

Project - 3

Design And Styling of Earthmover



V P B CHAKRAVARTHI . K

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Guide : Prof. **B.K.CHAKRAVARTHI**

IDC , IIT-Bombay

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 - **Research and Data collection**
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 - **Conceptualization**
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 - **Final design**
-

- Product is the most important statement.
- It reflects the values and concern of a company.
- With increasing competitiveness consumer sophistication, design is the detail that is assuming a crucial role in a corporate strategy.
- Earlier OEMs (Original Equipment Manufacturers) use to dress up their products with paint and decals, after the engineers are done with the approval and push in to the market. But... Today designer is the key member in the development team, helping to specify the product, reflecting the user in the design and lending the machine a “visual language” that speaks to its intended function.
- Companies seek competitive distinction via product features some are visually (or) measurably identifiable, some cosmetically implied, some claimed by reference to real or suggested hidden attributes that promise results or values those are different from those of competitors.
- The impact of design and designer on a industrial vehicle development is a tremendous one over the past few decades as they are influencing every category of the industrial vehicle and every component of the individual vehicle.

Commercial Vehicles



HEAVY Commercial Vehicles



Kings that rule the road...

MULTI-UTILITY Vehicles



For all terrain and purpose...

EMERGENCY Vehicles



When you are in dire need...

LIGHT Commercial Vehicles



A trifle light in weight...

AGRICULTURAL Vehicles



Reap what you sow...

EARTH MOVERS Construction



Move the earth you walk on...

Research and Data collection

2.1 Earthmover scenario

Various types earthmoving equipment addressing industrial, construction and agricultural needs.



Bulldozer



Hydraulic excavator



Telescopic handler



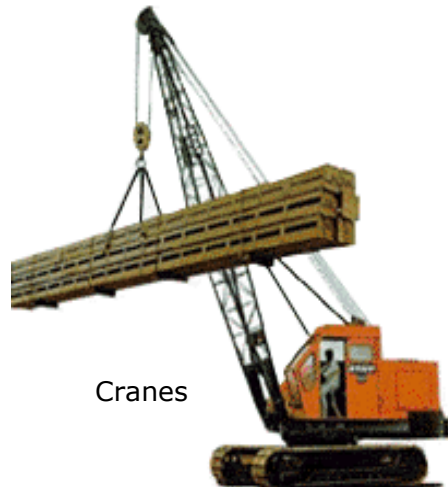
Backhoe loader

Motor graders



Wheel loaders

Road roller



Cranes



Skid steer loader



Mobile
crushers



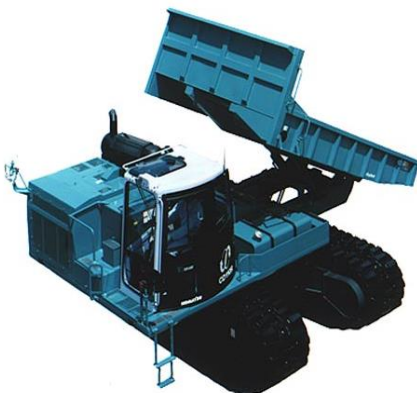
scrapers



Mining
trucks



Walking drag
liner

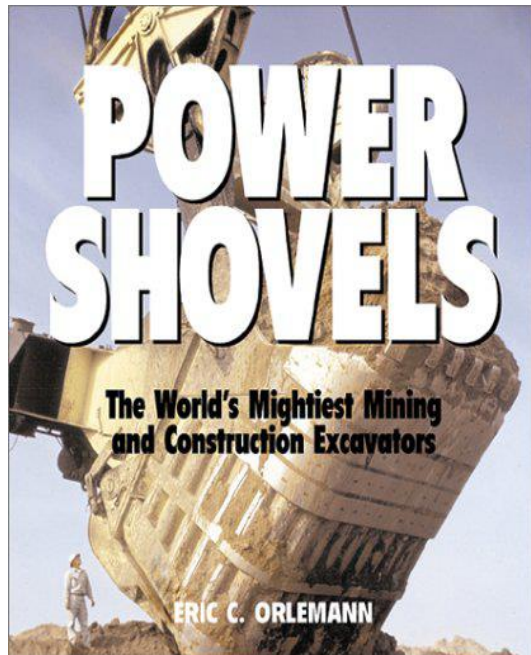


Crawler carrier



Rope shovel

World scenario of Earthmover



World's largest hydraulic excavator

Types of feet



Wheel type



Crawler type



Lower structure
Different kinds of feet.

There are two kinds of feet for almost every vehicle of earthmover. Each one has a different characteristics and serves different purposes.

Lower Structure

Different kinds of feet.



Crawler type



Lower Structure

Different kinds of feet.



Wheel type





Backhoe loader



User Study

What is a Backhoe Loader?

- A **tractor**
- A **loader**
- A **backhoe**

Each piece of equipment is suited to a particular sort of work. On a typical construction site, the backhoe operator usually uses all three components to get the job done.



A backhoe loader combines a backhoe, a loader and a tractor into one piece of equipment.

The Tractor

The core structure of a backhoe loader is rough terrain, powerful, **turbo-charged diesel engine**, large, rugged **tires** and a cab with basic steering controls (a steering wheel, brakes, etc.).

The Loader

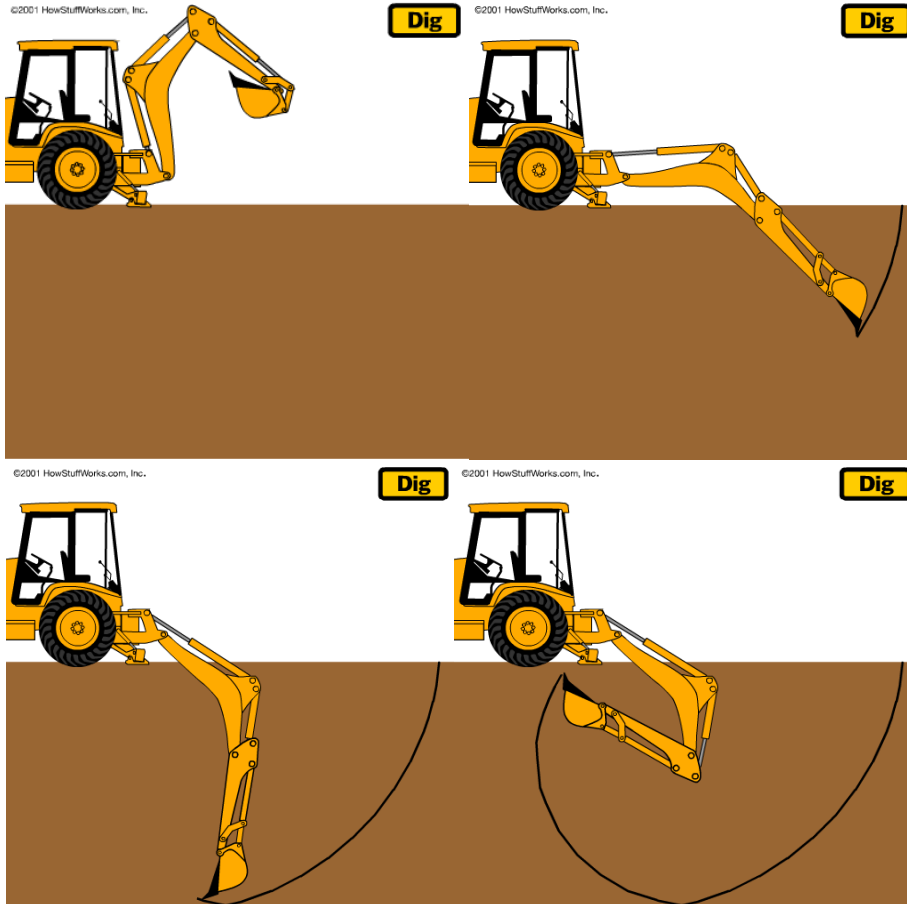
The **loader** is attached in the **front** and the backhoe is attached in the back. These two components serve very different functions.



- Used primarily to carry dirt, gravel and other material.
- Used like a big, powerful dustpan or coffee scoop.
- Usually it **do not** dig
- Used to pick up and carry large amounts of loose material.
- To smooth things
- To push dirt like a plow.
- The operator controls the loader while driving the tractor.

The Backhoe

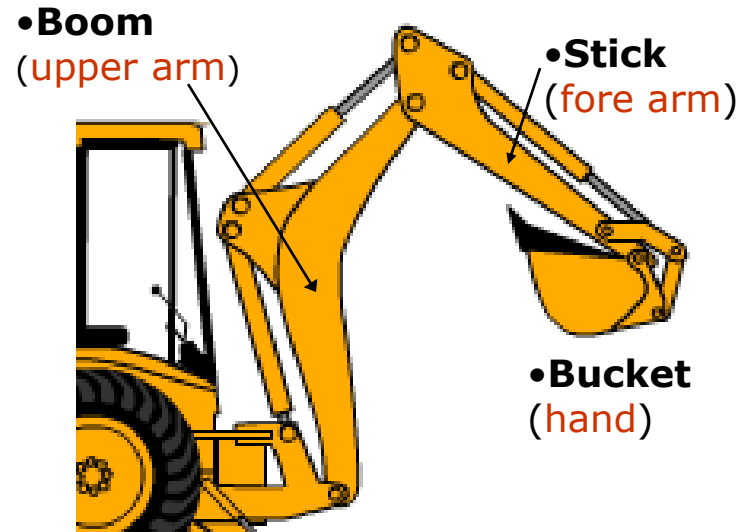
The **backhoe** is the main and **powerful digging tool** of the backhoe loader. It's used to dig up hard, compact material, usually earth, or to lift heavy loads. It can lift this material and drop it in a pile to the side of the hole.



The backhoe arm has a very wide range of motion.

The backhoe is a big, extremely powerful version of a human arm or finger. It has three segments:

- The **boom**
- The **stick**
- The **bucket**



The backhoe segments are connected by **three joints**

comparable to wrist, elbow and shoulder. The backhoe moves in pretty much the same way as your arm.

In a backhoe, the boom is bent upward to make it easier to dig with obstacles in the way.

This design also provides extra space for the bucket when the operator curls it in with a full load.

The backhoe can dig all sorts of holes, but is especially suited for digging **ditches**. To use the backhoe, the operator has to park the tractor and turn the seat around.



The loader and backhoe components are a natural combination for all sorts of jobs

Products in the market





VOLVO





CATERPILLAR®



Kubota

- Understanding the product (how it works, study of the existing products)
- User survey
- Analysis of the user Understanding the user and product

User survey

Questionnaire

- 1) Name ,age,working company
- 2) Qualification
- 3) How he became earthmover operator
- 4) What they operate on
- 5) Other equipments they operate
- 6) How many year's of experience of driving
- 7) How many years of experience on the construction equipment
- 8) Pay scale
- 9) Timings of the work (per month)
- 10) Duration of work(per day how many hours)
- 11) Type of work(construction,mining,agricultural,domestic..)
- 12) Type of environment they work in (dusty,elegergitic,sunny,rainy,cold...)
- 13) Complimenting cab or not..
- 14) Ergonomics of seating
- 15) Visibility(lightning)
- 16) Vibration of the equipment
- 17) User interface(CPO, gears and leavers, feedback from the machine,confusion)
- 18) Health hazards(occupational)
- 19) Accident and emergency situations
- 20) Responsible persons for the above question
- 21) Other machines he worked on
- 22) Did he identified any fluctuations in Performance levels
- 23) Maintenance and tooling (frequency)
- 24) Complaints regarding the equipment he operating
- 25) Safety and security

Interviewing the User



Mangal ravat , 25 Operator

Working for : chamunda const. Equipments , Powai

Edu. Qualifications : high school discontinued

Pay: 6,000-10,000(depends on work)

Works on: backhoe loader

Also familiar with: truck,bus,excavator,crawler excavator

Type of work: construction,gutter,mining

Experience: 4 years

Work timings: 8 hours(daily)

Max work does : 150hrs continuously

Back ground of becoming operator : fascinated at the age of 18 and first choice of employment is const. Equipment.



Jogeshwar , 21 Operator

Working for : New India const. Equipments, kolaba

Edu. Qualifications : metric

Pay: 7,500(depends on work)

Works on: backhoe loader

Also familiar with: truck,excavator, TATA,LnT

Type of work : roads and construction

Experience: 5 yrs (3yrs as operator)

Work timings: 8 hours(daily)

Max work does : 36hrs continuously

Back ground of becoming operator : as his brother is an operator he worked as "helper" to him and learnt the skill of operating . Feels very proud to tell his friends that he operates "JCB".

User

- Becomes operator only after getting trained as helper.
- Tremendous and tedious work with entire body moves hither and thither .
- Need to maintain the equipment thrice a day.
- Want to interact always while working (prefers "helper" presence)
- Prefers entertainment related to reduce monotony (FM radio etc.)
- Sleep in between for break and long distance travel
- Doesn't prefer to work in dusty environments
- Doesn't prefer to work on crawler types
- Can not hear the sounds from out side other than machine noise
- Struggles to see the dig locations incase of extendible backhoe
- Refers backhoe loader as JCB
- Feels proud to say that he is operator of JCB
- Strongly believe that work out put depends on man,machine and mitti.

Insights

Maintenance

- Required checking for oil,grease and water at least 3times a day.
- leakages and cracks that are unnoticed results in breakdowns and accidents



CAB

- No accommodation for the second person(HELPER) in the CAB
- No provision for dynamic seating inside
- Seating doesn't allow the operator to sleep
- operator can not do any thing other than operating
- can not protect from the dust ,elergetic, sun , rain and cold.
- not sound proof
- not odor proof
- can not cut the vibration



Visibility

- cant see the work location beyond 10 feet.
- worse when working on depths and with extendible backhoe



User interaction

- no feed back regarding the work load fluctuations
- no feed back from the bucket interruptions while digging
- no feed back for machine failures ,leakages



Accidents

- major no of times occur because of poor maintenance (depends on the helper)
- demands human intervention from time-to-time



Product considerations

- **Functional**

functional attributes that strongly affect the consumers reaction are to be designed in harmony with the final appearance by communicating in unspoken ways.

- **Usability**

Providing the user with the maximum possible convenience and the comfort while interacting with the equipment with substantial reduction of intervention.

- **Ergonomical**

For allowing user to interact most comfortably and safely with appropriate freedom and feed back .

- **Aesthetic**

To impart a new feel to the equipment with a strong and successful visual language that speaks out its intended function and the characteristic features of the equipment

- **Manufacturing**

use of contemporary materials and processing and achieving wide range of benefits

Weight reduction,

simplified assembly,

corrosion free components,

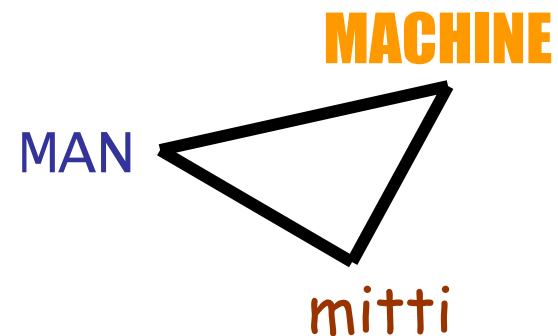
enhanced performance,

high durability and high strength-to-weight ratios at significantly lower over-all cost than steel or aluminum equivalent

plastics and composites (SMC,BMC)

RRIM,RTM

- Efficient work **out-put**
- Skilled, **active, healthy** and **enthusiastic operators performance**
- Skill and talent is converted in to creative performance only with **effective working system**
Supporting environment
Comfortable, energetic and
Interactive environment
- A well designed equipment which will **accommodate** the functional requirements of the different users **when ever it is intended** to be used



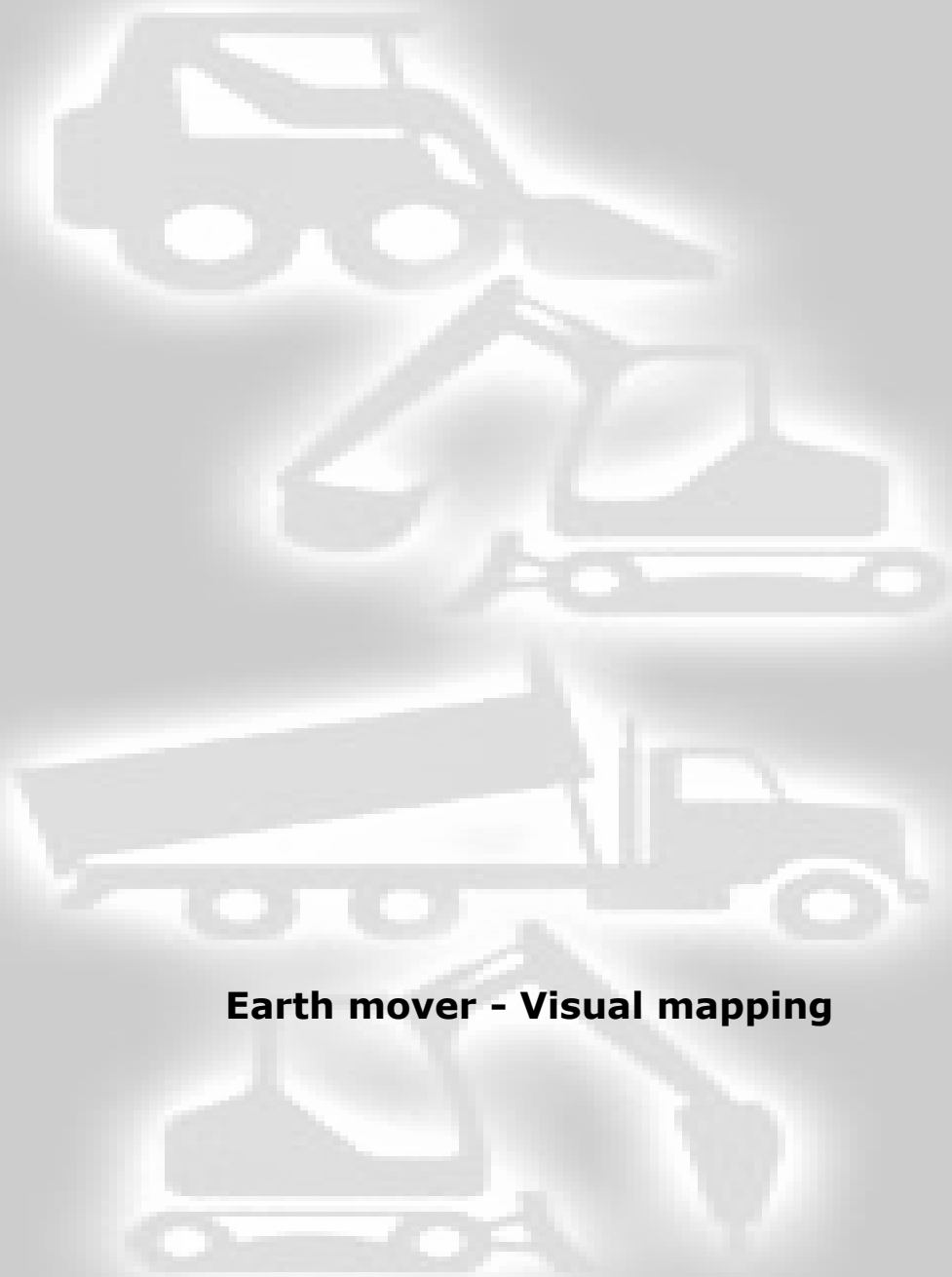
Why styling??

- A)** typicality (proto), average ness, or familiarity,
- B)** novelty or originality.

- Designs are quickly moving from **(A)** to **(B)**
- Industries to compete in global market.
- Novelty in designs are the crowd pullers and dictating the users decision
- Same category products are identical in technological performances
- User perception of the product depends on the aesthetic and emotional pleasure
- Technology driven product design does often not fit with real user needs and concerns.
- Design is developing the industrial vehicles that are just as pleasing to the eye as they are practical.

"From cameras to cars many different products are largely accepted world wide-industrial vehicles are no different"

—Gregg Montgomery, Montgomery design international (MDI), Westmont, Illinois



Earth mover - Visual mapping

Earth mover - Visual mapping



To understand.....

- the aesthetics of the earth mover and the styling implications,
- This influence from the products around
- influence of the whole psyche of automobile culture.
- to gauge the difference between a tractor and automotive interior or even the quality
- This increases the awareness of the interesting techniques,
- methods and materials from other industries.
- to relate the earthmovers with other category of automobiles and with other vehicles of the same category in terms of aesthetics.
- helps in generating the new visual language to the earthmover.

Public



Industry

Load
or work
capacity

Group



Personal

Individual



Place of earthmover category in transportation design

Society

Industry

Design And Styling of Earthmover



Agricultural



Construction



Mining



allowing effective, well-balanced use of both hands and feet.



Earth mover segment detailed



Load or work capacity

Dumping



Futuristic

Contemporary

In market

Yester year's

Mighty giants

Visual element – 1 : Front Bonnet



Ford



CAT



CAT



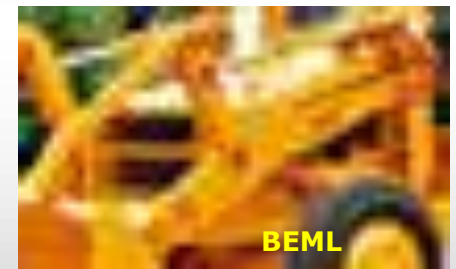
Cummins



JCB



JCB



BEML



Futuristic



Contemporary



In market

Yester year's

Visual element - 1 : Front Bonnet



Futuristic

Contemporary

Visual element - 2 : Cabin



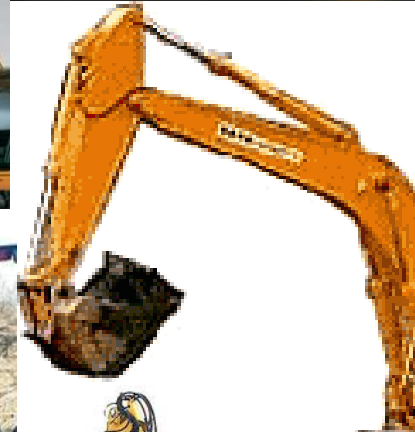
Futuristic

Contemporary

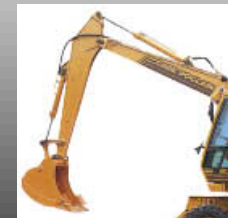
In market

Yester year's

Visual element - 3 : Boom



Ingersoll-rand



Futuristic

Contemporary

In market

Visual element - 4 : Loader



CAT



KOMATSU



Terramite



FORD



Kubota



CASE



BEML



Cummins



Derre



JCB

Contemporary

In market

Visual element – 5 : Tyre



TG Mockup



Futuristic

Contemporary

In market



Futuristic

Contemporary

In market

Yester year's

Mighty giants



Futuristic

contemporary

In market

Yester year's

Mighty giants

Target segment

Futuristic

contemporary

In market

Yester year's

Mighty giants

Identifying the need segment and benchmarking

VOLVO

NEW HOLLAND

CATERPILLAR

KOMATSU

VOLVO



VOLVO



- Volvo's construction equipment is styled with no sharp edges providing the visual convenience with contemporary look

- The cab structure has more of glass area with reduced clutter that obstruct the vision of the operator .with dual entry,pressurized,with deluxe trim,tilt steering column designed for the friendly environment inside the cab.

