

REDESIGN OF TIPPER TRUCK

MOBILITY AND VEHICLE DESIGN PROJECT II

BY

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126390010

GUIDE

PROF. RAMCHANDRAN



INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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Redesign of Tipper Truck

Mobility and Vehicle Design

Project II

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Submitted by
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Approval Sheet

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Requirements for the degree of Masters of
Design in Mobility and vehicle Design at
Industrial Design Centre,

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I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honest 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.

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I would also like to thank drivers,helpers and supervisors of Tipper truck working in IIT campus for providng valuable inputs and insights.

Saurabh S. Nimsarkar
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Abstract

Tipper truck/Dump truck is the most essential and necessary vehicle used in construction worldwide. Tipper truck are exposed to hostile terrain as it has to carry loose gravel soil over mountains and mines. There have been frequent incidents of toppling of tipper truck because of inadequate stability on uneven terrain and drivers' lack of visibility in unfriendly environment. In Indian scenario drivers work for prolonged period even in nights. This eventually causes fatigue and lack of productivity causing possible delay in subsequent loading and unloading cycles.

Owner of the truck usually buys the truck considering cost of the truck, capacity and fuel efficiency for overall productivity often ignoring drivers need and comfort. Lack of rules and guidelines for safety augments drivers problem.

A driver of the tipper truck faces serious problem of heat, vibration and dust inside the cabin which is claustrophobic and messy. There lack of visibility of dump bed and he does not get feedback of loading and unloading operation. Driver has to depend upon the helper for auditory feedback.

Problem is aggravated when dump is not evenly distributed on the bed and may lead to toppling.

Most Indian tipper are mounted on common HCV chassis and often tipper specific exterior essentials are often turned a blind eye.

An effort has been made to mitigate problems and make tipper more user centric.

Contents

Introduction 1

I Product Study 3

- 1 Brief History of Tipper Truck
- 2 How it Works?
- 3 Types of Tipper Truck
- 4 Environment Study
- 5 Global Tipper Truck Study
- 6 Indian Tipper Truck Study
- 7 Technical and Humanistic Aspects
- 8 Dimensional Drawing

II User Research 38

- 9 Observation
- 10 Activity analysis
- 11 Inference from activity analysis
- 12 Questionnaire
- 13 Inference from User Research
- 14 Design Direction and Brief

III Form and Function Exploration 63

- 15 Warm up Thumbnail Sketches
- 16 Packaging and Specification
- 17 Package Explorations
- 18 Layout form exploration
 - FunctionExploration Sketches
 - Renders

IV Form Selection 111

V Final Model 118

Redesign of Tipper Truck

Introduction

In the construction world, Tipper Trucks are ubiquitous and often cannot be ignored. Tipper truck or dump truck comes in various shape and sizes depending upon the requirement. They are used on highways for long hauls as well as in hostile environments like mining, forest, mountain and rivers and snow.

The project 'Redesign of Tipper truck' primarily deals with the need and requirement of the driver and helper making tipper more user centric. This includes changes in interior and exterior elements to arrive at a design solution.

This report is divided in chapters designated by roman letters (I,II,III and so on) and conform to the design methodology which is been followed. Each chapter further consists of section designated by digits(1,2,3 and so on). Each section has references at the end.

Report starts with an attempt to understand tipper truck from inside-out with a journey in to the past and evolution of tipper truck. Subsequently, report elaborates tipper product study to imbibe working mechanism. Study was made by venturing into environment where the tipper truck works. Furthermore a study of Indian and global tipper was done to understand the market and current trends.

The journey into the study of tipper truck gets more interesting with user res each.

In this chapter an attempt was made to apprehend empathetically through observation, activity analysis, interview and questionnaires. Problem were identified. Furthermore, all these factors culminated in design direction and design brief.

Eventually an attempt was made to seek design solution which is in accordance with formulated design brief, to arrive at a concept which will make design of tipper truck more user centric.

I

Product Study

Data collection was done in following parts to understand the background of the tipper truck/dumper truck. This was performed by visiting construction sites and through resources like books and internet. This part provides information about the technical and humanistic aspects of tipper truck. This study helped me to understand overall background to work further on this project.

1. Brief history of tipper trucks
2. How it Works?
3. Types of Tipper Truck
4. Environment Study
5. Global Tipper Truck Study
6. Indian Tipper Truck Study
7. Technical and Humanistic aspects
8. Dimensional Drawing

1

Brief History of Tipper Trucks

A tipper truck is a truck used for transporting loose material for construction and mining application. A typical dump truck is equipped with a hydraulically operated open-box bed hinged at the rear, the front of which can be lifted to allow the contents to be deposited on the ground behind the truck at the site of delivery.

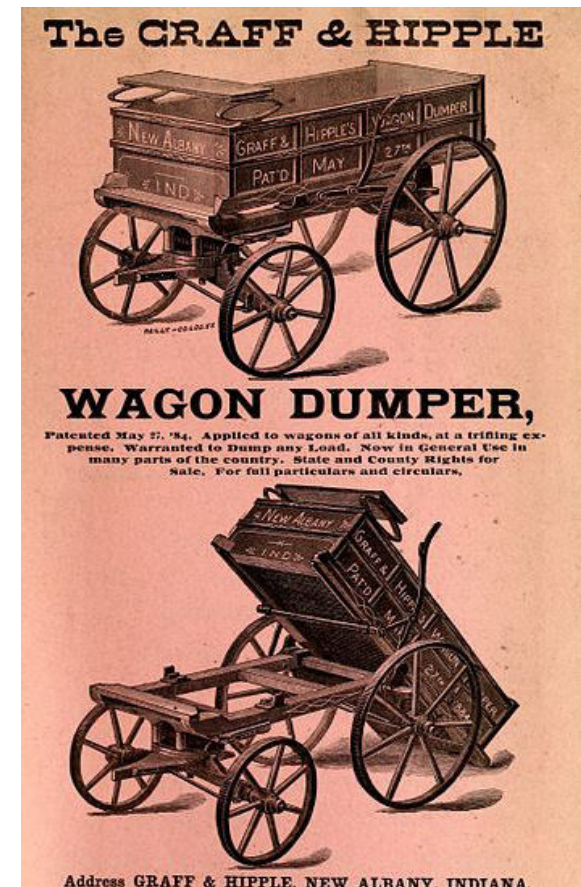
A dump truck is sometimes referred to as a Production truck, Dump, Dumper truck, or Hauler, and is used for hauling aggregate material such as sand, cement, bricks, concrete blocks, rocks, coal, gravel, dirt, hot asphalt in construction, road building and surface mining applications.

The very first version of a dump truck used to haul and dump material was nothing more than a simple dump body style cart drawn by horses. It would have consisted of a two-wheeled cart hinged to the axle with the centre of gravity, when loaded, just behind the axle. The loaded front body was hooked, and when unlatched, would dump. These carts were used in open mines and pulled by horses along a railway track. After 1900, a four-wheeled horse-drawn flatbed wagon with a rectangular body lifted with a hand hoist in the front was employed.

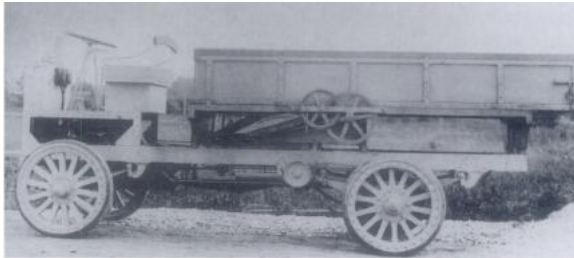
In the book, 500 Years of Earthmoving, Heinz-Herbert Cohrs cites that before the first dump trucks appeared, excavated materials were being removed and hauled by locomotives and trolleys like

box tip wagons and scoop tipplers.

The earliest versions of truck mounted dump bodies relied on the principle of gravity for dumping. The dump body pivoted off center and, when level, would be locked in place. Releasing the lock would activate the body to dump to the rear. The dump body, when empty, remained locked in a non-dumping position. When loaded, the dump body's center of gravity would shift, activating it to dump



The first motorized dump trucks in the United States were developed by small equipment companies such as Galion Buggy Co. and Lauth-Juergens among many others around 1910. Hydraulics were being incorporated into truck mounted dump bodies relatively early on. Records show that one of the first hydraulic dump bodies was the Robertson Steam Wagon with a hydraulic hoist that received power from an independent steam engine.



In the middle of the 1920s, crawler tractors pulling heavy dump trailers mounted on wheels or tracks were becoming increasingly popular. Sometimes crawlers would pull two to five attached trailers. Companies began developing wagons specifically designed for attachment to crawler tractors



Above image is Autocar Circa with scissors lift coal body introduced by Heil Co. in 1920.

In 1928, Graniterock, an American construction service provider introduced Model AA Antique Dump Truck. This truck was having a load capacity of 2 tons.



In 1934 the company introduced its 10/11-ton dump truck called the "Trak Truk". It was the first rear-dump truck that was designed for heavy-duty off road service.



By the 1940s the technological development of dump trucks had reached its peak. In the U.S., bottom dump trucks were already dominating earthmoving sites by the 1950s. As the industry moved away from a reliance on rail operations to haul material, the need for domestically produced construction site tippers began to emerge.

In 1952, truck with side dumping compartment was introduced by Fruehauf.



In 1951, for example, Euclid produced the world's largest dump truck when it manufactured the 1LLD.

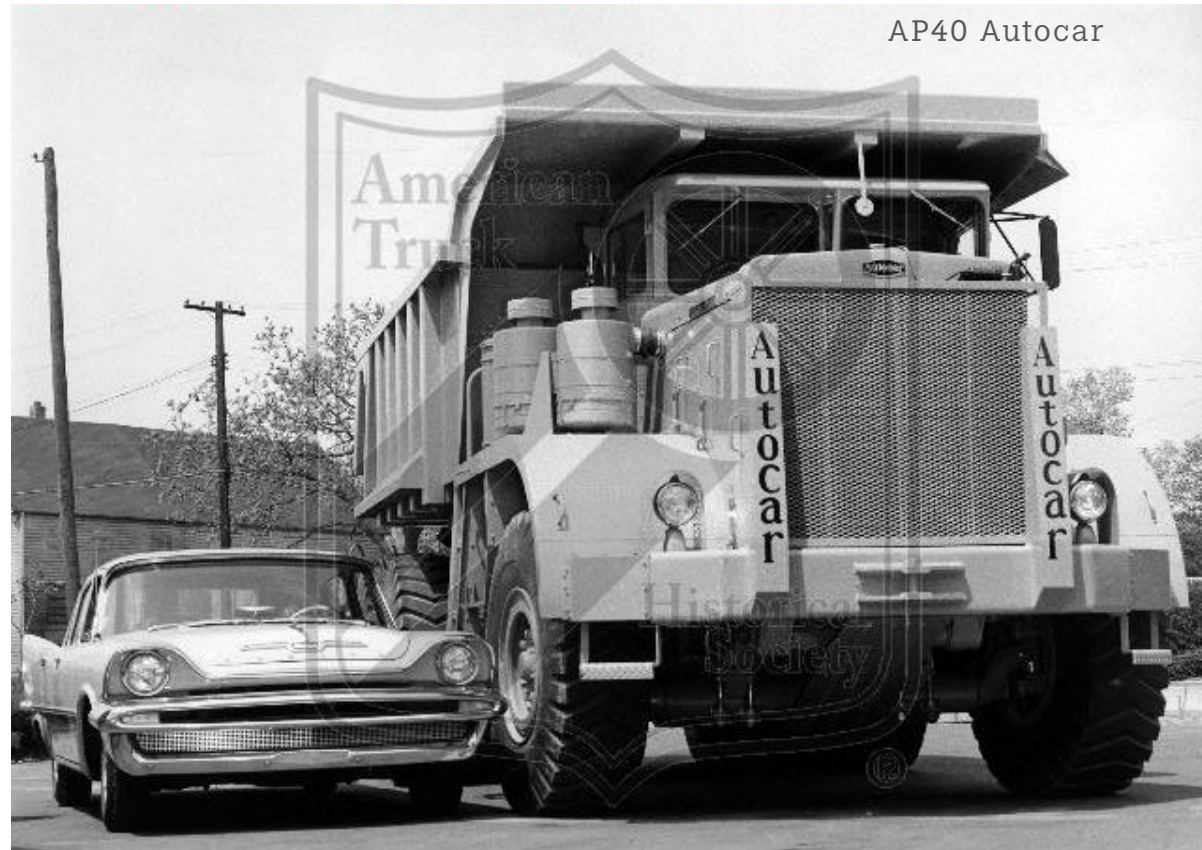


In 1954 Komatsu built the first dump truck on wheels that travelled at 26 miles (42 km) per hour and had a 13.60-ton payload.

In 1958, the 600 horsepower AP40 Autocar was the largest single engine dump truck on the market.

Onset of 1960 saw an increasing competition in world construction and mining industry. This led to emergence of more dump trucks from existing automobile manufacturer as well as new OEMs.

Some of the major OEMs of dump truck today are Volvo, Daimler, Scania, CAT etc. Comparing 1928 Model AA dump truck and Volvo of 2013 there is a considerable advancement in the tipper truck industry.



Reference:

History of Construction Equipment-Haycraft, W. (2011)

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Dump Trucks - Donald Woods

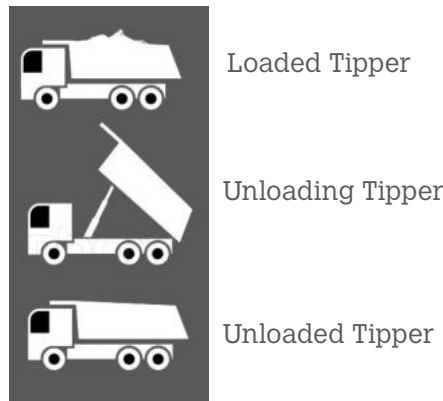
2

How it Works?

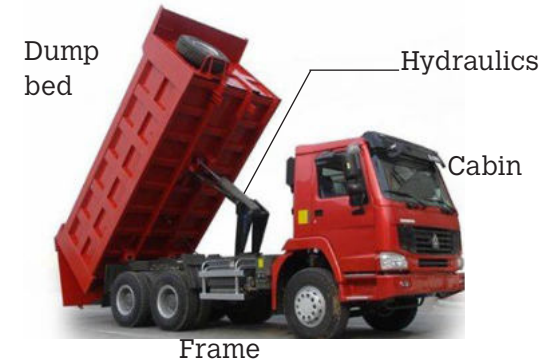
A dump truck can be roughly described as a giant vehicle with at least four wheels, commonly propelled by an internal combustion engine with a driver's cab for control and a huge steel box mounted on the chassis frame. A dump truck is sometimes referred to as a dump, production truck, tipper, hauler, tipper lorry.

Tipper truck or Tipper is used for hauling aggregate material such as sand, cement, bricks, concrete blocks, rocks, coal, gravel, dirt, hot asphalt in construction, road building and surface mining applications.

It is equipped with a hydraulically operated open-box bed hinged at the rear, the front of which can be lifted to allow the contents to be deposited on the ground behind the truck at the site of delivery.



Essentially a tipper consists of four major entities - **Truck frame, Driver cabin, Hydraulic system, Dump bed.**



Truck frame

It consists of two parallel boxed (tubular) or C-shaped rails, or beams, held together by cross members. These frames are referred to as ladder frames due to their resemblance to a ladder if tipped on end. The rails consist of a tall vertical section and two shorter horizontal flanges. The depth of the vertical section provides opposition to vertical flex when weight is applied to the top of the frame (beam resistance). Though typically flat the whole length on heavy duty trucks, the rails may sometimes be tapered or arched for clearance around the engine or over the axles. The holes in rails are used either for mounting vehicle components and running wires and hoses, or measuring

and adjusting the orientation of the rails at the factory or repair shop.

The frame is almost always made of cold rolled steel, but can be made (whole or in part) of aluminium for a lighter weight. It supports cabin, engine, dumpbody, and hydraulics with wheels on axles.

Image on right shows configuration of wheels and drive train available in tipper trucks.

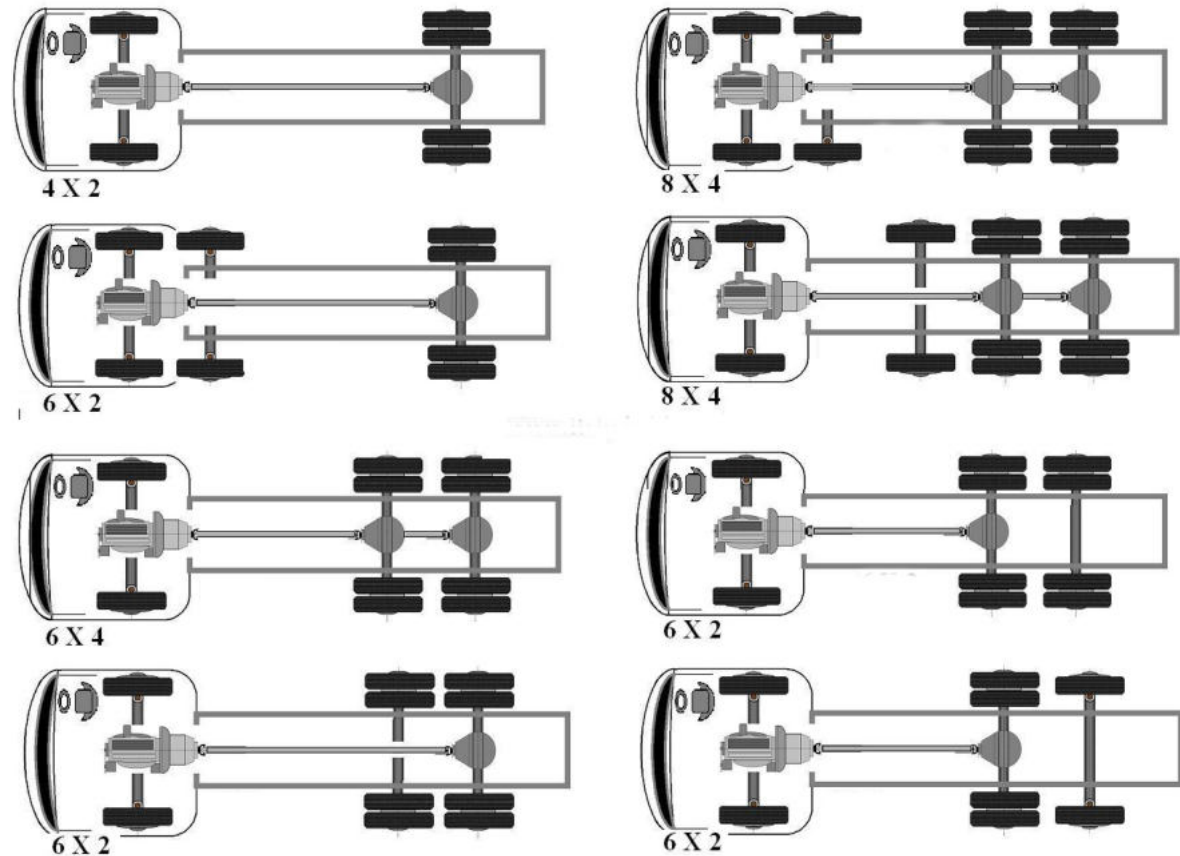
Tipper truck bodywork is considered to be torsionally flexible. Chassis and bodywork on tipper trucks are normally subjected to high stresses. During rear tipping when spreading for example, the tipper support shaft with attachments, frames and suspension in the rear axle take up the dynamically alternating stresses. In extreme cases this can lead to the vehicle toppling over.

If the ground suddenly gives way during tipping or if one side of the load has frozen, there is a large risk of toppling over and causing personal injury.

The following factors help safe operation of the vehicle in difficult conditions:

- Rigid suspension
- Anti-roll bar
- Tipper stabiliser
- An experienced driver

Truck Driveline Configuration



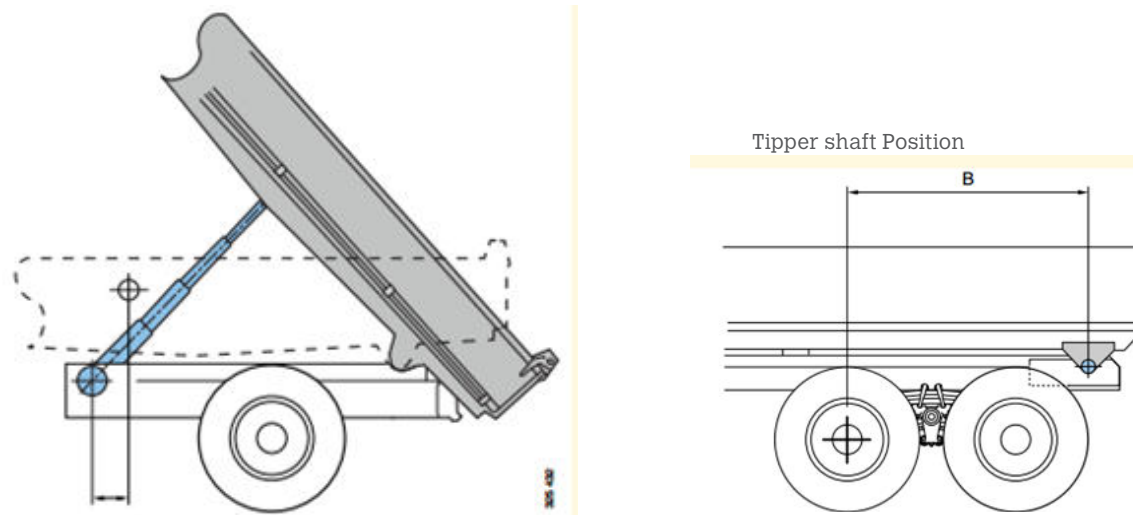
During tipping, there is a risk of overloading the rearmost axle. The weight should be evenly distributed over all rear axles during tipping. This is a function of bed dimension, tipping cylinder location with respect to rear axle and bed pivot with respect to rear axle.

Image on right shows Tipping cylinder location and Tipper shaft position.

The longitudinal position of the tipping cylinders is determined by the following factors:

- The length of the platform
- The load
- Type of tipper

The tipper shaft position is given as the distance from the first driving rear axle to the centre of the platform tipper shaft (B). Recommended maximum dimensions for the tipper shaft position are 1730 mm for 4x4 15 ton truck as shown in the adjacent figure.



Driver cabin

The cabin or cab of a truck is an enclosed space in a truck where the driver is seated. Following are the possible cab configuration :

- Cab over engine (CoE)
- Conventional cabs
- Semi-forward cabs
- Cab beside engine (CbE)

Cabin on the basis of usability can be day cabin, sleeper cabin, sleeper cabin for two or more.

Image on right shows different types of cabin used trucks.



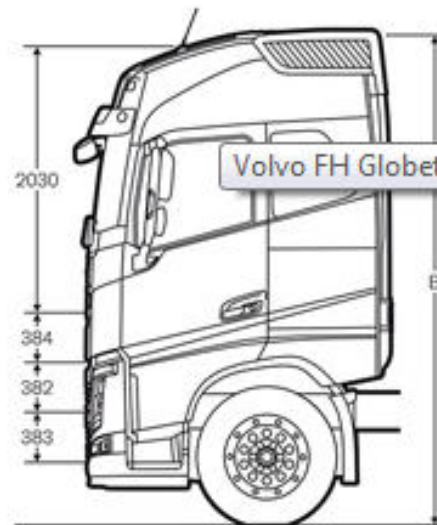
Image on right shows available cabin for DAF tipper trucks. They are available in day, sleep, space and super space cabs.



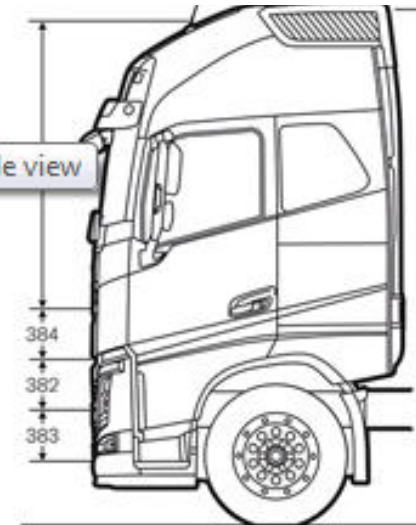
Following are the cab dimension and specification for Volvo Trucks.



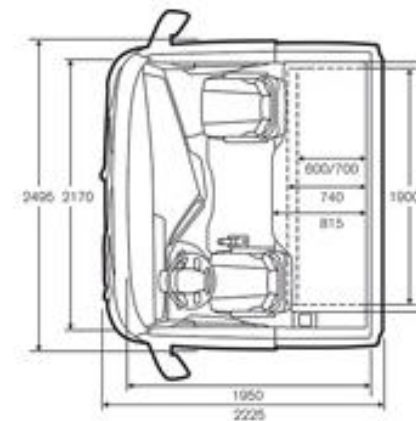
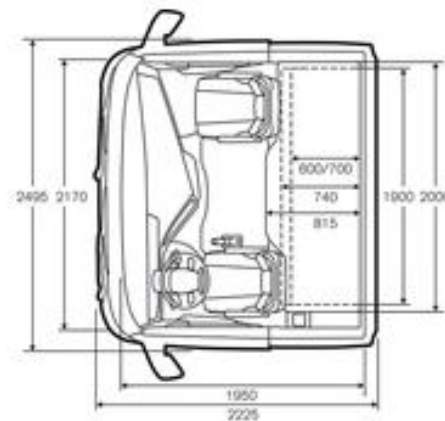
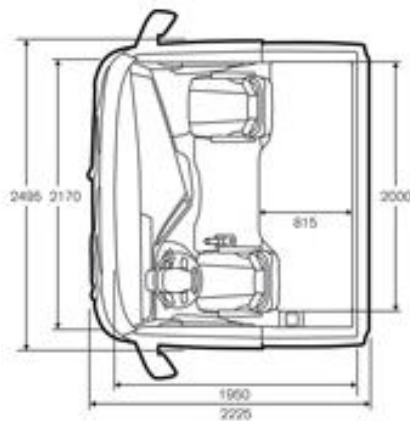
Sleeper cab (CAB-SLP)



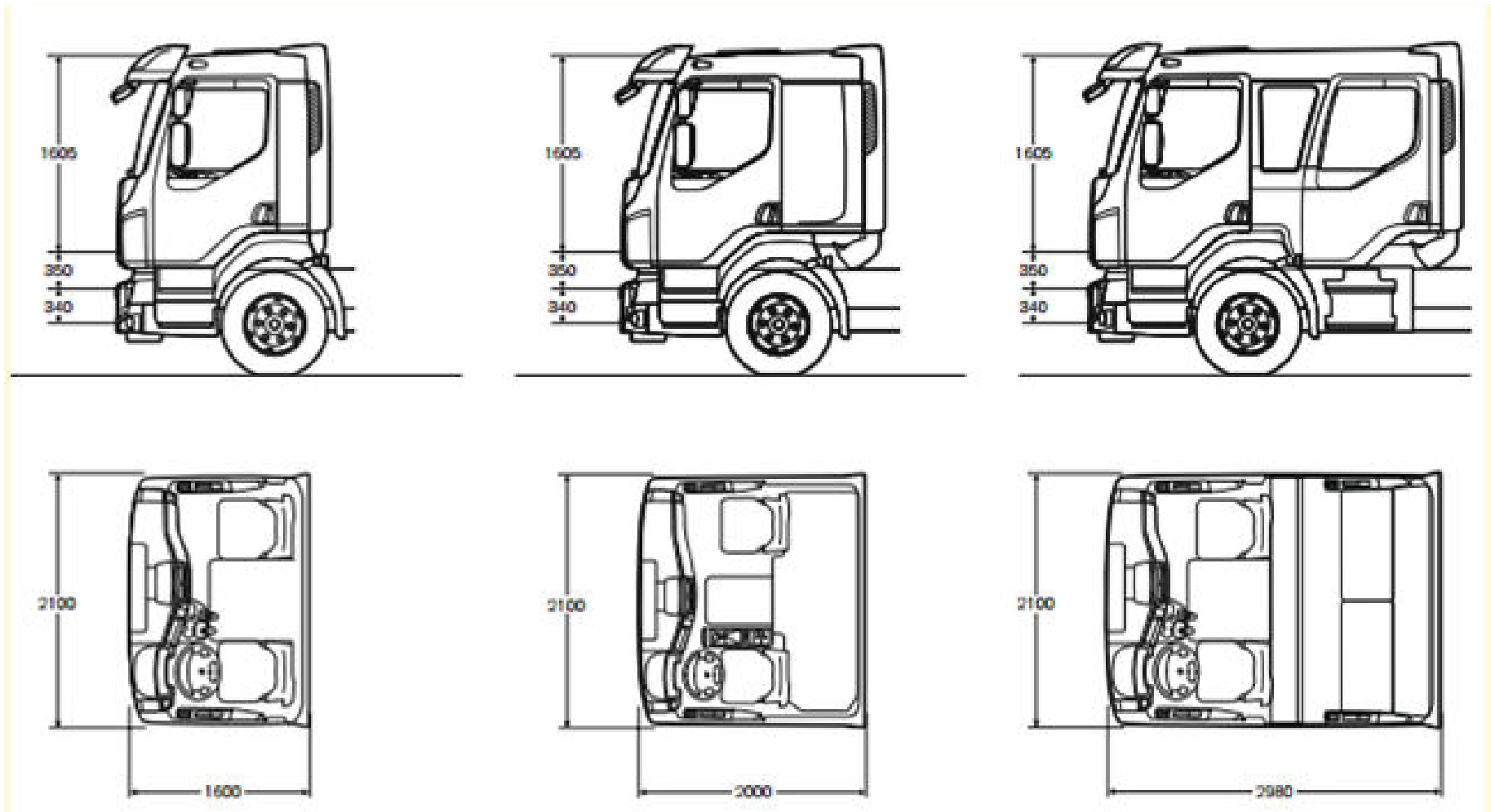
Globetrotter cab (CAB-HSLP)



Globetrotter XL (CAB-XHSL)



Volvo FL Truck cabin specifications



Day Cab
Interior height 1,605 mm

Comfort Cab
Interior height 1,605 mm

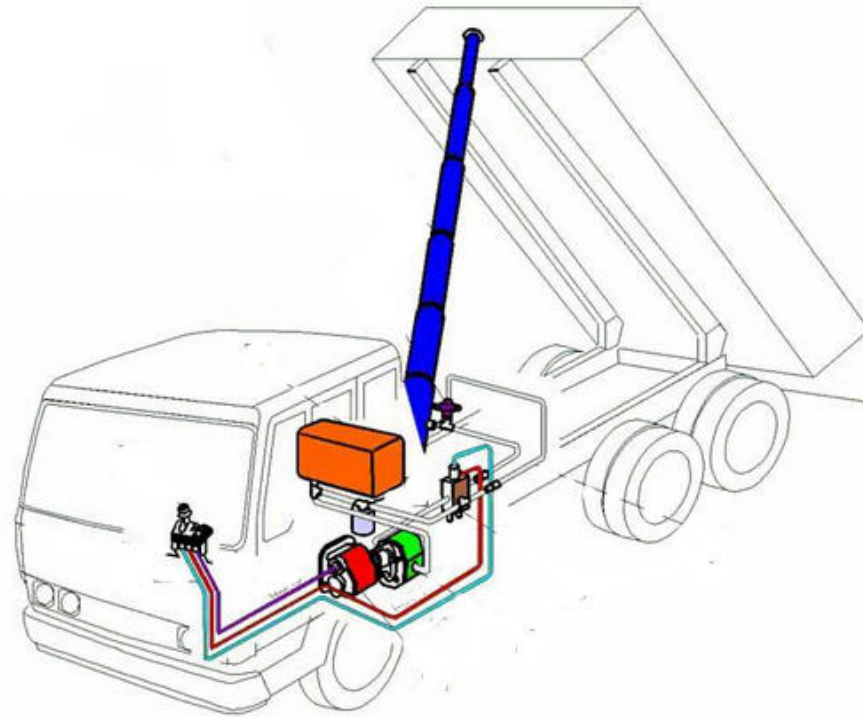
Crew Cab
Interior height 1,605 mm

Hydraulic system

The lifting mechanism of a dump truck is quite basic. One or more hydraulic pistons are used to lift the dump box, raising one end of the box high enough so its contents will be dumped out through the box's hinged tailgate. Hydraulic pistons are used as opposed to pneumatic ones because hydraulic systems use liquids that by their nature can't be compressed because the compression of the lifting agent would cause the pistons to slowly slip and lower the dump box unintentionally. Lowering the dump box is accomplished by releasing the hydraulic liquid slowly, allowing the pistons to lower again, thus pulling the dump box back into its original horizontal position.

Power for the hydraulic system is generally provided by the dump truck's transmission, meaning the dump box generally won't be able to be lifted or lowered unless the truck is running. Power is transferred from the transmission to the hydraulic piston system by means of the power take-off (PTO), a separate splined driveshaft that connects to the main transmission box.

Different types of hoist available are - Telescopic Hoist, Underbody Hoist and Scissor Hoist. They can have wither one or two piston depending upon the load carrying capacity.



Telescopic Hoist
Front - Single



Telescopic Hoist
Middle - Dual



Scissor Hoist
Middle - Single



Underbody Hoist
Middle - Single

Dump Bed

Dump bed mounted on frame by hoist are made of hardened steel or stainless steel depending upon the type of application.

Dump bed can have a tailgate opening, side opening or bottom/belly opening for unloading of dump.

Dump bed are available in -

- Standard type
- Scoop end type
- Rock Dump
- Three Way Dump Truck
- Sliding Bed Dump Truck
- Refuse body type (Waste Dump Truck)
- Elliptical demolition dump truck body



Standard Type



Scoop Type



Rock Dump Type



Three way Dump Type



Sliding Bed Type



Refuse Body Type



Elliptical Dump Type

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3

Types of Tipper truck

Standard dump truck

A standard dump truck is a truck chassis with a dump body mounted to the frame. The bed is raised by a vertical hydraulic ram mounted under the front of the body, or a horizontal hydraulic ram and lever arrangement between the frame rails, and the back of the bed is hinged at the back of the truck. The tailgate can be configured to swing up on top hinges (and sometimes also to fold down on lower hinges) or it can be configured in the "High Lift Tailgate" format wherein pneumatic rams lift the gate open and up above the dump body. The 4 axle eight wheeler has 2 axles at the front and 2 at the rear and is limited to 32 metric tons (35 short tons; 31 long tons) gross weight in most EU countries

Common configurations for a standard dump truck include the four wheeler (4x2) which has one powered rear axle, the six wheeler (6x2 or 6x4) with one or two powered rear axles, the tri-axle with one lift axle and two powered axles, and the quad with two lift axles and two powered axles



Transfer dump truck

A transfer dump is a standard dump truck which pulls a separate trailer which can also be loaded with aggregate (gravel, sand, asphalt, klinkers, snow, wood chips, triple mix, etc.)

The second aggregate container, (B box)[8] on the trailer, is powered by either an electric, pneumatic motor or hydraulic line,. It rolls on small wheels, riding on rails from the trailer's frame, into the empty main dump (A) box. This maximizes payload capacity without sacrificing the maneuverability of the standard dump truck. Transfer dumps are typically seen in the western United States because of the peculiar weight restrictions on western highways.

Another configuration seen is called a Triple Transfer Train, which consists of a B and C box.

Transfer dump trucks typically haul between 26 and 27 short tons (23.6 and 24.5 t; 23.2 and 24.1 long tons) of aggregate per load, each truck is capable of 3-5 loads per day, generally speaking.



Truck and pup Dump Truck

A truck and pup is very similar to a transfer dump. It consists of a standard dump truck pulling a dump trailer. The pup trailer, unlike the transfer, has its own hydraulic ram and is capable of self-unloading

Superdump Truck

A Superdump is a straight dump truck equipped with a trailing axle, a liftable, load-bearing axle rated as high as 13,000 pounds (5,897 kg). Trailing 11 to 13 feet (3.35 to 3.96 m) behind the rear tandem, the trailing axle stretches the outer "bridge" measurement—the distance between the first and last axles—to the maximum overall length allowed. Superdumps can be rated as high as 80,000 pounds (36,287 kg).

Semi trailer end dump Truck

A semi end dump is a tractor-trailer combination wherein the trailer itself contains the hydraulic hoist. A typical semi end dump has a 3-axle tractor pulling a 2-axle semi-trailer. The key advantage of a semi end dump is rapid unloading.



