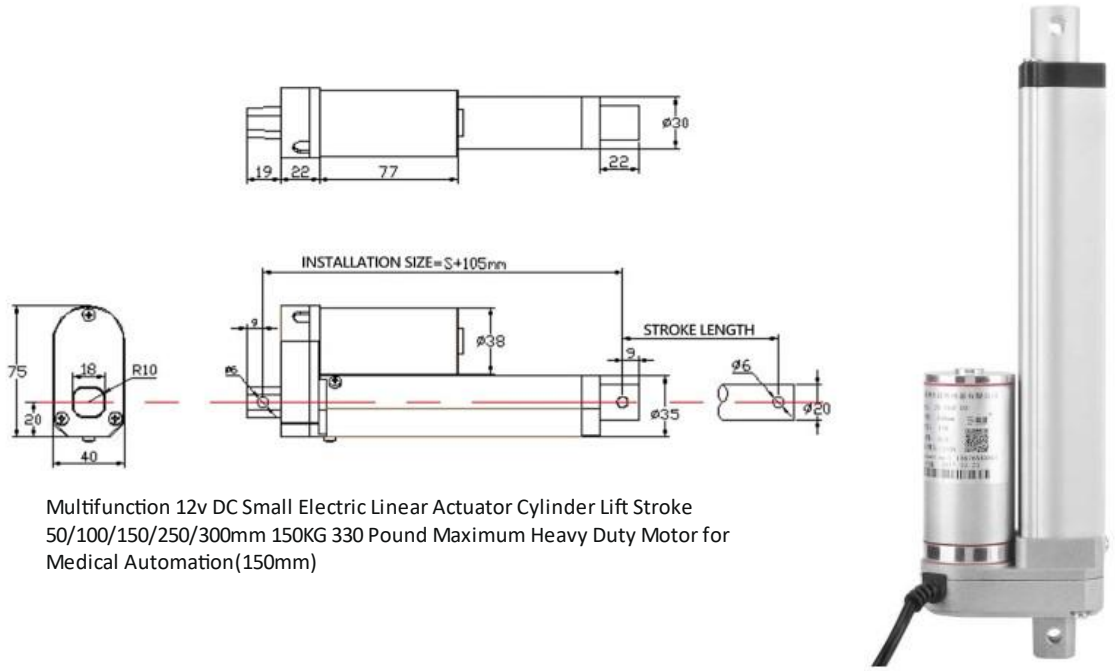
Figure S.3 The three positions for the 3D printed model

This 3D printed test proved successful. The chair was able to achieve all three positions with the correct angles. This 2D model with its rotation points was used to build the actual 3D CAD model.

Appendix T, Technical Drawings CAD (Confidential)

Appendix U, Actuator Specifications

Technical details of the used actuator can be seen in figure U.1. This actuator was chosen because of its dimensions and strength. As the lever that the actuator needs to push is relatively large, a strong force is required. By placing an actuator on both sides of the bench frame, a stable and steady movement can be created and the forces remain in the same direction. The rotation points of the system have been adjusted so the desired positions can be achieved within the range of the actuator. (See also Appendix S.)



Multifunction 12v DC Small Electric Linear Actuator Cylinder Lift Stroke 50/100/150/250/300mm 150KG 330 Pound Maximum Heavy Duty Motor for Medical Automation(150mm)

Figure U.1 The used Actuator (Amazon, n.d.)

Appendix V, French Tax Regulation Requirement

The requirement for the French tax regulation can be seen in figure V.1.

It was found that the L1 is 2.28m measured at 400mm height. According to the regulation. L2 > 0.5*L1+0.3, L2 must be longer than 1.44m. The measured length for L2 is 1.48m, so the product meets the French tax requirement.

The L3 version of the K0 is 0.35m longer at the back of the vehicle. As the positions of the front and backseat remains the same, the formula for this vehicle length is L2+0.35m > 0.5*(L1+0.35m) +0.3m

1.83m > 1.65m, so this product meets the French tax requirement for both the L2 and L3 version of the K0 LCV.

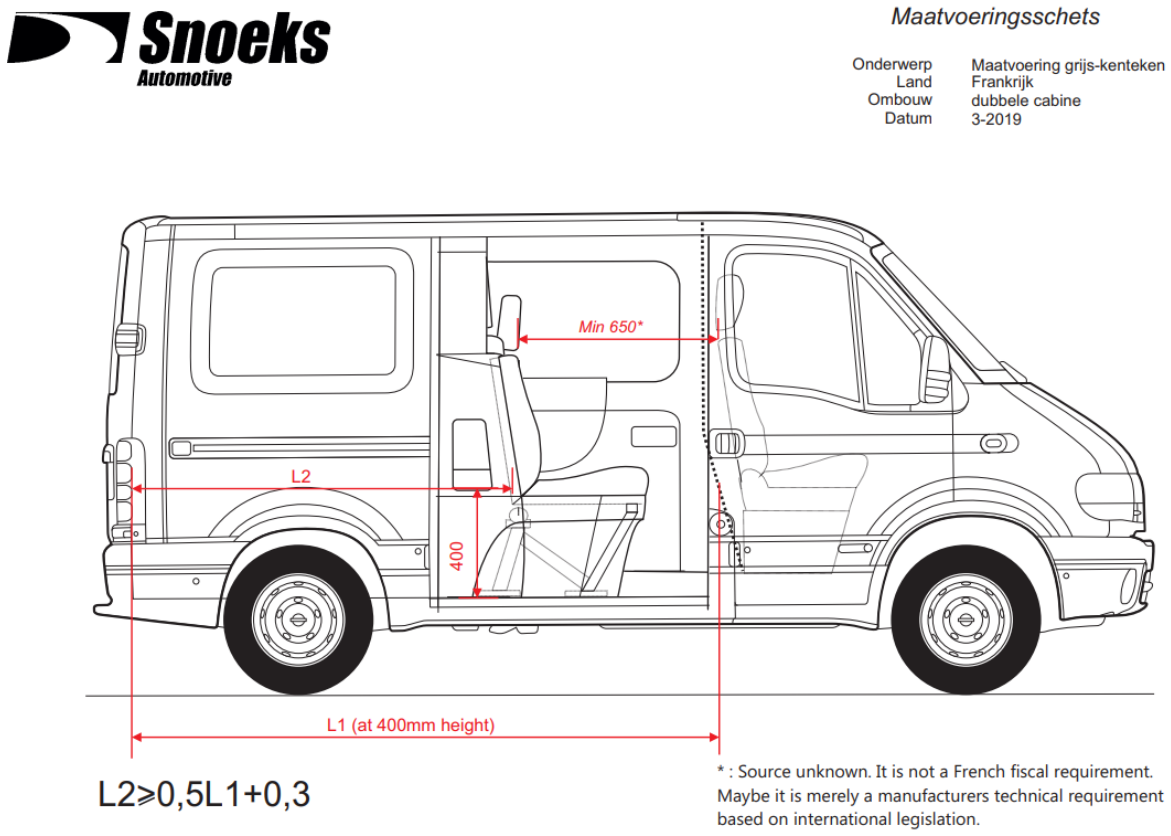


Figure V.1 French tax regulation (Snoeks Automotive, n.d.)

Appendix W, Cost Estimation *(Confidential)*