- The backhoe boom is designed with curved structure for enhanced performance and not fouled by the bucket while curling and includes switch activated hydraulic boom and swing locks.Allows greater range in loading trucks, less risk of boom damage from the bucket curl and improved load capacity.

- Ergonomically designed interiors.With joystick control human intervention is reduced and provides a better control.

- Interesting storage spaces in the vehicle for battery and tool kit.

- Strongly making a statement of purpose that what it can do and for what it is intended to do.

NEW-HOLLAND



TG Mockup



Montgomery Design International 3/20/01

Designed classically with a purpose making the strong statement of its functional use. The main contributing elements for the body language are the Tyres, curved bonnet and the cab. Implementation of new manufacturing methods and usage of new materials gave extensive flexibility for the design that is as pleasing to eye as it is practical.

Tyres are the major visual features expressing the strength and stability of the earth mover. fairly proportional and well balanced form makes it look consistent and appealing.

The bonnet is designed with a touch of intelligence assembling elements so that vehicle look rich in terms of visual language speaking out what it is for and what it can do .

A perfect balance between the bookends of appearance and function .



Alias data

Montgomery Design International 1/2001



CATERPILLAR



CATERPILLAR®



Caterpillar is one of the major player in this segment for its versatility of work. Well balanced form elements with all moving arms getting together for a purpose. curved boom design and strong loader bucket contributes for a strong visual language .

Strong points :

Available in both CAB and CANNOPE models . Variations in bonnet design color breakup's and flow of form with variations adds up surprising elements and makes it interesting .cross stabilizer legs makes it look more sustained when backhoe at work.

Weak points :

Small Tyres which are not matching with the form intension of the vehicle. There is a subtle expression of the protrusions on the Tyres.

KOMATSU



KOMATSU – a leading manufacturer of the equipment from mini to mighty sizes . The backhoe loader has a proportionality between the Tyres, the stance of the stabilizer legs and simple yet interesting cab makes it stay in the contemporary vehicle segment.

KOMATSU – is the name for its functionality and capacity of doing the wide range of work scale . Visibility issue is taken care of with the increased glass area.

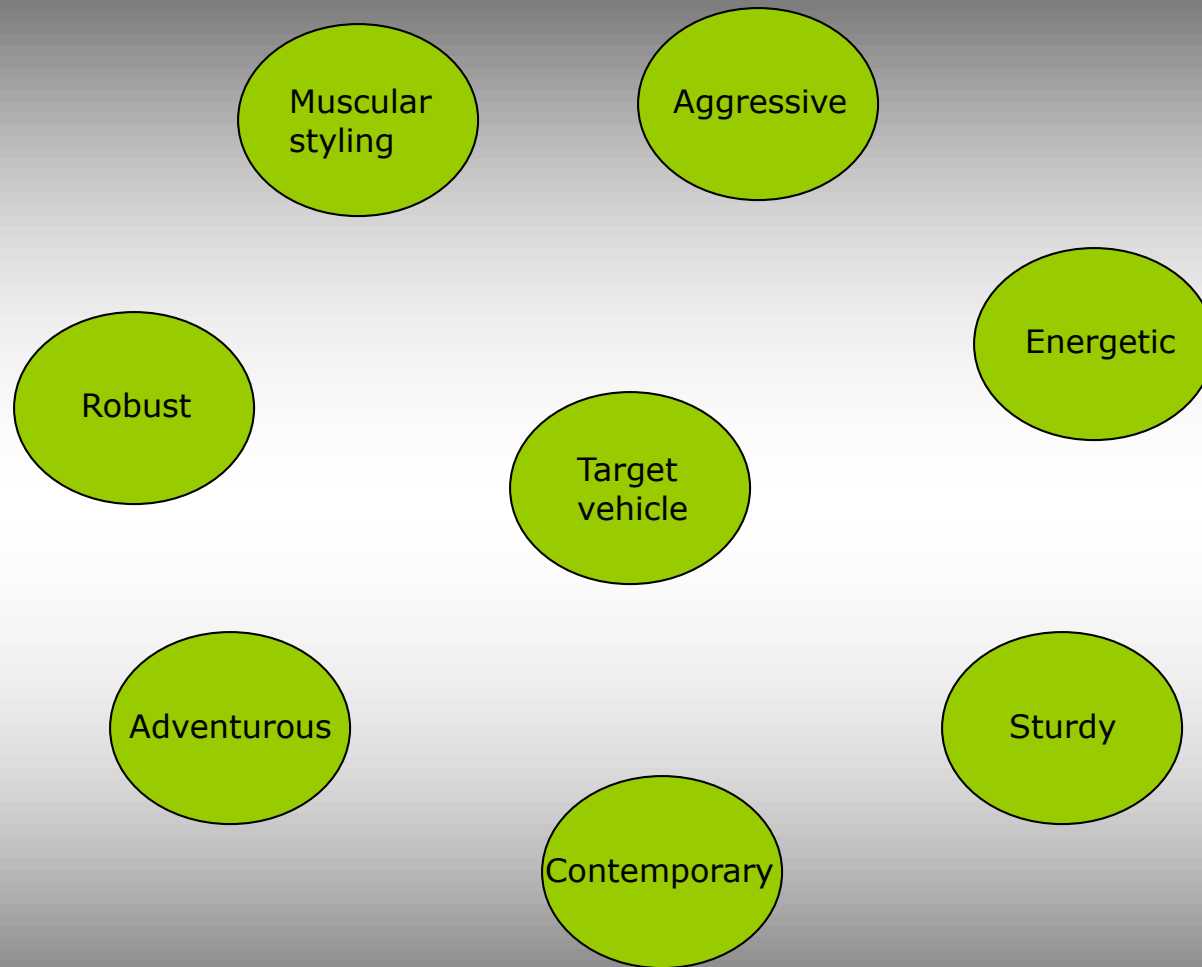
Weak points :

Expression on the front bonnet is very simple and not making a strong statement. Lighting on the cab is too less. Backhoe is not designed with curved boom. Chances of the bucket hitting the backhoe while curling .

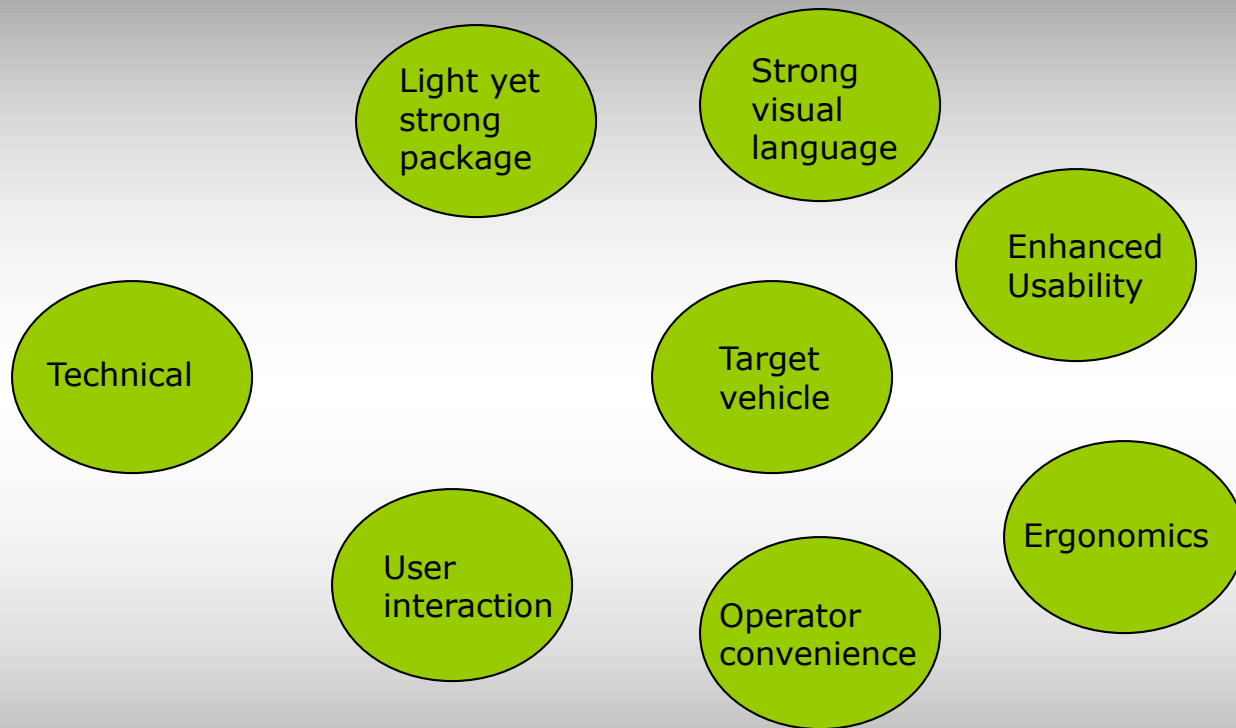


Overall thought there is not much surprising form elements the flow of the same and their placement is consistently maintained . Appearance is not strong as it is practical .

Visual language of the target vehicle



Design considerations for the target vehicle



Project brief

"The goal of the project is to achieve a perfect balance between the bookends of appearance and function and targets to develop the backhoe loader to enhance its service to the user in terms of functionality and user comfort with appropriate feed back and making it just as pleasing to the eye as it is practical."

Conceptualization

Concepts

Functional Concept-1

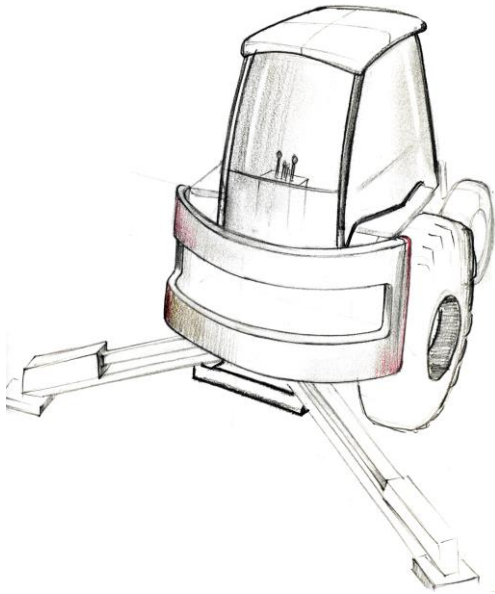
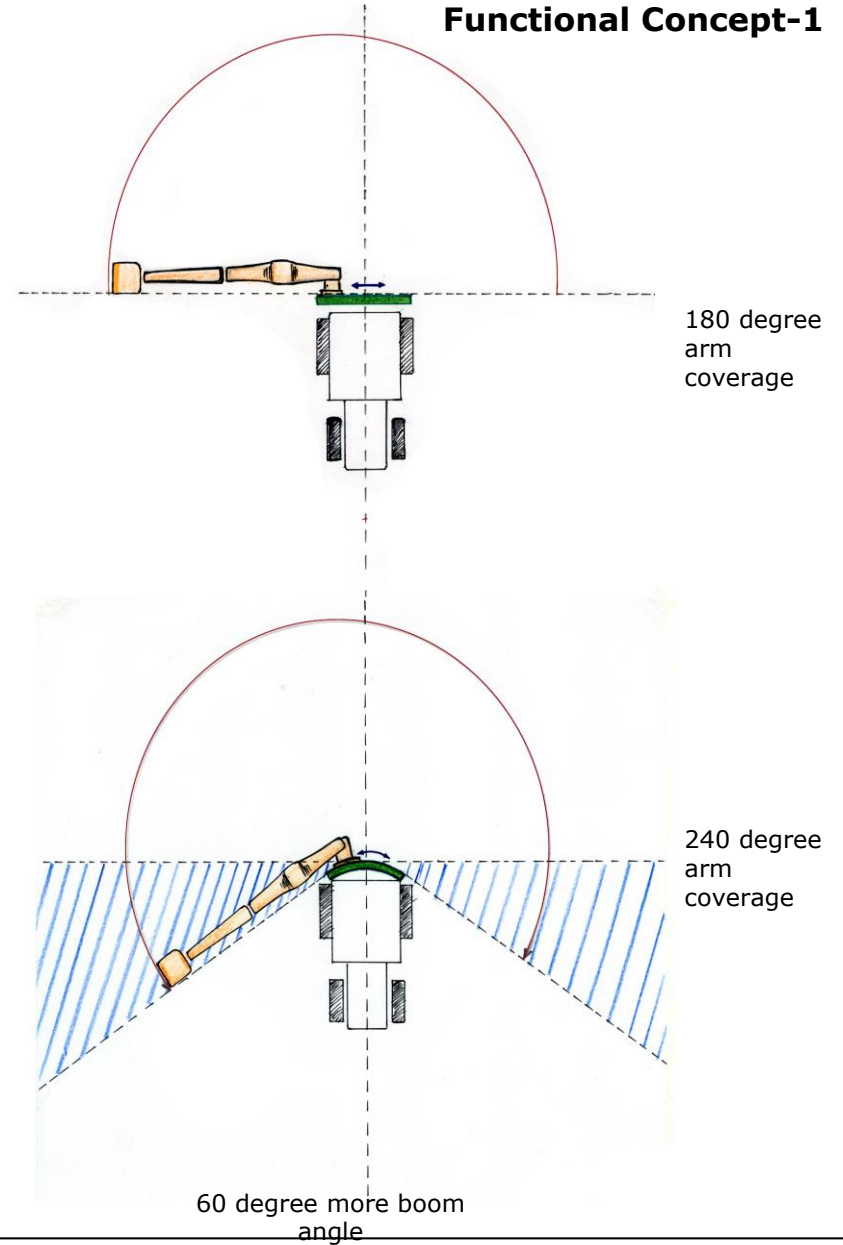


Fig-1

Boom coverage



Functional Concept-2

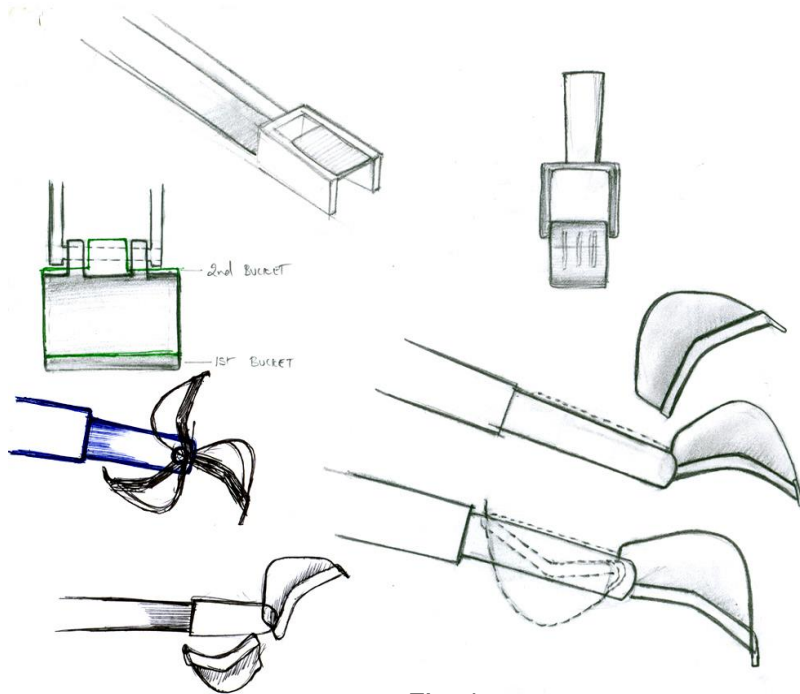


Fig-1

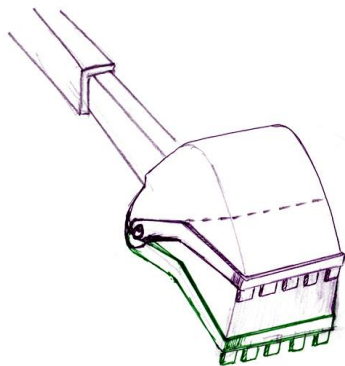
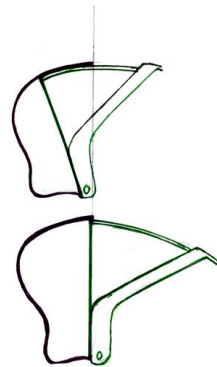
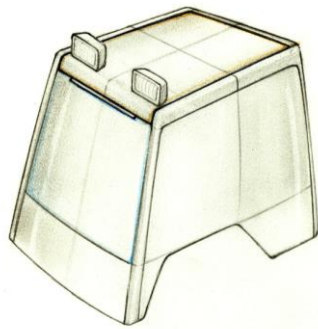


Fig-2

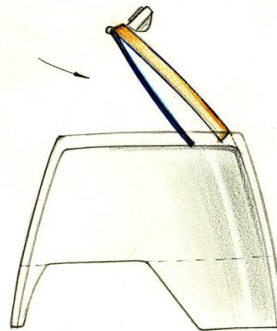
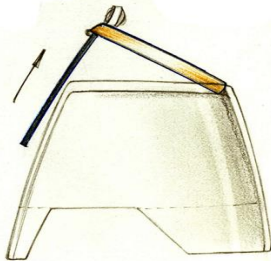
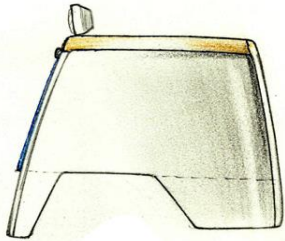
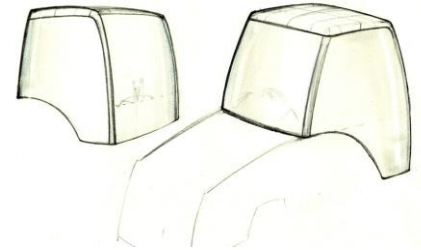
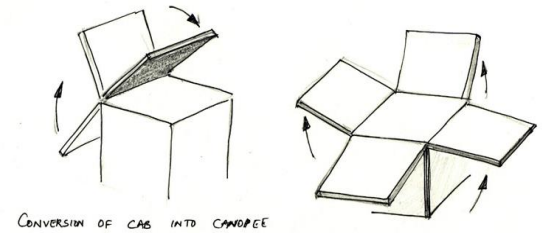
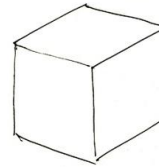


Bucket volume

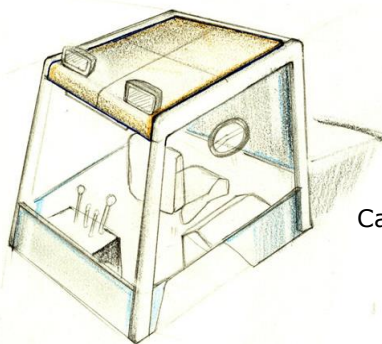
Usability Concept-1



Cab



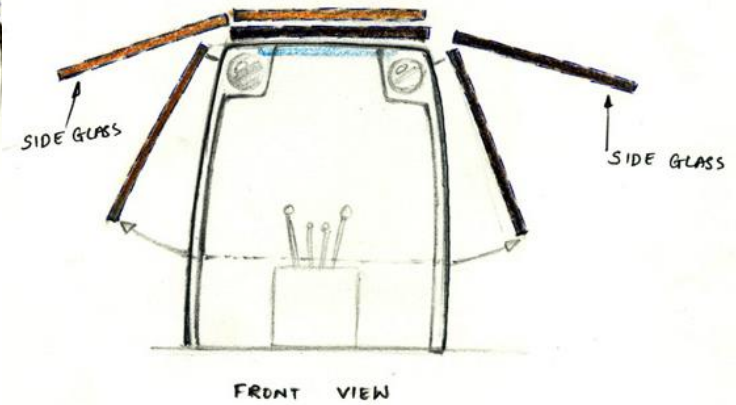
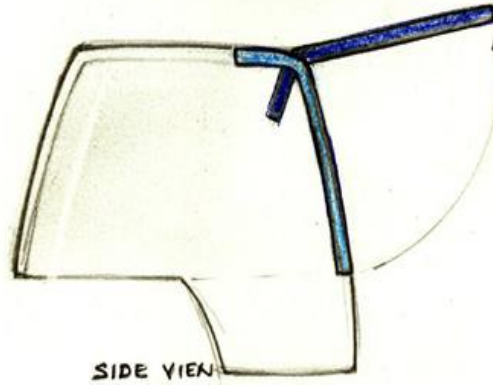
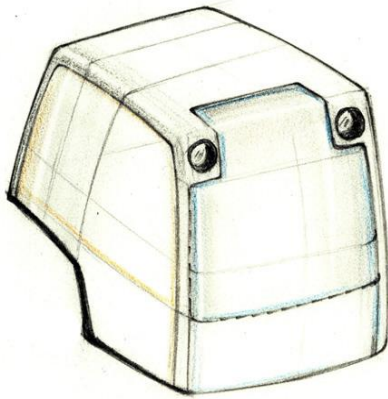
Cab panels are folded up in to a canopy



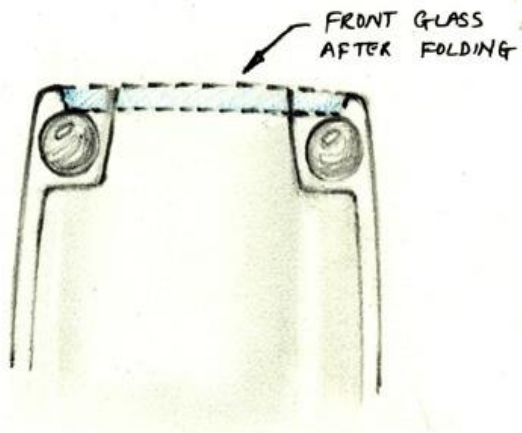
Canopy

Cab to canopy

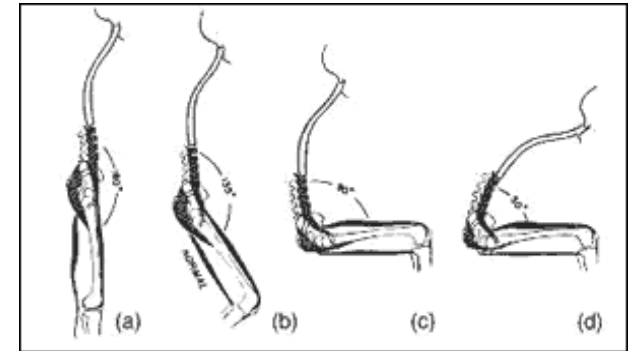
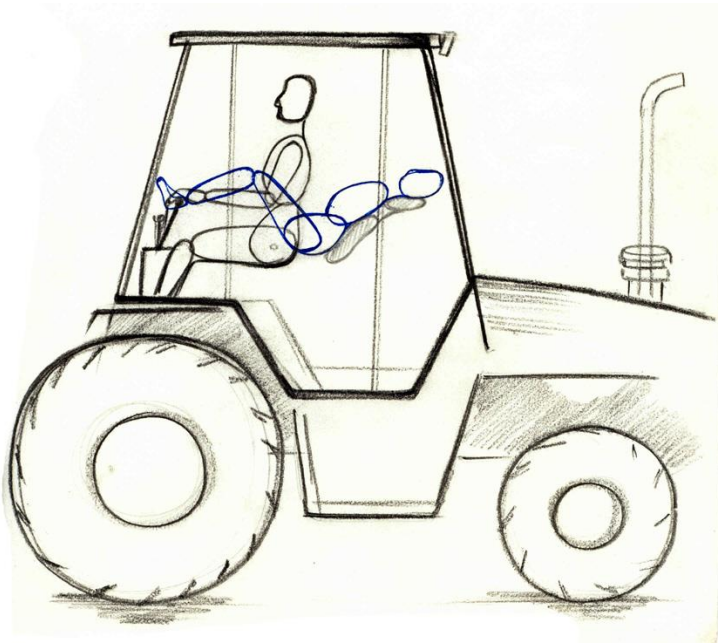
Usability Concept-2



