BIONICS IN MOBILITY DESIGN

Goods Carrying Two Wheeler
MVD II-25

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M.Des
Mobility and Vehicle Design
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Industrial Design Centre
Indian Institute of Technology Bombay
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Declearation

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Approval Sheet

This Mobility and Vehicle Design project report entitled “ Bionics in Mobility Design”, by Amol Bhangare is approved in partial fulfilment of the requirements for Master of Design degree in Mobility and Vehicle Design.

Project Guide-

Chair Person-

Internal Examiner-

External Examiner-

Date-

Acknowledgement

I would firstly like to thank my guide, Prof. Nishant Sharma for the support and valuable inputs that he has provided during the course of project. I also thank Prof K Ramachandran for his inputs on the project.

Last but not the least, I would like to thank my family and all my dear friends at IDC and from other places for being a constant source of support and inspiration throughout the project.

Amol Bhangare
Date:-

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Abstract

Nature has been a rich source of inspiration for design field throughout history. Bionic design can serve as a bridge between the modern design and the evolution of nature. Self-sustainability, efficiency, functional integrity and optimized forms are found in nature. Hence there is great potential of exploring the ideas that can help design better solutions in automotive design field.

1. Introduction

Bionics is the application of the biological methods and the systems found in nature to the study and design of systems and modern technology.

The word bionic was coined by Jack E. Steele in 1958, possibly originating from the technical term bion meaning 'unit of life' and the suffix -ic, meaning 'like' or 'in the manner of', hence 'like life'. Some dictionaries, however, explain the word as formed portmanteau from biology and electronics. It was popularized by the 1970s U.S. television series The Six Million Dollar Man and The Bionic Woman, both based upon the novel Cyborg by Martin Caidin, which was itself influenced by Steele's work. All feature humans given superhuman powers by electromechanical implants. The transfer of technology between lifeforms and manufactures is, according to proponents of bionic technology, desirable because evolutionary pressure typically forces living organisms, including fauna and flora, to become highly optimized and efficient. A classical example is the development of dirt- and water-repellent paint (coating) from the observation that the surface of the lotus flower plant is practically unsticky for anything.

Ekso Bionics is currently developing and manufacturing intelligently powered exoskeleton bionic devices that can be strapped on as wearable robots to enhance the strength, mobility, &

and endurance of soldiers and paraplegics.

The term "biomimetic" is preferred when reference is made to chemical reactions.[citation needed] In that domain, biomimetic chemistry refers to reactions that, involve biological macromolecules (for example, enzymes or nucleic acids) whose chemistry can be replicated using much smaller molecules in vitro.

Examples of bionics in engineering include the hulls of boats imitating the thick skin of dolphins; radar, medical ultrasound imaging imitating the echolocation of bats. In the field of computer science, the study of bionics has produced artificial neurons, and swarm intelligence. An Evolutionary computation was also motivated by bionics ideas but it took the idea further by simulating evolution in silico and producing well-optimized solutions that had never appeared in nature.

Before three thousand years BC, our ancestors imitated bird nest in the tree to defense beast. The imitations of the entrance hall in front of some ancient temples are the elephant legs. Leonardo Da Vinci lived in A.D. 1,500 years emulated bird's wing for bionic flying, and a series of equipment drafts and models are made. They became the prototype of the modem helicopters. Based on the imitation of fishes, ancients logged for making ship. The pectoral fins and tail fin of the fishes was be imitated as twin screw and rudder, so freedom of water transportation is obtained. Through a detailed study and imitation of the flying organs of birds, and according to the principle of bird's flying structure, then the manned flight glider can be made. In modem times, some

disciplines such as biology, electronics and dynamics promote the rapid development of bionic design, especially in the areas of industrial design. Using bionic designs for the variety of biological simulation and re-creating bring many excellent products.

1.1 Bionics

Bionics is an interdisciplinary field which deals with the structures, methods and the processes found in biological systems.

Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. Coined by an engineer and psychiatrist of the Air Force's Aerospace Medical Division, Jack E. Steele in 1958 with emphasis on neuroanatomy.

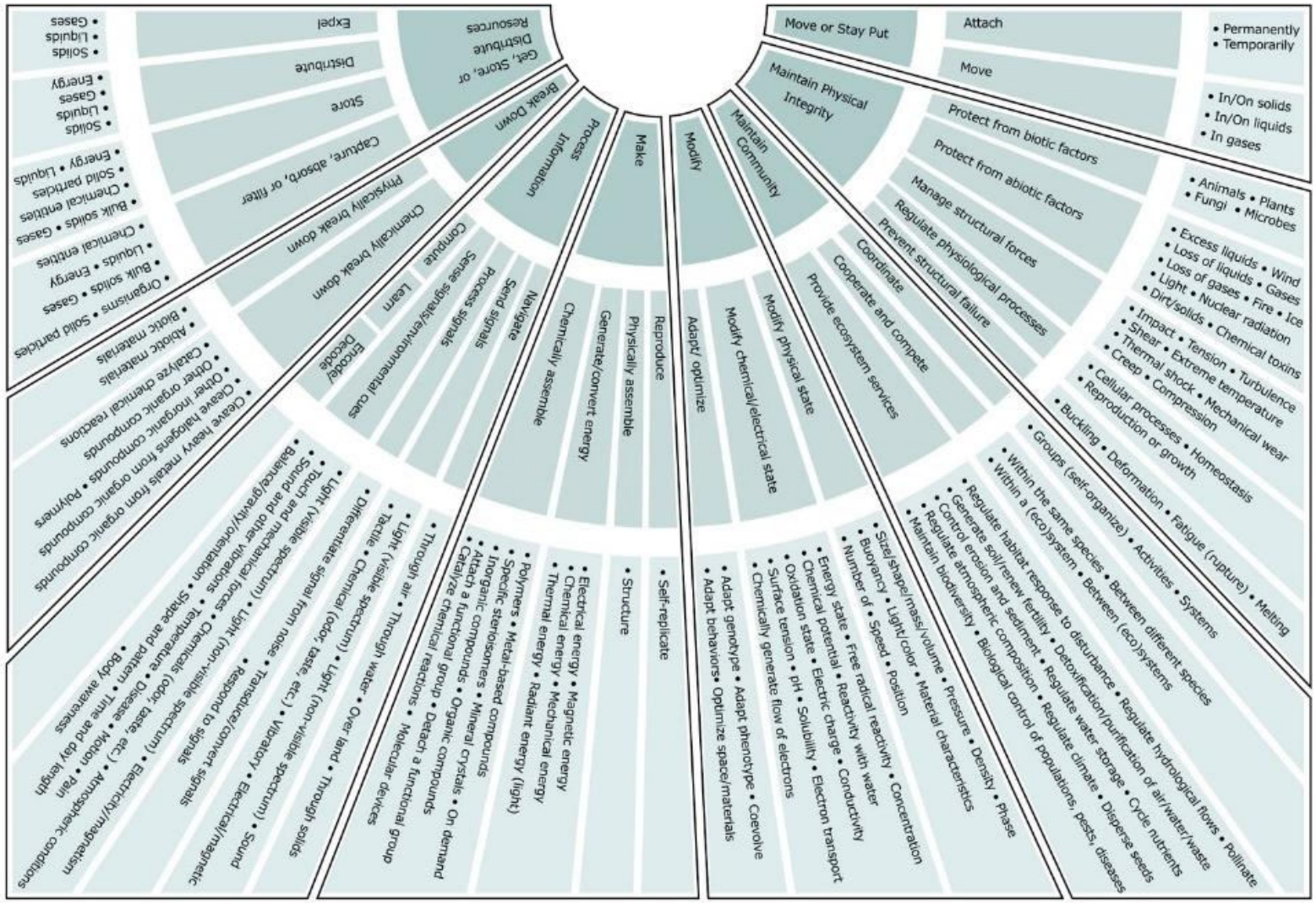
1.2 Biomimicry

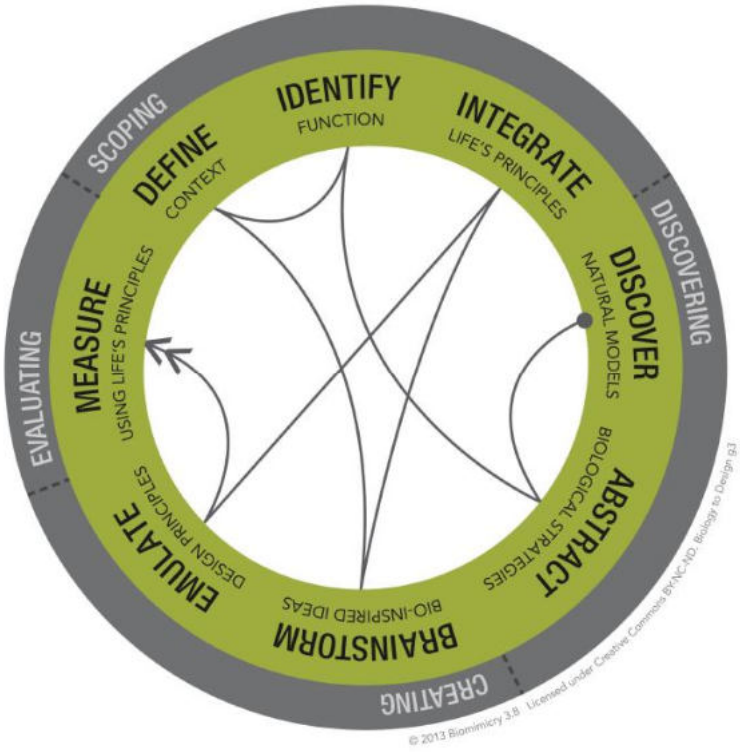
Biomimetic or biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems.

Bionics as the term for the field of study involving copying, imitating, and learning from biology was coined by Jack Steele of the US Air Force in 1960 at a meeting at Wright–Patterson Air Force Base in Dayton, Ohio. Otto H. Schmitt coined the term Biomimetic in 1969 (Schmitt, 1969) and this field is increasingly involved with emerging subjects of science and engineering. The term itself is derived from bios, meaning life, and mimesis, meaning to imitate.

Coined by Janine Benyus, a natural sciences writer with a degree in natural resource management and English literature/writing from Rutgers University.

1.3 Bio-Inspired Design taxonomy





1.4 Bionic Design Thinking

Biomimicry, as a term within bio-inspired design, has its roots in biomimetics and bionics. An early use of the term appeared in a chemistry dissertation in 1982. More recently, Benyus defines biomimicry as a 'science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems'. Benyus and colleagues developed taxonomies, methodologies (e.g. the Biomimicry DesignLens and Biomimicry Thinking). This methodology includes an integral repository and online system known as AskNature, an inspirational portal based on social networking and the sharing of biological knowledge.

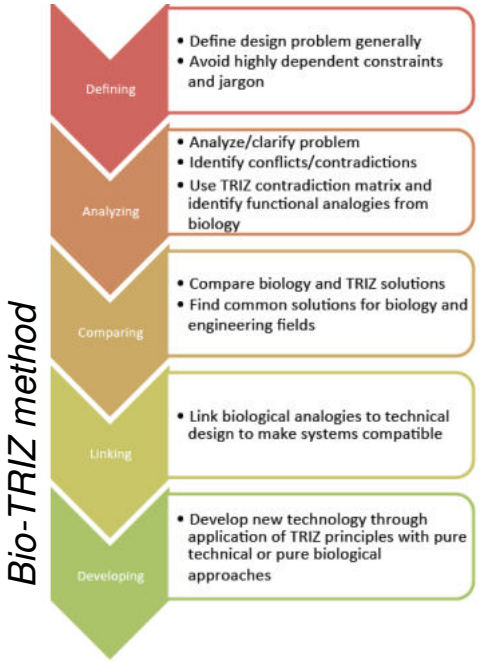
2 Research methods

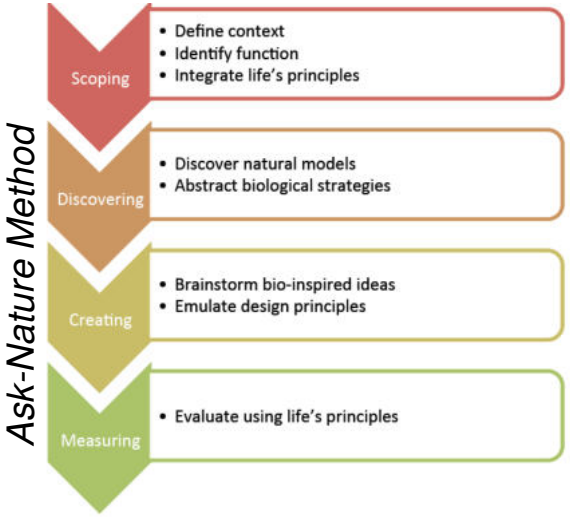
The goal of bionic design methods is to offer designers an organized process in order to attain a model that may be applied in design, inspired mostly by the relations between form and function in nature (Colombo, 2007). Despite the success attained in several cases from the use of this approach in design, the bionic design approach may still have room for improvement, in order to become more systematic. The application of bionic principles in a design project can be accomplished by means of processes which may be oriented according to two opposing directions: finding a solution to a problem in nature, or looking for a problem to which a solution was found in nature. The former approach starts with the identification of a problem (e.g. human applications, such as developing or improving products or services) or the consideration of a project need, and is followed by looking either for inspiration from nature or for an analogy to foster a solution to the problem (a bionic solution proposal). This approach is well suited to designers seeking inspiration for the development of a particular product. The other approach is based on the observation of nature and its system structures in order to collect useful information (solution based on inspiration) for human applications (design problems to be sought).

