Concept Vehicle for Difficult Terrain

Project 2

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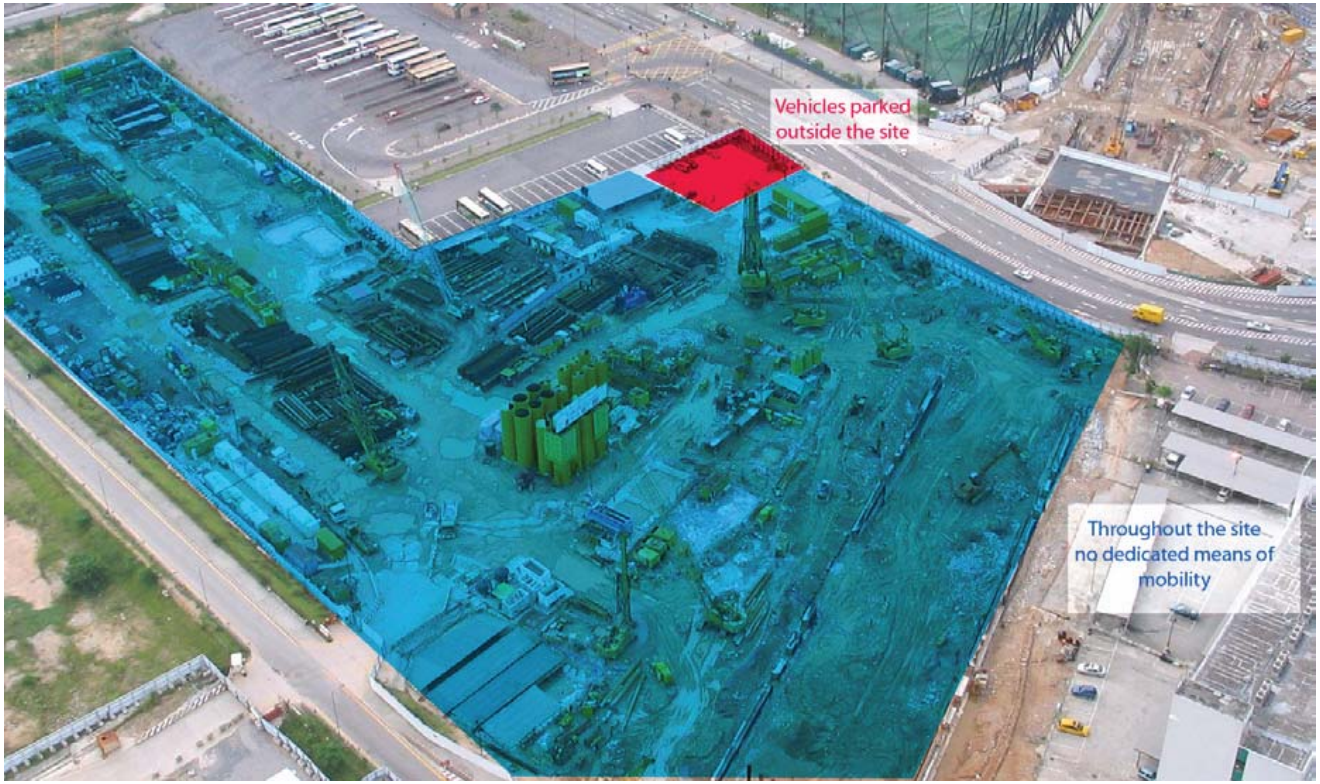
Scenario

Scenario

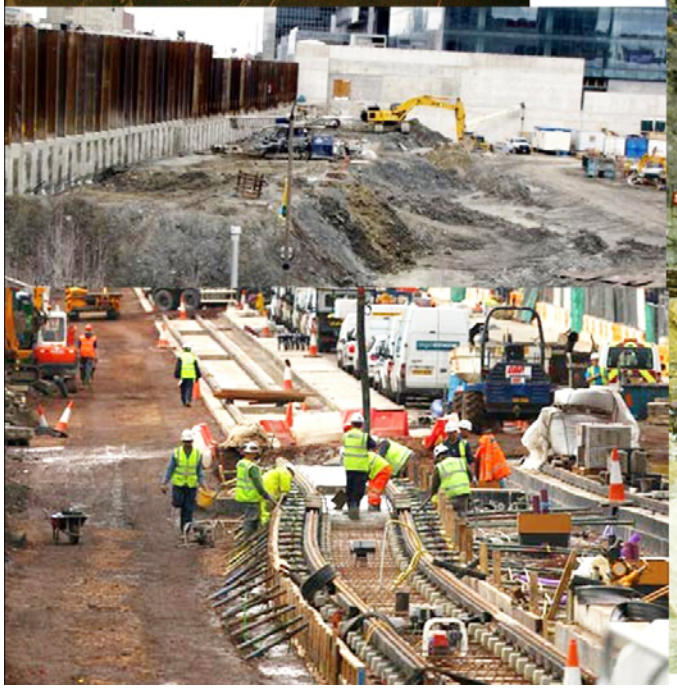


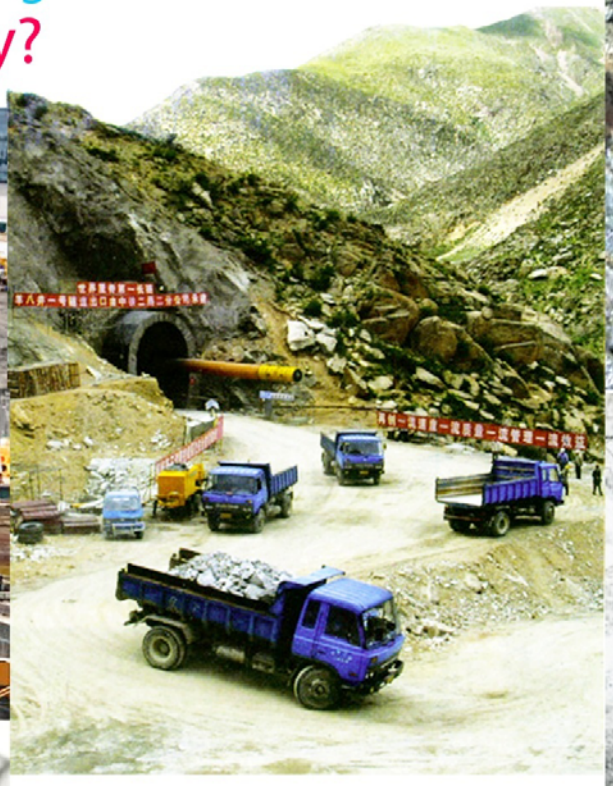
Vehicles are parked at the entrance of the site.

At and in the site one walks and only construction equipments operate.

Engineers on foot.

Why?





Scenario

Engineers at sites, construction or mining to name a few, either take lift in the construction vehicles or resort to walking.

Hence a single seater electric concept was thought of as the travelling range is less.

Existing Solutions

Existing mobility solutions for difficult terrain are too stiff and rigid. Hence they often

Get stuck

Loose contact

Tumble

Roll-over

This leads to loss of precious time and hence to inefficiency.

Human and the Concept

We, humans, assume different stances to tackle different terrain types. We

Walk, Run, Jog, Crawl or Climb to name a few.

Also different modes locomotion need different stances of the user.

Owing to our evolution we humans are more comfortable working upright.

- When the terrain expects dynamism why use vehicles that are rigid and static.
- We need a more dynamic vehicle which interacts more with the terrain.
- More interaction means more control.
- More control in the same static posture equals more tension and confusion.
- Hence the user for the dynamic vehicle needs to be dynamic as well.

Introduction

Introduction

- Most of the earth's land surface is inaccessible to regular vehicles
- Designed for traveling over relatively smooth, level or inclined, surfaces.
- Only vehicles that use ground contact for propulsion are considered
- Vehicles travelling through air or water are not included.
- These vehicles have applications including
  - Forestry
  - Agriculture
  - Exploration (planetary)
  - Adventure sports
  - Fire fighting
  - Disaster or hazardous areas
  - Construction sites
  - Mining sites

Difficult Terrain?

- The term difficult is not a very clear description of the terrain
- No clear distinction between easy and difficult terrain
- The difficulty dependent on the properties of the vehicle itself
- Its size and locomotion system
- Generally deserts, rocky areas, forests and swamps, and arctic areas consider difficult terrain

Research

Terrain Properties

The difficulty of terrain dependent upon several properties.

Geometric properties

- Form of the surface - its roughness and inclination
- Obstacles such as steps, holes and ditches.

Material properties

- Ground consistency
- Strength
- Friction
- Cohesion
- Moisture content
- Density
- Plasticity index

Temporal properties

- Time varying changes in the terrain.

Leh insights

- High Altitude
- Thin air
- The terrain is very loose
- Only the main roads are asphalt roads, majority of which are single lane
- Most of the roads are kuchcha roads
- Need experienced professionals
- The gradients of the roads are to be kept low for normal vehicles
- Laying of roads would hinder the beauty
- Climate changes very quickly
- The surface is often covered with a layer of ice

Images and inputs courtesy Wolf Dietrich, LEDEC, Leh.

Insights from Matheran Trip

- Dampening of the impact points of the vehicles
- Some vehicle to handle the extreme gradients would help
- The noise of the concept to be kept zero or negligible
- The width of the path varies significantly
- Flexible in terms of its maneuverability

Purpose of locomotion

Functional Characteristics

- Determine the use of the vehicle
- Transportation and/or special purposes
- The weight and size of the cargo has to be described for a transporter

Operational Characteristics

- Spatial factors
- Space needed and also the space available

Temporal factors

- Time available for performing a function
- Time for which the vehicle can work

Other constraints

- Vehicle size, fault tolerance, ecosystem and cost

Wheeled locomotion

- Wheeled locomotion is the most used locomotion system
- Superior to any other locomotion
- Smooth and energy efficient ride over relatively even surfaces

Advantages

- Smoothness and speed in relatively even terrain
- The technology is well developed and simple
- Payload to mechanism weight ratio is favorable as is their energy consumption.

Disadvantages

- Trouble if an obstacle is higher than the radius of the wheels
- Wheels follow ground contour

Tracked Locomotion

Tracks can handle relatively large obstacles and loose soil. They have been used predominantly in vehicles like tanks and excavators.

Advantages

- Smooth locomotion on relatively smooth terrain
- The technology is simple
- Superb traction on loose ground
- Can handle large obstacles and small holes and ditches
- Good payload capacity

Disadvantages

- Inefficiency due to friction in the tracks
- Slip friction when the vehicle turns.
- Rough ride
- Not adaptive to the ground
- Vehicles with one pair of belts suffer from impacts

Legged Locomotion

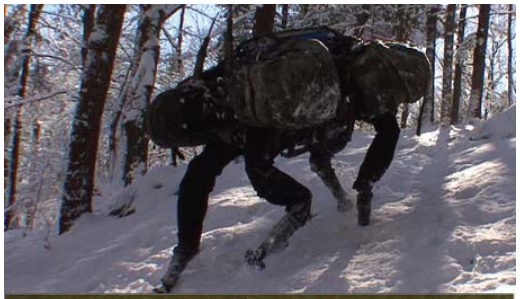
- Legs provide better mobility in rough terrain than wheels or tracks as they can use isolated footholds
- optimize support and traction
- wheel requires a continuous path of support

Advantages

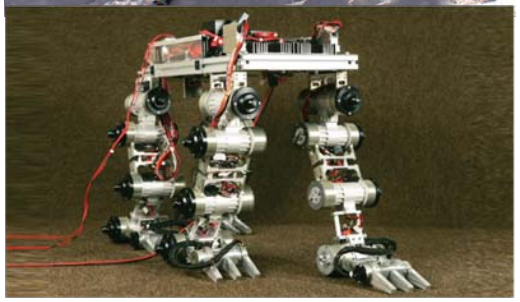
- Adaptive to uneven terrain
- Use isolated footholds
- Provide active suspension
- Environmental effects of legged vehicles are less than wheeled or tracked vehicles

Disadvantages

- Artificial walking mechanisms are heavy due to large number of actuators
- Control of walking is very complex and so far walking vehicles are rather slow
- Bad payload weight to mechanism weight ratio compared to wheeled or tracked vehicles
- Suffers an impact with each step

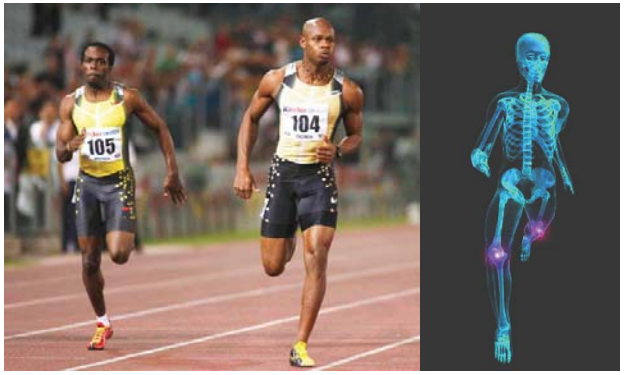


BigDog is a dynamically stable quadruped robot created in 2005 by Boston Dynamics.