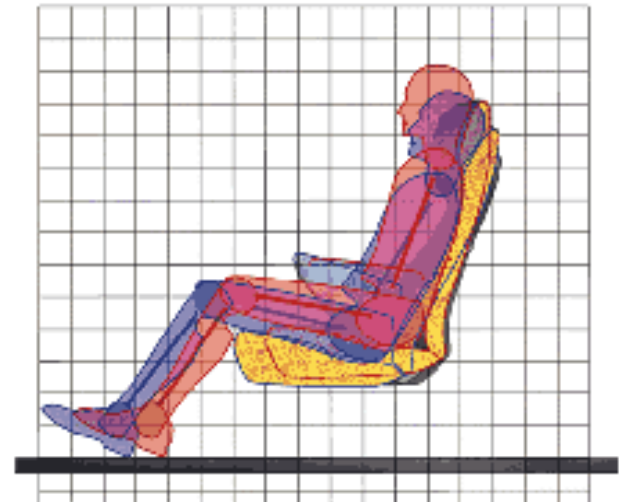
Flexibility in conversion of cab in to canopy



Ergonomics - seating

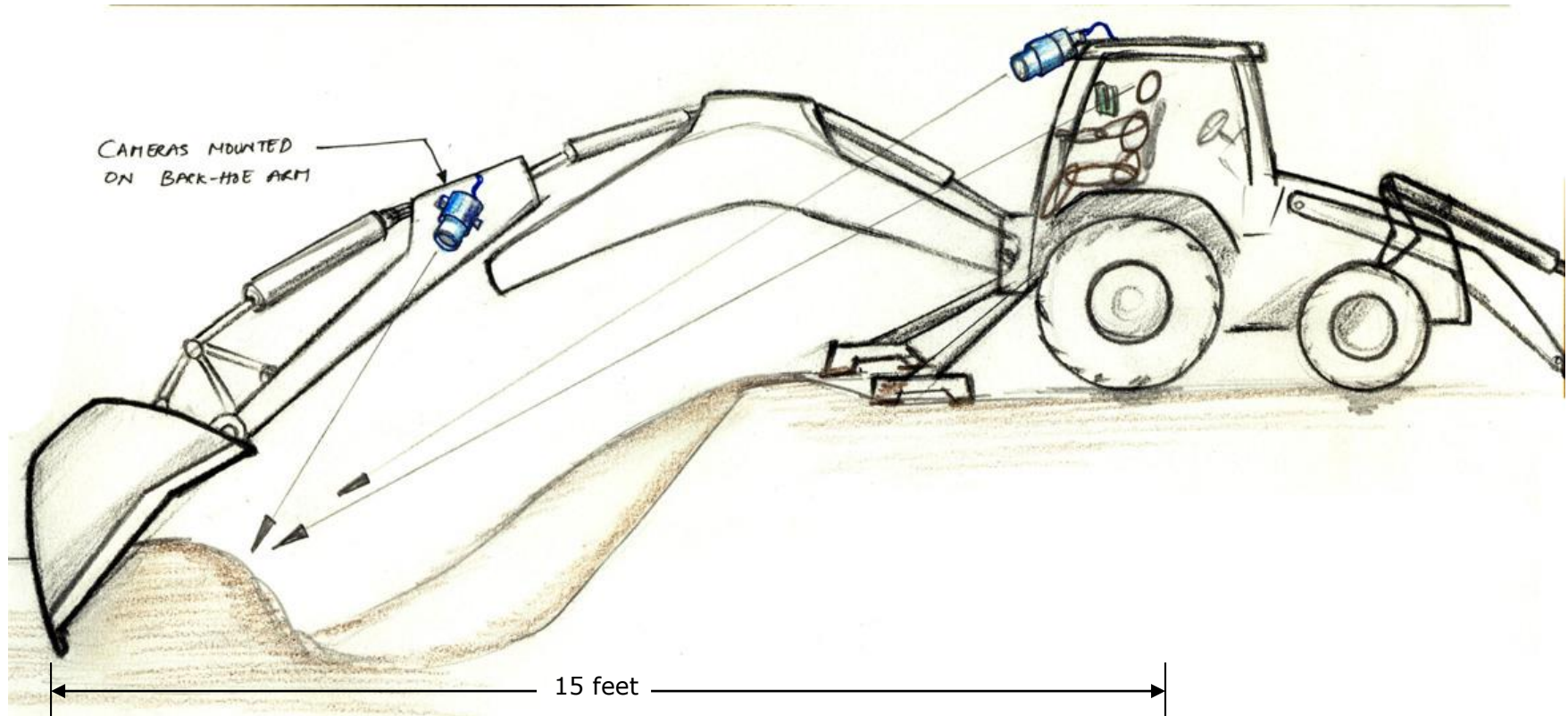


Neutral posture 110 - 135 degree

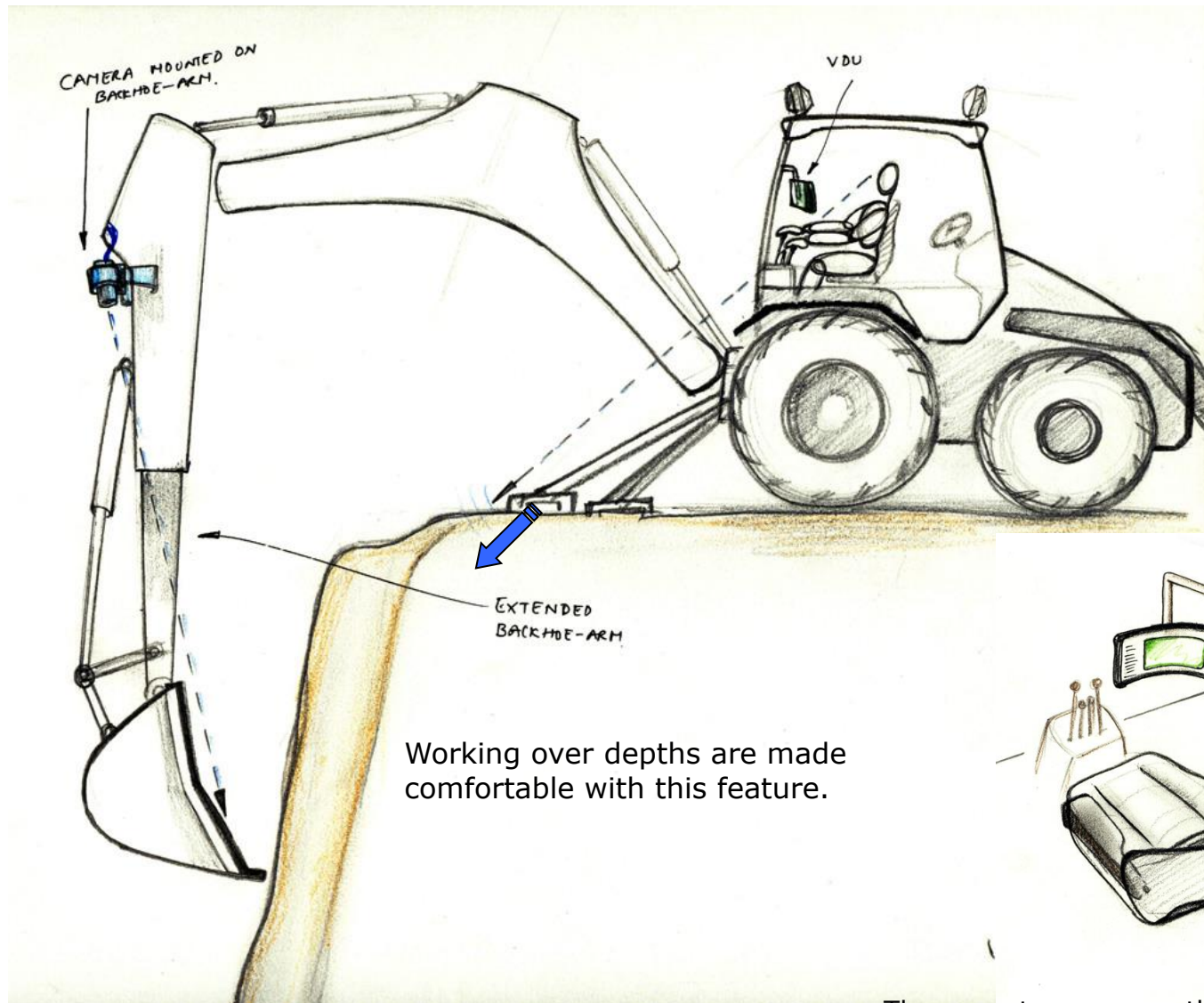


Provision for semi-sleep mode inside the cab

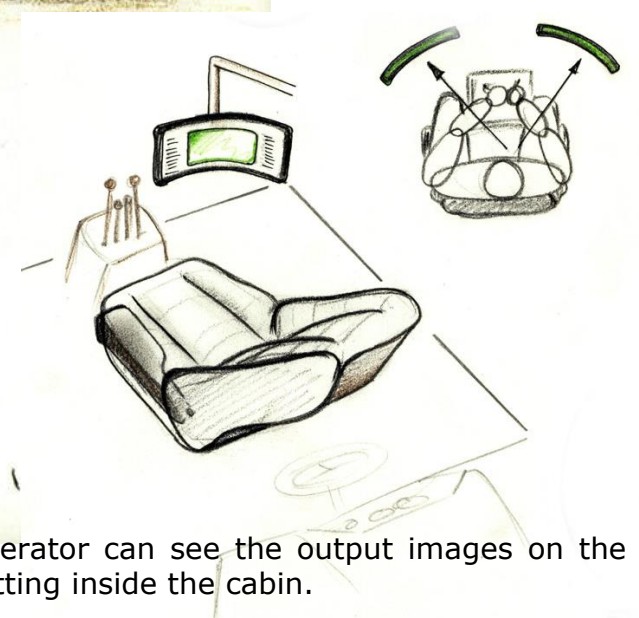
Visibility



Cameras mounted will give closer view of bucket operations

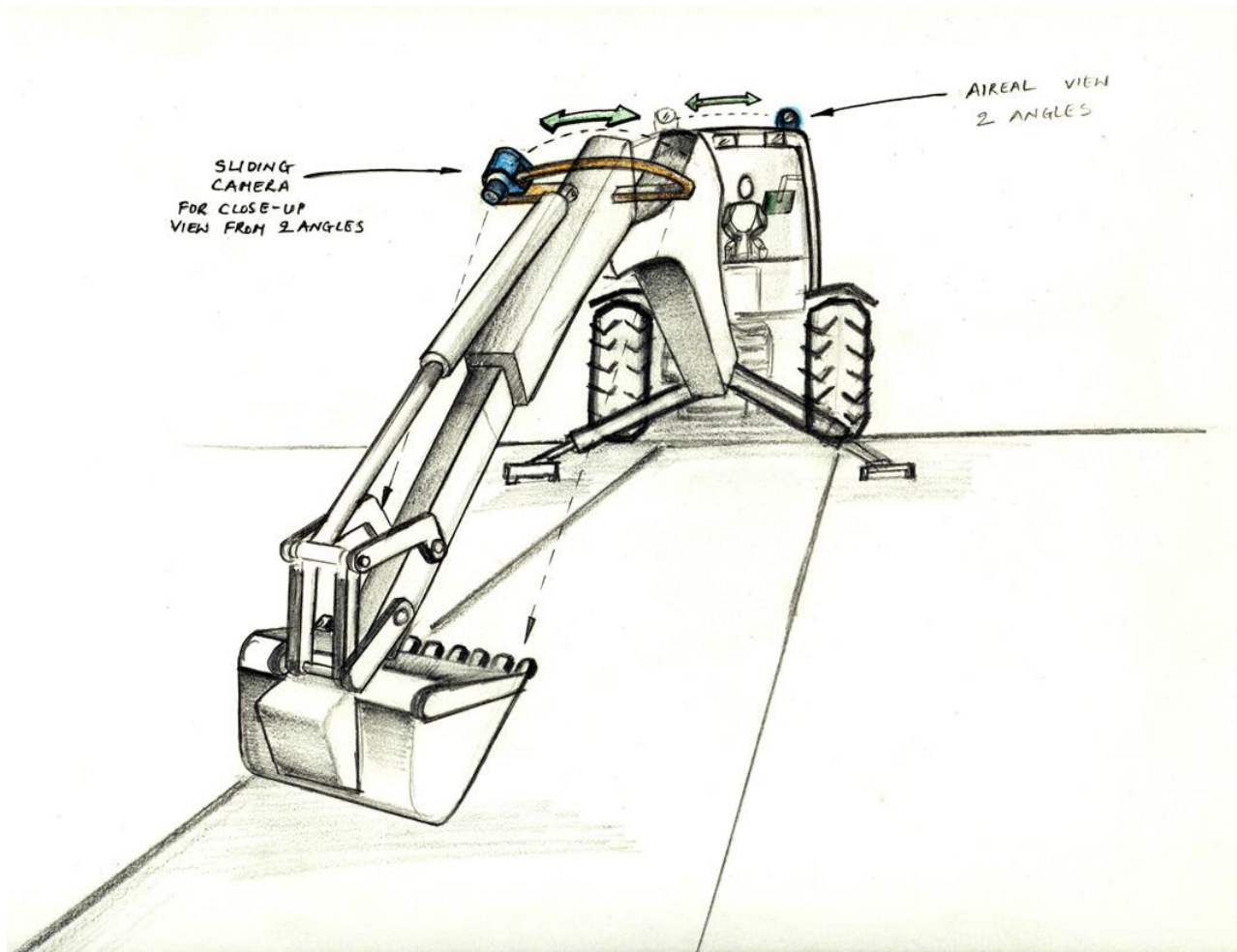
Visibility

Working over depths are made comfortable with this feature.



The operator can see the output images on the VDU sitting inside the cabin.

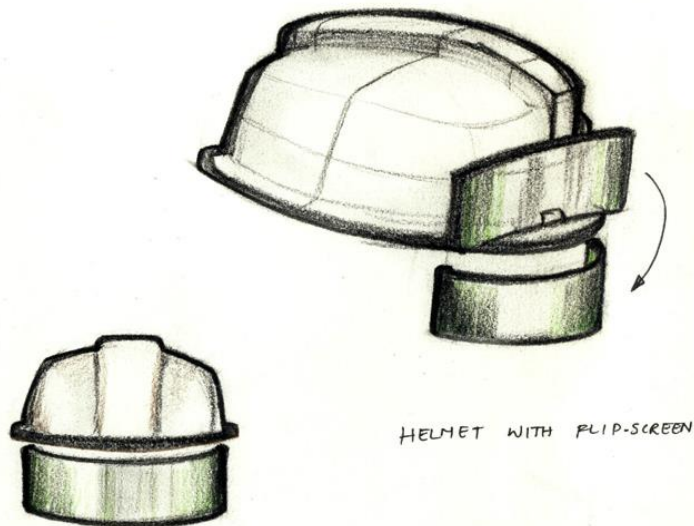
Visibility



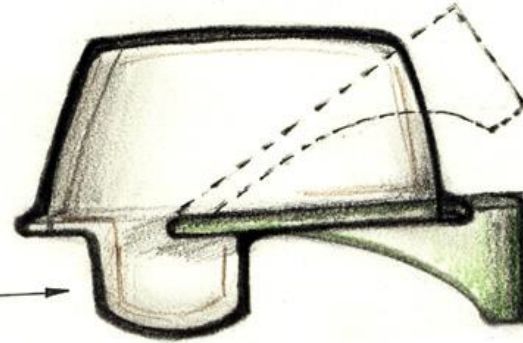
2- Sliding cameras
angles

4 - view
angles

User convenience

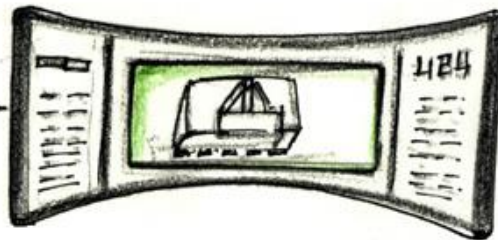


FOR NOISE
REDUCTION



Helmet with the flip-screen
provision

LEAKAGES AND
CRACKS IN
HOSES AND
PIPES
INDICATION



WORK LOAD MONITORING

OIL AND WATER LEVEL INDICATION

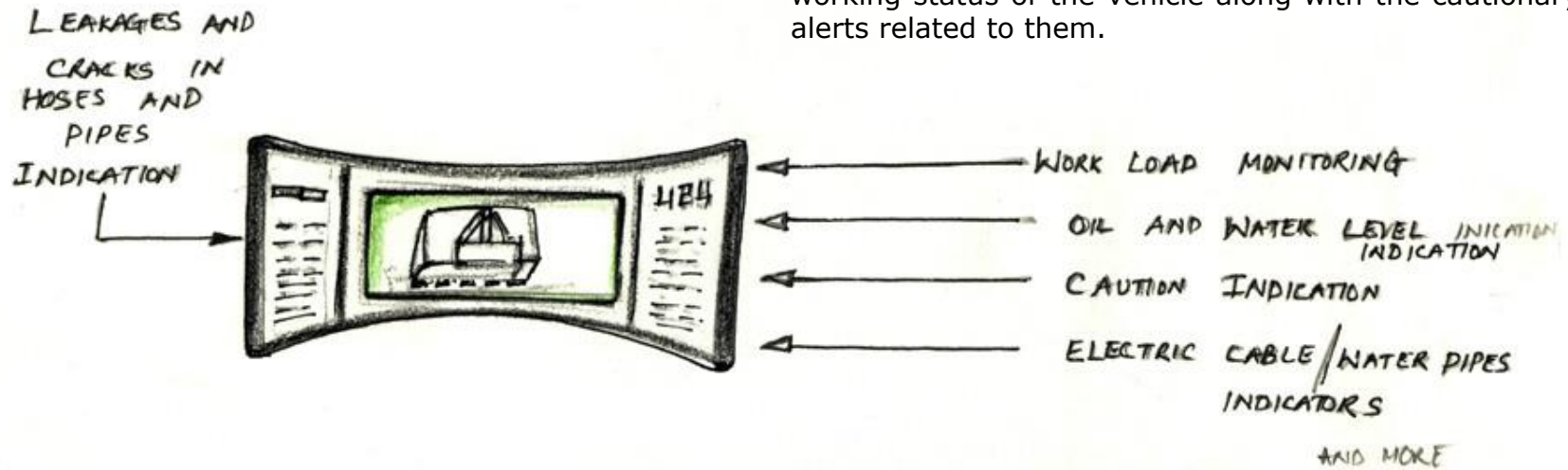
CAUTION INDICATION

ELECTRIC CABLE / WATER PIPES
INDICATORS

AND MORE

Precautionary feed back

VDU displays all the required indications about the working status of the vehicle along with the cautionary alerts related to them.



Feed back

Concept cluster-1

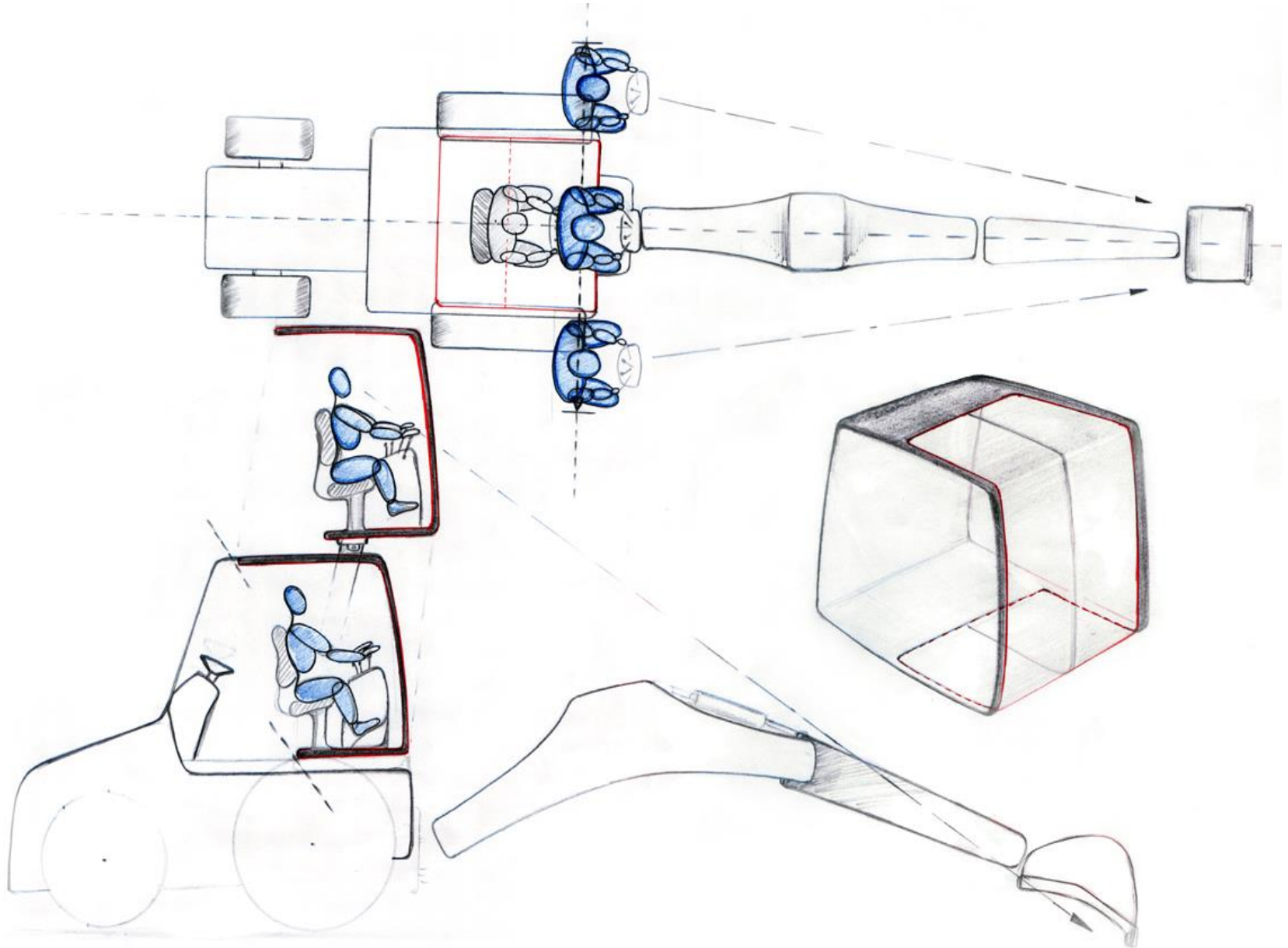


Fig.1

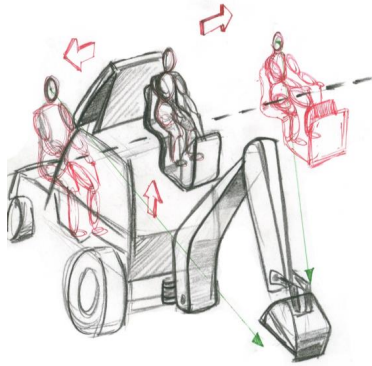
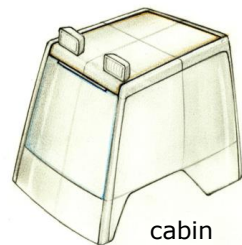
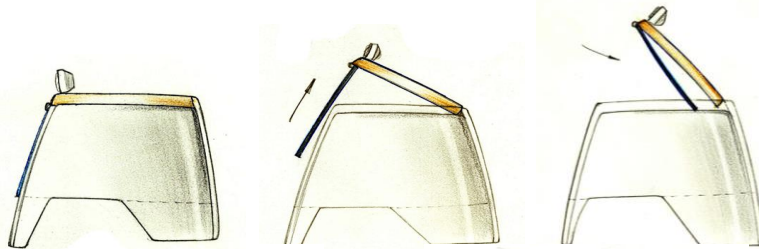
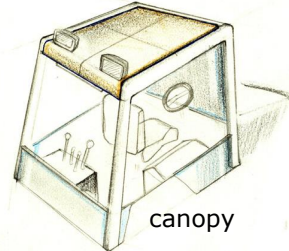


Fig.2



cabin



canopy

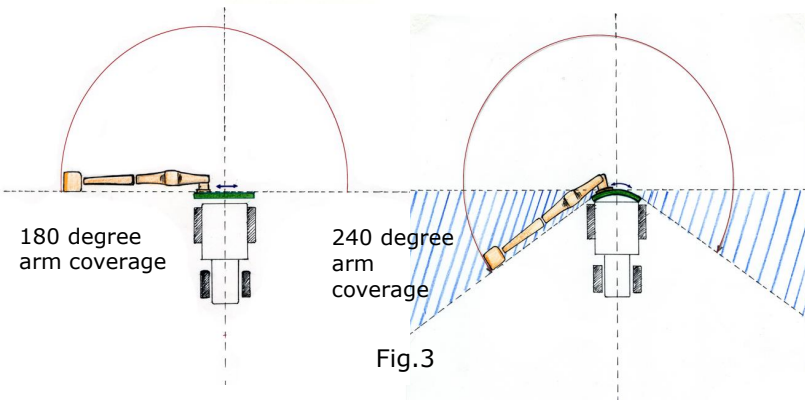
180 degree
arm coverage240 degree
arm
coverage

Fig.3

Other features

1. Visibility :

Predominantly operator moving out of the cabin for better visibility with a seating arrangement mounted over the telescopic arm. Fig.1

2. Cabin :

Small cabin that can be open up the top of the cab and helps the operator to move out.