2.1 Common Design Methods

Following are the common methods used in bionics design process.

- Ask-Nature Method
- IDEA-Inspire Approach
- BioTRIZ method
- DANE
- Engineering Bio Thesaurus





Define	• Define work area • Identify functions
Discover	• Discover Natural Models and Elements • Abstract Biological Strategies and Principles
Create	• Brainstorm Bio-Inspired Ideas [from abstract] • Bio-Principle integration
Develop	• Develop the concept/product

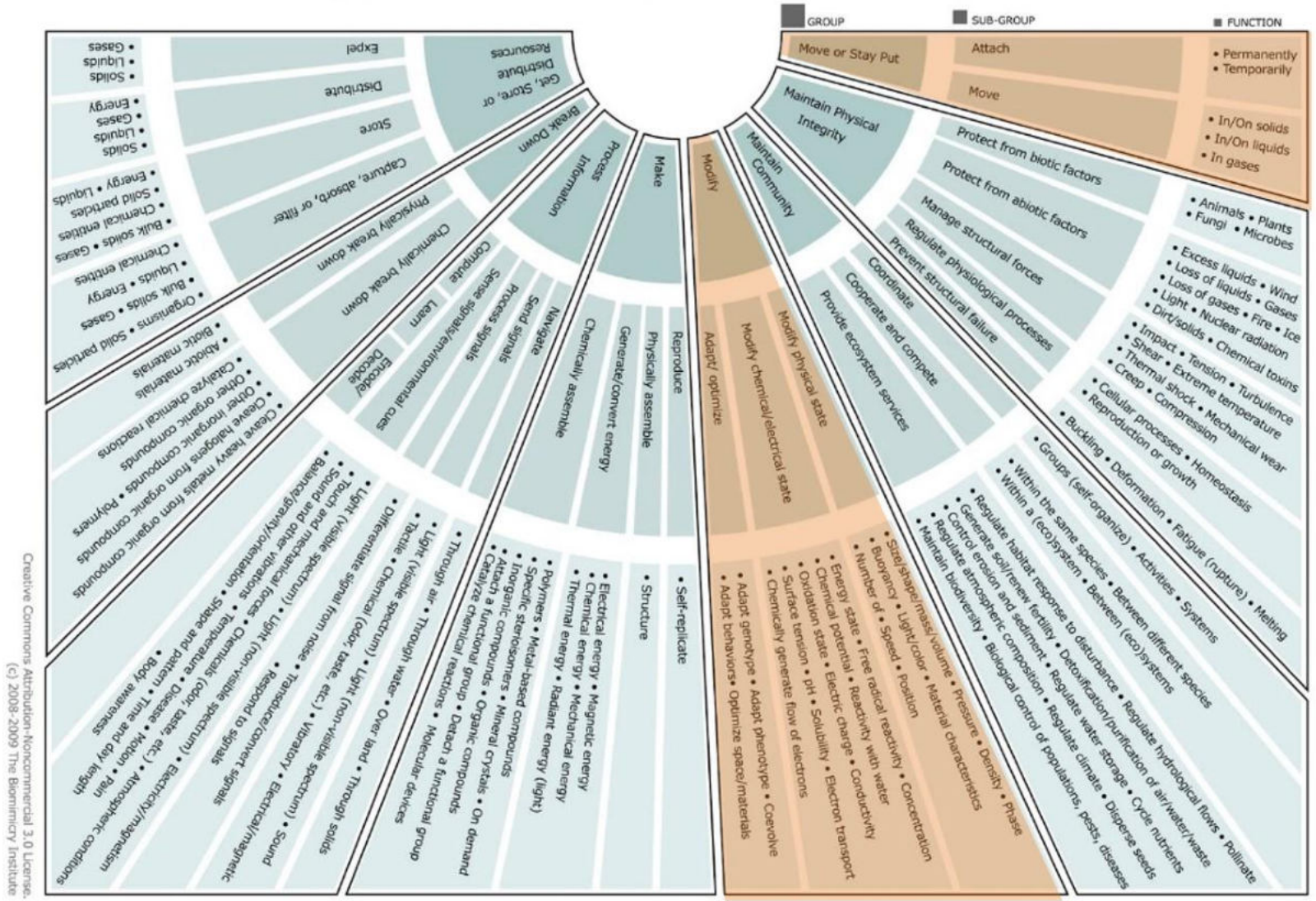
2.2 Approach

- Explore elements from nature related to field. [referring taxonomy fields]
- List down features that can be abstracted.
- Search for possibilities- where those features can help in Automotive field.
- Converge- shortlist natural elements based on its function [satisfying multiple taxonomy field functions]
- Ideation- Abstraction and ideation of the function(s) selected.

3 Taxonomy Field

Figure on following page shows the underlying structure of the AskNature system known as the Biomimicry Taxonomy. This taxonomy abstracts biological information in terms of high-level, intermediate-level, and granular functions, as well as some physical principles.

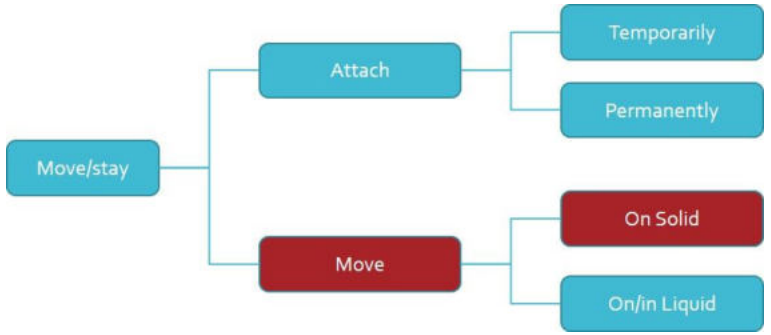
3.1 Selecting Taxonomy Field



3.2 Taxonomy-Move

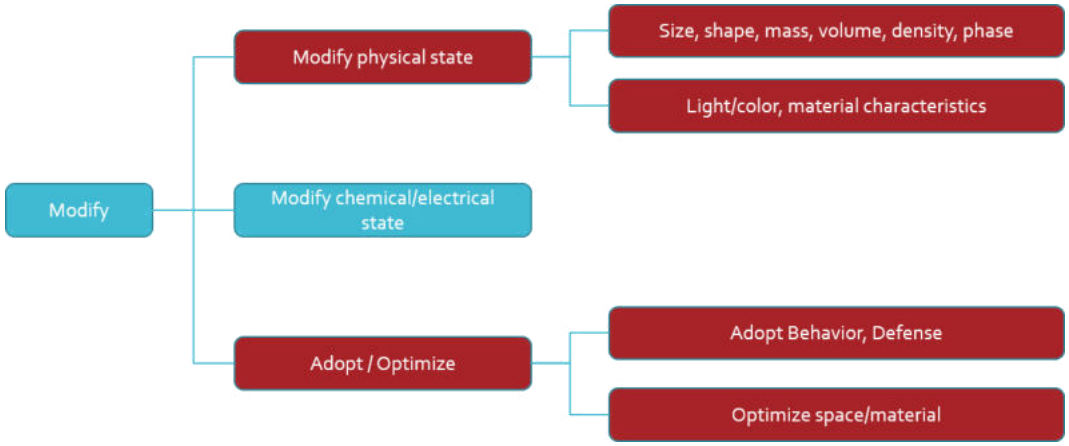
The taxonomy field move is related to automotive design field where the stages attach and move can be a part of design process. This branch of taxonomy includes possibilities of movement and stationary positions where something temporarily or permanently attached to other object.
Whereas movements can be taken as inspiration which can be on solid, under water, or through air.

Here the selected field is movement on solid, that is ground. This is because most of the transportation takes place on roads thus there's greater possibility of finding better solutions in road transportation.



3.3 Taxonomy- Modify

The taxonomy field Modify is taken for the approach as the subfields are ‘modify physical state’ and ‘adopt’. These fields can help in mobility design to solve many problems. Such as change in size or shape of the vehicle can reduce footprint. Change in color or material can improve experience as well as material can help in better design. On other hand, ‘adopt/optimize’ can be useful in cases of variable environment, optimizing spaces and material etc. hence there is better possibility of finding mobility solutions through this taxonomy and thus this branch was chosen.



4 Elements from Nature

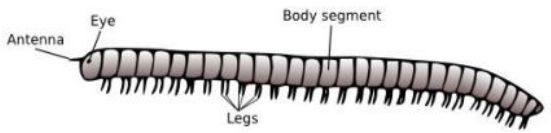
Based on the taxonomy fields selected, the expected feature are shortlisted as follows, which can be helpful in mobility design. Thus these words and features can help find elements from nature that can be taken as inspiration for the design.

Move
- Features that helps in mobility/movement [on solid surfaces]
- Maneuverability [terrain/turning][linear/lateral]

Modify
Physical modification
- Features which helps changing size or shape.
- Features which help changing light or color.

Adopt/optimize
- Features which help in self defense.
- Features which help in optimizing space/material.

Considering such features, some of the elements are were studied for exploring their features, and habits to help in mobility design.



4.1 Centipede/Millipede

Millipede

They can be found from 2 mm (0.079 in) to around 35 cm (14 in) in length. There are approximately 12,000 named species classified into sixteen orders and around 140 families. Most millipedes have very elongated cylindrical or flattened bodies with more than 20 segments. ”Pill millipedes” are shorter and can roll into a ball. Millipedes belonging to the subclass Chilognatha, have a hardened exoskeleton. Millipedes have segmented body [also called ‘body rings’]. 4 legs on each segment [2 on either side]. common species have between 34 and 400 legs. Some species[like Illacme plenipes] have 760 legs. Movement of the body is by coordinated movement of the legs.

Due to their lack of speed and their inability to bite or sting, millipedes’ primary defense mechanism is to curl into a tight coil – protecting their delicate legs inside an armored exoskeleton. A millipede's back is covered by hardened plates called tergites, but its underside is soft and vulnerable. Millipedes aren't fast creatures, so they aren't going to outrun their predators. Instead, when a millipede feels it is in danger, it will coil its body into a tight spiral, protecting its belly.

Co-ordinated leg movement

Millipede leg movements

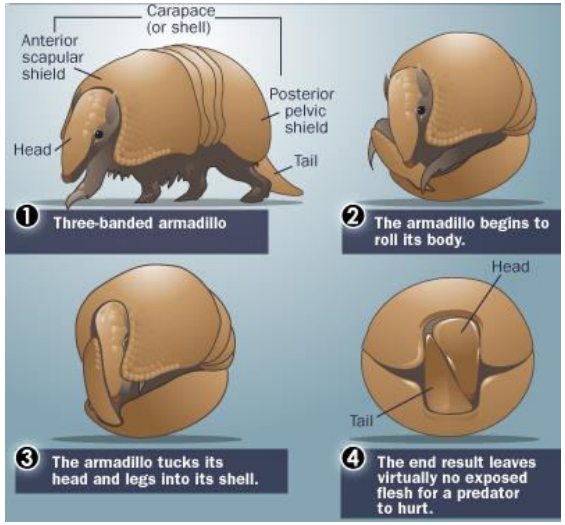
Millipedes have 4 legs on each segments [2 pairs]. Common millipede have 400 legs The leg movement of the millipede occurs in a wave along the body: certain groups of legs are moving forwards as others are thrusting backwards. At any given time there are always some legs in contact with the ground at intervals along its body.

4.2 Armadillo

The word armadillo means "little armoured one" in Spanish.

- Armadillos are the new world placental mammals with a tough and leathery amour shell.
- armadillos originated in South America.
- Species vary from 4 inches (about 10 centimeters) long to measuring up to 5 feet (1.5 meters) from head to tail.
- The three-banded armadillo can roll itself into a ball when endangered. It tucks its head and legs into its shell. It then curls its tail beside the head and pulls in tight. Since the top of the head and the tail are armored as well, the end result leaves virtually no exposed flesh for a predator to hurt.
- It has front and rear shield. Between those two shields are a series of bands that vary depending on the armadillo species. These softer bands look like an accordion and allow for mobility.

The key to the three-banded armadillo's defense mechanism is in its shell. A combination of bone and a tough tissue coating, whereas its shell is called a carapace (which, by the way, is the same term for a turtle's shell). About 2,000 tiny scales, or scutes, are composed of the protein keratin and make up the carapace.



Armadillo- defense

The three-banded armadillo is a type of armadillo that can roll itself into a ball when endangered. Folding its body in half, the three-banded armadillo tucks its head and legs into its shell. It then curls its tail beside the head and pulls in tight. Since the top of the head and the tail are armored as well, the end result leaves virtually no exposed flesh for a predator to hurt.

4.3 Ants

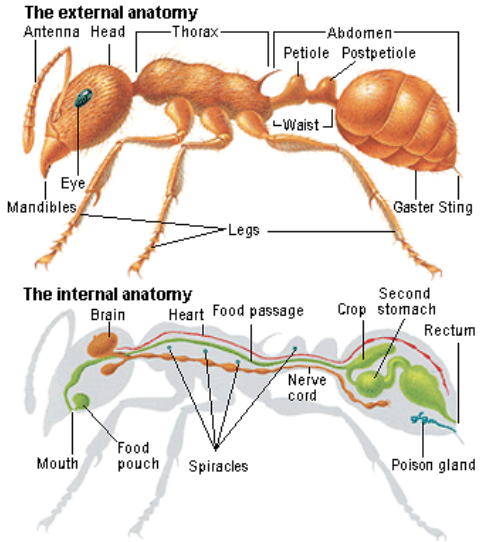
Ants are eusocial insects of the family Formicidae and, along with the related wasps and bees, belong to the order Hymenoptera. Ants evolved from wasp-like ancestors in the mid-Cretaceous period between 110 and 130 million years ago and diversified after the rise of flowering plants. More than 12,500 of an estimated total of 22,000 species have been classified. They are easily identified by their elbowed antennae and the distinctive node-like structure that forms their slender waists.