Bad payload weight to mechanism weight ratio

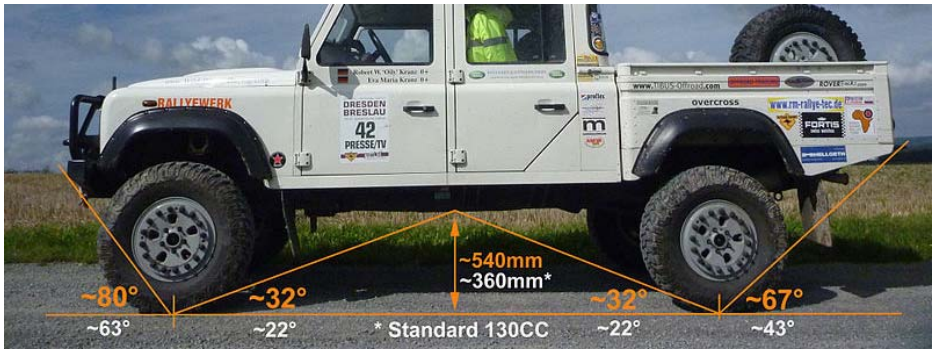
Isolated foot



Suffers an impact with each step

Study of Technologies

- Active Traction Control (ATC) system
- Hill Start Assist
- Crawl Control
- Kinetic Dynamic Suspension System
- Downhill Assist Control (DAC)
- Driving modes
- Electronic throttle control
- Locking differential
- Approach and Departure Angles
- Transfer Case



Niche

Search for a Niche

- The Questionnaire prepared for Scenario Generation

- Four Scenarios created
  - Defense
  - Construction Site
  - Agriculture
  - Photographer

- Common points given importance

- Picked one scenario

- Final Brief Created

- Study of nature and man made solutions

- Ideation

- Conceptualization

- What is your age?
- How often do you have to visit sites?
- Do you go alone or do you have to go in groups?
- Usually how long are the visits?
- What all do you have to carry along?
- Do you have to walk often?
- How easy or exhausting are the visits?
- Can you very roughly estimate the distances covered by you?
- Do you use any kind of vehicle to go for the visits?
- Does it cater to all you needs?
- Do you feel the need of a better vehicle that would take you around?
- What would you expect out of the vehicle that you takes you there?
- Would the noise of the vehicle affect your decision in choosing a vehicle?

Response - Defence

- Age: 25
- Leutenant
- Depends on the task. Generally
- have to go a lot in phases.
- First Aid + Ammunition+ Shelter+ Food+ Water+ Communication+ Shield
- The military vehicles take to the site. Once at the site have to walk mostly.
- Very exhausting.
- 30-40 km
- No. have to go on foot.
- Yes. Would like to have a Vehicle designed for such conditions.
- Reconnaissance
- Stealth
- Camping
- Bridging

Response- Construction Site

- Age: 25-45
- Every day in shifts of 5 hours and breaks of 1-2 hours
- Water + Some files and site plans + safety gear
- The company vehicle takes us to the site and once we are at the site , have to walk
- Inspection + Problems + Solutions
- Very exhausting as the land gradient varies a lot and often drastically
- 10-30 km
- We usually go in groups of 1-2.
- No vehicle caters to it
- Very Essential

Additional Inputs

- Big tires
- 4 Wheels
- As less area as possible
- They go in groups of one to three.
- solar power
- safety of head
- Panoramic View
- Seat rotation
- Steering in any direction any way
- Less noise as environmental noise is essential
- Electric

Response - Agriculture

- Age: 18-70
- Working days 40-50 days annually, Rest of the days it's used for travelling mainly in villages
- Time depends on activity. Like plouging takes more time than sowing. No matter what activity in a day it roughly lasts for 5-8 hours.
- Very uncomfortable: Vibrations, Exhaust
- 25-30km: high torque, high energy, density
- The problems faced are:
maintaining one line, turning, engine is lifted
- Better looks would help
- Better shelter, air , no closed cabin

- High versatility, single seater
- Least noise and vibration

Response - Photographer

- Age: 25-45

- 10-12 Visits every year. A visit usually lasts for 5-6 days

- Camera equipment, Food & water, Clothes, Shelter, Water proof (Completely or Partially)

- Have to walk a lot

- Very exhausting

- 60- 80km

- In the end have to get down from the vehicle for the job. Also during driving many a times one of the companions has to get out to guide the driver drive through .

- A new vehicle would help

- Inputs for the Vehicle

Additional Inputs

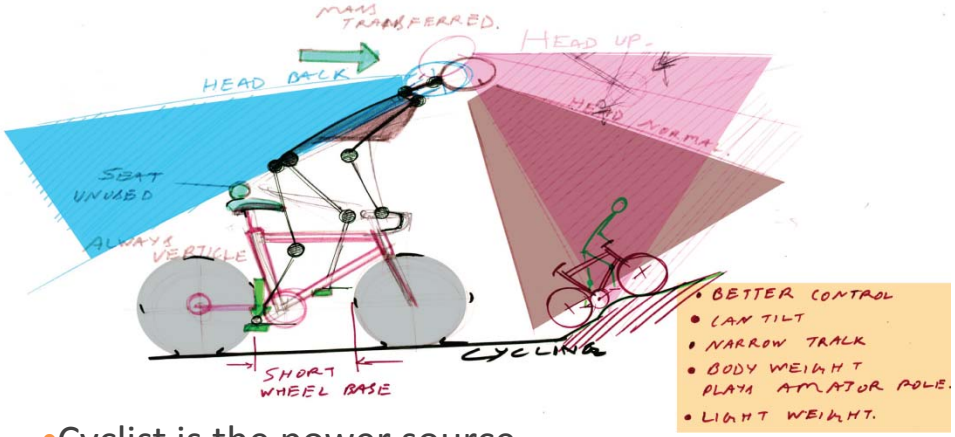
- Would like to have something for 3-4 days
- Very safe for equipment (expensive) and person
- Good tread
- Light weight
- Ropes and harnesses
- Should be highly functional
- Aligning the jeep is very difficult
- Suspension is very stiff
- Visibility - Fog, better without windscreen, fog lamps, high ground clearance
- Wheels get stuck with grass
- Less the noise, more better it is

Common points

- One needs to be highly experienced to maneuver these vehicles.
- The driver or operator alone is insufficient.
- Visibility is a problem - may be due to vehicle architecture, irregular gradient and hence the vehicle orientation on the surroundings for e.g. trees, fog etc.
- The orientation of the operator changes with the orientation of the vehicle.
- The centre of gravity of the vehicle always stays at the centre.
- The vehicle often gets stuck.
- Maintaining direction is very difficult.
- Noise is unnecessary.
- The weight of the vehicle to add to the sturdiness.

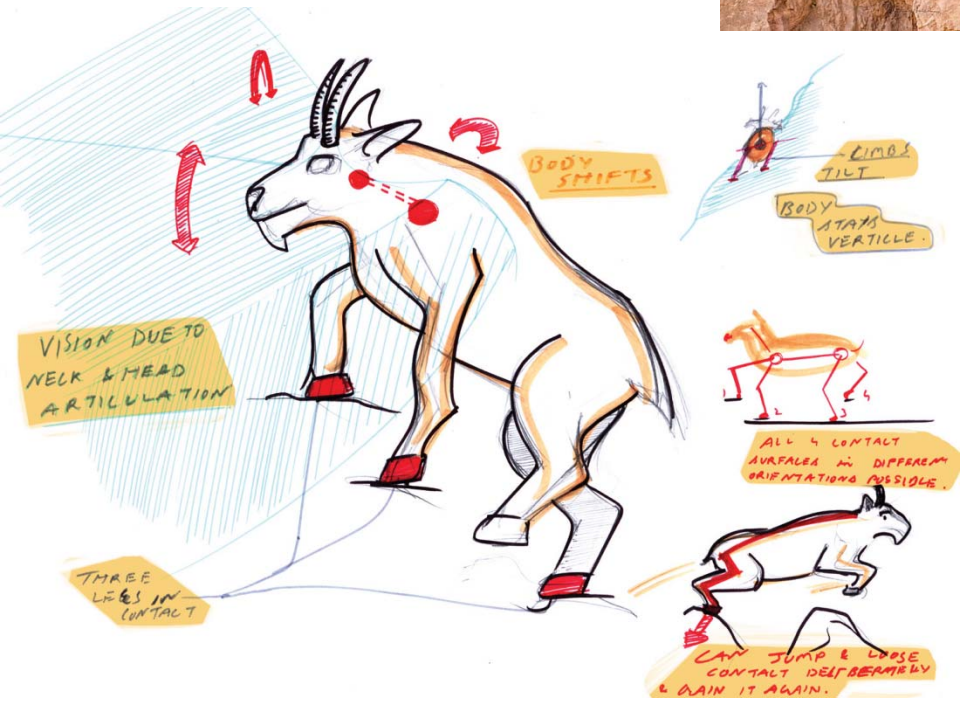
Study

Study of Existing Solutions - Cyclist



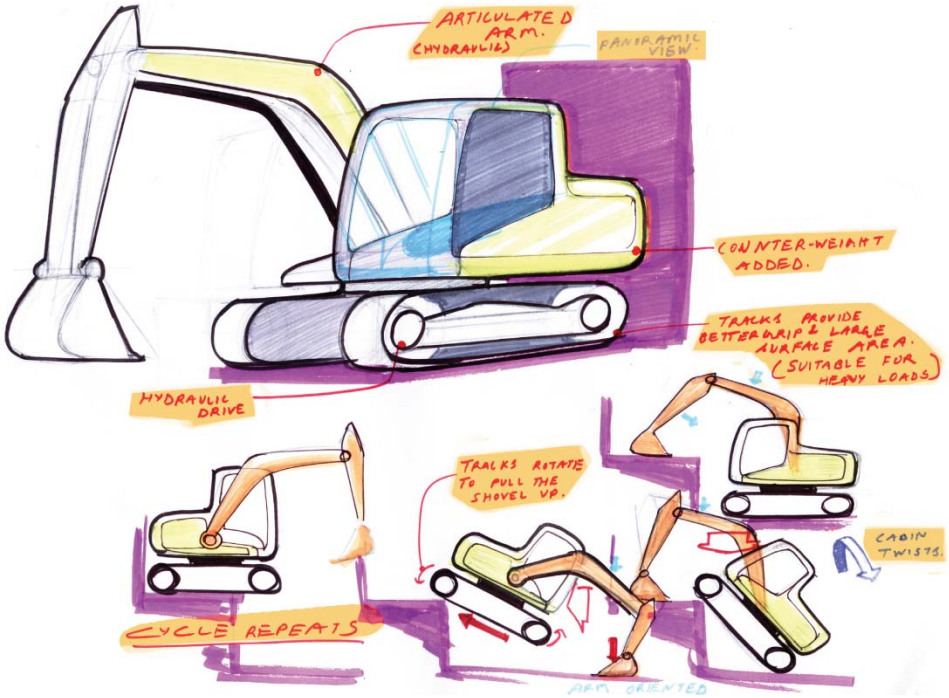
- Cyclist is the power source.
- Weight of the cyclist plays a major role in maintaining balance.
- Cycle has a very narrow track.
- It is very light weight.
- Heavy gradients can be tackled by shifting the body weight to the front or to the back.
- While cycling one naturally leans hence taking care of the banking needs at higher speeds.
- Narrow wheel base makes a cycle very responsive.
- When cycle demands greater power from the rider, the rider tilts forward. This makes you bend your neck and lean ones head backwards to maintain visibility.
- Seat is very narrow and uncomfortable.

Study of Existing Solutions – Mountain Goat



- Small and hard feet helps tackle hard rocky ans slippery surfaces.
- Four different points of contact.
- Points of contact vary from one to four.
- The head tilts in all axes giving beter view.
- The goat can jump and gain traction again by will.
- They tilt, at times put their body weight on the mountain walls, when the track available is very narrow.
- Body weight plays a major role in maintaining balance.

Study of Existing Solutions - Excavator



- Its articulated arm that is meant to dig also helps in its mobility.

- The arms helps in lifting the vehicle up and also crawl out of huge ditches as it grabs the ground providing extra pull needed.

- The operator operates from a glass cabin giving a panoramic view. The Off-centre placement of the cabin hinders visibility in the farther end.

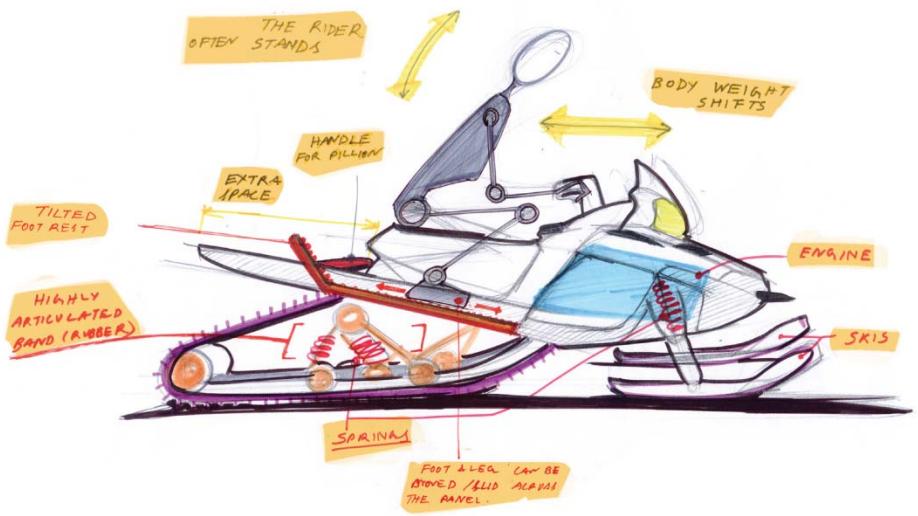
- It has a zero turning radius.

- Caterpillar tracks are rough on the terrain.

- Often due to ratation of the entire machine on a central pivot the excavator topples.

- Gradients in the direction of motion are easily tackled, but those in transverse direction, cause roll-over.

Study of Existing Solutions - Snowmobile



- It has got a highly articulated track, often made of rubber with metal spike.
- There is enough room for the rider to move his body and legs as needed to maintain balance.
- Skis in the front, with suspension, help maneuver in very soft and slushy terrain.
- It can also be tilted at higher speeds and hence take care of banking needs.
- Mobilization of the highly articulated track demands huge torques.
- In case of I.C. engine powered snowmobiles, an additive is added to the fuel to prevent freezing.
- Lack of shelter gives good visibility but jeopardizes operator safety.