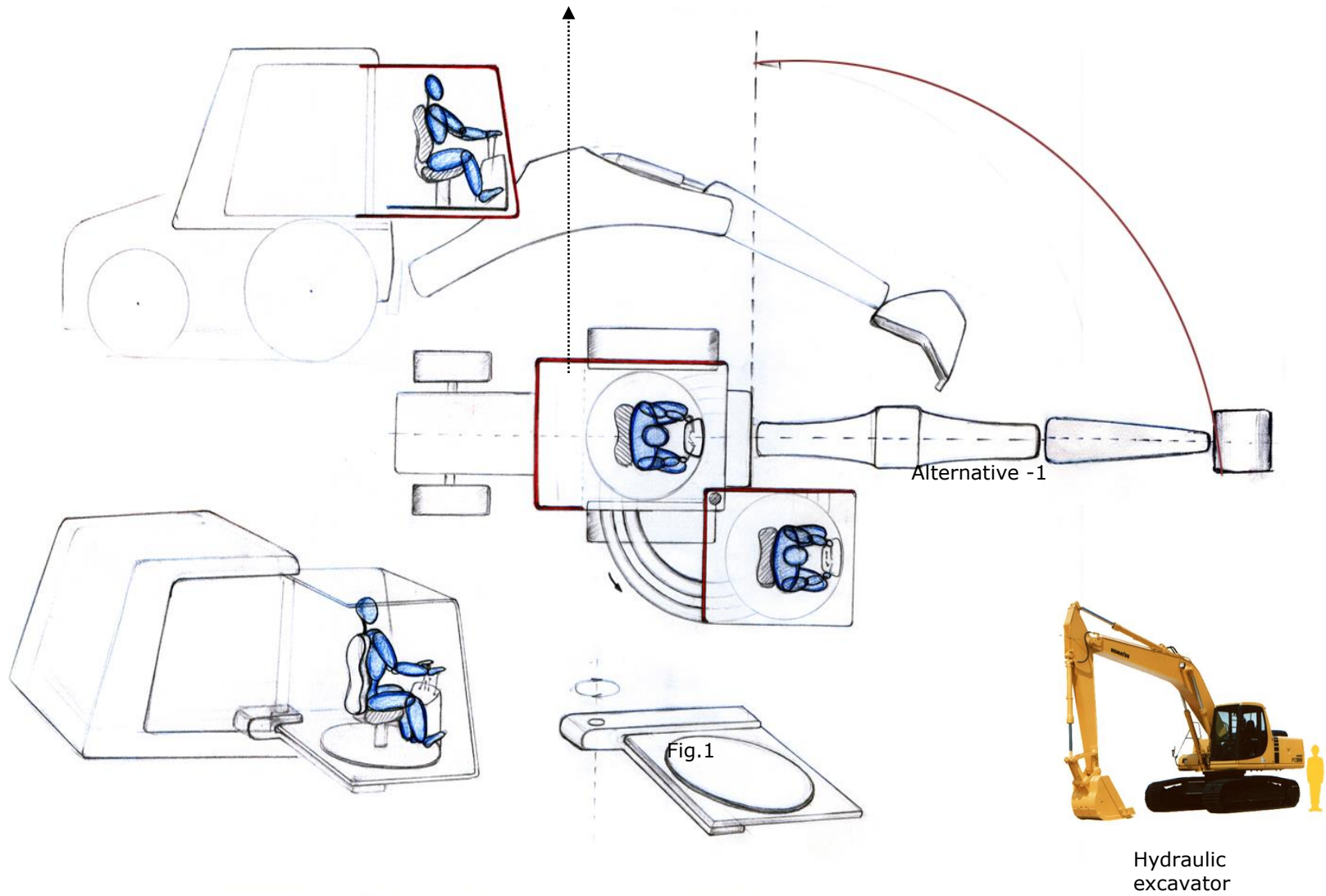
3. Functional :

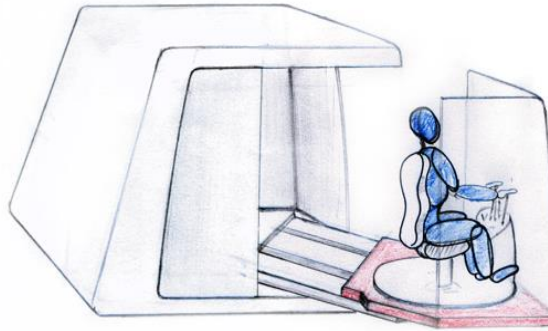
The excavation arm is mounted over the curved slider unlike the straight one, increasing the area of the boom coverage by 60 degrees. Fig.3

4. User comfort:

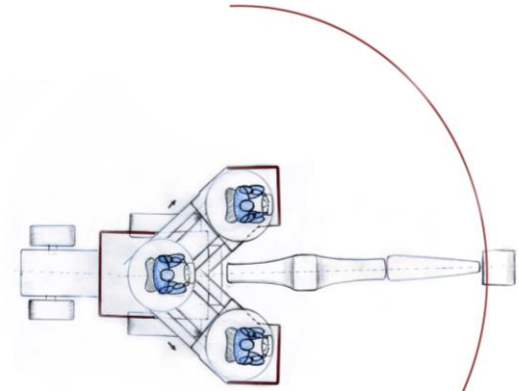
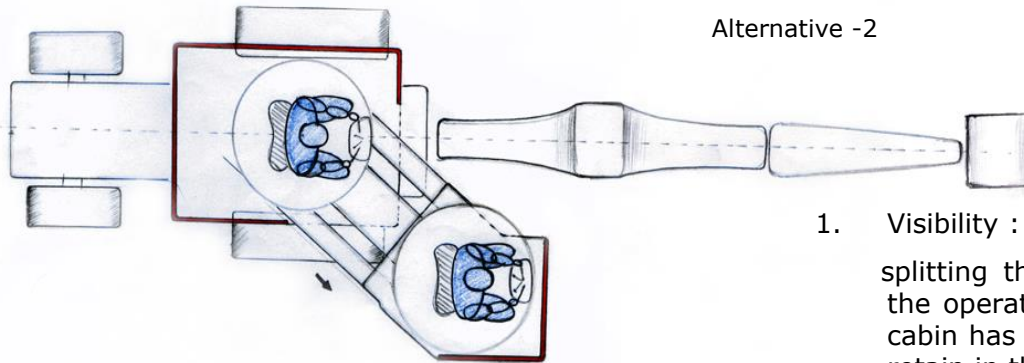
The side glass panes are made foldable making the cab convertible to canopy mode. Fig.2

Concept cluster-2





Alternative -2

**Other features**

1. Visibility :

splitting the cabin and swiveling it to the front, takes the operator closer to the dig location. the base of the cabin has a swiveling platform which makes the user to retain in the same position/direction

2. Cabin :

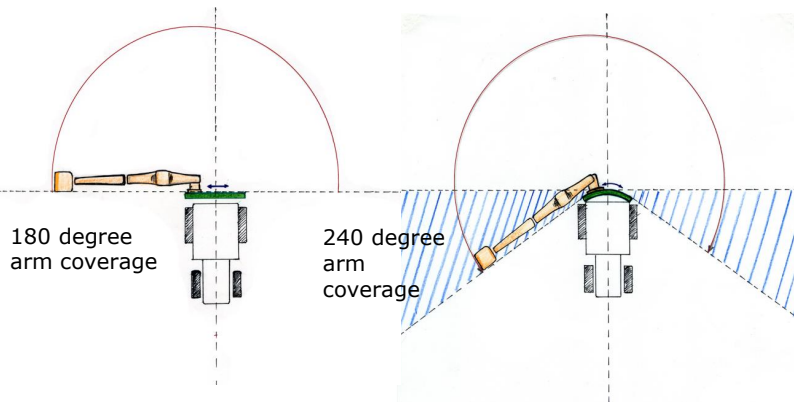
Small cabin that can be split to accommodate the user to move out either by the curved rail (fig.1) or by the sliding platform. (Fig.2)

3. Functional :

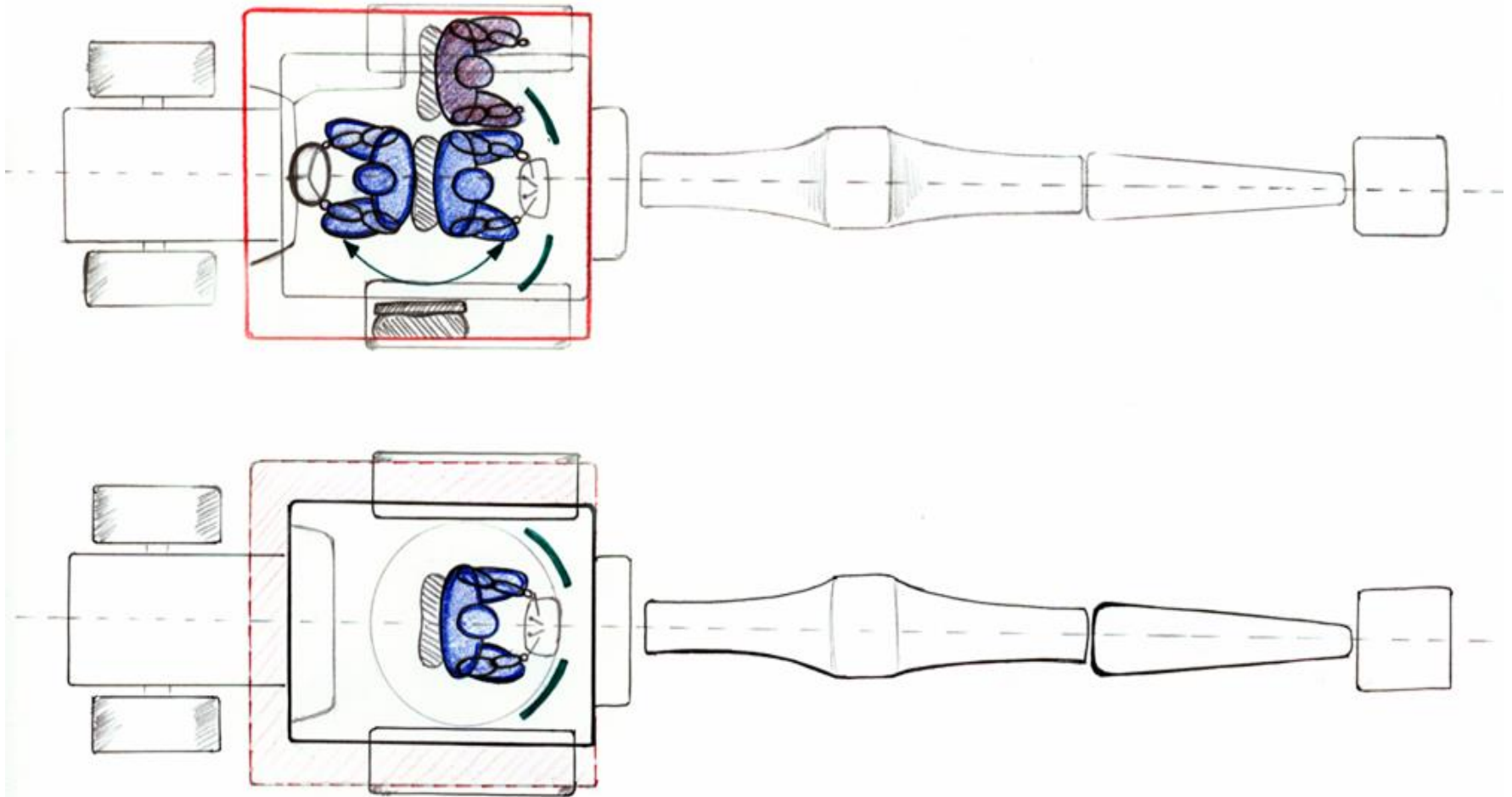
The excavation arm is mounted over the curved slider unlike the straight one, increasing the area of the boom coverage by 60 degrees. Fig.3

4. User comfort:

The side glass panes are made foldable making the cab convertible to canopy mode.



Concept cluster-3



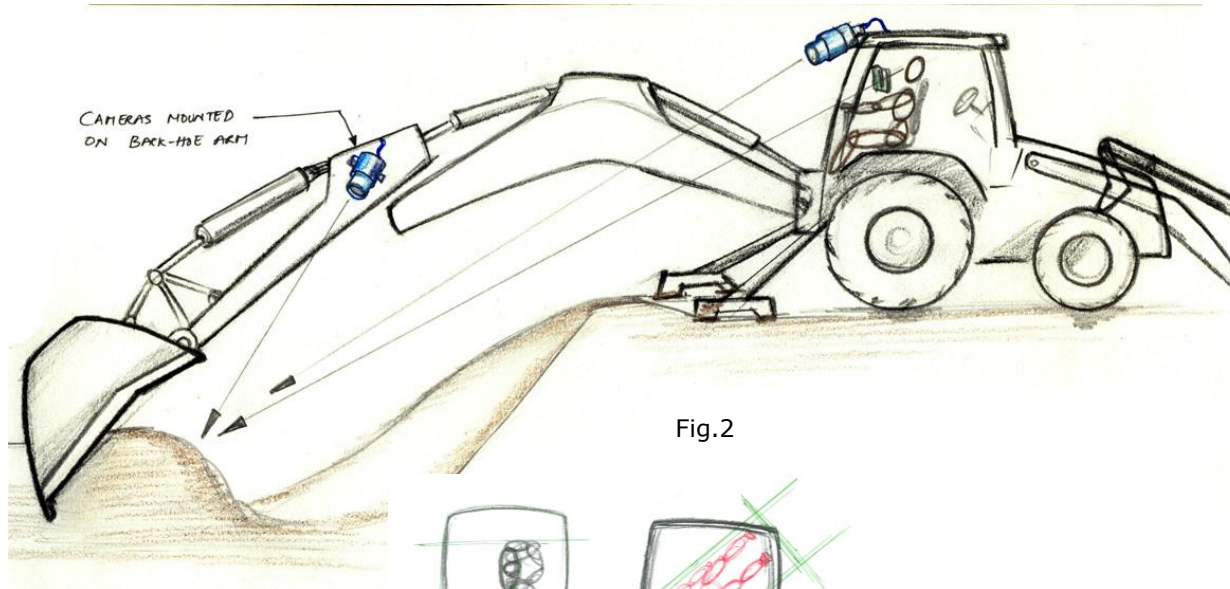


Fig.2

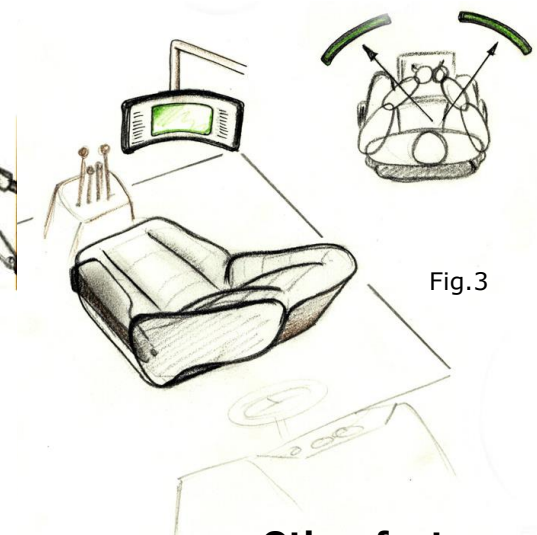
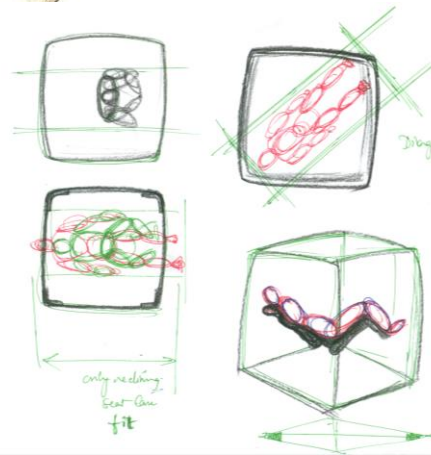


Fig.3

Other features

Fig.4



1. Visibility :

The camera is mounted on the backhoe so that to capture the close-up and aerial shots of the bucket operating location for clarified visibility on a LCD screen inside the cabin. fig.2

2. Cabin :

large cabin with sufficient area for the helper to sit in side. Operator can even sleep in a semi sleep mode.fig.4

3. Functional :

The excavation arm is mounted over the curved slider unlike the straight one, increasing the area of the boom coverage by 60 degrees.fig.5

4. User comfort:

air-conditioned cabin for user comfort and provision for the helper to reside in. fig.1

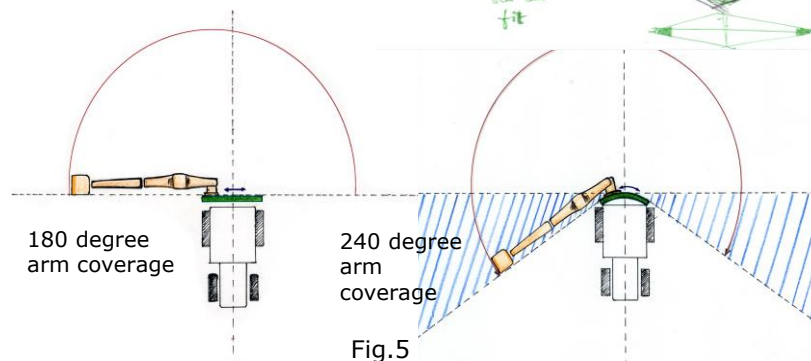


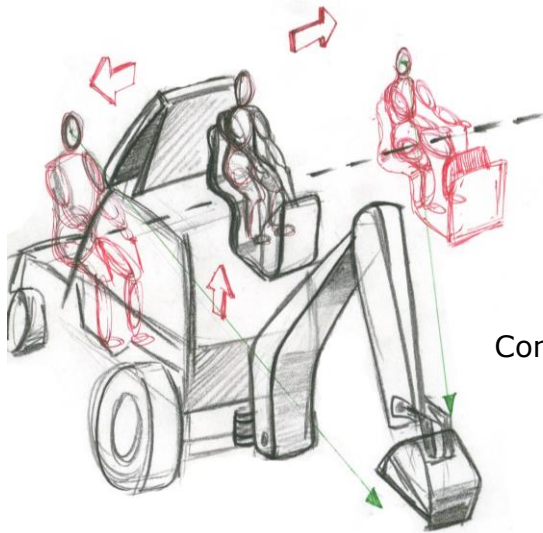
Fig.5

Concept evaluation

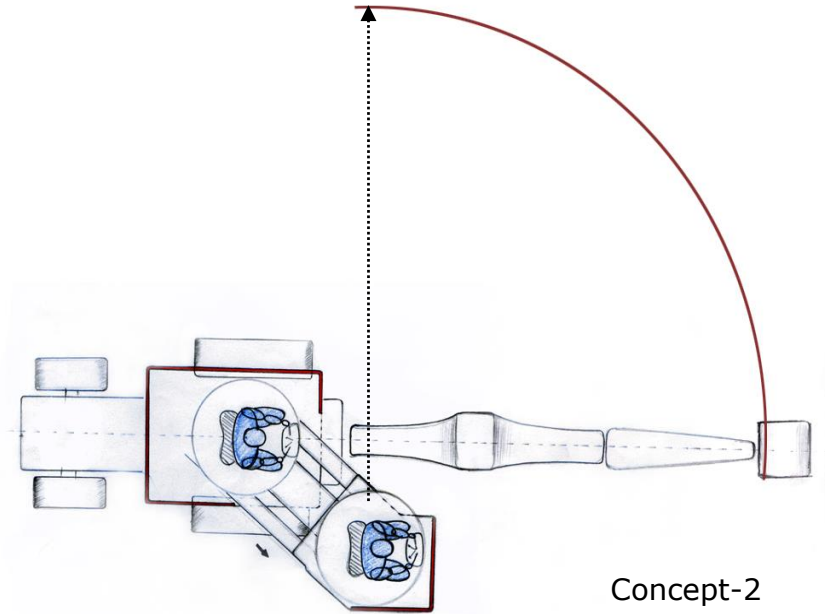
	Concept-1	Concept-2	Concept-3
Visibility	9	7	8
Feed back	7	6	8
Seating	5	6	9
User convenience Cabin/canopy	5	6	8
Bucket volume	6	6	9
More boom coverage	7	5	9
Cost factor	7	3	9
Weightage	46/70	38/70	60/70

All the three concepts were evaluated based on the product considerations listed earlier.