Ants form colonies that range in size from a few dozen predatory individuals living in small natural cavities to highly organized colonies that may occupy large territories and consist of millions of individuals. Larger colonies consist mostly of sterile, wingless females forming castes of "workers", "soldiers", or other specialized groups. Nearly all ant colonies also have some fertile males called "drones" and one or more fertile females called "queens". The colonies are described as superorganisms because the ants appear to operate as a unified entity, collectively working together to support the colony.

4.3.1 Properties of ants

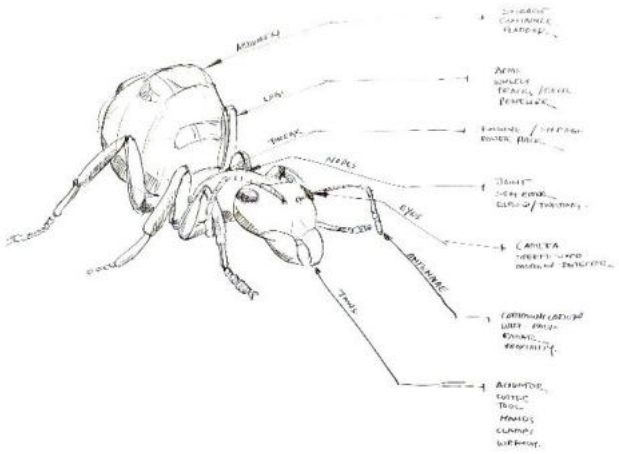
- Ants are capable of carrying objects 50 times their own body weight with their mandibles.
- Certain ant species defend plants in exchange for food and shelter.
- Ants will enslave other ants, keeping them captive and making them do work for the colony.
- Ants follow scent trails laid by scout ants to gather food.
- The ant is one of the worlds' strongest creature in relation to its size.
- Ants have two stomachs, one to hold food for themselves, and one for others.
- Most ants can survive around 24 hours underwater.
- Some wingless ants can perform a controlled glide when free falling.
- Ants don’t have lungs. Oxygen enters through tiny holes all over the body and carbon dioxide leaves through the same holes.
- Ants can work together to perform complex tasks. Ants divide their tasks and perform it honestly.

4.3.2 Ants Body



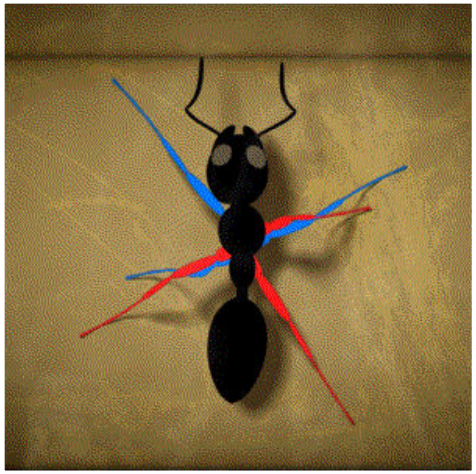
Ants vary in length from about 1/16 inch (1.6 mm) to nearly 2 inches (5 cm). Most species are red, black, brown, or yellow, and some are green or metallic blue. Ants, like other insects, have six legs. Their bodies are divided into three distinct segments: head, thorax, and abdomen. Unlike other insects, ants have elbowed (rather than straight or curved) antennae (feelers), and a pedicel, a narrow waist like indentation between the thorax and abdomen. The crop, an organ located in the abdomen, is used to store food, which can later be regurgitated to feed other members of the colony.

Most ants are smooth-bodied, although some have spiny projections. Ants have strong jaws called mandibles, which are adapted for killing, crushing, chewing, cutting, or tearing, depending on the species and what it eats. Some species of ants have glands that produce formic acid, a strong acid that can be squirted on enemies, causing a burn or sting. Many ants have stingers that contain poison, and some, such as the harvester ants and fire ants, can inflict painful and, occasionally, fatal stings on humans and other animals.



Ant has 3 body sectors . Head , thorax and abdomen. The parts are connected by a tiny joint. The joint portion is called node or pedicel. Two antennae serves sensing the smell as well as communication with other ants. Ants have compound eyes and they don't really have good vision. Relating the body parts and function with automotive part. What does it takes for a machine to perform same task.For example, cameras can play role of eyes whereas, antennae can become Radar/Proximity sensor. This helps in exploring possibilities to achieve same functions or mimicking function in some application area.

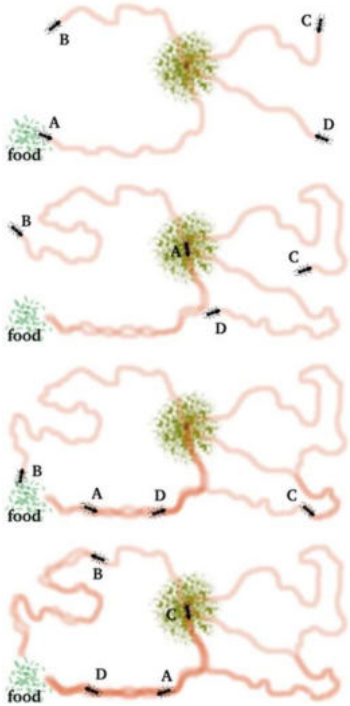
4.3.3 Walking and Navigation



Ants have 6 legs which acts in two groups of 3 legs each. The walking pattern is shown in fig. where at any instance, ant is resting on 3 legs making it stable on ground. Ant legs are attached to over part of body which can act as spherical joint, giving ant freedom of moving legs up-down as well as sideways.

For long-distance navigation, ants use their eyes – they can see the polarization patterns produced by star-/sun-/moonlight and use them as compasses. Forest ants, who are unable to see the sky, memorize the silhouette of the canopy and make a map of their location. That's for getting their general bearings. When going to a certain goal (a food source), they count their steps as a distance measure.

After a certain number of steps they will turn back and take a “snapshot” of how far they’ve gone, and they can remember these images on their way back so that they know that they’re on the right track. On foraging trails or other well-used paths, pheromones can be layed down continuously to keep traffic in order, but pheromones aren’t used much otherwise for navigation because they’re too volatile.

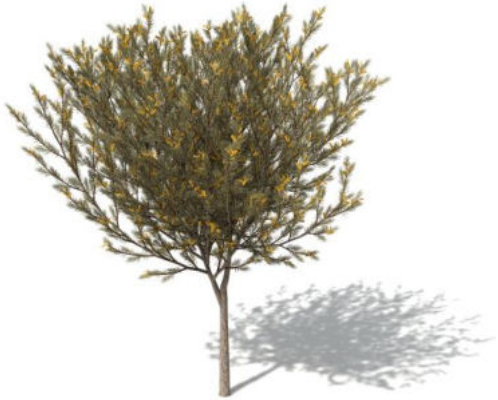


4.3.4 How do ants find thier food?

Pheromones help ants keep track of food and also direct each other through their environment. When searching for food, ants will walk around randomly (“scouting”). Each ant leaves a trail of pheromone as it searches for food. When an ant finds food, it can follow its own trail back to the nest laying more Pheromone. When other ants run into a trail of pheromone, they give up their own search and start following the trail. In second picture, ant D discovers the double-strength trail left by ant A and starts to follow it.

When other ant also finds food, on the way back, an ant reinforces the trail by laying down more pheromone. As shown in third picture, path is reinfornced by pheromons. When theres no food left, ants stop laying pheromone and return to nest. Thus fading out the trail route which tells the ants not to follow trail anymore.

4.3.5 Honeypot Ants



Phyllode of mulga showing honey droplet

Honeypot ants got their name from the shape of the gaster of repletes which resembles honeypot. The sub cast amongst the honey ants, called repletes, have ability to expand their abdomen/gaster to store honey. This ability is gained because of the resilin structure of their gaster skin made of protein fibres. These ants mostly found near mulga trees. Mulga is a shrub or small tree native to arid outback areas of australia, such as the western australian mulga shrublands. Australian tribes consider honey ants as delicacy.

The life cycle of the honeypot ants is shown here. The honeypot ants largely found in australia are “camponotus inflatus”. There are 5 major types of honey ants in the world.

What do they eat?
-Honey from mulga leaves.
-Body fats from insects.
-Liquids from dead insects.

Honey ant hanging to ceiling

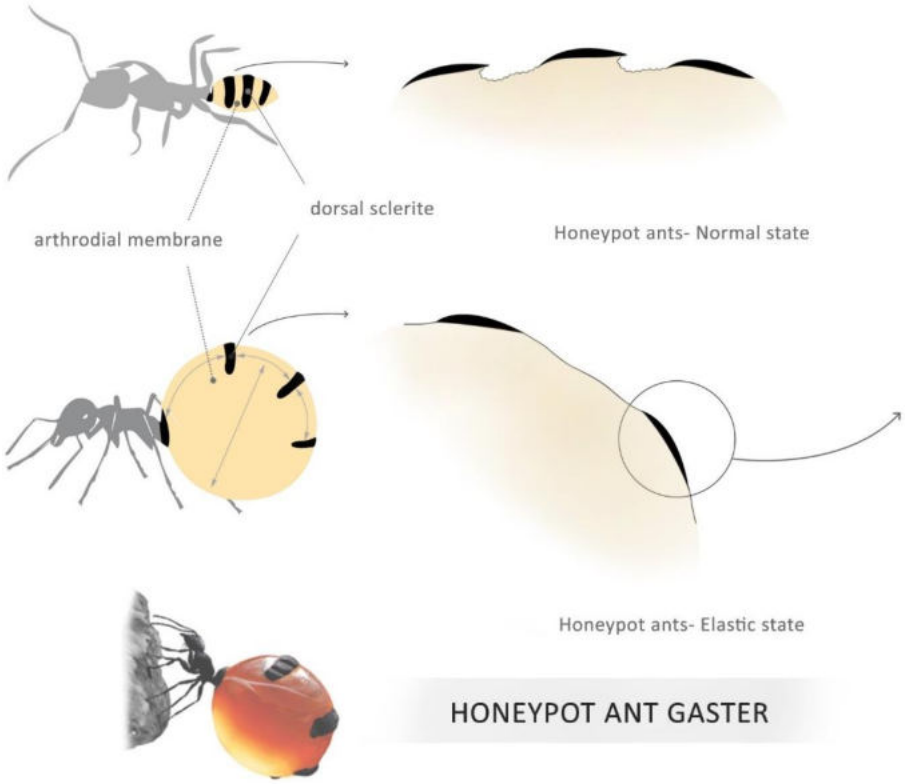
Repletes store the food in their Gaster. The size of the gaster inflates as big as grape, making ant unable to move. Thus repletes spend their entire life hanging to ceiling of the nest.
Other ants can tap on the gaster with their antennae to signal the repletes to regulgitate the honey. Which then can be fed to other ants.

honey ants cab be found all over world in dry and hot regions. their ability to store food helps them survive the drought season of the year.

Common types of honey ants are as follows

- Myrmecocystus
- Plagiolepsis trimineni
- Melophorous
- camponotous Inflatus
- Laptomyrmex

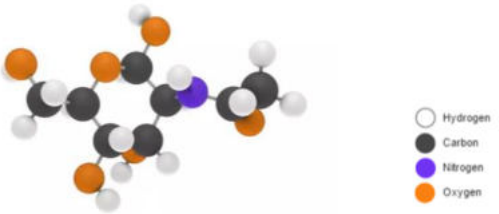
4.3.6 Honeypot Ant - Gaster



Honeypot ant's gaster can expand to store the honey. This is interesting property of honey ants and hence the study was conducted to understand how honey ants can stretch their skin. The study shows that honey ants skin is made of chitin and resilin, where the harder part is chitin and the softer part is resilin which can be stretched.

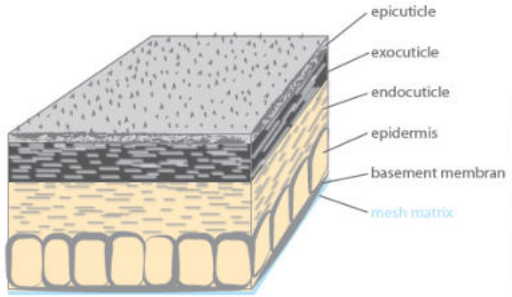
Chitin

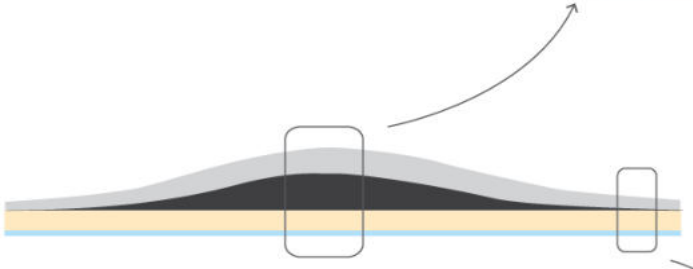
A tough, semitransparent substance that is the main component of the exoskeletons of arthropods, such as the shells of crustaceans and the outer coverings of insects. Chitin is also found in the cell walls of certain fungi and algae. Chemically it can be called a nitrogenous polysaccharide (a carbohydrate).



