Design of Low-Cost Rural Public Transport

Submitted in partial fulfillment of the requirements

of the degree of

Master of Design

by

Harsh Vardhan Tripathi

126390002

Supervisor:

Bidyabijay Bhaumik

INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

2014

DESIGN OF LOW-COST RURAL PUBLIC TRANSPORTATION

HARSH VARDHAN TRIPATHI

GUIDE: BIDYABIJAY BHAUMIK

Approval

This report entitled Design of Low-Cost Rural Public Transportation by Harsh Vardhan Tripathi is approved for the degree of M.Des

Examiners

Supervisor (s)

Chairman

Date : _____

Place : _____

DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been inclded, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Harsh

Harsh Vardhan Tripathi
126390002

11.7.2014
Date

CONTENTS

ABSTRACT

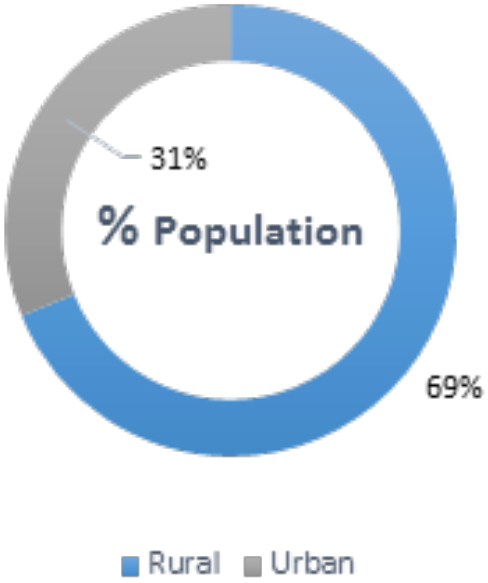
Public transport in rural and semi-urban India is largely privately owned, but suffers from the problem that the vehicles available in the market are designed with urban/semi-urban markets in mind. Hence, the owners modify these vehicles extensively to suit the rural requirements, which compromises the safety, comfort and integrity of the vehicle. Also, since the vehicles were not designed with rural markets in mind, they do not tackle the problems in Indian villages specifically.

The project was to develop a vehicle tailored for the low end of the rural market, improving upon the existing autorickshaws, but being cheaper than the UVs. The focus, however, was on the interiors.

Since the population under study was mostly illiterate and not very articulate, most of the study was done by observation, although a basic questionnaire was also used.

An interior layout was prepared which was found to address the problems found in the best possible way. A digital model and a physical model of the same were also made .

INTRODUCTION



Rural India still has a greater population [1] than the urban areas. There have been efforts recently to connect the villages to roads, as the people need to travel to markets, towns and other villages. [2] However, since the rural people are generally a low-income group, they cannot afford private transportation. Government-run public transportation I hardly available in rural areas, so most of these people end up using privately-owned public transport.

The issue here is that the vehicles that are available in the market for this purpose have been designed with urban/semi-urban areas in mind. As a result, the rural people are forced to modify these vehicles to better suit their needs. This includes adding additional seats, changing configuration of existing seats, and the like. Alternatively, they create contraptions or "Jugaad" by hacking together different parts from several donor vehicles/ farm equipment. This dangerous practice causes discomfort to the passengers and puts their life in danger.

The scope of this project is to conceptualise a new vehicle that would be better suited for rural conditions. It should be tailor made for rural application, and be simple enough so that it can be used with ease and rugged enough to withstand rural conditions. Since the vehicle would be according to the needs of the villages, it would eliminate the need of modifying it, hence preserving the integrity of the vehicle and ensuring safety to the passengers. Also, the vehicle needs to be cheap enough, in terms of overall cost of ownership and not just low initial cost, so that rural population can afford it.

MARKET STUDY


1


2

JUGAADS


3


4

Jugaads are vehicles made locally in villages by combining parts borrowed from various donor vehicles/farm implements and putting them onto a rudimentary frame. They are used as a basic motorised replacement for bullock carts. Origins of the Jugaad are uncertain, however Punjab and Meerut in the 1950s [3] are mostly considered. Meerut is especially considered with its availability of scrap dealers and discarded Army Jeeps.

Power is via a single cylinder diesel engine of the Lister design. [3] It is a vertical, single-cylinder DI diesel engine with displacement between 500cc to 650cc, and producing 5-8 HP.

The chassis is like tractor trailers. It's a basic ladder frame made with two I-beams and welded cross-members. The bodywork is made out of wood and bolted onto this frame, like in trucks.

Image Reference:

1. http://indianjugaad.wordpress.com
2. Team-BHP.com (Also 3 & 4)

AUTORICKSHAW

Three wheeled autorickshaws are widely used. These are however vastly modified to accommodate more passengers, by adding more bench seats, and/ or moving and reconfiguring the existing ones.

1


2


3

Image Reference:

1. http://piaggio.co.in
2. http://www.loupiote.com
3. http://balajiforce.com

UTILITY VEHICLES (UV)

Several MUVs and UVs are used widely in the rural markets as public transport. These vehicle have side-facing jump seats and extended lengths (Force Toofan, Mahindra Maxx, etc.) to augment their passenger capacities

Image Reference:

1. www.autopictu.com
2. sheshank.blogspot.com

1

2

3

FOUR WHEELED CABS

TATA ACE MAGIC

Tata Ace Magic is a people mover based on the Tata Ace truck. It uses the same 700cc engine producing 16bhp and seats up to D+7 passengers.

TATA MAGIC IRIS

The magic Iris is a people carrier based on the Ace Zip. It has a rear mounted 610cc engine producing 11bhp, seating up to D+4 passengers.

4

MAHINDRA GIO

The Mahindra Gio cab is a 4-wheeled people mover based on the Mahindra Alfa 3-wheeler platform. Thus, it offers additional space, flexible seating and more safety than the Alfa. It uses the same 9bhp single cylinder engine from Alfa, and seats up to D+6 passengers.

MAHINDRA MAXXIMO

The Mahindra Maxximo is a small Indian minivan is a non-AC minivan designed to carry people short distances. Equipped with a 1.1 l diesel engine producing 25bhp this vehicle can reach only up to 70 km/h (approx. 45mp/h) speed and is widely used by the middle class. The minivan version has 4 doors and seats up to D+7 passengers.

Image Reference:

1. www.motorbeam.com
2. www.team-bhp.com
3. autos.maxabout.com
4. www.motorbeam.com

TECHNICAL STUDY

BASIC TEMPLATE

A basic template is to be chosen to help benchmark the new vehicle package being developed. This also helps to reduce the engineering portion of the package development.

The first step was to compare and eliminate the competing platforms to select a benchmark. UVs were eliminated first due to prohibitive costs. Autorickshaws were next, as they lacked safety at high speeds, which these vehicles might touch on the highways.

Next was the Jugaad. Since this was not a well thought out design, basing a new vehicle on it would mean extensive re-engineering, which would go out of the scope of this project.

The comparison with the rest is tabulated above. Final selection of the basic template will be made in the Packaging Layout section.

	Gio	Maxximo/Magic	Magic Iris	Ape/Alfa	Jugaad
Price	1.95lakhs	3.4lakhs	2.2lakhs	1.5lakhs	~50 thousand
Fuel Economy	30kmpl	20kmpl	33kmpl	36kmpl	NA
Resale value (1yr)	1+	2+	1.5+	1.1+	NA (NIL)
Floor Height	NA	NA	450-493mm	NA	NA
Seating Capacity	D+6	D+7	D+4	D+3	20persons+
Ground Clearance	165 mm	160 mm	160 mm	175 mm	NA
Wheelbase	2005 mm	2100mm	1650mm	2005 mm/1750mm	>2430 mm
L	3180 mm	3677 mm/3800mm	3020mm	2990 mm	>3810 mm
B	1480 mm	1540 mm/1500	1480mm	1480 mm	>1650 mm
H	1950 mm	1845 mm	1800mm	1905 mm	>1930 mm

POWERTRAIN

The Magic Iris retails for a slightly higher price, but has a larger & more powerful engine. Gio was intended for D+6 passengers. If the vehicle needs to haul 10 passengers, it needs more power. For simplicity, we can assume the Magic Iris' powertrain.

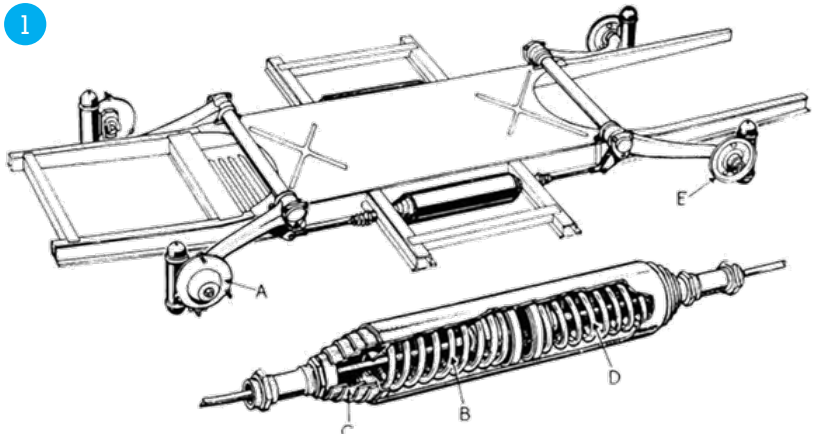
FUEL

Given the lack of infrastructure of CNG/LPG in urban India [4], there is no timeframe for Rural India. Additionally, given dismal electricity supply to villages, electric/plug-in hybrid vehicle is ruled out.

Diesel seems most viable option given its cost advantage over Petrol, and the torquey nature of Diesel engines.

Another alternative is Biogas. Villages have rich sources of animal & plant refuse, which can be fed into digesters installed in the farms to provide freely available indigenous fuel to the villages.

1



SUSPENSION

2

Although most vehicles in this class have leaf springs or trailing arm suspensions, a lateral examination was also made into the Citroen 2CV's suspension. The Design brief for 2CV was for a cheap car which could handle rough roads of post-war France. [5] It was supposed to carry an egg crate through a ploughed field, without the eggs breaking. This fits with the vehicle required in this project nicely, as Indian rural roads are poorly constructed/absent totally. And also that this vehicle too needs to be cost-effective.

Hence, when compared to the suspensions available in the current vehicles, the Citroen 2CV's layout offers the following advantages:

- The suspension is very soft, yet shows less body roll than a fully independent suspension.
- Since the components are mounted on the outside edge of the frame, there is minimal intrusion into the cabin space
- The slight interconnection between the front and rear suspensions help improve ride over bouncy road surfaces
- Simple construction means it's cheap to produce too.

Image Reference:

1. autoseed.com
2. forums.vwvortex.com

USER STUDY

DEMOGRAPHIC

The users for this vehicle are both the drivers and the passengers. As such, a questionnaire was prepared, keeping both of them in mind with questions for both the parties.

Since this vehicle is for rural population, the study had to be done in a rural setting. Thus, Karjat area outside Mumbai, and Muradnagar and surrounding villages outside Ghaziabad, UP were chosen. This gave a fairly diverse user base with geographical and cultural diversity. 7 users from Karjat and 5 users from Muradnagar were asked the questionnaire, and many more were studied on-location.

USER PROFILE

USER TYPE 1:

- The user is the driver of the vehicle. Almost always male.
- He seldom owns the vehicle (more dominant in Maharashtra), instead the vehicle is on a lease from a collective owner (more predominant in UP)
- Aged 28-35 years, he is a local of the village
- Driving the vehicle is his primary and only source of income

USER TYPE 2:

- This is the village public
- Although evenly distributed between different age groups and genders, males travel more frequently
- Older females are almost always accompanied by another female
- They have to travel long distances between villages and/or cities, hence often carry luggage.
- Low income group, hence need to travel long distances at low prices
- This vehicle is not an end to end transport for them, as they have to travel a considerable distance on foot before and after

USER TYPE 3:

- This is an out of context user, which was seen quite frequently: College students and factory workers from units situated in villages or located along highways
- Age and gender equally spread due to unavailability of alternate means of transport in most cases
- They are usually not local to that area, and mostly from cities
- They have exposure to the type of public transport available in cities
- They use this vehicle type as their transport from campus/factory to nearest urban centre

QUESTIONNAIRE

1. How many passengers on an average?

a. Do they stand/hang? How many?

2. Do passengers sit in the front row?

3. What distance do you cover in one trip? How many trips in a day?

4. Do you travel alone or in groups?

a. How many people in the group?

b. Do you get seats for everyone?

c. Do you have to stand/hang?

5. Do you experience problems during boarding/de-boarding?

6. Do problems occur during rainfall?

7. Do you carry luggage with you?

a. How often/much?

b. Do you have to pay for it?

c. Where do you have to keep it?

8. Is the vehicle comfortable to travel?

a. Are you able to talk to otherpassengers or on your mobile phone?

b. When de-boarding the vehicle, is any pain/ numbness experienced?

c. Are your legs/knees free?

d. Do you travel after evening? Any problems faced then?

9. What other problems do you face?

First set of observations were made in Muradnagar.

The Autos were modified to have 3 transverse rows of seats, by moving the original seat back, and adding a row in the middle and another at the back.

1. Empty Auto
2. Luggage kept on the seats & floor, blocking access and reducing passenger space
3. Unsafe seats mean passengers have to grab onto the bodywork for support.

1


2

3

Passengers sitting in the last bench with feet hanging outside.

Second set of observations was made at Karjat. The rear seats were side facing in this case and tthere was no middle bench.

1. Empty Auto
2. Rear benches
3. People boarding the auto

1. Cramped middle row
2. Cramped middle row
3. Passengers in the last rows. Notice most passengers are carrying oversized luggage like sacks, bags, etc.

1. Cramped middle row
2. Cramped middle row
3. Passengers sitting in the front alongside the driver, even though there is little/no space.


1


2


3

1. Passenger hanging at the rear since no seat inside is vacant.
2. Women sitting with bags in their laps
3. Women sitting with bags in their laps
4. Passenger lifting sack of grains into the auto. since the rear door is blocked, the sack has to be lifted all the way up.

1. Middle row of an auto with right side exit blocked.
2. Four passengers sitting in a row of three


1


2

1. Passenger bending head to get off the vehicle
2. Passenger bending head to get off the vehicle
3. Baby being carried on lap
4. View of the driver's cockpit
5. Bags kept on the floor in the first row.

1. Passenger unrolls the rain cover
2. He threads the string into the hoop in the A-Pillar
3. He pulls the rope
4. And, secures the cover
5. Driver side rope has worn away, so the driver holds the rain cover with one hand leaving only one hand free for driving.

COMMON OPINIONS

Basic Insights are common, yet quite a few contrasts appear in the Maharashtra & UP demographics

1. How many passengers on an average? 10-11 on an average, which is almost 3x the capacity

a. Do they stand/hang? How many? Hanging / Standing is a common practice in UP, while not seen at all in Maharashtra

2. Do passengers sit in the front row? Yes, almost on every trip

3. What distance do you cover in one trip? How many trips in a day? More than 10kms

4. Do you travel alone or in groups?

Mostly in groups

a. How many people in the group? Mostly twos

b. Do you get seats for everyone? Yes in Maharashtra and Sometimes in UP

c. Do you have to stand/hang? No in Maharashtra and Yes in UP

5. Do you experience problems boarding/de-boarding? Yes, Passengers on Middle bench lock knees

6. Do problems occur during rainfall? Get Drenched as all water comes in

7. Do you carry luggage with you? Mostly

a. How often/much? at least 1 bag

b. Do you have to pay for it? Seldom/No

c. Where do you have to keep it? Floor or Lap

8. Is the vehicle comfortable to travel? No, Ride is bad on Bad roads

a. Are you able to talk to others/on mobile phone? Able to talk

b. When de-boarding the vehicle, is any pain/ numbness experienced? Numbness not an issue, but accessibility is

c. Are your legs/knees free? No

d. Do you travel after evening? Any problems faced then?

9. What other problems do you face? Front passenger feels vulnerable and insecure. Rearmost passenger feels unprotected. Need to constantly hold onto something. Feel the need of some protection

DESIGN INSIGHTS

DEFINED NEED

- Needs to be at least a 10 seater
- The vehicle's front should be wide enough for the side passenger
- Not a 3-wheeler (Also increased safety at high speeds)
- Should have comfortable ergonomics/NVH levels for long trips
- Inside surfaces should be padded
- Better knee room (avoid facing benches)
- Properly covered sides with closable windows and properly waterproofed
- Easy access to storage space space
- Comfortable suspension is a priority
- Doors / some sort of gates are required for all passengers, even for rear most bench
- Proper interior lighting at rear
- Floor height should be lower
- Floor should be flat and as free of undulations as possible to allow multiple modular seating arrangements

UNDEFINED NEED

- Since no side bolstering is available to middle passengers in bench seat, some grip support
- A large, sturdy step
- Crash worthy body for highway use
- Steering wheel controls instead of handlebar for stability at speed
- High Ground clearance, Low CG, since high passenger weight will alter both of these
- Left side entry/exit only

DESIGN DIRECTION

VITAL

- Seating capacity of 10
- Safety for passengers
- Wide enough for front passenger
- Door at the rear
- Keep Cost Low

ESSENTIAL

- Sufficient Knee-room
- Storage/Stowage space
- Wide Entry point
- Low Floor Height
- Rain-proofing

DESIRABLE

- Flat Floor
- Bolstering/Support for middle passenger
- Structural Rigidity & Rollover protection
- Even Weight Distribution & Low CG
- Comfortable Suspension
- Interior Lighting

PACKAGING

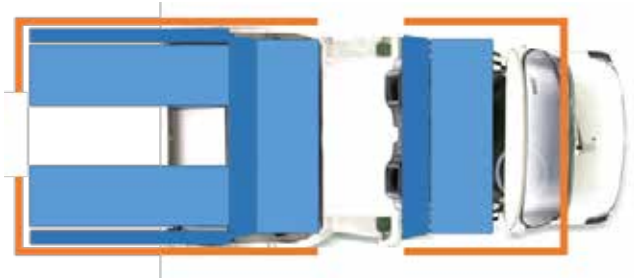
BASIC PLATFORM

For a starting point to avert complex engineering analyses, we select an existing vehicle as a template to benchmark our new package against. The basic package selected was Mahindra Gio.

The reasons were:

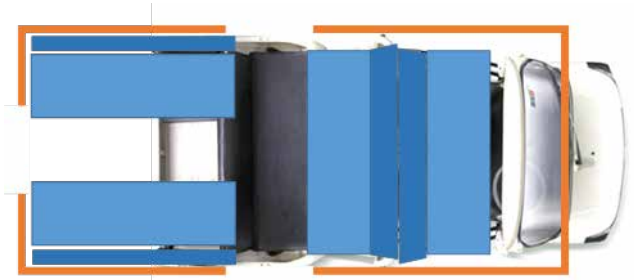
	Gio [6]	Maxximo/Magic [7]	Magic Iris [8]	Ape/Alfa [9]	Advantage	Reason
Price	1.95lakhs	3.4lakhs	2.2lakhs	1.5lakhs	Reasonably Priced	Added value for operator
Fuel Economy	30kmpl	20kmpl	33kmpl	36kmpl	Decent FE	
Resale value (1yr)	1+	2+	1.5+	1.1+	Decent value	
Floor Height	490mm	NA	450-493mm	NA	NA	Undefined need
Seating Capacity	D+6	D+7	D+4	D+3	High Passenger/Size ratio	10 passengers required
Ground Clearance	165 mm	160 mm	160 mm	175 mm	On the higher side	Should be high for bad roads
Wheelbase	2005 mm	2100mm	1650mm	2005 mm/1750mm	Second Highest	More space & Undefined need: Flat floor
L	3180 mm	3677 mm/3800mm	3020mm	2990 mm	Possibility of stretching for more space	Can be extended without becoming cumbersome as users are familiar with vehicles of this size
B	1480 mm	1540 mm/1500	1480mm	1480 mm	Possibility of stretching for more space	
H	1950 mm	1845 mm	1800mm	1905 mm	Excellent height for ease of ingress/egress	Less bending while getting in/ out

SEATING LAYOUT



LAYOUT 1:

Lengthening the rear jump seats, we can add 4 more passengers to make it a D+10 seater

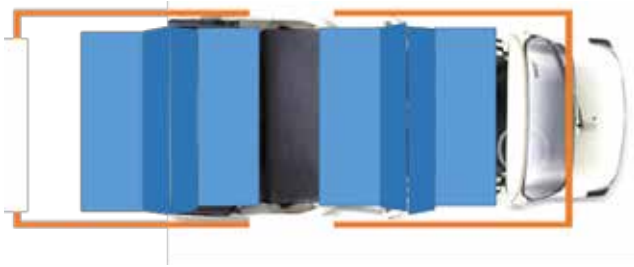


LAYOUT 2:

Turning the middle bench rearward, we can allow for an alternative for the rear jump seat passengers to get in/out via the side

LAYOUT 3:

Alternating front and back facing seats



LAYOUT 4:

Closing side entry point, there can be two long rows of sideways facing jump seats with D+9 capacity

These 4 Layouts are judged on the basis of how well they fit into the design direction and design brief.

For this, their effects on the desired and undesired needs is classified into a table, and prioritised based on whether they are Vital, Essential or Desirable.

Then accordingly, weightage is assigned and a score out of 5 is derived for the different layouts to choose the one with the highest score

Hence, clearly Layout 4 is better than the others in the areas defined by the design brief, and hence it is chosen.

Direction	Weightage	Layout 1	Layout 2	Layout 3	Layout 4
Seating capacity of 10	1	5	5	5	2 D+9
Low Cost	1	4	4	2	5

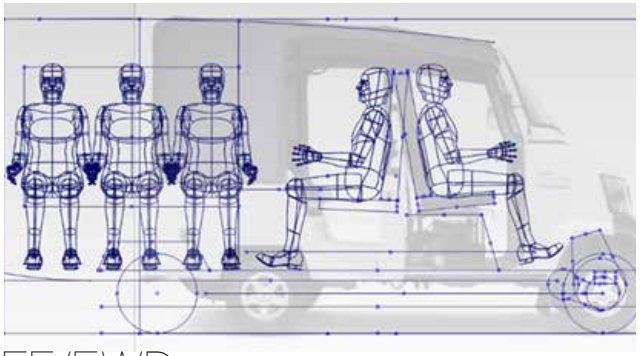
Direction	Weightage	Layout 1	Layout 2	Layout 3	Layout 4
Sufficient Knee-room	0.5	4 Knees least Entangled	3 More Entangled	5 Least Entangled	1 Most Entangled
Easy Entry/ Exit	0.5	4 Easy	5 Easier: Rear passengers can use 3 exits	5 Easier: All passengers are located close to exits	2 Difficult: for rear passengers

Direction	Weightage	Layout 1	Layout 2	Layout 3	Layout 4
Even Weight Distribution & Low CG	0.25	3	4	5	3
		Fair	Better	Best	Fair
Total		11.75	14	13.25	9.25

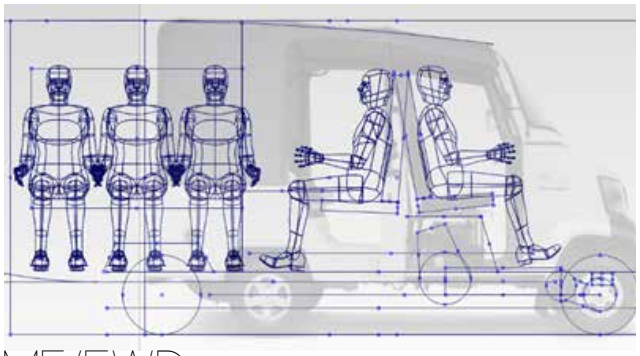
POWERTRAIN PLACEMENT

There can be the following possible combinations for powertrain packaging: Rear engine, Rear wheel drive, Front Engine & Front wheel drive. Mid-engine & rear wheel drive and finally Mid-engine & Front wheel drive

However, in RE/RWD format, floor height restricted by height of engine below floorboard. The engine placement doesn't allow seats to be lowered to same level, which is required for a flat floor. Therefore it clashes with the seating Layout selected before, and is hence rejected.