Superdump Truck



Semi trailer dump truck

Semi trailer bottom dump truck
(Bottom dump trailer)

A semi bottom dump (or "belly dump") is a 3-axle tractor pulling a 2-axle trailer with a clam shell type dump gate in the belly of the trailer. The key advantage of a semi bottom dump is its ability to lay material in a wind row (a linear heap). In addition, a semi bottom dump is manoeuvrable in reverse, unlike the double and triple trailer configurations described below. Major disadvantage of this is the dump spreads jam and do not work well with larger materials.



Side dump Truck

Side Dump Industries Train Set.

A side dump truck (SDT) consists of a 3-axle tractor pulling a 2-axle semi-trailer. It has hydraulic rams which tilt the dump body onto its side, spilling the material to either the left or right side of the trailer.

The key advantages of the side dump are that it allows rapid unloading and can carry more weight in the western United States



Off-highway dump trucks

Off-highway dump trucks are heavy construction equipment and share little resemblance to highway dump trucks. Bigger off-highway dump trucks are used strictly off-road for mining and heavy dirt hauling jobs



Haul trucks

Haul trucks are off-highway, two-axle, rigid dump trucks specifically engineered for use in high production mining and heavy-duty construction environments. They can have payload capacities of up to 400 tons



Articulated hauler

Articulated dump truck or dumper

Main article: Articulated hauler

An articulated dumper is an all-wheel drive, off-road dump truck. It has a hinge between the cab and the dump box, but is distinct from a semi-trailer truck in that the power unit is a permanent fixture, not a separable vehicle. Steering is accomplished via hydraulic cylinders that pivot the entire tractor in relation to the trailer, rather than rack and pinion steering on the front axle as in a conventional dump truck. By this way of steering, the trailers wheels follow the same path as the front wheels. Together with all-wheel drive and low center of gravity, it is highly adaptable to rough terrain. Major manufacturers include Volvo CE, Terex and Caterpillar.



References:

Wood, Donald (2001). Dump Trucks
Available online on Google Books

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4

Environment Study

Mining

Tipper trucks work in the most hostile environment - the coal mines. Such environment is abundant with coal ash and dust, heat, particulate matter and noise. Tipper travel on loose soil and in slippery gravels.



City Construction site and Roads

Tipper are used in cities for construction work and often has to travel along highways. Such areas are usually crowded with other vehicles and pedestrians. Truck has to be manoeuvred a lot in cities than highway. Ground condition are often good on road within cities, however, at the construction site, tipper has to travel on rocks, gravel, loose soil and mud.



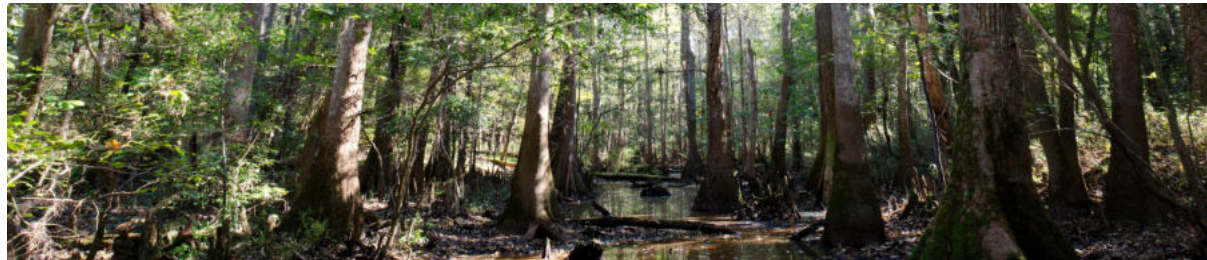
Snow

Tipper truck are used in winters and in cold region to dump snow collected by snow plougher. The environment is very cold and foggy. The road condition are uneven,slipper and soft.



Rain,River and Forest

Tipper trucks are often used to carry wooden logs used in winters and in cold region to dump snow collected by snow plougher. The environment is very cold and foggy. The road condition are uneven,slipper and soft.



5

Global Tipper Truck Study

Major Global Manufacturer of Tipper Trucks

Ford

Freightliner

Hino Motors, Ltd.

International

Iveco

Kenworth

Mack

MAN

Mercedes-Benz

Moxy

Peterbilt

Scania

Sterling

Volvo

Wesco

Western Star

Hyundai

DAF

Isuzu

Nissan

Fiat Group

Tatra

References:

Available at <http://www.ritchiewiki.com/wiki/index.php/Dump_Truck#ixzz2fpYcBi6h> [Accessed 1 September 2013]

Available at <<http://oica.net/wp-content/uploads/ranking-2010.pdf>> [Accessed 15 September 2013]

Volvo Tipper Trucks

Volvo FM Dumper
Vovo FMX Tipper
Volvo FM Tipper

Important Technical Specifications

Chassis specifications

Chassis heights
Max. front axle load
Rear suspension
Fifth wheel coupling heights
Towbars
Fuel tanks
AdBlue tanks
Fifth wheels
Volvo Dynamic Steering
Tag axles
Pusher axles
Brakes

Driveline specifications

Engines Emission standard Euro 6	
No. of cylinders	6
Displacement	10.8 dm ³
Stroke	152 mm
Bore1	23 mm
Compression ratio	17.0:1

List of Humanistic features

Headlights

The Volvo FH headlights have been redesigned and inculcates many new technologies. Among the highlights are:

- Improved main beam
- Dynamic headlights
- Enhanced static cornering lights
- Approach light

Front Underrun Protection Systems (FUPS)

FUPS are barriers integrated into the front of trucks OR built as specially designed bullbars and bumpers.

Primary Information display Cluster And Secondary Information Display.

Built-in GPS navigator

Volvo FH has a brand new, fully integrated navigator. Knowing the truck's specification, it can use map data to help you choose a route that suits your axle load and vehicle height.

Exterior vision cameras

Secondary Information Display shows the input from up to four cameras in full resolution.

Driver times feedback

Helps handling driving and resting times.

Audio system

Information on each track, and navigate easily among them.

Phone

Connects via Bluetooth, browse your phone book, talk into the built-in microphone and listen through the speakers.

Dynafleet

No separate display needed. All information from Volvo's transport management system is now integrated.

Driver Information Display.

Gauges your way

Plenty of status indicators and trip information. The customised view lets you select up to three favourites.

Driver Alert Support

If unfocused driving is detected, a clear message shows up in the display.

Load indicator

The enhanced load indicator allows you to precisely monitor axle load.

Understandable error messages

No perplexing fault codes. The error messages quickly and accurately tells you what's wrong – in plain text.

The electronically controlled suspension (ECS)

ECS improves driving comfort and helps making sure the cargo travels safely. You have perfect control, regardless of whether you're sitting behind the wheel or walking around the truck.

5 levels for loading. 3 for driving.

ECS includes four bellows per axle (two for pusher axles), providing a virtually parallel lift of the chassis. You can easily set the height you prefer. You can also choose from one preset and two custom driving levels, to optimise ground clearance or aerodynamics.

Keeping the chassis steady. And the load in place.

ECS steadily keeps the chassis level, regardless of how the cargo is distributed. It prevents sideways rolling, making sure the truck is always in balance. The Work Remote also allows you to manually compensate for side kneeling.

Load indicator. Accurate and easy to overview.

Intuitive menus and displays let you see exactly how the load is distributed along the vehicle. Weights, axle loads and bogie loads are all specified separately, so you can easily make sure they are within the limits, on the truck as well as on the trailer.

Driver support systems.

Volvo FH can be equipped with several cutting-edge safety systems, effectively reducing the risk of an accident:

- Stretch Brake (new)
- Adaptive Cruise Control and Collision Warning with Emergency Brake
- Lane Keeping Support
- Driver Alert Support
- Lane Changing Support
- Emergency brake light (new)
- Electronic Stability Program

Stretch Brake.

In certain situations, such as turning or driving downhill on a slippery road, the trailer risks catching up with the truck, creating a hazardous jack-knife effect. The Stretch Brake is a new Volvo feature, designed to stop that from happening. By pulse braking the trailer, the vehicle combination is stretched, and the danger reduced. The system can be automatically activated in risky situations, at speeds up to 50 km/h.

Adaptive Cruise Control and Collision Warning with Emergency Brake.

Follow the traffic rhythm without effort. The radar-based Adaptive Cruise Control (ACC) keeps a safe distance to the vehicle in front by controlling the accelerator and all available brakes. If there's a risk of collision, warning lights are projected on the windscreen. The Collision Warning with Emergency Brake takes this one step further. It automatically assists you in emergency braking if an impact is imminent, thus significantly reducing the risk of severe injuries.

Lane Keeping Support.

Drifting out of lane is a common cause of many serious accidents. Lane Keeping Support tracks the road markings with a camera, and alerts you if you should unintentionally cross them.

Driver Alert Support.

Driver Alert Support is an intelligent system that tracks your driving behaviour. If it differs from normal and indicates tiredness, you are alerted by a signal and a message in the display, advising you to take a break.

Lane Changing Support.

The blind-spot area on the passenger side can easily hide other road users. Lane Changing Support is equipped with a radar that checks that area when you activate the indicator. If the area's not clear, you are notified by a sound and a flashing icon by the mirror.

Electronic Stability Program.

Volvo's Electronic Stability Program (ESP) efficiently reduces the risk of skidding and rollovers. In risky situations it instantly steps in, reducing engine power and braking the truck and trailer. Each wheel of the truck is braked individually.

Emergency brake light.

If you slam on the brakes, the brake lights flashes rapidly to alert the vehicles behind you. An easy way of avoiding rear-end collisions, which can be fatal or lead to major pile-ups.

Volvo Dynamic Steering.

Enables perfect stability at high speeds. Total control at low speeds. And drastically reduced strain on your muscles.

At high speeds:

Driving straight isn't as easy as one would think. In fact, you often have to compensate for kicks from road ruts, pot holes and road markings. Or correct your course after braking on a mixed-friction surface. Sometimes even side winds can disturb the ride. VDS helps loosen grip on the wheel, concentrate on the traffic and be sure the truck won't change direction until you want it to.

At low speeds:

Steer with one finger and save your back. This is where Volvo Dynamic Steering really is forefront because you no longer need to strain your muscles to manoeuvre the truck at low speeds. Volvo Dynamic Steering provides you with all the steering force you need. You can literally steer the truck with one finger. This not only gives you complete control of the vehicle but also practically eliminates the strain on your neck and shoulders.

Inside The Cabin

Only 261.5 cm from road to roof. For car transporters and other height-sensitive applications, the new Volvo FM's low sleeper cab is the perfect choice.

1.39 metres at disposal.

If you transport cars, you know how to appreciate a low truck. Because whether there's room for one more or not is often a matter of centimetres. The low sleeper cab on the new Volvo FM is lower – only 2.61 metres. This leaves as much as 139 centimetres for cargo, if you need to stay within the European 4-metre limit.

A clean cab roof.

If you want to take advantage of the low cab height, you don't want anything sticking up from the roof. Fortunately, the antennas on the Volvo FM can all be moved out of the way. The WLAN antenna can be moved to the front shelf, the phone antenna to the dashboard and the toll collect, FM, CB radio and Dynafleet antennas can be fitted to the cab sides.

Easy entry and exit.

One of the most appreciated features of the Volvo FM cabs is the entry step. X-Low chassis allows only 26 cm above the ground point of ingress. Door that opens a full 90 degrees and an optional grab handle, allows you to comfortably enter and exit many times a day without strain.

See what you need to see

The instrument cluster puts vital information where the driver can see it at a glance, while less frequently used controls are further away. The Secondary Information Display is now integrated in the new instrument panel – which was previously a pop-up model. Louise Karlsson explains the reason for a pure and clean design, “*It’s important to keep everything calm inside the cab so the driver can concentrate on what’s happening outside. Drivers who have driven the new truck have confirmed that visibility is now even better.*”

Put your best buttons in the best places

Many technical improvements come from the recently launched Volvo FH. Such as the flexible switches that let the driver choose which functions are closest to the steering wheel. “*This lets you rearrange them if you have some special way of working that we couldn’t foresee*” says Malin Gabre.

On and off

Driver determines when more drive axles are needed. : 4×4 ,6×6 ,8×6

Free rolling

With a switch on the dashboard the driver can revert to rear-wheel-drive when conditions allow. This means direct transfer between the engine and rear drive axle, so the other wheels are free rolling – and consuming less fuel.

At one with the wheel

Several functions have moved from the stalks to the controls embedded in the steering wheel. Here they are logically grouped according to their functions and easy for fingers to find them. According to Louise Karlsson, the new design is also good for tired arms: “*The new steering wheel has plenty of grip alternatives, so the driver will always find one that’s comfortable. Together with Volvo Dynamic Steering, which takes the strain out of steering, this really improves ergonomics for the driver.*”

A better place to work

“*We’ve thought a lot about the cab in terms of a work-place. It’s the place drivers spend most of their time – and where they keep all their things. So there’s a new storage space beside the driver’s seat for paperwork and a much better compartment on the side of the door. This is spacious but doesn’t get in your way when climbing in and out,*” says Malin Gabre.

Say goodbye to sand and debris

Another new feature is the air gun which is driven by compressed air from the seat. Louise Karlsson explains why it’s useful, “*It’s an easy way to keep your controls and dashboard clean in an environment that is often very dusty. As there are no sills or edges in the doorway, you can just blow the dirt out.*”

When things get extreme

In the six-wheel-drive trucks the first thing you need is an inter-axle differential lock – diagonally locking two of the rear drive wheels across the bogie. “*If things start getting really slippery you engage the driven front axle. . Pressing the locks the front differential making it very hard to steer the vehicle – but allows you to get back onto dry land.*”

Steeper hills and deeper ditches

The front drive axle has been relocated 100 millimetres closer to the front. This gives the truck a far better approach angle, but also means it can be combined with the full range of chassis components and engines.

Lower fuel consumption

While permanent all-wheel-drive is the common solution for construction trucks, Volvo prefers to let the driver engage it – as and when needed. Jonas Odermalm recalls from research carried out in the desert: “*It’s really only needed between two and five percent of the time. This means that 95 percent of the time All-Wheel-Drive is a waste of fuel – unless it’s an FMX and the driver can choose when to apply it.*”

References:

Available at <<http://www.volvotrucks.com/trucks>> [Accessed 11 November 2013]

Available at <http://www.volvotrucks.com/SiteCollectionDocuments/VTC/Market/Trucks/volvo-fh-series/PDF/cab/Volvo-FH-Series_Specifications_Cab_UK.pdf> [Accessed 10 November 2013]



6

Indian Tipper Truck Study

Major Local Manufacture of Tipper Trucks or Global OEM's Having local Presence

- Ashok Leyland
- Force Motors
- Hindustan Motors
- Mahindra Navistar
- Swaraj Mazda
- Tata Motors
- Volvo
- CAT
- JCB
- Eicher
- AMW
- Bharat Benz
- Scania

References:

Available at <http://www.ritchiewiki.com/wiki/index.php/Dump_Truck#ixzz2fpYcBi6h> [Accessed 1 September 2013]

Available at <<http://oica.net/wp-content/uploads/ranking-2010.pdf>> [Accessed 15 September 2013]



Tata Tipper Trucks

Tata 1616/1613 Semiforward Truck
Tata 2518 Cab over Engine
Tata Prima Range

Important Technical Specifications

Driveline specifications

EngineTata 697 TCIC BS III
Max Engine Output116 KW(155 Hp) @2250 RPM
Max. Torque630NM@1400(+/-100 RPM)
Outside Dia of Clutch Lining.....352 mm
Tata G 600550 Nm at 1400 rpm
No.of Gears.....6 Forward, 1 Reverse
Suspension Type.....Semi elliptical leaf spring
Tyre Size.....10.00 x 20 -16 PR
Cab/Cowl Type.....Day Semi Forward Fixed Cab
Max Geared Speed94kmph for 36 WB
.82 kmph for 42 WB

Max Climbing Ability In First Gear...26% for36WB
....., 31% for 42WB

Min Turning Radius(mm) 7.250 for 36 WB,

List of Humanistic features

Basic Features

Headlamps
Iconic semiforward cab
1/2 seat day configuration cowl
Air inlet and side windows
Instrument cluster with gear oil,hydraulic oil,speed,diesel,temperature and battery indicator

References:

Available at <http://tabindia.weebly.com/uploads/1/1/9/4/11941217/se_1613_tcic_4x2_bs2.pdf> [Accessed 1 September 2013]

Available at <<http://www.construck.tatamotors.com/16ton-semi-forward-tippers/SK-1616.asp>> [Accessed 7 September 2013]



7

List of Technical and Humanistic Aspects

Any product has two aspects associated to it - Technical aspects and Humanistic aspects.

There should be a right synergy between both of them for a product to be called as good and successful design.

Technical aspects consists of -

- Materials engineering
- Processes
- Mechanism
- Performance and reliability
- Usefulness

Humanistic aspects consists of Design factors such as -

- Ergonomics
- Aesthetics
- Acceptability
- Fit and finish
- Usability

References:

Design as a State Policy - Imperatives for India and other Developing Countries - K. Munshi

Available at <<http://www.idc.iitb.ac.in/munshi/Design%20as%20state%20policy.pdf>> [Accessed 16 October 2013]

Technical Aspects of Tipper truck -

- Material and manufacturing process to make tipper light weight and crash resistant
- Light weight material for better fuel efficiency
- Efficient process for cost effectiveness
- Mechanism for gear shifting, steering wheel, Hydraulics, driver safety and crash worthiness mechanisms
- Performance of tipper truck and reliability in service conditions
- Usefulness of tipper truck- Travelling and dumping

Humanistic Aspects of Tipper Truck

- Ingress and Egress of Driver
- Eye mapping and activity analysis of driver to reduce fatigue and noise
- Signal to noise ratio for productivity
- Driver seat comfort
- Character of the truck
- Aesthetic appeal of the truck
- Fit and finish of the interior
- Usability includes how is the operation performed taking in account system level design.

8

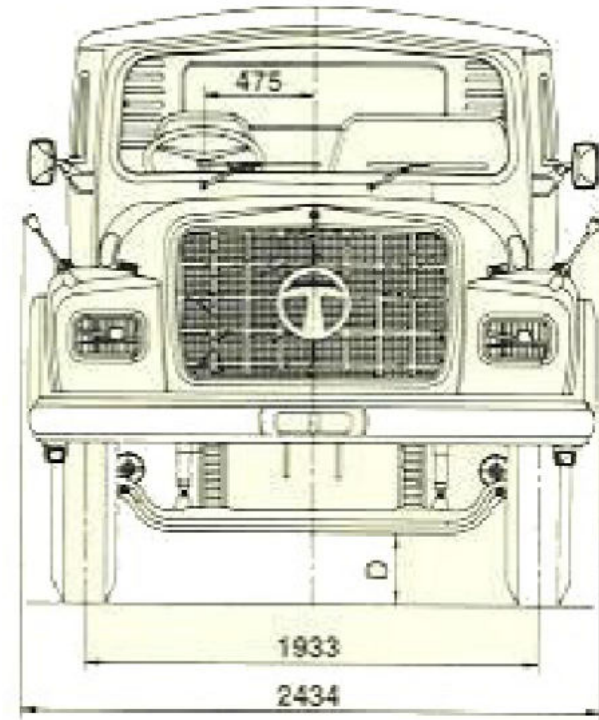
Technical Drawing

All the dimensions of the truck were measured manually and plotted on the graph to determine the approximate dimension.
Deviation from the actual dimension is approximate 50~60 mm

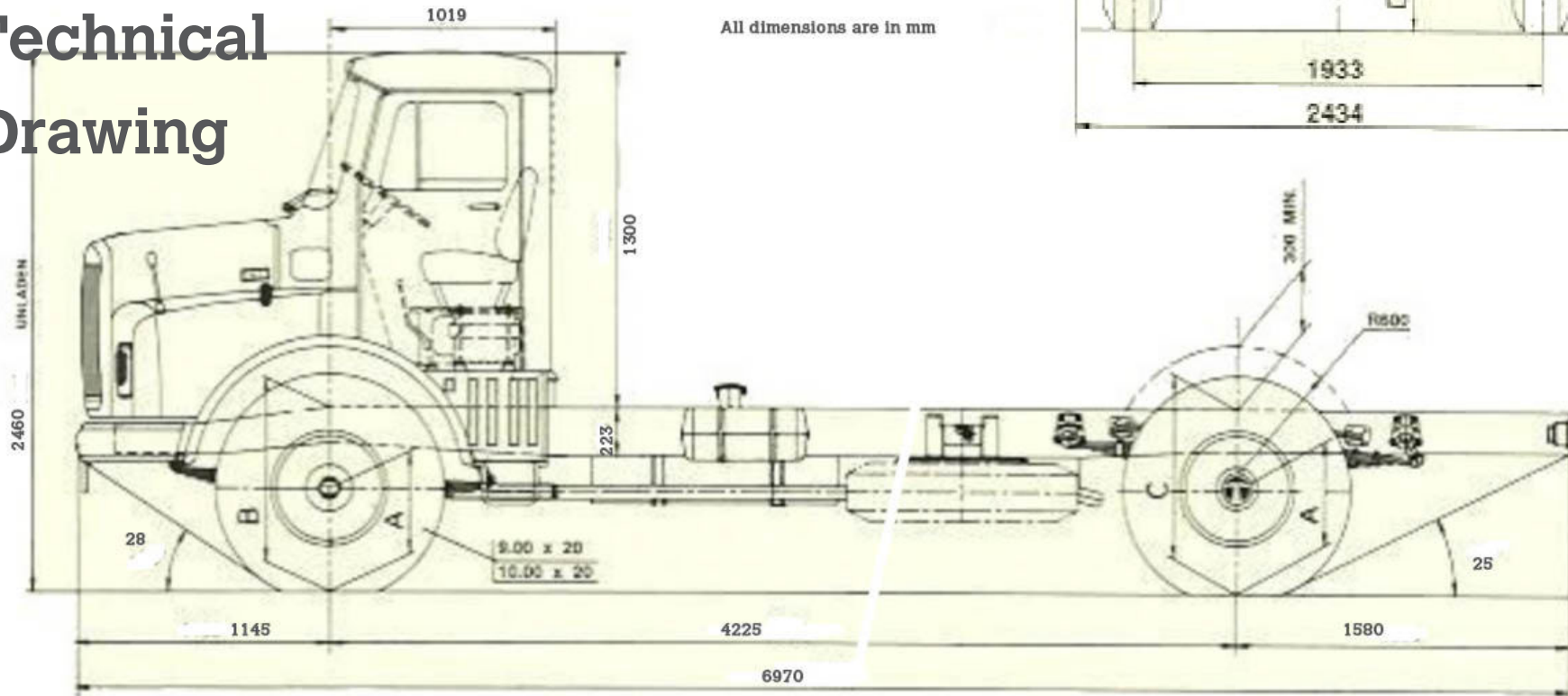


References:

Available at <http://tabindia.weebly.com/uploads/1/1/9/4/11941217/se_1613_tcic_4x2_bs2.pdf> [Accessed 1 September 2013]



Technical Drawing



II

User Research

For User Research I went to the construction sites to observe and interview the primary user which in this scenario is the driver of the tipper truck. Firstly, I observed the driver and helper while they were working by sitting in the cabin and travelling with them. Set of questions were asked to them regarding usability of tipper. I also talked to the excavator operator who the dump truck to get insights. In the process I interviewed the supervisor and owner of the tipper truck as well. All these culminated to envisage and cull cut problem of existing tipper truck and formulate design direction and consequently the design brief.

9. Observation on the site
10. Activity Analysis
11. Inference form Activity a
Interview and Questionnaire
Inferences from User Research
Design Directions and Brief

9

Observations on the site

Tipper truck which are most common in India are Tata Tipper trucks especially Tata 1613 and 1616 semi forward 16 ton truck.

A brief **Market Research** was done of the tipper industry in India.

Volvo trucks operate only in select premium and niche segments in India and hold the Number 1 position in the premium European truck segment in India. It holds 70% of the market share in India

“With higher productivity at optimum cost being the need of the hour, we have designed the Volvo 10x4 in such a way that it'll strike the perfect balance between productivity, performance and efficiency,” - Philippe Divry, Managing Director, Volvo India Private Limited during launch of Volvo FM480 10x4 Dump Truck in India

Tata Motors has an extensive network across the country for tipper truck servicing with more than 1000 workshops and over 7700 retailers and provides 24x7 onsite service

According to industry figure, after last recession, from 16T to 31T truck and tipper registered growth of 26% and 37% YOY respectively in F10 and F11. 16T and 25T truck and tipper grew at 20% and 17% during the same period and tippers had large share of growth averaging above 35%. Despite slowdown, the mid-term demand is expected to go up approximately 8%.

The demand is definitely characterized by requirement of tipper trucks with advanced operational features for higher productivity and fast operational cycle accordingly, characterizing quicker equipment turn round between loading and unloading points, enabling the trucks to make more number of trips. Also, higher hauling capacities are being added to the trucks with faster turn round features. The trend to incorporate 'value engineering' is well likely to gain strength as fuel costs continue to pass through rising spirals.

Clearly Buyer of the tipper truck looks for cost, productivity, load capacity and has a concern for raising fuel prices.

The Primary User who uses Tipper truck is the driver or operator the tipper truck. Secondary user is the helper who assist the driver and tertiary user is the supervisor or the owner of the tipper truck

Primary User : Driver
Secondary User : Helper
Tertiary User : Owner

After interviewing tertiary user it was inferred that tertiary user buys a tipper on the basis of cost and capacity.

The primary user which is the driver has no say on the choice and thus usability of the truck is often ignored.

Moreover, Owner also stated driver often complain about the truck because they do not want to work.

Clearly there is a mismatch between the usefulness and usability of the tipper truck. Owner wants to transport the dump however usability of the truck is not efficient as far as driver is concerned.

Supervisor and owner perceive driver as workers rather than professionals. Driver will obviously appreciate the details that help them do a better job in everyday situations. The robustness of design may help them get more work done with less annoying delays and with ease.

For getting insights I travelled with the driver to observe the work on the construction site.

Name of the Driver : Amin

Age : 55 years

Height : 1.7 m

No occupational disability

Vehicle used : Tata 1613

Environment : Cloudy weather , Uneven terrain, Noisy condition.

Equipment used : Sony DSLT A58

Mode : Video and Pictures











10

Activity Analysis

In activity analysis all the actions and movements of the driver are recorded. This gives insights on the process or method he follows and possible problems driver encounters during the intended job or function.

In this scenario, driver activities were recorded just after he arrives at the site and awaits for supervisors order.

Scenario :

Name of the driver : Amin

Age :55 yrs

No Disability

Environment : Cloudy,Good visibility

Truck Tata 1613

Recording Medium : Video ,Notebook

Device used : Sony DSLT A58

Gets location of site from supervisor

Prepares to go to site
Checks oil : Transmission, brake oil, Hydraulic, gear oil.
All oil gauge are in different position.

Operator enters the vehicle through the door. Uses Right Hand to open the door. Step of foot rest with right foot. Uses left hand to hold hand grab. Gets left foot in the cabin first.

Operator sits on the chair
Helper sits beside him

Operator starts the ignition
With the left hand, key on the left side

Vehicle starts on neutral gear.
If vehicle is not on neutral gear , operation Is done with left hand.
Vehicle is started.

Operator Drives the vehicle at the site. Along the way he changes gear and checks in the rear mirror by moving his neck

At the work site, helper gets down the vehicle and guides driver instructing driver by shouting loud.

Transmission is set in reverse direction and driver reverses. He often looks back and do not use rear mirrors

Driver manoeuvres the vehicle near the excavator . Driver stops at the signal of helper and switch off ignition.

Driver awaits.

Excavator switches off ignition. Driver gets out of the truck and peeks in the dump bed. Once confirmed from excavator operator driver starts engine.

Helper gets in the cabin. Driver changes gear and goes to the unloading site.

Helper gets down and guides driver to the specific unloading point.

Helper stops the driver and moves to the rear of the vehicle to remove the hook at the back for unloading.

Helper signals operator.

Driver uses unloading liver by left hand which is at left hand side of the driver

Driver also accelerates by right foot keeping his right hand on steering.

Helper instructs driver to move front. Driver changes gear and moves forward to unload the truck.

Once unloaded,Driver lower the bed with lever on left.

Helper gain fixes the hook of the bed and get in the cabin.

Driver leaves for the next loading operation and process repeats for around 2 hours.

After the work , operator drives back the truck at the office site

Helper checks the vehicle and cleans it

11

Inferences from Activity Analysis

- From the activity analysis following problems were inferred -
- Most of the dials on the instrument cluster is not working. Driver has to check vital indicator like brake oil,hydraulic oil and gear oil manually.
- Foot rest in Tata 1616 is not integrated with the body hence is broken. This add to difficulty of Ingress and Egress
- Cab is too high,driver faces problems while getting in the cab
- Novice user get no affordance for usability in order to get in the cab
- Placement of the ignition key which is frequently used during operation is visually and physically obstructed by steering wheel
- While driving slowly, driver has to rotate the steering wheel a lot. Steering wheel is very hard and very difficult to operate and leads to fatigue
- While driving down a straight road, and at high speed driver has to control steering wheel
- Driver frequently gazes at the rear mirror,particularly at left mirror where he turns his neck very often
- Driver depends on helper to manoeuvre the vehicle at the construction site and seldom use mirrors.
- While taking a reverse driver peeks back through the right window and checks left mirror frequently. This leads to fatigue and can lead to accident.
- While excavator is loading the dump, driver has to wait in the cabin. Cabin is hot when truck is not moving. Driver has to wait in such hot and humid condition. This leads to frustration and fatigue and obviously decreases the productivity of the driver
- For feedback of proper distribution of dump on flat bed,driver has to step out of the cab and peek in the bed. This is a vital activity because improper distribution of dump can lead to toppling of vehicle. Stepping out of the cabin is dangerous and adds to fatigue and work load of the driver.
- Helper has to unlock and lock the hook of the bed for unloading and loading respectively
- Driver has to move the vehicle to unload the dump and does not get feedback whether dump is unloaded or not. He gets feedback from the helper.



12

Questionnaire

1. What is your educational qualification?
2. How many years of experience you have?
3. Have you had any training in operation of Tipper truck? If so how many years?
4. What are the other vehicles you drive or have driven?
5. Currently working on which vehicle?
6. Are you the primary driver of the truck?
7. What are the in which environments you have previously worked?
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?
9. In night shift where do you take rest or sleep?
10. Do you have any previous history of occupational hazard/disability or problem?Out of the following which is the most troublesome?
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
11. Out of the following which is the most troublesome?
Left rear– Right rear – front left- front right – Dump bed
12. How many people travel along with you while working and driving? Min/max?
13. Do you have any technical complaints?
14. Do you have any usability complaints?
15. Desired feature sought by driver and helper?
16. Out of the known trucks in the market which one is most desired? Why?

Name : Nandu

Age : 27 years

Tipper Truck : Tata 1613

1. What is your educational qualification?..... No Education
2. How many years of experience you have?..... 5 Years
3. Have you had any training in operation of Tipper truck? If so how many years?..... Helper ; Then Driver
4. What are the other vehicles you drive or have driven?which you like..... Only 1613
5. Currently working on which vehicle?..... 1613
6. Are you the primary driver of the truck?..... Yes
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. How many hours you work in day, night and overtime duration?..... 8 hrs ; 1-2 hrs ; 2 hrs overtime
9. In night shift where do you take rest or sleep?..... Sleep on ground , never in cabin
10. Do you have any previous history of occupational hazard/disability or problem?Out of the following which is the most troublesome? Rate on 5.....
Cabin Temperature – Noise – Dust – Vibration– Visibility issue 5 - 3 - 1 -2 - 4
11. Out of the following which is the most troublesome?Rate on 5.....
Left rear– Right rear – front left- front right – Dump bed 5 - 4 - 3 - 3 - 2
12. How many people travel along with you while working and driving? Min/max?..... 2/3
13. Do you have any technical complaints?..... Brakes,Puncture,Jack is hard
14. Do you have any usability complaints?..... Hot Cabin,Lights,Steering is difficult,mirror Adjustment.
15. Desired feature sought by driver and helper?..... A/C, Power Steering
16. Out of the known trucks in the market which one is most desired? Why?..... Better than 1613

Name : Amin

Age : 55 years

Truck : Tata 1616/1613

1. What is your educational qualification?..... No
2. How many years of experience you have?..... 30 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... Helper then driving
4. What are the other vehicles you drive or have driven?which you like..... **1613, Tempo, 407, All Tata**
5. Currently working on which vehicle?..... 1613/1210
6. Are you the primary driver of the truck?..... Yes
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?..... 8-10 hrs ; 4 hrs ; Weekends overtime
9. In night shift where do you take rest or sleep?..... In the cabin of other truck not in dumper
10. Do you have any previous history of occupational hazard/disability or problem?Out of the following which is the most troublesome?.....
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
5 - 4 - 1 - 1 - 3
11. Out of the following which is the most troublesome?
Left rear– Right rear – front left- front right – Dump bed
5 - 4 - 2 - 2 - 1
12. How many people travel along with you while working and driving? Min/max?..... 2/4
13. Do you have any technical complaints?..... Brake, clutch hard,Oil leak
14. Do you have any usability complaints?..... Mirror adjustment,Steering hard.
15. Desired feature sought by driver and helper?..... None
16. Out of the known trucks in the market which one is most desired? Why?..... I can Drive all vehicles

Name : Dattatraya

Age : 42 years

Truck : Tata 1616/2513

1. What is your educational qualification?..... 42 years
2. How many years of experience you have?..... 15 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... Helper - Driver
4. What are the other vehicles you drive or have driven?which you like..... 2518, 1613, 1210
5. Currently working on which vehicle?..... 2518
6. Are you the primary driver of the truck?..... Yes
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?..... 8-10 hrs ; 1-2 hrs ; 2 hrs overtime
9. In night shift where do you take rest or sleep?..... Not in cabin , outside in tent
10. Do you have any previous history of occupational hazard/disability or problem?Out of the following which is the most troublesome?..... 5 - 1 - 1 - 1 - 4
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
11. Out of the following which is the most troublesome? 5 - 4 - 5 - 4 - 2
Left rear– Right rear – front left- front right – Dump bed
12. How many people travel along with you while working and driving? Min/max?..... 2/4
13. Do you have any technical complaints?..... No
14. Do you have any usability complaints?..... Mirror adjustment,Brake very hard,Hot cabin
15. Desired feature sought by driver and helper?..... A/C, Power steering,Mirror adjustment
16. Out of the known trucks in the market which one is most desired? Why?..... CAT,Volvo

Name : Bharat

Age : 35 years

Truck : Tata 1613

1. What is your educational qualification?..... 7 th Class
2. How many years of experience you have?..... 15 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... Helper then driver
4. What are the other vehicles you drive or have driven?which you like?..... **Tata 407, Tata 2518,Tata 1616**
5. Currently working on which vehicle?..... Tata 1616
6. Are you the primary driver of the truck?..... Yes
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?..... 8-10 hrs, 3 hrs, 4 hrs overtime
9. In night shift where do you take rest or sleep?..... Outside cabin on ground or tent
10. Do you have any previous history of occupational hazard/disability or problem?Out of the following which is the most troublesome?.....
Cabin Temperature – Noise – Dust – Vibration– Visibility issue 5 - 4 - 2 - 2 - 3
11. Out of the following which is the most troublesome?
Left rear– Right rear – front left- front right – Dump bed 4 - 2 - 2 - 1 - 4
12. How many people travel along with you while working and driving? Min/max?..... 2/4
13. Do you have any technical complaints?..... Steering is very hard,Puncture jack
14. Do you have any usability complaints?..... Mirror broken,fan not working
15. Desired feature sought by driver and helper?..... A/C or fan
16. Out of the known trucks in the market which one is most desired? Why?..... Volvo,Bharat Benz

Name : Harikesh

Age : 36 years

Truck : Tata 1613

1. What is your educational qualification?..... 9th
2. How many years of experience you have?..... 15-20 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... No . training for JCB
4. What are the other vehicles you drive or have driven?Which you like..... JCB, 1616, 2518
5. Currently working on which vehicle?..... JCB
6. Are you the primary driver of the truck?..... No
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?..... 8-11 hrs ; 2 hrs ; Weekends overtime
9. In night shift where do you take rest or sleep?..... Outside ground or tent
10. Do you have any previous history of occupational hazard/disability or problem?out of the following which is the most troublesome?..... 5 - 3 - 4 - 3 - 2
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
11. Out of the following which is the most troublesome? 4 - 3 - 4 - 2 - 4
Left rear– Right rear – front left- front right – Dump bed
12. How many people travel along with you while working and driving? Min/max?..... 2/5
13. Do you have any technical complaints?..... Oil leak, Brake fail
14. Do you have any usability complaints?..... Steering and brake hard, Mirror breaks
15. Desired feature sought by driver and helper?..... A/C, Power steering, Auto gear
16. Out of the known trucks in the market which one is most desired? Why?..... JCB,Navistar, Volvo

Name : Rupesh

Age : 33 years

Truck : Tata 1613

1. What is your educational qualification?..... 5th
2. How many years of experience you have?..... 10 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... No .
4. What are the other vehicles you drive or have driven?Which you like..... 1616, 2518
5. Currently working on which vehicle?..... 1613
6. Are you the primary driver of the truck?.....
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. How many hours you work in day, night and overtime duration?..... 8-11 hrs ; 2 hrs ; Weekends overtime
9. In night shift where do you take rest or sleep?..... Outside ground
10. Do you have any previous history of occupational hazard/disability or problem?out of the following which is the most troublesome?..... 5 - 3 - 4 - 3 - 4
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
11. Out of the following which is the most troublesome? 5 - 3 - 4 - 2 - 4
Left rear– Right rear – front left- front right – Dump bed
12. How many people travel along with you while working and driving? Min/max?..... 2/4
13. Do you have any technical complaints?..... Oil leak, Brake fail, Foot rest broken
14. Do you have any usability complaints?..... Steering and brake hard, Mirror breaks
15. Desired feature sought by driver and helper?..... A/C, Power steering
16. Out of the known trucks in the market which one is most desired? Why?..... Anything better

Name : Ilyaas

Age : 40 years

Truck : Tata 1616

1. What is your educational qualification?..... 10th
2. How many years of experience you have?..... 15-20 years
3. Have you had any training in operation of Tipper truck? If so how many years?..... No .Licensed
4. What are the other vehicles you drive or have driven?Which you like..... 1613,2518
5. Currently working on which vehicle?..... 1616
6. Are you the primary driver of the truck?..... Yes
7. What are the in which environments you have previously worked?.....
Day – Night – Cold – Fog – Rain – Snow – River – Hilly region – Forest
8. .How many hours you work in day, night and overtime duration?..... 8-10 hrs ; 3 hrs ; Weekends overtime
9. In night shift where do you take rest or sleep?..... Outside ground or tent or House
10. Do you have any previous history of occupational hazard/disability or problem?out of the following which is the most troublesome?..... 5 - 3 - 4 - 3 - 4
Cabin Temperature – Noise – Dust – Vibration– Visibility issue
11. Out of the following which is the most troublesome? 3 - 3 - 4 - 2 - 4
Left rear– Right rear – front left- front right – Dump bed
12. How many people travel along with you while working and driving? Min/max?..... 2/3
13. Do you have any technical complaints?..... Oil leak, Brake fail,Tyre Jam,Mirror break
14. Do you have any usability complaints?..... Steering and brake hard,
15. Desired feature sought by driver and helper?..... A/C, Auto gear
16. Out of the known trucks in the market which one is most desired? Why?..... Volvo

13

Inferences from User Research

Most of the driver do not have educational qualification and they started as a helper and learned driver. They haven't had any training.