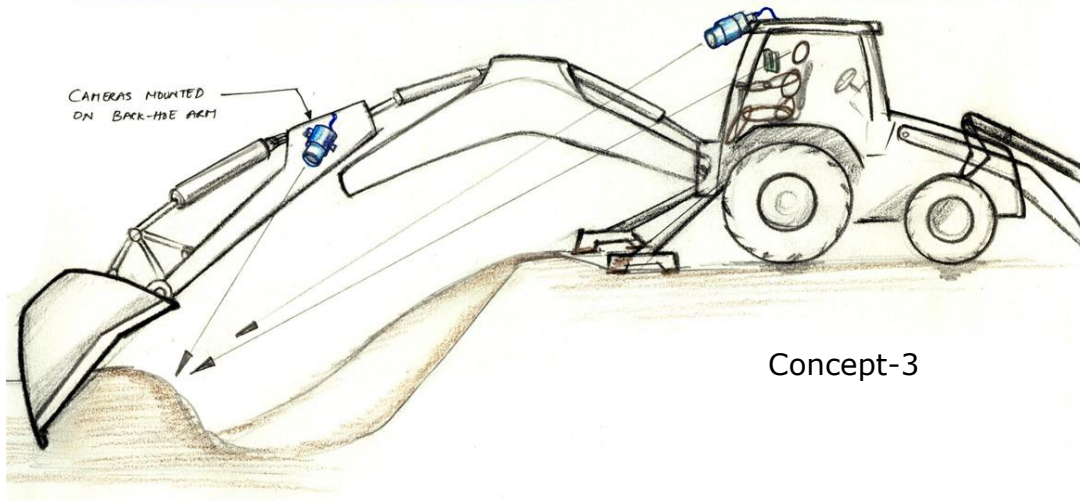
Analysis of concepts



Concept-1



Concept-2



Concept-3

5.5 Chosen concept

Design specifications for the chosen concept

1. Visibility :

The camera is mounted on the backhoe so that to capture the close-up and aerial shots of the bucket operating location for clarified visibility on a LCD screen inside the cabin.

2. Cabin :

large cabin with sufficient area for the helper to sit in side. Operator can even sleep in a semi sleep mode. Sliding doors and netted backing doors for dust proofing

3. Functional :

The excavation arm is mounted over the curved slider unlike the straight one, increasing the area of the boom coverage by 60 degrees.

4. User comfort:

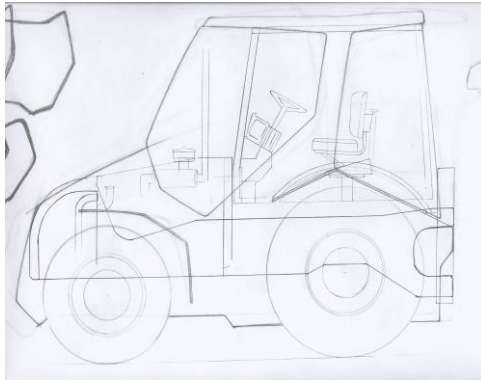
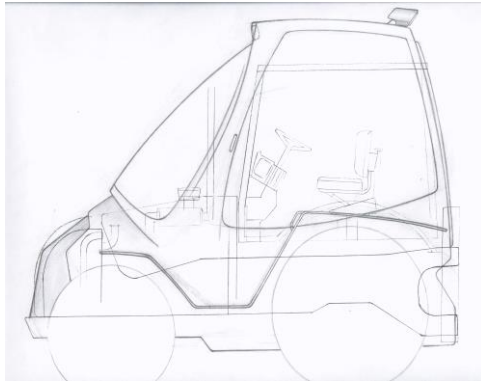
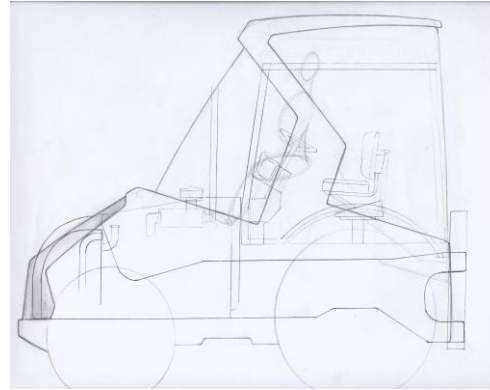
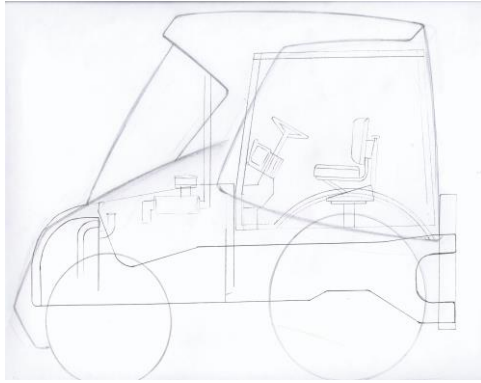
Air-conditioned cabin to make it climate friendly, seating arrangement to enable the operator for semi sleep mode's.

5. Feed back :

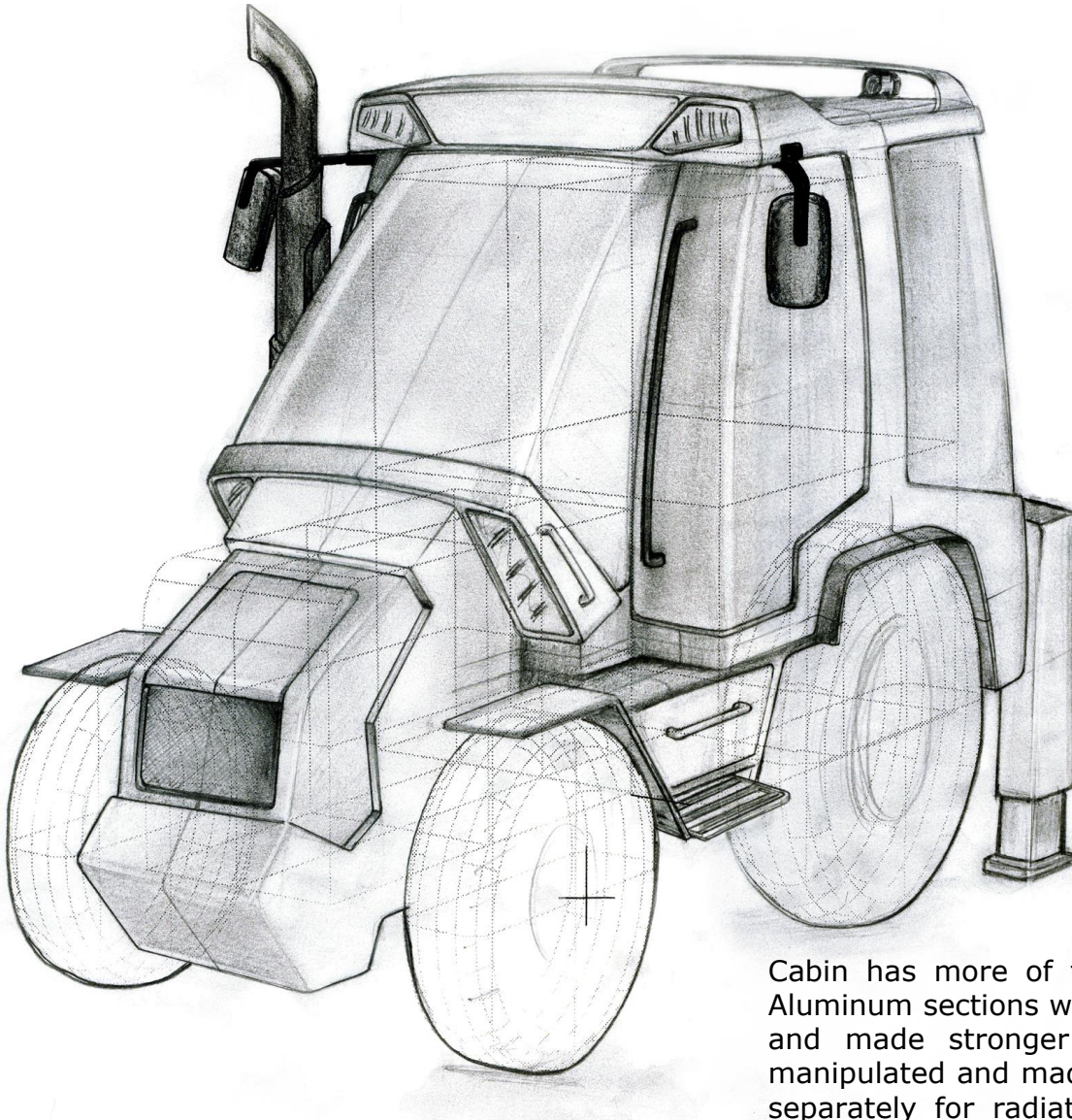
monitoring of cracks, leakages, working load monitoring, oil and water level indications, caution indication, electric cables, water pipelines sensing and monitoring.

Form alternatives – large cabin

6.1 Initial sketches

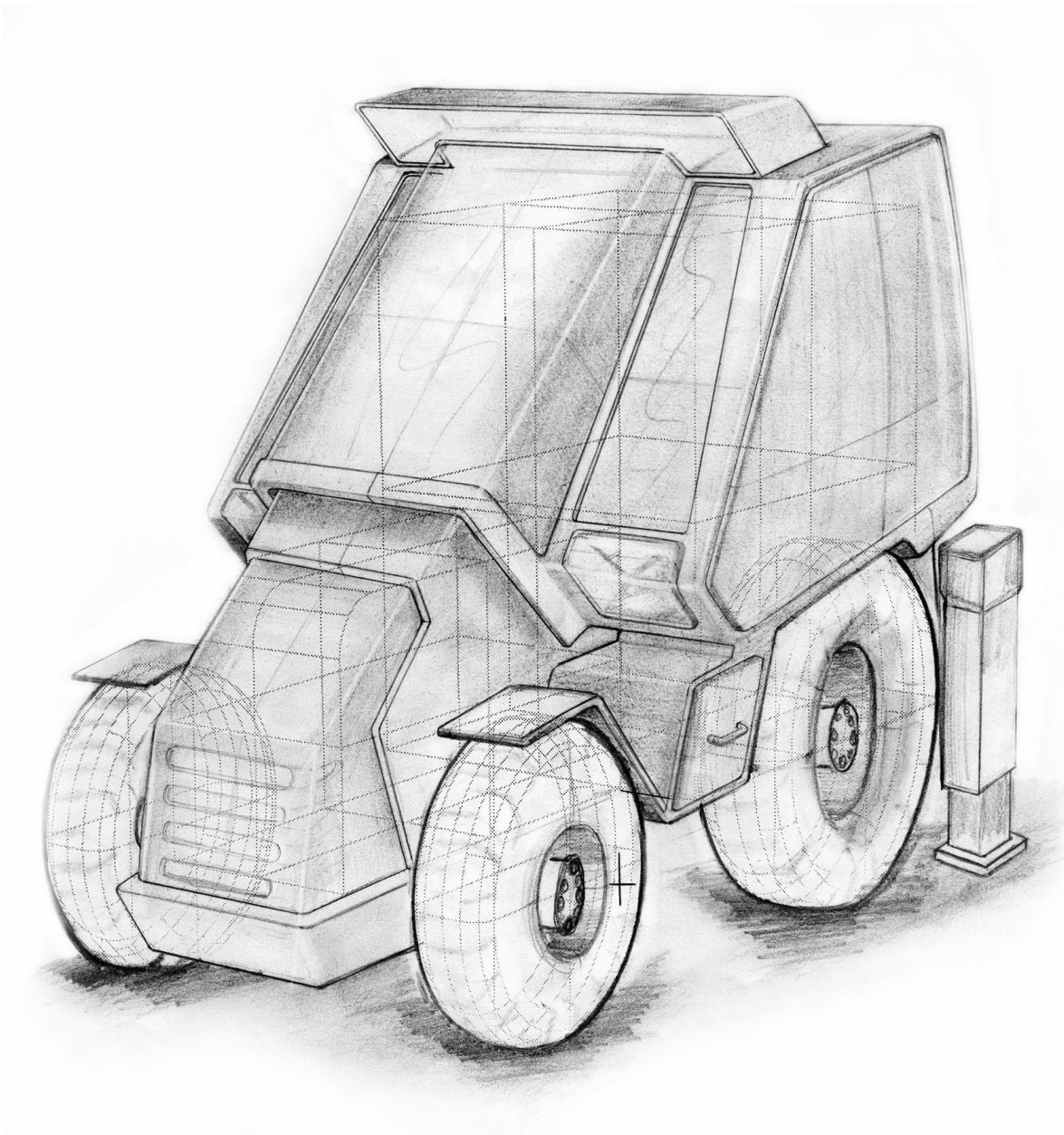


Alternatives are made over the basic chassis and different types of glass arrangements .

Large cabin
Alternative-1

Cabin has more of the glass area to have good visibility. Aluminum sections were removed to reduce the visual clutter and made stronger on the front side. Front bonnet is manipulated and made into a single entity instead of 2 doors separately for radiator water fill and the hydraulic oil fill. Alternatives generated trying out different arrangements of the glass and its supporting sections.

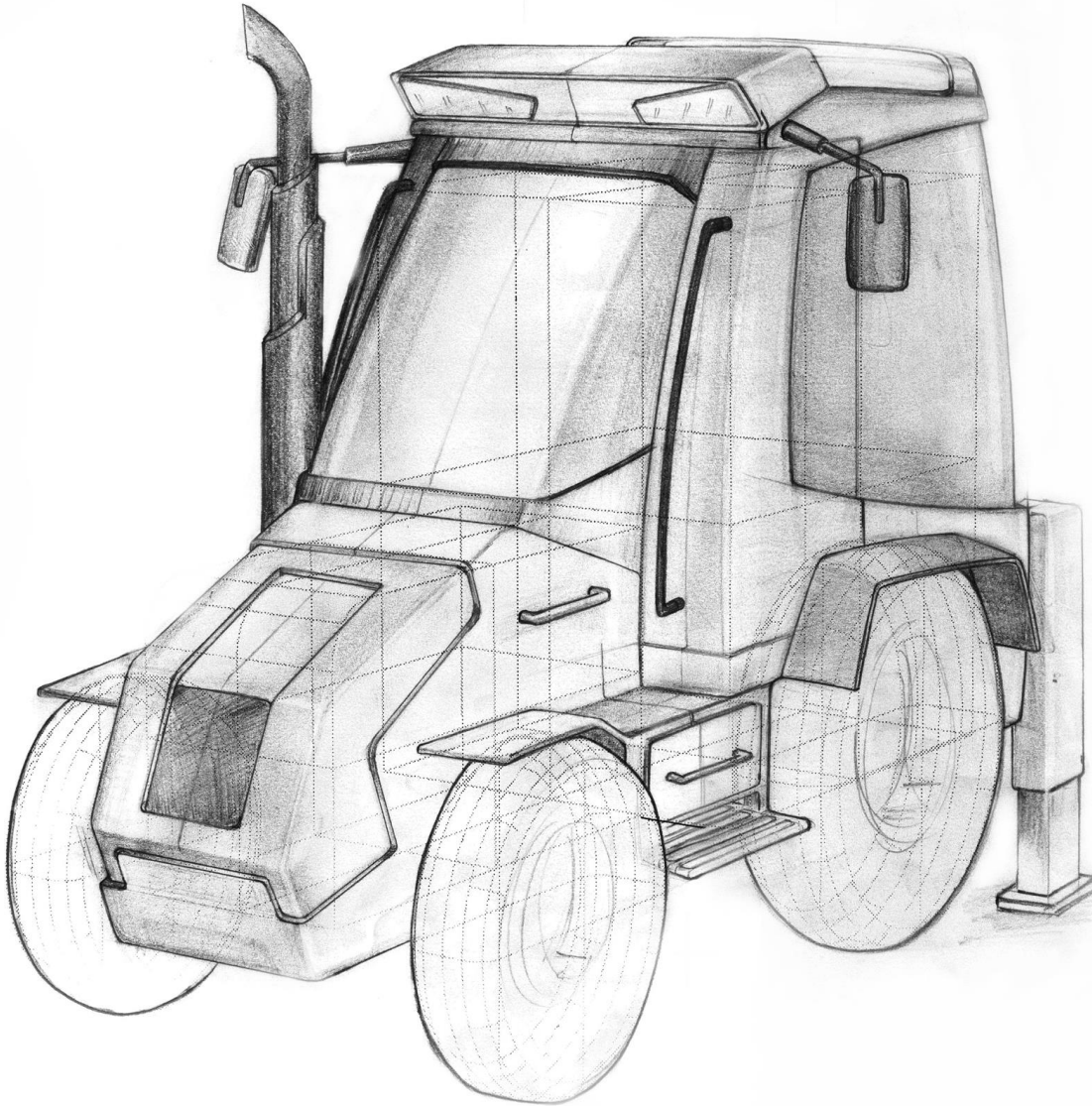
Large cabin
Alternative-2

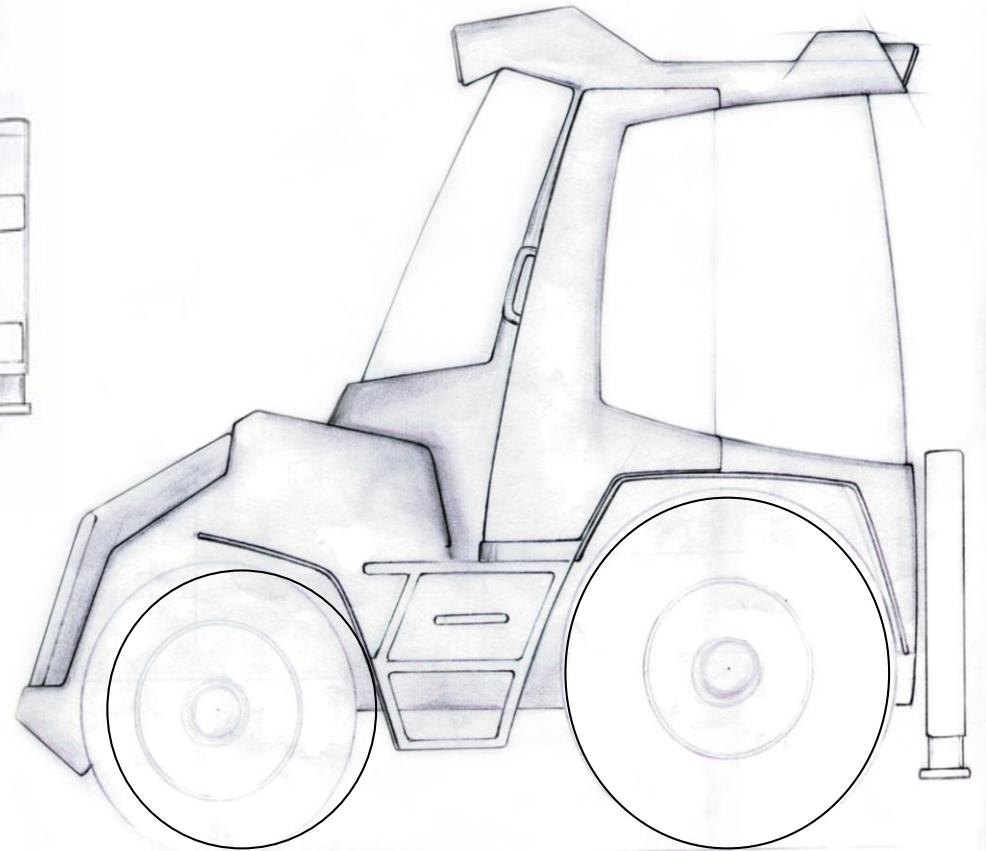
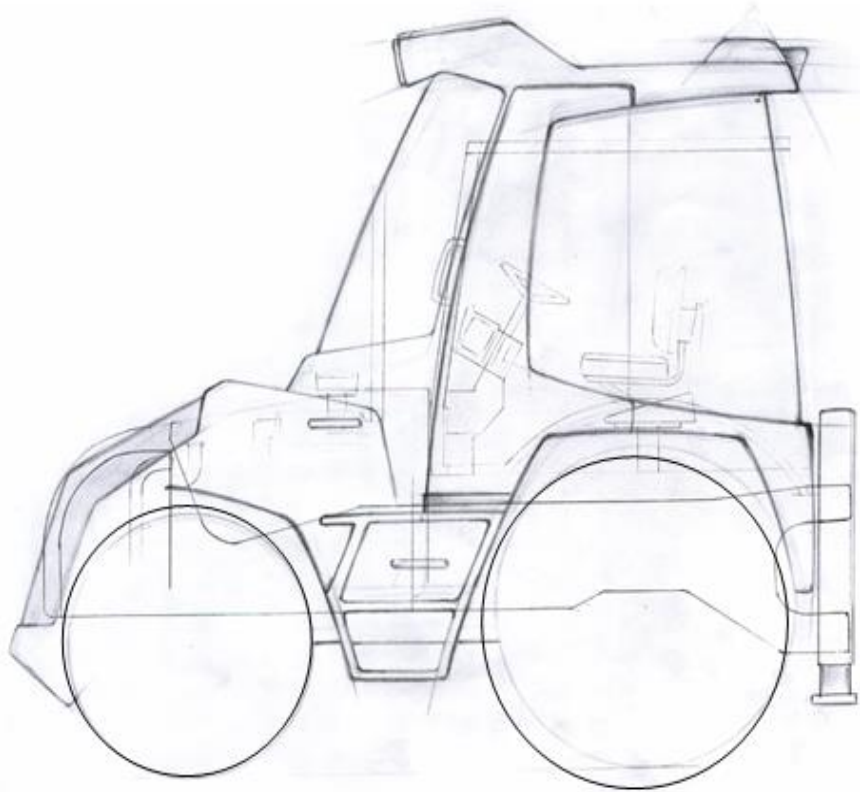


Large cabin
Alternative-3



Large cabin
Alternative-4

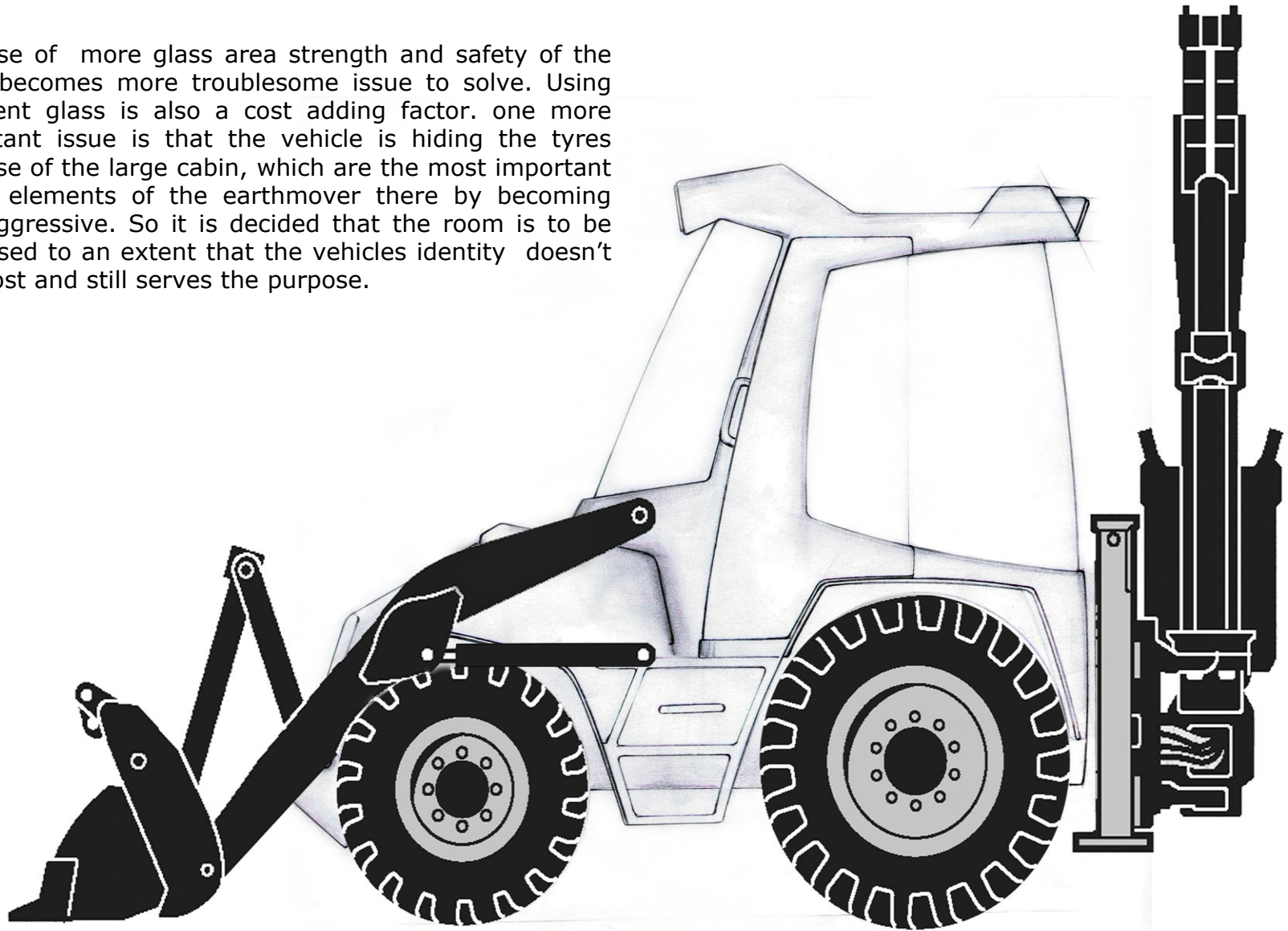




A single strong structure runs all over the cabin. While operating the backhoe the user will not see any metal sections in his visual frame.