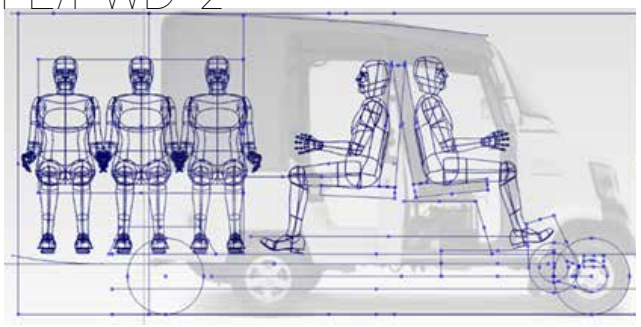


FE/FWD

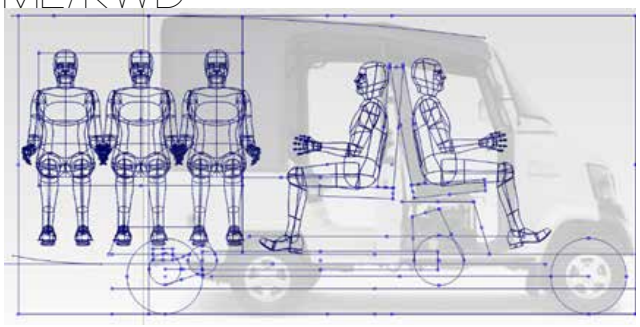


ME/FWD

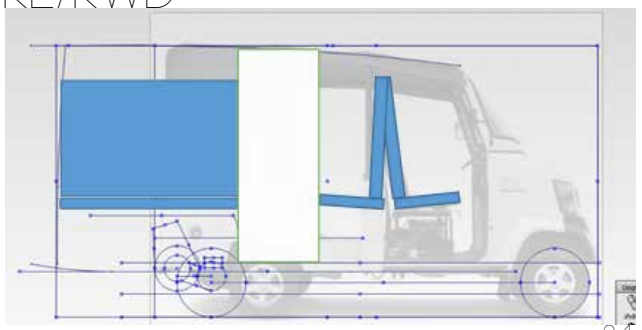
FE/FWD 2



ME/RWD



RE/RWD



Again a similar table is created and the layouts are judged on the basis of how well they fit into the design direction and design brief.

For this, their effects on the desired and undesired needs is classified into a table, and prioritised. Then accordingly, weightage is assigned and a score out of 5 is derived for the different layouts to choose the one with the highest score

Now, clearly, FE/FWD is the best suited layout.

Direction	Weightage	Front Engine/ FWD	Mid-Engine/ FWD	Mid-Engine/RWD
Low Cost (Powertrain)	1	4/3	2	3
		Higher than RE/RWD	Cost is highest	High cost due to addition of prop shaft
Low Cost (Crumple Zone)	1	2	4	5
Low Floor	.5	5	4	2
Rear Floor Height		380-400mm	380-400mm	500mm*
Front Floor Height		380-400mm	500mm	500mm
Flat Floor	.5	5	4	2
		No Tunnel/ Flat Floor	Rear floor flat/Front Floor has tunnel for Prop Shaft	Tunnel for prop shaft at the rear & Hump at rear for Transaxle mount
Even Weight Distribution & Low CG	.5	5	4	3
Total Score		13.5/12.5	12	11.5

FLOOR & OVERALL HEIGHT

High Floor height means difficulty in ingress & egress. But high overall height means passengers dont have to bend down.

According JNNURM guidelines Urban Low floor buses should have <400mm step height. [10]

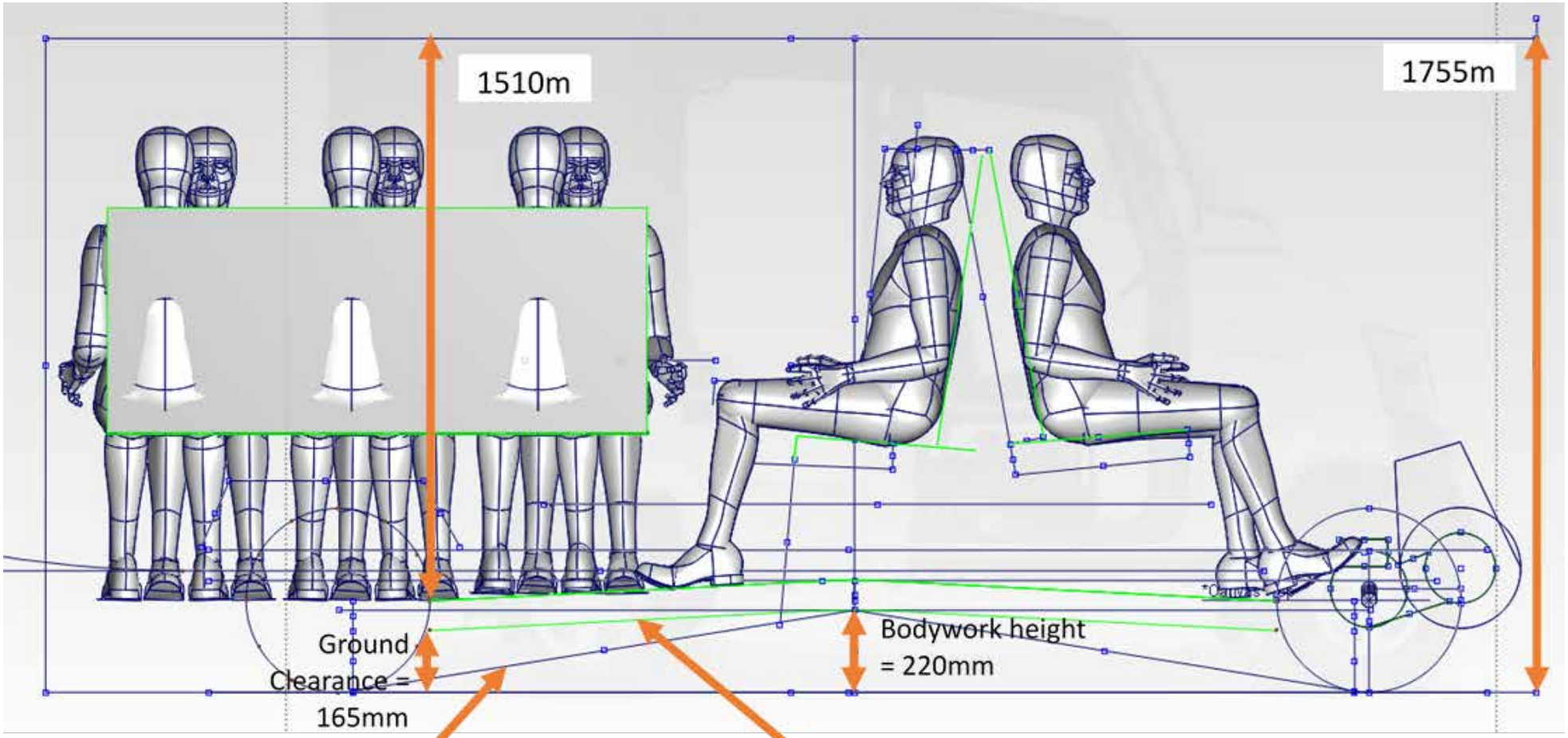
Although, this is a rural vehicle, and need is not explicitly stated, difficulty in ingress/egress was documented repeatedly on multiple users.

Also, vehicles in the nearest class already have comparable floor height (Magic Iris: 490mm) [8], hence, floor height of 380-400mm is seen as a reasonable target.

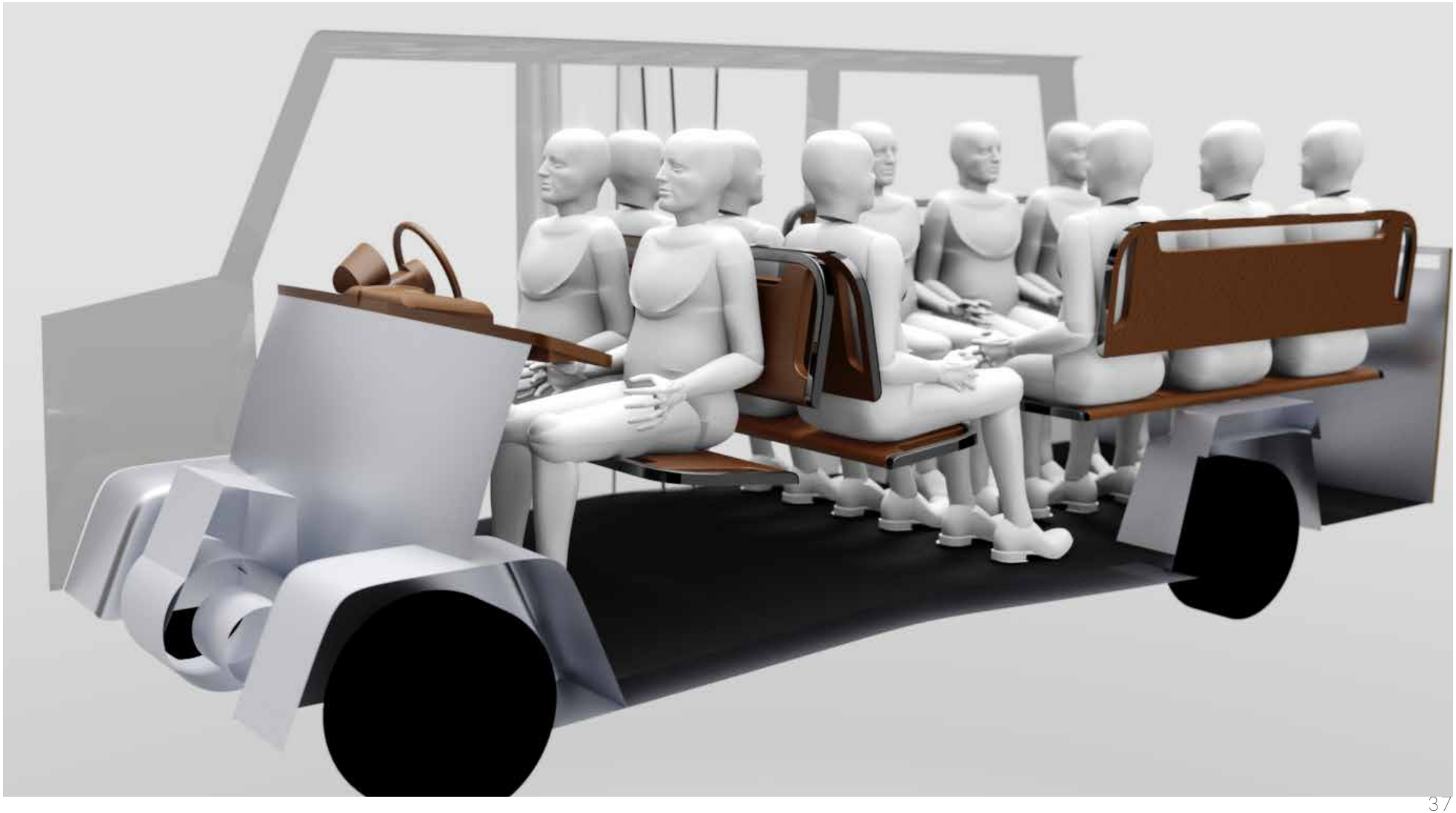
However, existing platform has a large overall height, which is associated with negatives like body roll and aerodynamic drag. Hence, it can be further lowered. Again, due to the layout of the seats in the vehicle, there is a lot of passenger movement that would happen inside the vehicle. Since, the passengers would need to get up from their seats while moving, which would require a high roof. The current roof height is at par with vehicles with similar seating layouts (Tata Winger) [11], and passengers had no reported issues with the height of the roof and the slight crouching was considered acceptable. Hence, we can conclude that cabin height (1510mm) should not be altered, which forces us to shave the bodywork height from the ground.

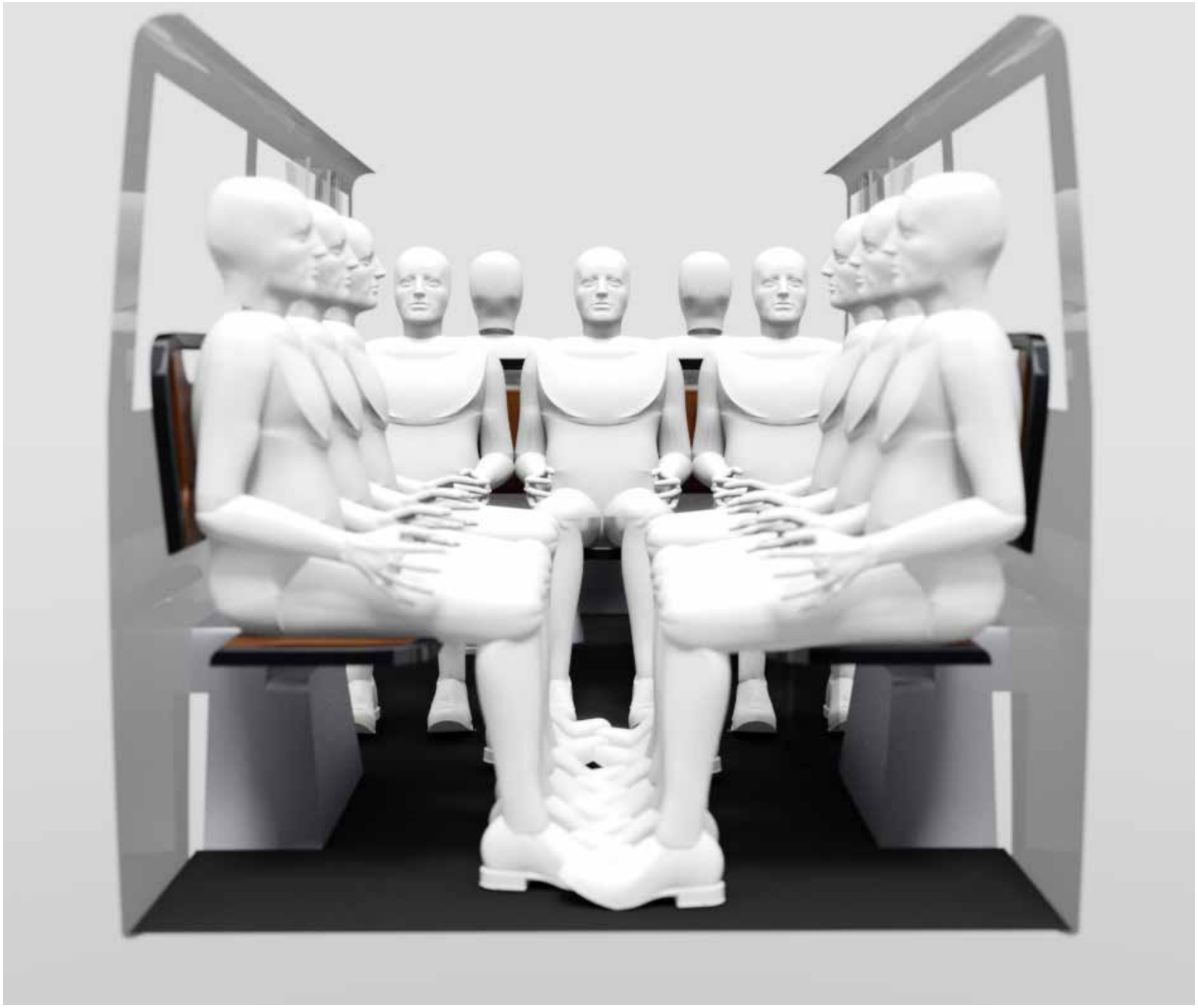
The major concern in this scenario would be the break-over ramp angle. Since the wheelbase has already been increased, hence, it is essential that the angle is not decreased, as doing so would render the vehicle useless over broken rural terrain.

Bodywork heights for SUVs in the market was studied, and break over angle was plotted for the new wheelbase and wheel size. Considering a thickness of 80mm for the floor panel, the floor height of 300mm is achieved. To further shave off height the floor is given a slight curvature, which reduces floor height to 245mm and overall height to 1755mm from 1900mm.


1510m
1755m
Ground
Clearance =
165mm
Bodywork height
= 220mm
Same Ramp angle
Slightly curved floor

CAD LAYOUT





AESTHETICS

Image Reference:

1. surfindia.com
2. http://www.stockpicturesforeveryone.com
3. http://www.museindia.com
4. fineartamerica.com
5. www.indiawaterreview.in
6. www.travelsageindia.com
7. http://nationalcraftsmuseum.nic.in/

To begin, the aesthetics of the surroundings in a village were observed.

Farm implements and other scenery around villages was looked at

Image Reference:

1. www.indiamart.com
2. www.panoramio.com
3. www.tradeindia.com
4. www.mahindracarsindia.com
5. www.freepik.com
6. www.nif.org.in
7. www.twitsnaps.com

For the aspirational emotion, the "Kothis" in the villages were looked at as they are the most direct form of inspiration to the villagers

Image Reference:

1. wikimapia.org
2. expedia.com
3. www.tripadvisor.co.id
4. www.airbnb.com

DESIGN BRIEF

Design a four-wheeled vehicle to be used as a public transport vehicle in rural and semi-urban India. The customers are those people who travel between villages and towns for visiting markets, work, education, etc. Hence, it should have low initial and running costs and seat about ten passengers apart from the driver in relative comfort. It should be cheaper than the existing 4-wheeler cabs, but bigger than the autorickshaws. It should have enough space so that passengers can enter and leave the vehicle quickly and with ease, and sit without getting entangled with others. The interiors should be well ventilated for summers and well insulated for winter and monsoons.

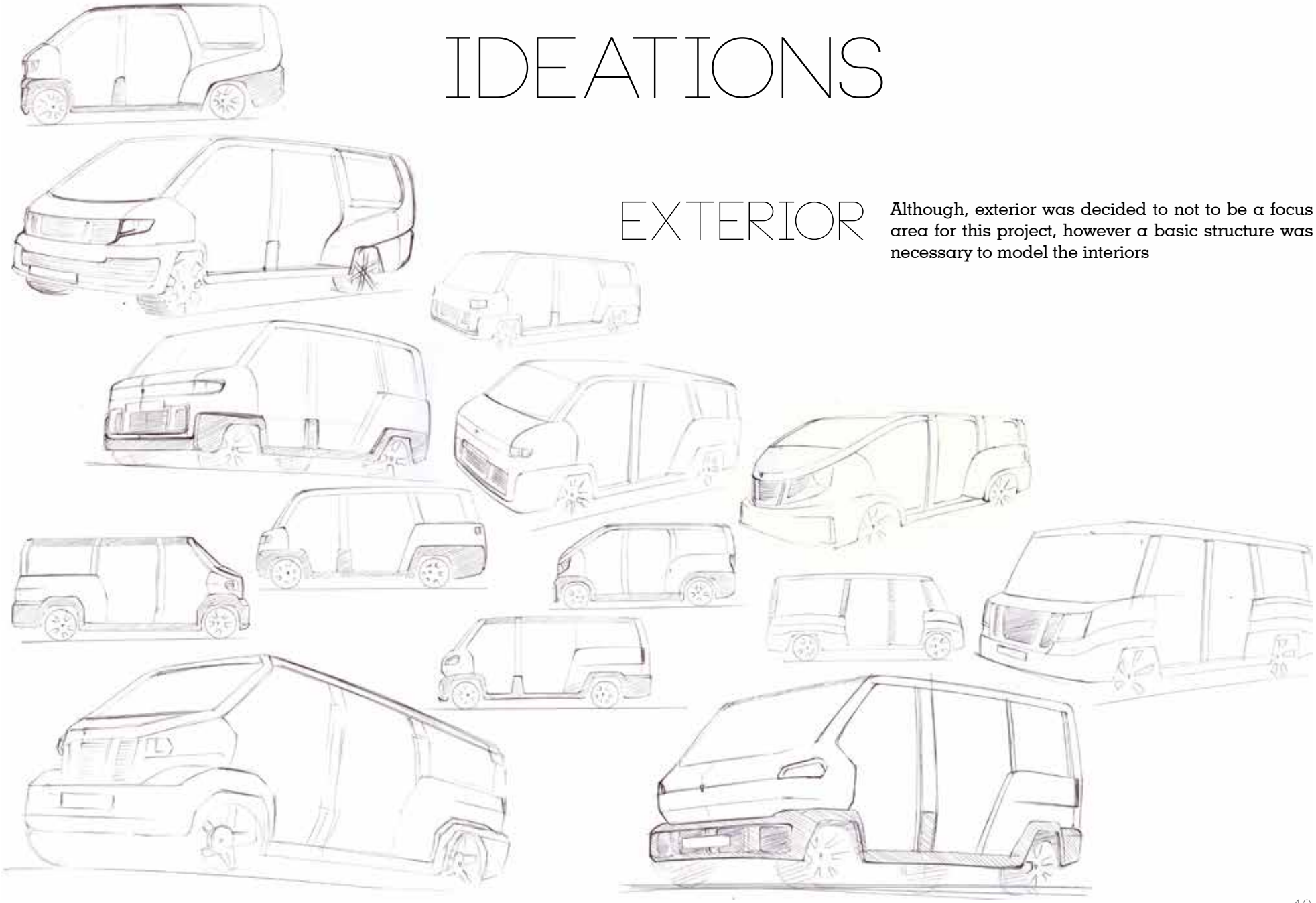
It should not compromise on safety as the vehicle will run on highways while moving from village to village or village to city. The passengers should also have easy access to some type of stowage space for their luggage. Since the vehicle will ply over broken surfaces, it should have a comfortable suspension so that the passengers sit in comfort. The floor of the vehicle should be as flat as possible to ensure easy movement of passengers within the cabin space.

The aesthetics of the vehicle should be such that it blends well with the rural setting. Local motifs and items of daily use in villages should be chosen as metaphors for the form of the vehicle. Similarly colour palette should be selected according to the colours used and seen in Indian village scenes.

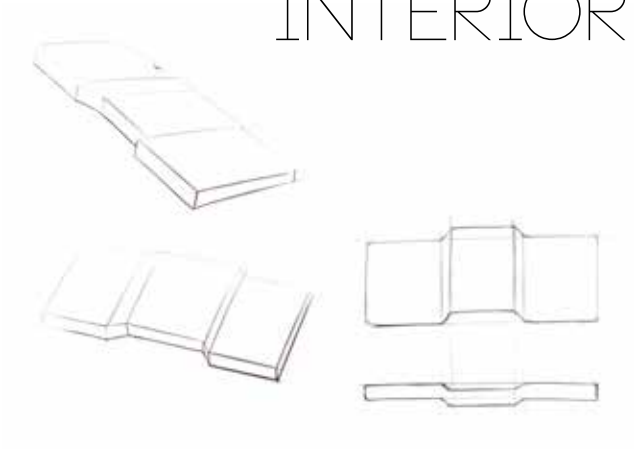
IDEATIONS

EXTERIOR

Although, exterior was decided to not to be a focus area for this project, however a basic structure was necessary to model the interiors



INTERIOR



For ideations of Interiors, we must first consider the scenarios that arise during the usage of this vehicle;

SCENARIO 1:

Seat:

1. The vehicle accelerates/decelerates/takes a turn. As the passengers are seated on bench seats, there is no under-thigh or lateral bolstering. Hence they lean towards the passenger seated next to them. This creates an unpleasant situation, especially if one of the passengers is a female.