Insights from the Study done

Insights based on the survey and study done

- The existing locomotion, wheeled locomotion in particular, is capable to a certain degree.
- The performance of the vehicles is highly restricted due to the interface used for the control of such vehicles.
- If these shortcomings are addressed the capabilities and hence the range of the vehicles can
- be improved to a great extent.

The shortcomings would be :

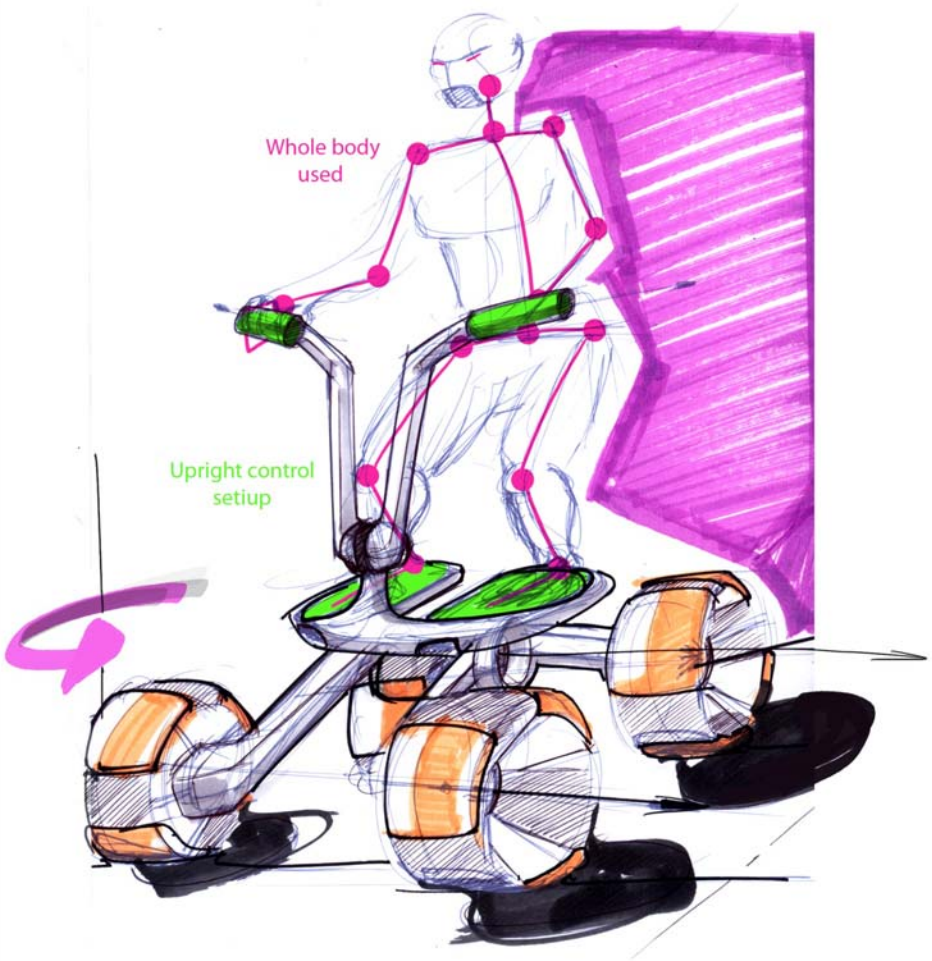
- One needs to be highly experienced to maneuver these vehicles.
- The driver or operator alone is insufficient.
- Visibility is a problem - may be due to vehicle architecture, irregular gradient and hence the vehicle
- orientation on the surroundings for e.g. trees, fog etc.
- The orientation of the operator changes with the orientation of the vehicle.
- The centre of gravity of the vehicle always stays at the centre.
- The vehicle often gets stuck.
- Maintaining direction is very difficult.
- Noise is unnecessary.
- The weight of the vehicle to add to the sturdiness.

Important Inputs

- Big tires.
- Speed to be approximately 8-10 kmph.
- 4 Wheels.
- As less area(foot print) as possible.
- Solar power.
- Safety of head.
- Panoramic View.
- Seat rotation.
- Steering in any direction any way.
- Less noise as environmental noise is essential.
- Electric.
- Light Weight.

Ideations

Water-scooter Concept



- User stands

- All Limbs used: More intuitive and better controlled as the interface doesn't restrict the user in any way.

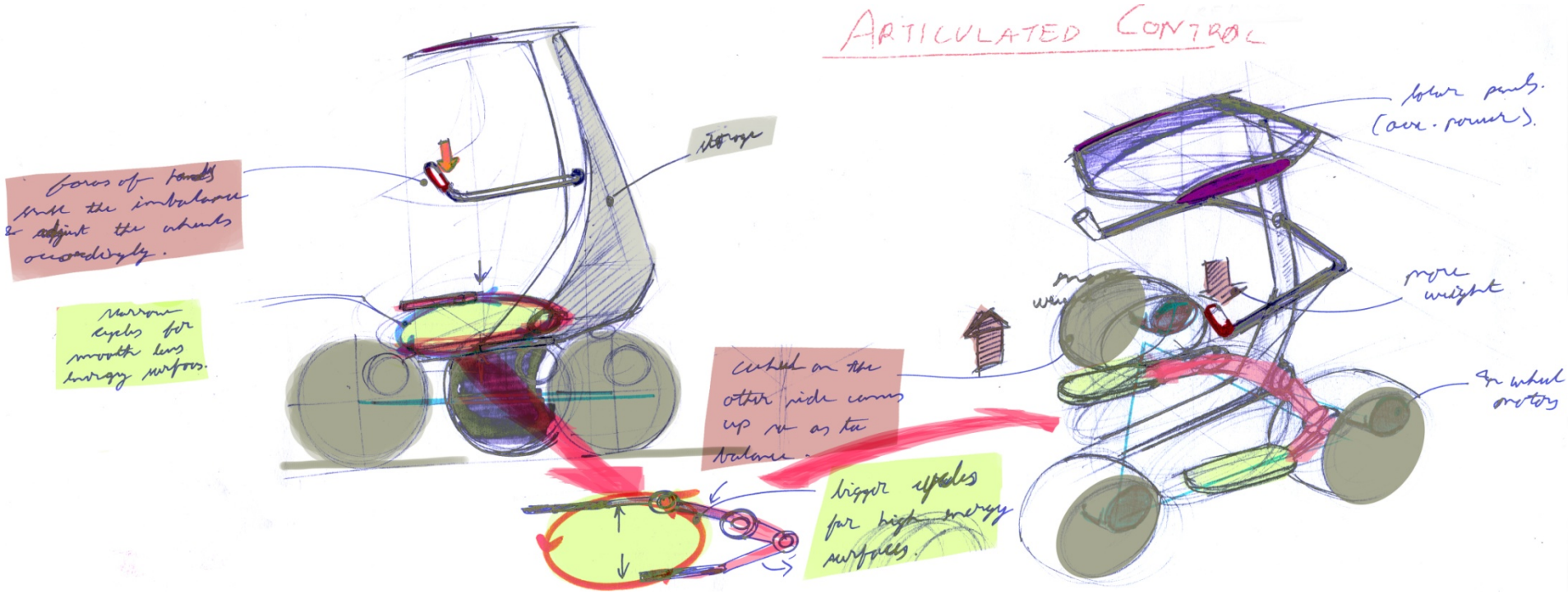
- More tiring for user

- Exposed to surroundings: more scope of interaction. Body weight can be used to enhance balance. Lack of safety.

- Articulated wheels : Lower energy consumption. The grip available may be an issue.

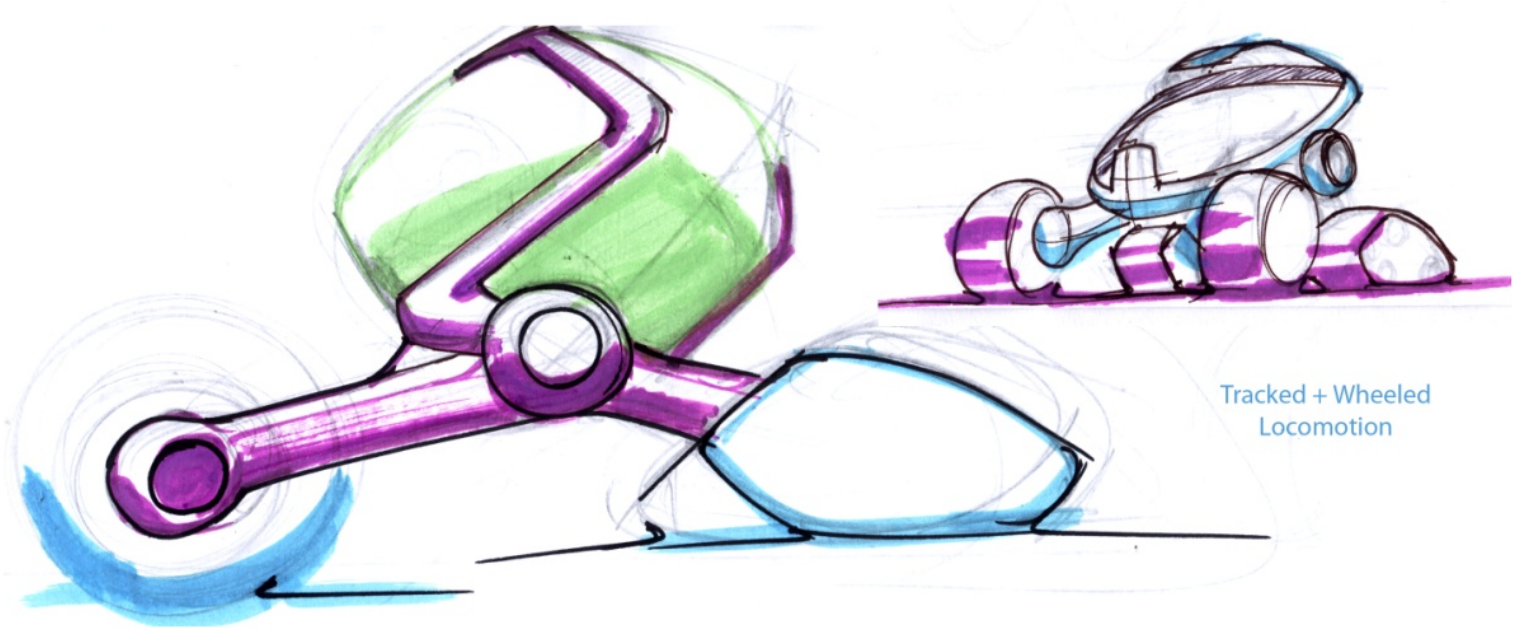
- Controls in the front: Visibility may be an issue.

Jogger Concept



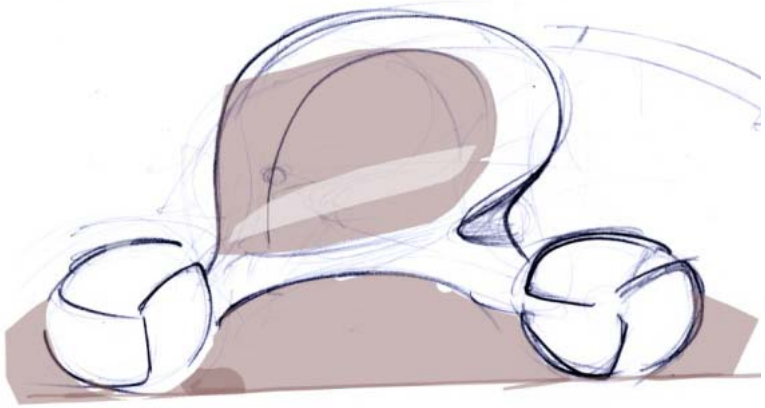
- Same as water scooter concept + Roof + Front is free + 3 Wheels
- Better safety
- Body completely exposed from the front.
- The entire cabin Revolves around a pivot.
- Forces front the limbs control the vertical positions of the wheels.

Fusion of wheeled and tracked locomotion



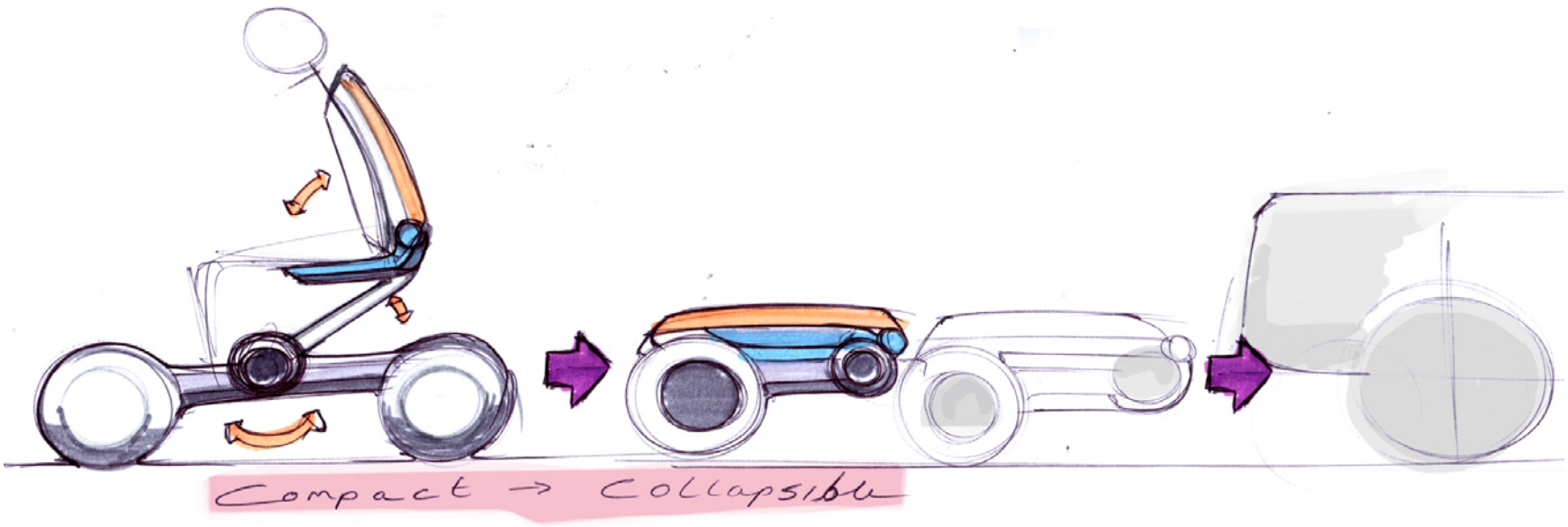
- Better grip due to track at the rear. More damage to the environment.
- Seat swivels in the cabin.
- Steering has to be given a thought.
- Variable ground clearance.