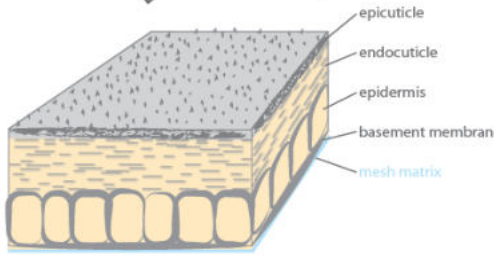
CUTICLE LAYER DENSITIES

The exocuticle is best seen in the hard plate on the back of the honeypot ant. It consists of a higher density of chitin than resilin, giving it rigidity.

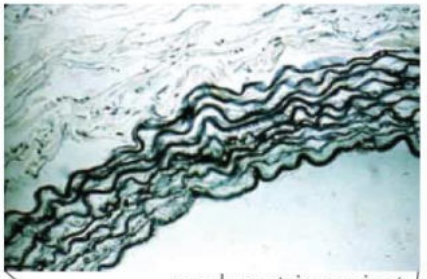




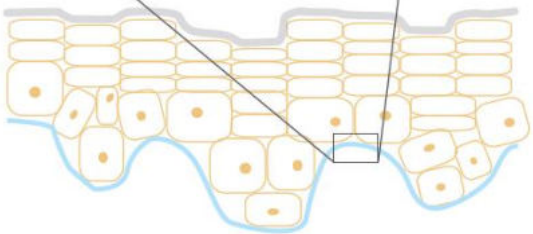
The endocuticle is more prevalently seen on the yellow skin of the ant's abdomen. It consists of a higher density of resilin than chitin which allows greater flexibility



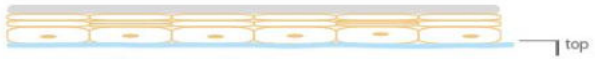
FOLDING + UNFOLDING



mesh matrix against epidermis cells

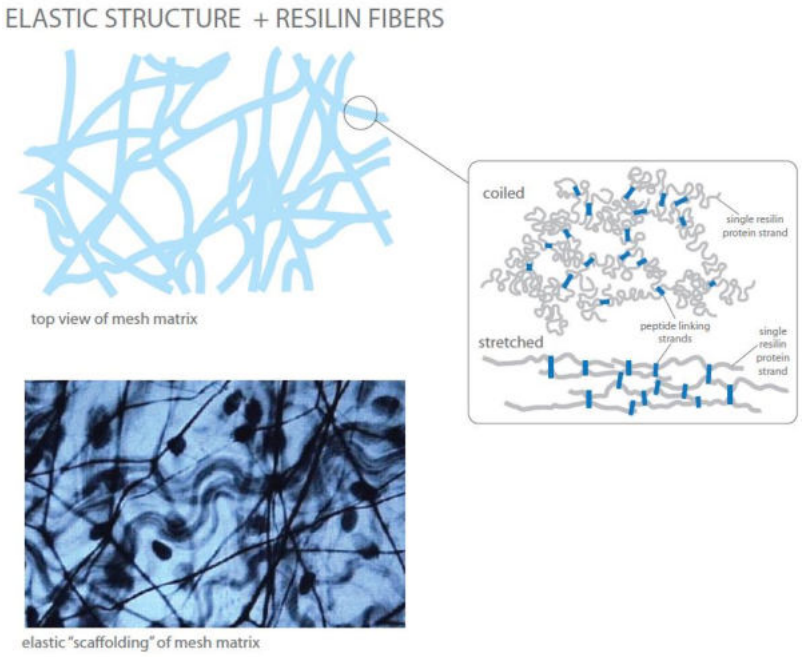


cuticle cells - normal state

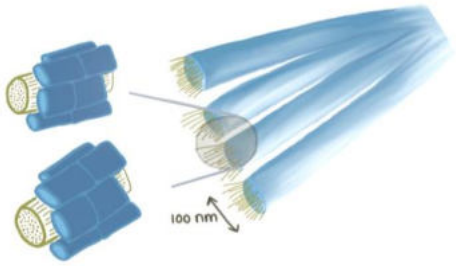


cuticle cells - stretched

Resilin



An elastic material formed of cross-linked protein chains, found in insect cuticles, especially in the hinges and ligaments of wings. Resilin is currently the most efficient elastic protein known. The elastic efficiency of the resilin isolated from locust tendon has been reported to be 97% (only 3% of stored energy is lost as heat). It does not have any regular structure but its randomly coiled chains are crosslinked by di- and tri-tyrosine links at the right spacing to confer the elasticity needed to propel some jumping insects distances up to 38 times their length.



Protein Fibers

4.4 Abstracted Features [Taxonomy]

4.4.1 centipede/millipede

Move-

- multiple legs [movement pattern-wave type]
- Body segments [flexibility-directional]

Modify-

- Change shape [as per terrain]
- Coiling [optimize space]

Adopt-

- Hardened ring type exoskeleton
- Coiling ability [defense]

4.4.2 armadillo

Move-

- Body segments [mid band] allow for mobility.

Modify-

- Change shape [optimize space]

Adopt-

- Hardened exoskeleton
- Ability to roll into ball [defense]

4.4.3 Ant [Honeypot ant]

Move-

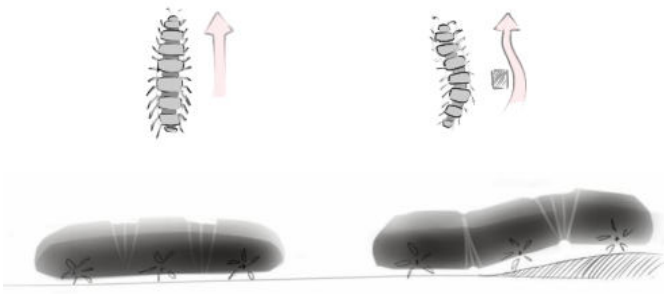
- Body segments allow for mobility.
- Legs attached to bottom lowers the CG.

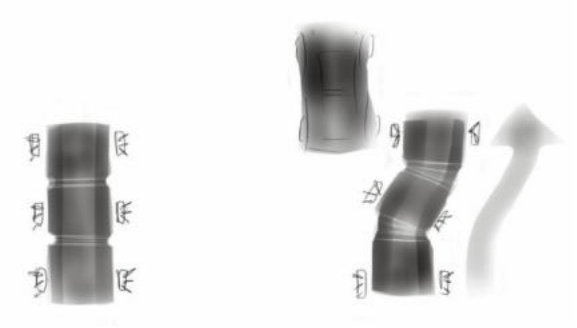
Modify-

- Change shape [optimize Volume]

Adopt-

- Hardened exoskeleton
- Ability to store liquids
- Softer stretchable protein skin.





5 Abstraction of Functions

5.1 Move

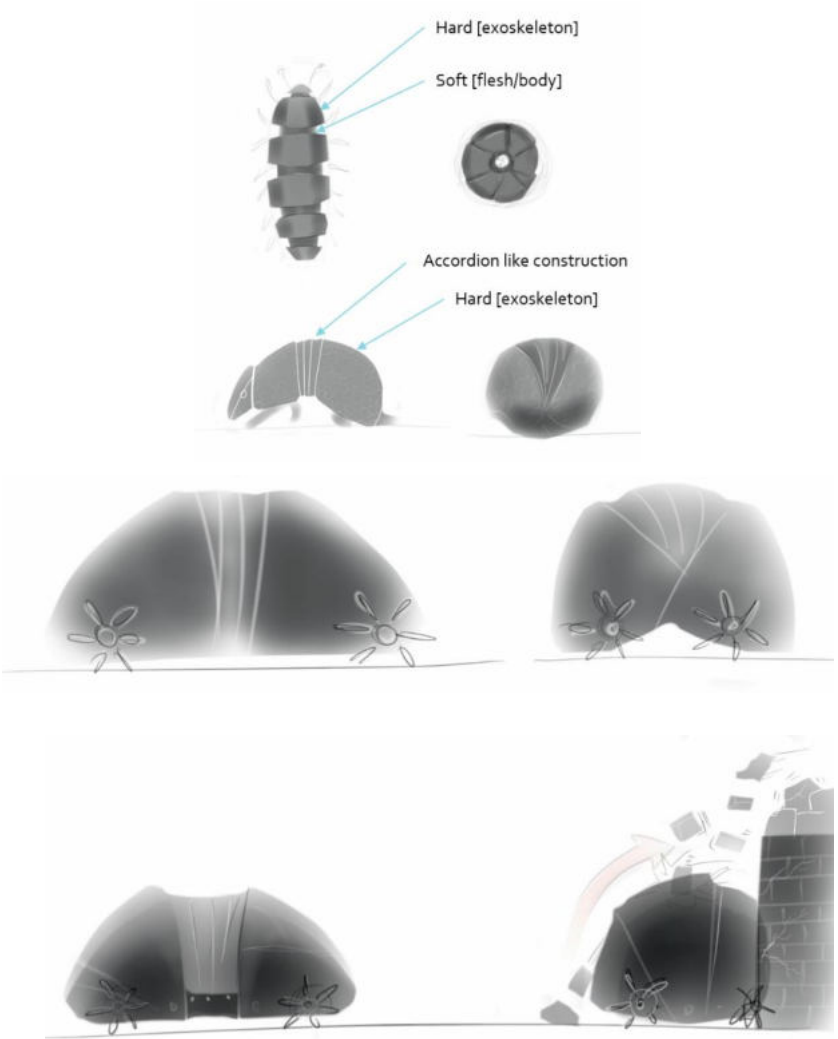
- Ring type body segments can move to change the body position to a curved path easily.
- Curved body form is supported by number of legs on each segment, hence body remains perfectly balanced.

Segmented body helps

- To take curved path
- To go over uneven surfaces.
- To stretch and contact body length to certain extents.

Segmented body-Lateral Movement

- Directional maneuverability
- Stability while shifting CG [legs/wheels]



5.2 Modify [shape]

- Ring type body segments can allow millipede to coil itself.
- Similarly armadillo has 3 segment body which allows itself to coil/roll up in form of ball.
- Both the organisms have tough exoskeleton. Which protects them from predators.
- The tough segments do not change the shapes whereas the middle band of the armadillo is constructed like an accordion allowing the shape changing movements.

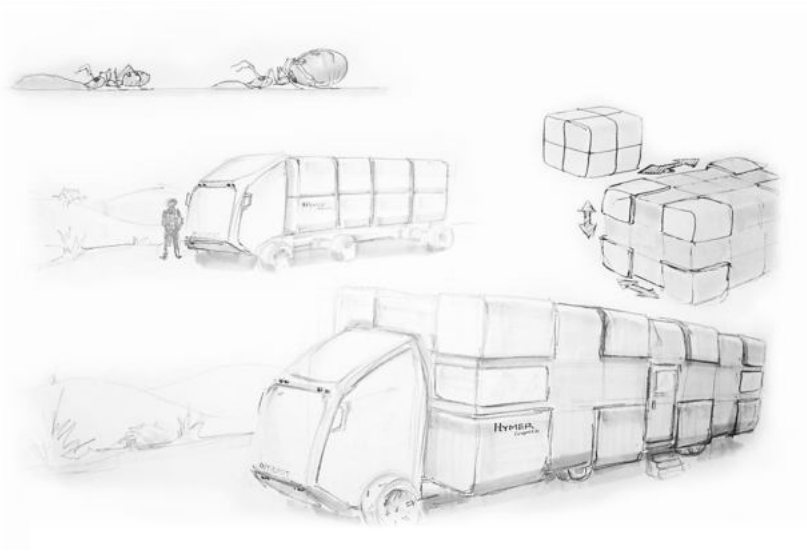
Ability to change shape- optimize space

- Folding ability [carrying/storage]
- Parking space management
- Change in height/orientation
- Utilizing space/shape for different purpose

Ability to change shape-Defense

- Safety-Protection against failure [accidents]
- Safety- Casing/storage
- Damping-Losing inertia via mass shift.
  [small cars-less crumple zone.]

5.2 Modify/Optimize [Volume]



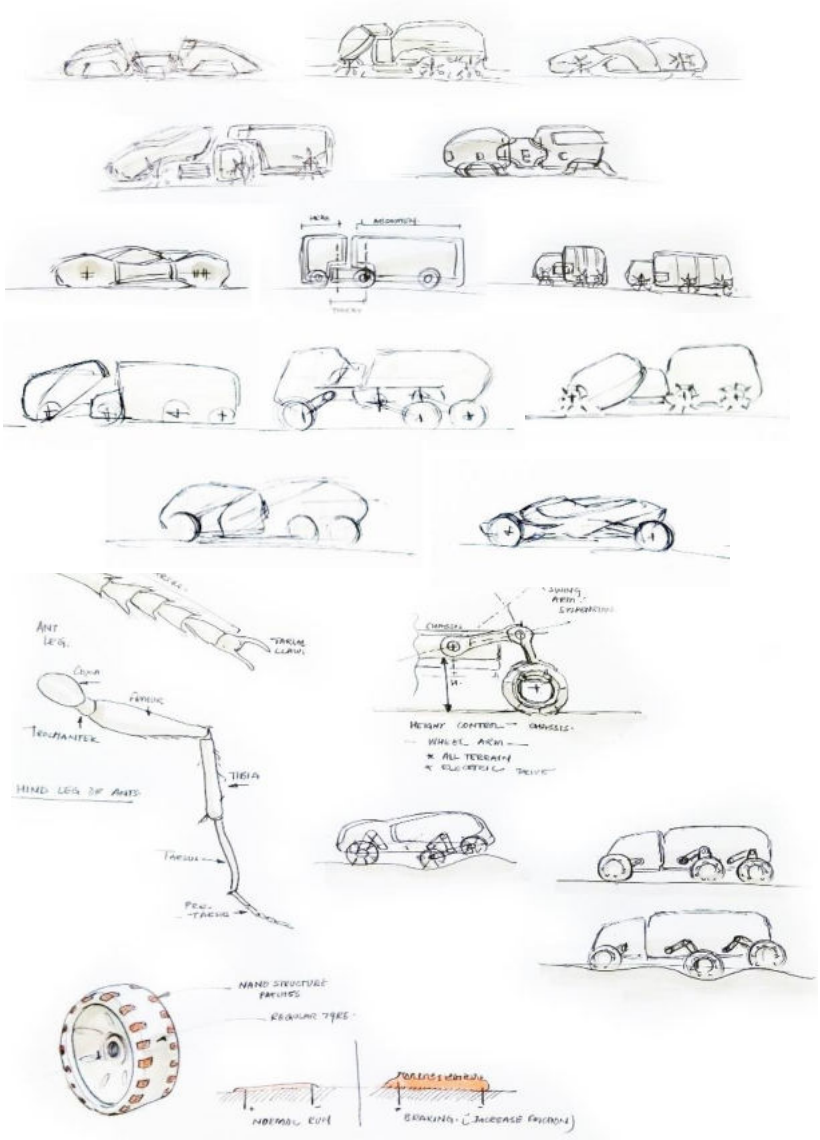
Honeypot ants have ability to store honey in their abdomen. The ant can store honey and later the honey can be fed to other ants and larvae. Taking inspiration from ants ability to lift heavy loads, and from honeypot ants, here's a concept of a mobile home. The body of the mobile home can expand to avail more space mimicking the abdomen of the honeypot ants.