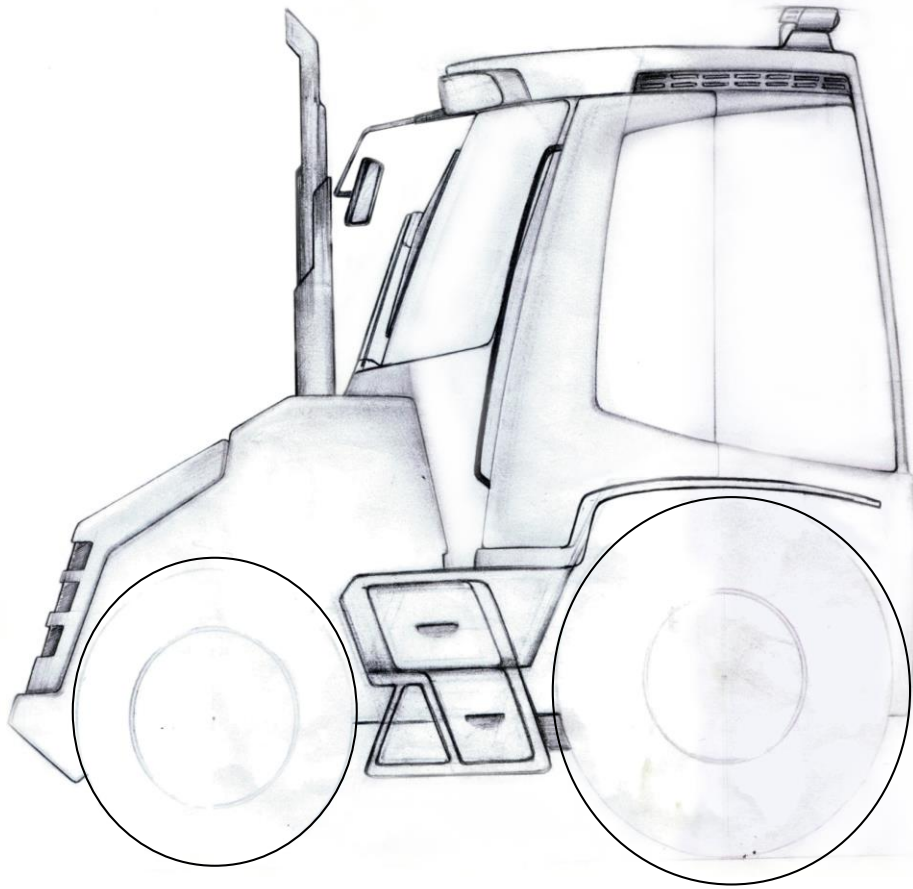
Limitations

Because of more glass area strength and safety of the glass becomes more troublesome issue to solve. Using the bent glass is also a cost adding factor. one more important issue is that the vehicle is hiding the tyres because of the large cabin, which are the most important visual elements of the earthmover there by becoming non aggressive. So it is decided that the room is to be increased to an extent that the vehicles identity doesn't gets lost and still serves the purpose.

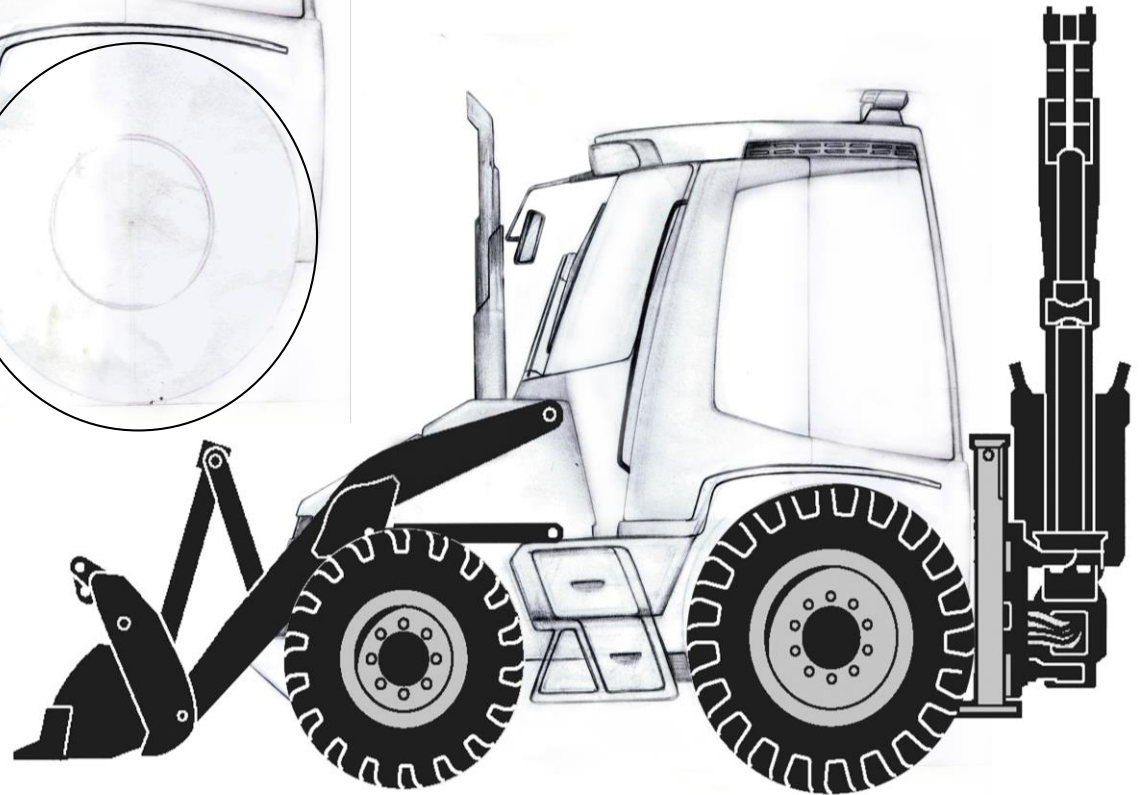


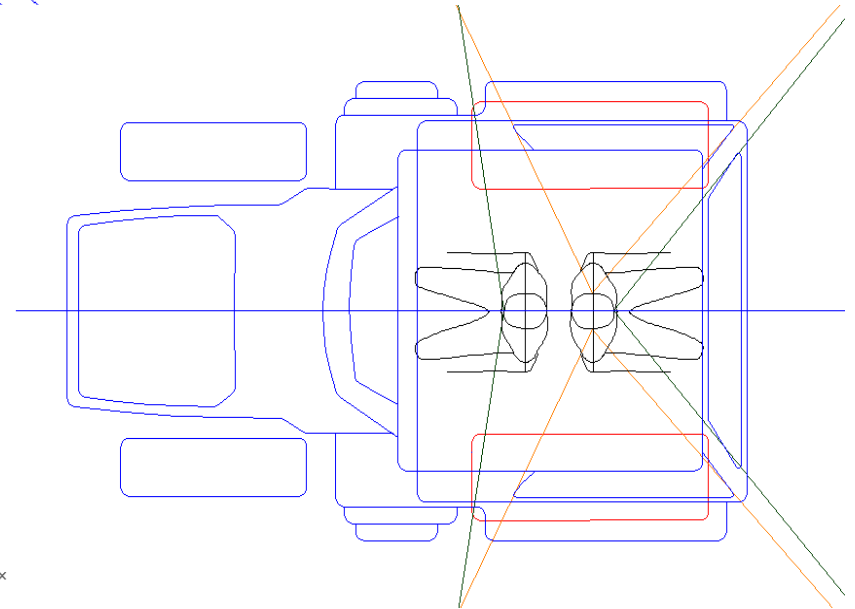
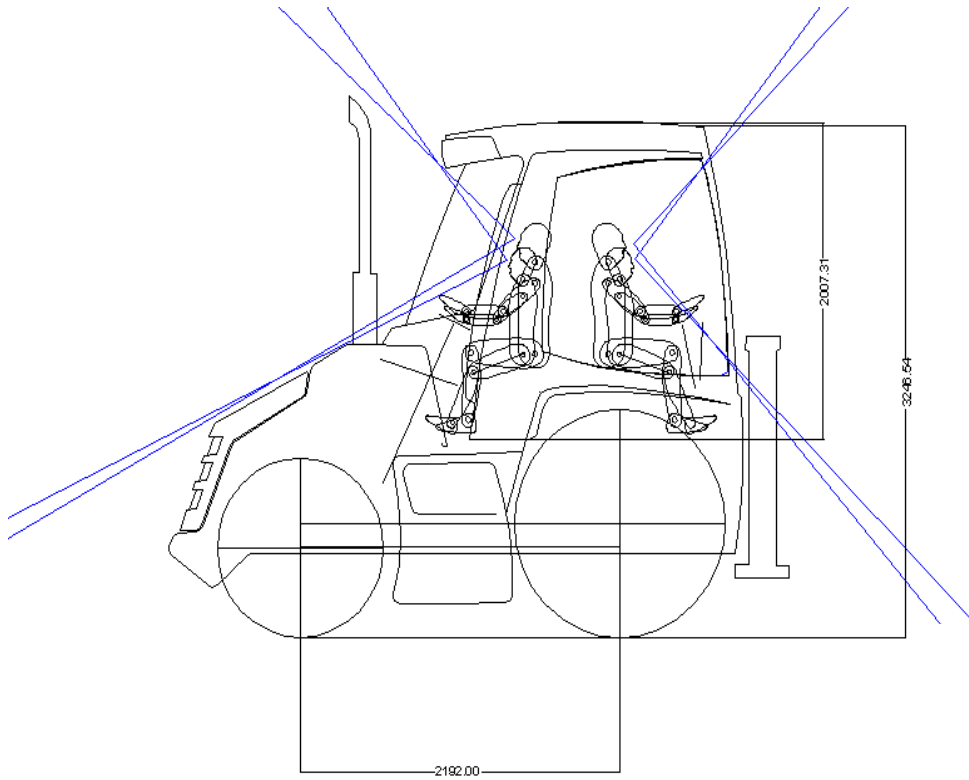
Refinements
Stage-1

Refinement-1



Considering the constraints, the continuous bent glass is replaced by the 3 piece glass and thin aluminum sections were included to add strength . Based on this form refinements are done.

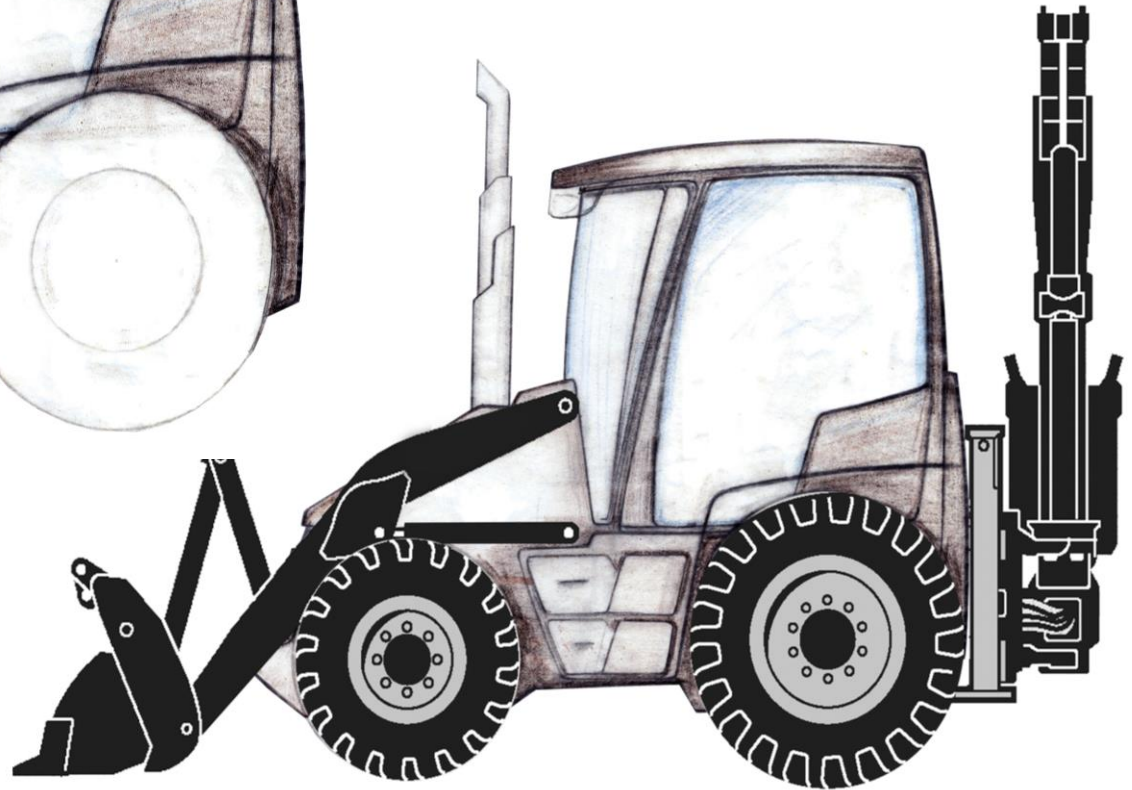




Refinement-2



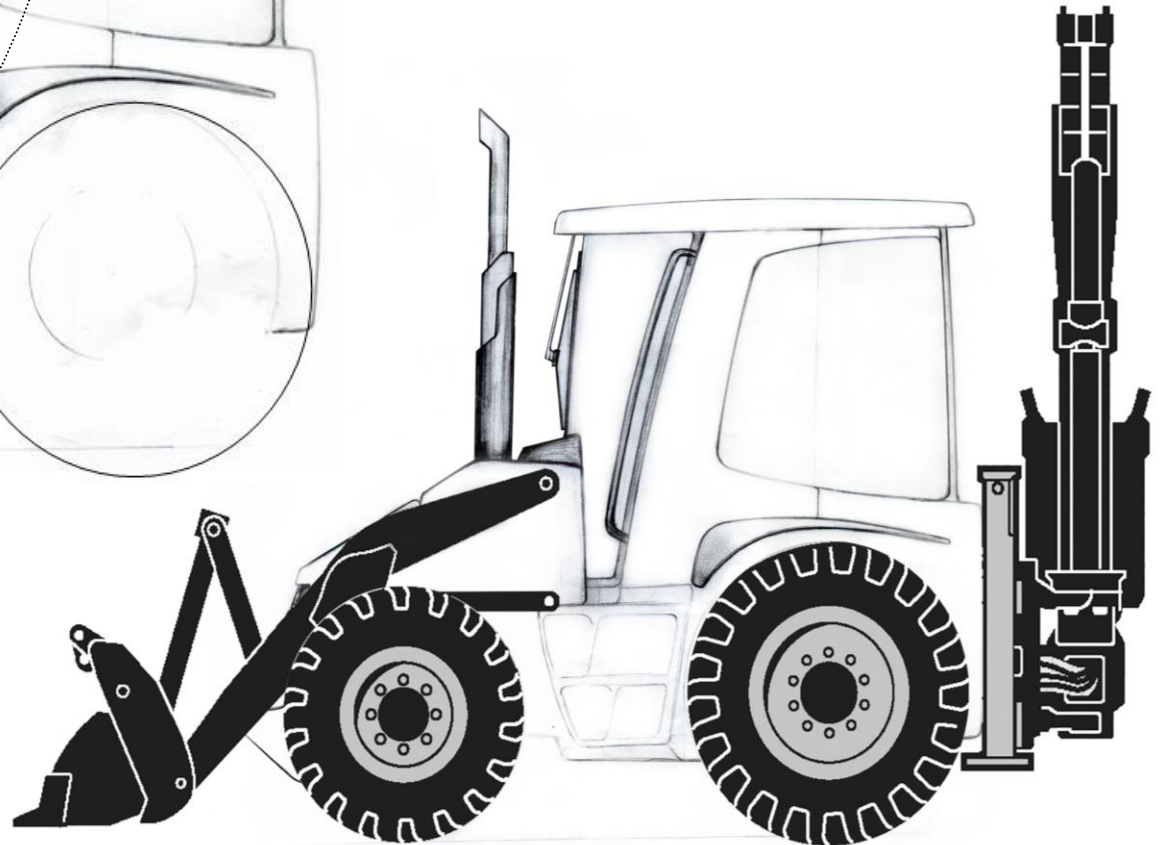
Front covering is removed to let the operator see the loader operations. The cabin's top is changed.



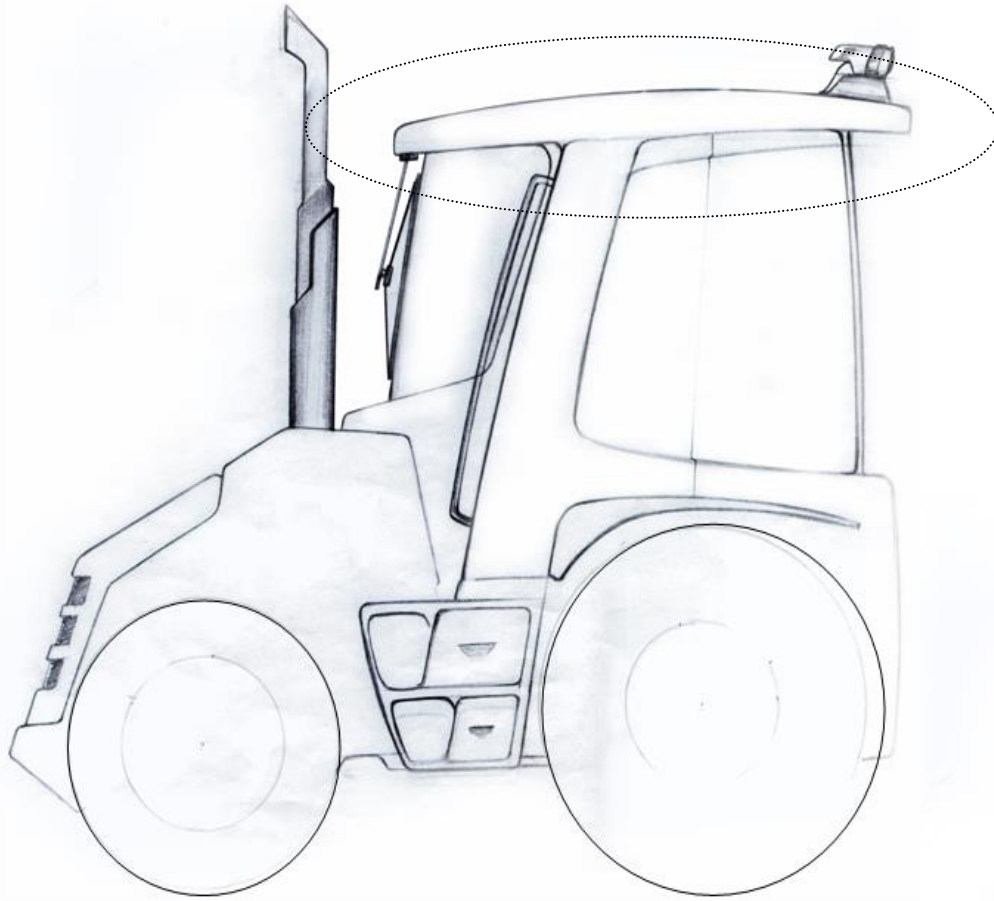
Refinement-3



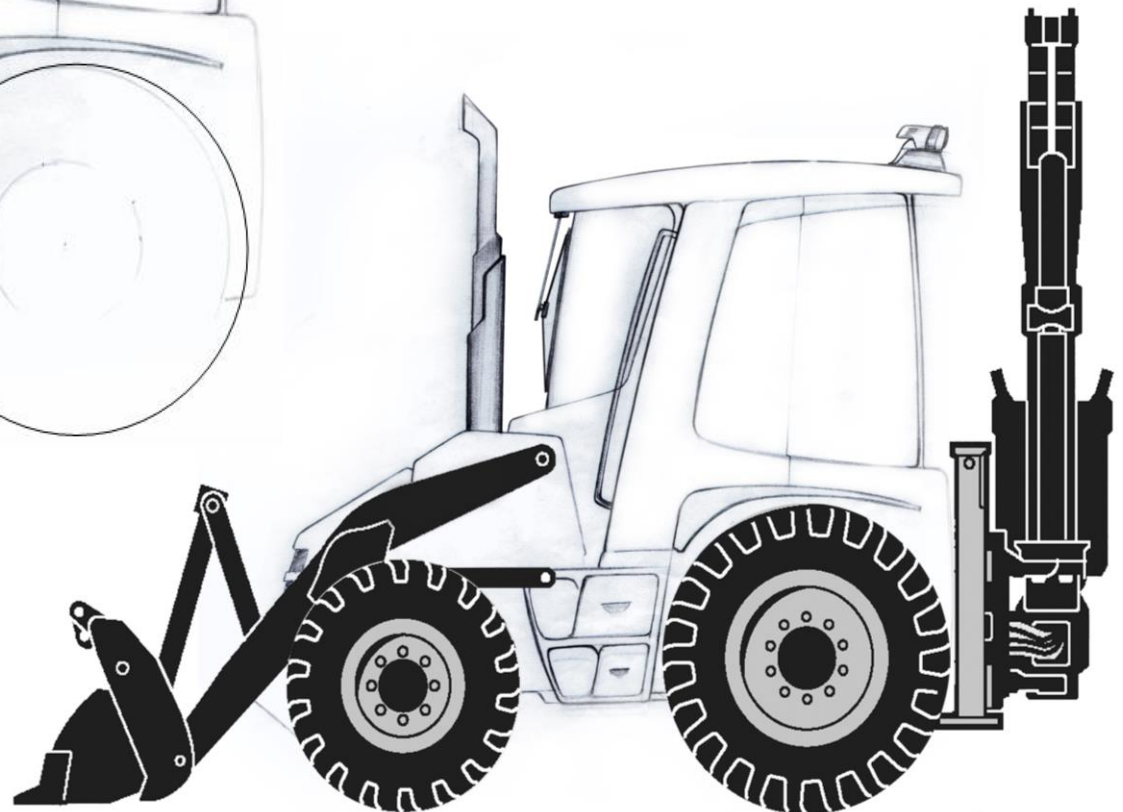
The gradual supporting section is replaced with the section which is more parallel and visually more stable.