Most European and American have training and assessments and has government regulated guidelines and handbook. A similar initiative to train driver about driver and occupational hazards is challenging in India scenario.

4 out 5 driver are illiterate
5 out of 5 driver haven't had training

Most of the driver have driven more than one truck. Hence the are not full time tipper operator. Most of them like vehicles other than tipper because they like driving rather than halting at construction site. The reason being driving keeps cabin cool because of air flow.

3 out 5 liked other vehicles

Almost all user drive their own truck, that is they are primary user. Therefore response is more honest and responsible.

None of the driver has worked in the snowy region for given sample size.

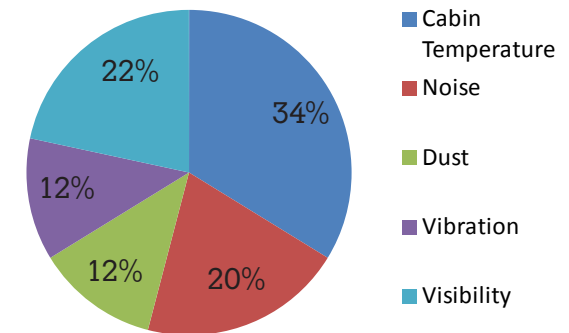
All driver work for 8-10 hrs and has a one hour break. All will do overtime either in nigh or on weekend.
Europe and America has driving and

working hours laws which is not there in India. Driver has to take a break every 4 hrs of driving and working of 15 min - European regulations

Average rating of the Problems from user on a scale of 5 -

Cabin Temperature.....	5
Noise.....	3
Dust.....	1.8
Vibration.....	1.8
Visibility.....	3.2

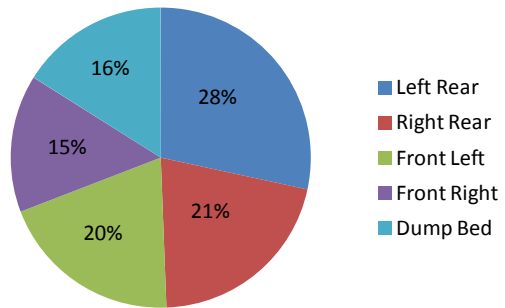
Problems Identified by User



Average rating of visibility problem on a scale of 5

Left Rear.....	4.6
Right Rear.....	3.4
Front left.....	3.2
Front Right.....	2.4
Dump Bed.....	2.6

Visibility Problems Identified by Users



Cabin has minimum two person and maximum 4 .

The usability of brake and steering is a major issue for the drivers. Mirror condition and adjustability issues were raised by almost all driver.

All driver complained about the temperature and humidity in the cabin, Mirror adjustability, Brake and steering problem. All desired air conditioned cabins. They rest and sleep outside cabin.

14

Design Direction and Brief

Objective :

To design cabin of a tipper truck which is user centric

Target User :

Primary User i. e. Driver of the Tipper truck

Market :

Please Refer Page 26 to 35

Design Directions from User Research and Analysis :

- **Ingress and Egress should be user centric**

It was inferred from activity analysis that ground clearance is too high and driver faces difficult while getting in the cabin. Novice user was also observed to have the same problem.

- **Cabin which allows driver to sleep and rest**

Question was asked to the driver - where they take rest and sleep in overtimes and in night shifts and all of them responded that they prefer to sleep outside the cabin on ground or in tents. A Cabin which allows driver to take rest and reduce work fatigue will make them love their work, stay in the cabin and consequently increase work productivity.

- **Design solution to make cabin more**

comfortable by reducing noise, heat and vibrations.

All Driver complained about cabin temperature and humidity. A cabin which addresses problem of heat, noise and vibrations can suffice to reduce fatigue

- **Enhanced Visibility of Dump bed , minimize blind spots and reduce dependence of helper**

It was observed from activity analysis that driver take help from helper to get feedback of unloading and gets out of the cabin to confirm loading is done properly or not. There are also blind spots/dead zones. A solution to this problem will significantly make driver work a lot easier .

- **Unexpressed recommendations :**

Bull bar or Bumper - American and European nations have Front Underrun Protection System (FUPS) norm. Considering the ground clearance and approach angle of 1616/1613, a bumper is a necessary for safety. A bumper design integrated with cabin can be explored. Sun Glare Protection while driving and working.

Emergency Exit for safety.

Specification :

Existing Chassis of Tata 1613 will be used to design new semiforward sleeper cabin. Cabin will be designed for minimum two and maximum three persons. Any alteration in the chassis if required will be specified.

Engine, Wheelbase, Track, Tyre dimension, Bed hoist mechanism will not be

changed.

Deliverable :
Scale model of cabin 1:10

Schedule :

Task Title	September			October			November		
Product Study	████████████████████								
User Research ,User profile and persona study		████████████████████							
Inference and Design Direction			████████████						
Concept form exploration			████████████████████████████████████						
Form selection					████████████████				
2D renders and final Concept Selection					████████████████				
Scaled down Model			██						
Report	██								

III

Form and Function Exploration

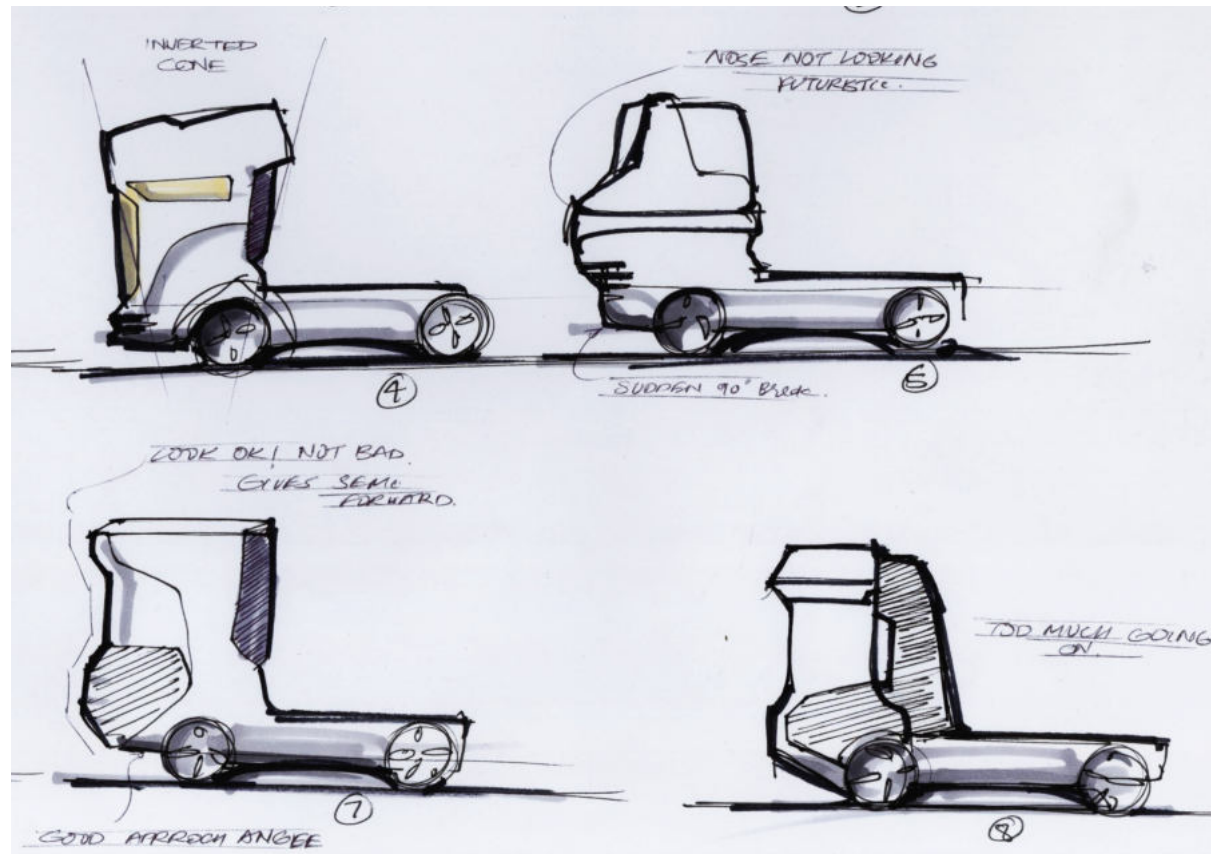
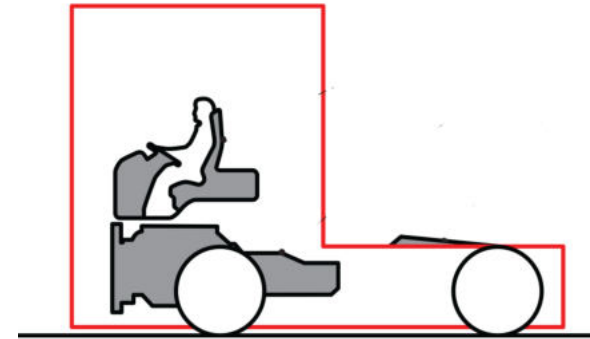
Keeping in mind the design direction and brief form and function exploration was done through thumbnail sketches, perspective sketches and quick mockup models. The objective of exploration is to generate solution to problems defined in the design direction. This section includes the following chapter :

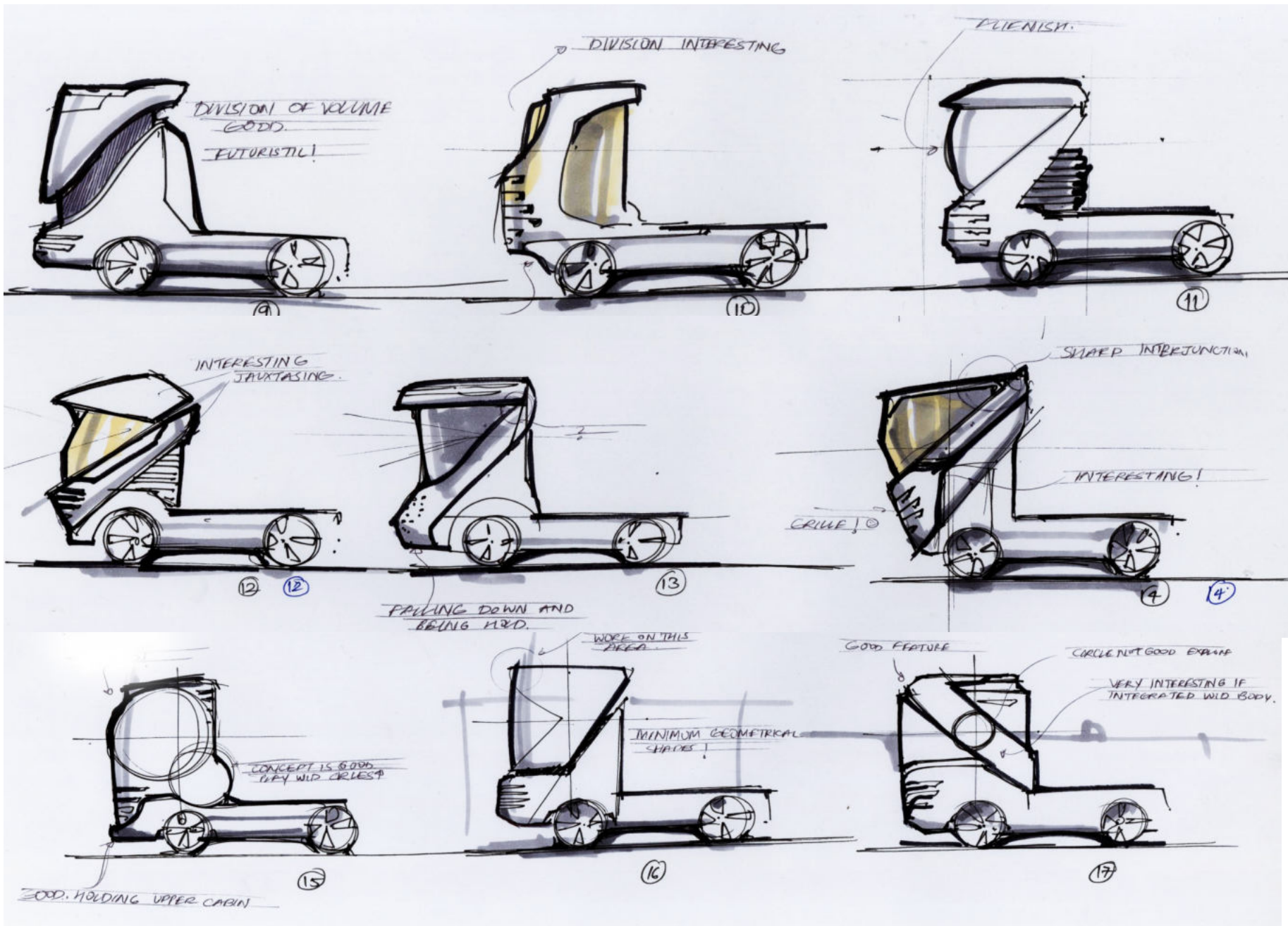
15. Warm Up Thumbnail Sketches
16. Packaging and Specification
17. Package Explorations
18. Layout Form Exploration Sketches
19. Function Exploration Sketches
20. Cabin Renders

15

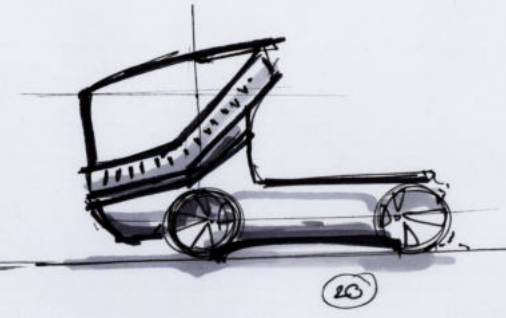
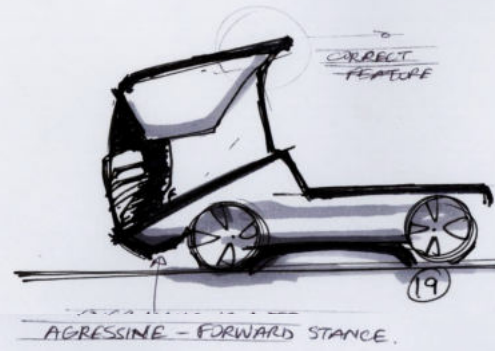
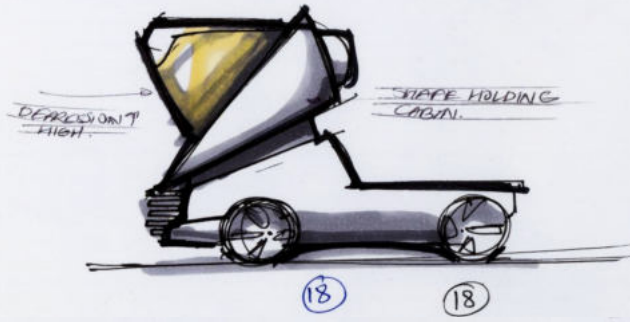
Warm up Sketches

Package of a Scania Trailer was used to make warm up sketches shown in the adjacent image. This is to sensitize towards trailer dimension and form. Sketches were also used to find any radical and interesting form which may suffice to tipper requirement. Here sketching was done without much thought and hand was allowed to move freely. After the exercise, sketches were explored visually for radical form and ideas and any unintentional happy accidents while drawing if any.

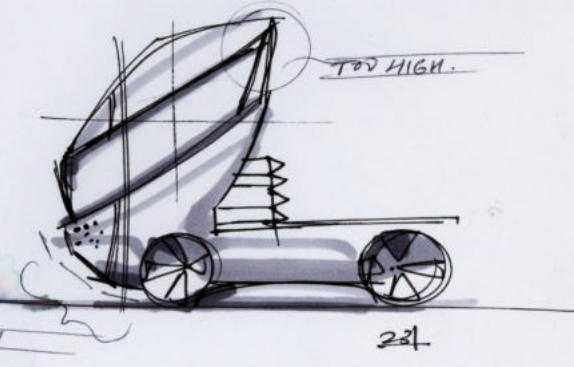
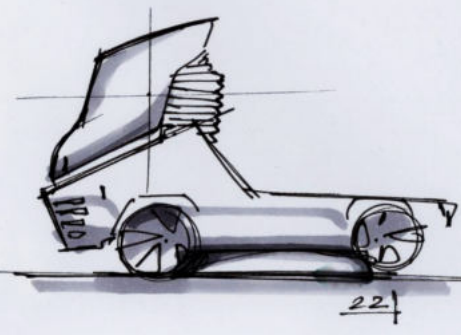
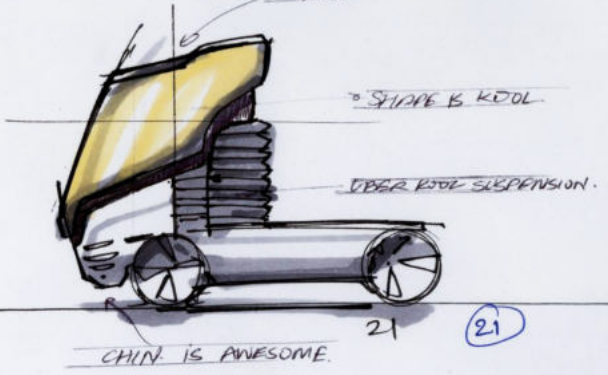




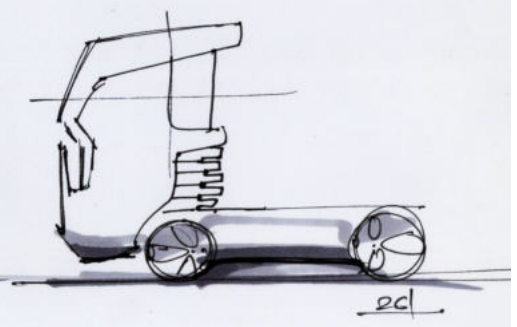
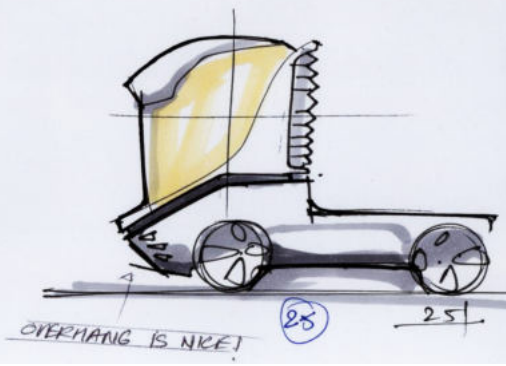
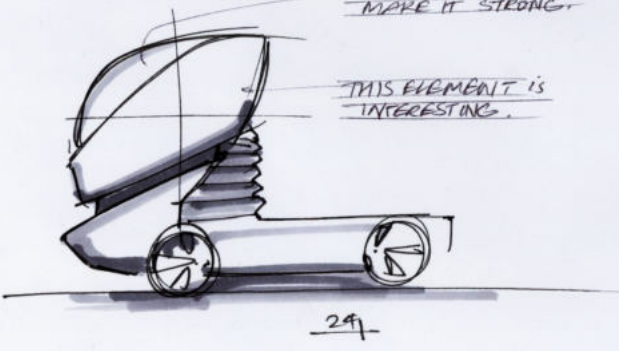
INTERESTING GEOMETRY

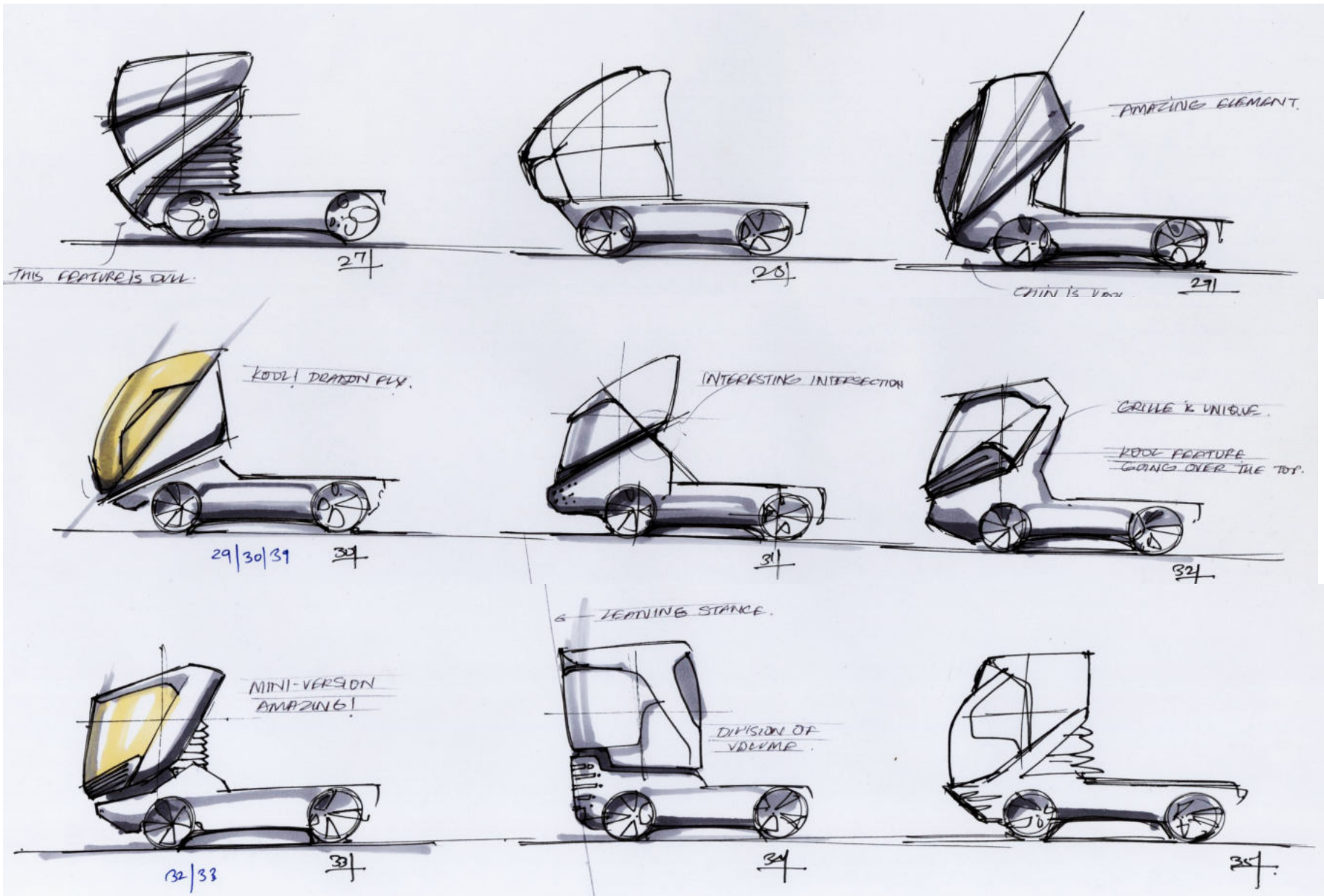


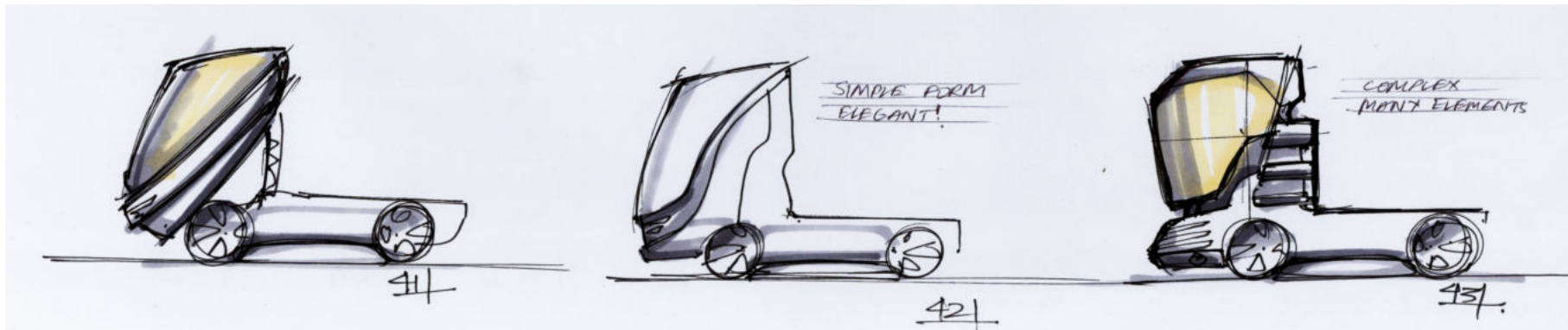
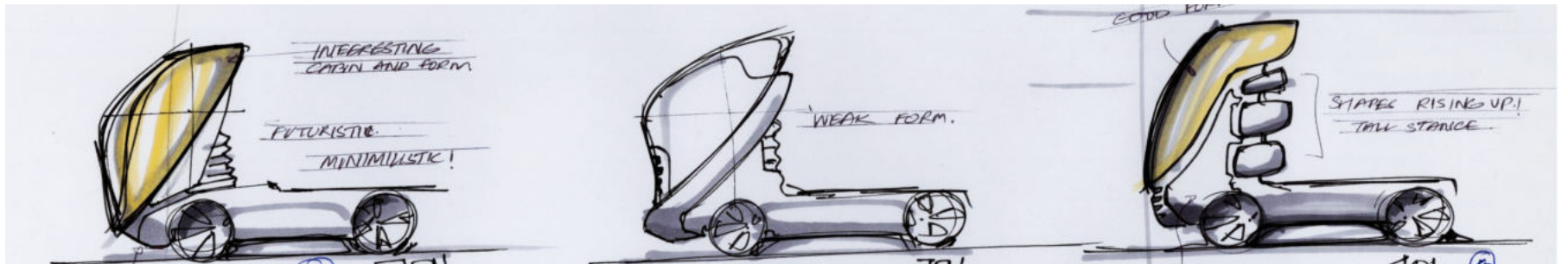
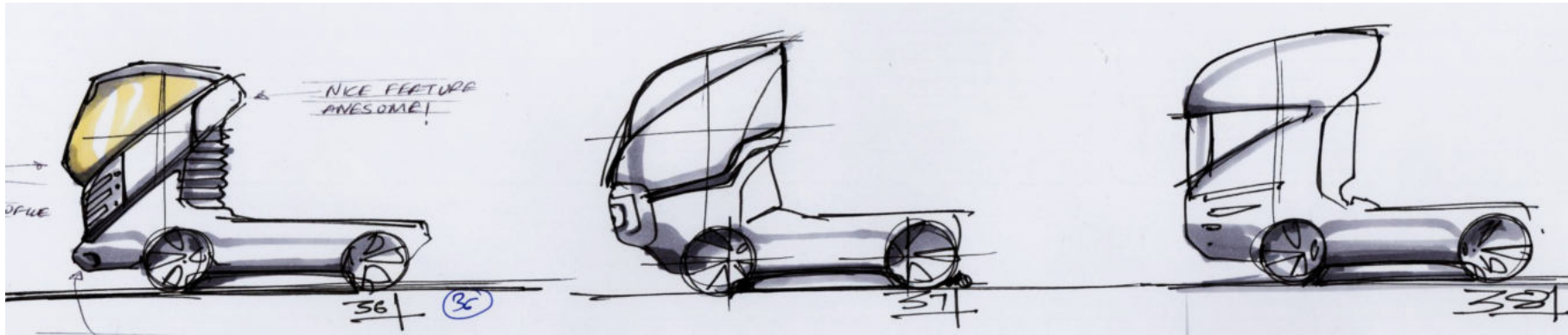
ROOF LINE DYNAMIC

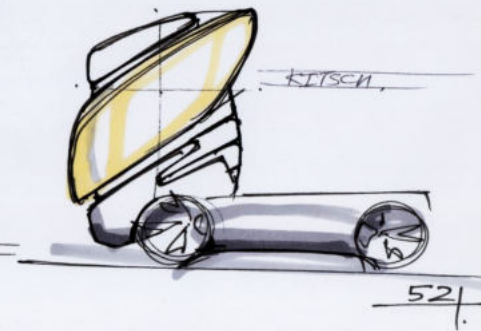
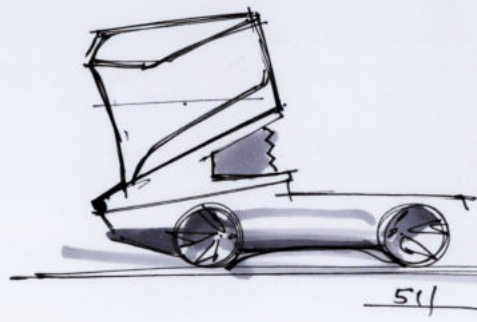
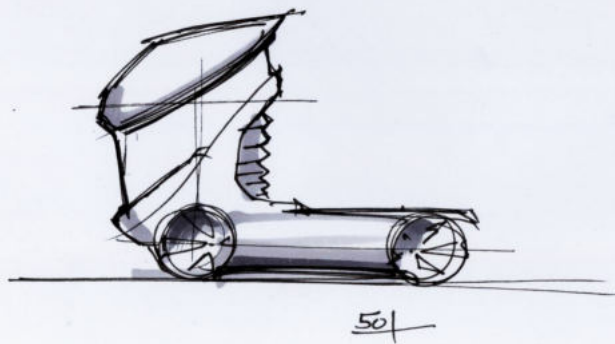
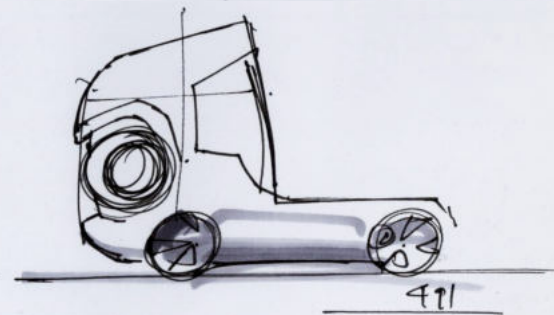
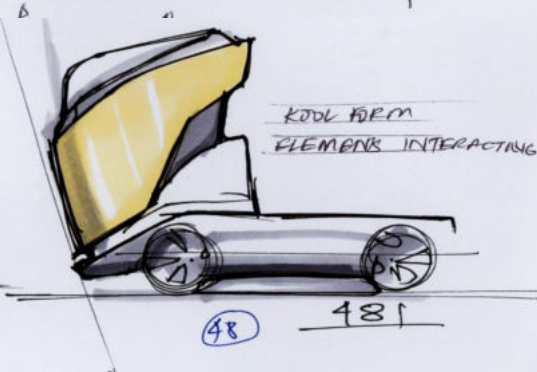
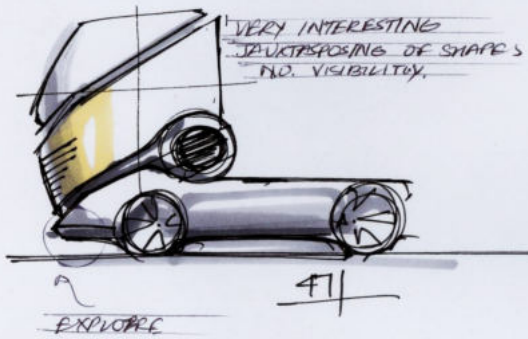
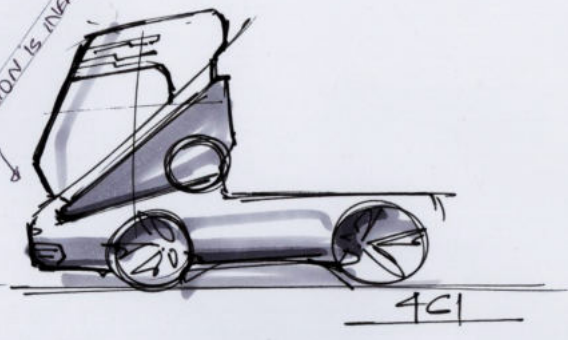
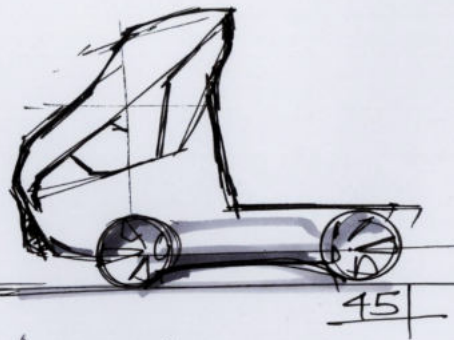
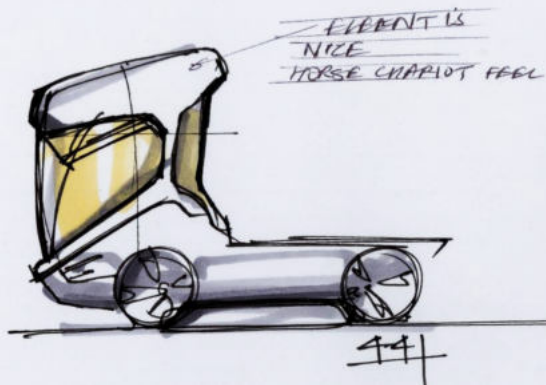