- Honeypot ants abdomen
- Ants ability to carry load
- Ability to go over terrain.

The feature of carrying heavy load can be combined with the ability to transform. The concept shown here is a cargo trailer. The cargo compartment can be transformed to accommodate more cargo. Whereas when not needed. It can collapse, to make the vehicle compact, easy to handle and easy to park.

Ability to change shape/ optimize volume

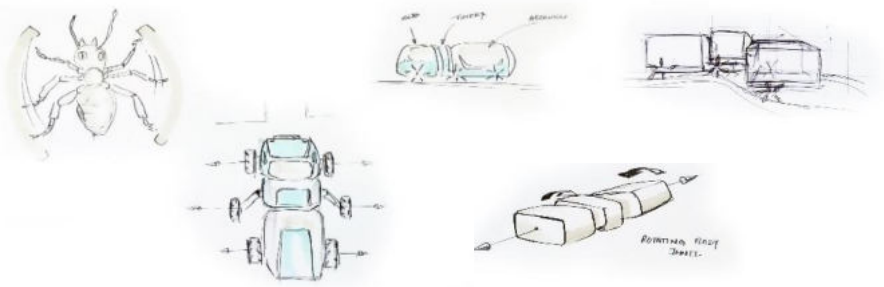
- Ability inflate gaster
- Harder exoskeleton patches for protection against external forces.

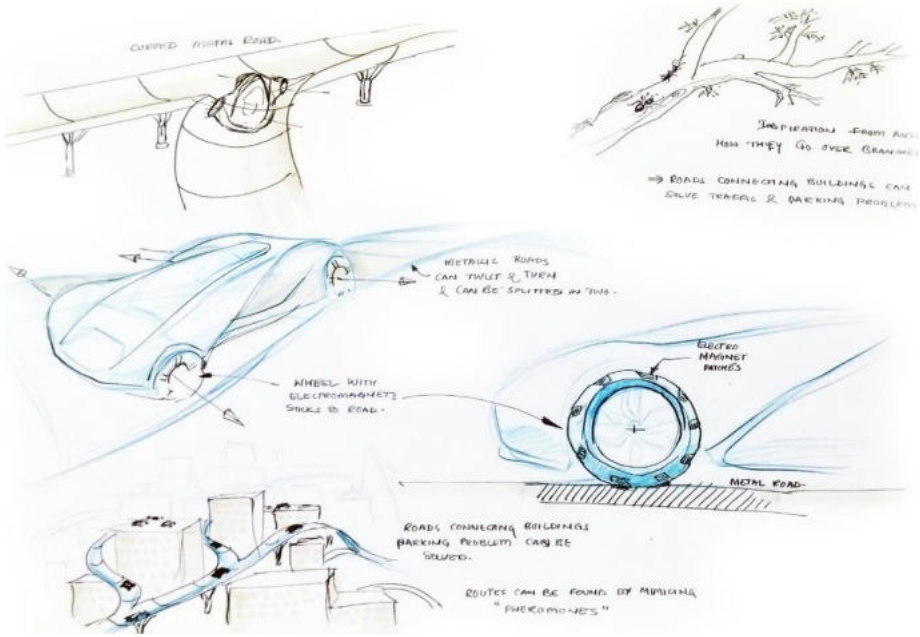


6 Ideation

Ants body is divided into 3 sectors, bodies are connected with a small joint called Pedicel or Nodes. Concept here shows similar 3 body structure which is connected by a small rotary joint that allows vehicle to have degree of freedom of twisting motion.

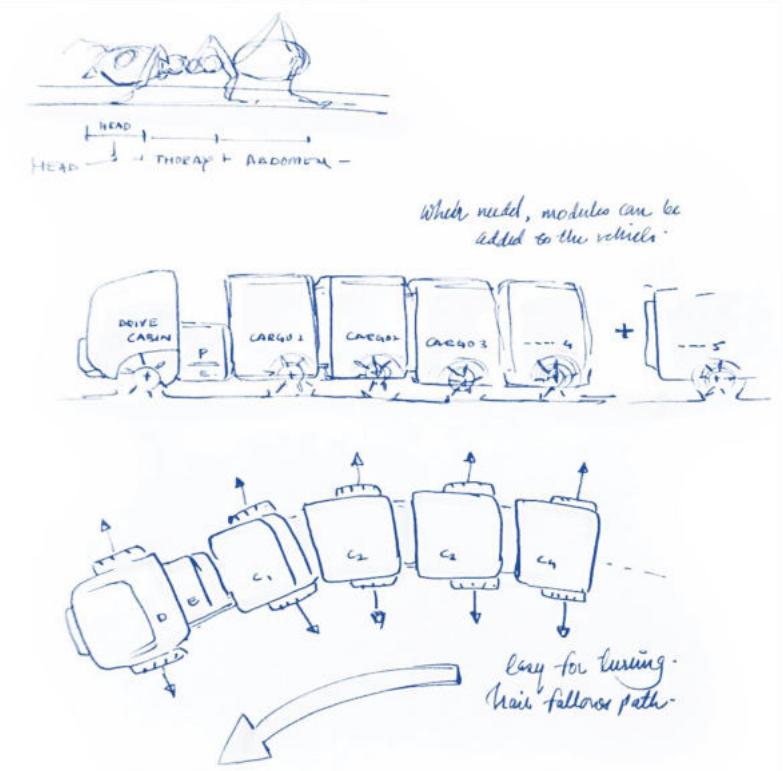
Ant legs have mainly 3 joints. The main reason why ants can carry heavy load is the muscles strength to size ratio. The leg have tiny fibers and jaws on it, to hold to surface. Taking inspiration form the ant legs, the when concept is shown here with swing arm and a joint. The muscle strength is replaced by servo motors. This concept helps go over terrain and maintain the body stability. For doing so, the swing arms have to take heavy loads, mimicking the ant legs working.



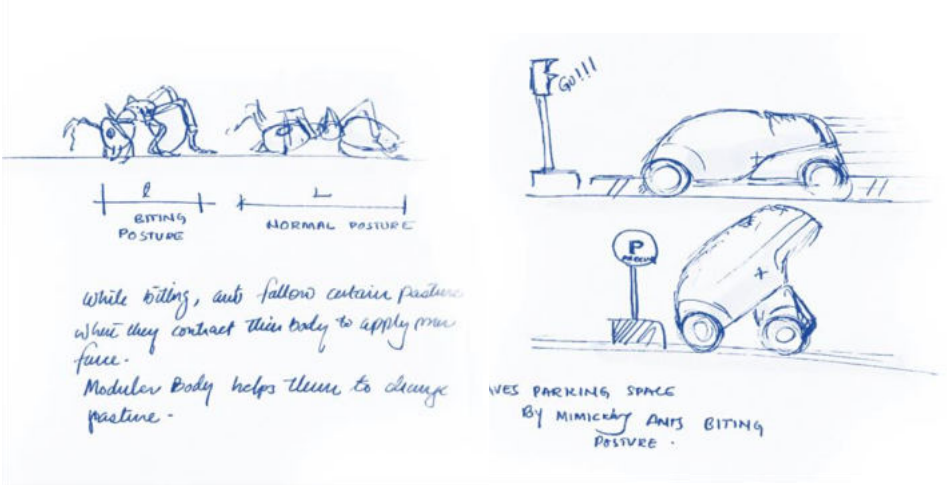


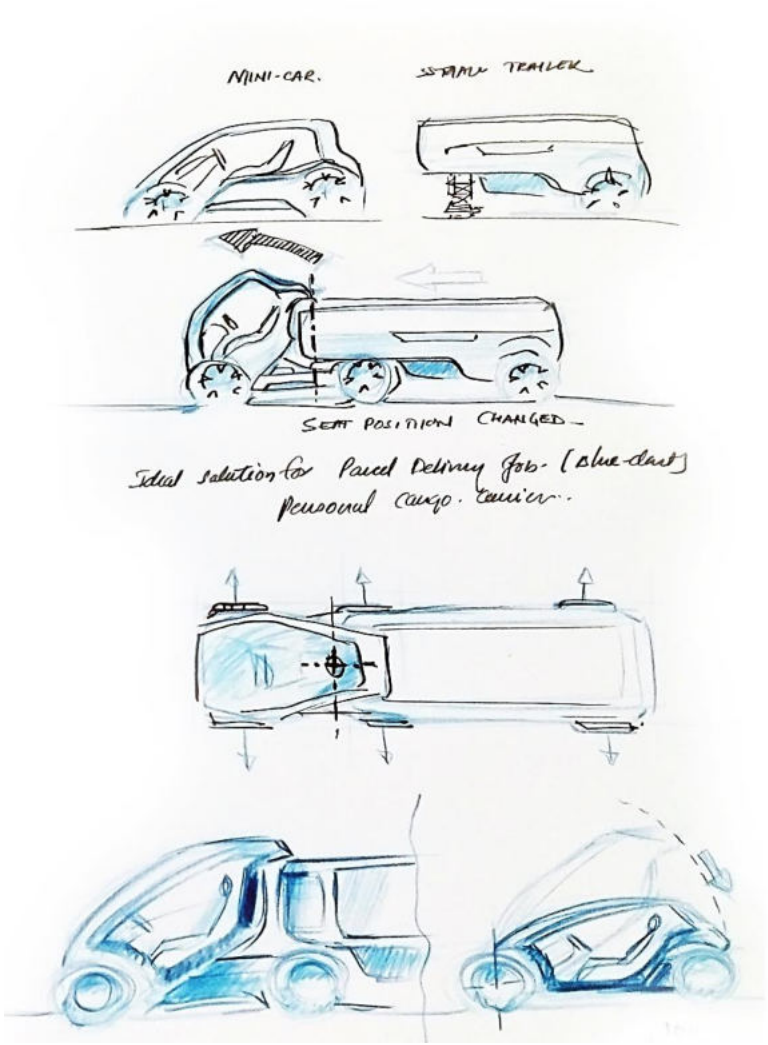
Ants have legs with tiny jaws, to hold on to surface. The inspiration here is taken from ants going over tree branches.

The future city can consist of metal roads running through city. Every building can have its own road leading to terrace or a parking zone well above ground level. Thus cars can go over the road mimicking the behavior of ants going over branches.
This will help a person to get to his office/destination by directly getting in to building. Also road traffic on the ground will be reduced.



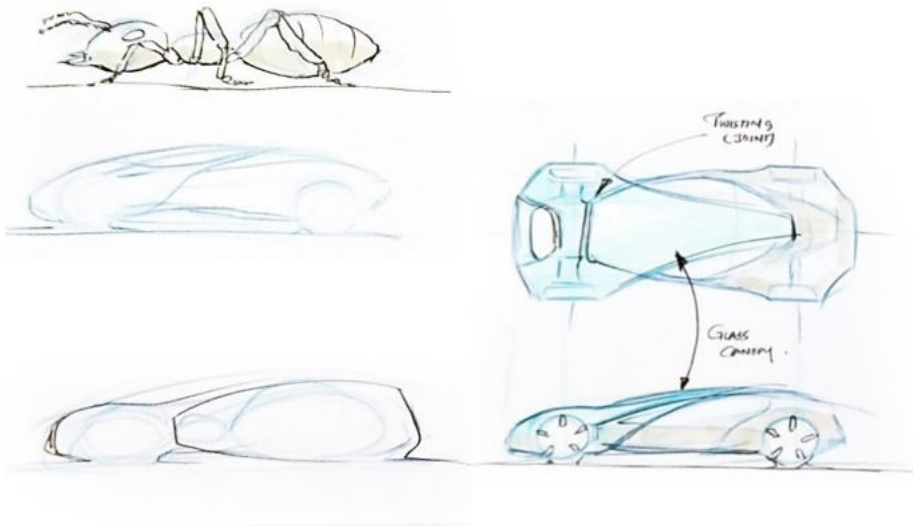
Ant body is divided into segments. And every body have different purpose and is designed for that function only. The concept here has same body segments with head as control cabin, mid engine compartment, and tail abdomen as storage. Where abdomen can be split in multiple modules for different cargo. Another concept mimics the biting posture of ants to save space in parking by folding its body.