Variable diameter wheel concept



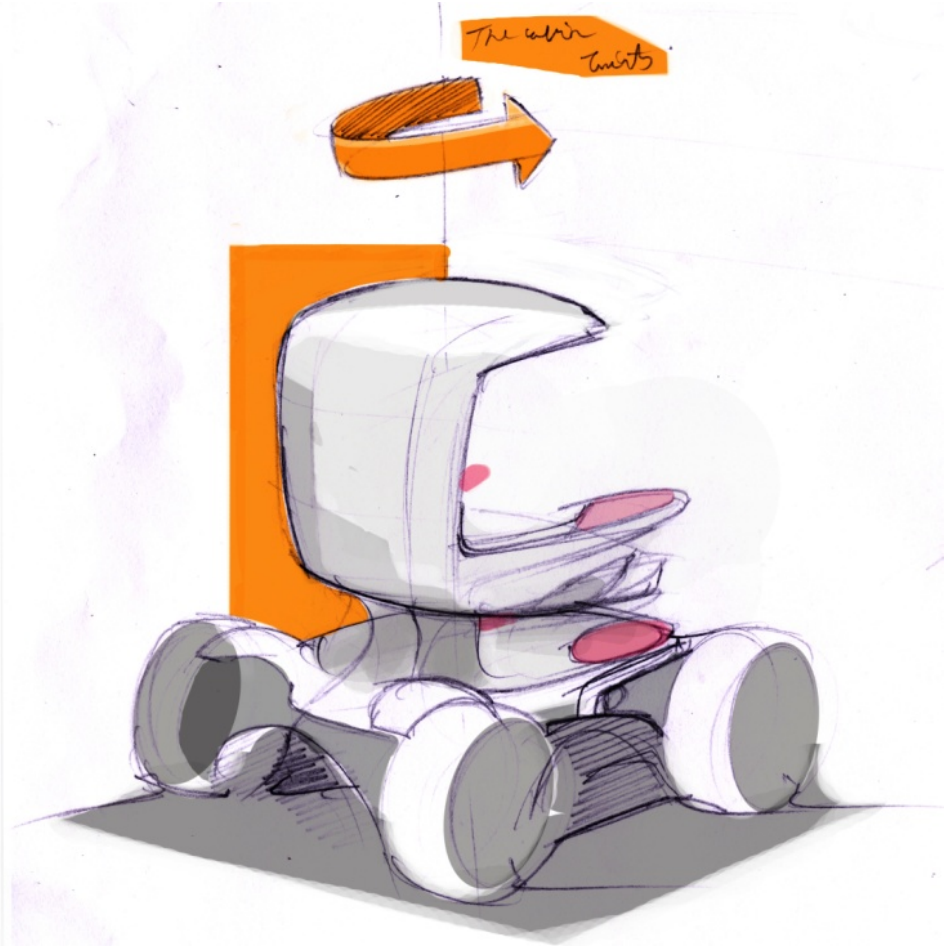
- Separate suspension not needed.
- Variable diameter wheels.
- Zero turning radius.
- The centre of gravity can be shifted.
- More conventional layout.

Collapsible compact concept



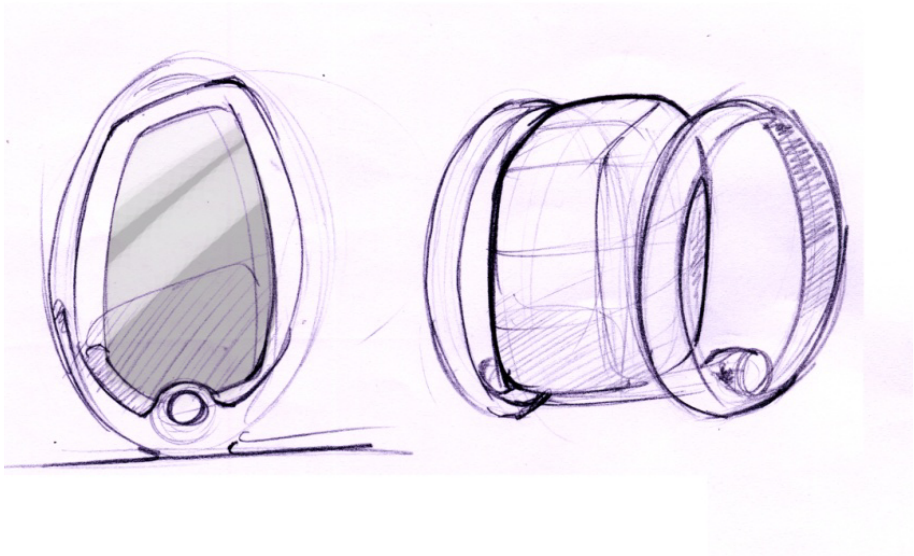
- Can be attached to the existing means of locomotion.
- More freedom.
- Range may be lesser.
- May not be as agile as the other options.
- User exposed.
- Essentials(Safety + Shelter) and Peripherals(Information) needed by the users.
- Smaller volume to control. More convenient.

Wheel chair concept



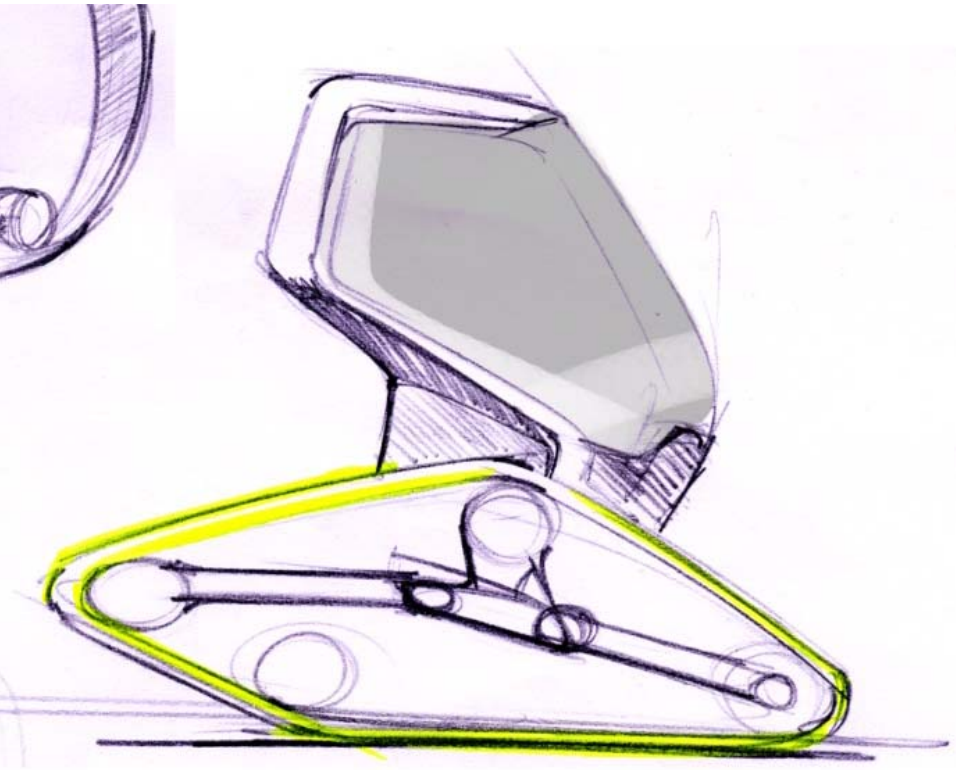
- Controls attached to the seat.
- The Seat and control swivel.
- Distant surveillance possible.
- Panoramic view.
- Better safety.
- User sits all the time.

Tracked wheel concept



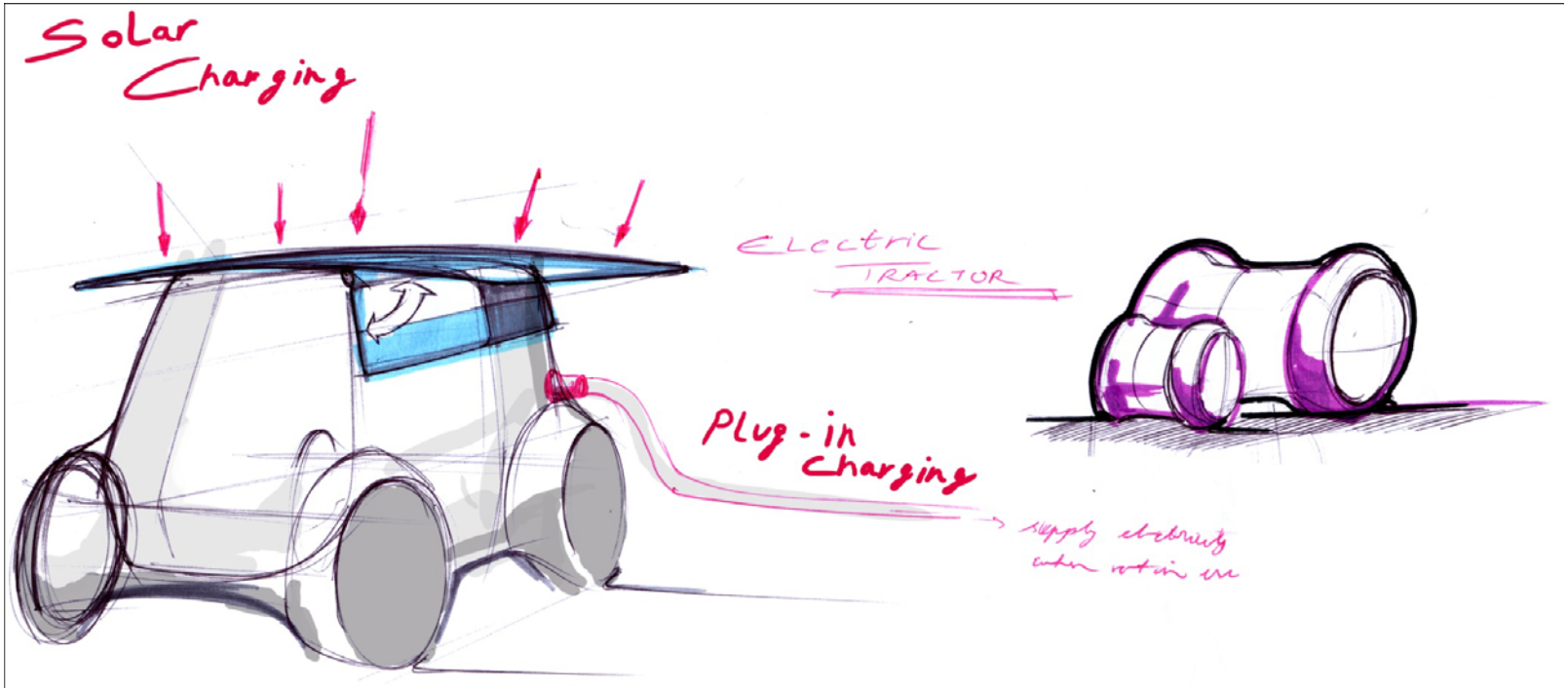
- Advantages of tracked and wheeled locomotion.
- Relatively more power consumption.
- Hindrance to the panoramic view.
- The whole vehicle rotates or turns.
- User encapsulated : More protection. Disconnect form the environment.
- More Compact.

Pure Tracked Concept



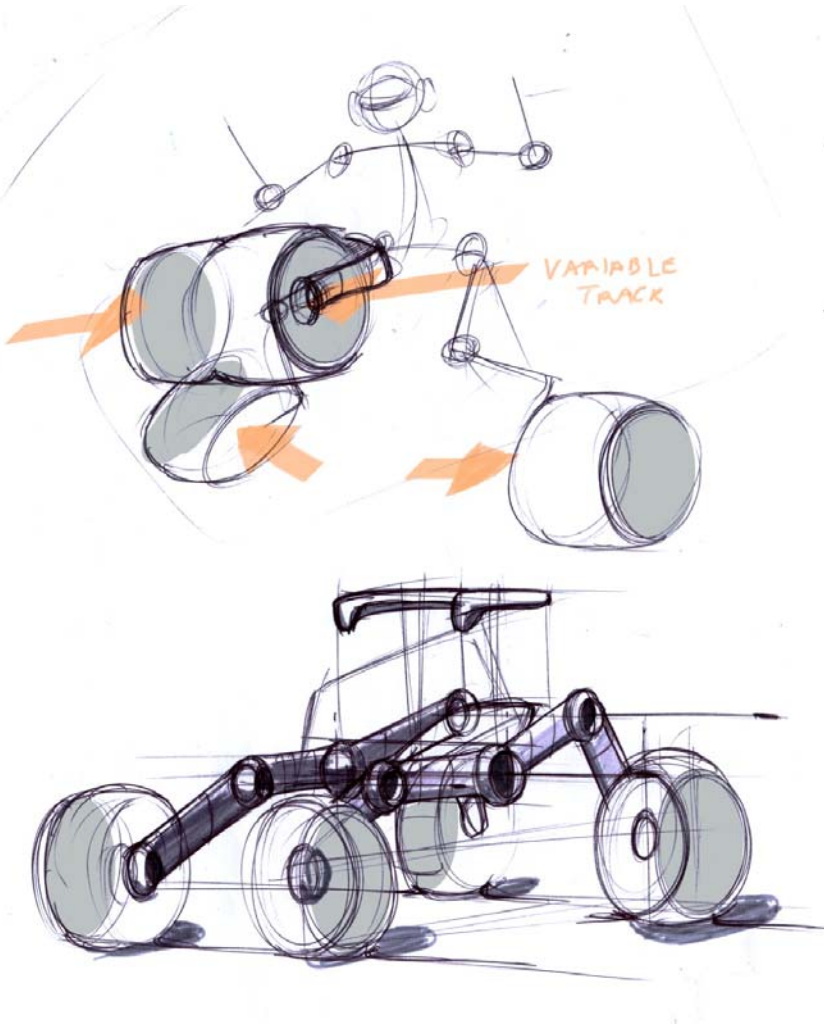
- Smoother on relatively smooth terrain.
- Very good traction on loose ground.
- Can handle small obstacles and ditches
- Huge payload possible.
- More energy consumption.
- Not very agile.
- Rougher ride.