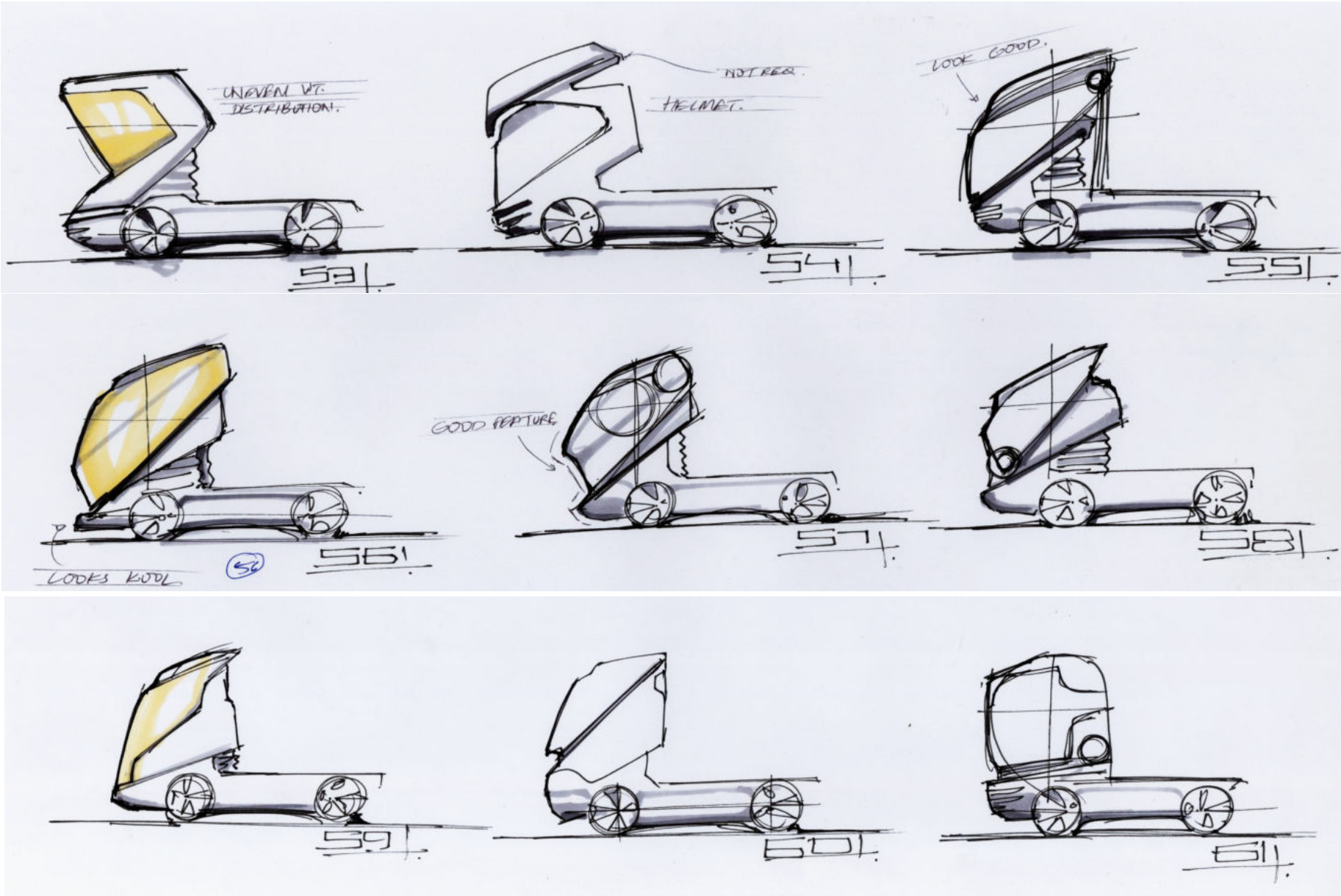
CHANGE UPPER ELEMENT MAKE IT STRONG

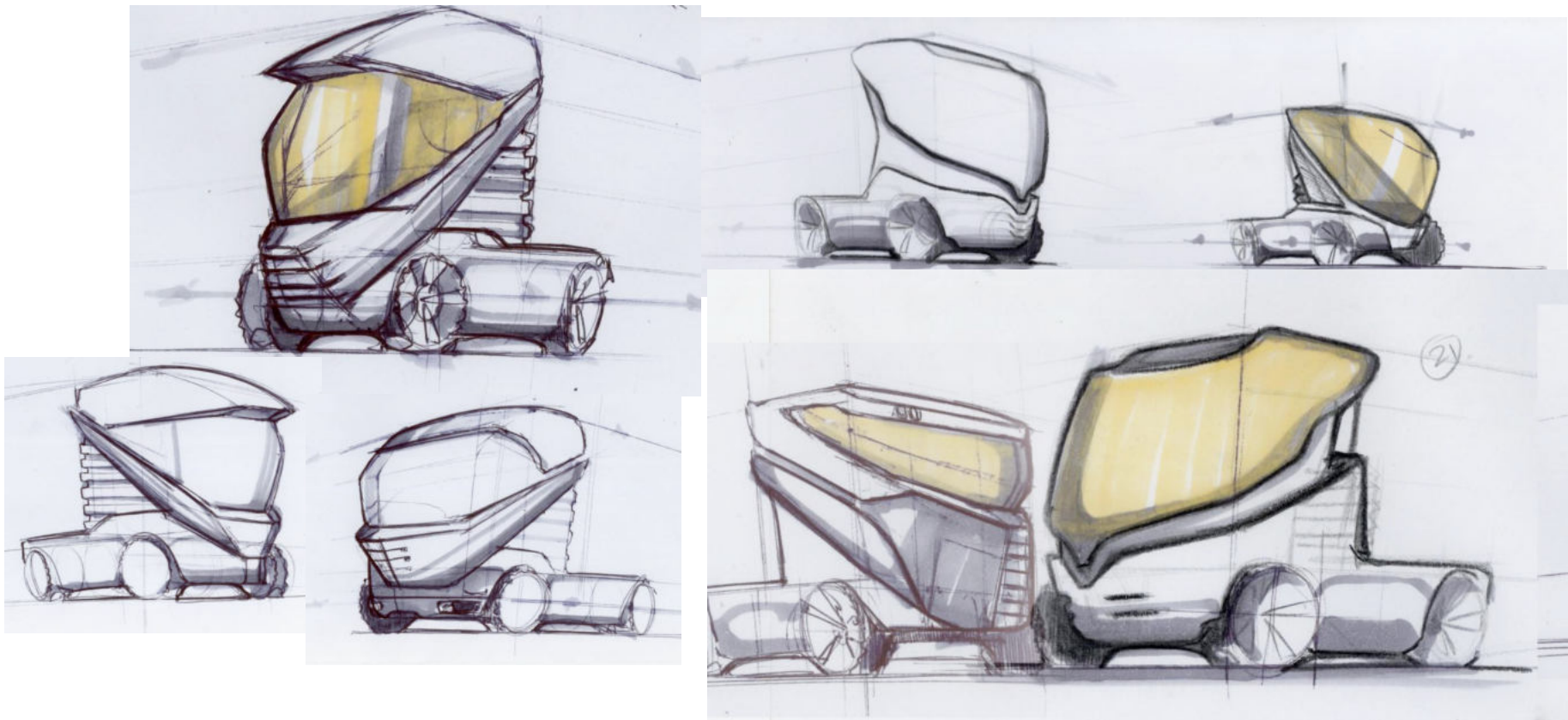








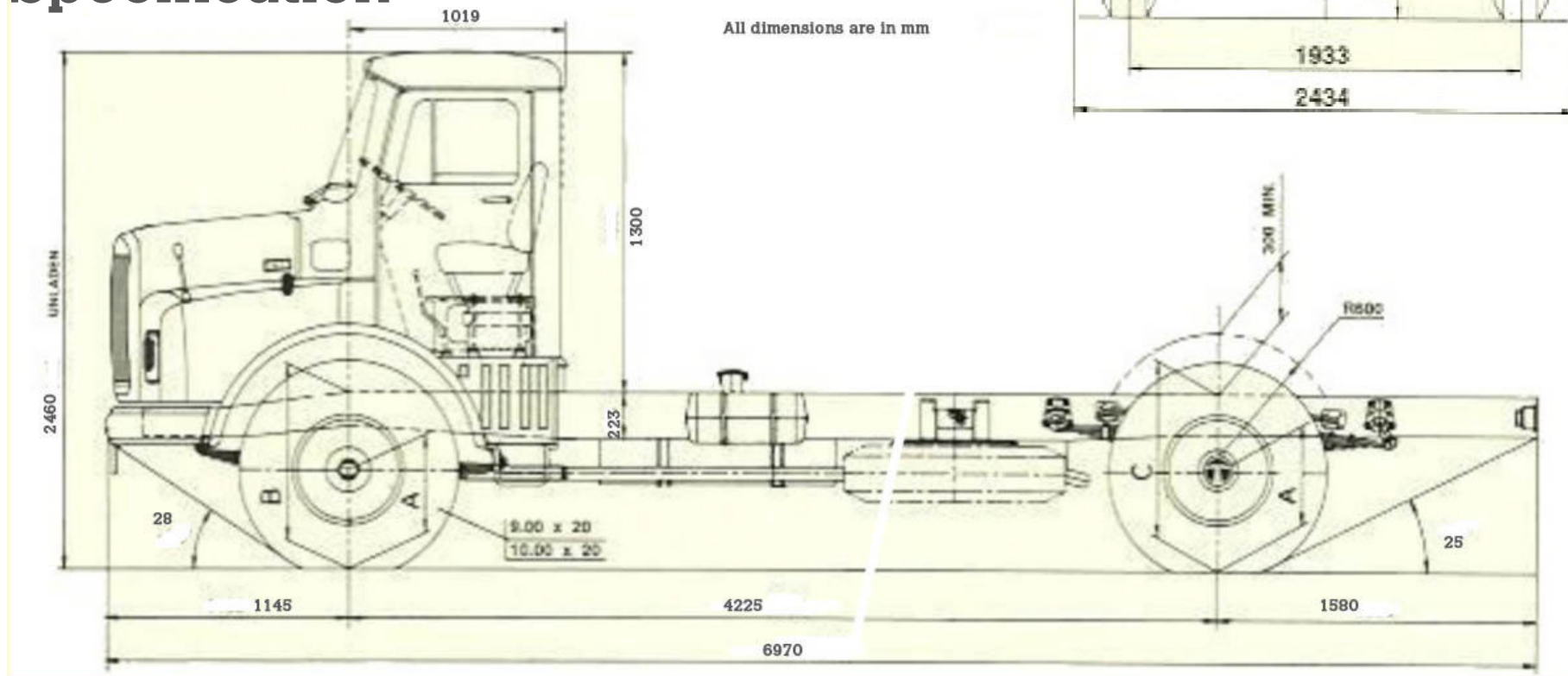
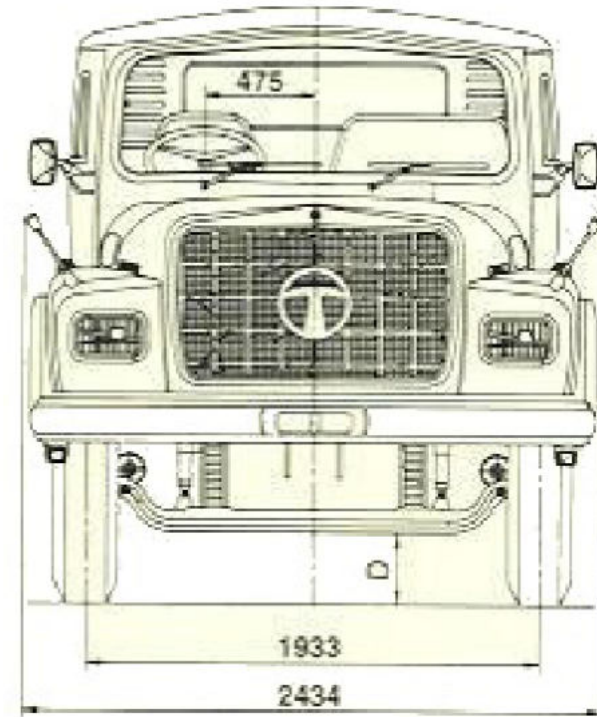


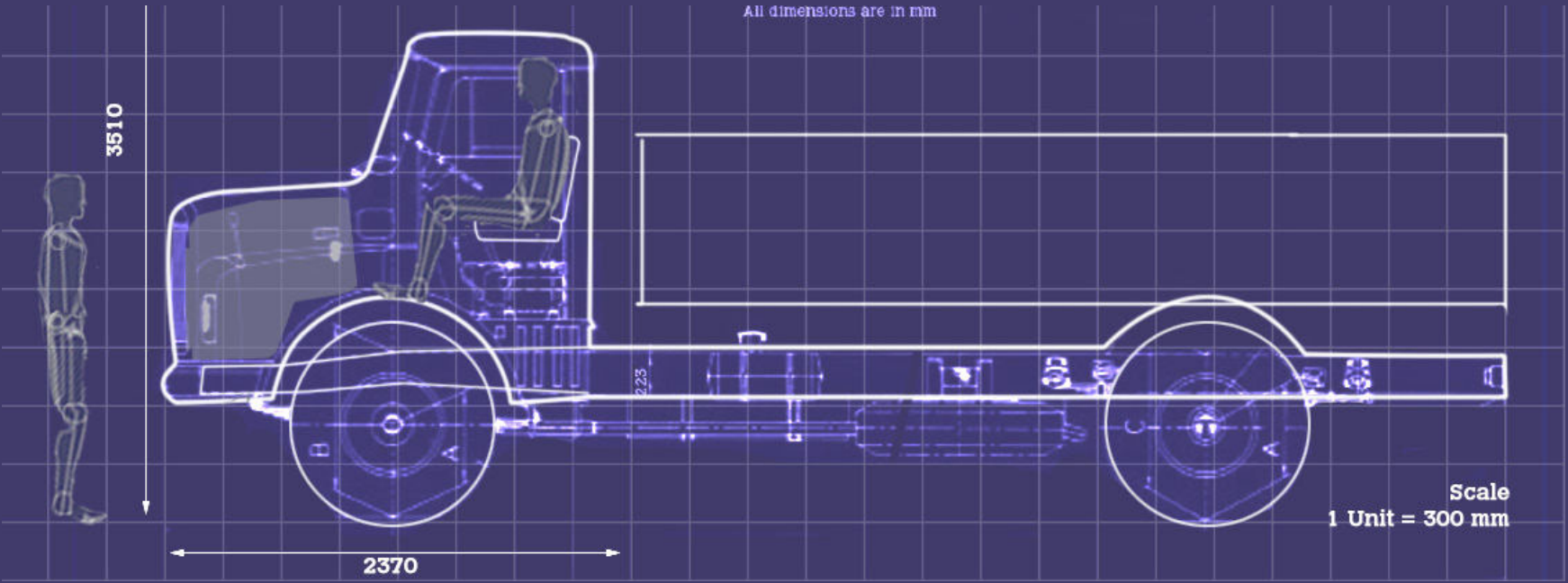


16

Existing Chassis of Tata 1613 will be used to design new cabin. Any alteration in the chassis if required will be specified.
Engine, Wheelbase, Track, Tyre dimension, Bed hoist mechanism will not be changed.

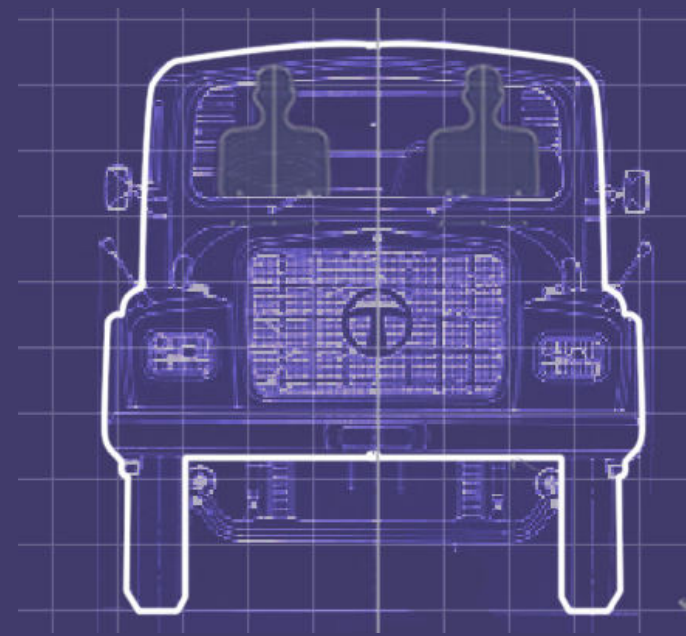
Packaging and Specification



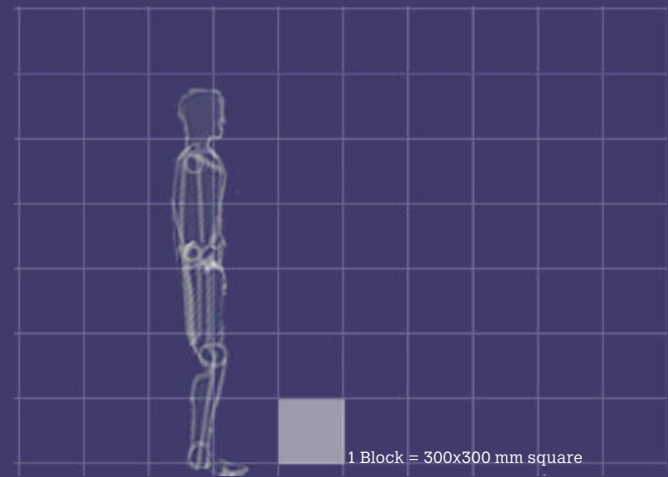


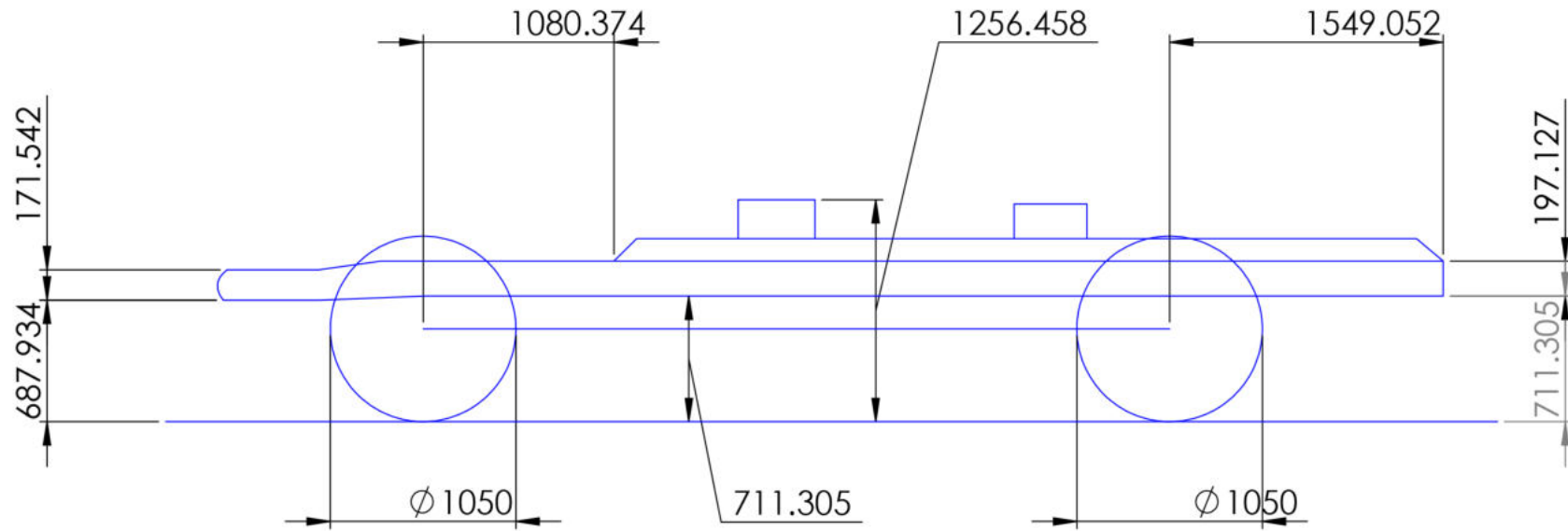
Tata 1613 Package

Manikins Dimension = 1.77 m
 As per Indian 95% male height
 Reference : Indian anthropometric
 dimensions for ergonomic design
 practice - Debkumar Chakrabarti.

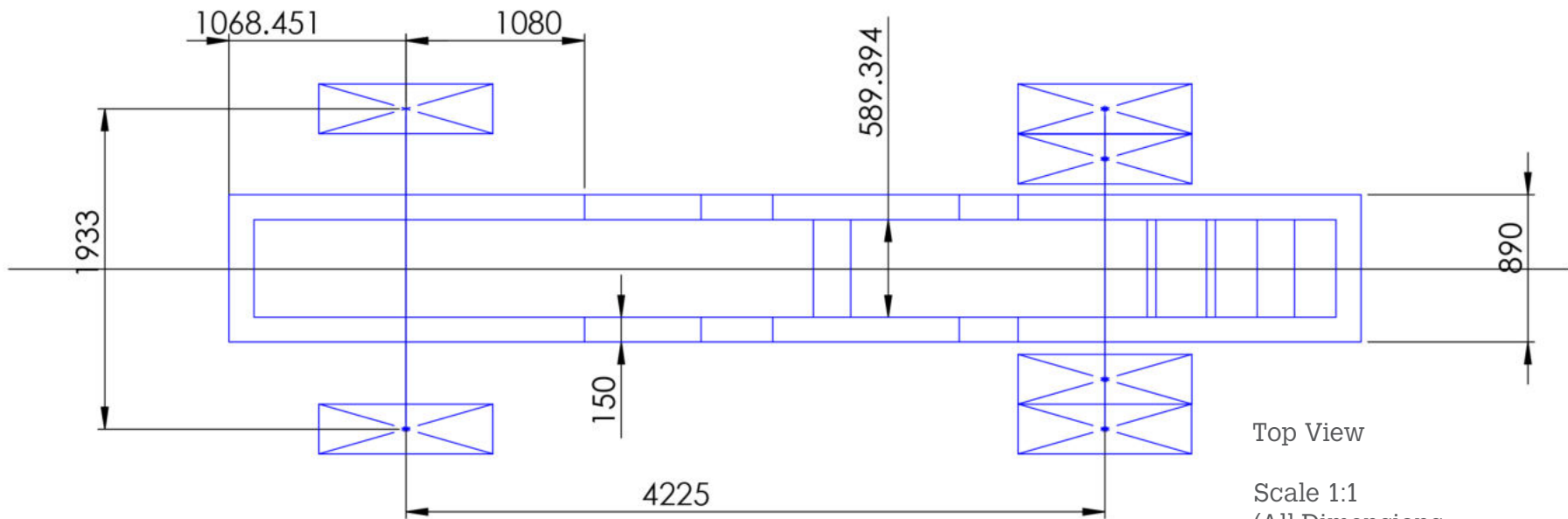


Existing cabin is a Day cabin and is very claustrophobic. It is observed from interview and questionnaire that minimum two and maximum four people travel in the cabin.





Side View



Top View

Scale 1:1
(All Dimensions are in mm)

17

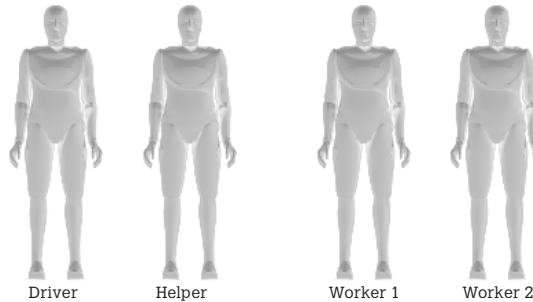
Package Explorations

Following is inferred from user research, observation and interview :

- 1 Two to four people travel in the cabin.

These four people are - Driver, Helper and other two are workers.

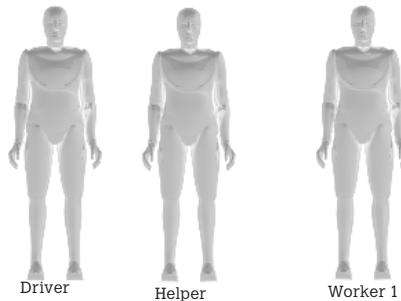
Driver and Helper always travel and work together.



Existing 1613 has seating for 3 in (1+2) configuration.

Four people travelling is not recommended and is not advisable neither safe in the small space.

Therefore it was decided to design cabin for maximum three person. Primarily for Driver and Helper and one extra person can be accommodated while driving.



- 2 All drivers work in the night and do over-time. Fatigue due to long working hours is a major problem which consequently leads to decrease in productivity.

All driver sleep outside the cabin in the night or in temporary tents.

Current claustrophobic day cab would not suffice in this scenario. Therefore sleeper cabin is proposed for driver comfort and ease.

Cabin will be air conditioned hence sealed to mitigate dust, noise and vibrations.

- 3 Driver steps out of the cabin during loading process, to get visual feedback of the distribution of load in the dump bed. Rear window is too small for any substantial feedback. Refer images on the facing page.

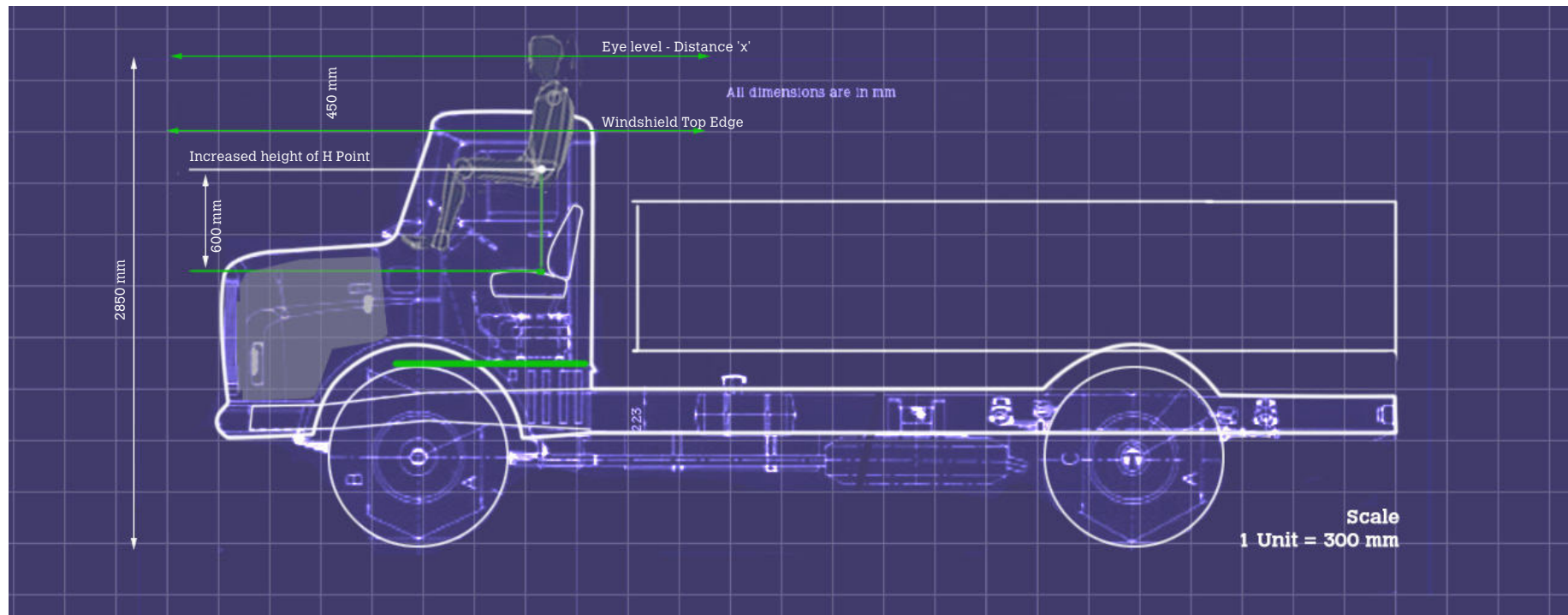
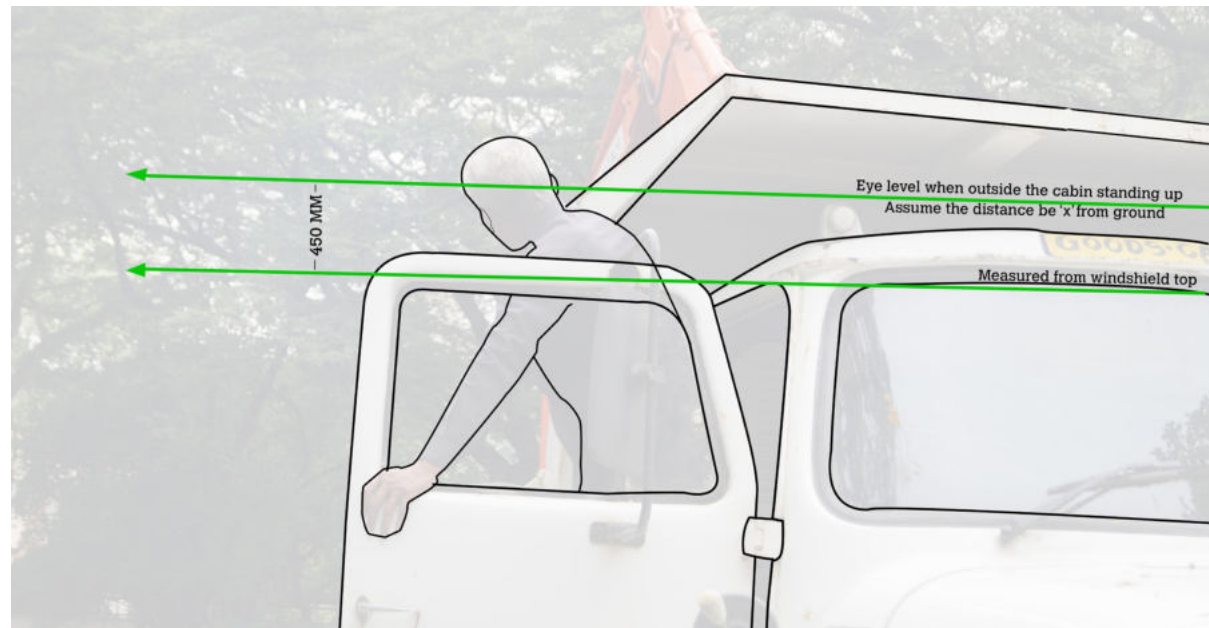
Stepping out the cabin and examining bed is dangerous and can cause occupational disability.

Furthermore for a proposed air conditioned cabin it won't be advisable to step out of the cabin frequently.



Driver eye level was measured (say 'x') with respect to ground. This was done when driver was outside the cabin examining bed. This is least height at which dump bed is clearly visible. For convenience of measurement reference point top edge of windshield was taken and eye-level distance was measured. This was measured to be 450 mm. Refer adjacent figure.

In the below figure, manikin was raised so that eye level coincide with x level. New H Point was measured to be 600mm. Consequently floor height will be raised by 600mm.



Raising floor height will be beneficial because -

- Driver will get feedback of loading without getting out of the cabin. Driver can be inside the cabin all the time.
- The action of looking back at bed while sitting is consistent with previous action except for standing outside cabin.
- Raising floor height may be useful as it will provide more space to sleeping bed.

Idea of cameras was also considered for visual feedback of dump, however cameras was prone to breakage considering the hostile environment the truck works in. Moreover dust settle on the lens and needs frequent cleaning. Therefore camera for visual feedback was not taken forward.

Cabin Layout for seating and sleeping :

Indian male 95% percentile manikin was used. Dimension were taken from Indian anthropometric dimensions for ergonomic design practice - Debkumar Chakrabarti.

Seat width and thickness were taken from volvo truck and were checked for compatibility with Indian anthropometric dimension. Following are the dimension for 95th % Indian make for sitting position :

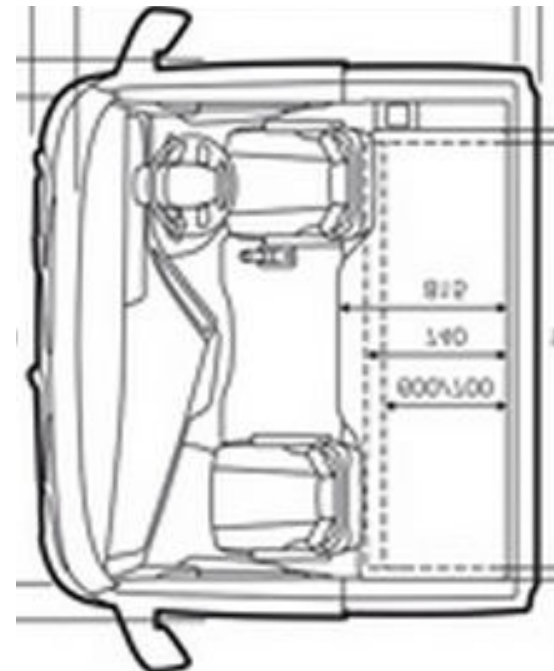
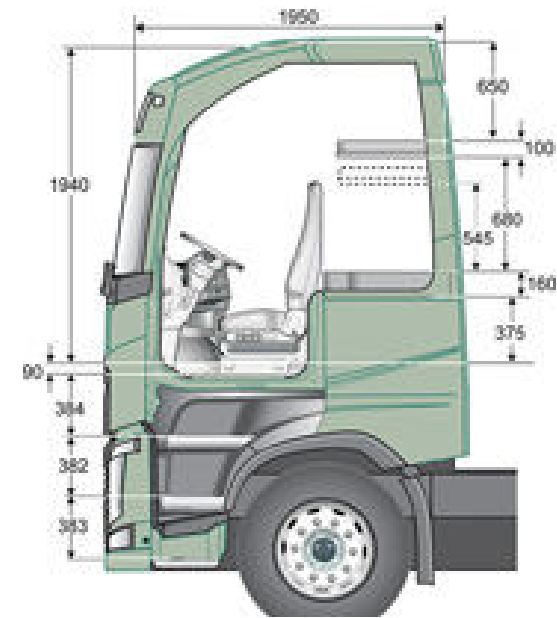
- Hip - 405
- Thigh Single - 164 mm
- Elbow to elbow relaxed - 644 mm
- Knee to knee relaxed - 535 mm

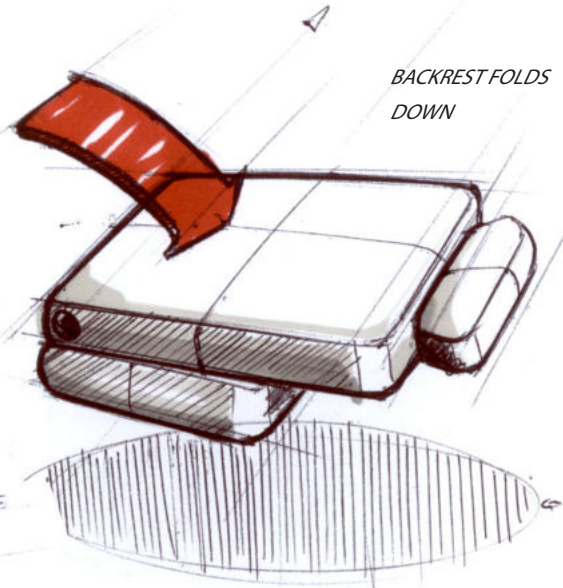
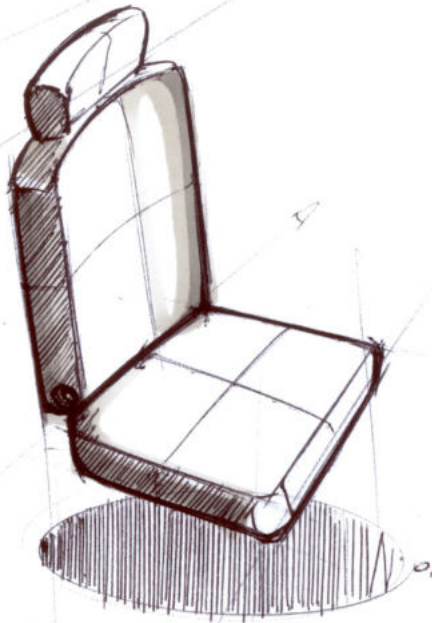
It was observed that Volvo seat dimension can be benchmarked for Indian anthropometric dimension aswell.