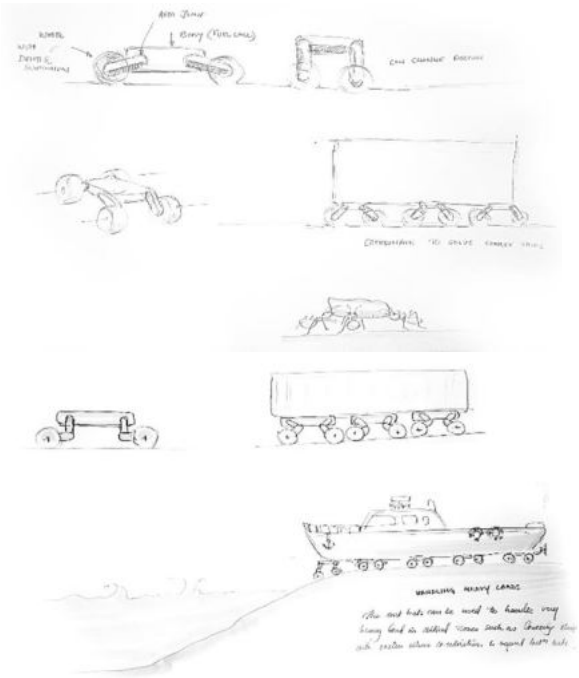




Body sectors

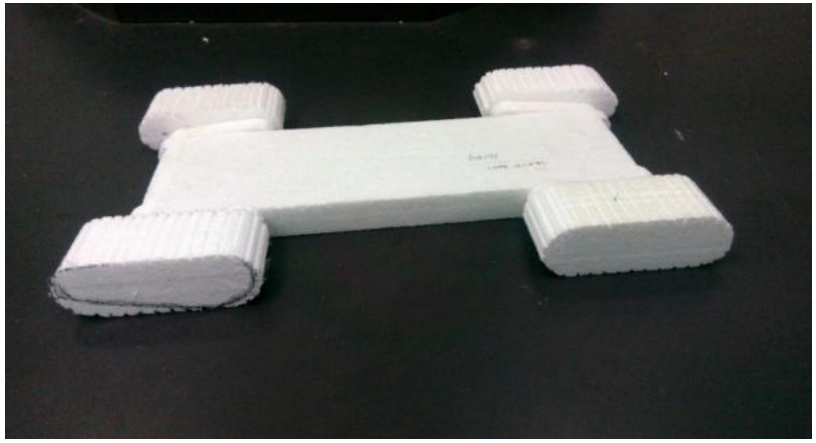
The concept on left shows a vehicle inspired from the body joint. This vehicle have one more degree of freedom i.e. twisting movement. The concept on right side is inspired from ants ability to carry load and the body architecture. The vehicle has two parts, mainly a mini-car, and a cargo trailer. The car can transform in to working posture and can be attached to a cargo trailer. This has applications in courier delivery van where a single person can deliver parcels and can detach trailer to return home in a car.

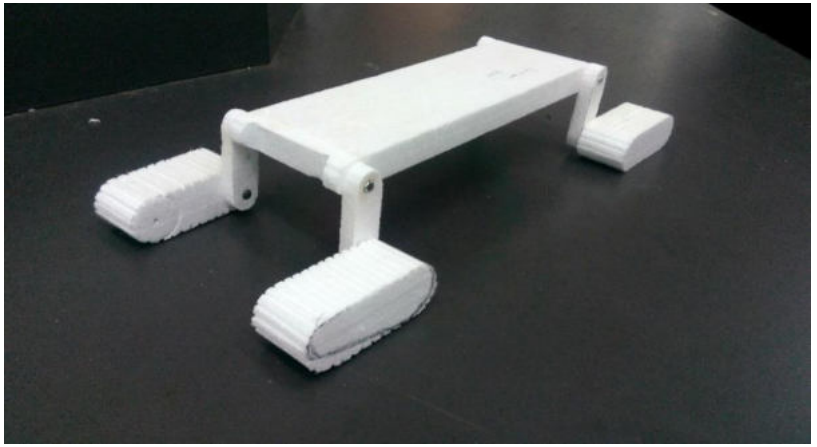
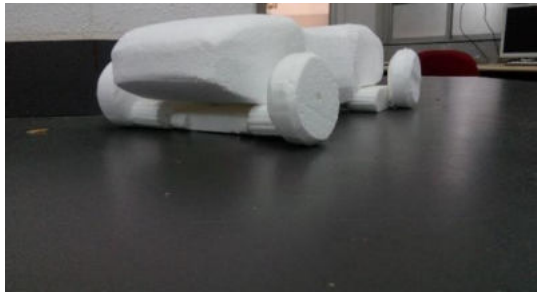




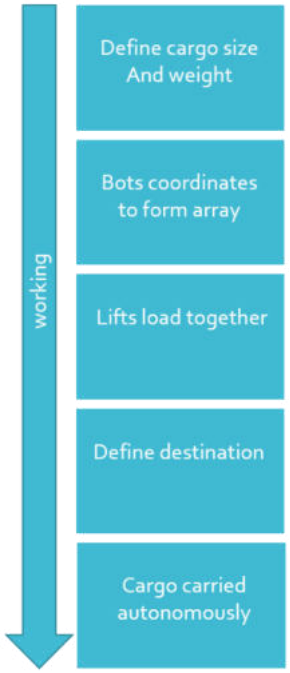
6.1 Ant bots

Ants are tiny creature. But they have ability to communicate to solve problems. Thus ants can collaborate and work together lo lift heavy loads. Taking this as inspiration, the concept is shown. The vehicle is an autonomous bot. which is smaller in size and each capable of lifting load more than 50 times by taking the advantage of scale to strength ratio. Mimicking Ants ability to lift weight, communicate and collaborate. The legs attachments to the wheel gives it ability to change its ground clearance, lift loads and helps to over terrains. These bots can be used for any size of heavy cargo as they can come together and can act as a single body to carry the load. This concept can have many applications. Critical applications such as ship launching, space shuttle carrying etc. and can be used for container handling and odd size cargo handling. Heavy haulers come in fixed sizes and are too expensive, hence these bots can solve problem of variation in size by their ability of coordination.



The bots have swing arm joints. This helps bot to change the height. Thus the bot can lift heavy weights. Ant bots are smaller in size compared to conventional cargo carriers or heavy haulers. Thus making them more efficient in lifting weight and carrying.



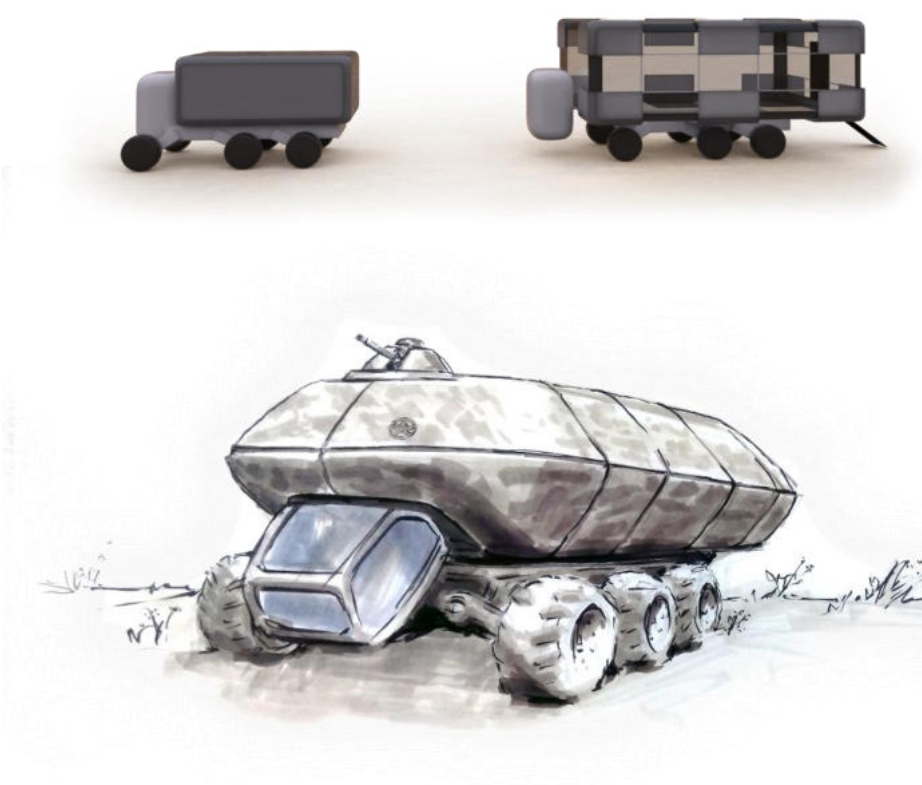
- These vehicles can mimic ants by following the leading vehicle.
- They can perform various task together by coordinating.
- Can lift heavy loads because of scaling principle i.e weight to strength ratio.

The bots can communicate within themselves and hence, by defining the base size of the load and the load weight, bots can arrange themselves in a pattern and start acting as one body. Here onwards all bots can turn, accelerate and stop as one body. This makes moving the heavy load easier. All bots have camera and proximity sensors for autonomous drive and hence the front bots can take decisions whereas rest can follow, mimicking the ant behavior.

The bots can take load of a heavy container or any cargo and can collaborate to go over any terrain. As each of the bot can change its height, it becomes easy to overcome the potholes on the way.

The unloading part needs heavy cranes, but arranging crane for one load only not economic. In such case, bots can lover the load to rest on a support and can escape, thereby unloading the heavy loads without cranes.

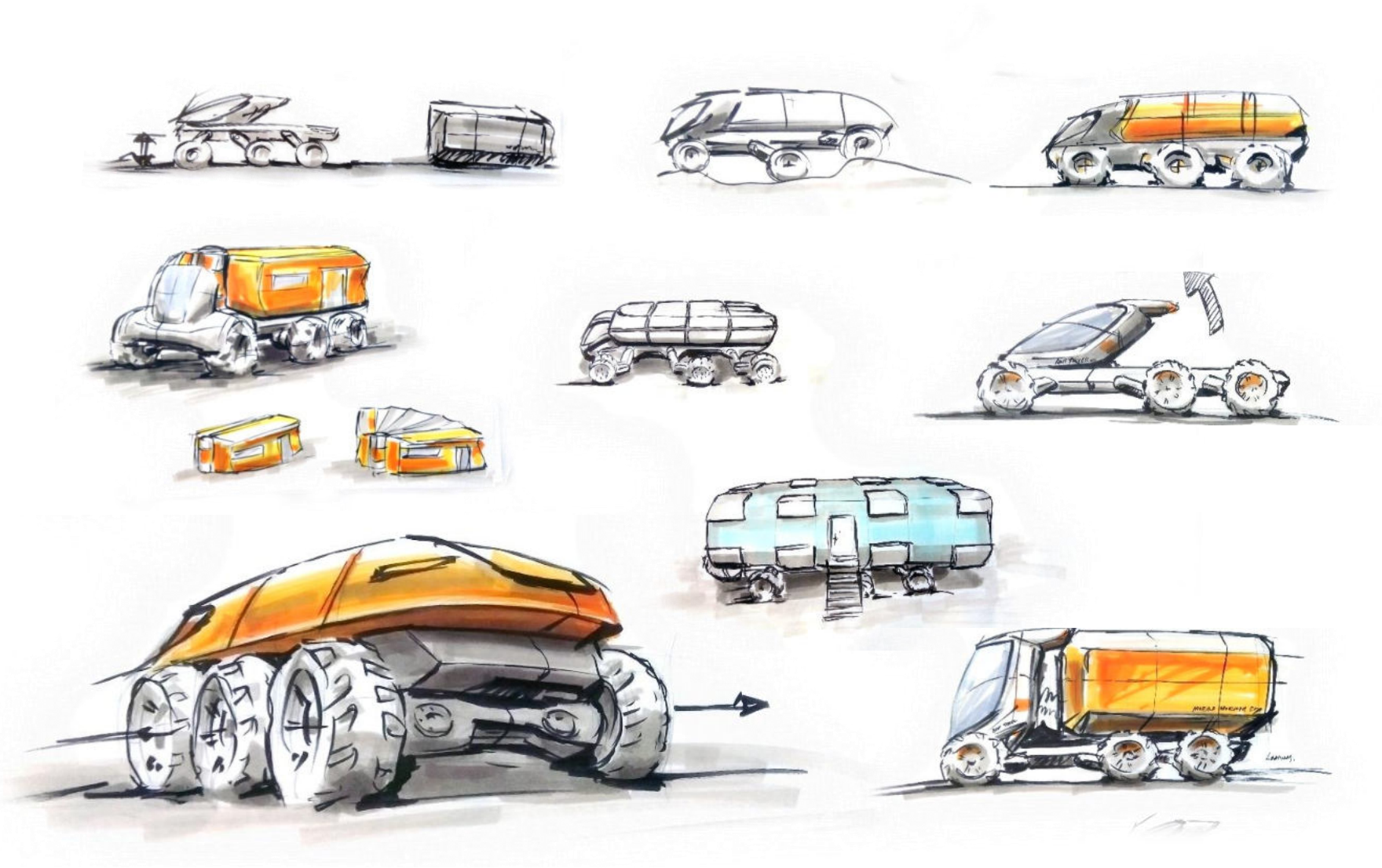
6.2 Mobile Home



Honeypot ants have ability to store honey in their abdomen. Thus they can transform from few mm to grape size. Thus the feature of carrying heavy load can be combined with the ability to transform. The concept shown here is a cargo trailer. The cargo compartment can be transformed to accommodate more cargo. Whereas when not needed. It can collapse, to make the vehicle compact, easy to handle and easy to park. Taking inspiration from honey ants, concept of a mobile home is made. The body of the mobile home can expand to avail more space mimicking the abdomen of the honeypot ants.