Solar powered concept



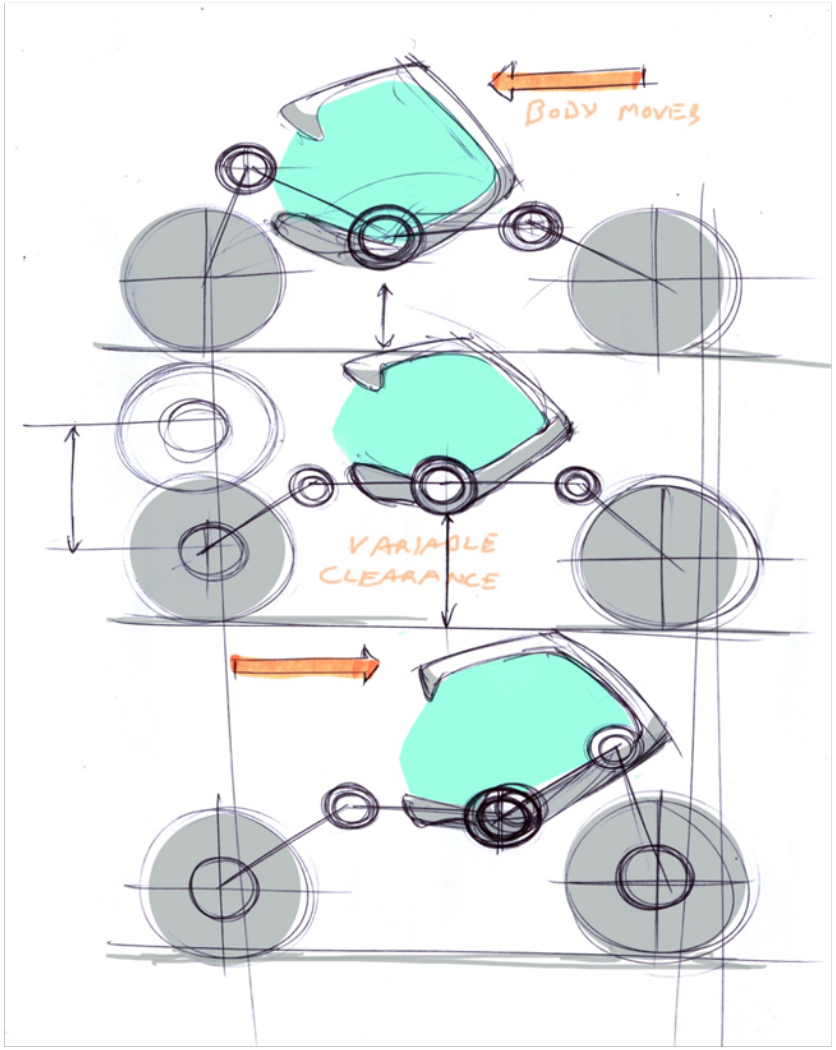
- Improved range.
- The battery can be charged at site when in/not in use.
- Sunlight is a variable phenomenon.
- Solar panels are delicate.
- Can be an auxiliary power source for other devices.

Variable track concept



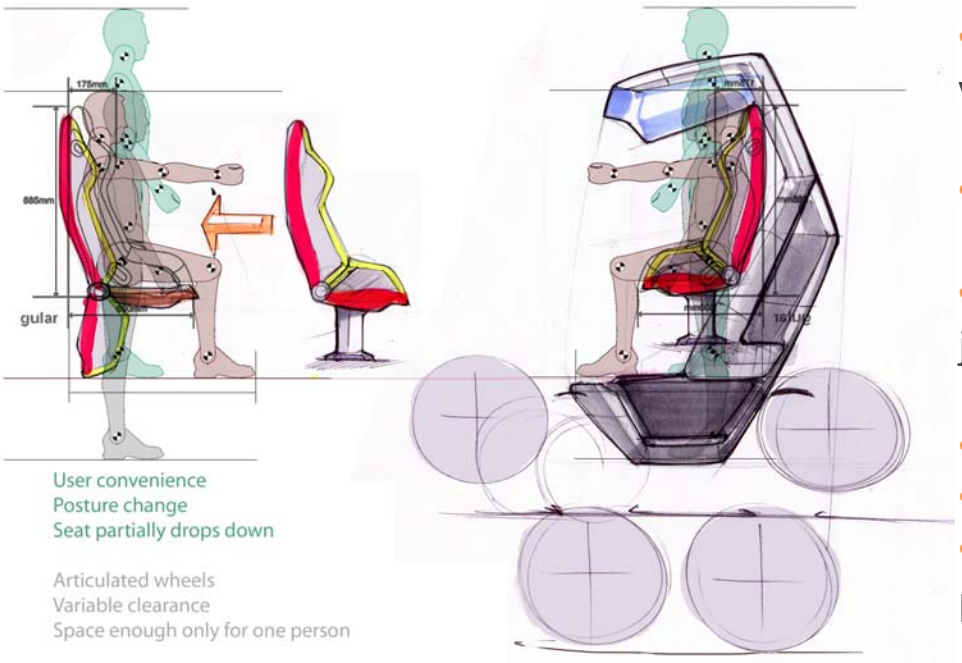
- The wheels come close as and when needed.
- Variable track.
- May cause imbalance.
- The arrangement becomes delicate.

Wheeled Legged concept



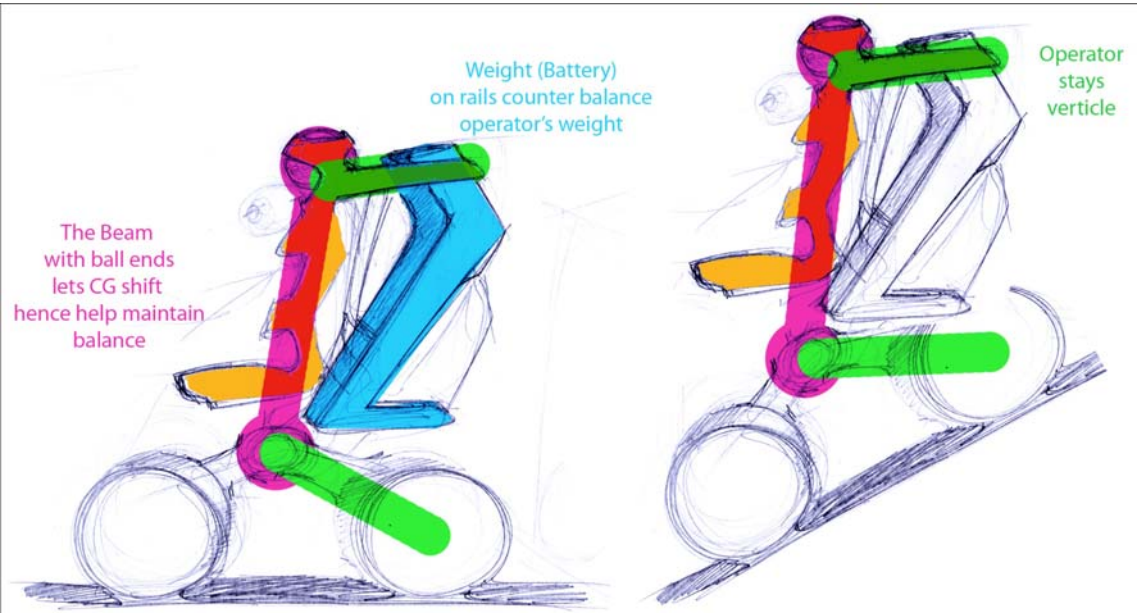
- The articulated arms for the wheels enables CG shift.
- Vertical position of the user maintained.
- Wheels can be locked as and when needed and the arms alone address motion.
- Complex motion and control.
- Grip provided by the wheels in their form may be an issue and lead to ineffeciency.
- If the wheels could act as claws: better grip. Increased complexity.

Variable operation posture concept



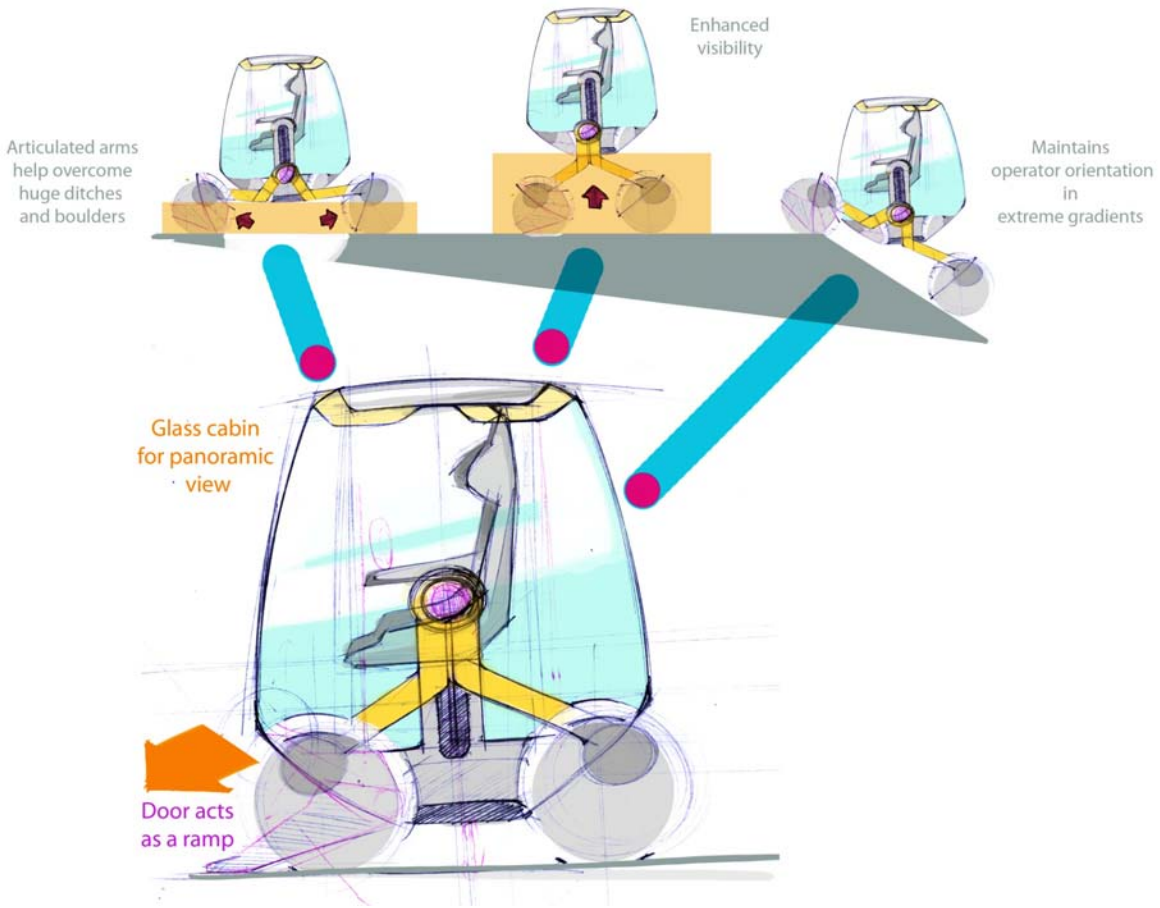
- User can sit as well as stand and control the vehicle.
- Sit while relaxed operation
- Stand when in a tricky situation: Enhanced judgment and convenience.
- The Bucket seat converts to a cycle/bike seat
- .
- The eye level stays the same irrespective of the posture of control.
- Extra leg room needed when in standing mode.
- Articulation of wheels: Variable wheel base, Variable foot print.

Balance concept



- Two platforms(base +seat) connected through a Beam with ball ends.
- Beam with ball ends lets CG shift hence help maintain balance.
- Counter weight(battery) on rails to balance operator's weight.
- Operator stays vertical irrespective of the topography.
- 360° CG shift possible: Lateral +transverse +diagonal.
- Restriction of swinging.
- Vehicle may topple if not controlled properly.
- User safety to be reworked upon.