2. Passenger tries to enter the vehicle from the side opening. The seats have their corners sticking out which strikes the knees & acts as a barrier.

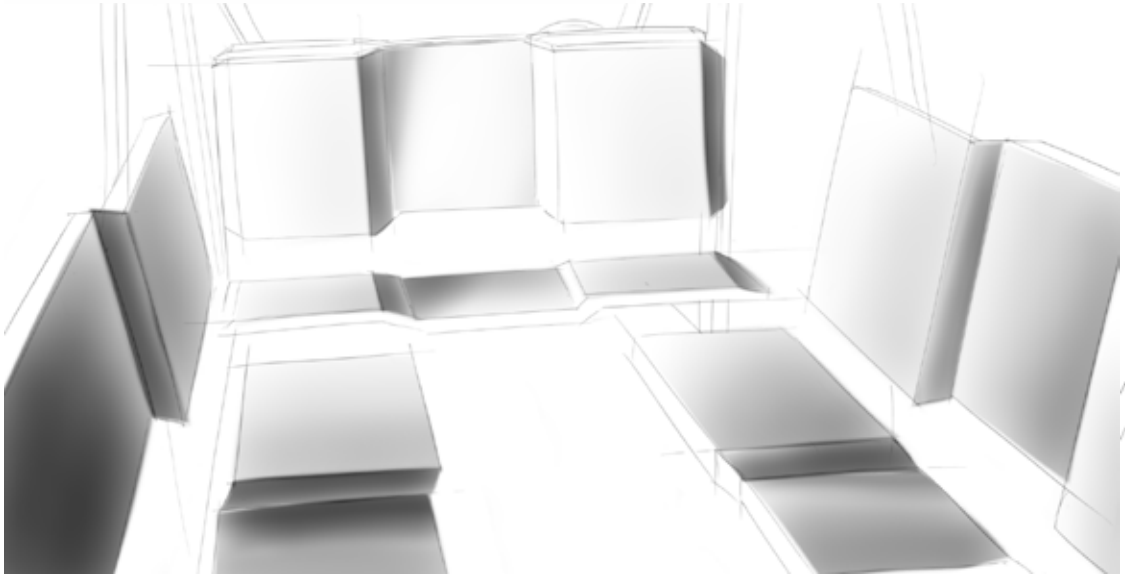
SOLUTION:
CONCEPT 1:

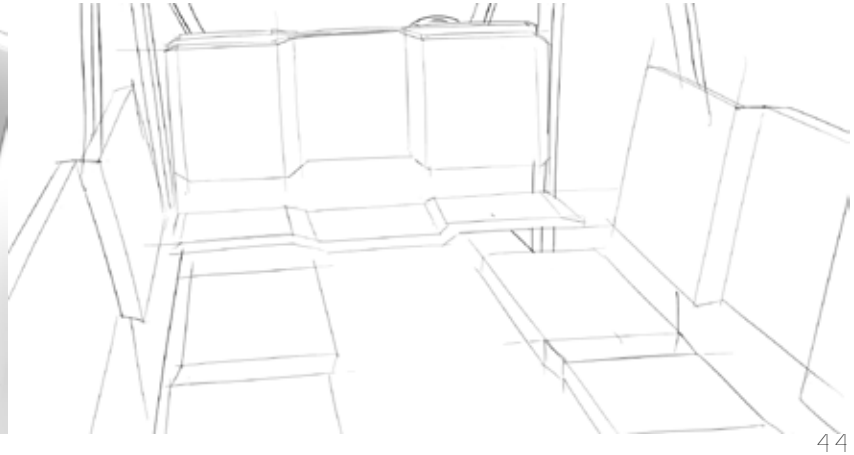
Advantages:

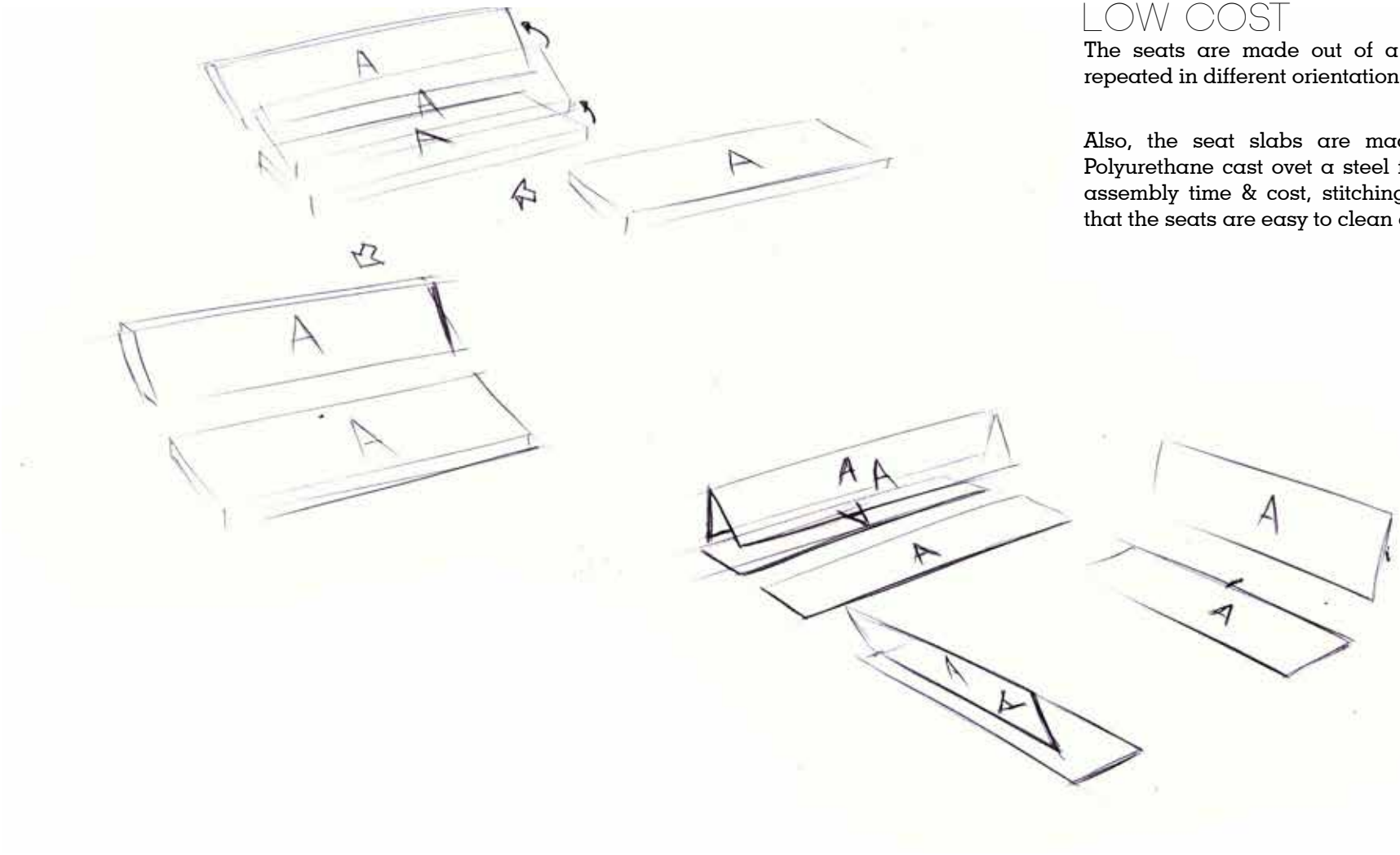
- Provides lateral support to passengers
- Only one piece in different orientations is used to make all the seats

Disadvantages:

- If 4 or more passengers sit, it causes discomfort







LOW COST

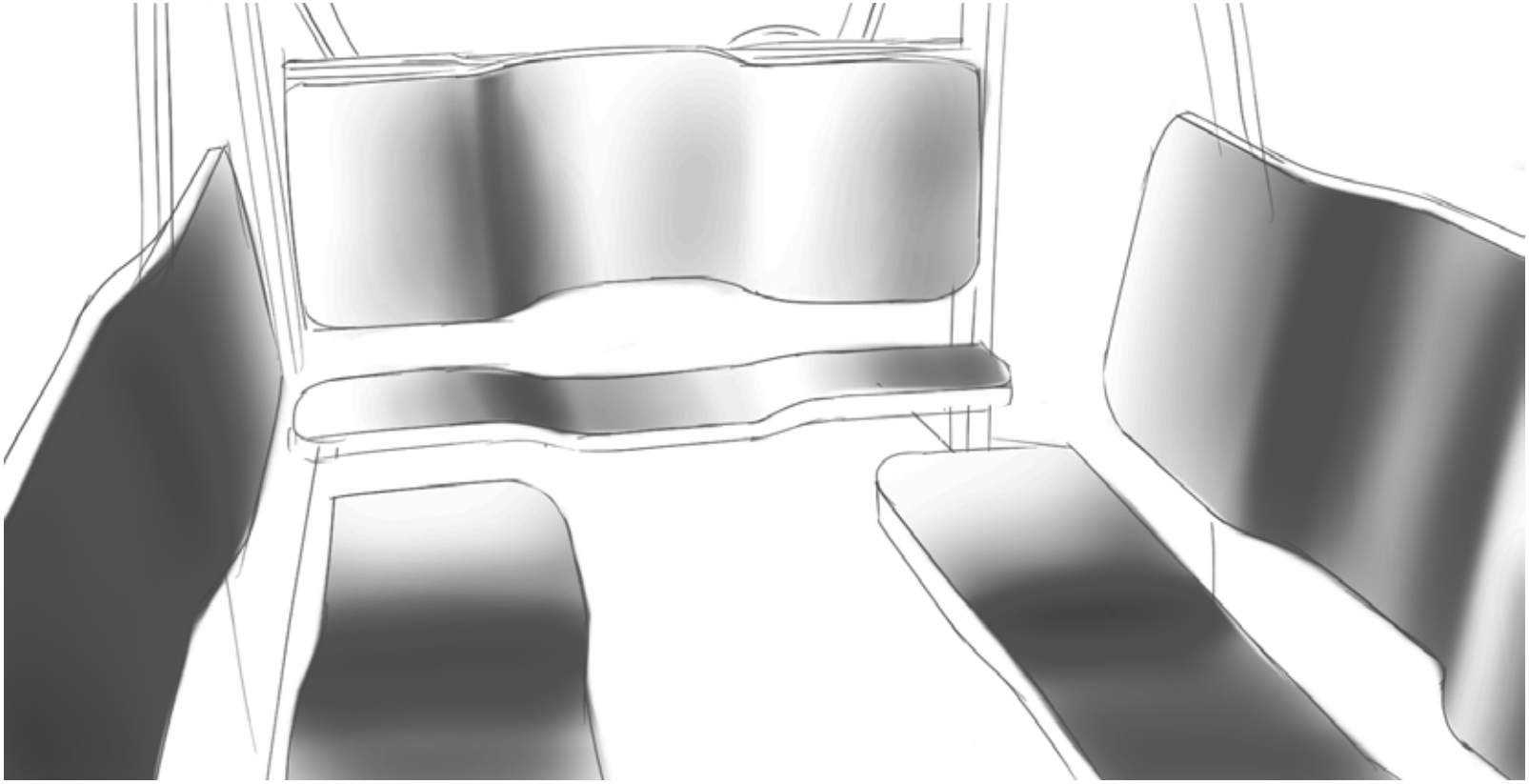
The seats are made out of a single unit that is repeated in different orientations. This saves cost.

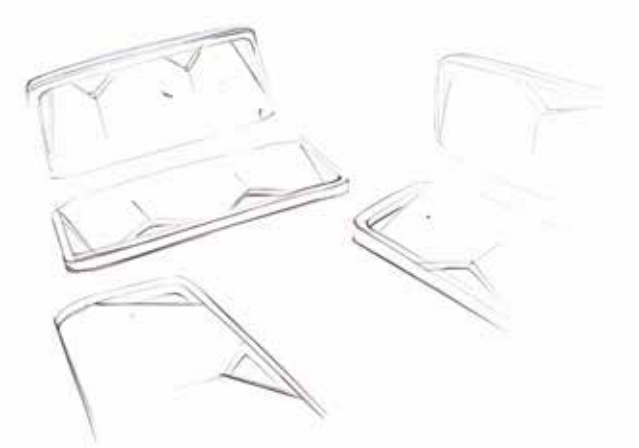
Also, the seat slabs are made up of a single Polyurethane cast ovet a steel frame. This reduces assembly time & cost, stitching cost, and ensures that the seats are easy to clean and waterproof.

VERSION 2:

Advantages:

- Smoothed out edges to match filleted aesthetics of village houses
- Smoother fillets means comfort even when seating >3 passengers





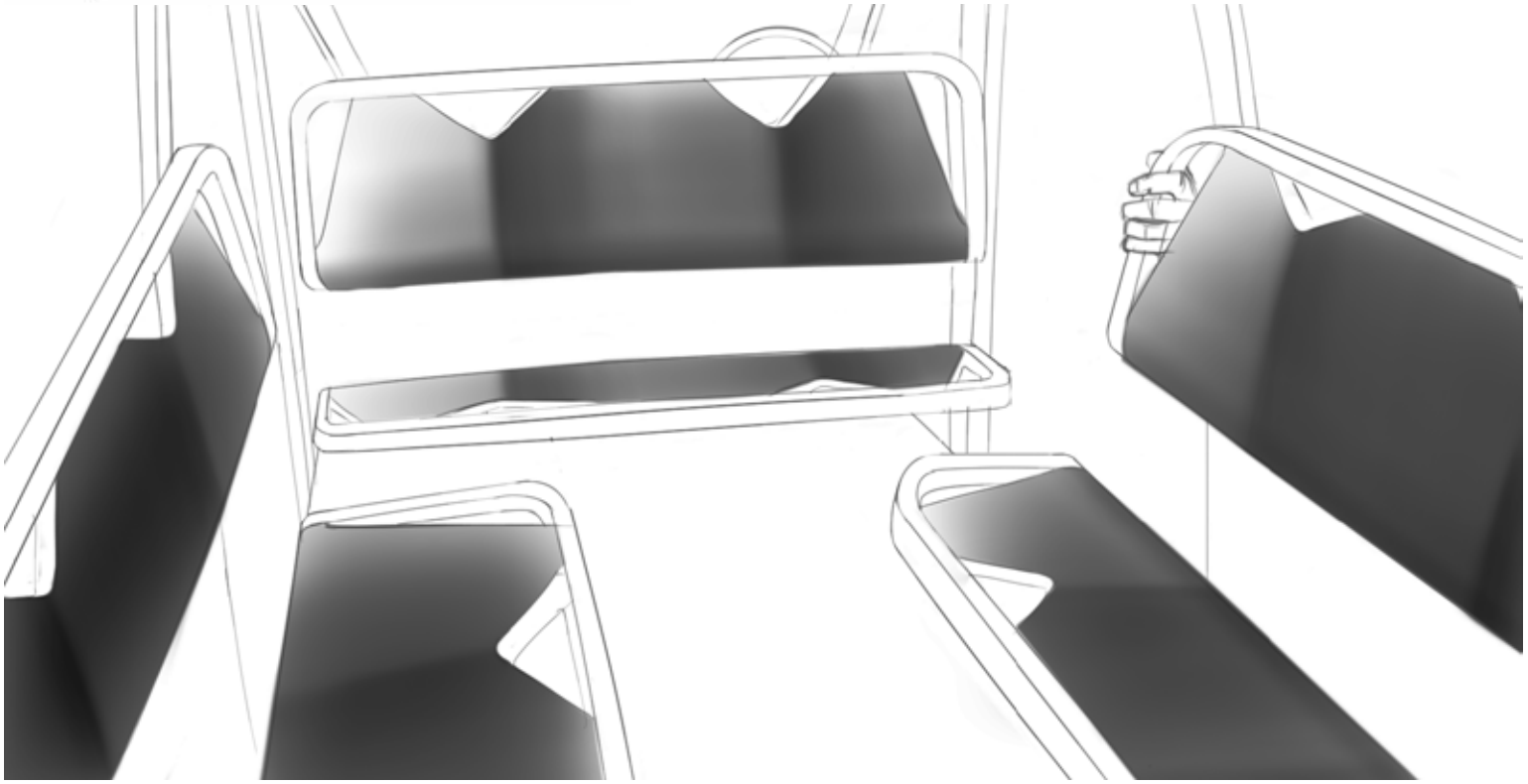
CONCEPT 2:

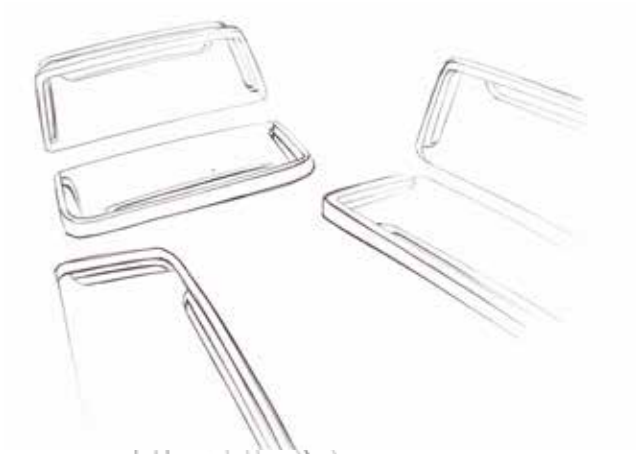
Advantages:

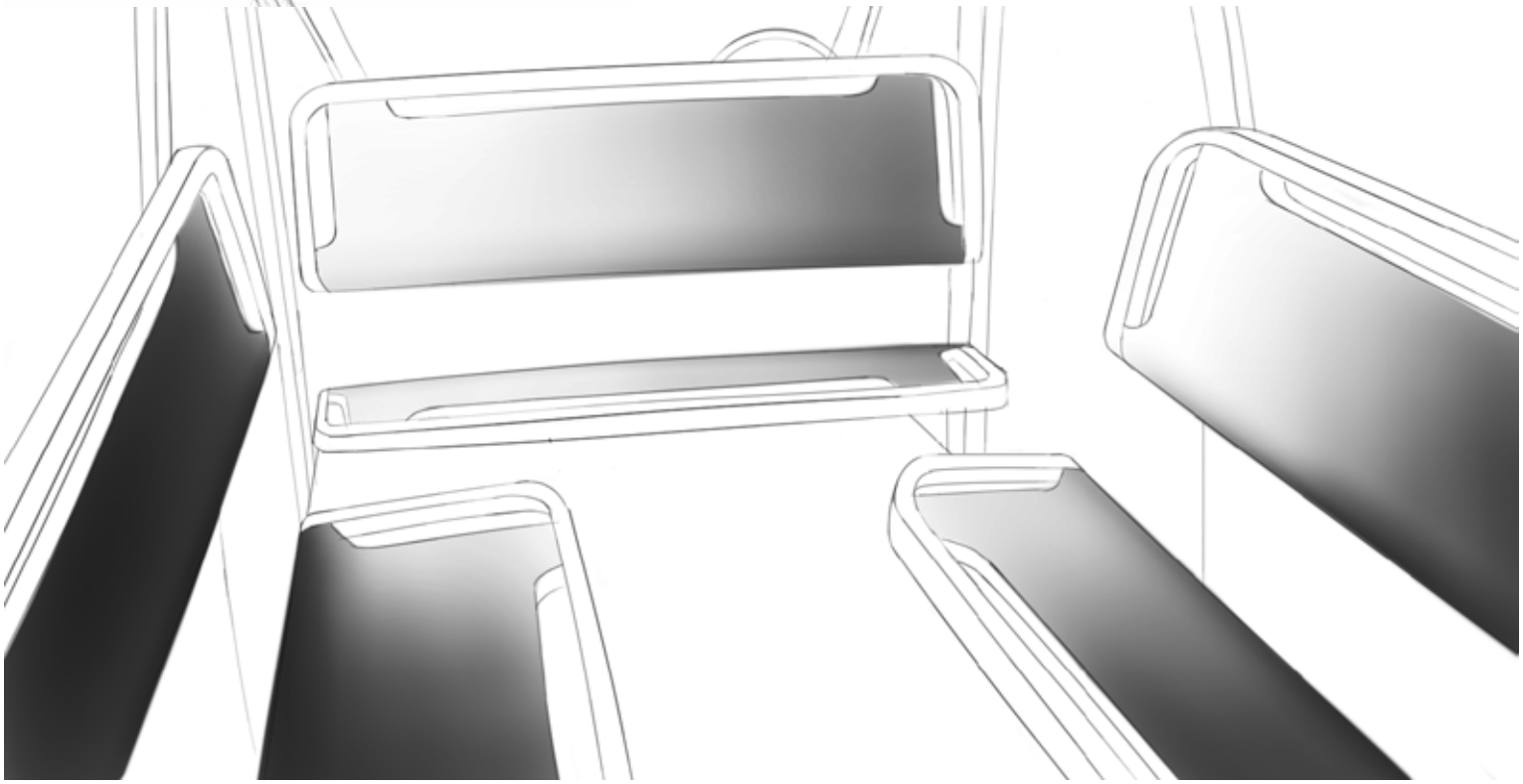
- Cut-outs on the seat itself to hold onto while turning/accelerating
- 4 or more passengers can sit comfortably
- Gentle curvature in seat provides some lateral support

Disadvantages:

- When being used by 4/more passengers, cut-outs are not available for everyone's hands