The concept on left can be useful for defense tech houses which have all tracking and planning systems, computers and radio equipment. This vehicle can move to any desired site and set up a mobile command center for defense application.

This can be implemented as mobile laboratory in polar region. Where scientist have to shift their locations and take samples n reading from different location to analyze.



Ideations for mobile home

7 Scenario

Carrying things over two wheeler is a tough task for people like Paperwala, Dabbewala, E-shopee Delivery boys etc. The main reason is that a bike is not designed for such purpose and thus it does not have space to store such volume of cargo.

Often people carry a bag with them for carrying the glossaries and they have to tie it to their bike. As a designer, one has to look in to this problem and try to solve the storage issues in two wheeler sector. Though two wheeler is not designed to carry the goods, people need to carry their everyday shopping's, vegetables, tiffin box etc. and some users use the bike as full time goods carrier to supply goods to different stores. Thus there should be provision to store goods or there's a need to redefine the two wheeler for goods carrying application.

There’s a need to introduce a goods carrying solution. The two wheeler form can be redefined to help carry goods and can accommodate the variable volume goods.

User -2 Wheeler User and Delivery boys
Context -Goods Carrying

8 Brief

Design a 2 wheeler for carrying goods. Using Bionic Approach, redefine the form of the 2 wheeler if needed for carrying goods and ways of constraining goods on 2 wheeler.

Target Audience

-2Wheeler users
-Delivery Boys

Deliverables

-Detailed Renders.
-Scale model of Design.
-Design Report.

9 User study




People prefer carrying load on bike as it is easy. But in many cases the load is either large in volume, delicate or odd in shape. Thus it becomes difficult to carry it. Observations shows the different practices of carrying things on bike. These images show the bikes with load that is daily delivered to the shops. in such cases, the volume is very large and its very difficult to tie and un-tie that load.

Some people use their motorbikes or bicycles to travel place to place. They carry their tools with them. e.g. sheet metal technician, Plumber etc.

Market is a place where people carry material on bikes as the quantity of load is less. They often attach grills or carrier to help constraining the load.

Some users carry handmade cloth woven bags with them to carry vegetables. Whereas customer carry bags with them which they tie to side of the bike or rear carrier of bike. Observation shows that most of bikes are noticed carrying vegetables from market at time of evening. Often people have a leather bag attached to bike but as it is not sufficient, they have to use extra bag, which then they tie to the support hook.

Most people visit market after their job shift and while returning home.

Mopeds have enough space in front to keep things and thus one need not to tie the bag to the bike. Whereas the conventional bikes don't have space to keep the bags and thus people attach extra metal hooks to hang the bags. Carrying things over two wheeler is a tough task for people like paperwala, dabbewala, e-shopee delivery boys etc. The main reason is that a bike is not designed for such purpose and thus it does not have space to store such volume of cargo. There's a need to introduce a bike that can help in such tasks and can accommodate the variable volume of cargo.

Conventional way of tying the luggage to the bike is the elastic mesh. The elastic mesh consists of synthetic rubber fibers reinforced with nylon threads. The nylon layer is made in such a way that it protects the rubber from cuts and acts as fail safe tensile structure.

The carrier boxes for bikes have very less space inside. An average size box can have less than 10 liter volume. The containers are made of hard materials and can only accommodate object of specific size. These boxes are hard attached to the bike with bolts and fixtures. Often people prefer soft bags over these containers, compromising the locking facility.

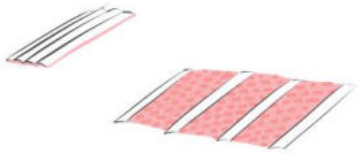
10 Ideation for goods carrier

Scenario of containing a material needs a space to be expanded. E.g. dust bin container

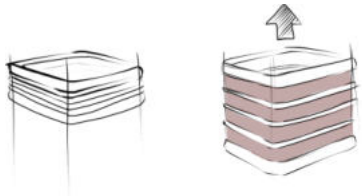
Container	- 3D object
Stretching	- 2 Directional [x,y]
	- 3 Directional [x,y,z]

Scenario like Covering a roof top, Lid, availing more surface need to be stretched linearly. E.g. coupe convertible roof

Surface/canvas	- 2D object
Stretching	- 1 Directional [x or y]

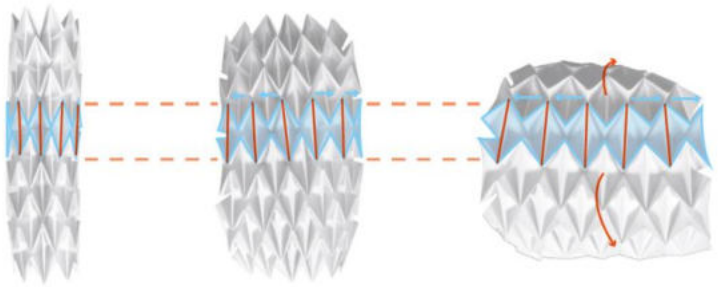


One Directional, 2D object stretching

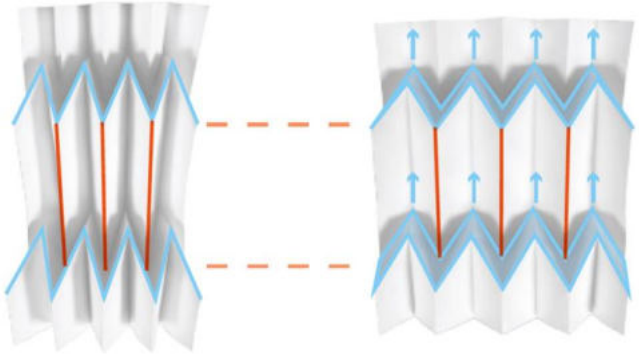


One Directional, 3D object Stretching

Two Directional, 3D object Stretching



Fold A



Fold B

10.1 Paper-Fold study

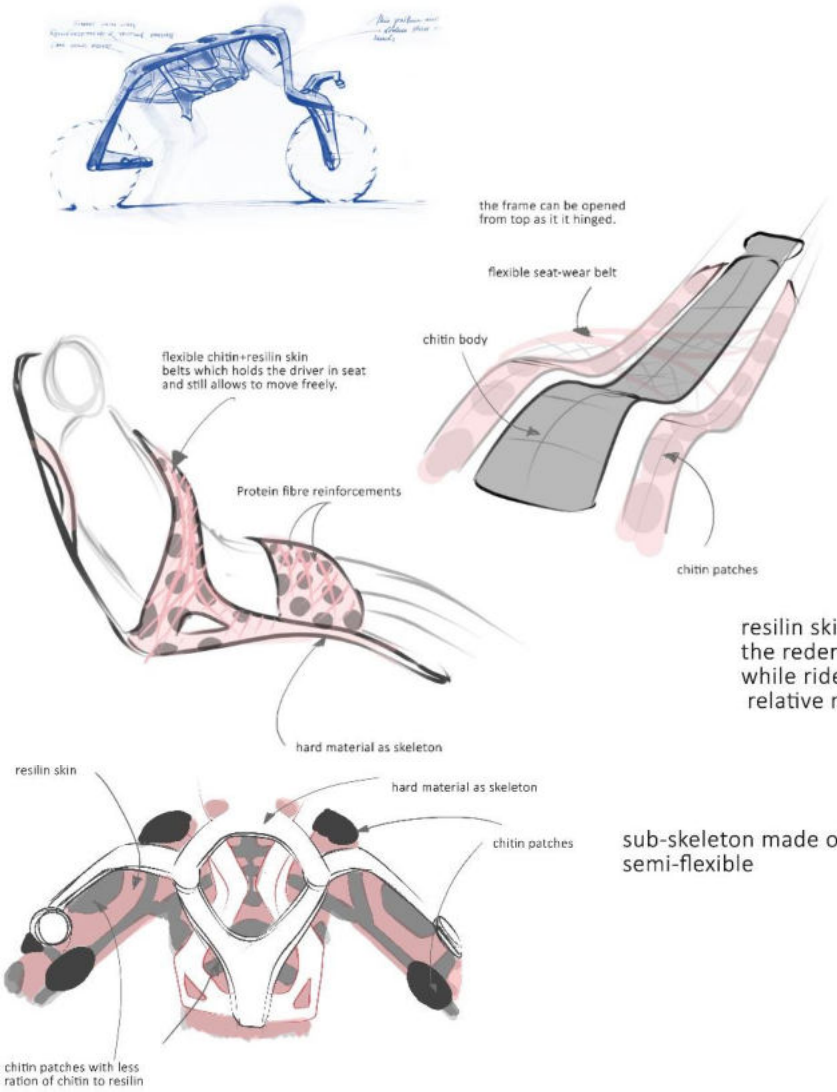
The folds shown in figure allows paper to contract its shape. These Folds can help organize the retracted skin and the stretching mesh in contacted position. Thus two types of folds were studies to help understand the compact shape and expansion-retraction nature of folds.

Fold A- This type of fold when stretched in linear direction, starts to curl in lateral direction and vice versa.

Fold B- these folds have ability to stretch the lateral surface when pulled.

10.2 Ideation-User protection

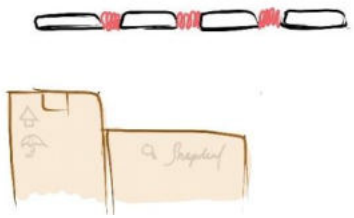
The concept shown here is a bicycle with a spine support that can take the entire weight of the rider and the resilin skin fits over the body. Chitin structure provides protection from forces and acts as a structural member. Another concept shown is an exoskeleton. The exoskeletons are made for specific person, thus they are very expensive. A skin made from resilin and chitin can allow the exoskeleton to be used by any person as the skin can fir over any body and still can take forces, making the exoskeleton usable for more than one person.

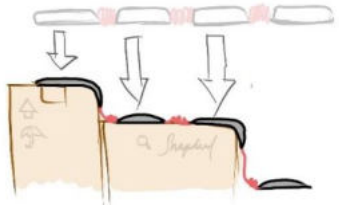


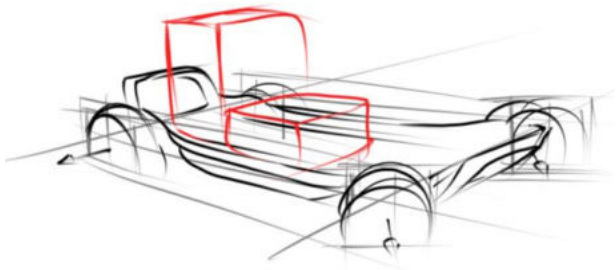
Use of resilin and chitin in bike.

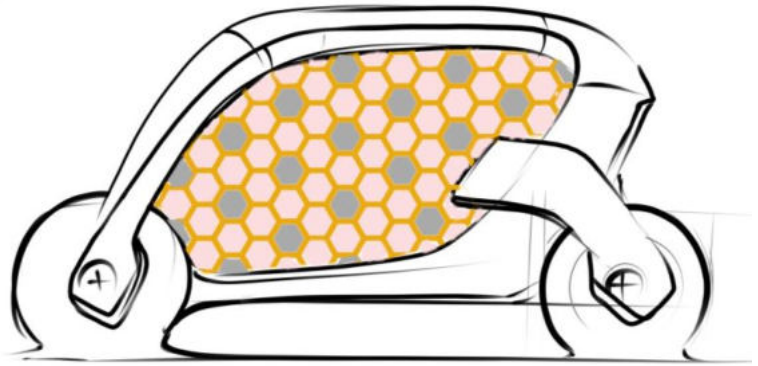
10.3 Use of chitin-Resilin skin [goods carrying]

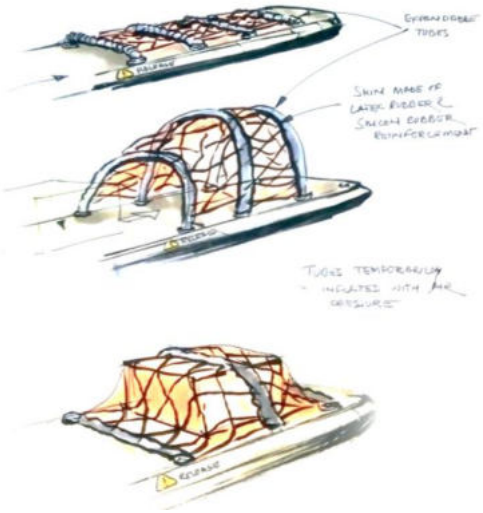
Automated delivery vehicle which is balanced by gyroscopic stability assist and does not need to tie the cargo as the skin made of chitin and resilin can hold the cargo firmly.
A skateboard concept can be implemented for delivering cargo faster, the thin skin over the skateboard chassis can protect the cargo from environmental variables, as well as it can hold it firmly to keep safe.