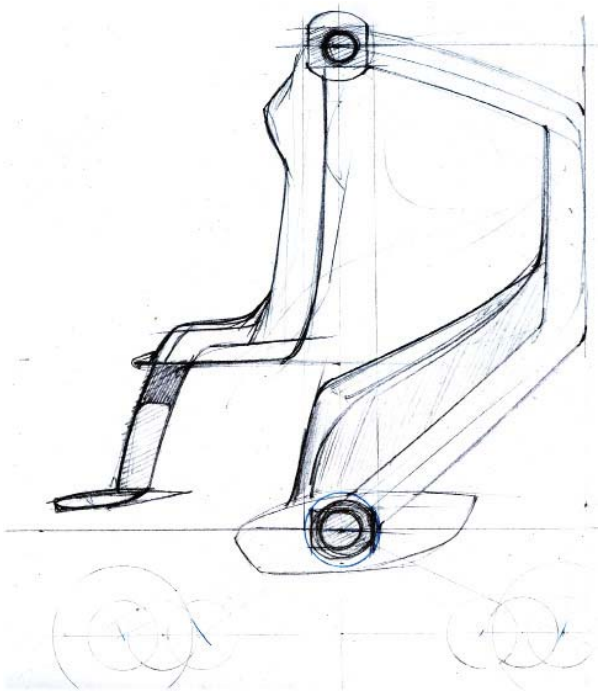
Lifeguard concept



- Articulated arms help overcome huge ditches.
- Seat swivels: Enhanced visibility
- Maintains operator orientation in extreme gradients.
- Variable footprint.
- Encapsulated operator: more safety.

Three Concepts

Concept 1



Work space stays upright during ascend.

Work space stays upright during descend.

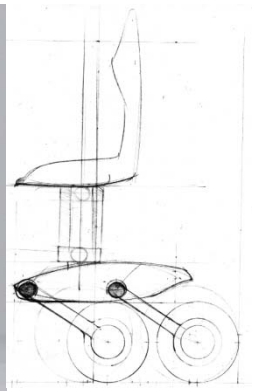
Work space stays upright while on a slanted surface

- This concept has a ball-and-socket joint type pivot point at the top from which the workspace hangs.
- The wheels are connected to the main body through articulated arms.
- Upright workspace all the time.
- The work space is open enabling good visibility.
- Safety is an issue.
- The concept has zero turning radius which is very helpful in tight spaces.

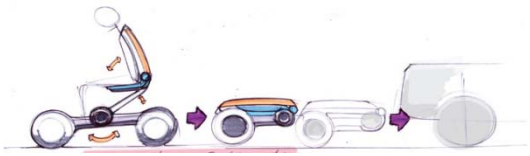
Observation

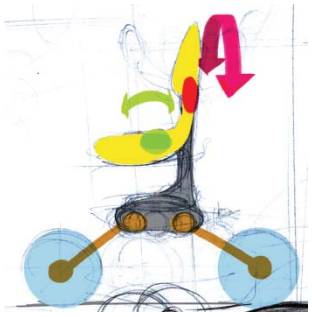
On making the concept verification prototype it was found that the ball-and-socket joint at the top is unnecessary.

Concept 2



Collapsed position while towing.

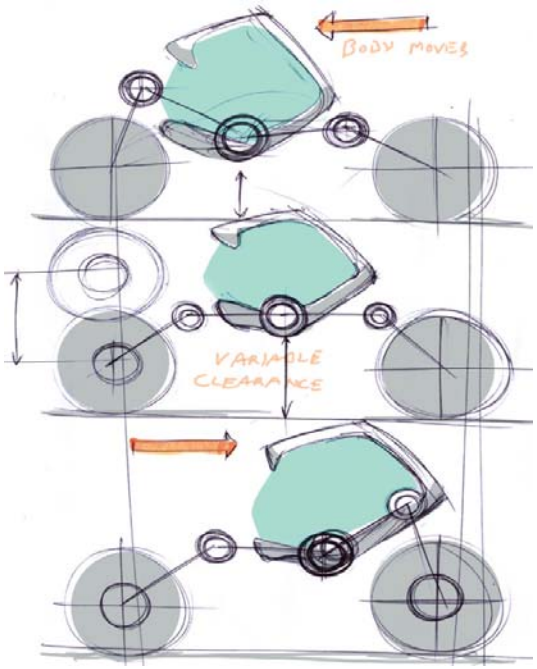




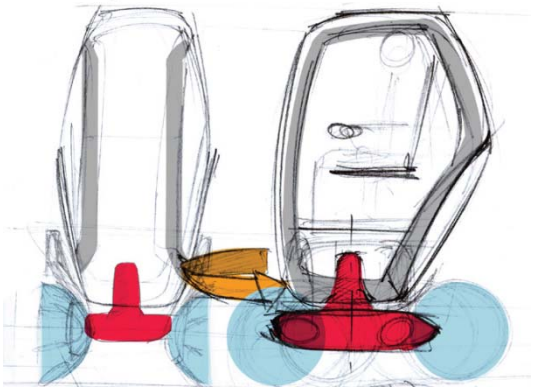
Open mode while in operation.

- This concept is a collapsible concept meant to be towed as close to the work site by regular vehicles.
- It has the advantage of being lighter and easier to maneuver than the other concepts.
- This concept is not as agile and hence is less capable.

Concept 3

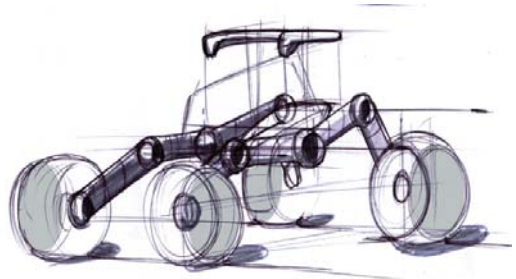


Articulated arms facilitate shifting of the centre of gravity hence preventing toppling and roll- over

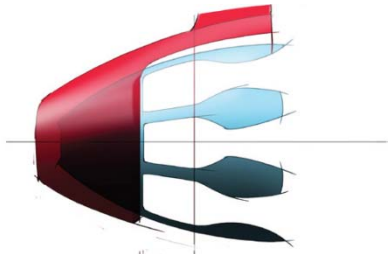


Closed cabin gives maximum safety.

- This concept consists of wheels that are connected to the body through two links each.
- Under normal circumstances the arms only help keep the work space upright.
- As and when the need be the wheels get locked and the arms enable crawling.
- The cabin is covered hence providing safety to the operator.
- The operation may be complexed as there are two modes of operation.

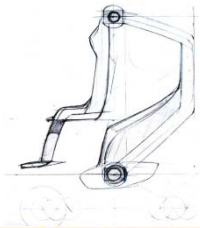


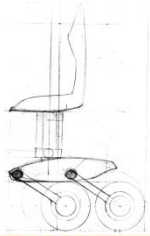
Wheel articulation explained. Each wheel is conected to the body with two links. The concept can crawl too.

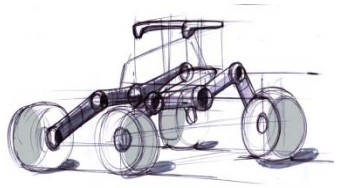


Segmented wheels more suitable for rough terrain.

Concept evaluation







Evaluation 1

Concept		Concept1		Concept 2		Concept 3	
criteria	Weight	User	marks	User	Marks	User	Marks
Stability	5	4	20	4	20	5	25
Convinence of Operation	3	5	15	4	12	3	9
Manuverability	5	3	15	4	20	5	25
Visibility	4	4	16	3	12	3	12
Simplicity	3	5	15	4	12	3	9
User safety	2	2	4	5	10	4	8
0	22	23	85	24	86	23	88

Evaluation 2

Concept		Concept1		Concept 2		Concept 3	
Criteria	Weight	User	marks	User	Marks	User	Marks
Satbility	5	2	10	2	10	5	25
Convinence of Operation	3	5	15	2	6	2	6
Manuverability	5	2	10	2	10	5	25
Visibility	4	5	20	2	8	2	8
Simplicity	3	4	12	3	9	1	3
User safety	2	1	2	5	10	4	8
Total			69		53		75

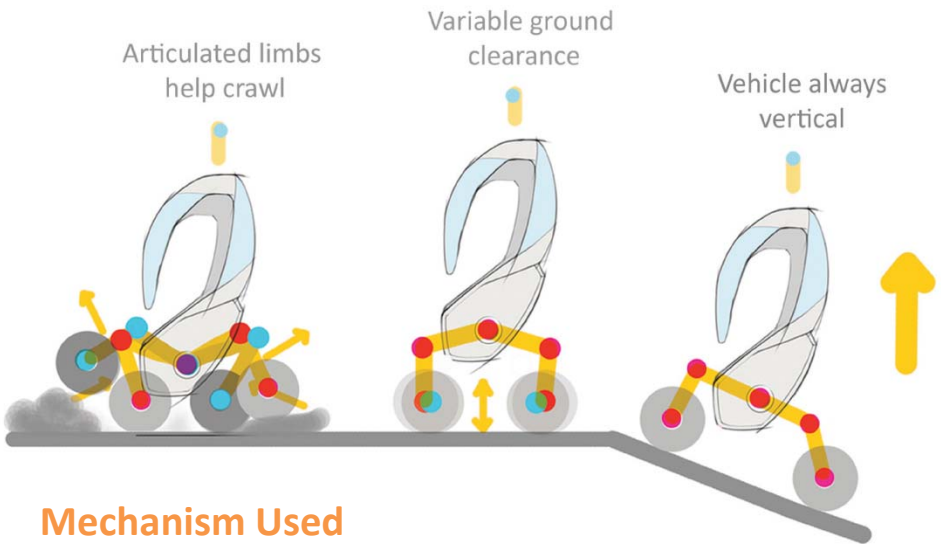
Evaluation 3

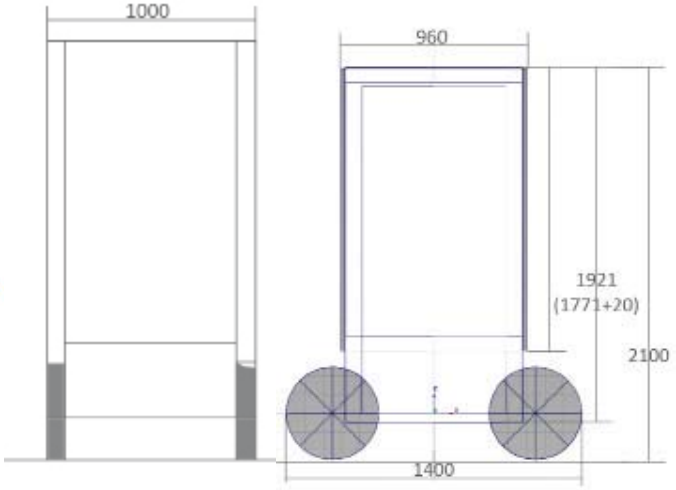
Concept		Concept1		Concept 2		Concept 3	
Criteria	Weight	User	marks	User	Marks	User	Marks
Satbility	5	2	10	1	5	5	25
Convinence of Operation	3	1	3	3	9	2	6
Manuverability	5	3	15	2	10	5	25
Visibility	4	2	8	4	16	3	12
Simplicity	3	1	3	3	9	1	3
User safety	2	3	6	2	4	3	6
0	22	12	45	15	53	19	77

Evaluation 4

Concept		Concept1		Concept 2		Concept 3	
Criteria	Weight	User	marks	User	Marks	User	Marks
Satbility	5	1	5	3	15	4	20
Convinence of Operation	3	3	9	5	15	1	3
Manuverability	5	3	15	1	5	4	20
Visibility	4	3	12	5	20	3	12
Simplicity	3	3	9	1	3	2	6
User safety	2	1	2	3	6	4	8
Total			52		64		69