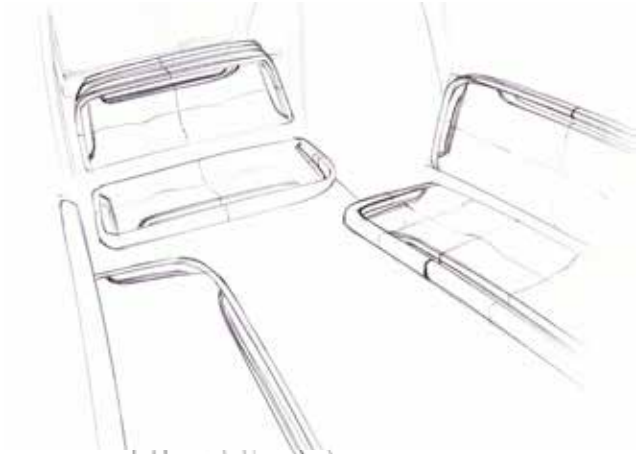


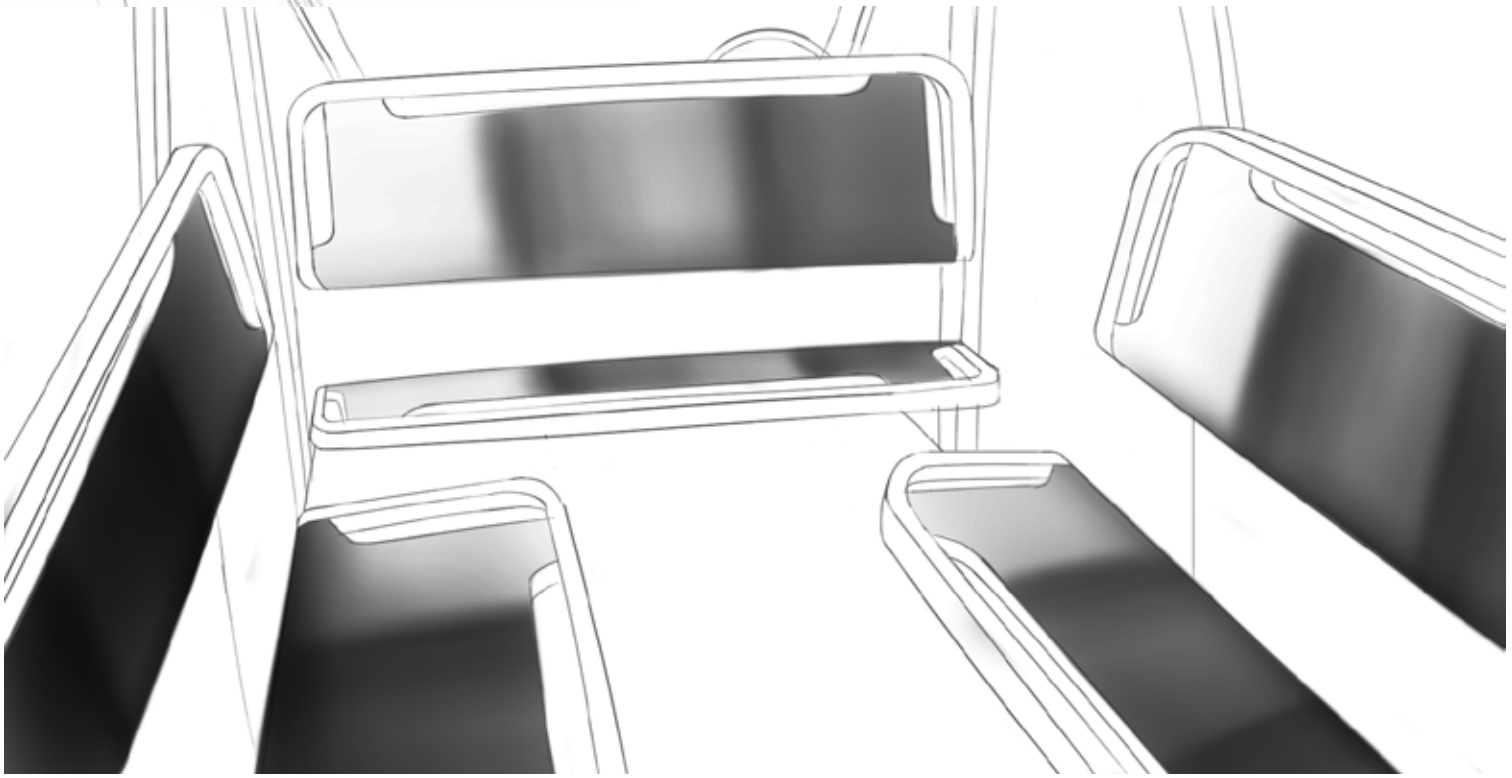


CONCEPT 3:

Advantages:

- Continuous cut-out provides grip for 4 or more passengers
- Side cut-outs also act as handles for passengers to grab onto while climbing into or out of the vehicle



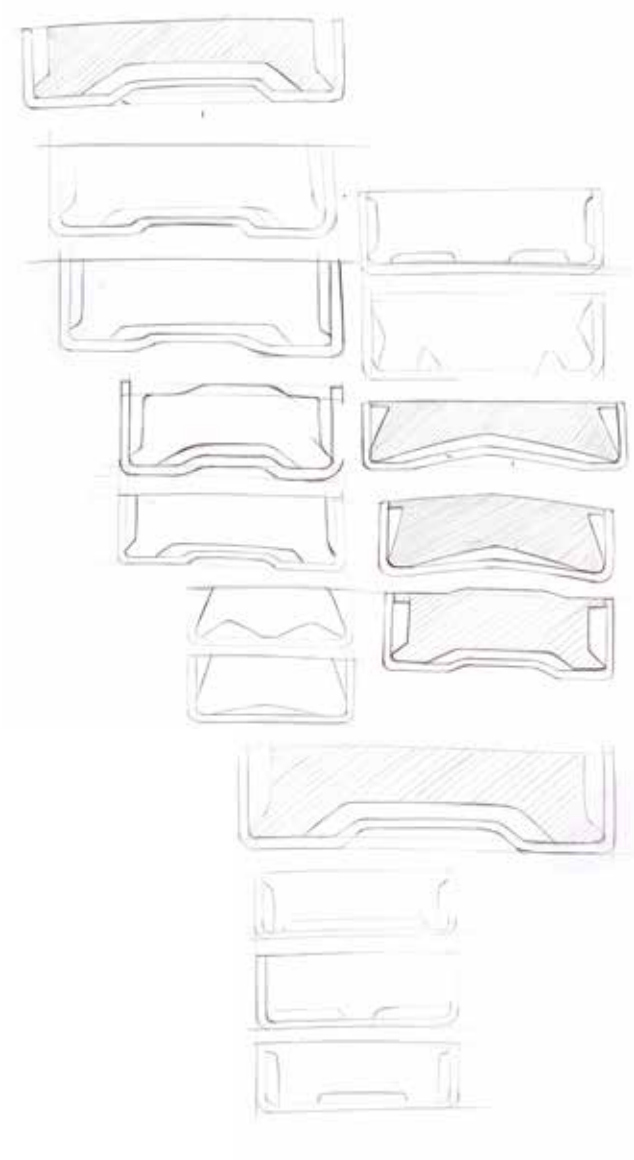


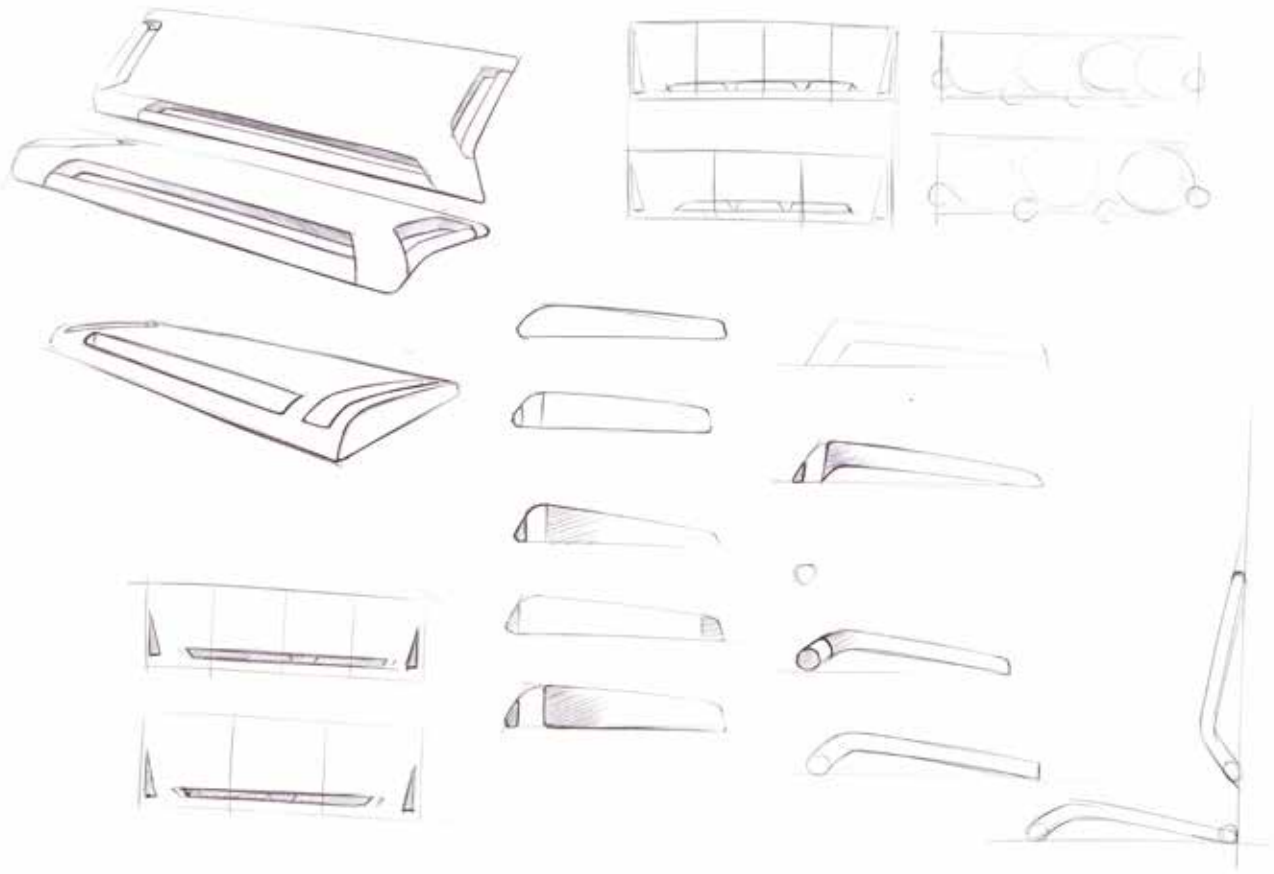
VERSION 2:

Ridges from concept 2 added for added side support

CONCEPT 4:

Seat has a bent profile for bolstering

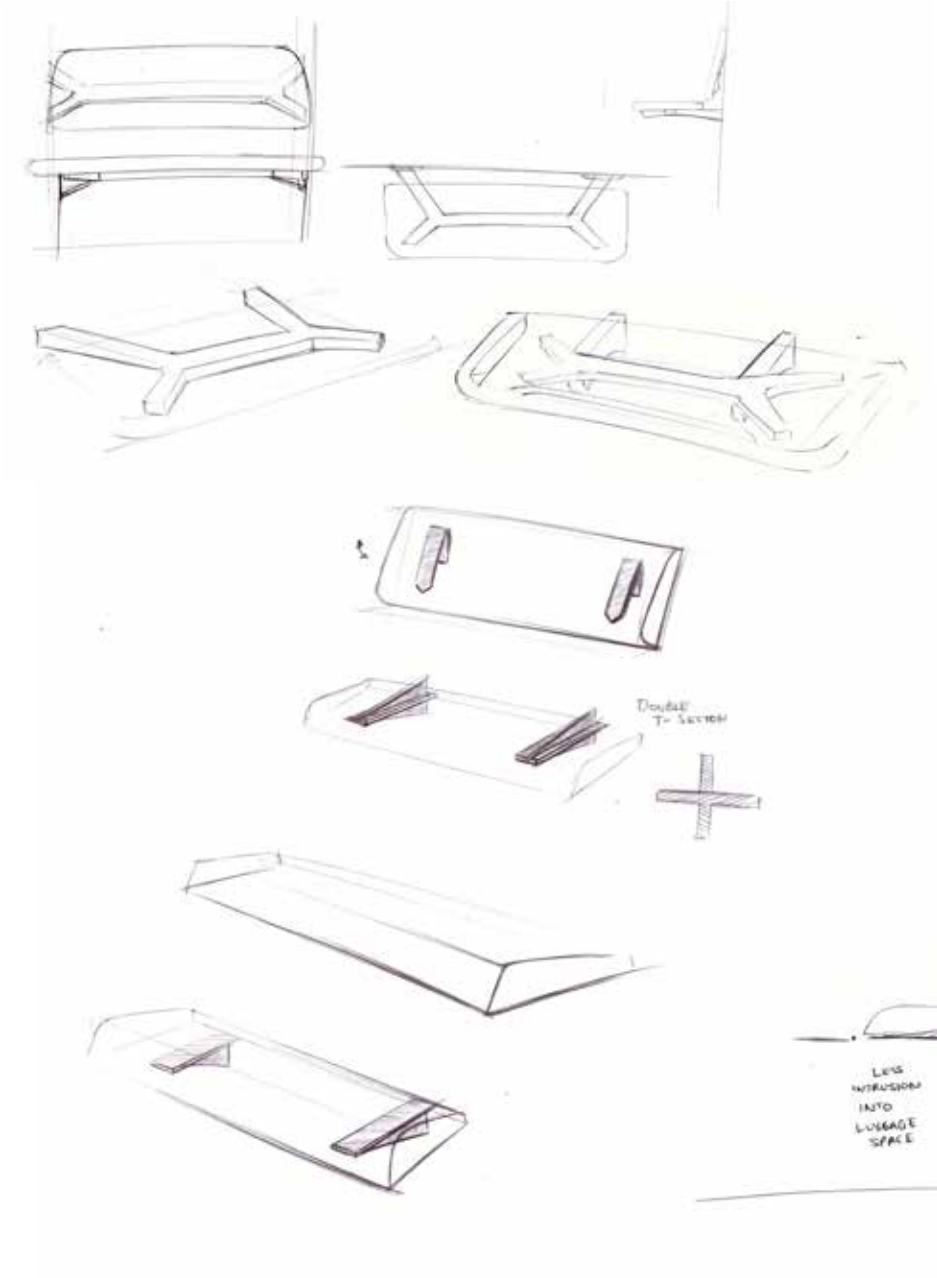




SELECTION

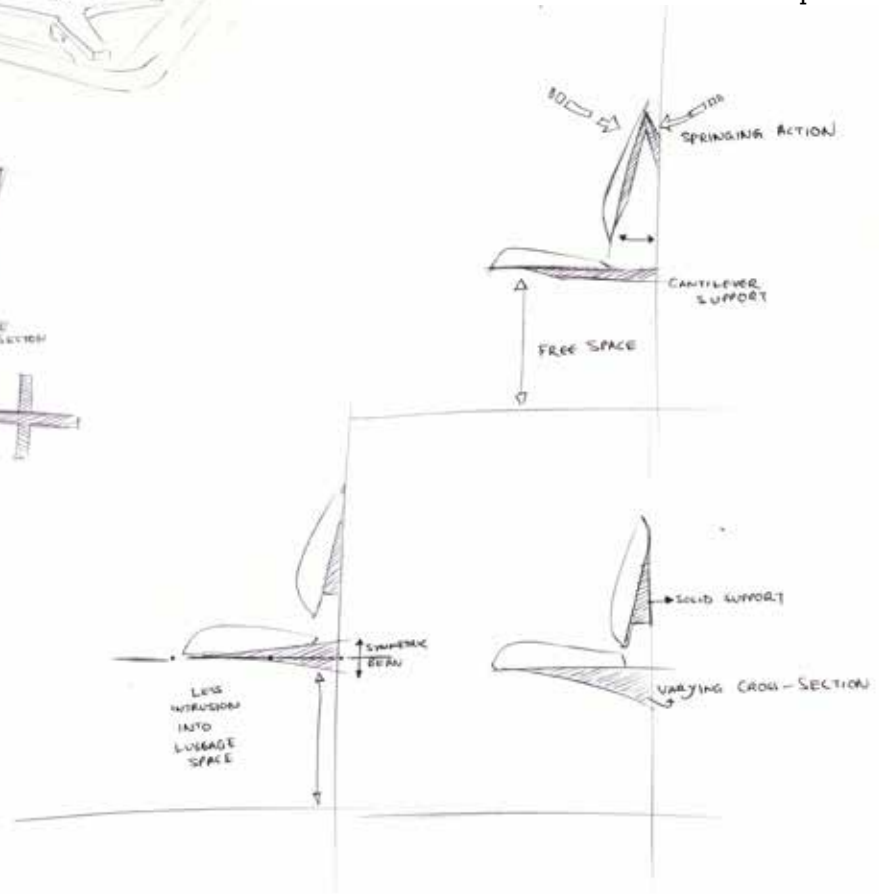
The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

	Concept 1		Concept 2	Concept 3		Concept 4
	Version 1	Version 2		Version 1	Version 2	
Low Cost						
Seats 10 Passengers	1	2	2	5	3	5
Easy ingress & egress	1	2	4	4	4	4
Less entanglement of knees						
Ventilation						
Insulation						
Space						
Total	2	4	6	9	7	9



SEAT FRAME

Seat frame is made cantilever to provide large & continuous space below the seats



SCENARIO 2:

Luggage:

1. Passenger tries to board the vehicle with luggage. Luggage consists of a backpack, or a carry bag. The bag generally contains important items, and hence the passenger holds the bag in their lap

2. Passenger tries to board the vehicle with luggage, but luggage consists of a sack of grains and is too big to haul inside the cabin without disturbing the other passengers. The luggage item is too heavy to be kept on lap and is kept on the floor

3. Passenger tries to board the vehicle with luggage. The luggage consists of a suitcase/ travel bag/ chest. The luggage item is very large, and when it's stored on the floor, it blocks the complete aisle/legroom.

4. Alternatively, there is no space inside the cabin for the suitcase. It has to be kept on the roof luggage carrier. The driver/co-driver has to get down, climb the side of the vehicle and haul up the luggage. He then ties it to secure it from falling due to shocks from rough terrain.

5. The vehicle brakes heavily. The luggage and loose items kept on the vehicle floor slide forwards. This poses inconvenience/danger for the passengers.

SOLUTION

Under seat area is completely unobstructed and continuous to allow keeping objects of any size.

This is done by using seats mounted on a triangulated cantilever bracket

Steel ribs on the floor prevent luggage from sliding

Additional space is provided for oversized luggage in the form of a rooftop luggage carrier

CONCEPT 1:

Side opens downwards and bottom members are rollers

Roof member acts as handle to hold when climbing to access the luggage rack, while the recess acts as a step for climbing to access the luggage rack

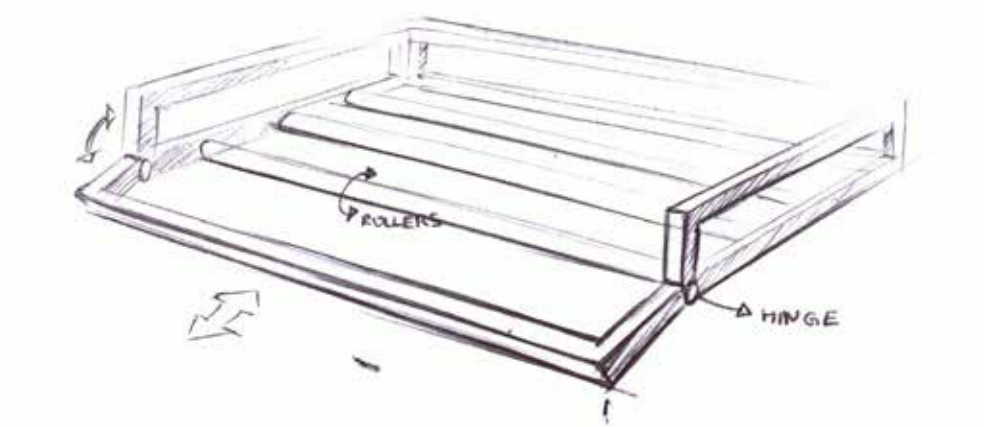
`

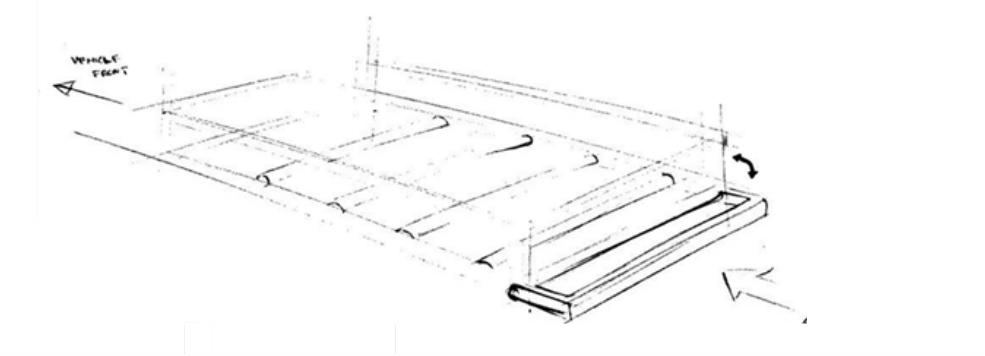
Advantages:

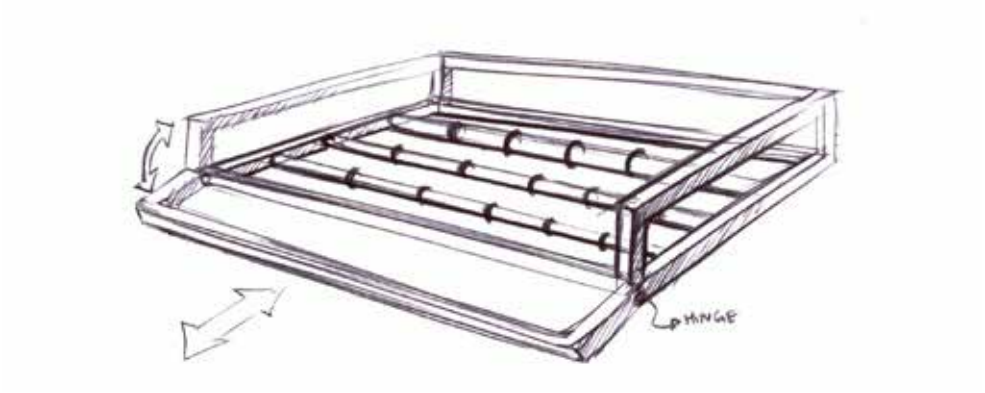
- Luggage can be slid in from sideways

Disadvantages:

- Heavy luggage on one side could prevent rolling of entire roller







VERSION 2:

Access from rear instead of sides

Advantages:

- Rear of the vehicle already has a floorboard, making it easier to climb to access the rack

Disadvantages:

- Allows access from only 1 side, forcing LIFO (Last In First Out) protocol

VERSION 3:

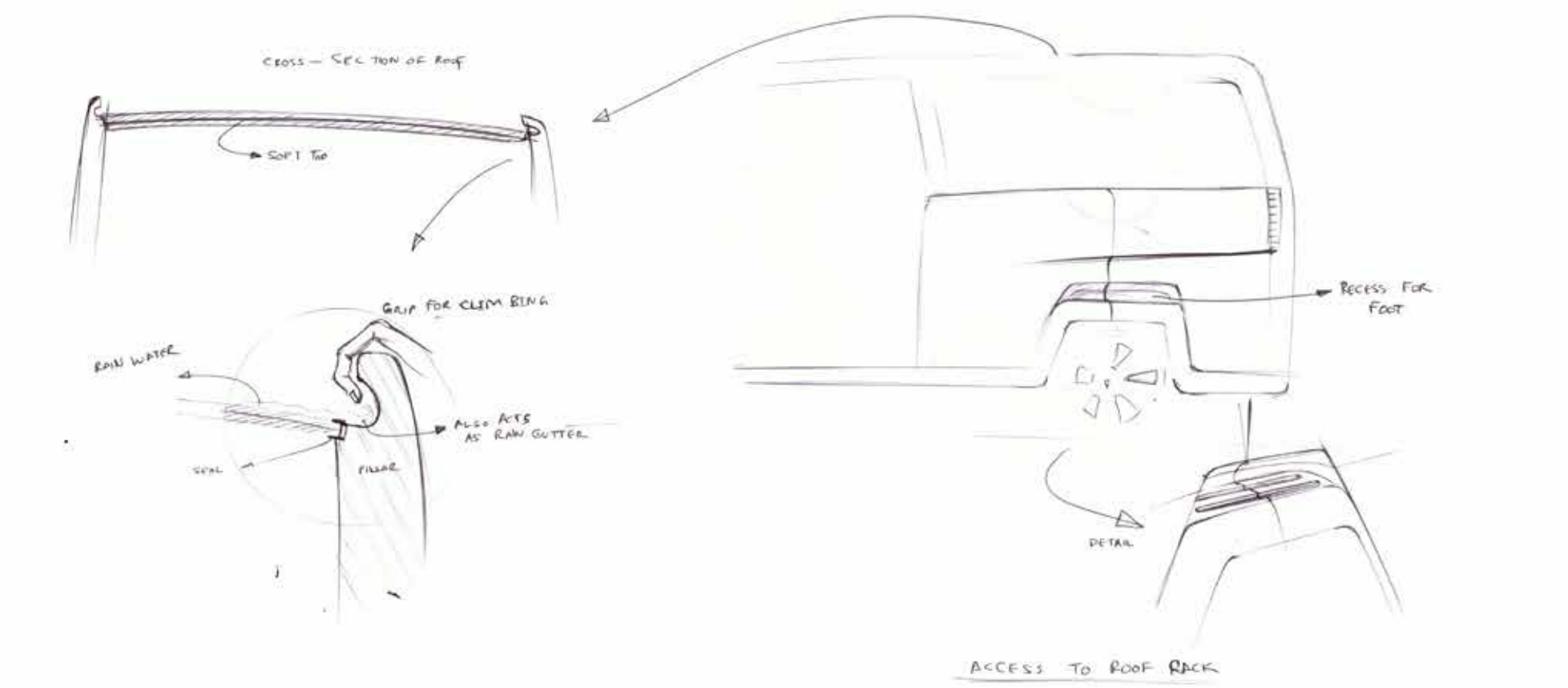
Side opens downwards and bottom has tiny wheels instead of rollers