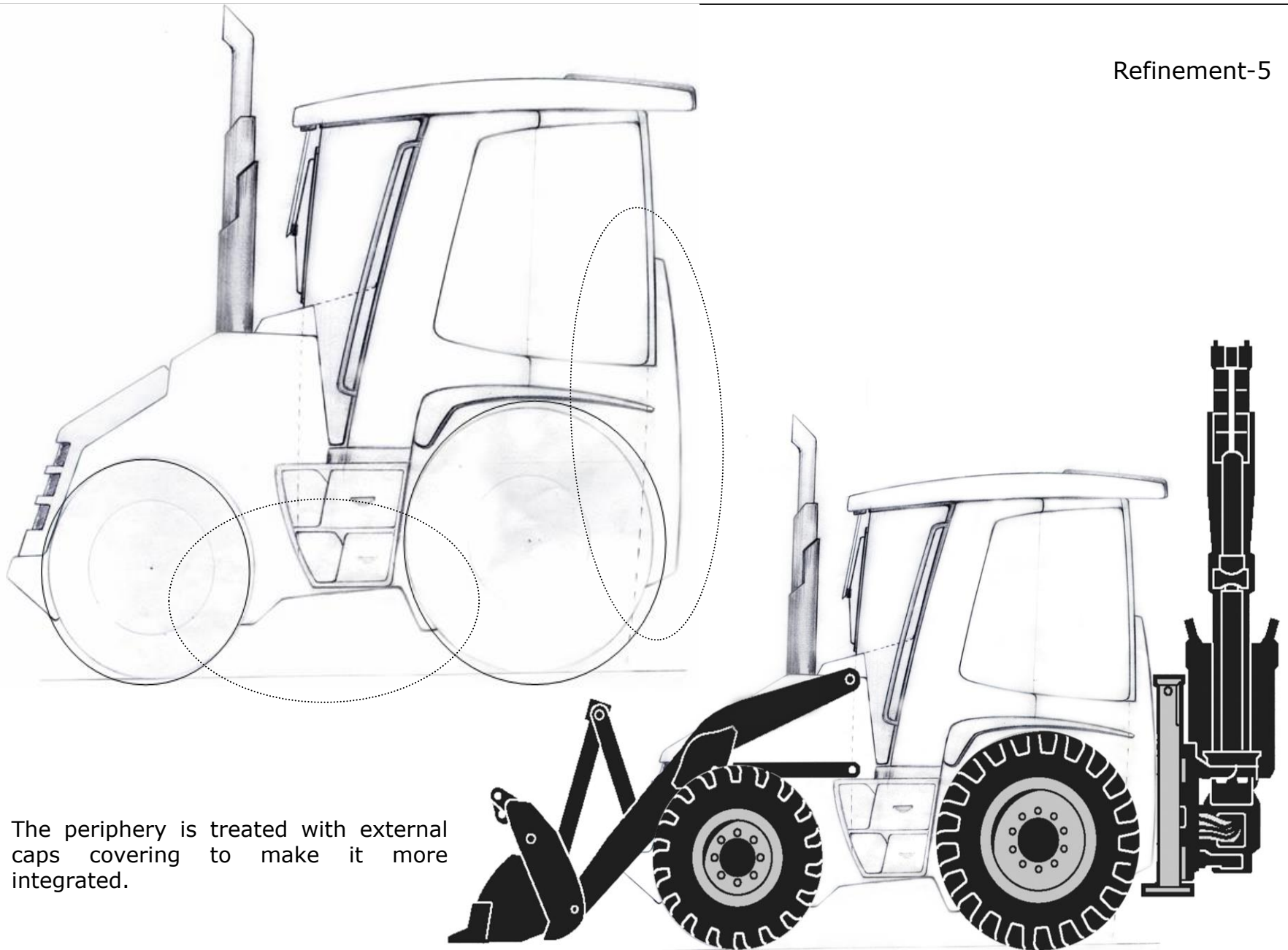
Refinement-4



Cabin's top is tilted to an angle and is treated to make it look more dynamic unlike in the case refinement -3, which is flat.



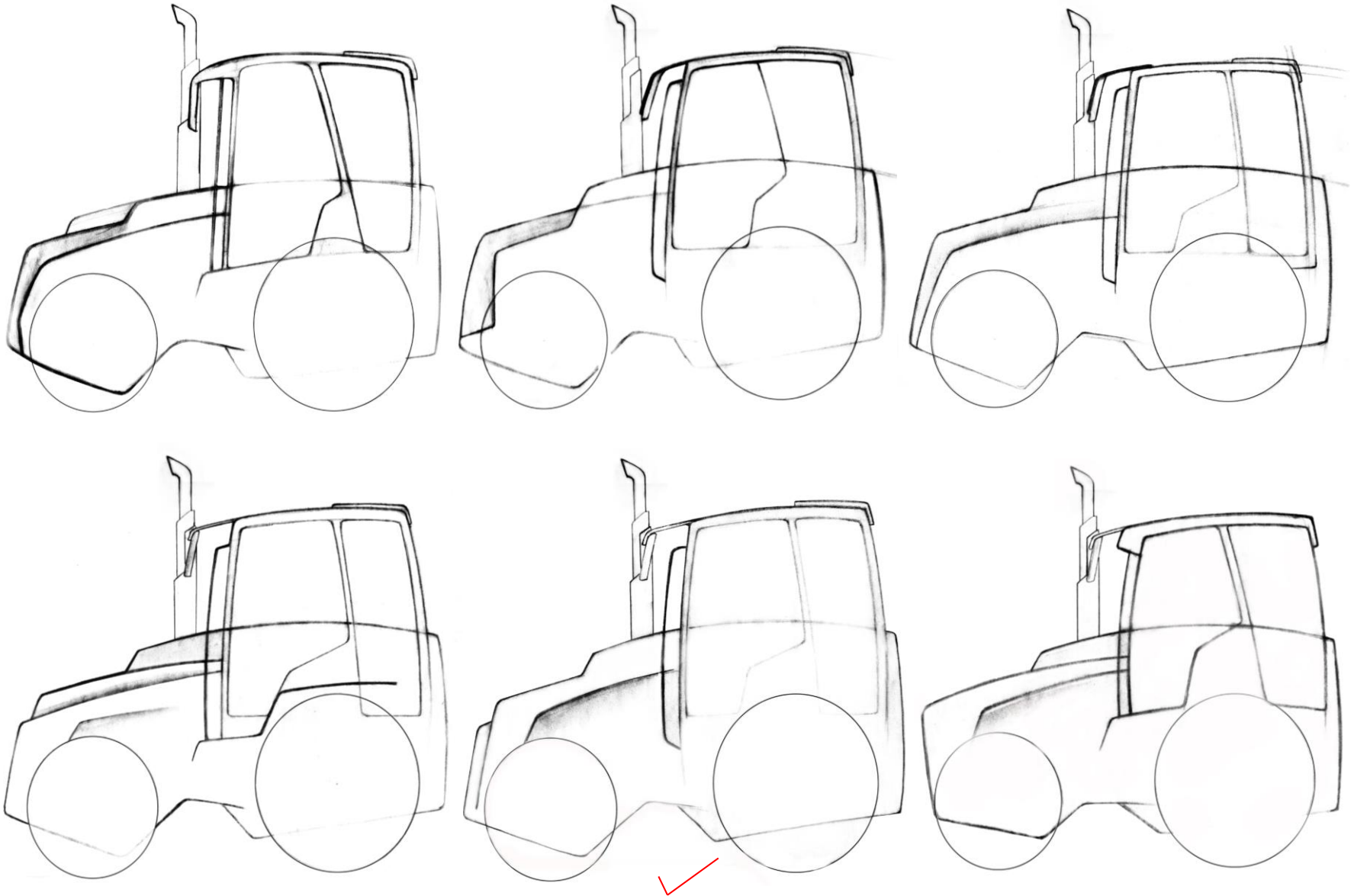
Refinement-5

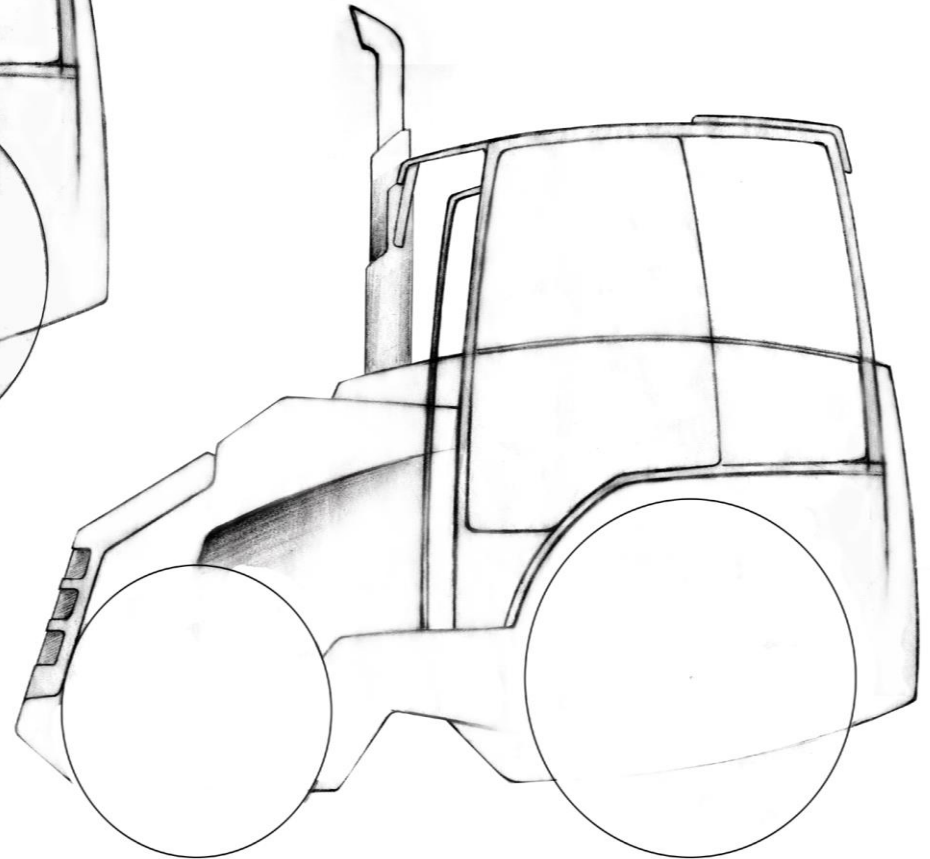
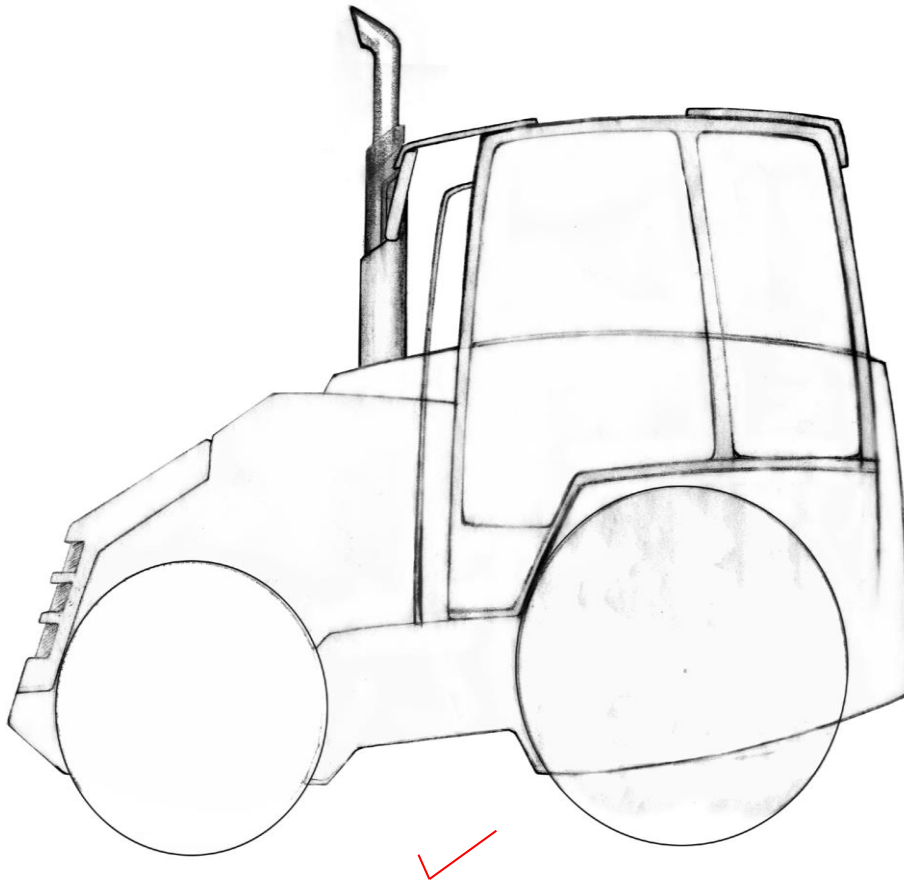


The periphery is treated with external caps covering to make it more integrated.

Final form - Refinements

7.2 Stage-2





Refinements are done to the final form and two alternatives are chosen for the final renderings.

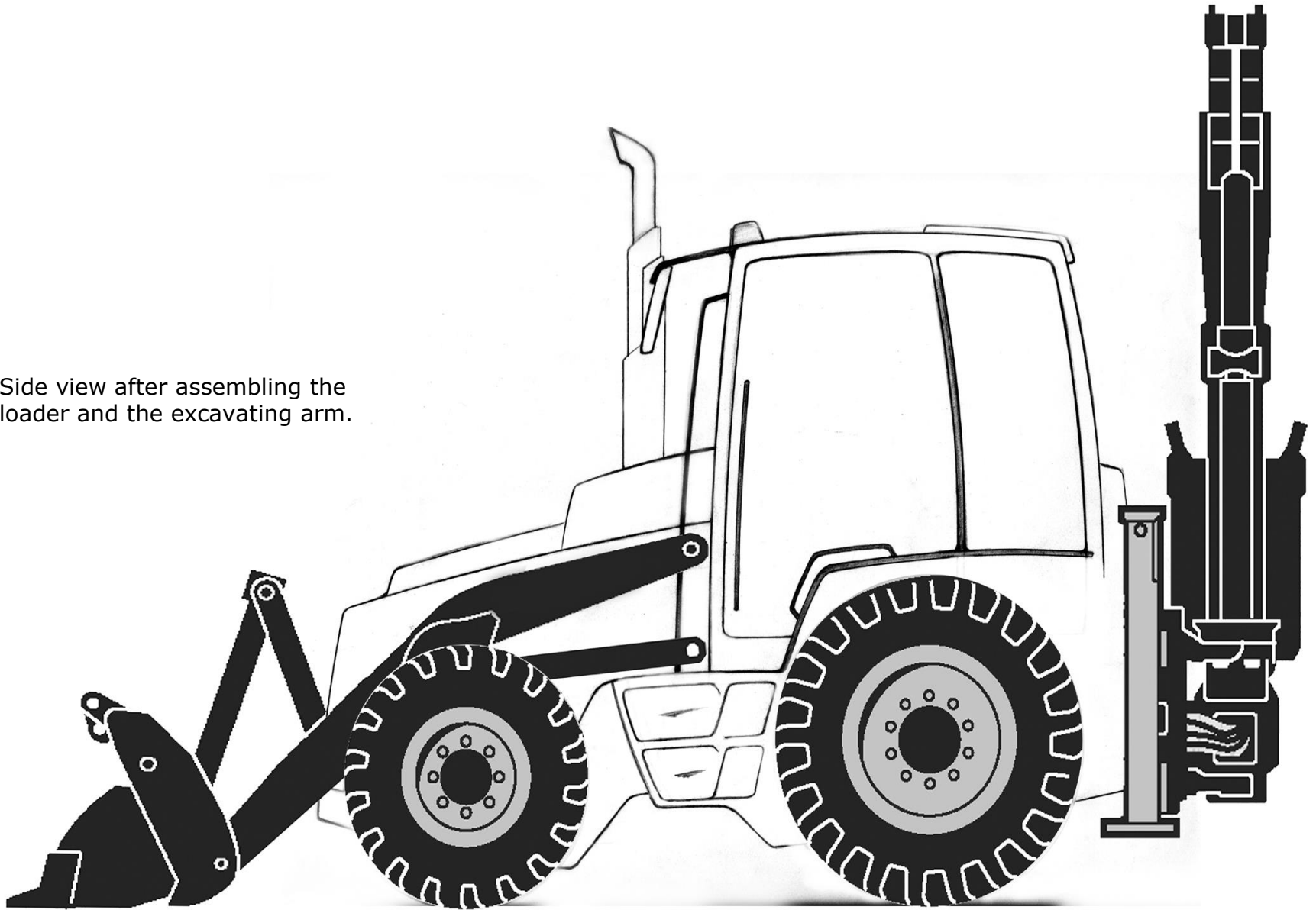
Final design

Final design



Side views of the vehicle alone.

Side view after assembling the loader and the excavating arm.

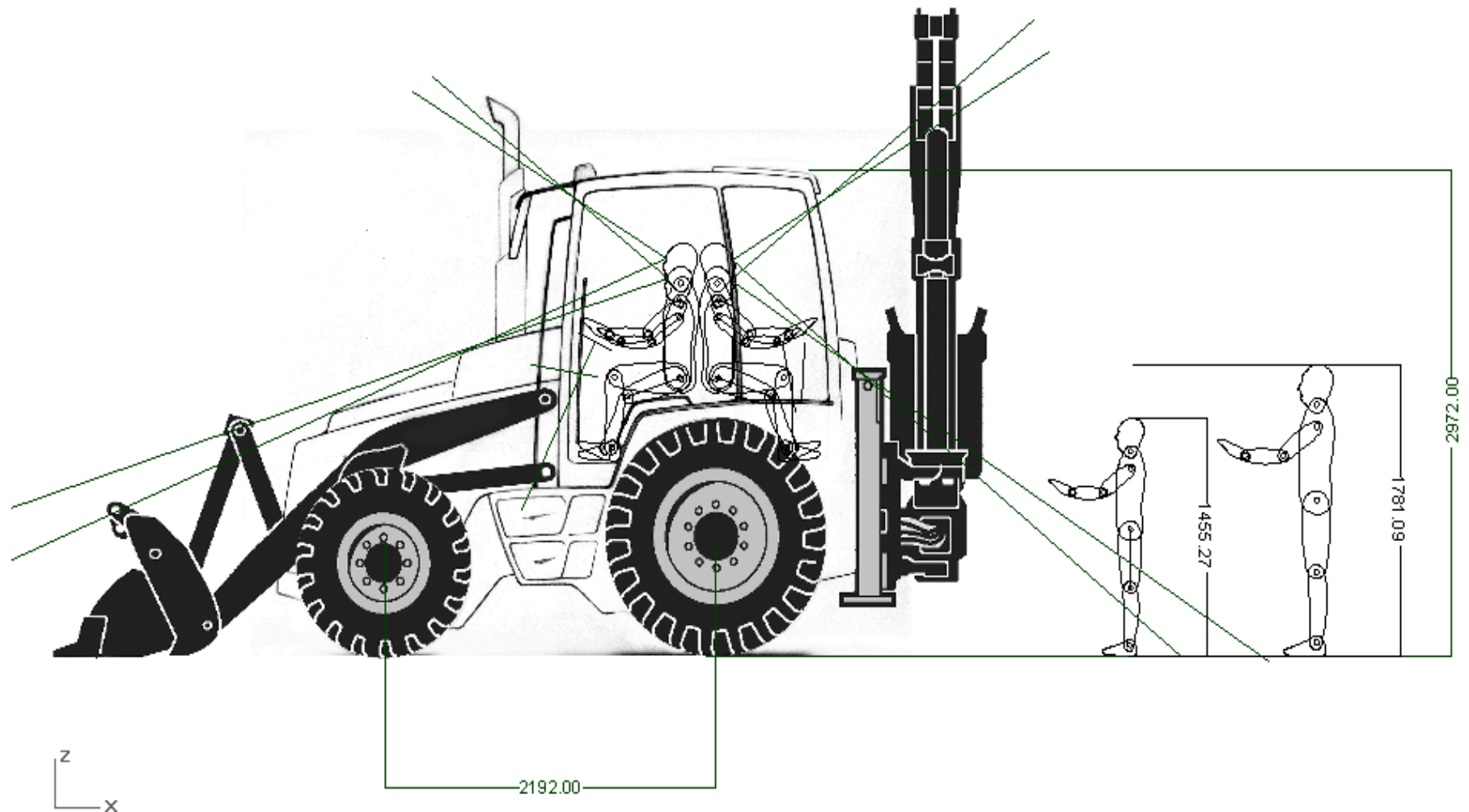


8.1 Features

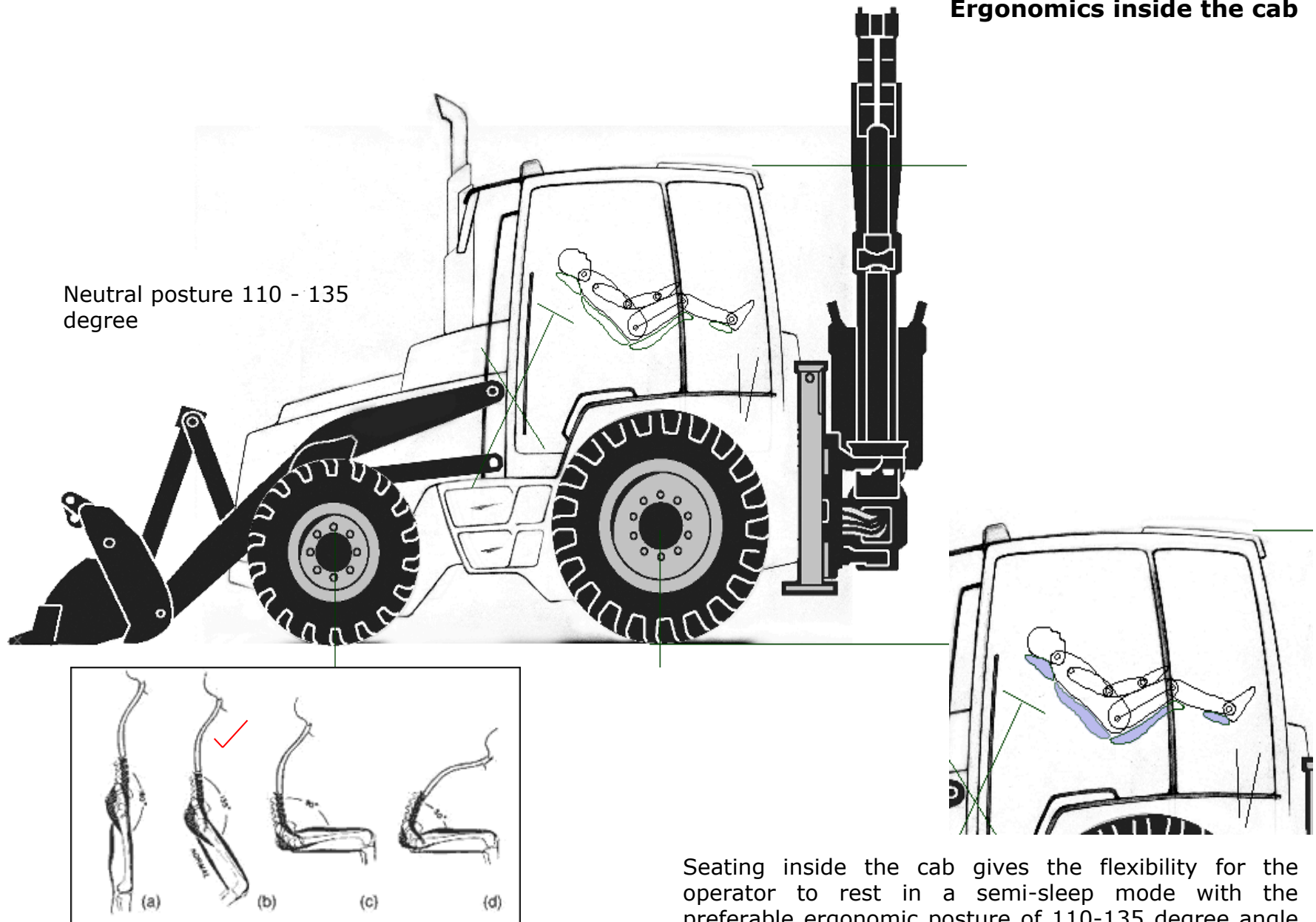


Single bonnet opening for hydraulic oil-fill and radiator water-fill unlike two doors in the existing one. Integrated camera on the cabin's top is safely assembled and pops out while operation. Sliding door for the operator ingress.