Driver and Helper seat configuration is not changed i.e. (1+2).

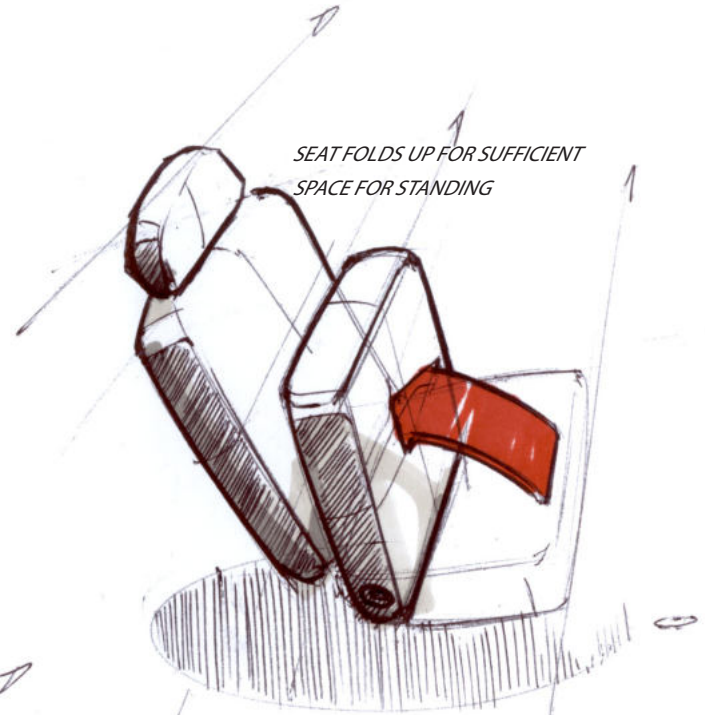
Width of the vehicle is same as existing 1613 i.e. 2434 mm

Cabin roof height will depend upon the seating and sleeping configurations.

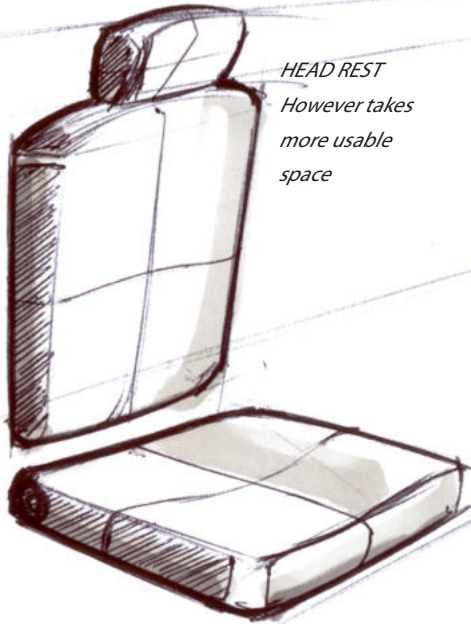




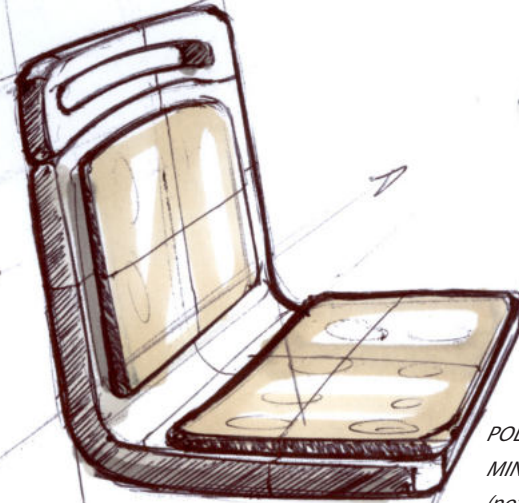
*BACKREST FOLDS
DOWN*



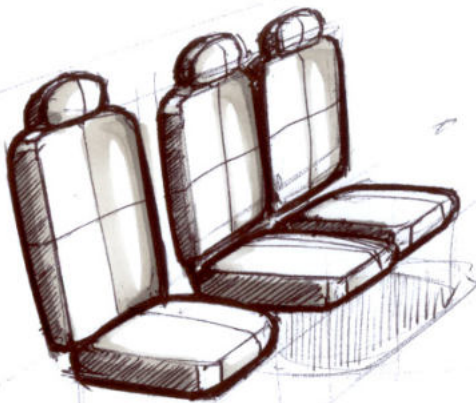
*SEAT FOLDS UP FOR SUFFICIENT
SPACE FOR STANDING*



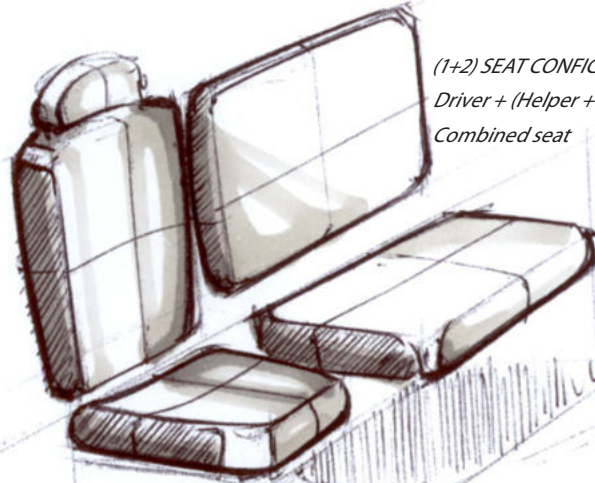
*HEAD REST
However takes
more usable
space*



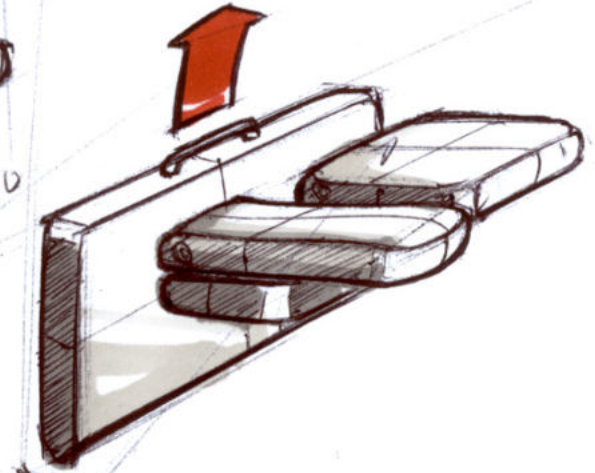
*POLY CARBONATE CHAIR WITH
MINIMUM FOAM
(not comfortable for long
rides)*



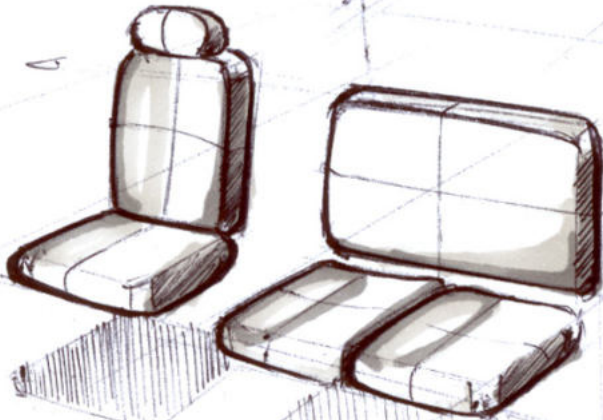
*(1+2) SEAT CONFIGURATION
Driver + Helper + Worker*



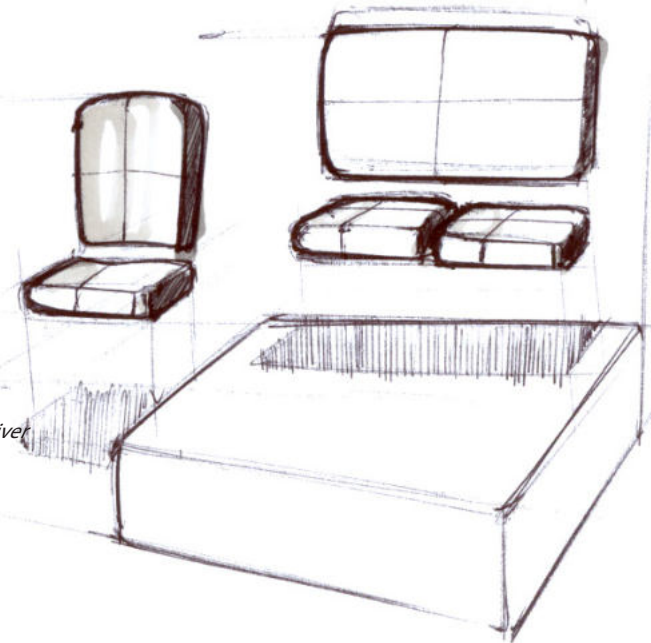
*(1+2) SEAT CONFIGURATION
Driver + (Helper + Worker)
Combined seat*

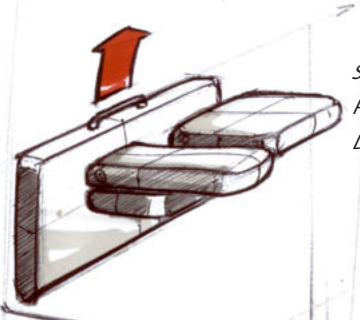


*SLEEPING BED BEHIND SEAT.
PULLED UP AND SWIVELLED
DOWN*

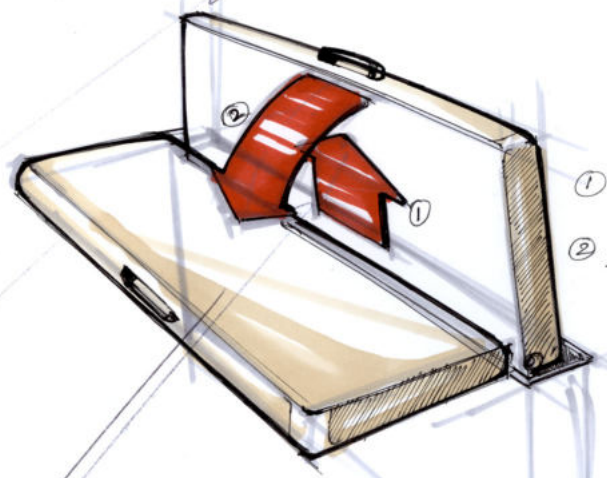
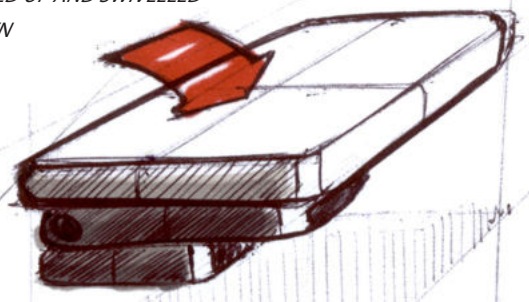


*(1+2) SEAT CONFIGURATION
Helper seat raised for better
visibility for helper. However Driver
visibility is compromised.*



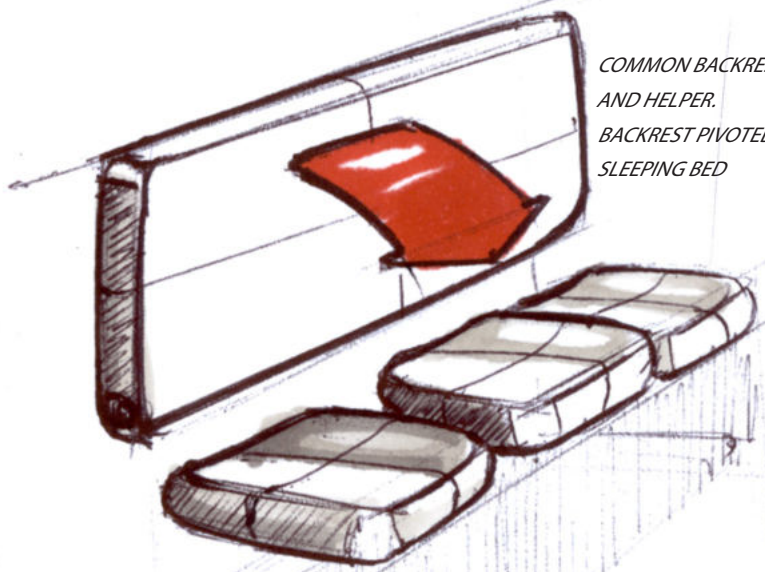


SLEEPING BED BEHIND SEAT.
PULLED UP AND SWIVELLED
DOWN

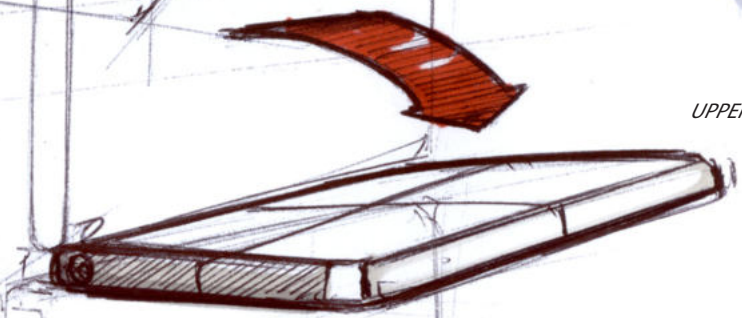


- ① PULL UP
ALONG CHANNEL
- ② MAKE HORIZONTAL

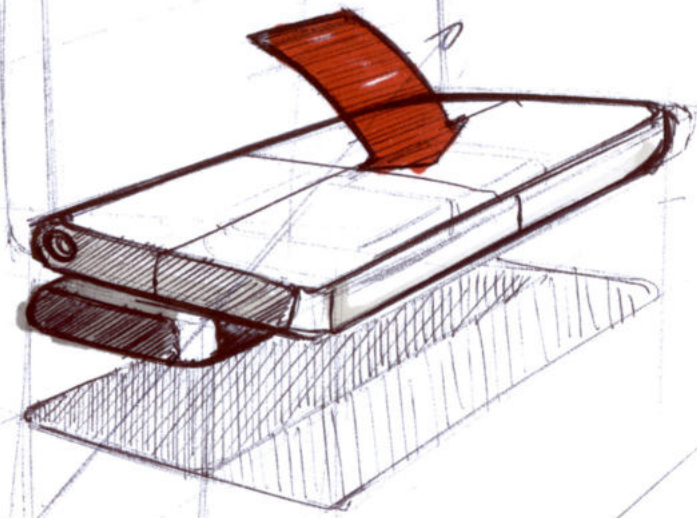
SLEEPING BED
CONCEPT.



COMMON BACKREST FOR DRIVER
AND HELPER.
BACKREST PIVOTED DOWN FOR
SLEEPING BED

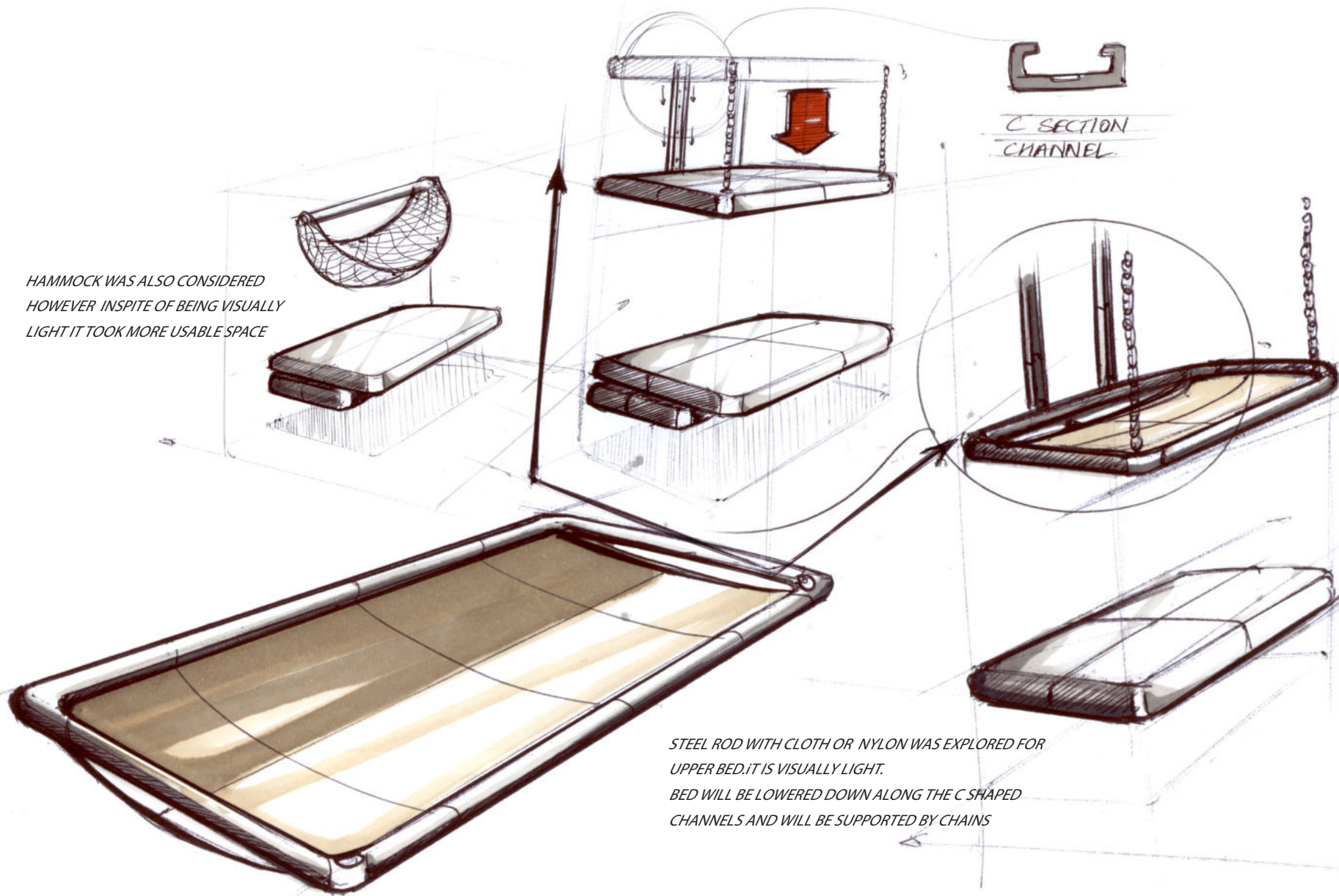


UPPER BED

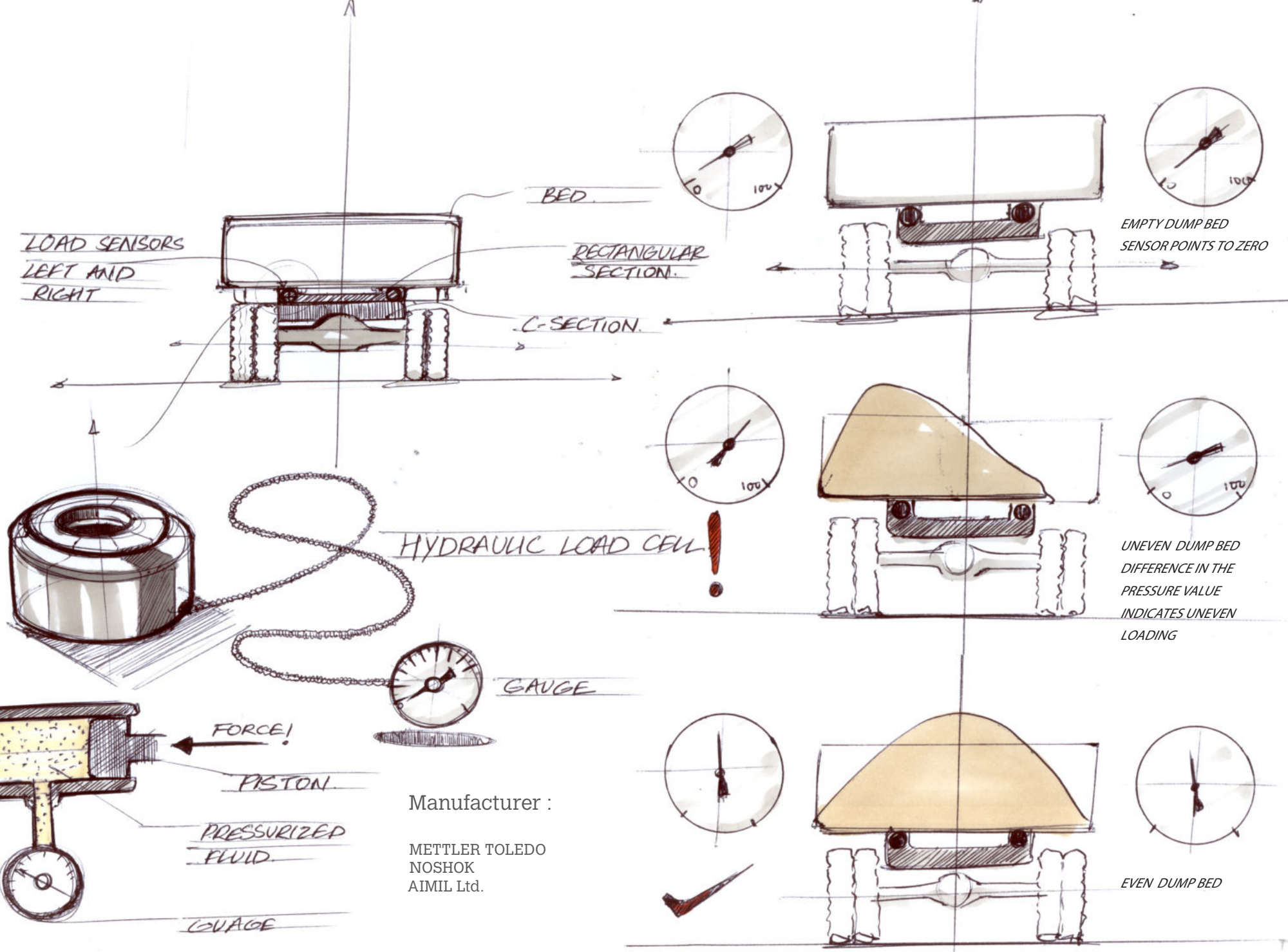


LOWER BED

HAMMOCK WAS ALSO CONSIDERED
HOWEVER INSPITE OF BEING VISUALLY
LIGHT IT TOOK MORE USABLE SPACE



STEEL ROD WITH CLOTH OR NYLON WAS EXPLORED FOR
UPPER BED. IT IS VISUALLY LIGHT.
BED WILL BE LOWERED DOWN ALONG THE C SHAPED
CHANNELS AND WILL BE SUPPORTED BY CHAINS



LOAD SENSORS
LEFT AND
RIGHT

BED

RECTANGULAR
SECTION

C-SECTION

EMPTY DUMP BED
SENSOR POINTS TO ZERO

HYDRAULIC LOAD CELL

GAUGE

UNEVEN DUMP BED
DIFFERENCE IN THE
PRESSURE VALUE
INDICATES UNEVEN
LOADING

FORCE!

PISTON

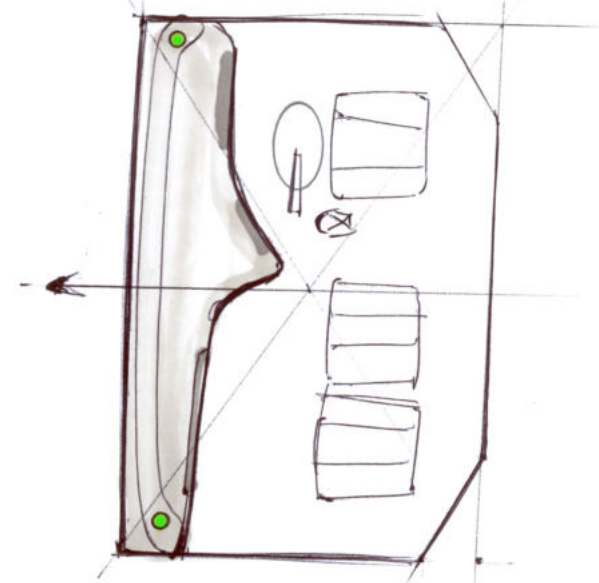
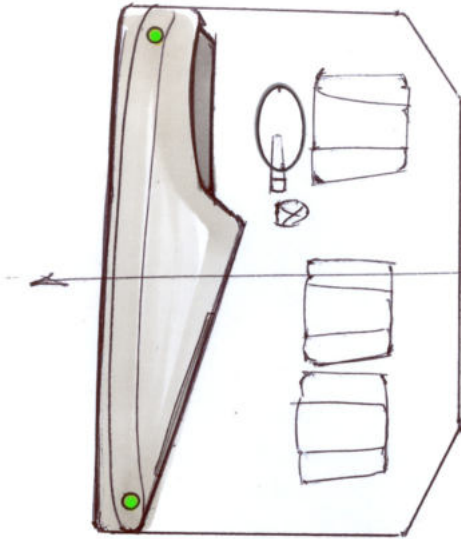
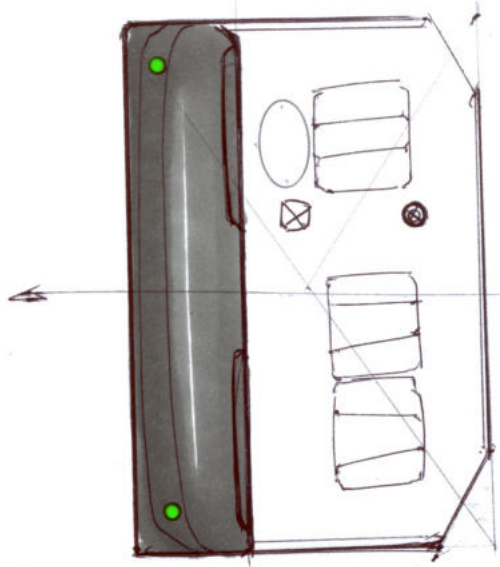
PRESSURIZED
FLUID

GAUGE

Manufacturer :

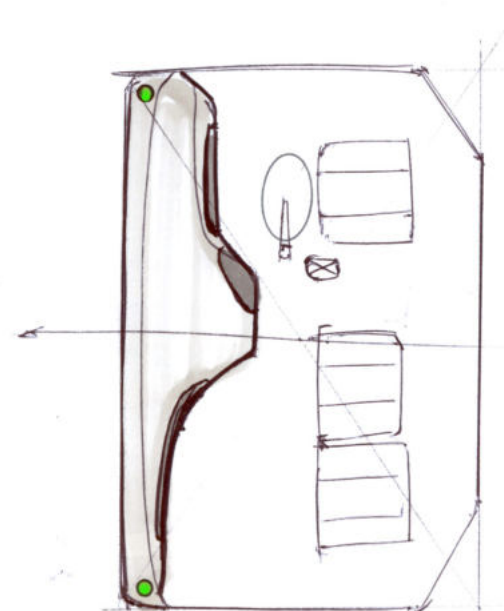
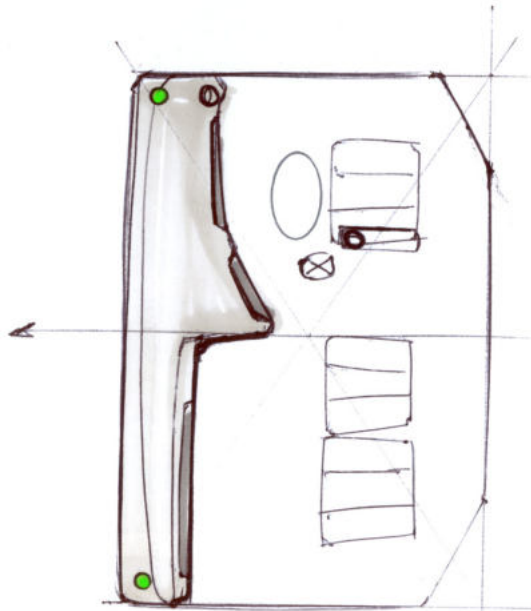
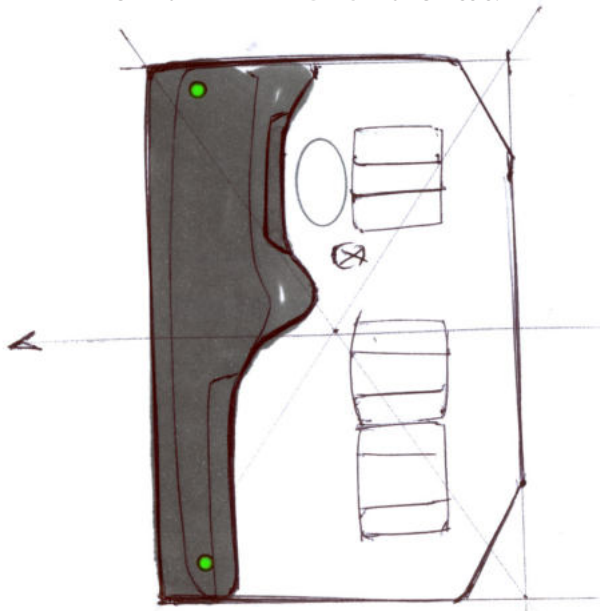
METTLER TOLEDO
NOSHOK
AIMIL Ltd.

EVEN DUMP BED



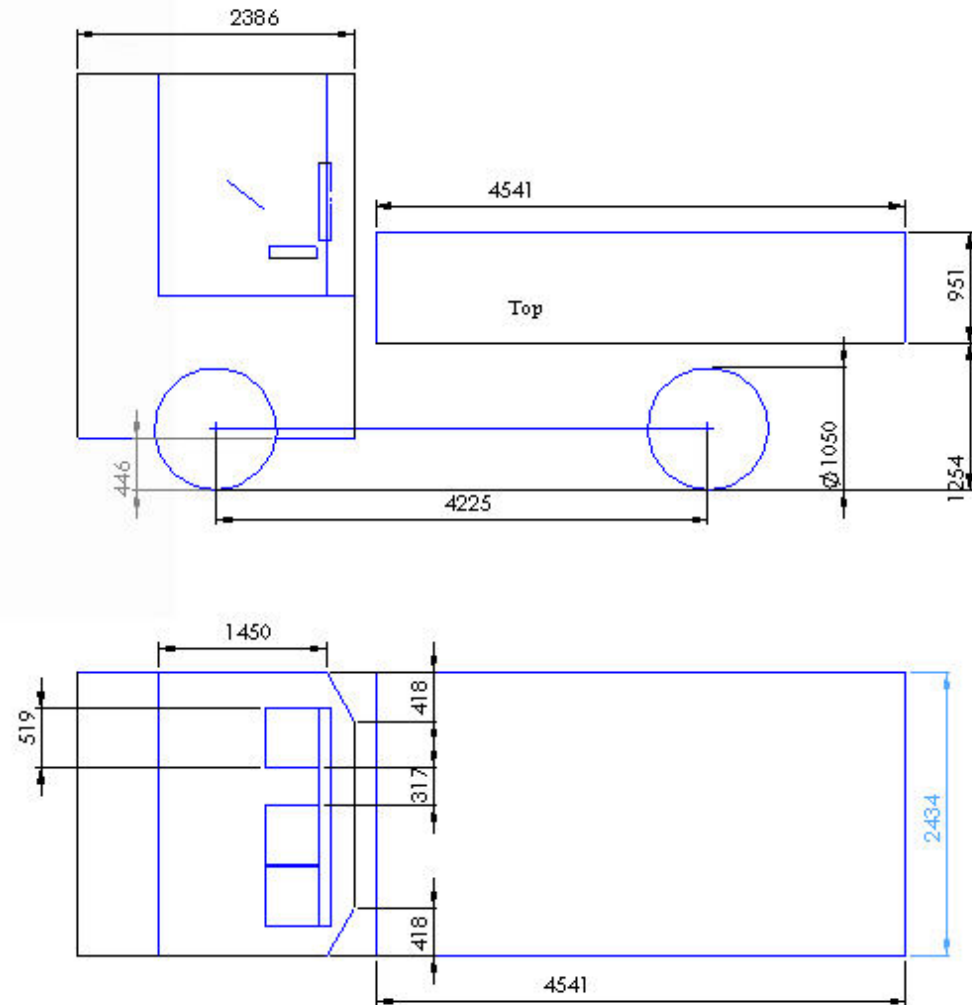
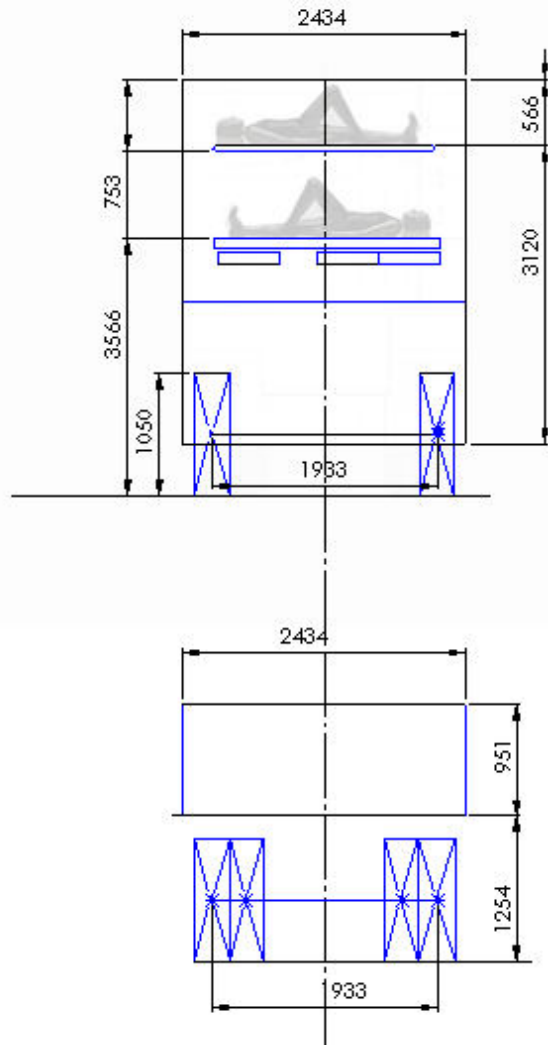
CABIN INSTRUMENT CLUSTER LAYOUT WAS EXPLORED.