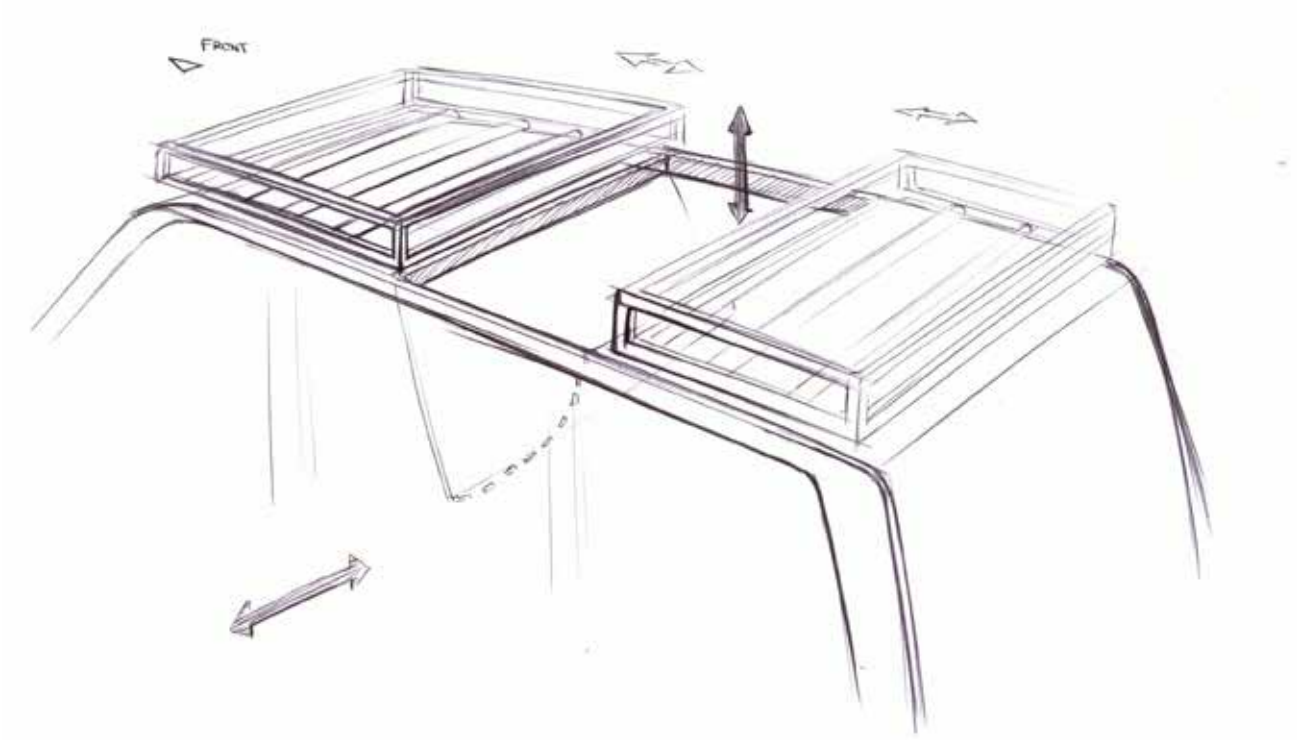
Advantages:

- Less wear

Wheels can move even when other luggage items are in the rack

Roof member acts as handle to hold when climbing to access the luggage rack, while the recess acts as a step for climbing to access the luggage rack


CROSS – SECTION OF ROOF
SOFT TOP
GRIP FOR CLIMBING
RAIN WATER
ALSO ACTS AS RAIN GUTTER
SEAL
PILLAR
RECESS FOR FOOT
DETAIL
ACCESS TO ROOF RACK



CONCEPT 2:

Access from within the vehicle by opening a hatch in the roof

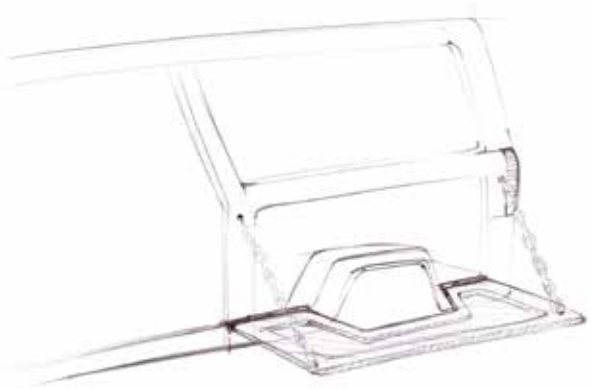
Advantages:

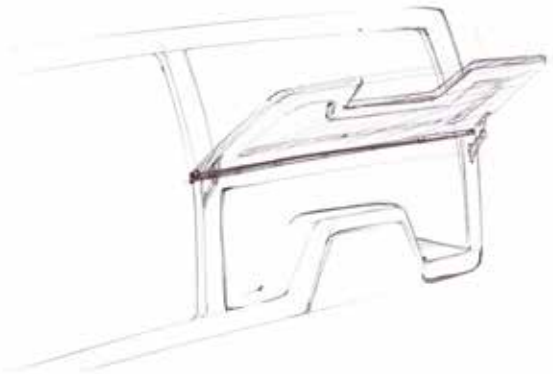
- Easy access by standing inside the vehicle no climbing
- Rollers on bottom members allow easily sliding the luggage into the rack

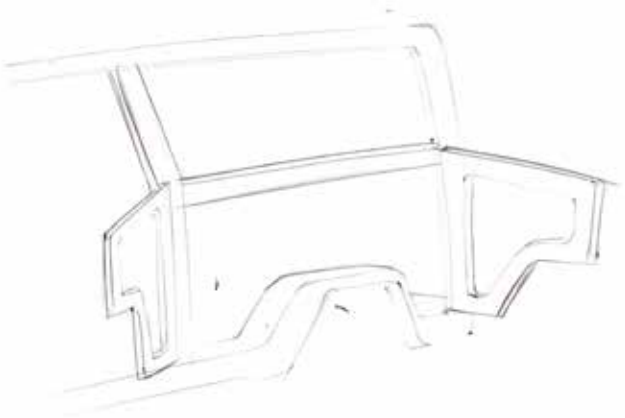
Disadvantages:

Space used for the hatch is wasted and cannot be used to store luggage

- Water-proof sealing hatch in soft-top is difficult and expensive







CONCEPT 3:

Side opening doors

Advantages

Luggage can be moved inside without disturbing passengers

Disadvantages:

- Security of luggage
- Limited size of the opening

Hence, this was not used in final concept

VERSION 1:

Drop down type

Advantages:

- Door acts as shelf
- Even if luggage shifted during drive, it won't fall out

Disadvantages:

- Increases distance between user and vehicle

VERSION 2:

Lift up type

Advantages:

- Remains shut due to gravity

Disadvantages:

- Luggage shifted during drive might fall out

VERSION 3:

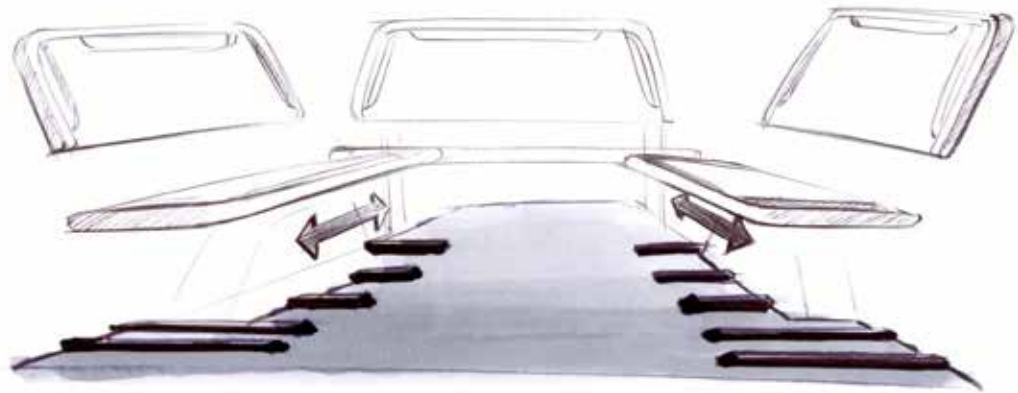
Side opening type

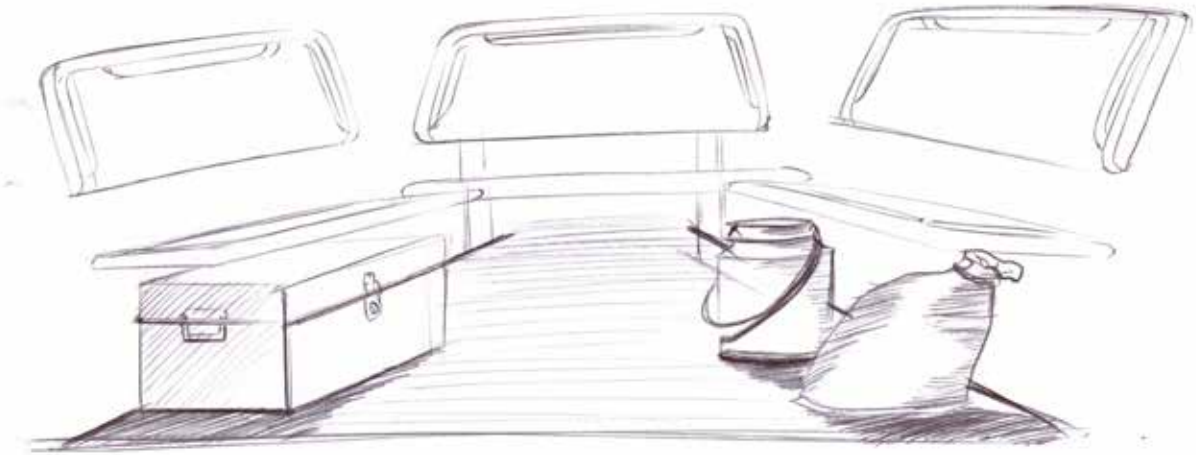
Advantages:

- Only one side can be opened

Disadvantages:

- Luggage shifted during drive might fall out

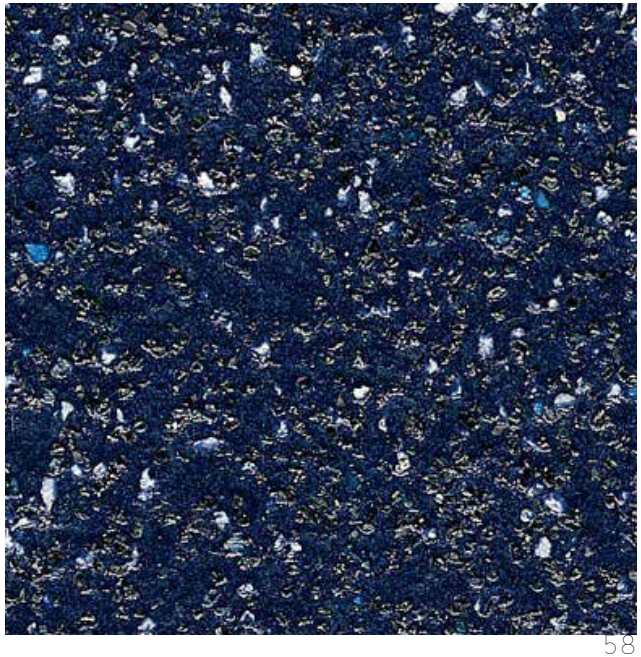




ANTI SKID

To prevent luggage from sliding, some anti-skid device is needed:

- Ribs on the floor
- Anti skid silicon-infused Vinyl layer



SELECTION

The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

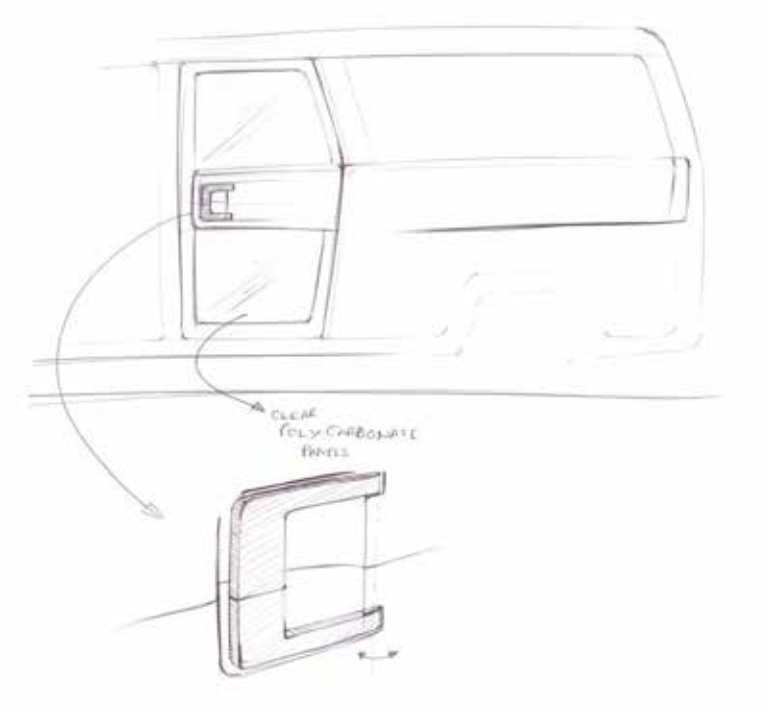
Here, Concept 1 Version 1 is preferred over Concept 1 Version 2 due to problems in usability

	Concept 1			Concept 2
	Version 1	Version 2	Version 3	
Low Cost	5	5	4	2
Seats 10 Passengers				
Easy ingress & egress				
Less entanglement of knees				
Ventilation				
Insulation				
Space	5	5	5	3
Total	10	10	9	5

SCENARIO 3:

Rain:

1. It starts to rain. Passengers and driver untie and unroll a cover and tie it to the door opening. This takes time and lets water in.
2. As the vehicle moves, due to Bernoulli's effect, the cover buffets in the wind, and lets water in
3. The cabin turns dark due to being sealed with waterproof cloth.



SOLUTION:
CONCEPT 1:

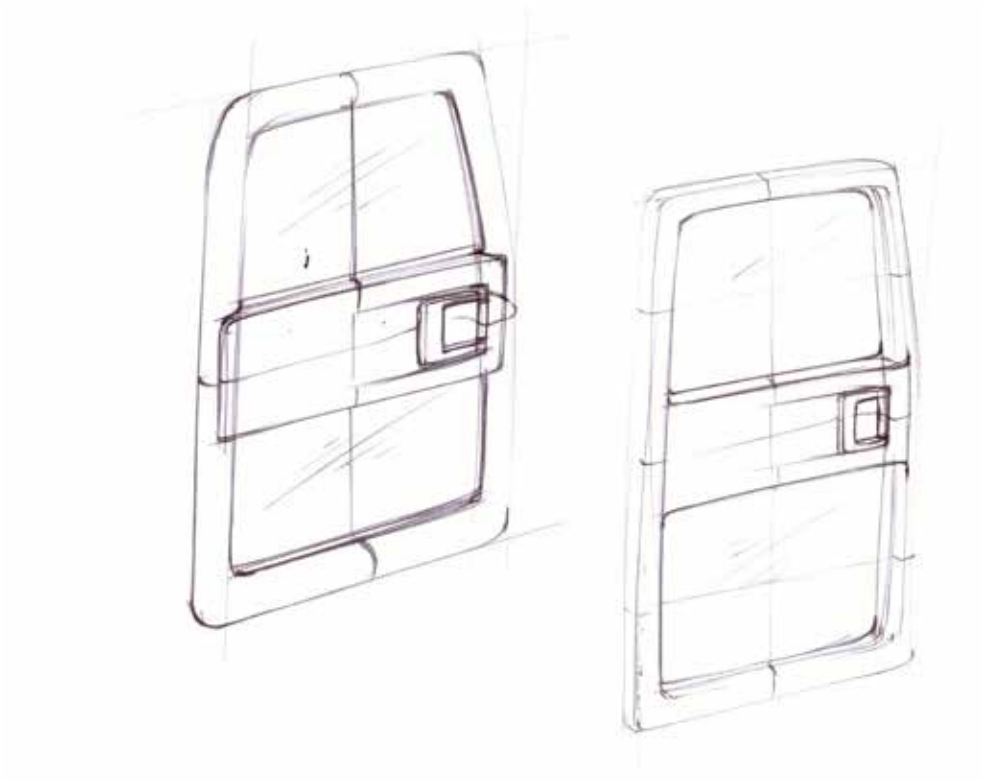
Side doors with Polycarbonate panels

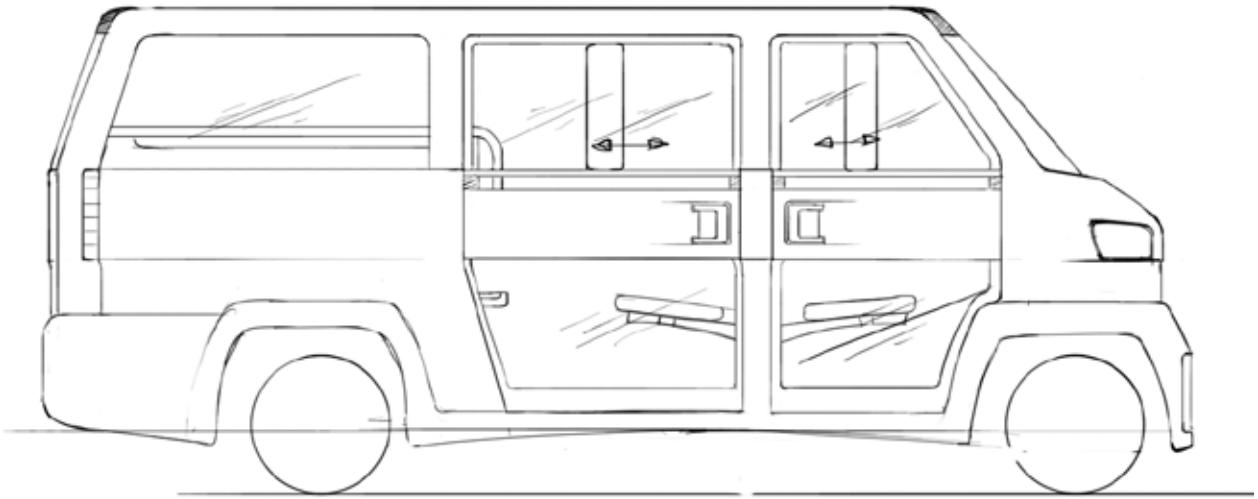
Advantages:

- Full door gives best rain protection
- Polycarbonate is stronger, cheaper and less brittle to use

Disadvantages:

- Additional cost of door
- Mechanical complexity more than open door





VERSION 2:

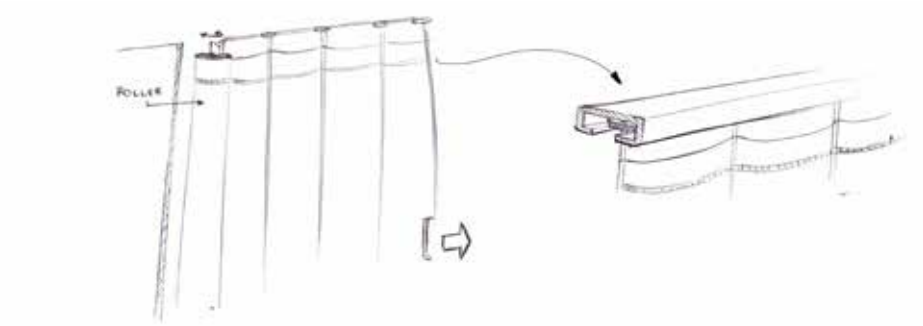
Advantages:

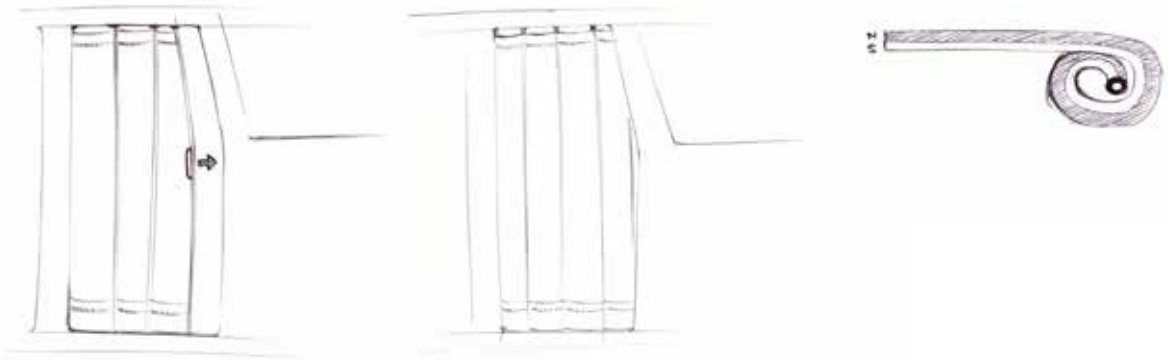
- Low cost construction by using tubing to form frame of door
- Frame is stronger