8.2 Ergonomics inside the cab

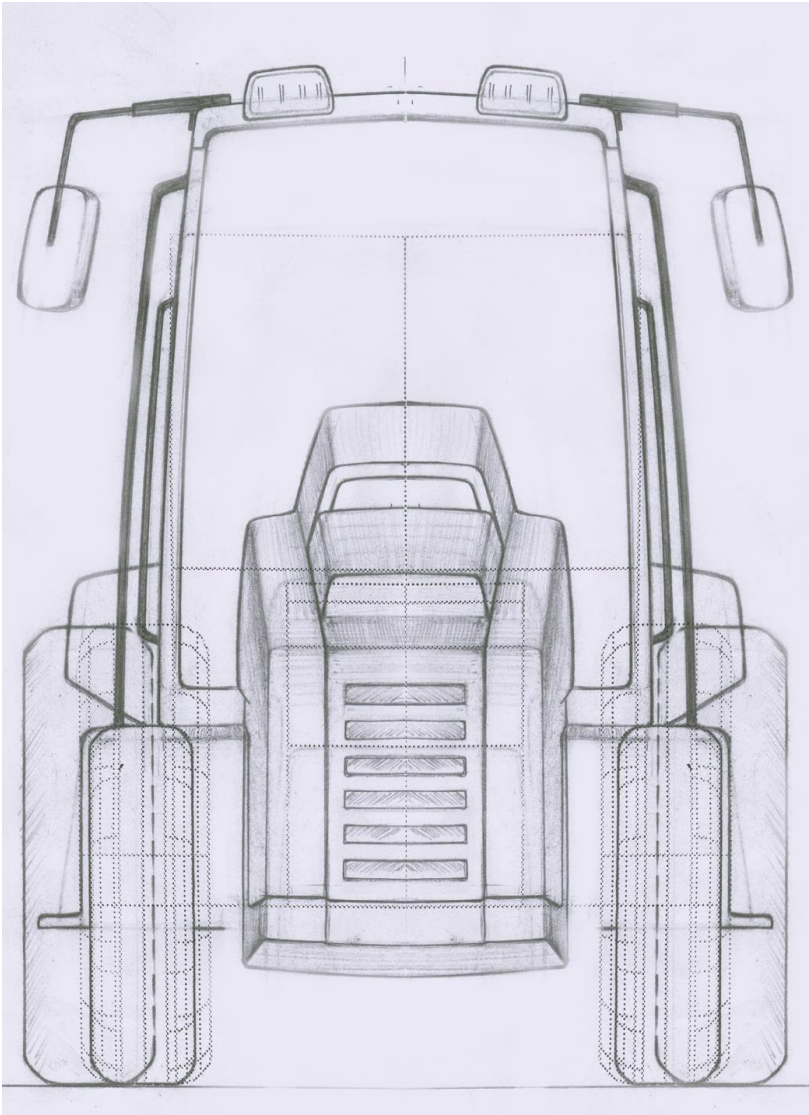


Visual cone and the seating arrangement of the user inside the cab for both operating modes.

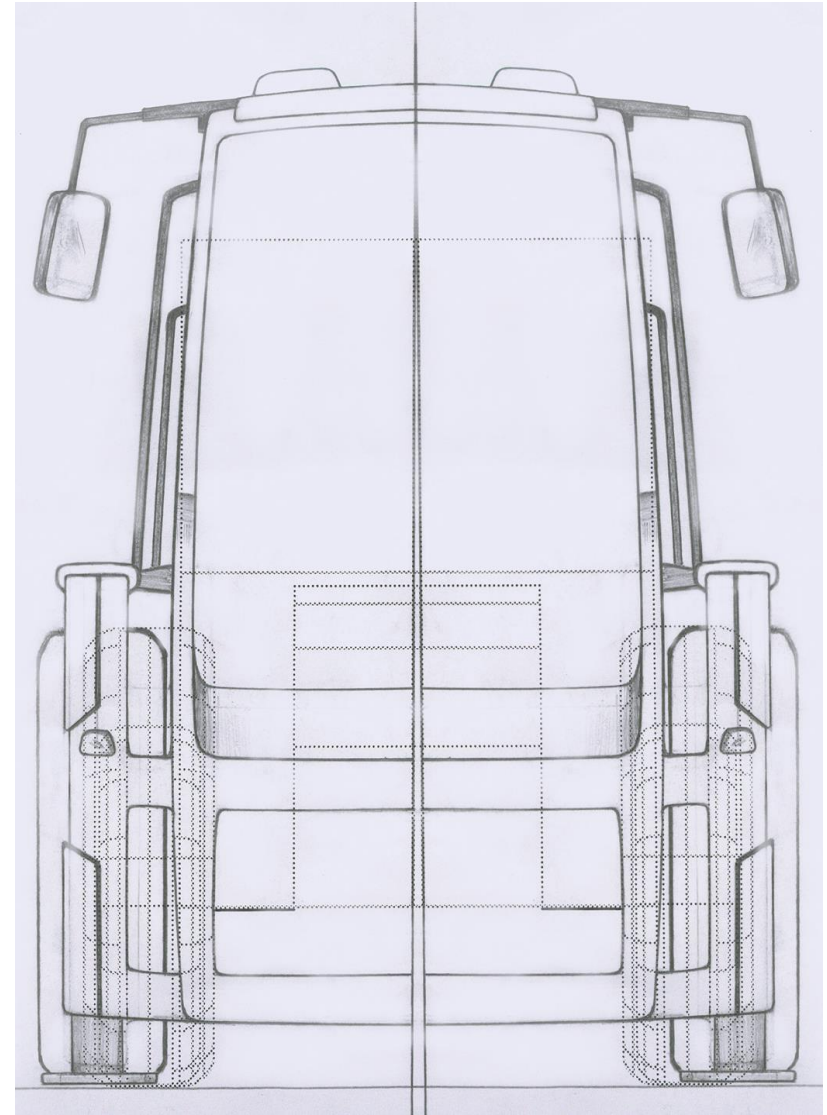
Ergonomics inside the cab

Seating inside the cab gives the flexibility for the operator to rest in a semi-sleep mode with the preferable ergonomic posture of 110-135 degree angle between thigh and trunk.

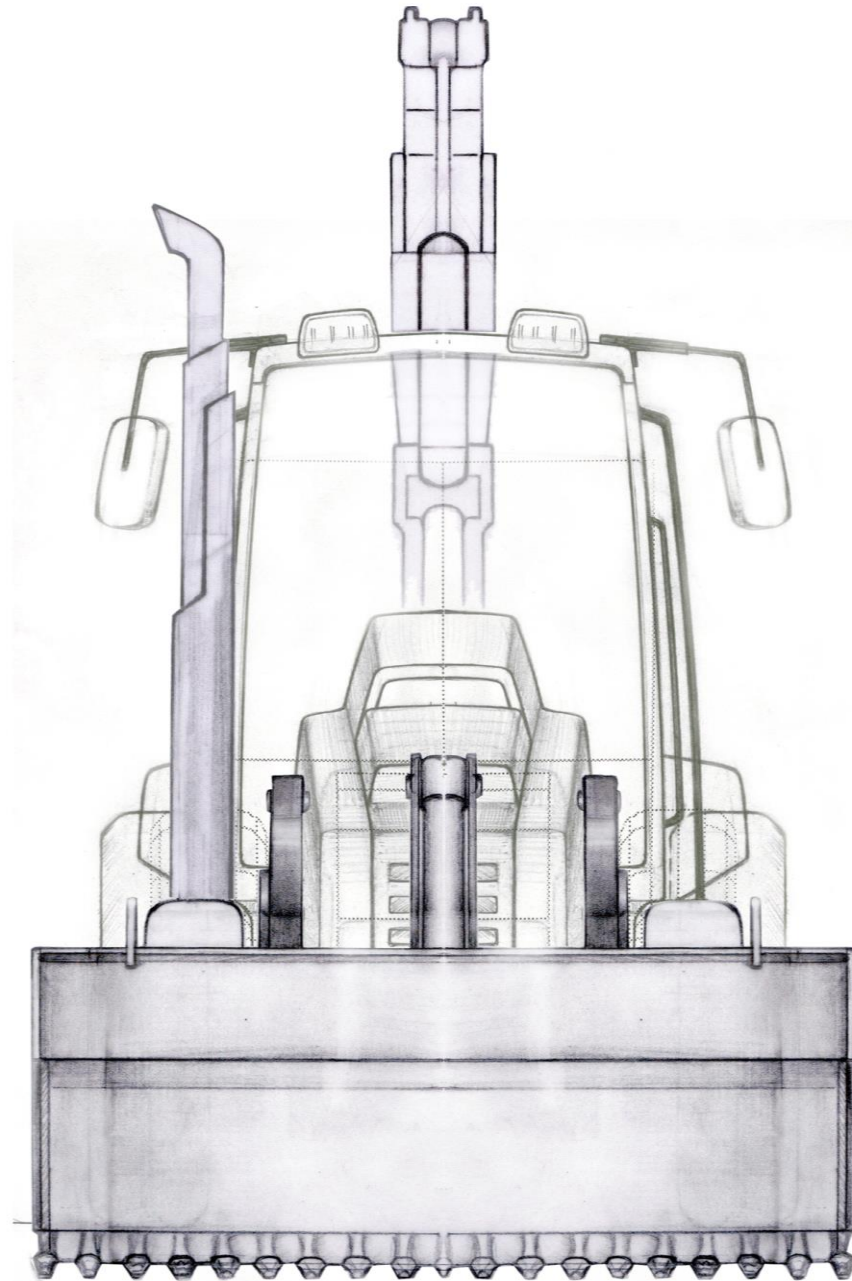
8.3 Views

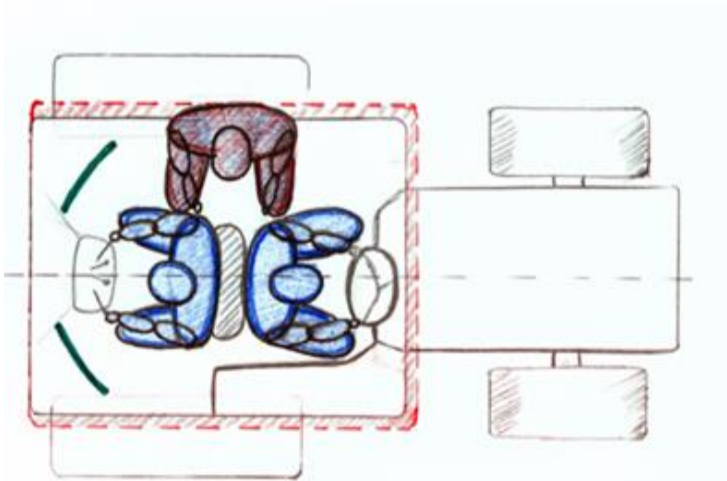


Front view

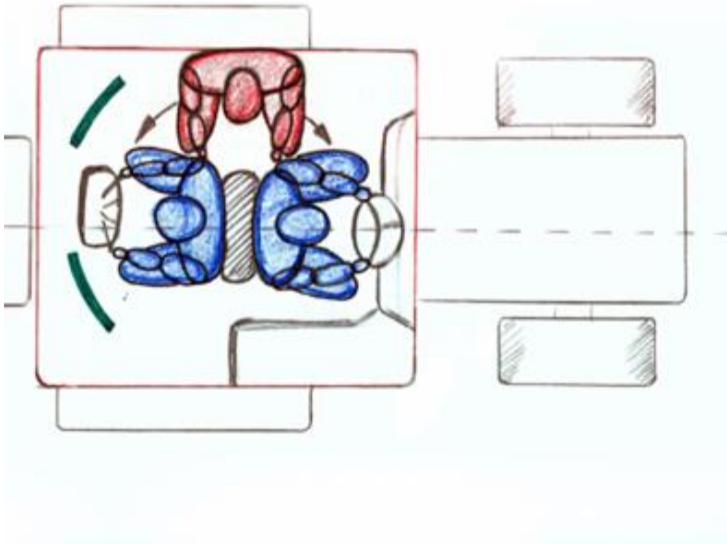


Back view



Final concept- Cabin Layout

This lay out shows that for optimum seating of the second person, the cabin has to be increased to 15 percent more.



The second person can comfortably sit inside the cabin along with the driver . This kind of lay out does not hide the tyres too.

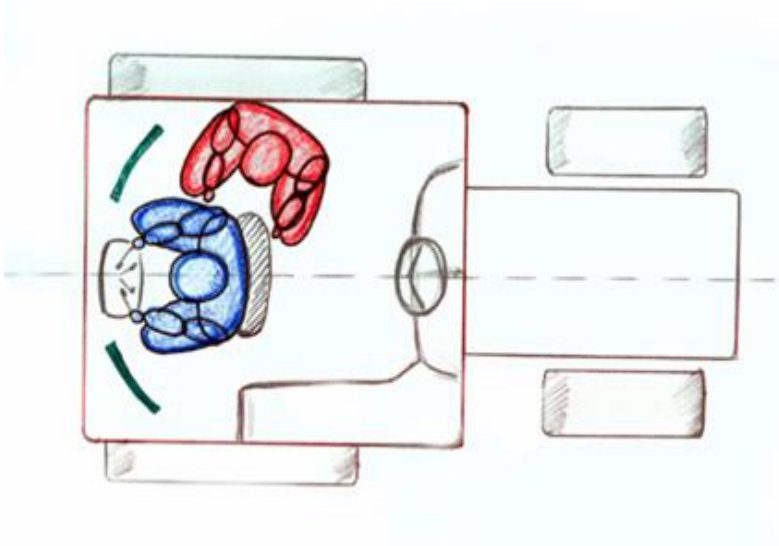


Fig.2

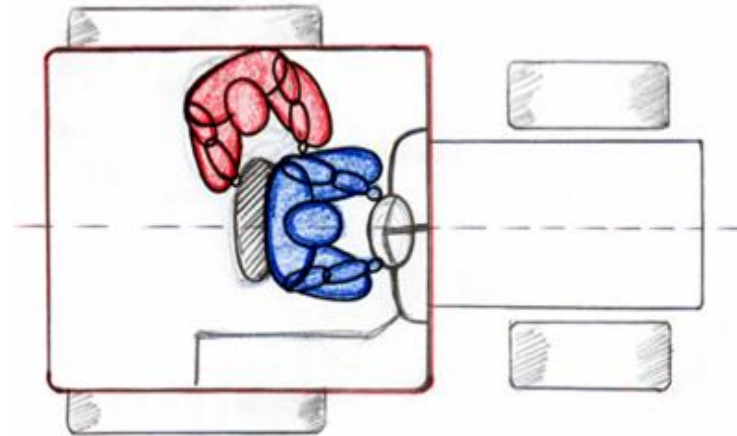


Fig.3

Accommodation for
second person

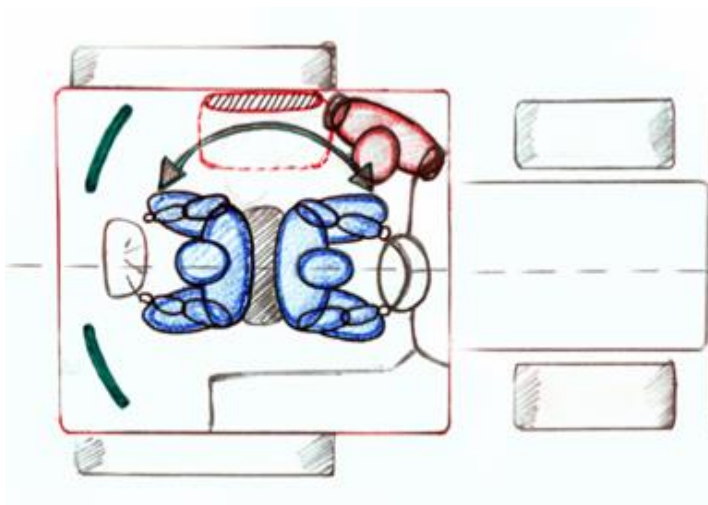


Fig.1

Concept renderings

Alternative -1



Alternative -2



Alternative -1



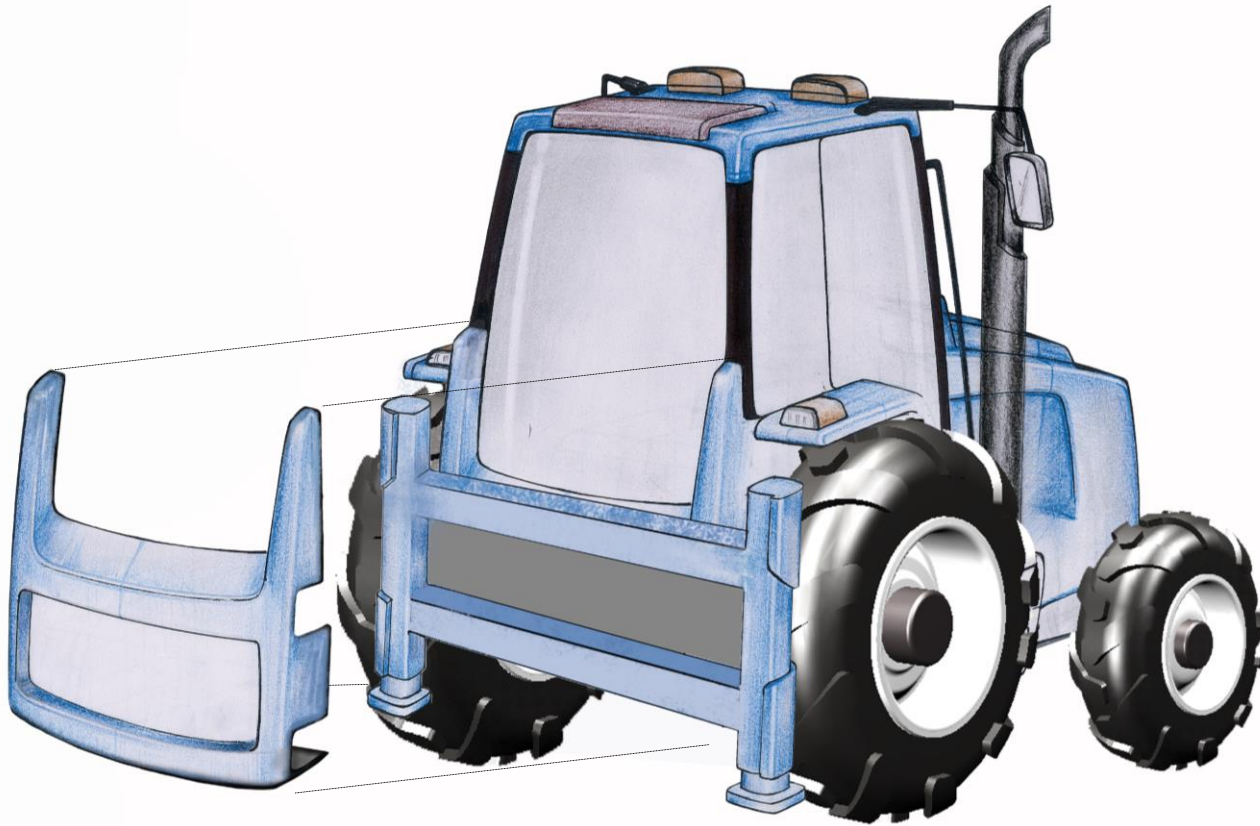
Alternative -2



Among both the alternative-1 is becoming more static than the second one because of the faceted bonnet. Alternative-2 has the element of dynamism and is looking more contemporary. This fits in the target segment for its formal features. Hence the alternative -2 has been selected as the final design .

Final design





Boom slider and the cabin are no more a separate attachments. They are made integrated in the new design. Due to this the visual clutter removed.



Final model

The new design of the backhoe loader is a package of unique selling points in terms of usability and functionality. Serves the user with comparatively a very good visibility and more convenience inside the cabin. Comfort, confidence in working and capability of getting job done are the major factors in its make-up. The relation between the operator and the machine has been made closer with its new design features.

Thank u