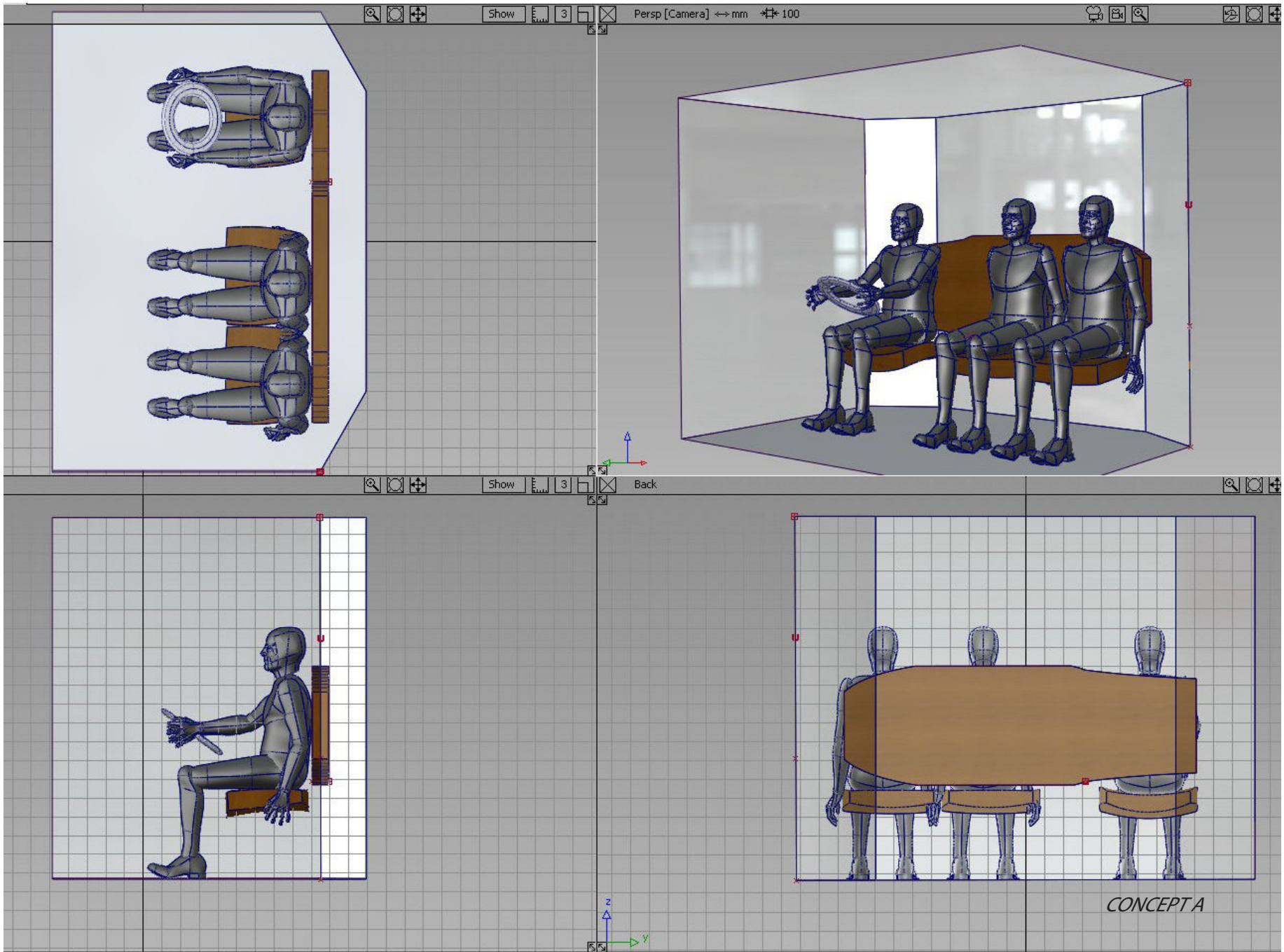
CABIN WILL HAVE PRESSURE GAUGE AND LOAD SENSOR LIGHT ON LEFT AND RIGHT FOR EACH CORRESPONDING LOAD CELL OF THE LEFT AND RIGHT OF CHASSIS.

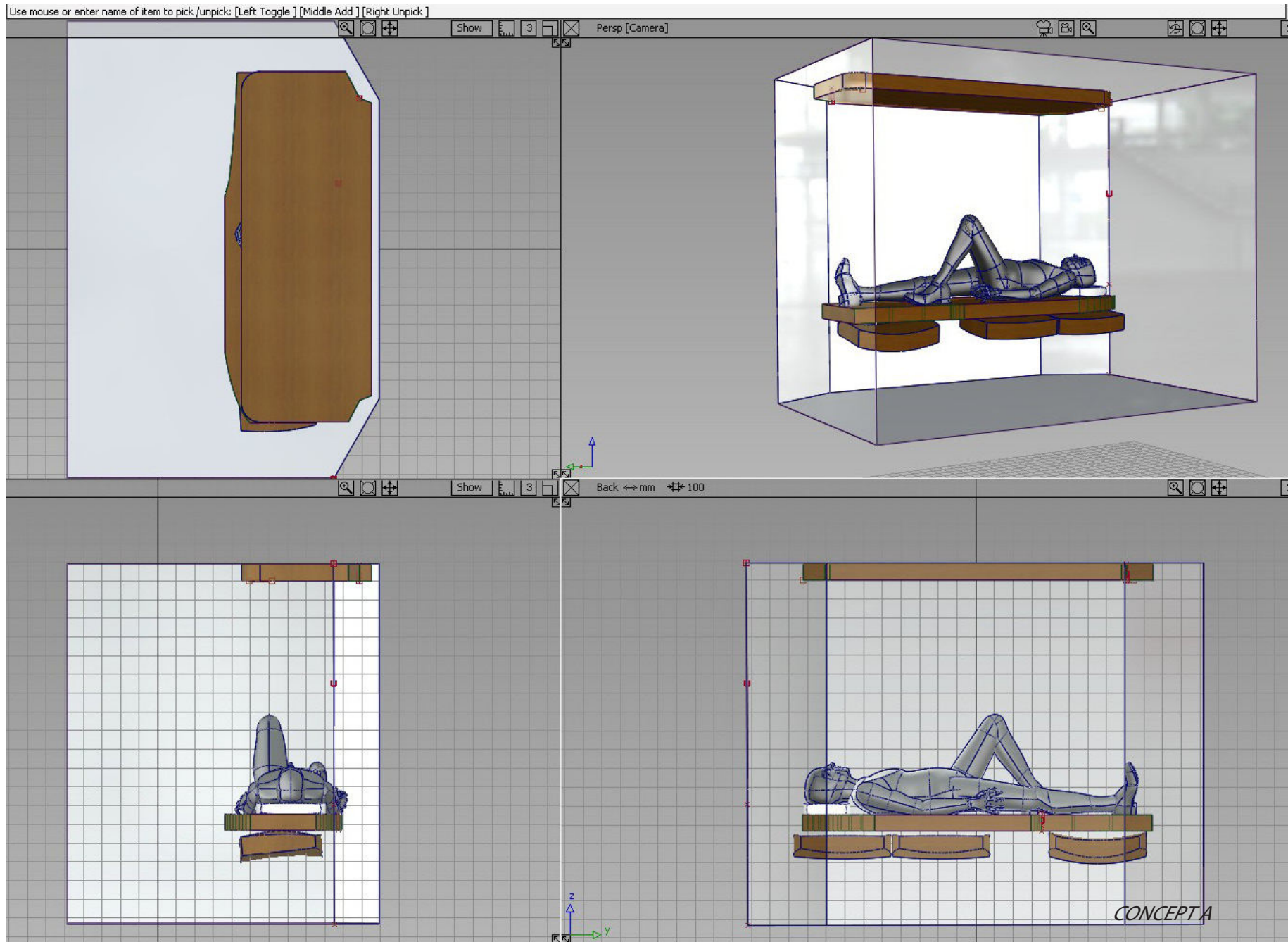


LEFT INDICATOR WILL GLOW IF DUMP BED IS LOADED ON LEFT SIDE MORE THAN THE THRESHOLD LIMIT AND LIKewise FOR RIGHT SIDE..SIMILAR LIGHTS WILL BE ON THE TOP OF THE CABIN AS WELL FOR EXCAVATOR OPERATOR.

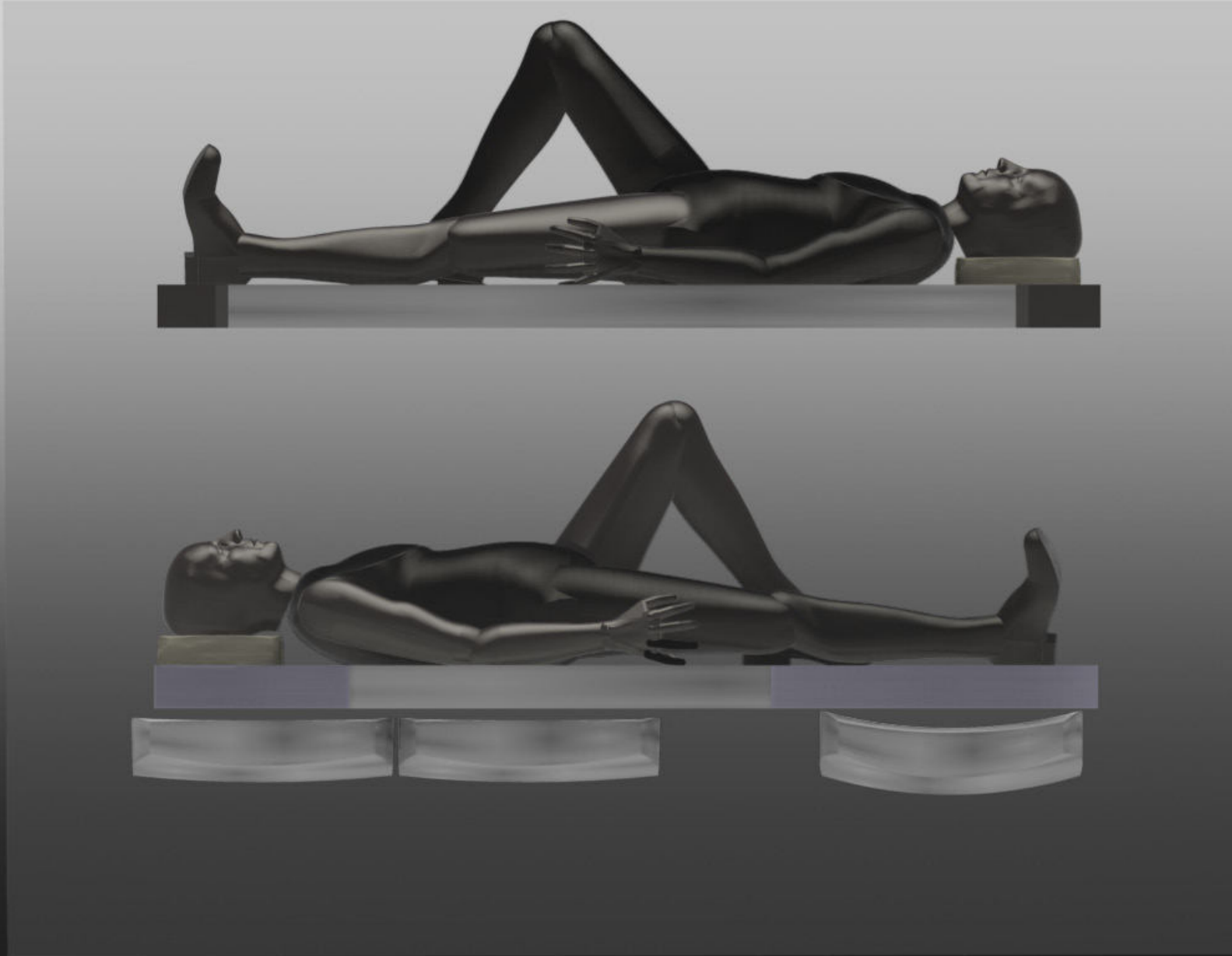
Dimensional Drawing



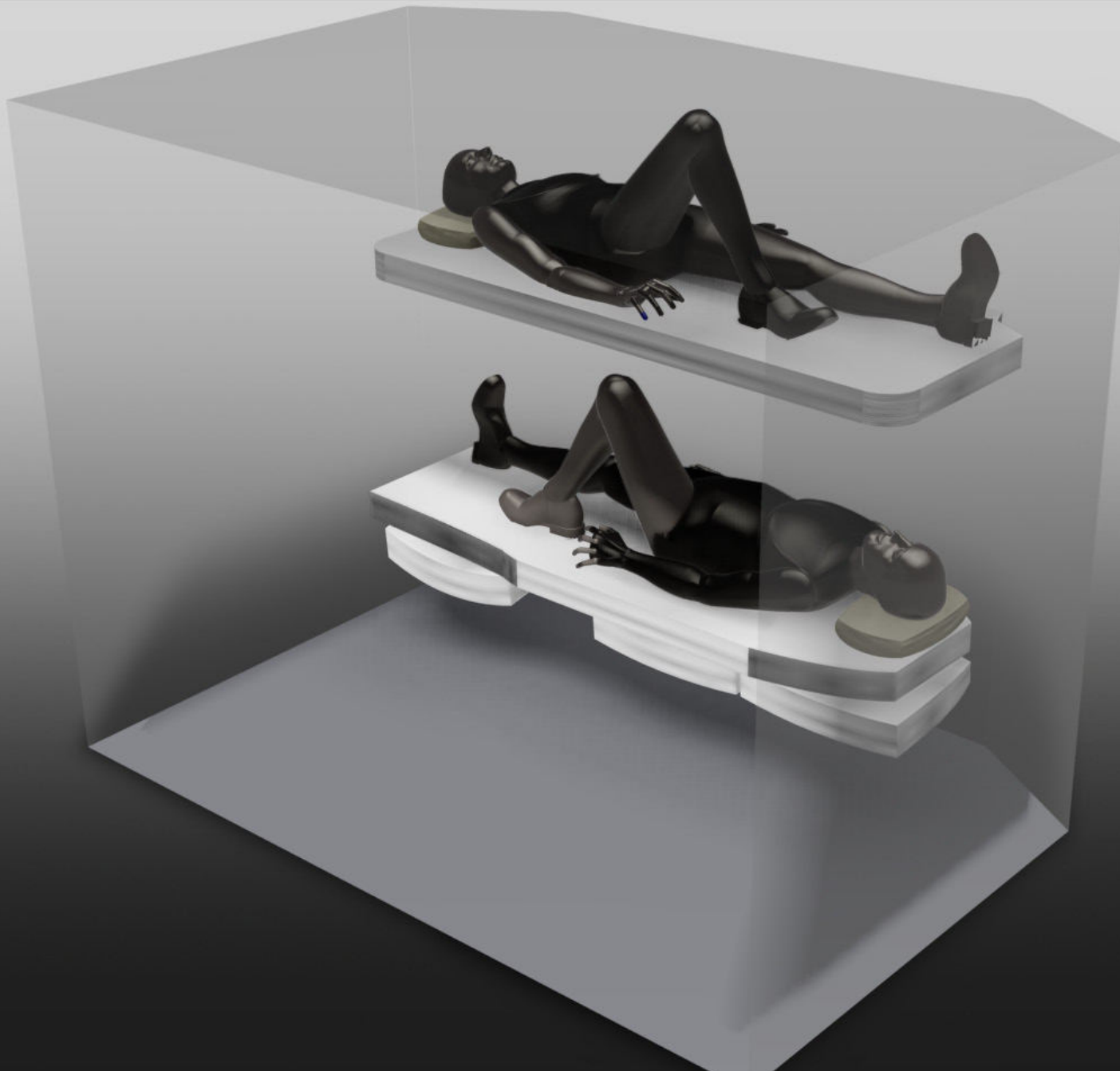


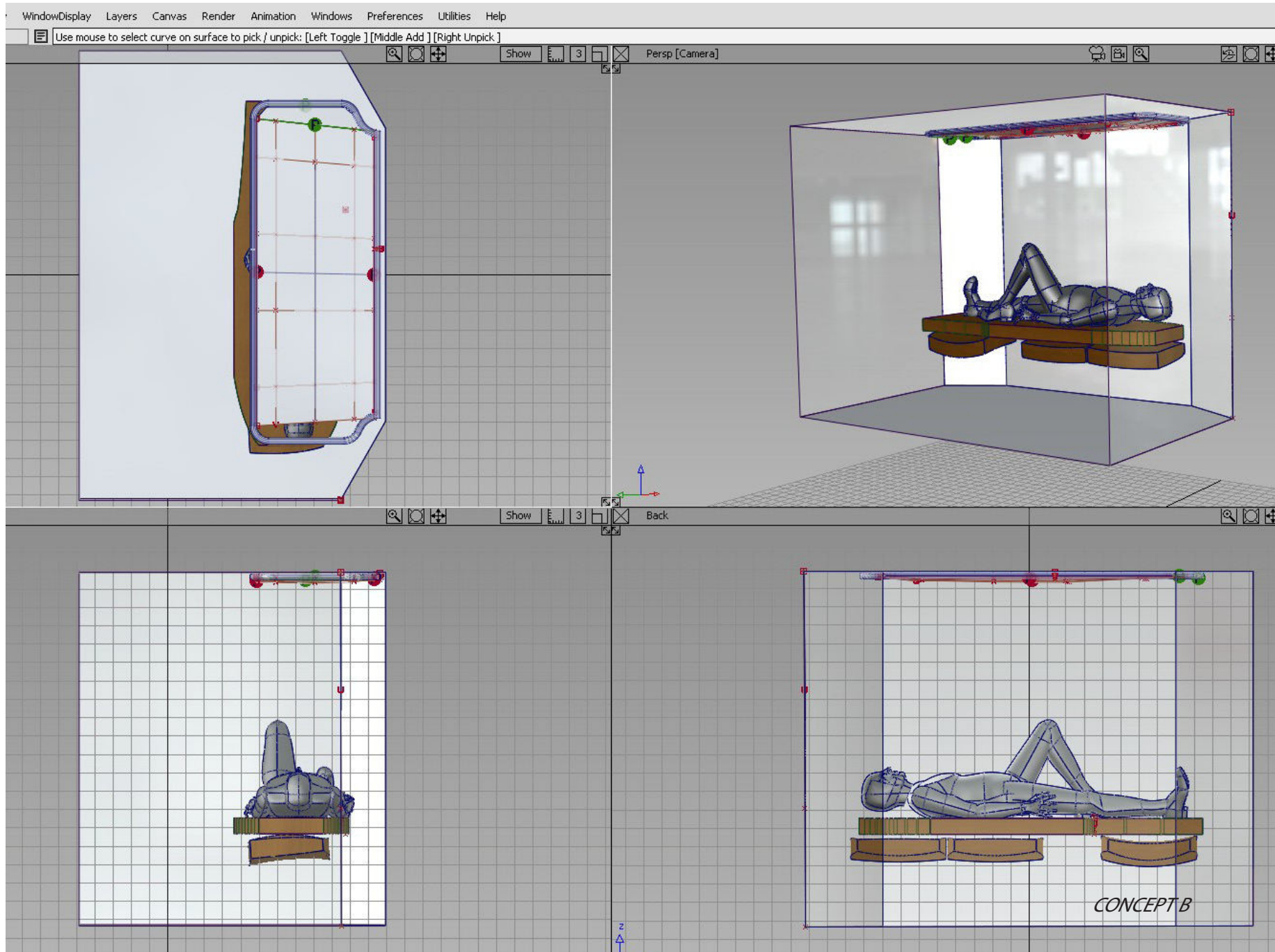


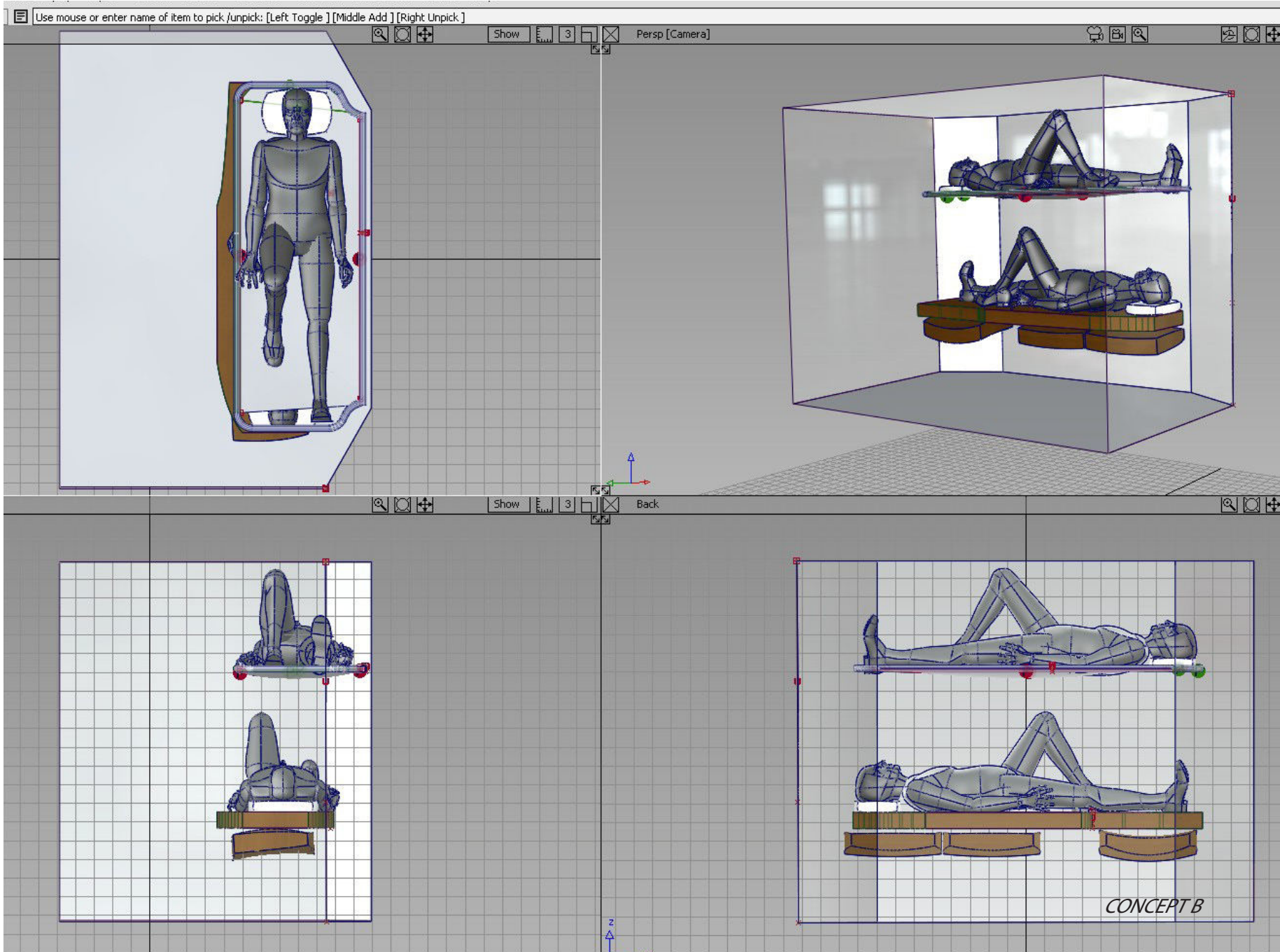
CONCEPT A



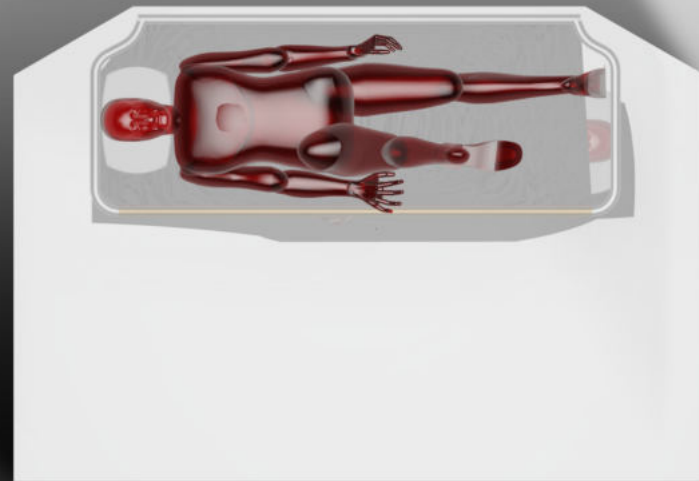
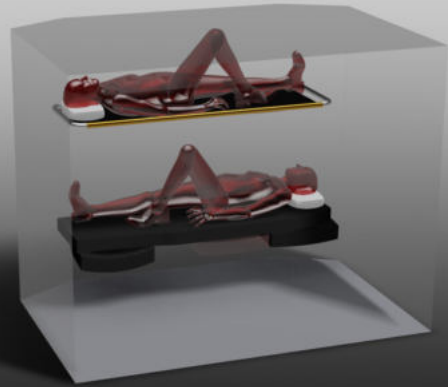
CONCEPT A



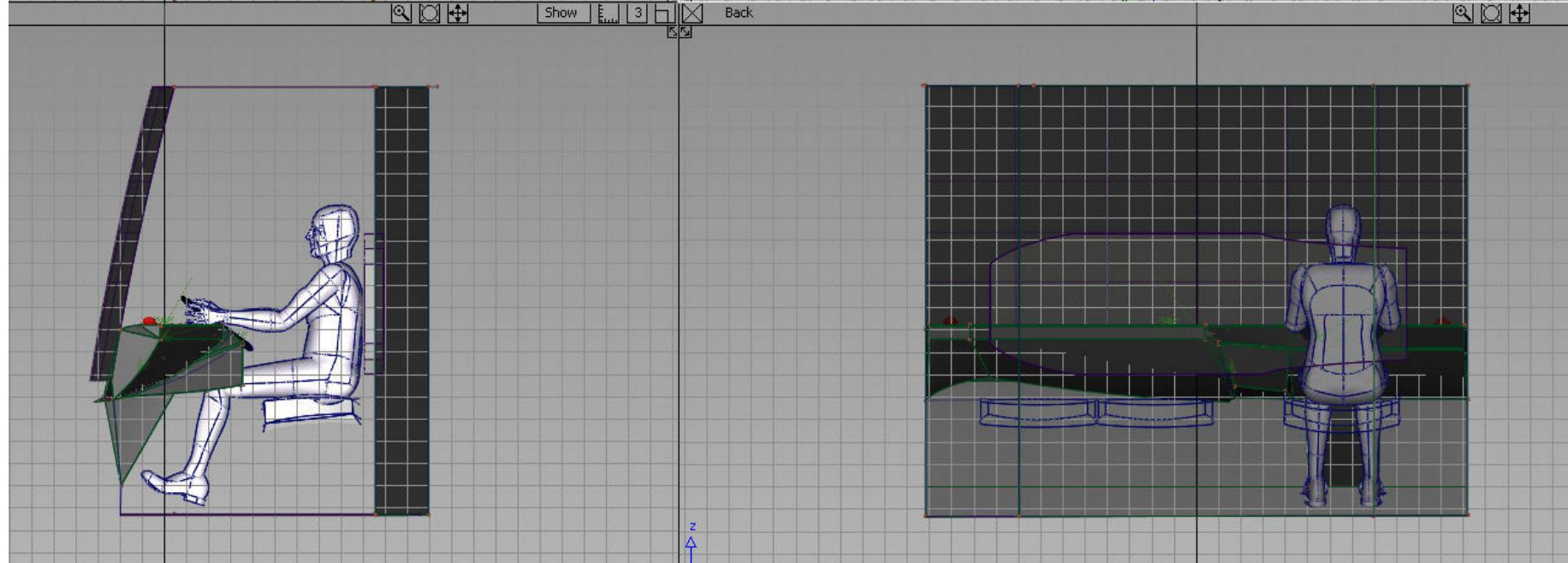
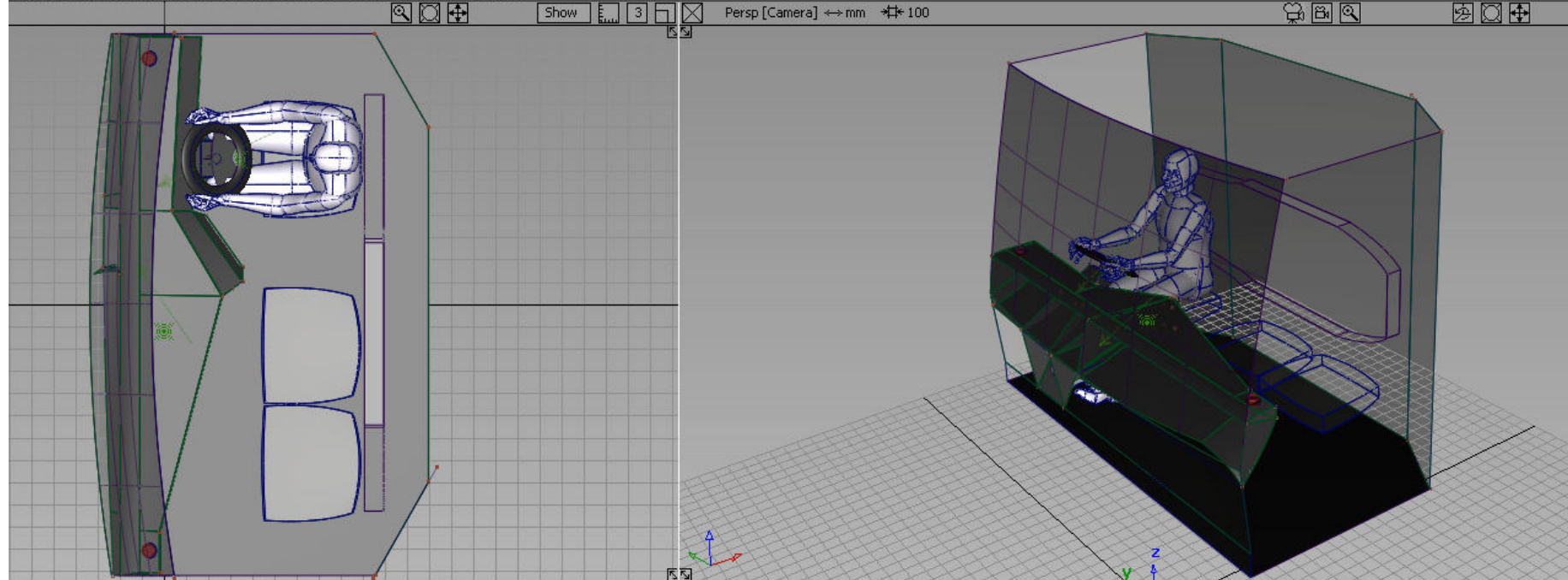




CONCEPT B



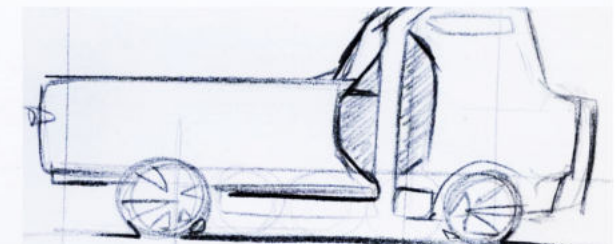
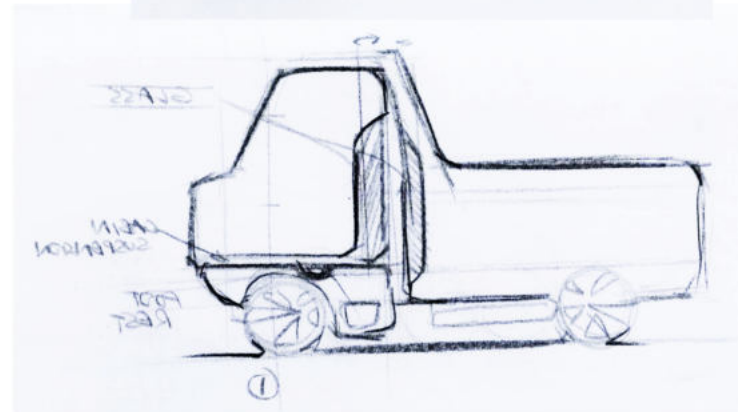
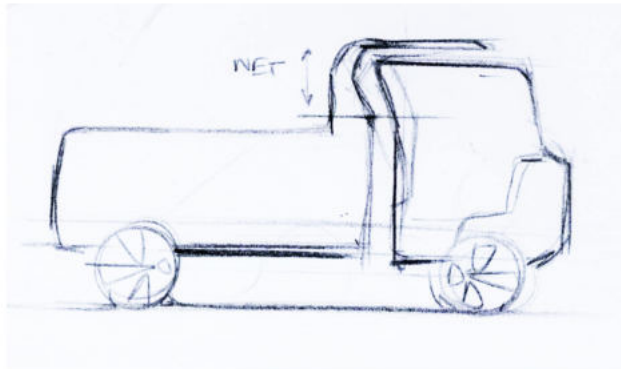
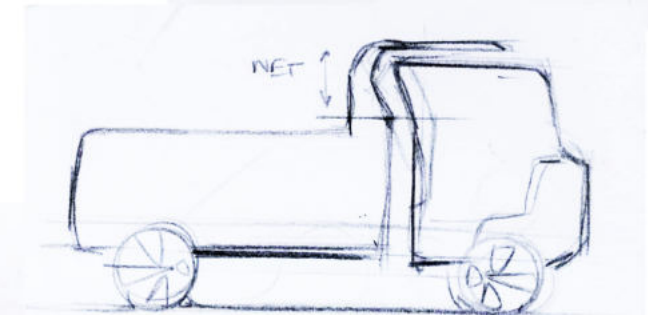
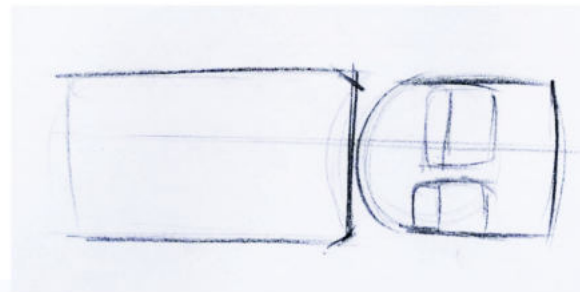
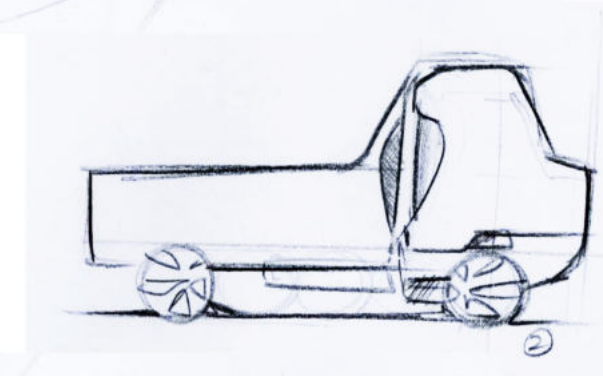
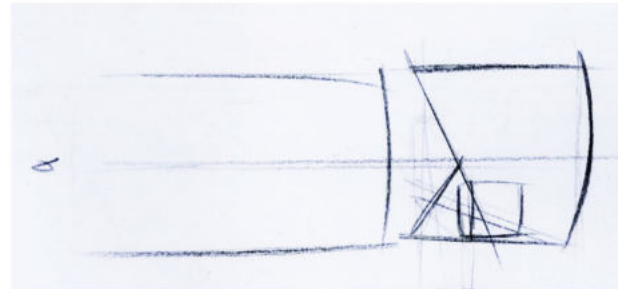
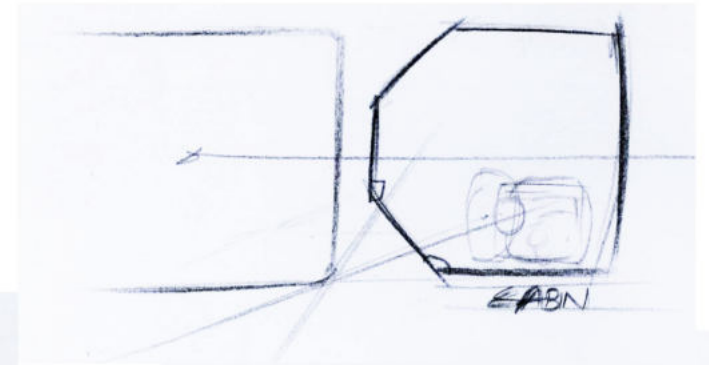
ouse or enter name of item to pick /unpick: [Left Toggle] [Middle Add] [Right Unpick]