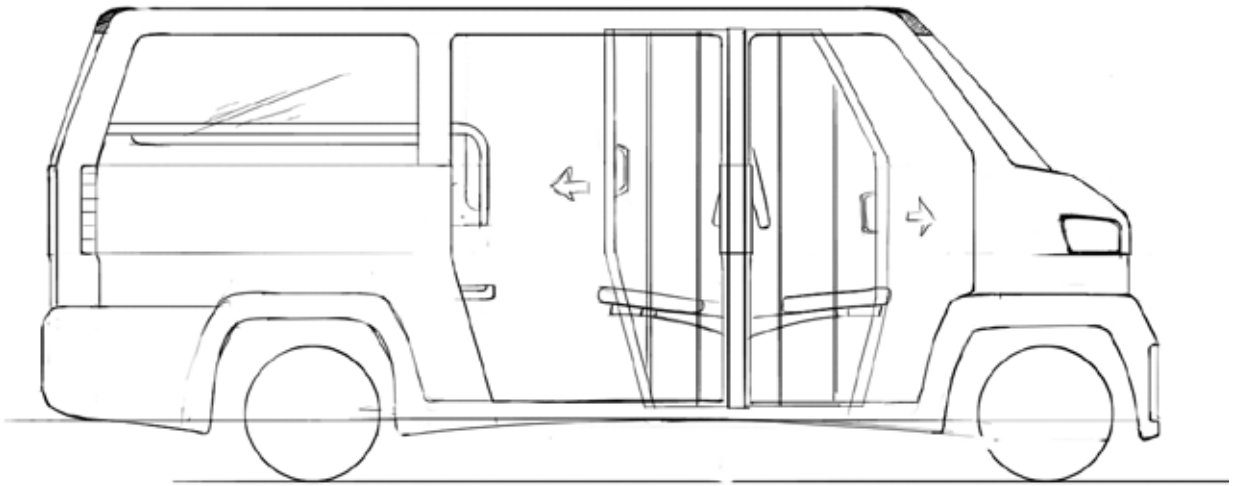
Disadvantages:

- Aesthetically not appealing

Version 2 in side view with sliding panels for top clear panes







CONCEPT 2:

Clear PVC curtains reinforced with ABS sticks

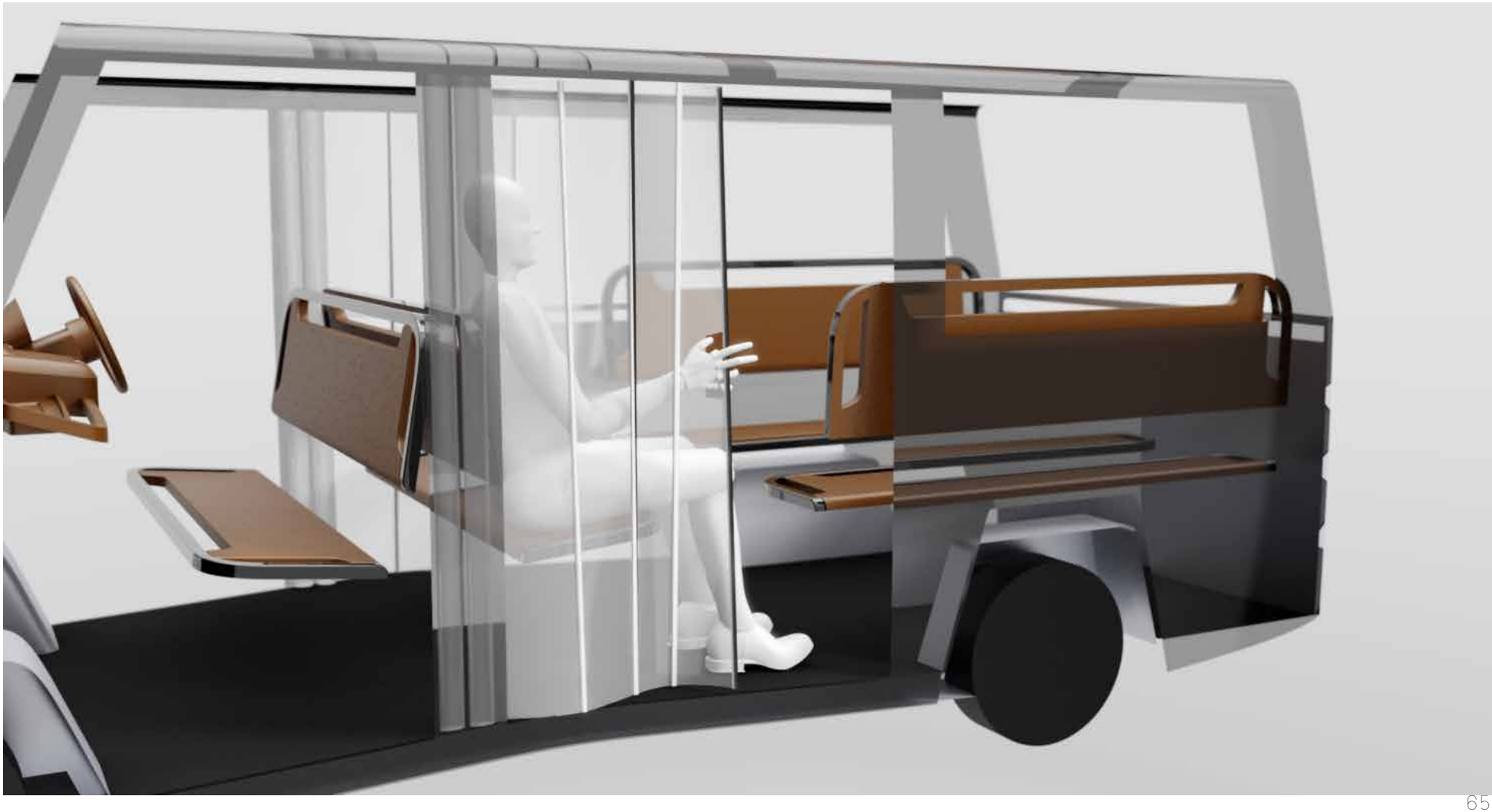
Curtain runs on rails at the top, and is secured to the body via a Magnetic seal (Refrigerator type)

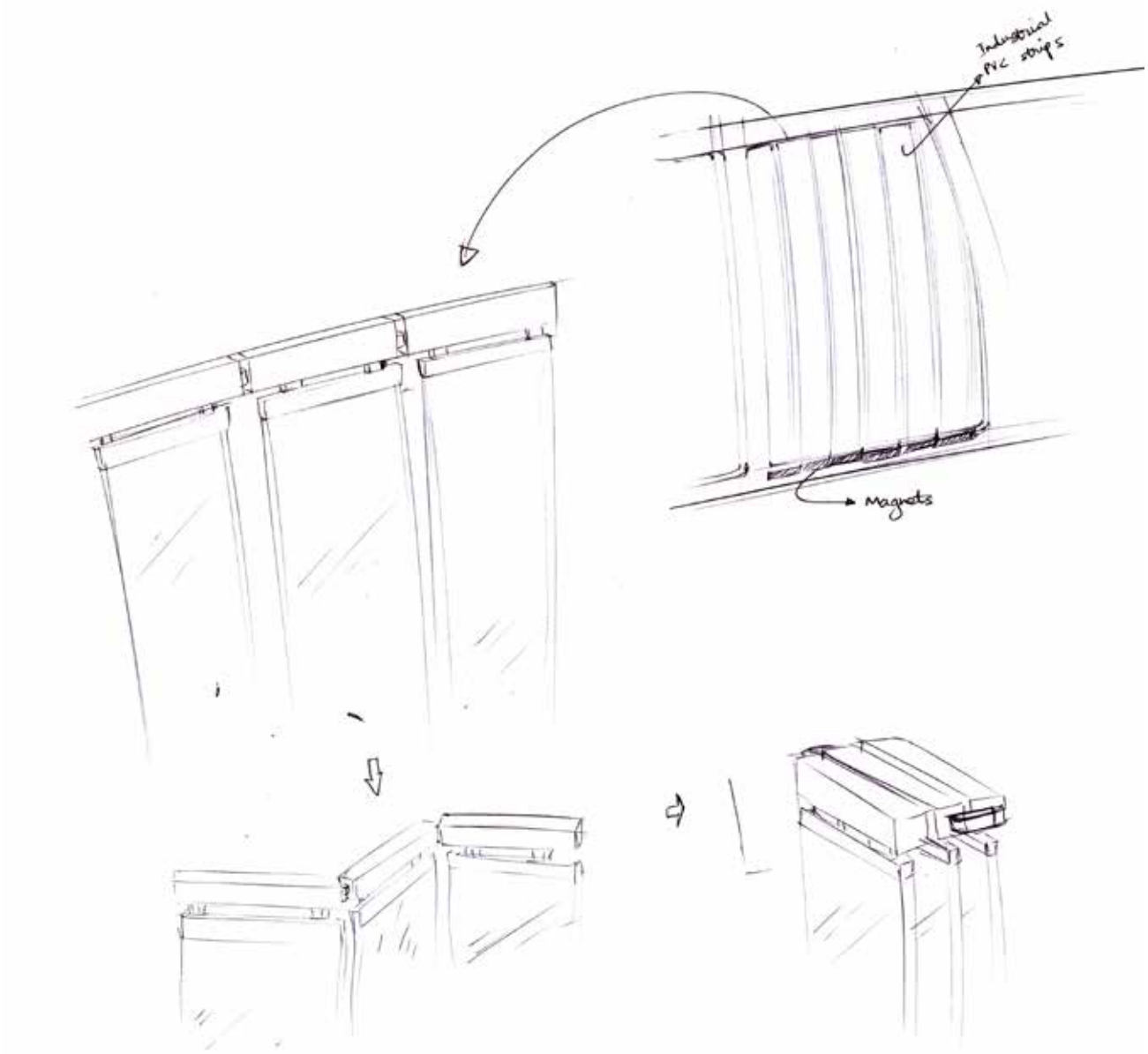
Advantages:

- Open ambience
- Cheaper/Simpler construction
- Magnetic strip provides proper sealing and prevents buffeting in the wind
- Magnetic strip rolls to align poles to retain magnetism

Disadvantages:

- Rails are subject to dust & grime
- Shape of the opening is a limiting factor for the placement of the curtains as the curtains are rectangular





CONCEPT 3:

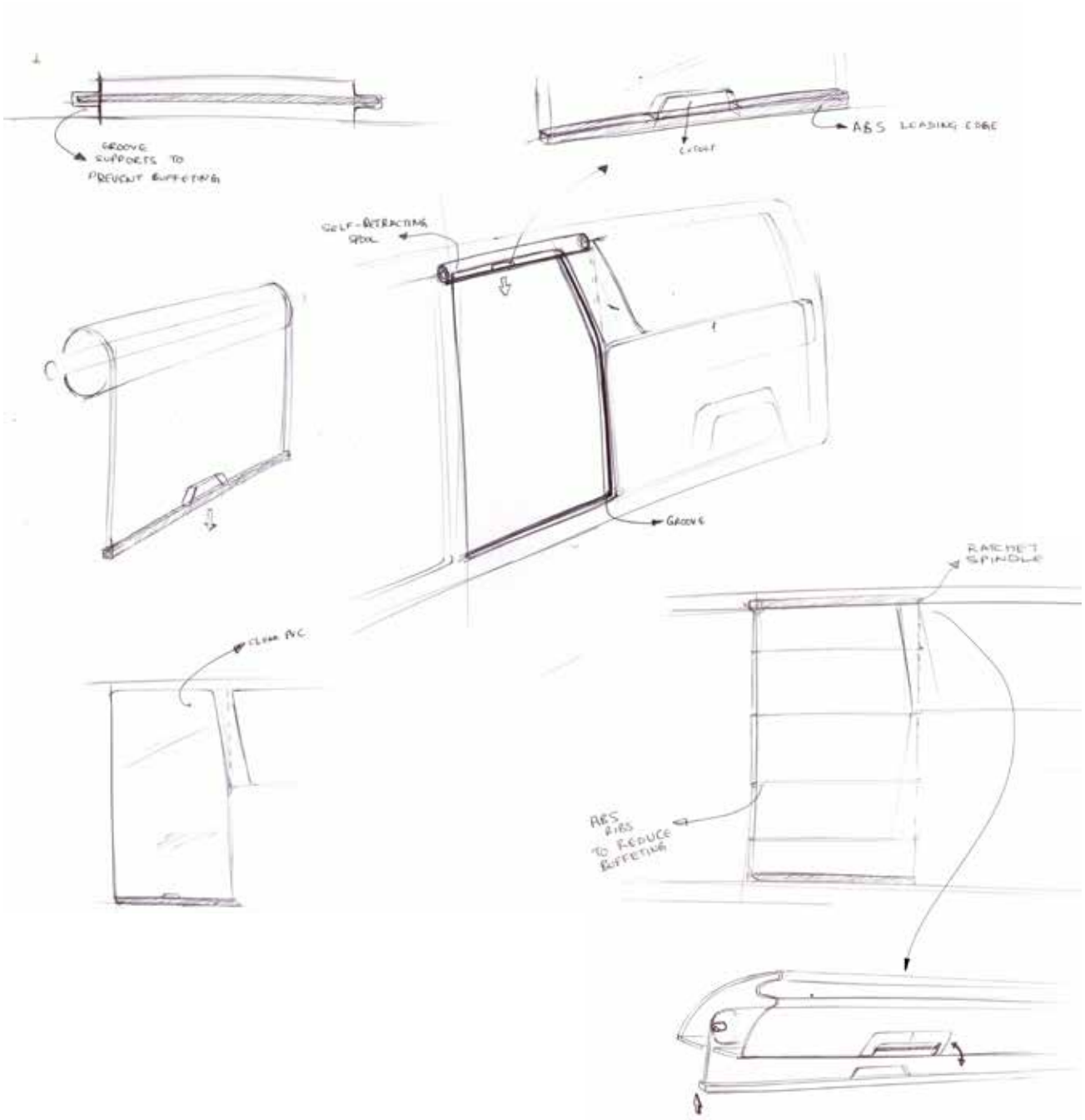
Heavy (industrial) clear PVC curtail that folds instead of rolling

Advantages:

- Buffeting is prevented by magnets
- Durable PVC as no seams are present

Disadvantages:

- Gaps between individual strips may not be perfectly sealed
- Again, shape of the entire system is rectangular, mismatches with rake of A-pillar
- Folding mechanism prone to mechanical wear/failure



CONCEPT 4:

Clear PVC curtain with spindle on top

Advantages

- Simple mechanism: less wear
- Since sheet runs within grooves, no buffeting

Disadvantages:

- Again , shape of the entire system is rectangular, mismatches with rake of A-pillar
- PVC may tear at the joint with ABS edge

Spindle has a single directional ratchet mechanism, which is released by top mounted handle

SELECTION

The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

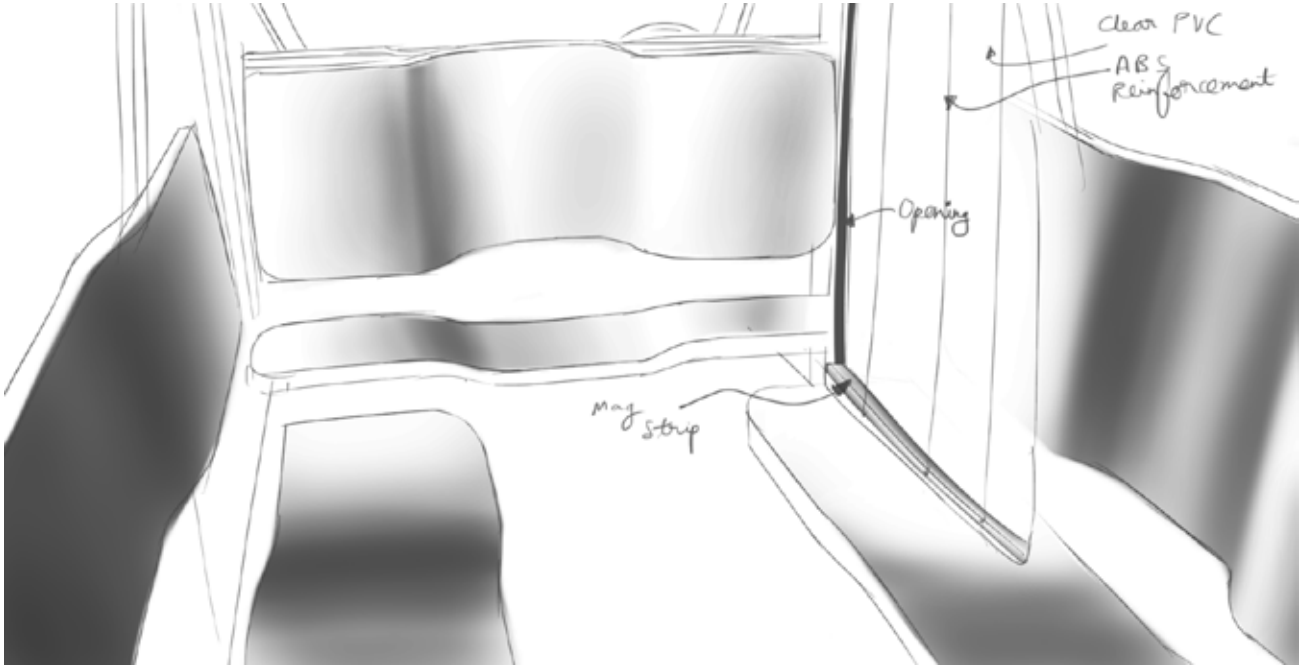
Here, Concept 1 Version 2 is preferred over Concept 4 due to problems in matching contour of the A and C pillars

	Concept 1		Concept 2	Concept 3	Concept 4
	Version 1	Version 2			
Low Cost	1	1	4	4	4
Seats 10 Passengers					
Easy ingress & egress	2	2	3	4	3
Less entanglement of knees					
Ventilation	3	4	3	3	3
Insulation	4	4	3	3	3
Space					
Total	10	11	13	12	13

SCENARIO 3:

Seating order:

1. Female passenger tries to enter the vehicle. There is only one seat empty in the vehicle, but it's on the far right side of the vehicle. The other passengers refuse to move as their destination is coming up. The passengers seated are male, and the female passenger does not wish to climb inside and brush against the male passengers.



SOLUTION: CONCEPT 1:

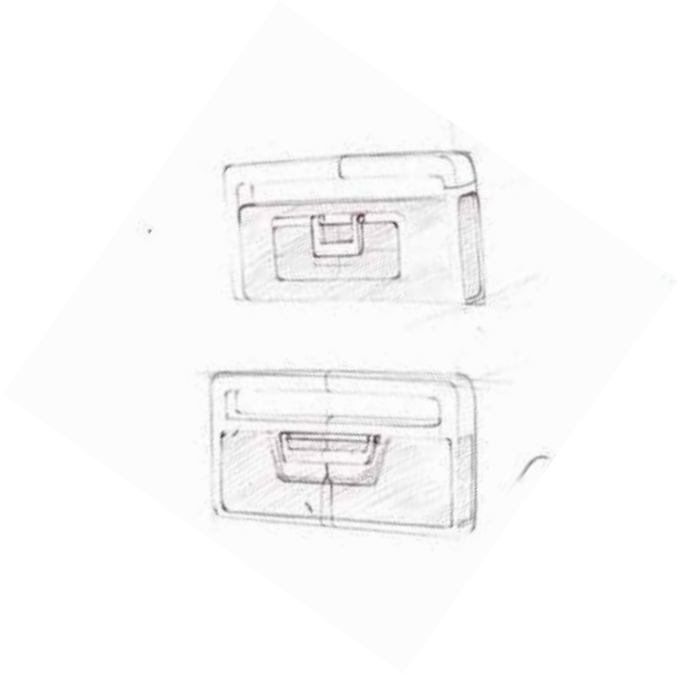
A Right Hand Side passenger opening is provided and is covered with rain protection

Advantages:

- Allows access from both directions
- Is a simple & cheap solution

Disadvantages:

- It is unsafe, as passengers alighting from the Right Hand Side opening would likely be in the way of oncoming traffic



CONCEPT 2:

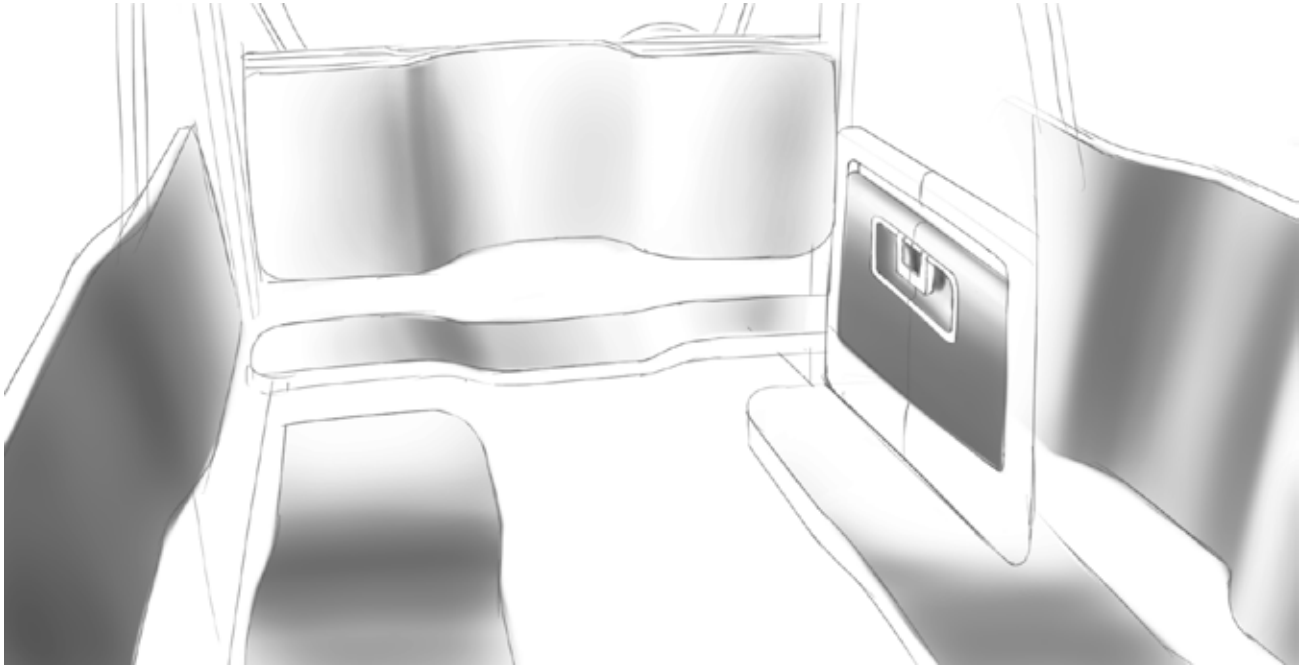
A semi door is provided which is openable

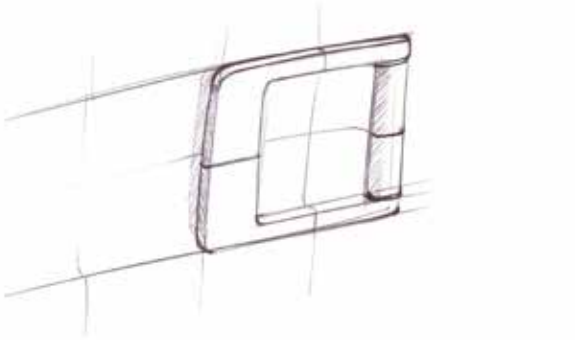
Advantages:

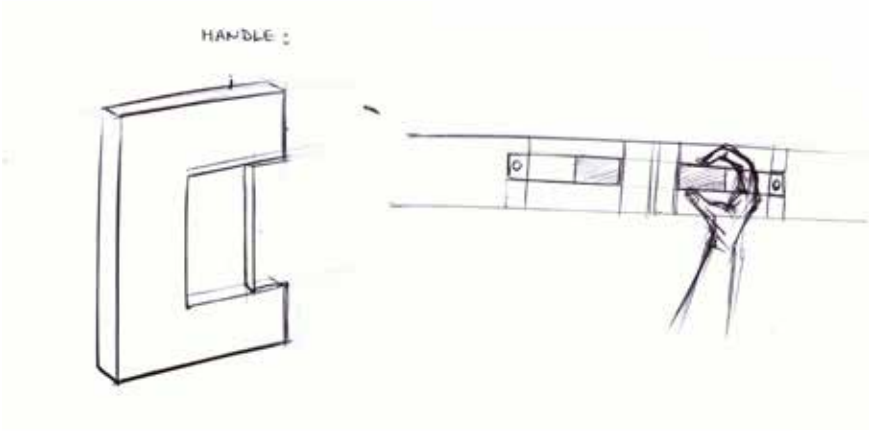
- Allows access form both sides
- Is safer, as opening the door is an extra task, and adds a deterrent to use the Right Hnd Side opening unless very necessary.