Evolution of Controll





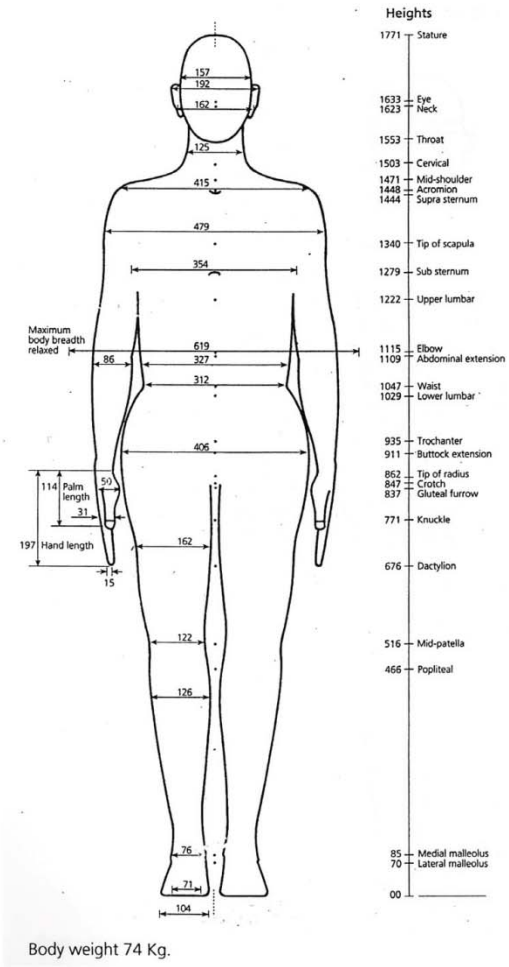
Mechanism Used

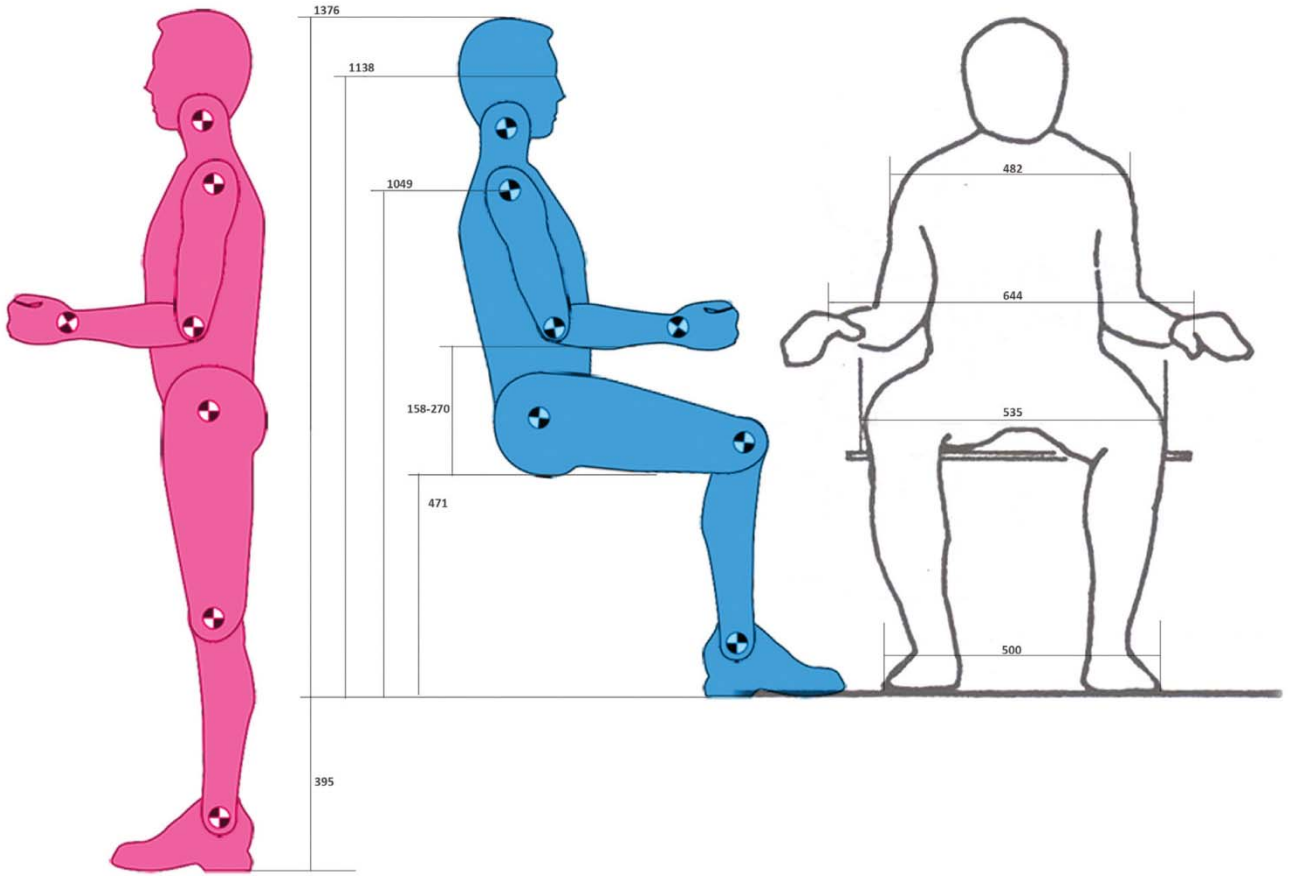
- The idea of big wheels is no more valid as the dimensions to be kept minimum.
- Smaller, articulated, wheels have used.
- In very difficult situations the wheels can lock and act merely as feet.
- The arms articulate and hence the vehicle crawls its way out.

Concept Packaging

- For height of the cabin a clearance of 200mm has been addded to the 95th percentile Indian Man's height.
- Width kept 1000mm so as to maintain narrow track of the vehicle.

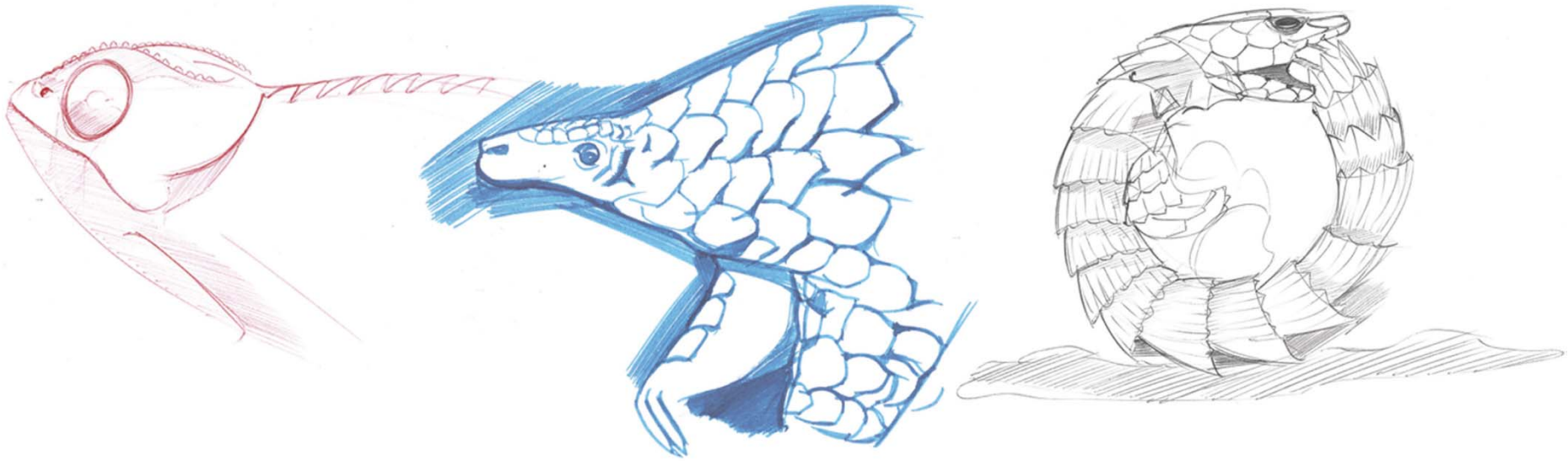
Anthropometry and Ergonomics





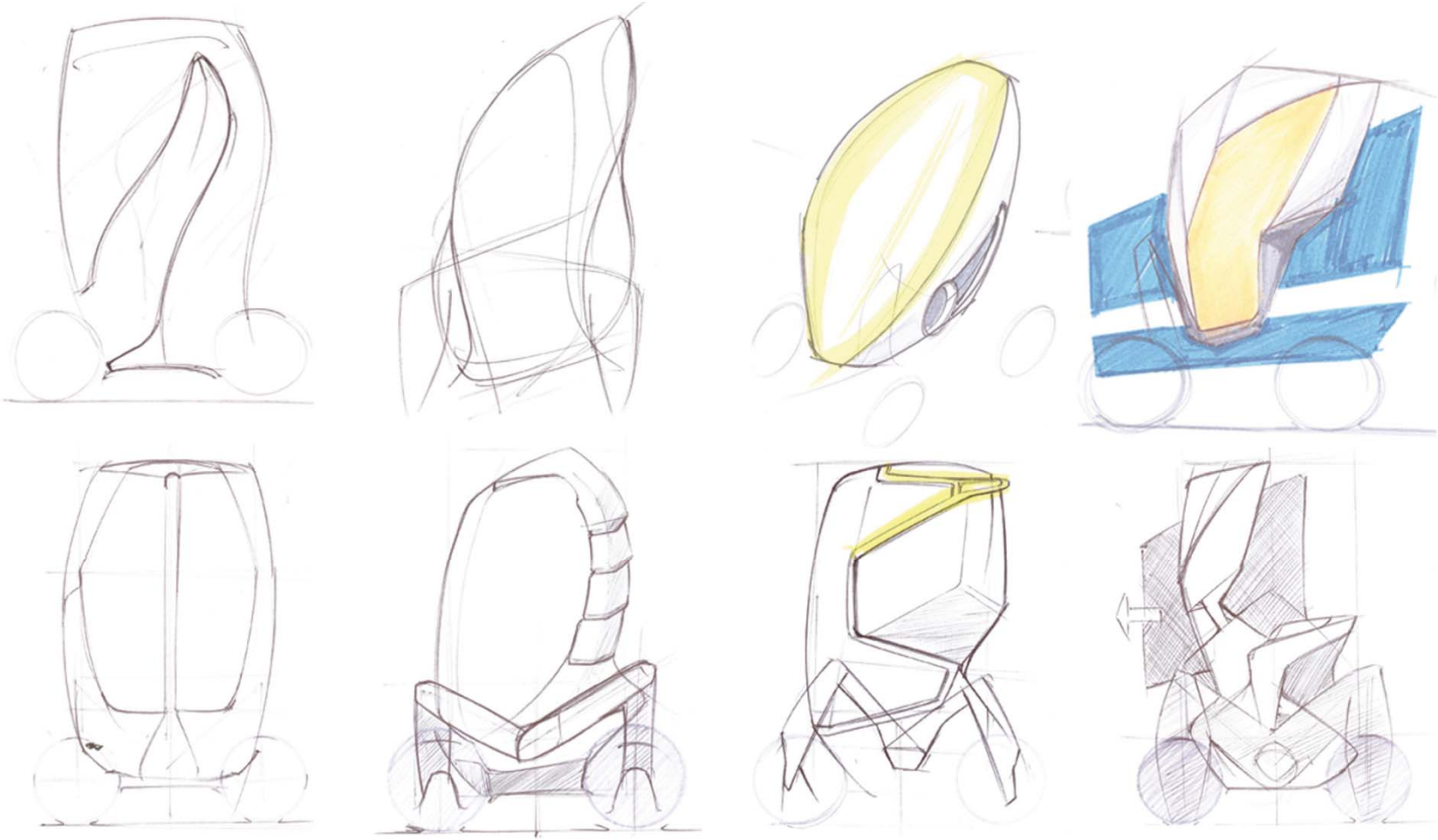
Form Inspiration and Exploration

Climb. Balance. support. Grab. recover. move. Conserve. Trailblazer. function. Electric.

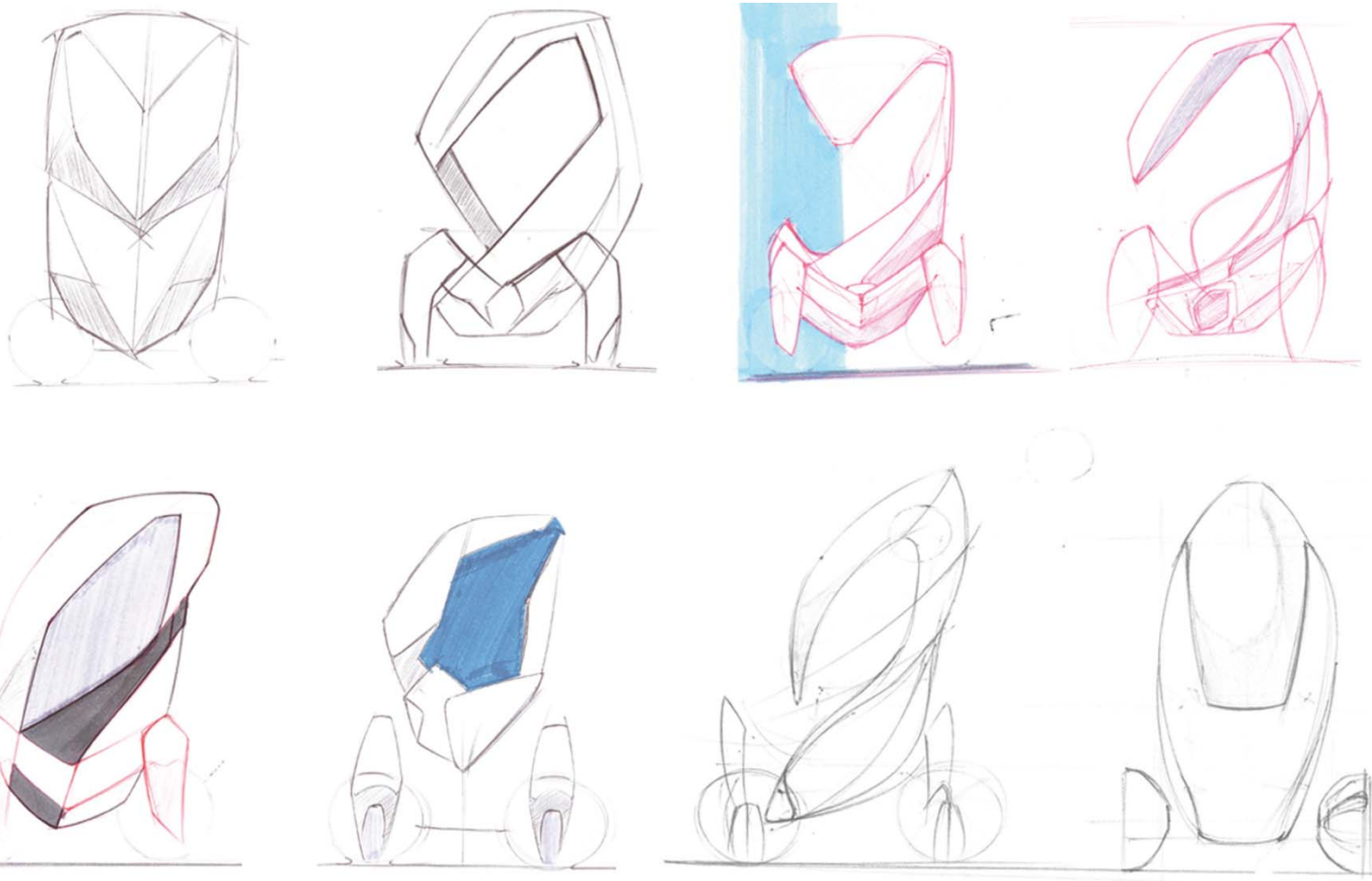


Chameleon **Pangolin** **Armadillo Lizard**

Explorations



Explorations



Form Exploration

Form and volume verified on PS Foam mockups.