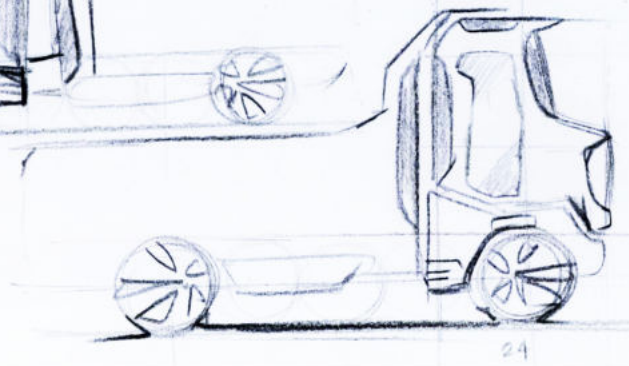
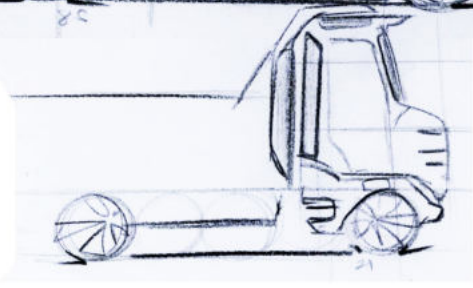
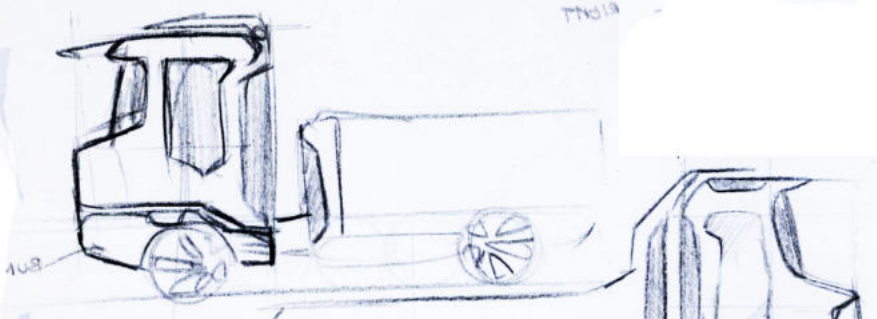
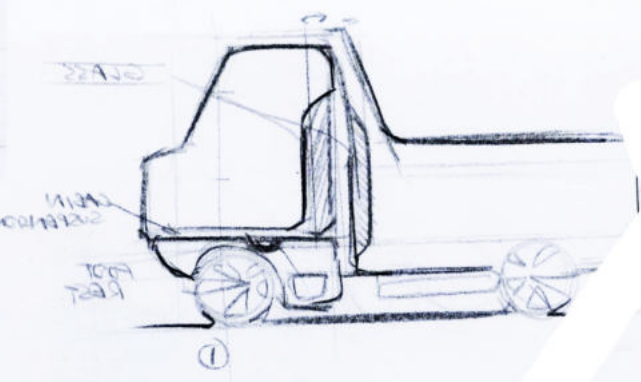
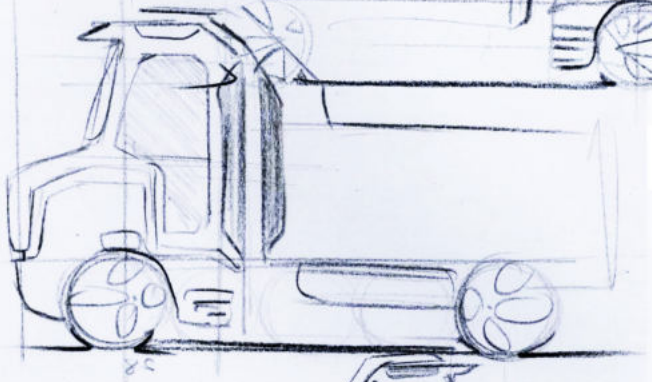
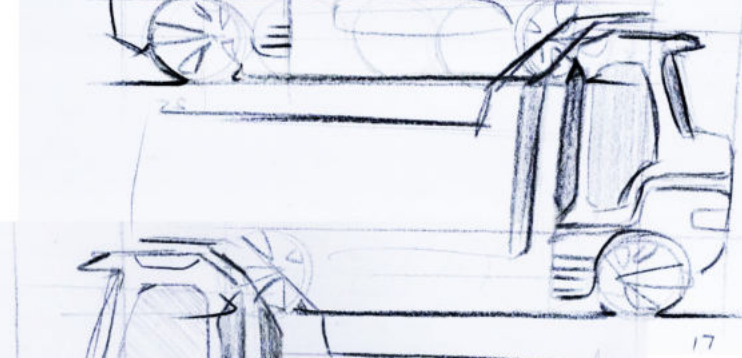
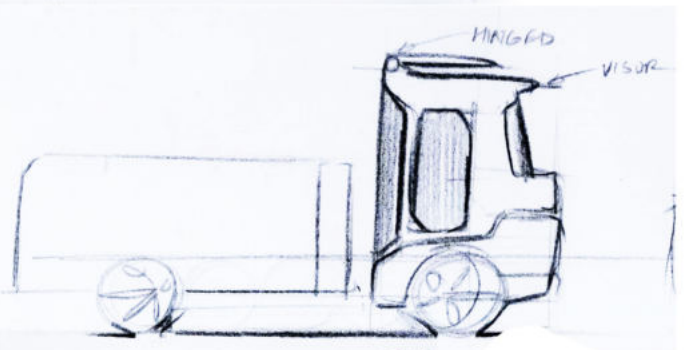
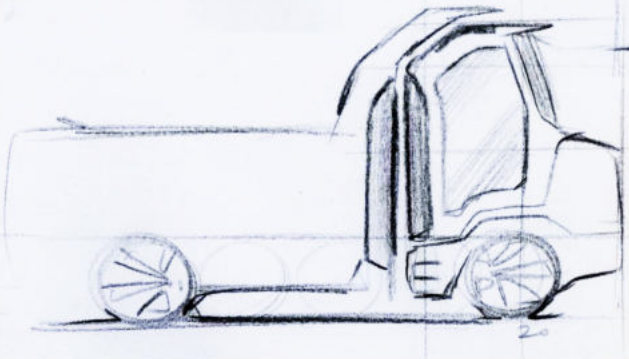
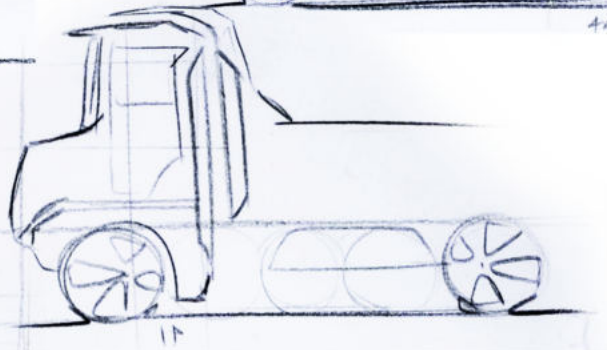
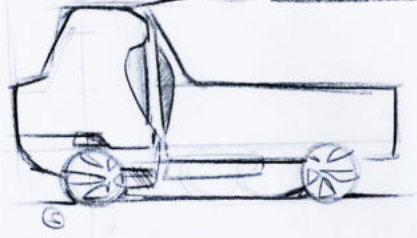
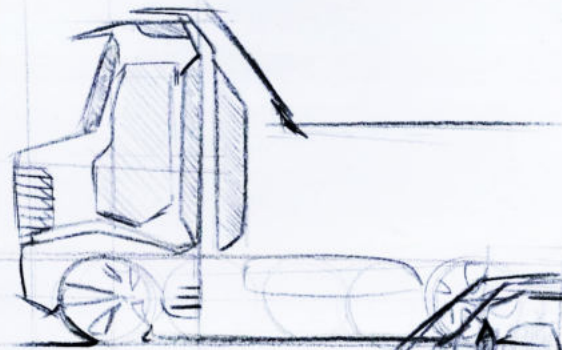
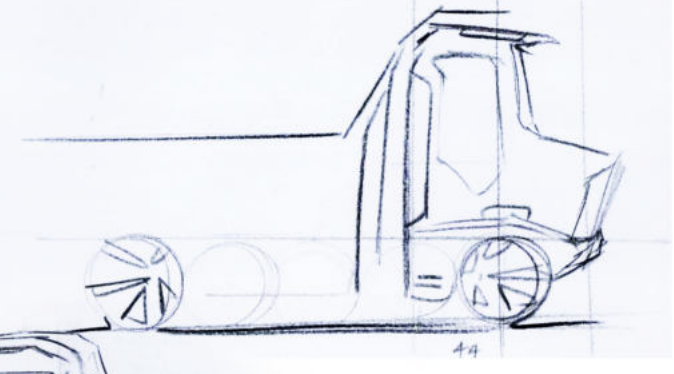
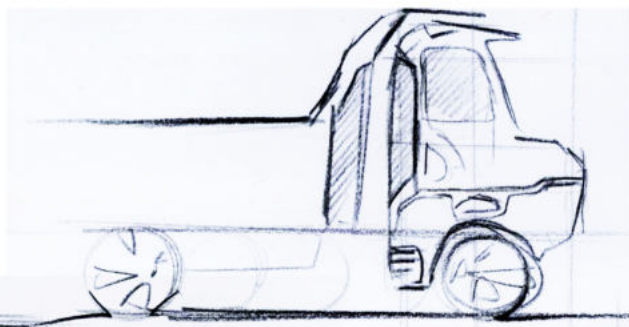
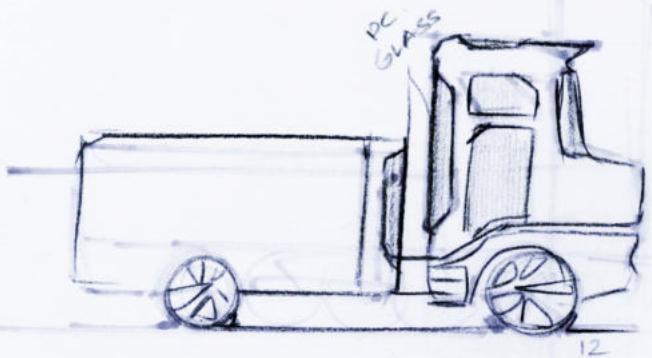


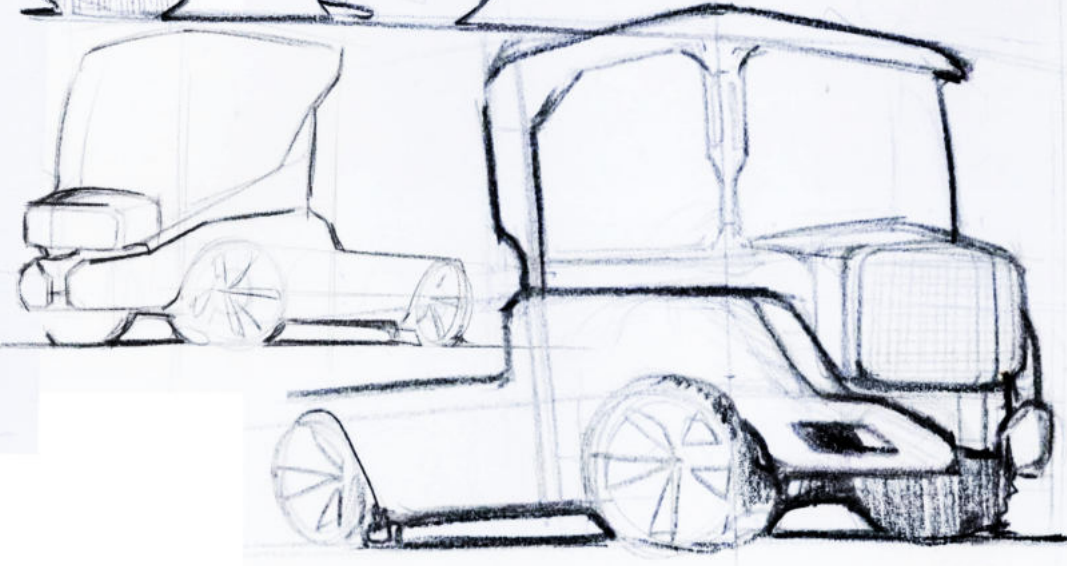
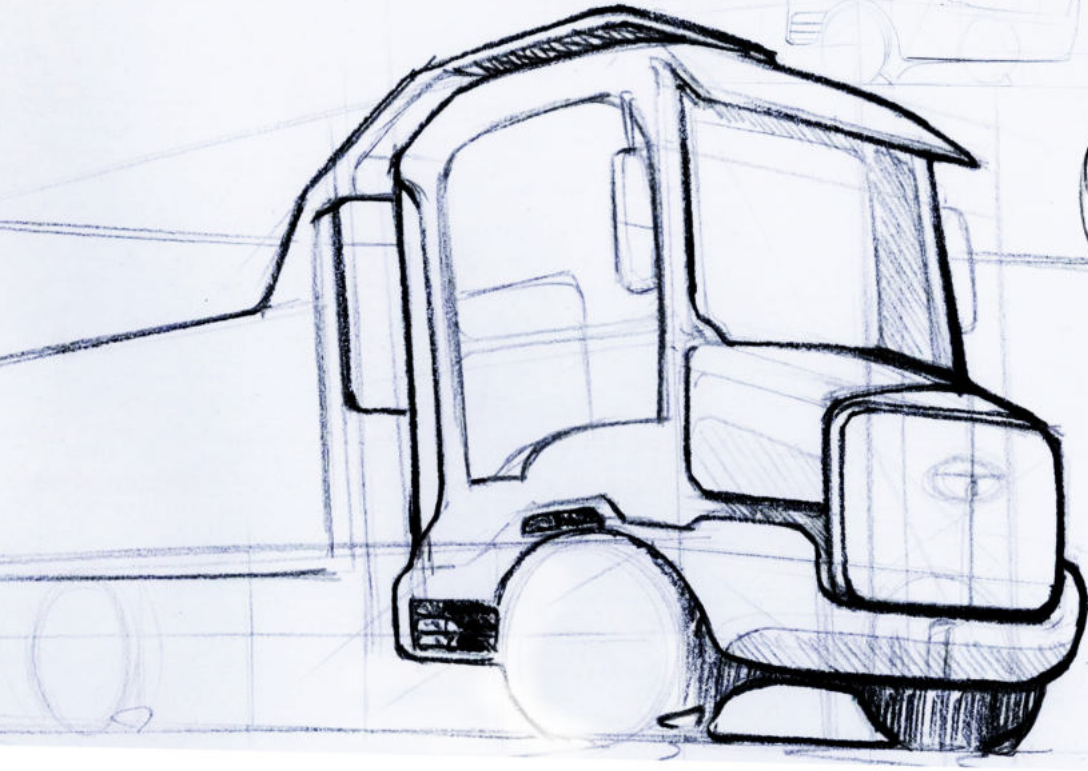
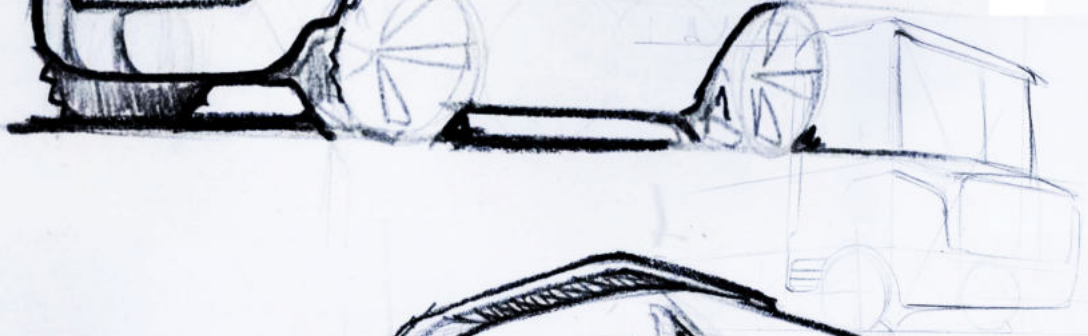
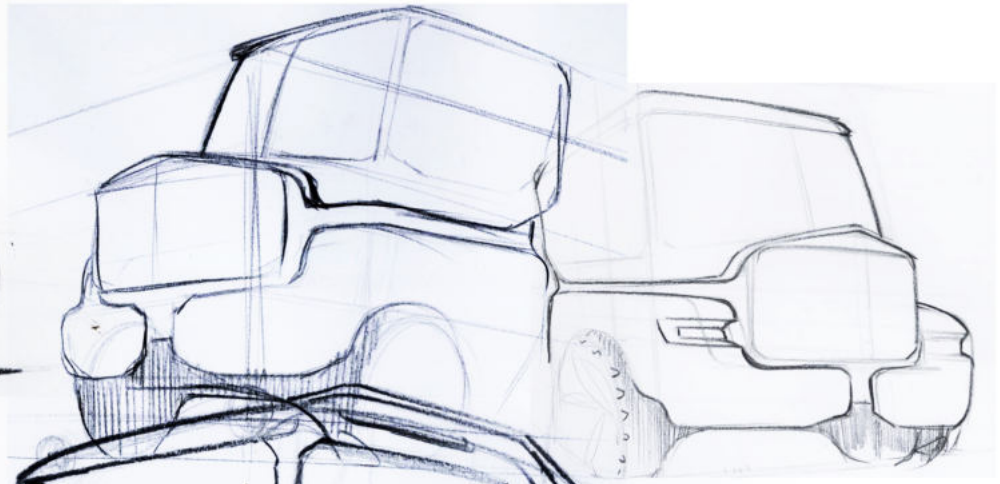
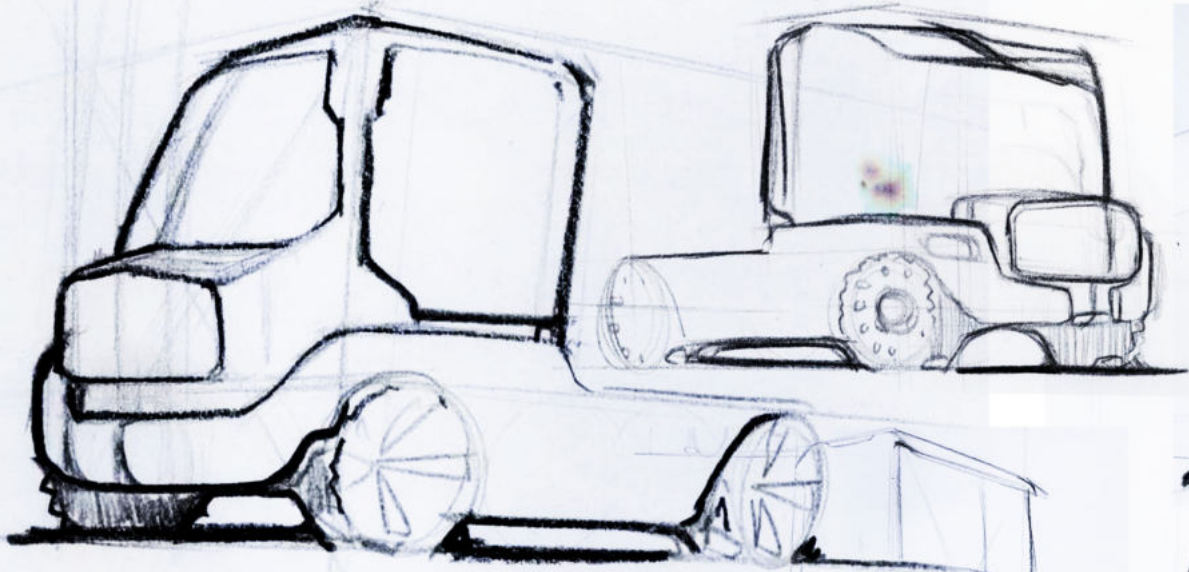
18

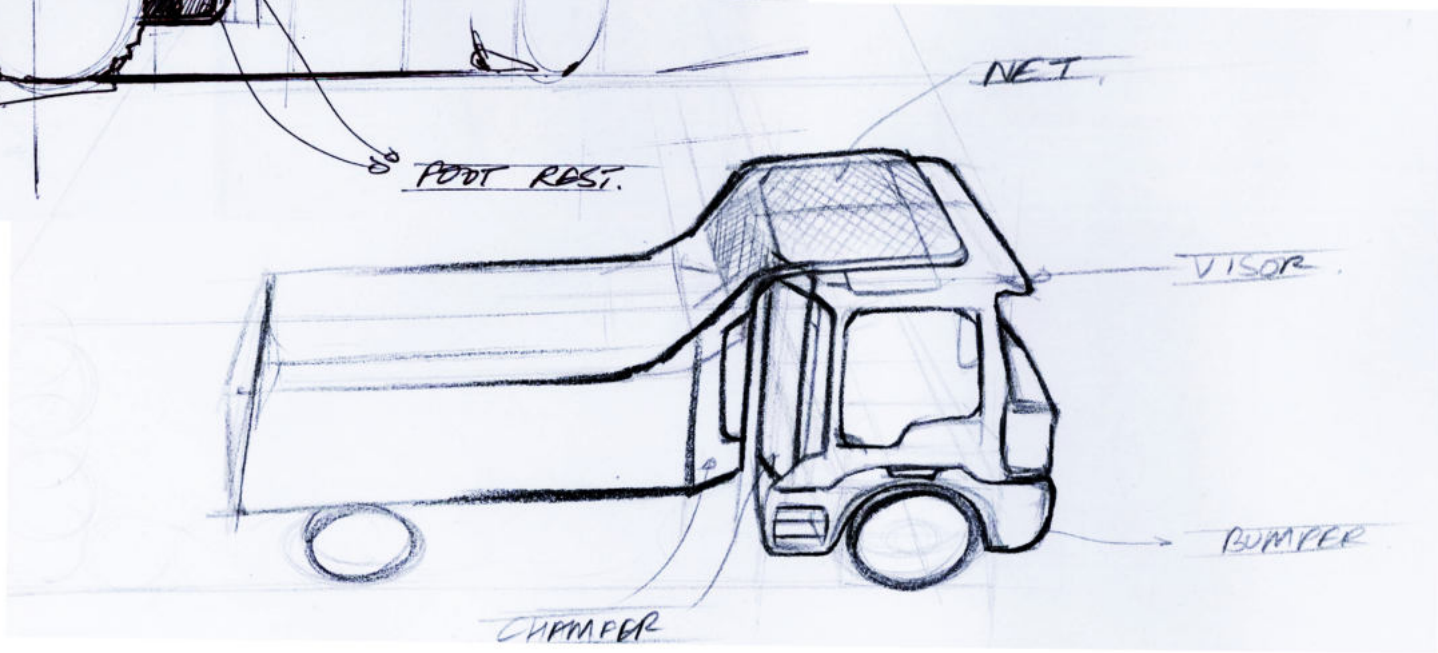
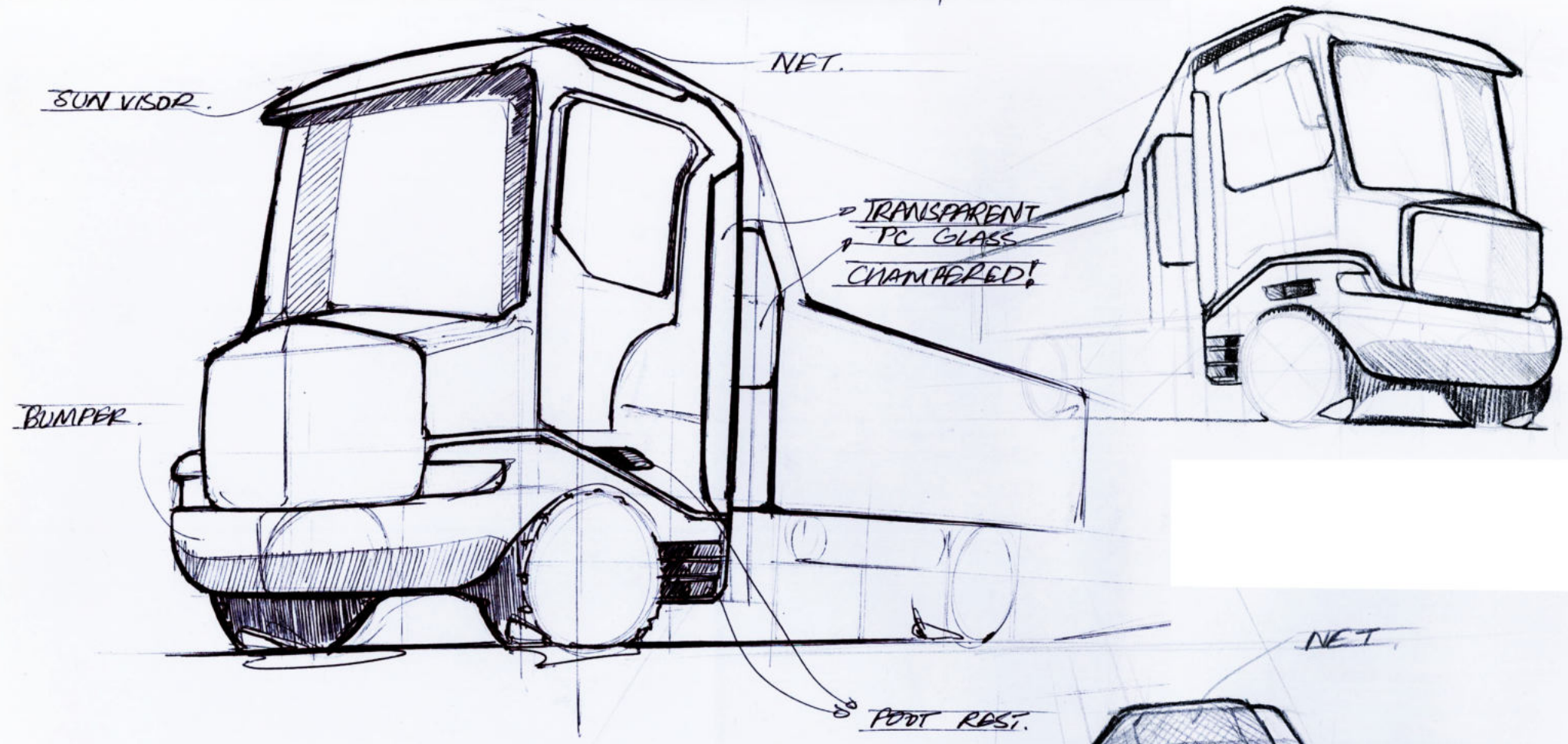
Layout Form Explorations

Thumbnail sketches were made based on the proposed package and form was explored. These were also drawn considering the design direction.



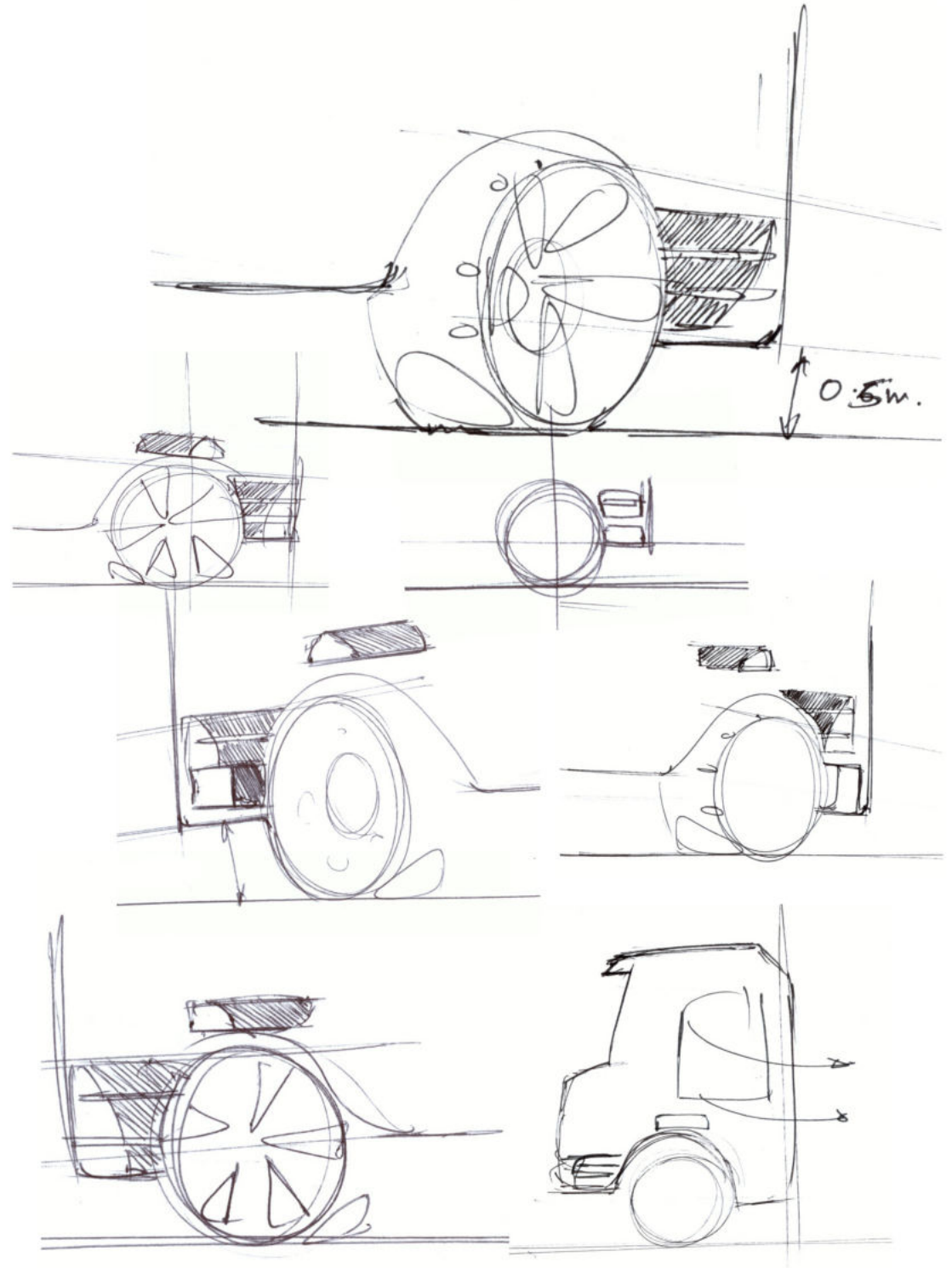


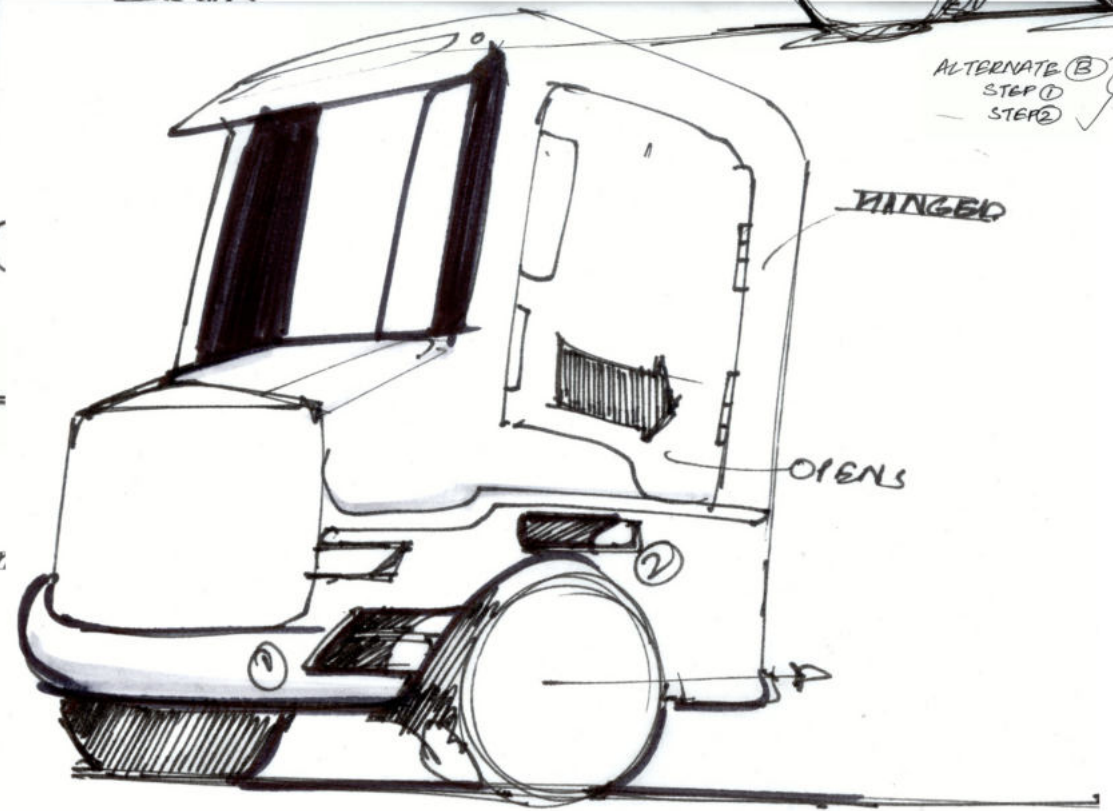
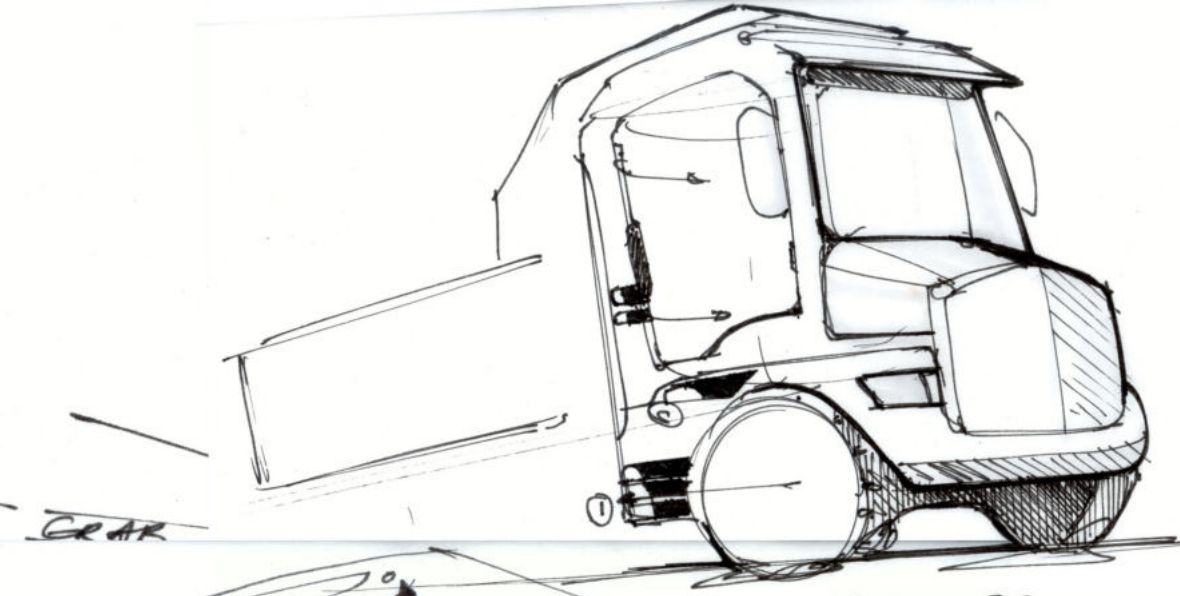
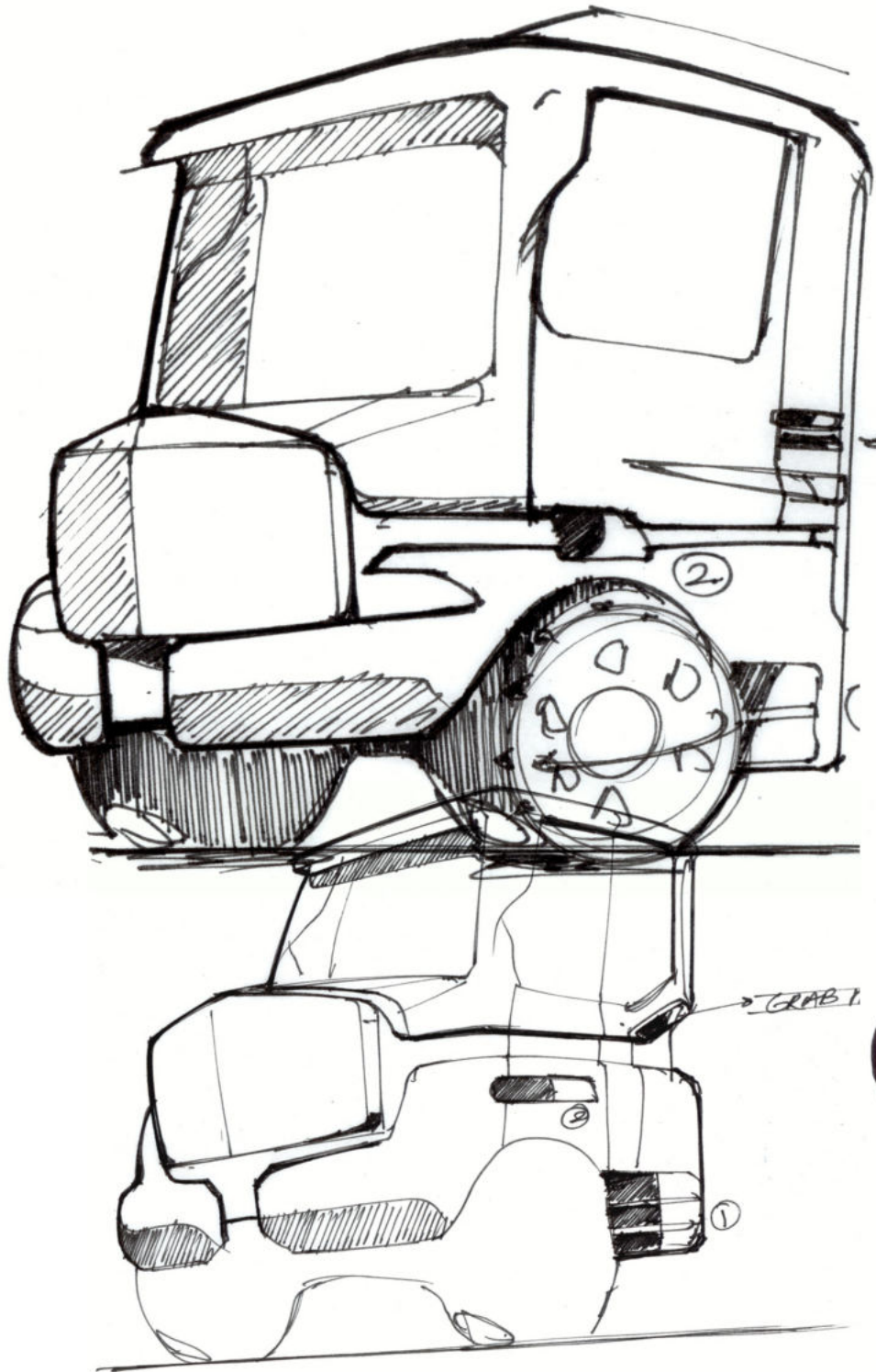