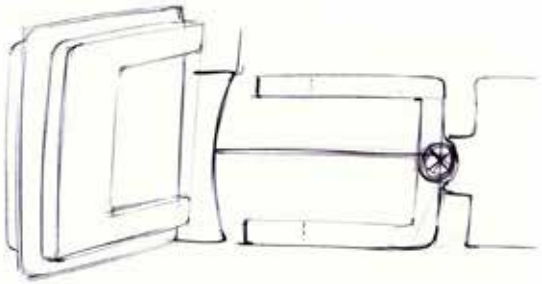
Disadvantages:

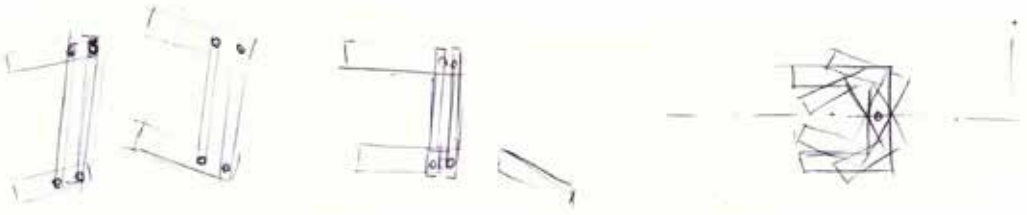
- Additional Cost











HANDLE

The handle is made of a single piece which is accessible from both the outside & inside through a gap in the bodywork.

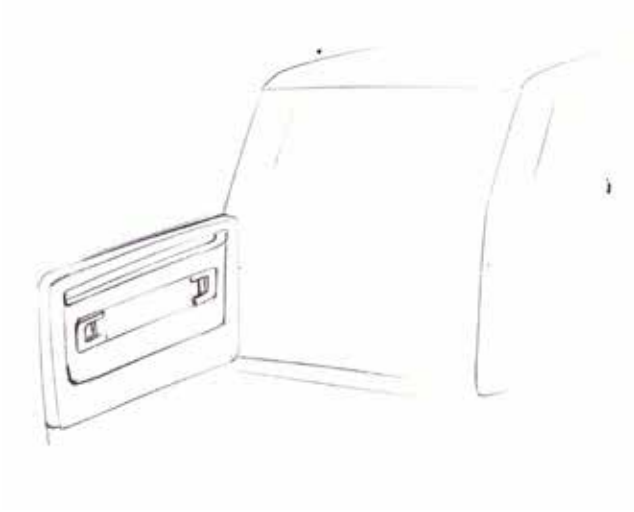
Thus, only one piece is necessary, instead of two different handles for the exterior & interior, saving overall cost.

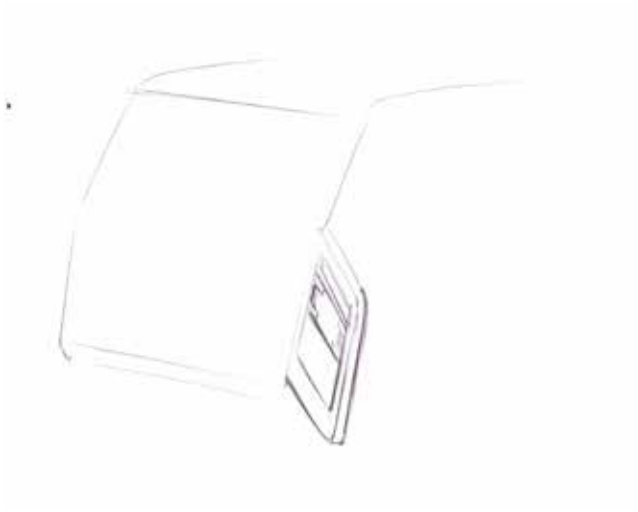
SELECTION

The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

However, in this case, Concept 2 is chosen over Concept 1 due to added safety benefits.

	Concept 1	Concept 2
Low Cost	5	3
Seats 10 Passengers		
Easy ingress & egress	5	4
Less entanglement of knees		
Ventilation		
Insulation		
Space		
Total	10	7





SCENARIO 5:

Rear-door:

1. The rear passengers feel unsafe while travelling as a sudden jerk might throw them out of the vehicle

2. If a door is provided, then opening and closing it becomes an additional task. Which gets more difficult if passengers have hand luggage.

SOLUTION: CONCEPT 1:

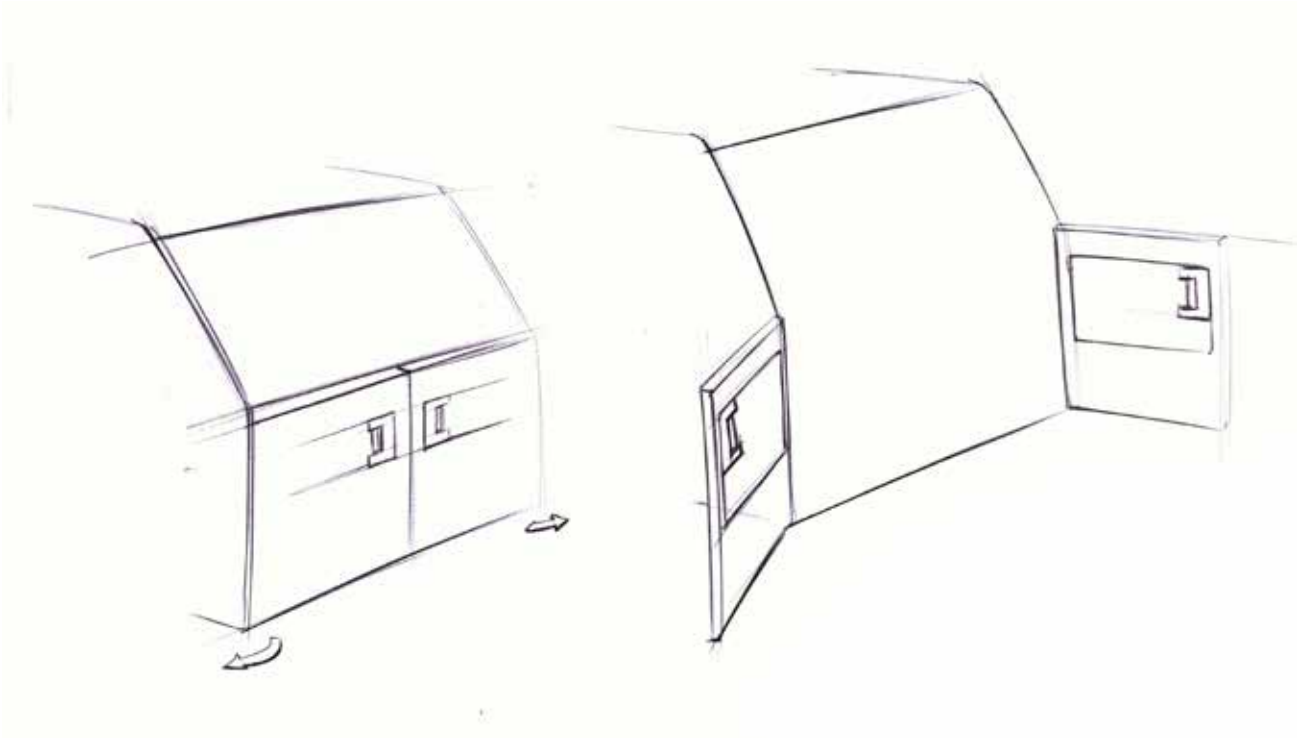
Either-side opening/Double hinged

Advantages:

- Can be opened according to which side person wants to ingress/egress

Disadvantages:

- Complex Construction of hinges adds cost



CONCEPT 2:

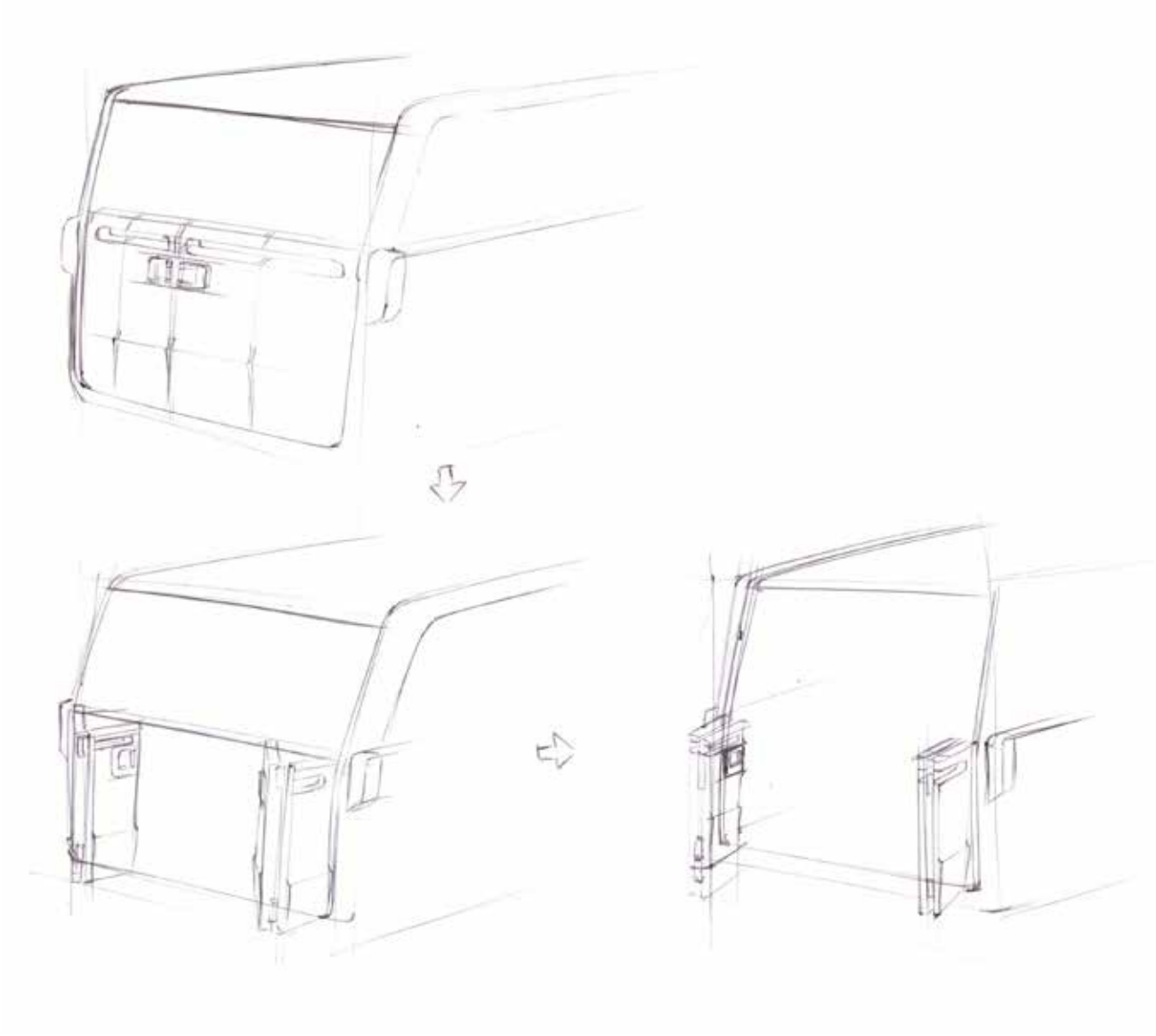
Two-door with separate handles for each

Advantages:

- Lighter doors- Can be closed from inside without bending or reaching out
- Can be opened according to which side person wants to ingress/egress
- The axis of the hinge is tilted. This makes it auto-closing

Disadvantages:

- Second door needs to stay in place, necessitating locking mechanism in the floor



CONCEPT 3:

Folding Doors

Advantages:

- Can be operated without getting down/ bending to reach out
- Easier to operate

Disadvantages:

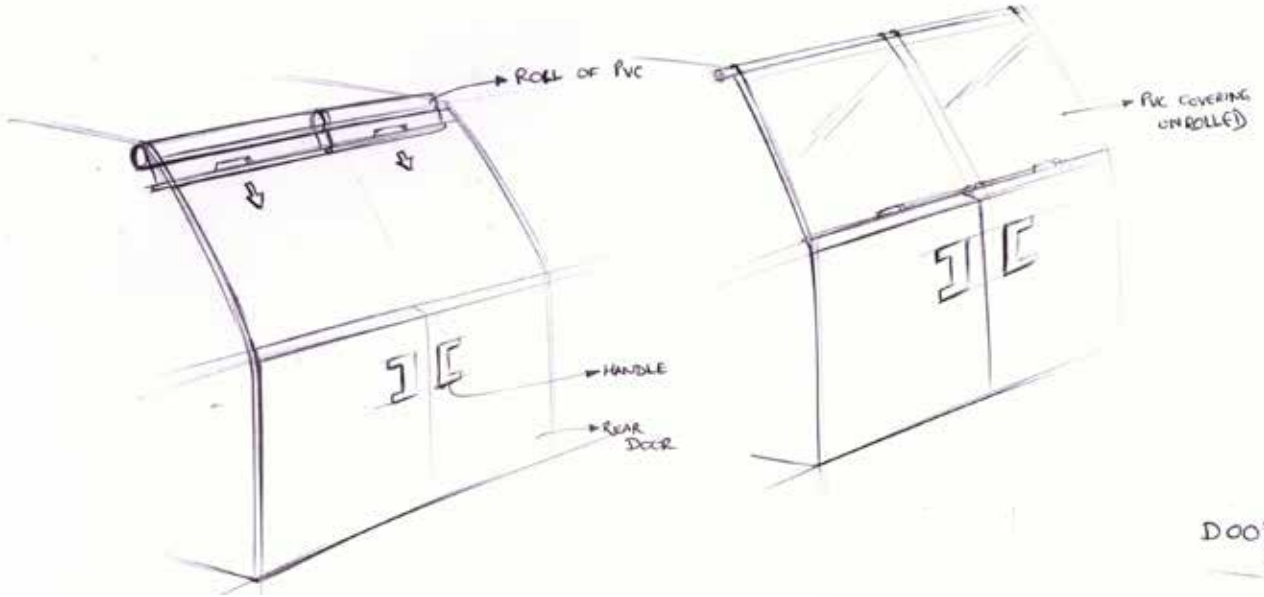
- Mechanism is more complex
- Hand entrapment at the folds

SELECTION

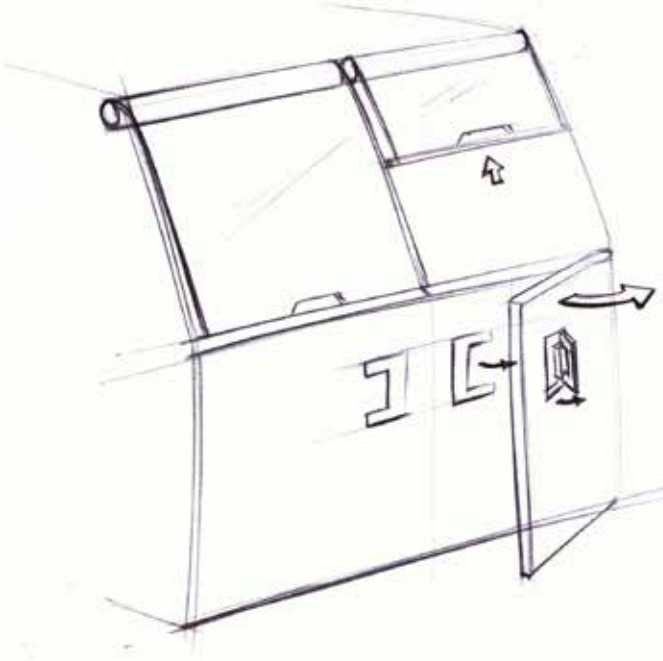
The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

	Concept 1	Concept 2	Concept 3
Low Cost	1	4	2
Seats 10 Passengers			
Easy ingress & egress	3	4	5
Less entanglement of knees			
Ventilation			
Insulation			
Space			
Total	4	8	7

REAR RAIN COVER



DOOR OPENING :

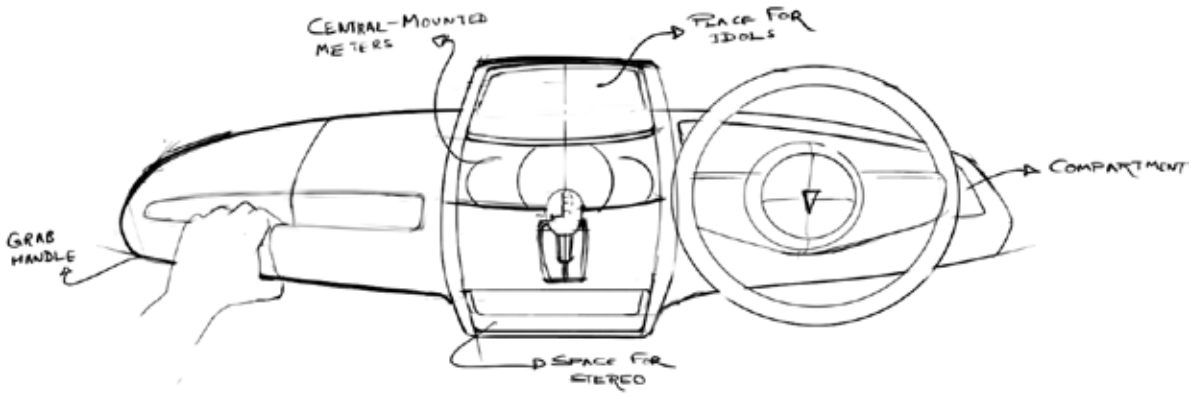


OPENING / PULLING HANDLE RELEASES THE HOOK HOLDING THE PVC SHEET

SCENARIO 6:

Driver:

1. The driver needs a lockable compartment to keep money/change. The lockable glove-box provided usually is on the other side.
2. At night time, he need a light to see the currency items. He usually manually turns on the cabin light every time.
3. Most drivers also install Idols of Gods/ Goddesses. They require a flat surface for that
4. Since it is a long journey, the drivers usually install stereos/radio
5. The front passengers are often seen grabbing onto a handle provided on the A-pillar. If there are more than one passengers up front, this handle is inaccessible to them.



SOLUTION:

Essential features:

- Compartment to keep money/change
- Place for Idols of Gods/ Goddesses

Additional:

- Space for stereo
- Grab handle
- Small size
- Flat front: maximise cabin space

Light for night-time usage

CONCEPT 1:

Advantages:

- Meters in the centre
- Looks more car-like

Disadvantages:

- Bulky and intrudes into passenger space

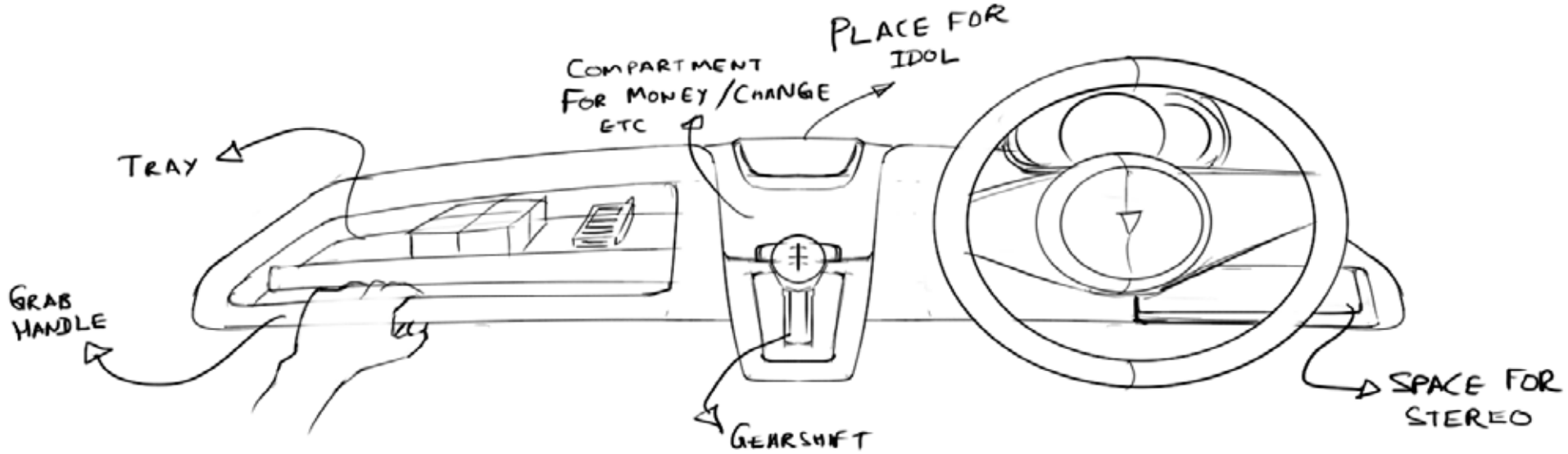
CONCEPT 2:

Advantages:

- Flat and less space occupying

Disadvantages:

- Compartment in centre console is small



CONCEPT 3:

Advantages:

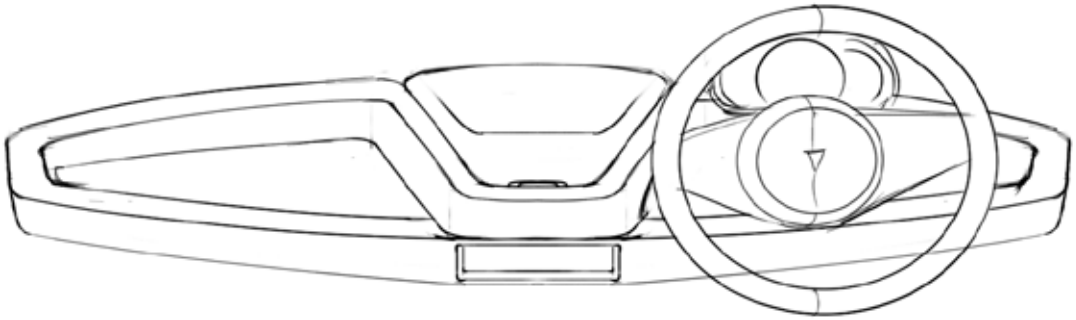
- Compartment is bigger

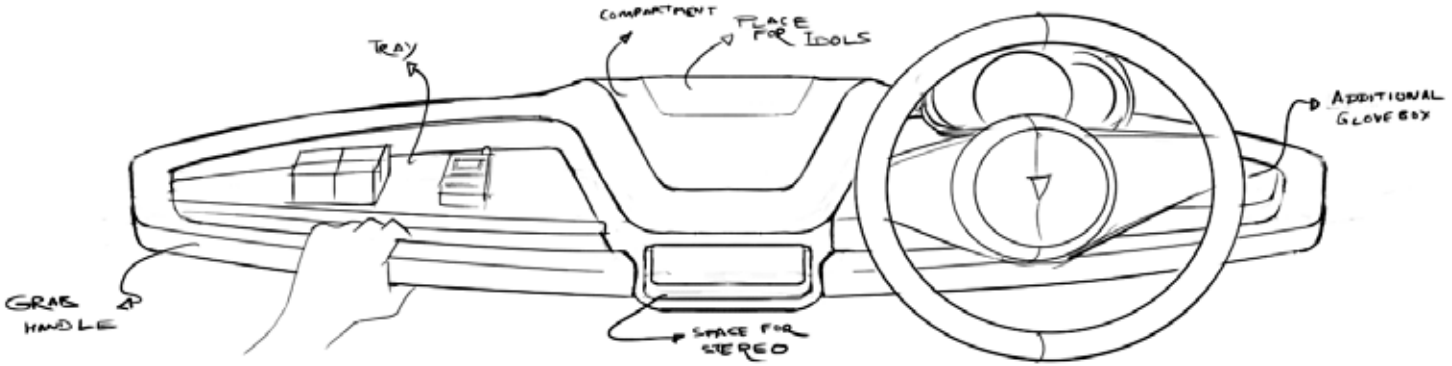
Disadvantages:

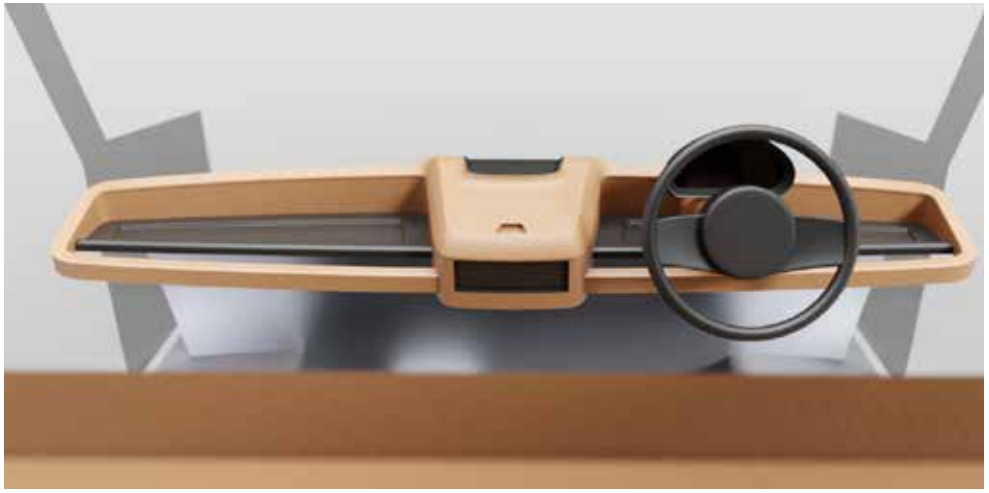
- Symmetric construction: can be used with little modification for LHD markets as well

VERSION 2:

- Added tray





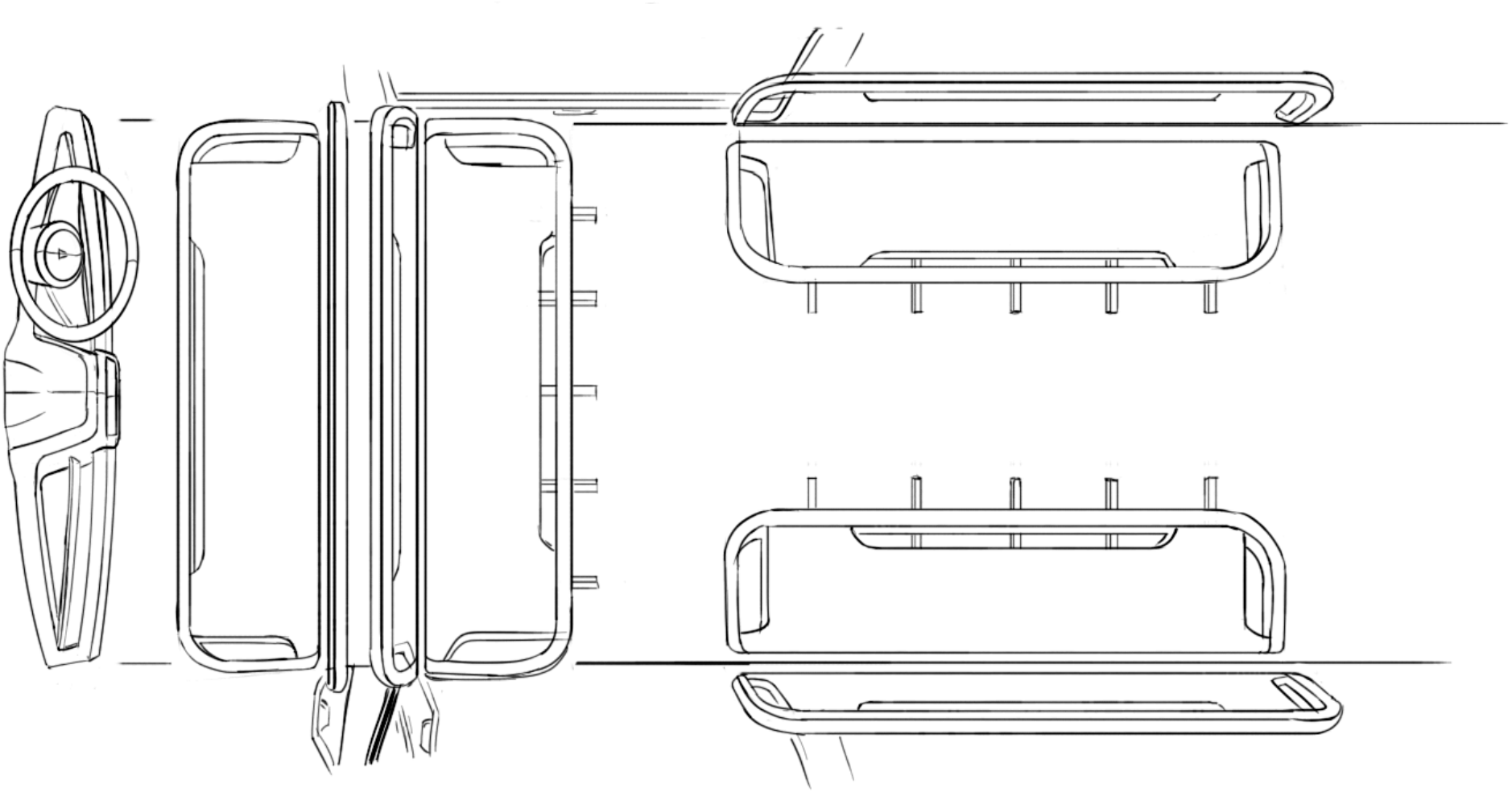


SELECTION

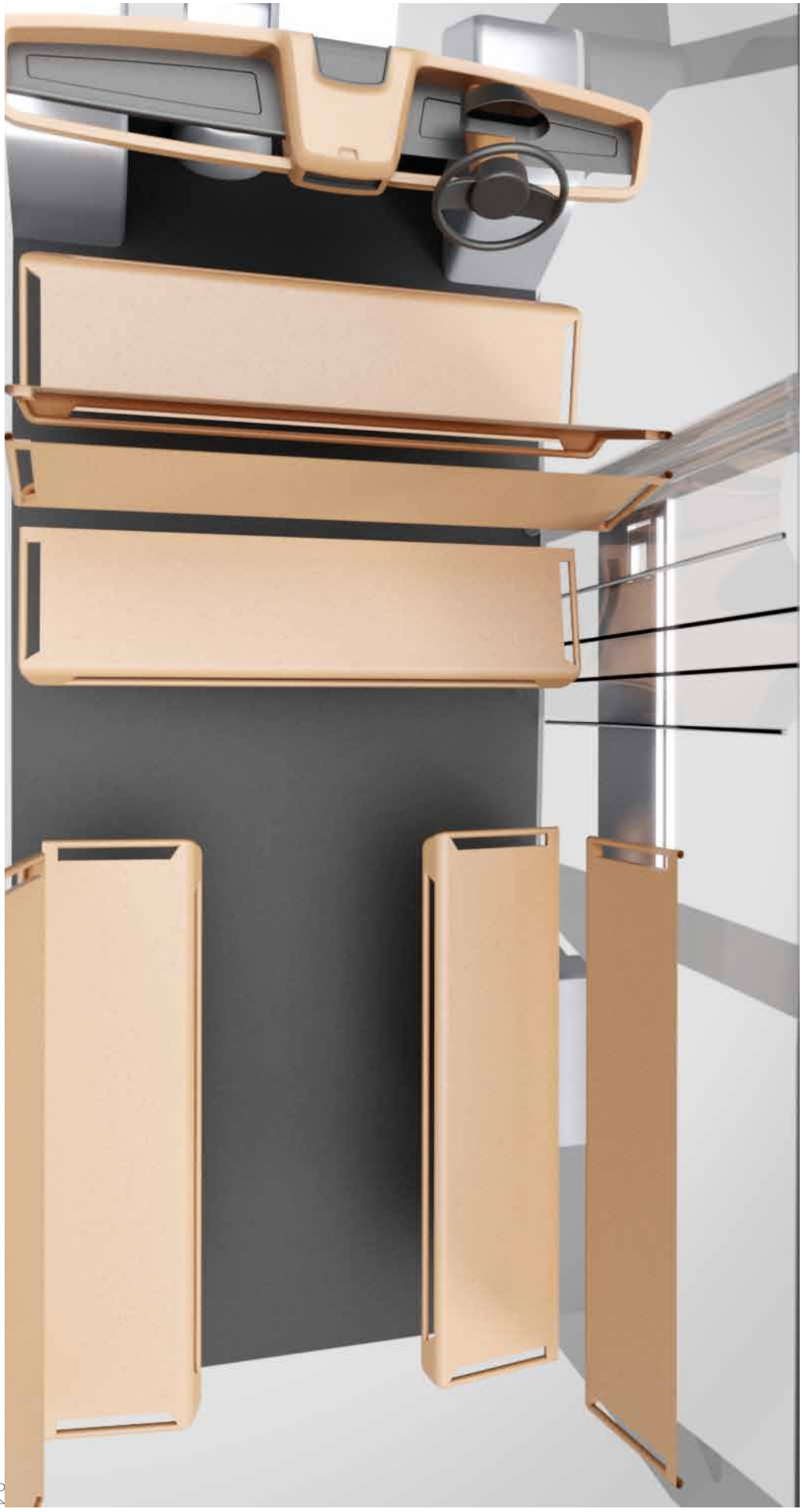
The various concepts and versions are compared and ranked on the basis of the Design Brief. The design with the most points is selected.

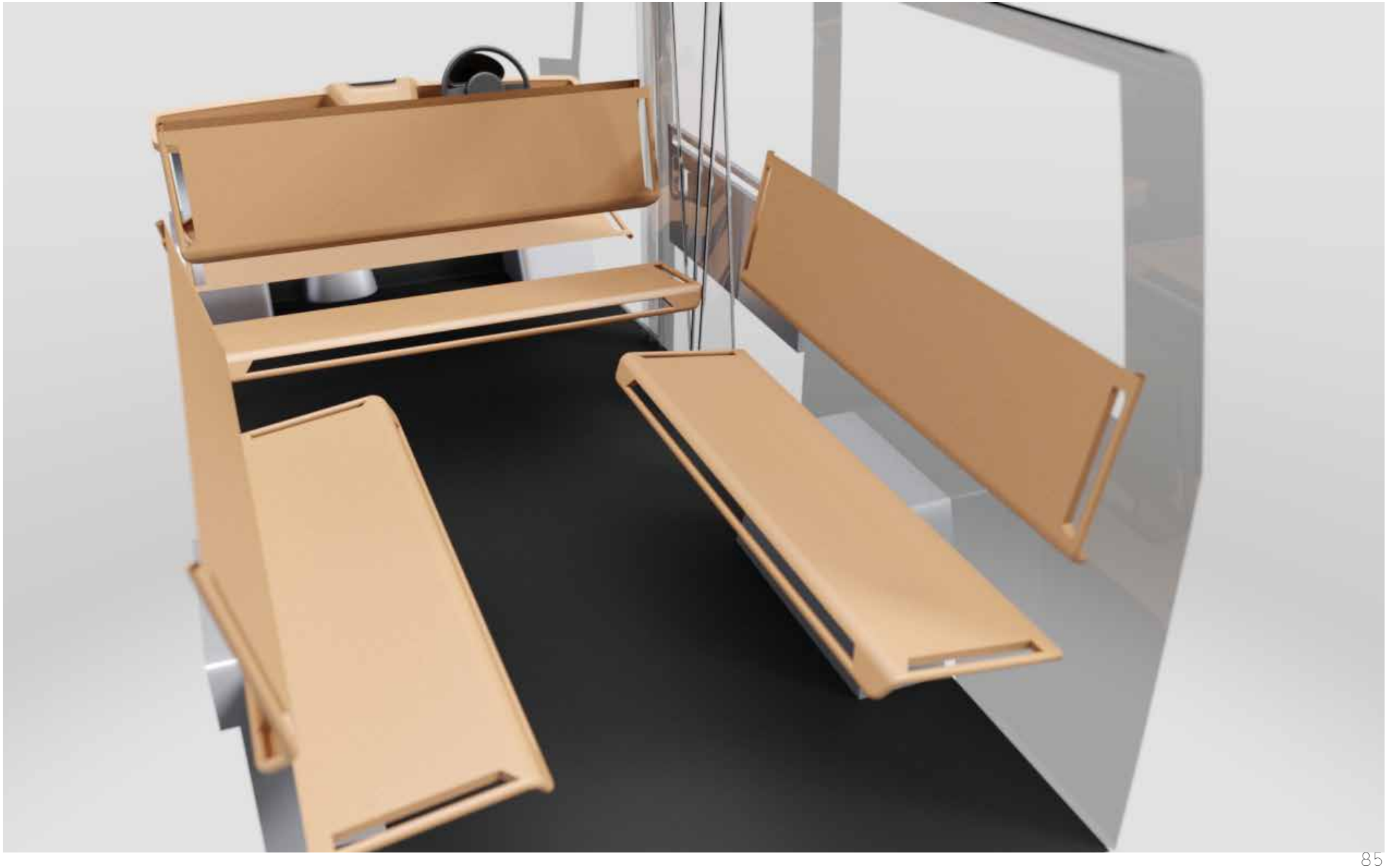
	Concept 1	Concept 2	Concept 3
Low Cost	1	4	2
Seats 10 Passengers			
Easy ingress & egress	3	4	5
Less entanglement of knees			
Ventilation			
Insulation			
Space			
Total	7	9	10

TOP VIEW

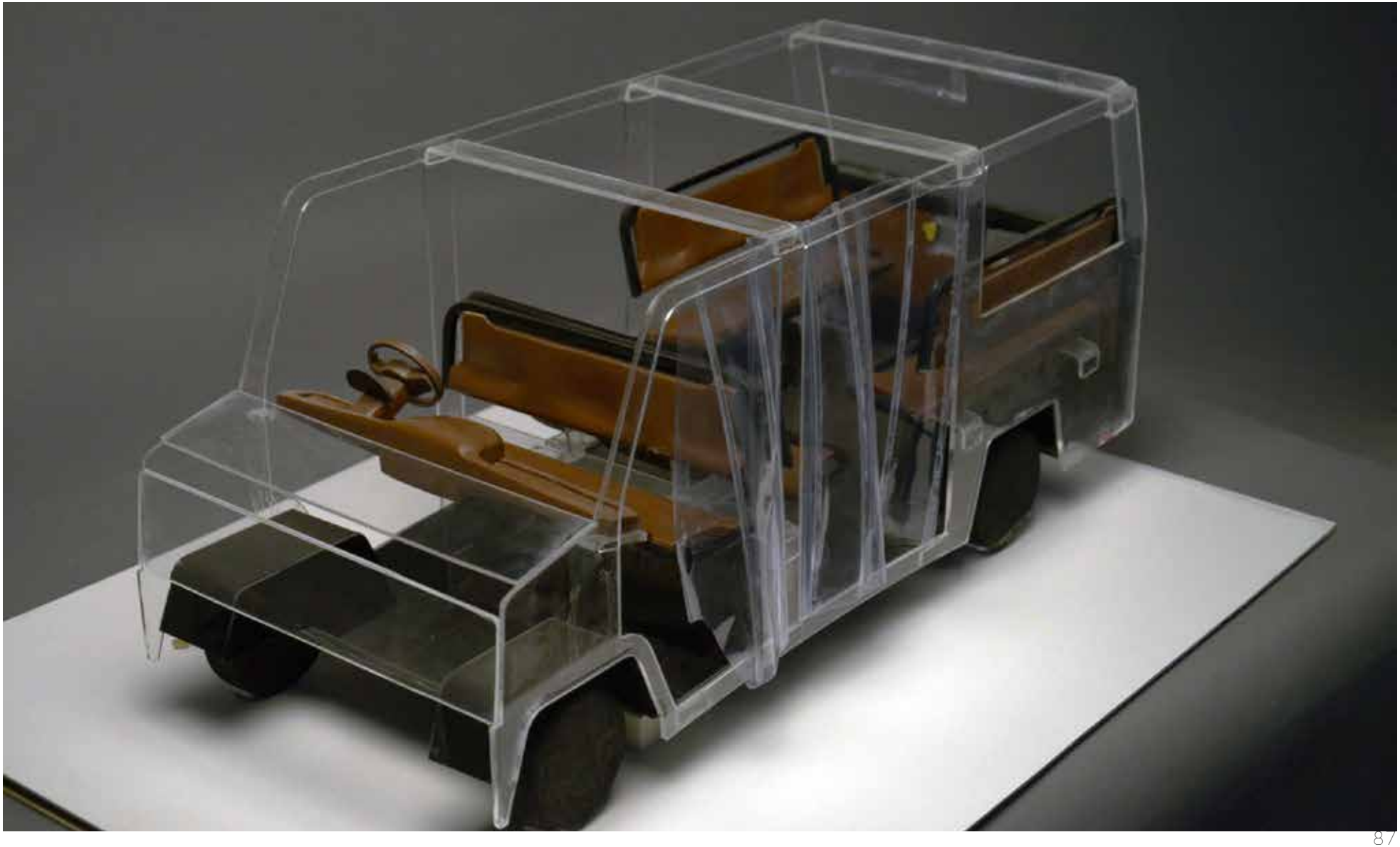


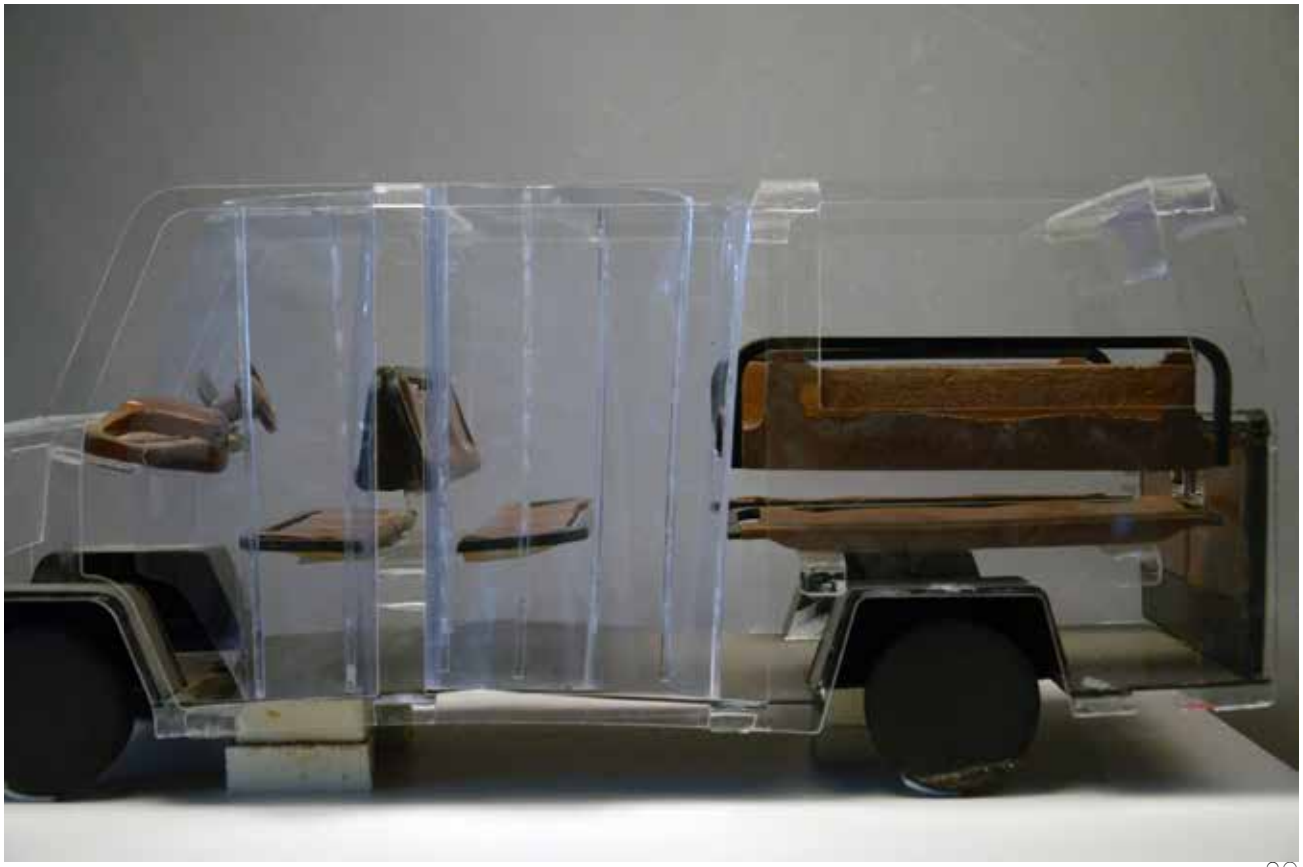
CAD MODEL





MODEL





REFERENCES

[1] 27 9 2013. [Online]. Available: http://censusindia.gov.in/2011-prov-results/paper2/data_files/india/Rural_Urban_2011.pdf.

[2] 27 9 2013. [Online]. Available: pmgsy.nic.in.

[3] "The Jugaad- Team BHP," 13 11 2013. [Online]. Available: http://www.team-bhp.com/forum/commercial-vehicles-india/117066-jugaad.html.

[4] A. Roychowdhury, 13 11 2013. [Online]. Available: http://www.cseindia.org/userfiles/cngfuture_pdf.pdf.

[5] J. Reynolds, Citroen 2CV, J H Haynes & Co Ltd, 2009.

[6] "Mahindra GioMini cab," [Online]. Available: http://www.mahindragio.com/giocab/index.html. [Accessed 13 11 2013].

[7] "motortrend," [Online]. Available: http://www.motortrend.in/newcars/mahindra/maxximo-plus/specifications.htm. [Accessed 13 11 2013].

[8] "IRIS Technical Specifications," Tata Motors, [Online]. Available: http://www.magiciris.tatamotors.com/iris/technical-specifications.aspx. [Accessed 13 11 2013].

[9] "Vicky," [Online]. Available: http://www.vicky.in/trucks/piaggio/ape-xtra-pickup/. [Accessed 13 11 2013].

[10] "Urban Bus Specifications – II, Ministry of Urban Development, Government of India," [Online]. Available: http://jnnurm.nic.in/wp-content/uploads/2012/12/Urban-Bus-Specifications.pdf. [Accessed 13 11 2013].

[11] "Winger Mxi Van," Tata Motors, [Online]. Available: http://www.winger-tatamotors.com/tech-specs/overview.html. [Accessed 13 11 2013].