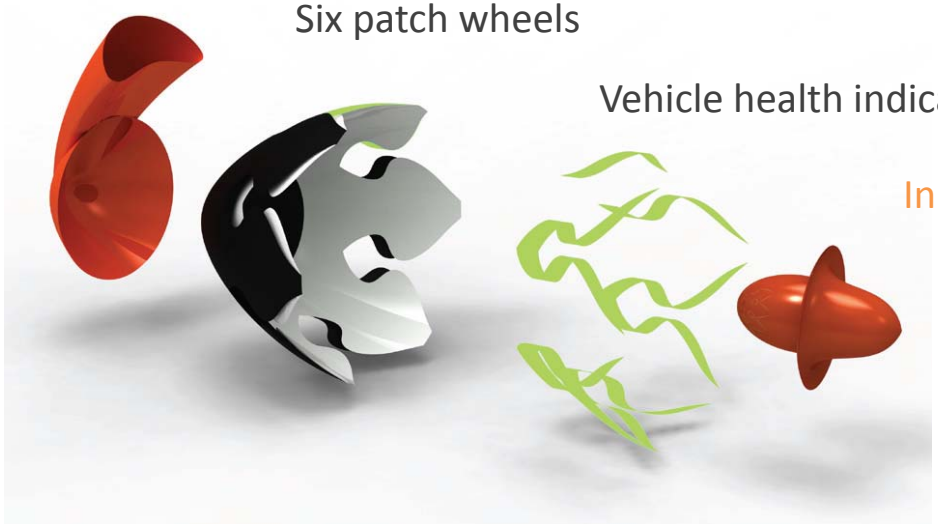
Final Form

Constroll

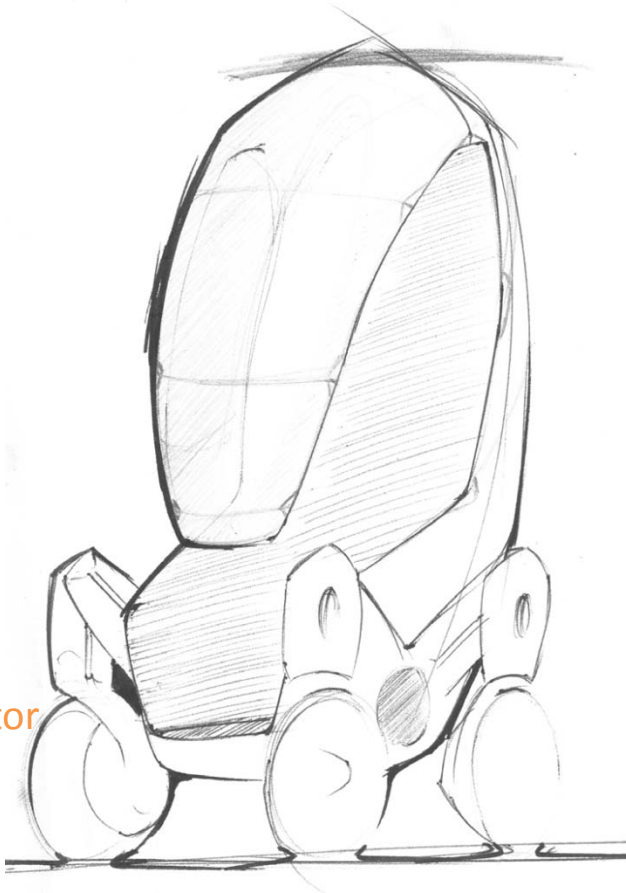
Wheel Hub

Six patch wheels

Vehicle health indicator



In wheel electric motor

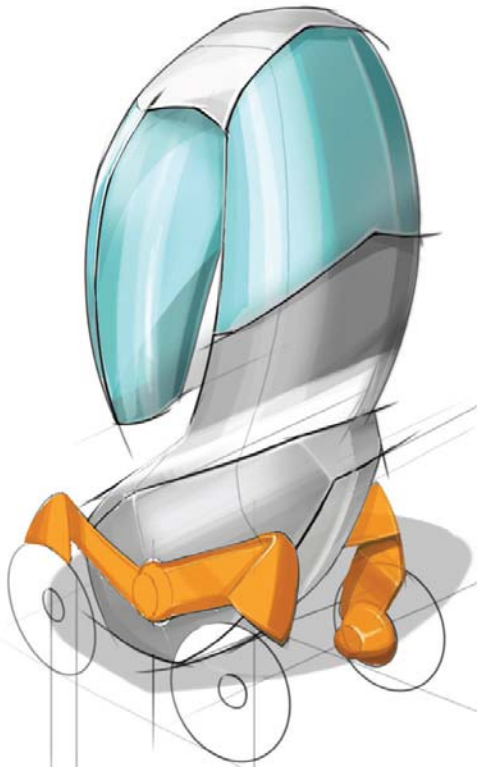


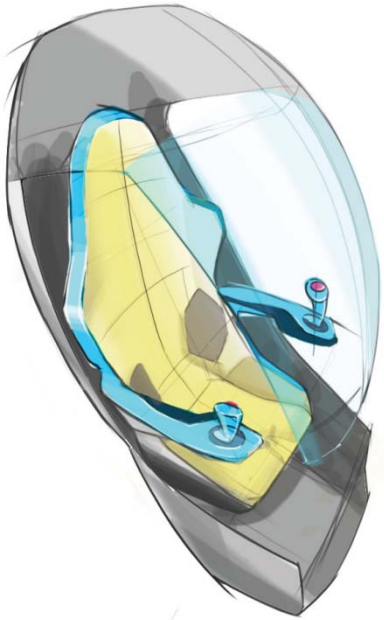
Constroll – The Name

Construction and Mining sites + Stroll (as the concept walks) + Roll (as the concept moves also on rolling wheels)

ConstRoll

ConstRoll

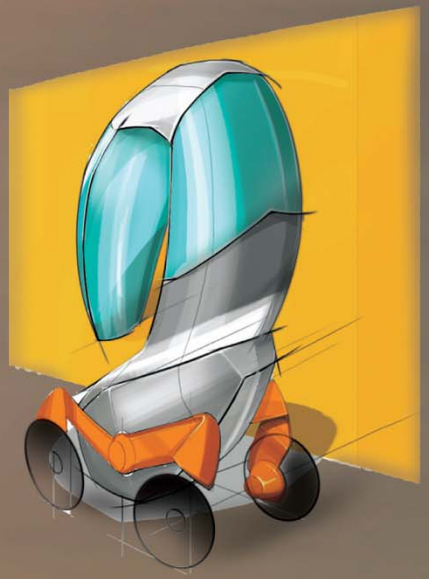


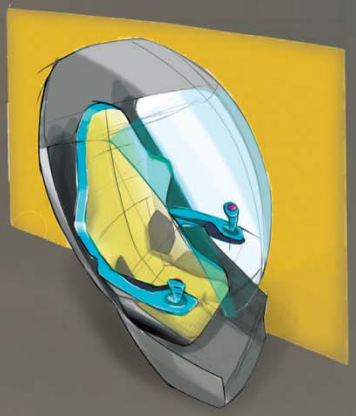


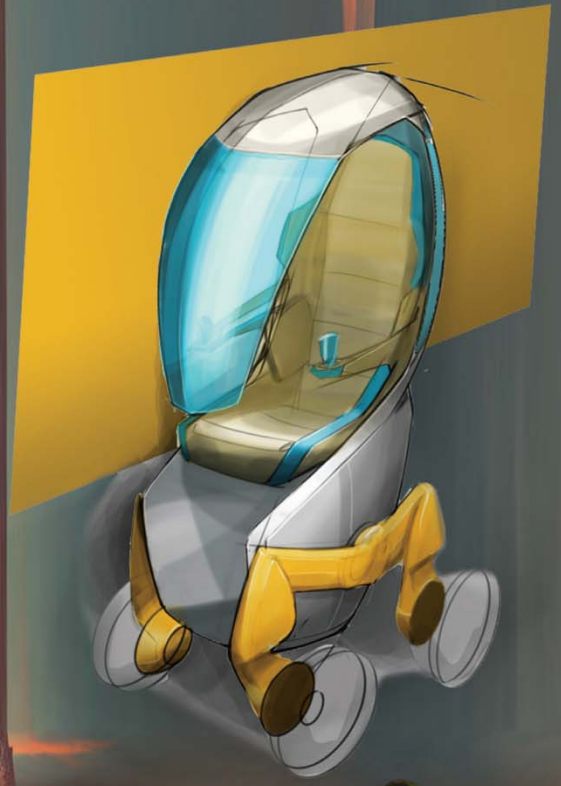
CONSTROLL

CONCEPT FOR DIFFICULT TERRAIN

Joystick control.
Bucket seats.
The thigh support of the seat drops down enabling standing and manuvering as and when needed.







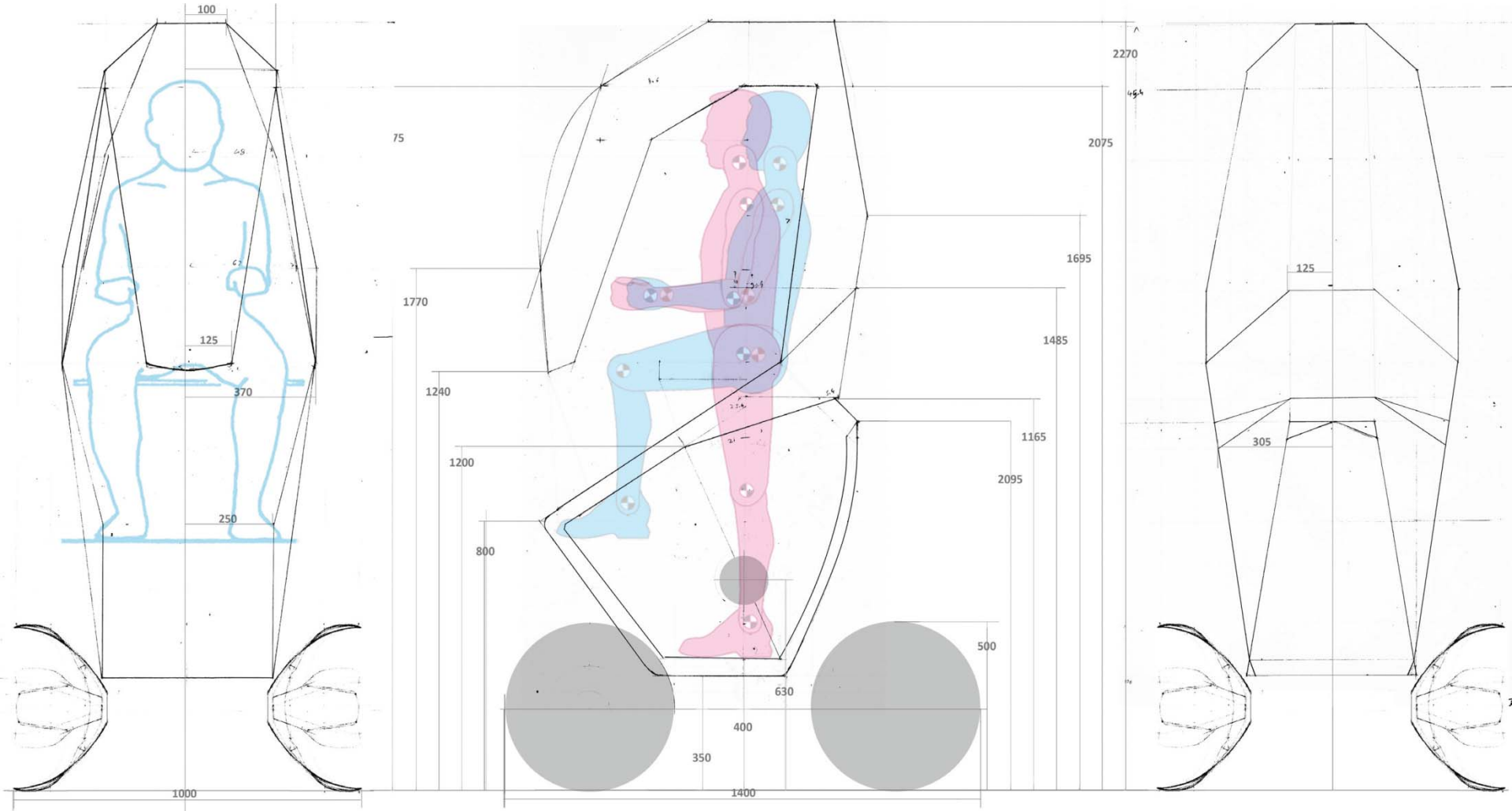
FUNCTIONAL AESTHETICS

Electric difficult terrain vehicle for engineers. The concept uses wheels that roll and give drive. When terrain gets tricky for wheels, they lock, and the articulated arms enable crawling your way out.

The form is derives insperation from Pangolin and Armadillo Lizard. They usually crawl but can also roll as a defence mechanism. They do it when their lives are in jeopardy. Hence aptly suitable for the concept.

The windscreen narrows down like the head of a pangolin enabling wheel visibility and unrestricted view around.

Dimensions of Constroll



Possible Improvements

- Concept with a closed cabin can also be worked upon.
- The articulated arms could be concealed into the form.
- A simpler mechanism for the crawling of the concept can be thought of.
- A more up-to-date anthropometric data could be used.
- More exploration and work can be done on details of the concept.

Learnings

- Searching for and discovering a new niche.
- Understanding the requirements of a concept and the limitations of application of technologies and solutions.
- Anthropometry.
- Application of anthropometric data and ergonomic considerations to be done while fixing dimensions.
- Working under constraints.
- Maintaining a record of progress.
- Self discipline.
- Qualitative and quantitatively assess the output.
- Sensitivity towards form.
- Working under pressure.
- Rendering skills in Adobe Photoshop.
- Working in Adobe InDesign.
- Fabrication using different materials.
- Clay modeling.
- Sketching in set dimensions.

Thank you.