19

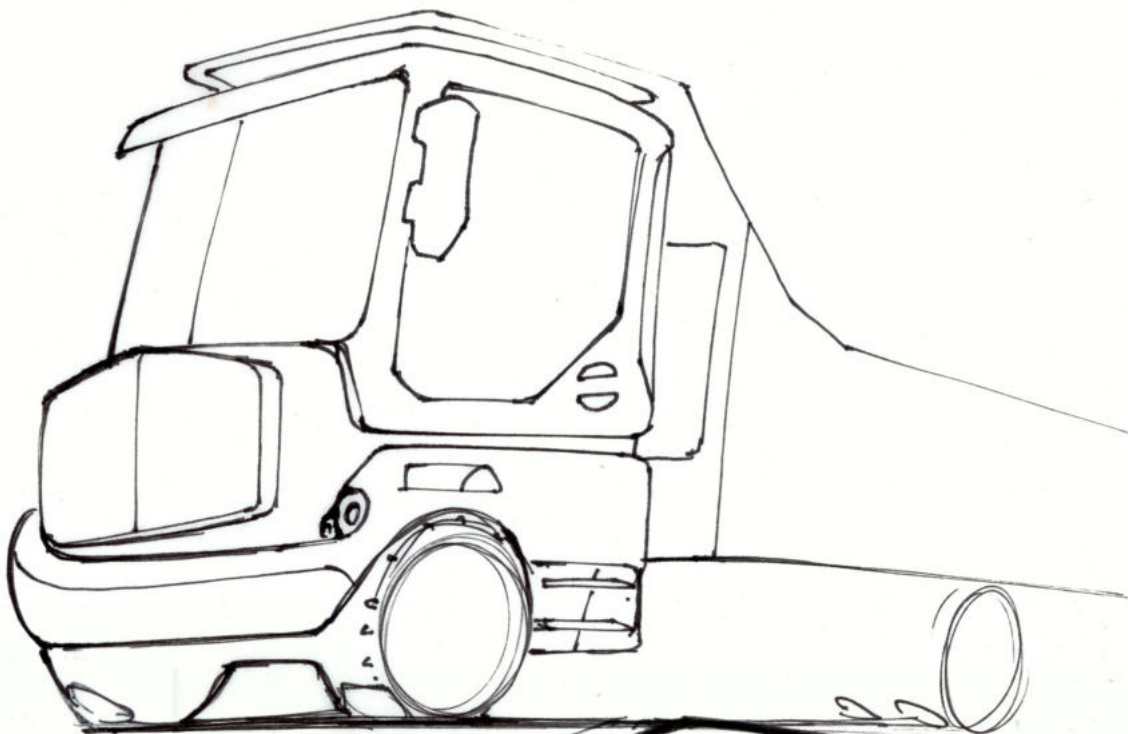
Function Exploration Sketches



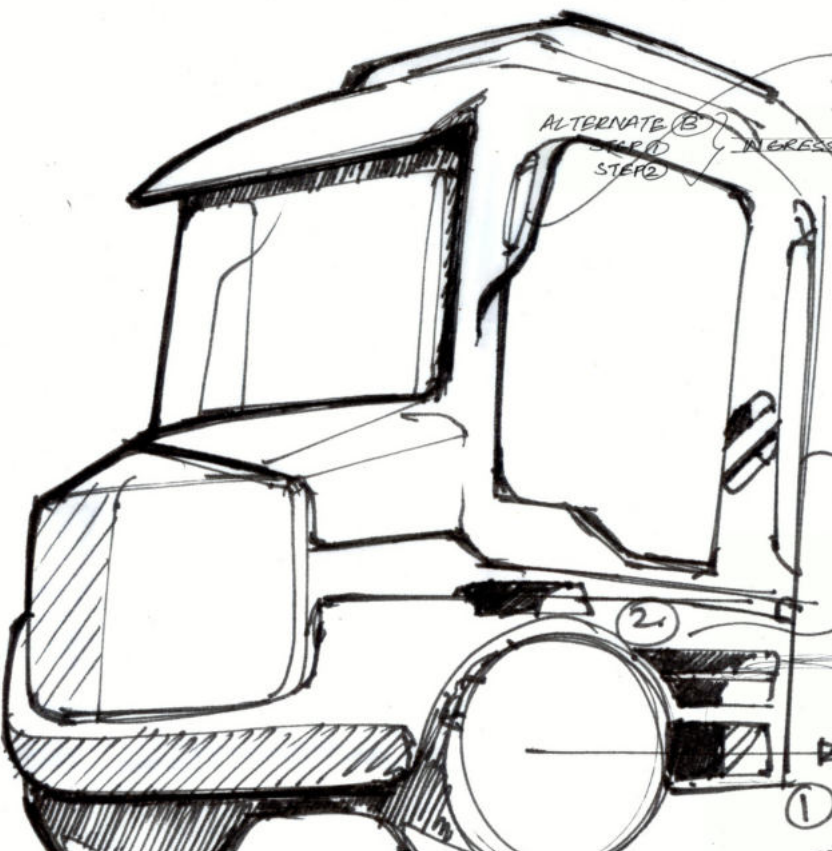


ALTERNATE (B)
STEP ① } INGRESS
STEP ② }

ALTERNATE (A)
STEP ① } INGRESS!
STEP ② }



MIRROR IN A PILLAR
FIXED IN
BODY.

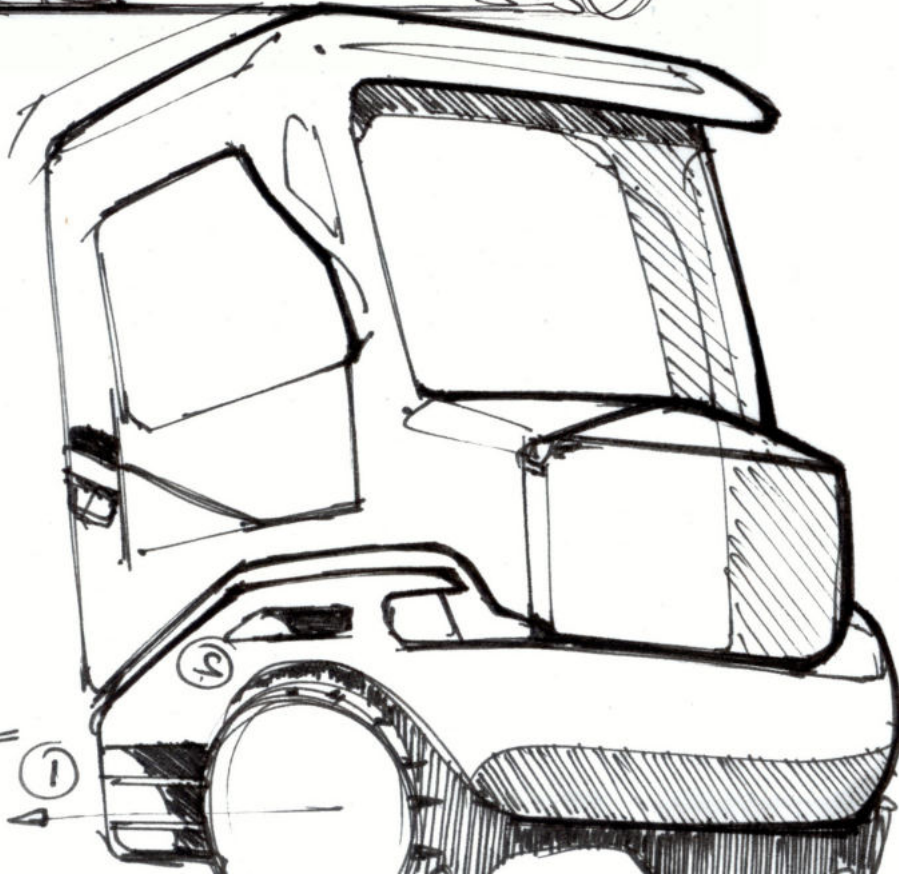


ALTERNATE B
STEP

GRAB!

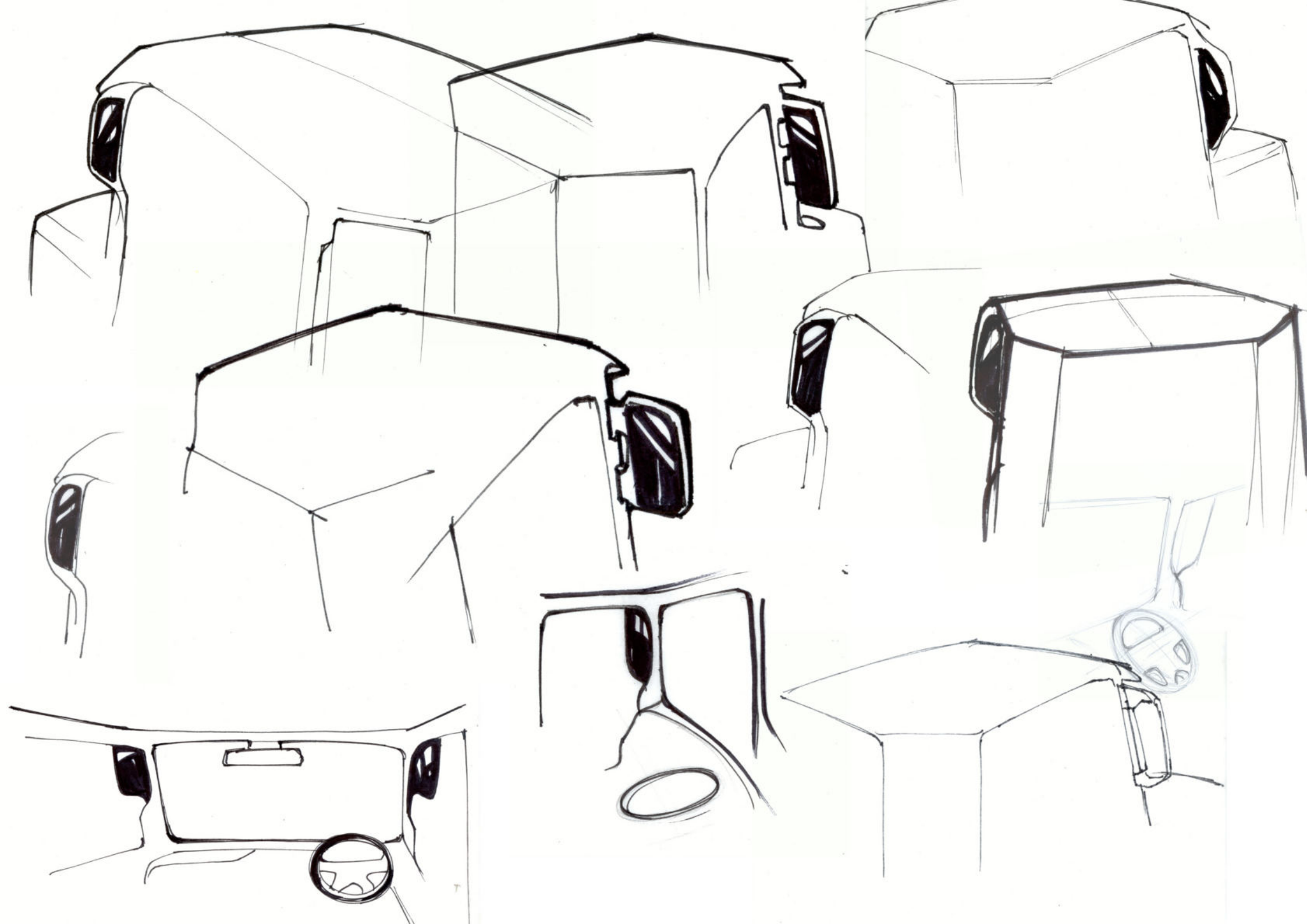
STEP

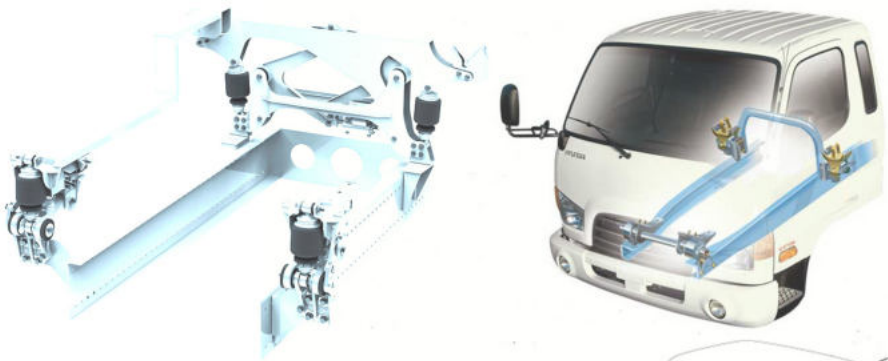
STEP



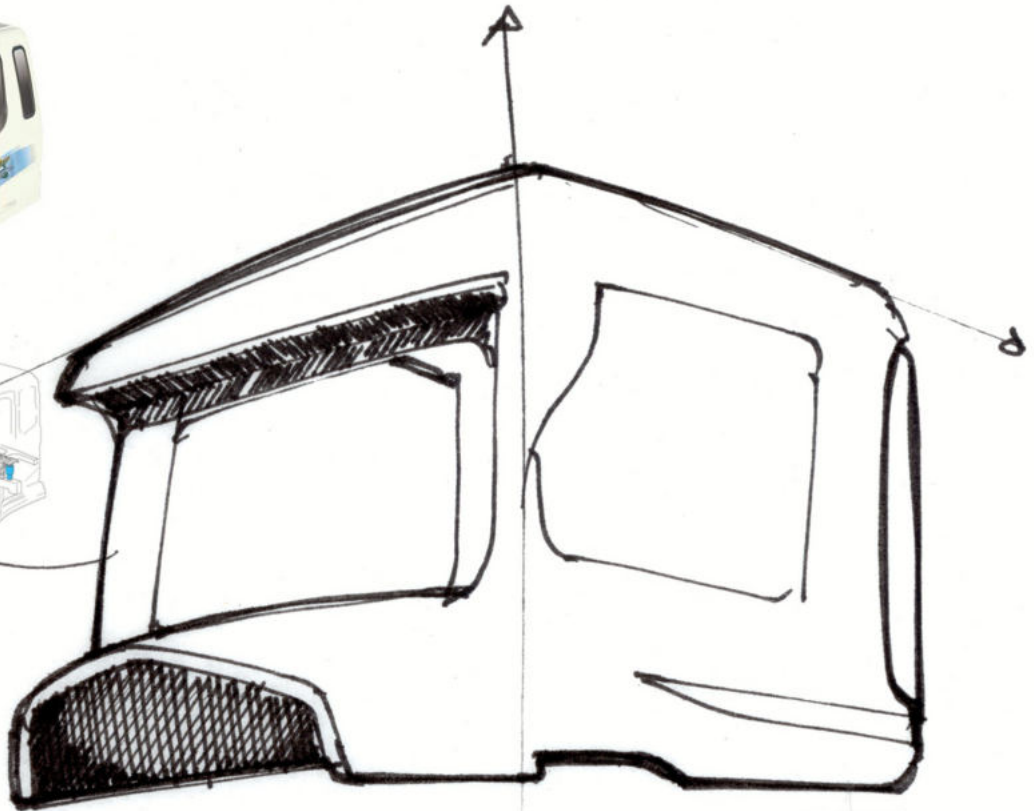
2

1



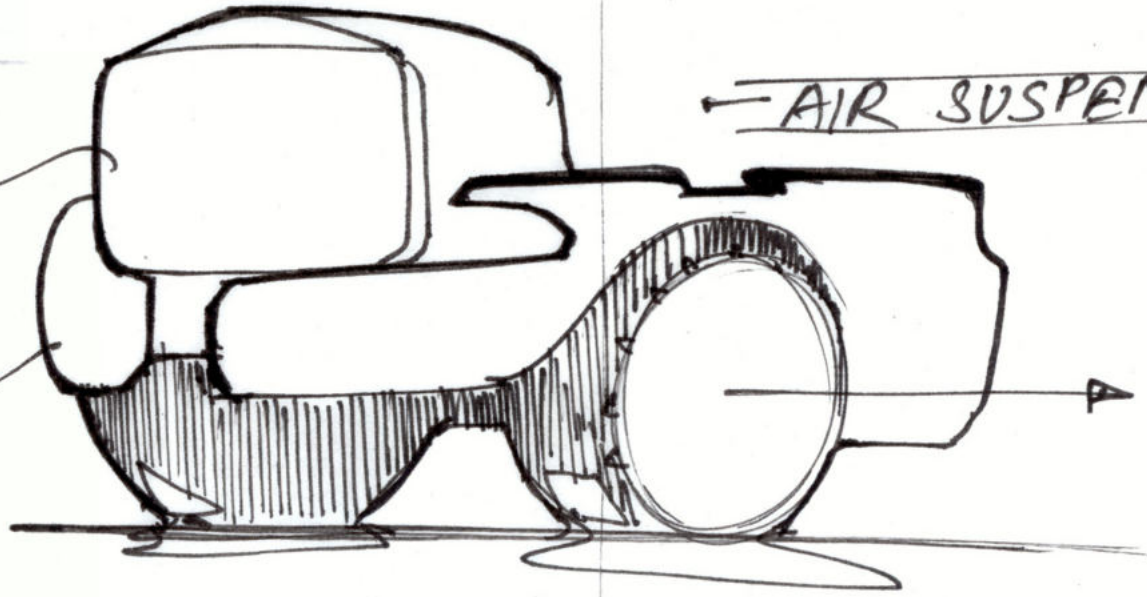


UPPER
SECTION
NO
ENGINE

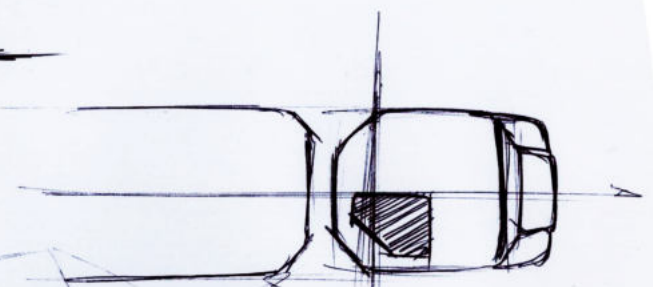
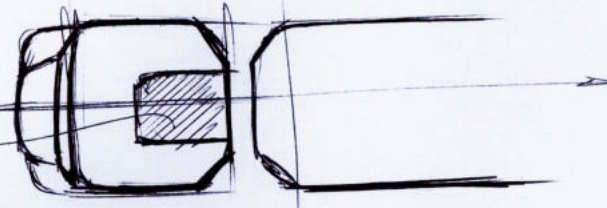


ENGINE
ON
LOWER
SECTION.

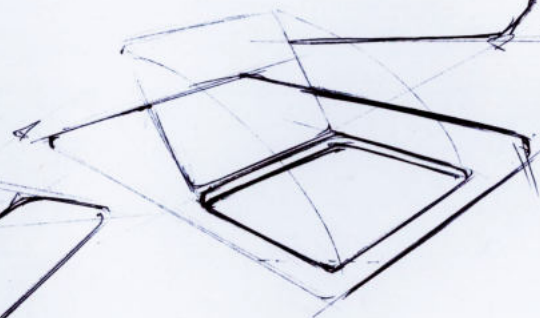
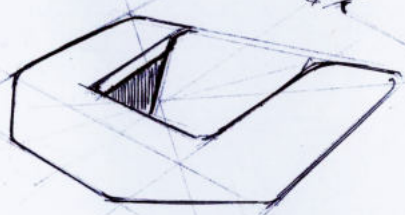
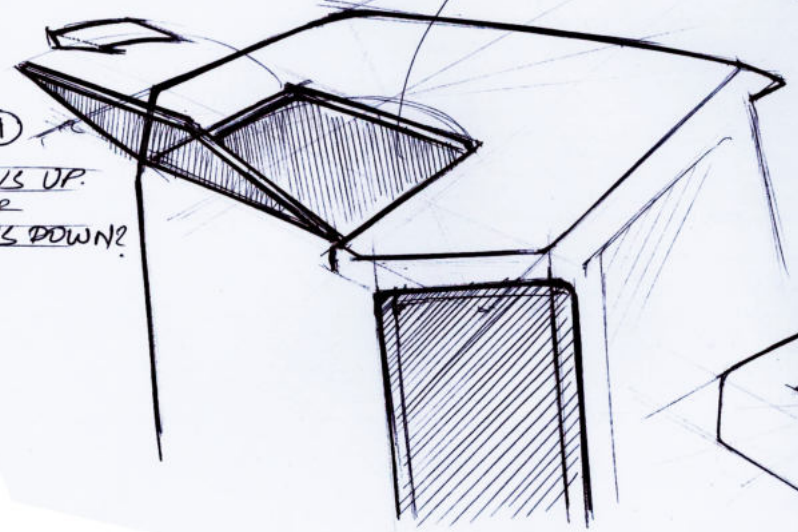
AIR SUSPENSION



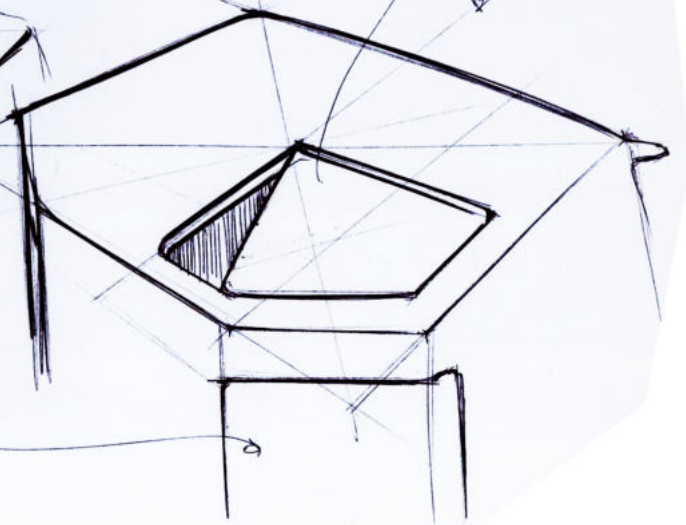
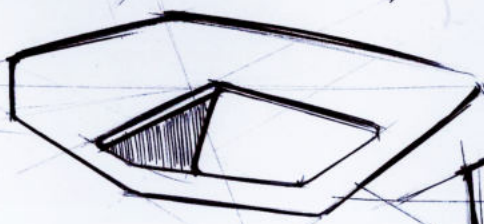
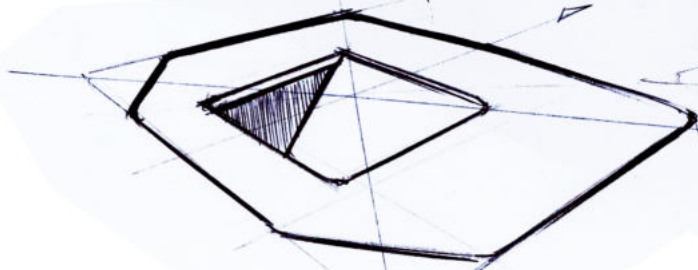
EMERGENCY EXIT.



①
OPENS UP.
OR
OPENS DOWN?

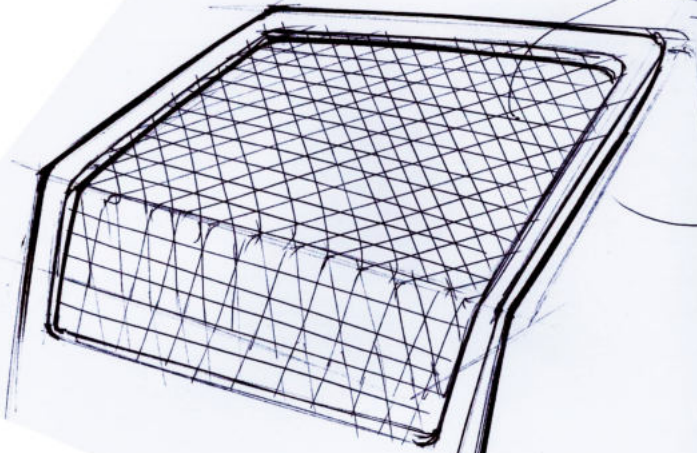


EMERGENCY EXIT.
OPEN IN CABIN.

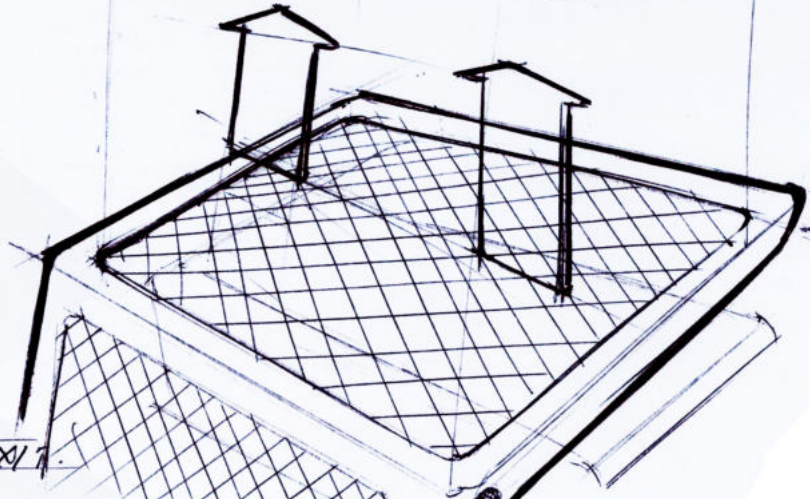
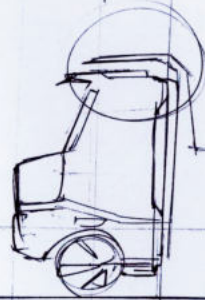
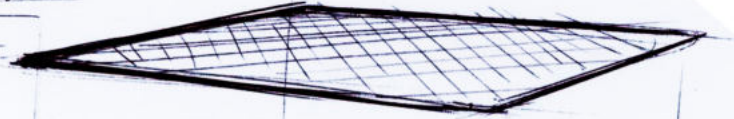


GLASS

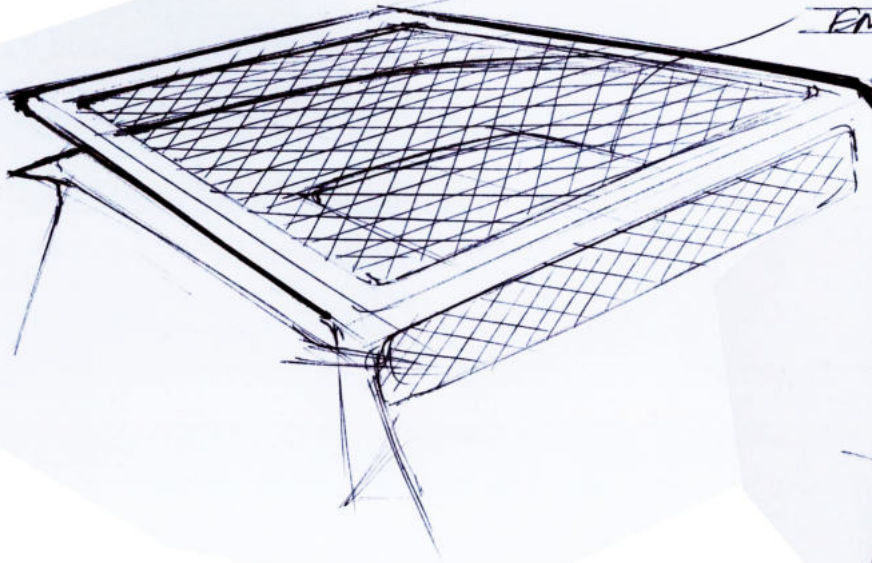
NET FOR PROTECTION OF CABIN.



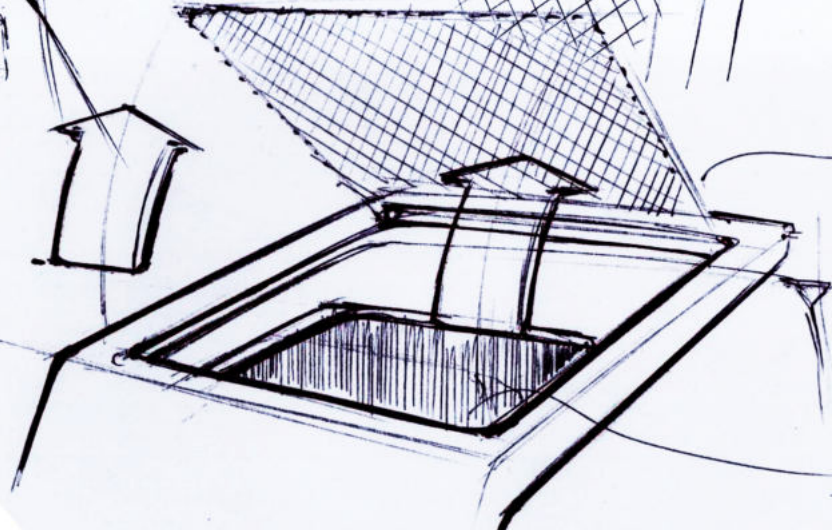
NET PUSHED OUT.



EMERGENCY EXIT.



NET OPENS UP. HINGED.



EMERGENCY EXIT.

20

Renders



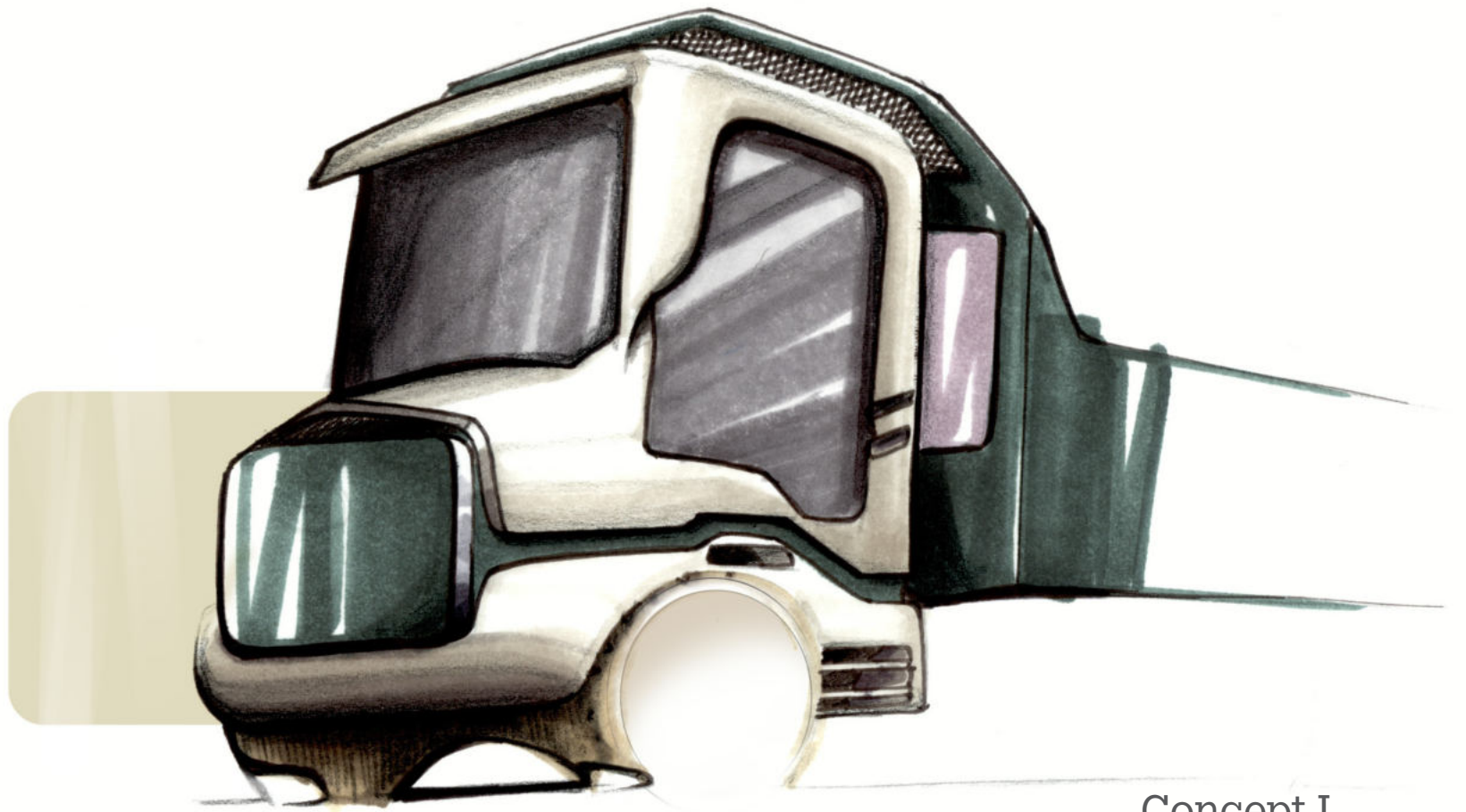
Concept I



Concept II



Concept III



Concept I



concept II



Concept III

IV

Form Selection

Concept evaluation was done by peer review. Concept A and Concept B of package exploration were as a result of series of exploration and ideation illustrated in the chapter 17. The two concept differed only in upper sleeper seat. Concept B was finally chosen as it was modular and light weight. Furthermore in the claustrophobic cabin upper bed was perceived to be visually light.

Parameters relating to exterior form were taken and were rated on the scale of 10. These parameters were Sun visor effectiveness, Mirror Adjustability and ruggedness, Reduction in dead zones based on cabin DLO, Bumper Ruggedness, Cabin Overall Ruggedness and Aesthetic, look and Style.

Refer Evaluation table on the next page.

Overall and individual sum for each parameter is calculated and exterior form was selected for the fixed interior package concept B.

Concept I



Concept II



Concept III



User	Sun Visor			Mirror Adjustability and ruggedness			Reduction in dead zones			Bumper Ruggedness			Cabin Overall Ruggedness			Aesthetic, look and Style		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1	7	8	6	9	6	7	7	6	8	6	8	7	7	8	8	8	7	9
2	7	8	5	8	5	5	7	6	8	6	7	5	5	8	6	6	7	8
3	7	7	7	7	8	6	7	6	7	6	8	7	6	8	7	7	8	8
4	8	8	7	6	7	6	6	8	7	7	8	8	7	8	8	7	8	9
5	7	8	6	6	6	7	6	7	6	6	8	7	6	8	8	8	7	8
6	7	8	7	7	7	6	8	6	7	6	7	7	6	7	6	8	7	8
7	7	8	7	6	7	6	8	6	8	6	8	6	7	8	7	6	6	7
SUM	50	55	45	49	46	43	49	45	51	43	46	47	44	55	50	50	50	57

Concept I
Overall Score = 285

Concept II
Overall Score = **297**

Concept III
Overall Score = 293

Selected Concept



Concept II

Selected Concept