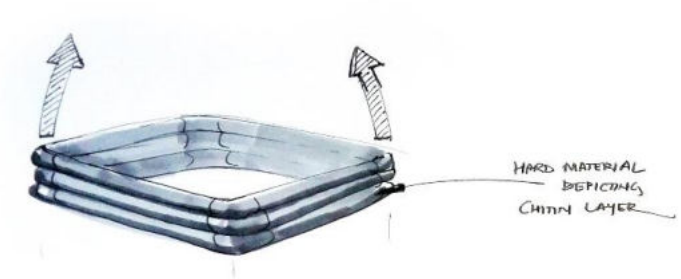


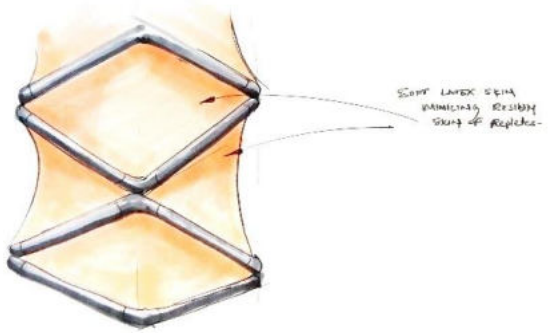


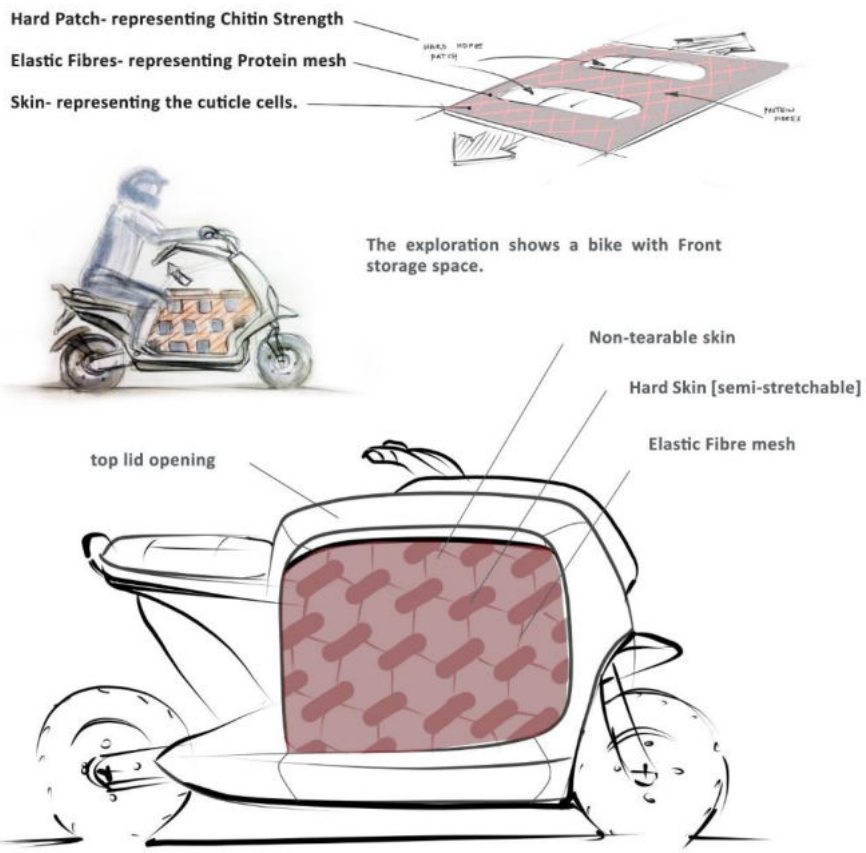
The composite skin of chitin and relilin can hold cargo firmly. Where the main shocks and forces are taken by the chitin patches and the resilin skin protects it from rain and sunlight.

The concept has structural skeleton that can collapse to fit in compact space. When stretched, it can open up as a bag and can provide more storage space.

The second concept has the tubes can expand with help of air pressure and make space. The cargo can be slide in. Then the pressure can be released to hold cargo firmly.



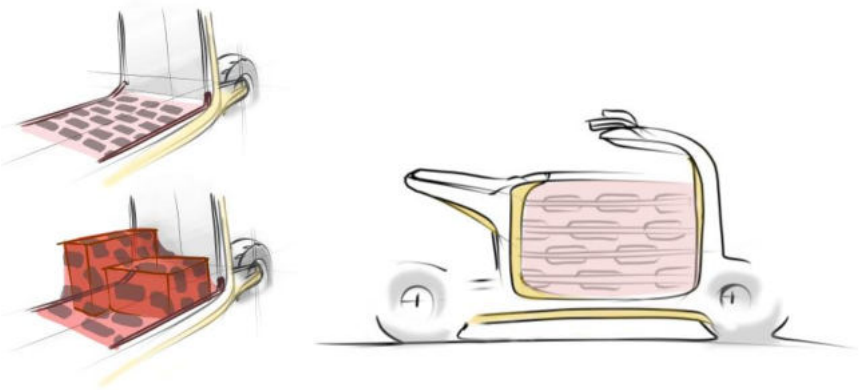




10.4 Wheeler For Goods Carrying

The front storage concept is shown below with resilin skin attached to the walls of the bike.

Concept bike shows foot rest space covered with resilin skin. The skin can be stretched and used for keeping the load under it. The load can be constrained by the skin only. Thus it becomes easier to carry goods on bike.

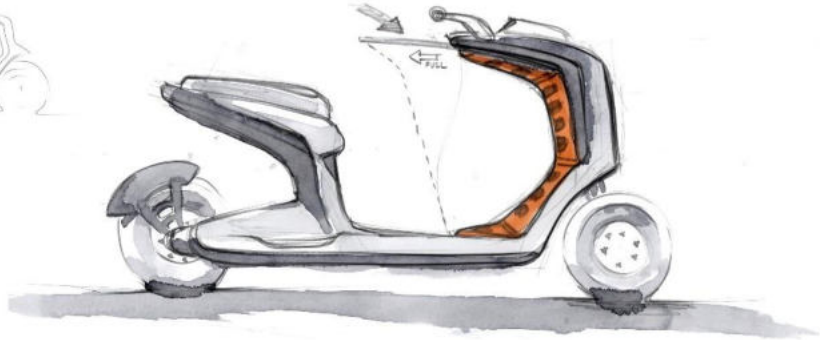


11 Explorations

The idea of using resinil-chitin skin can be very helpful in designing 2 wheeler goods carrier. The main reason for using such material is that its self retracting, can be stretched and has hard patches that can protect the goods from external forces. Thus the need of constraining the load with ropes is eliminated.

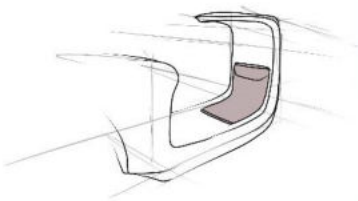
Following pages shows the exploration for the goods carrying two wheeler.

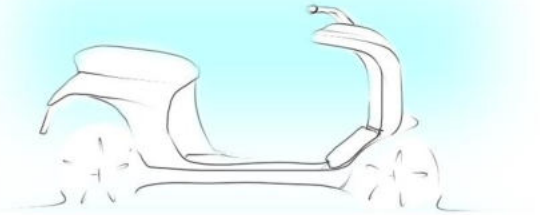
THE PANEL CAN BE PULLED OUT

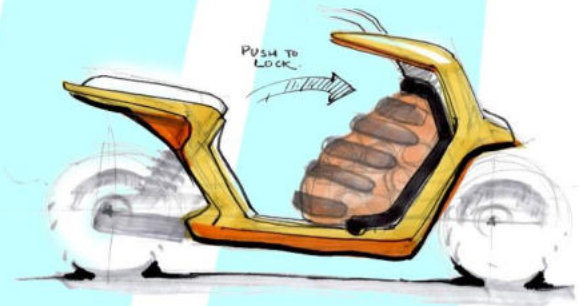


STRAPS ACT AS SIDE CONTRAIN

STORAGE AT FRONT

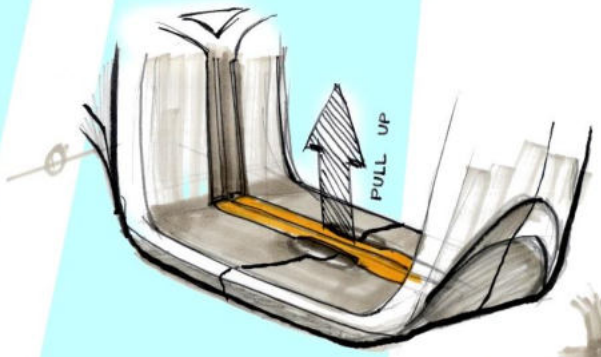




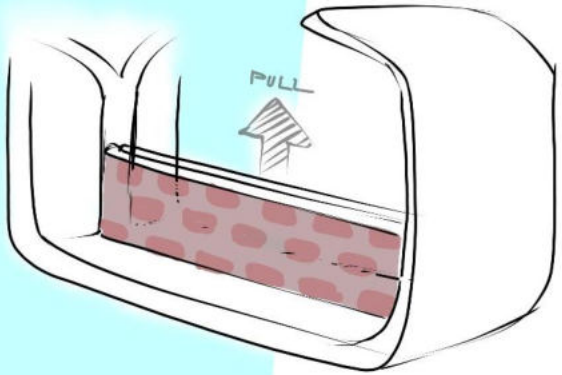


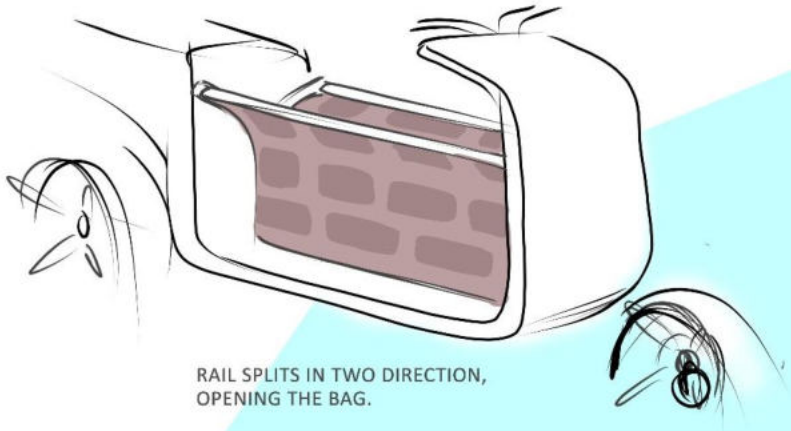
WHEN NOT IN USE, THE STORAGE BAG RETRACTS , MAKING SPACE FOR OTHER STUFF.

HARD FRAME IS GUIDED BY A RAIL
IN BIKE BODY PANEL



FRAME CAN BE PULLED OUT TO SKTETCH
THE STORAGE BAG.

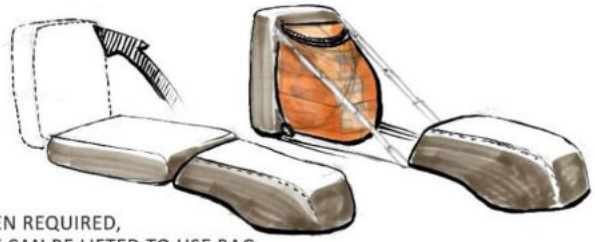




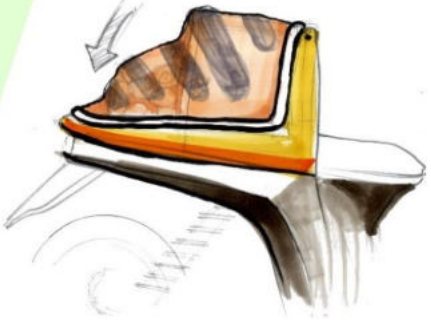
RAIL SPLITS IN TWO DIRECTION,
OPENING THE BAG.

REAR SEAT SPACE IS USED FOR STORAGE

REAR SEAT CAN HAVE RESILIN BAG

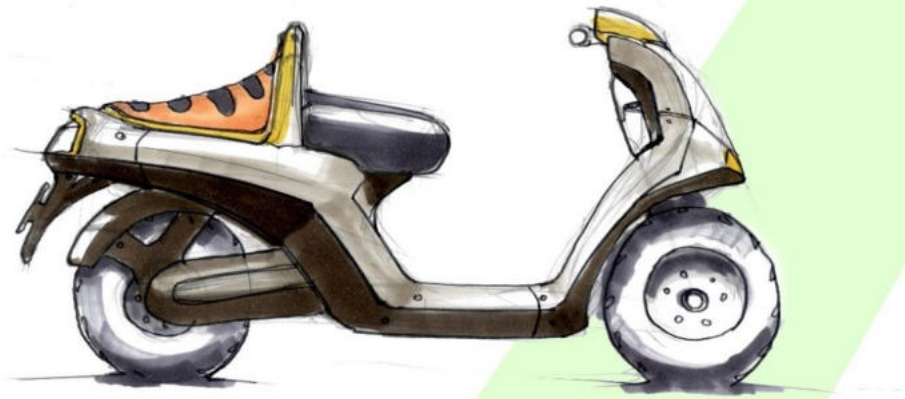


WHEN REQUIRED,
SEAT CAN BE LIFTED TO USE BAG



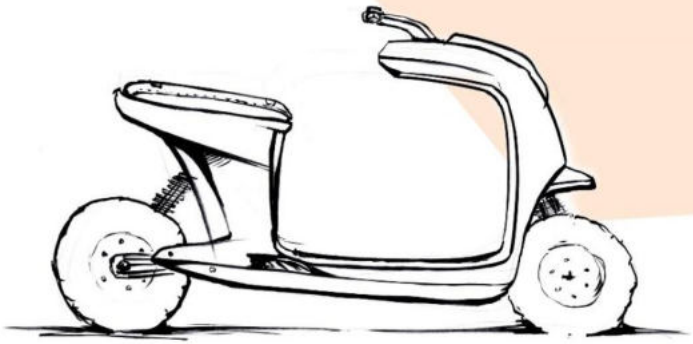
WHEN CLOSED, SKIN APPLIES PRESSURE ON OBJECTS TO KEEP THEN IN PLACE.

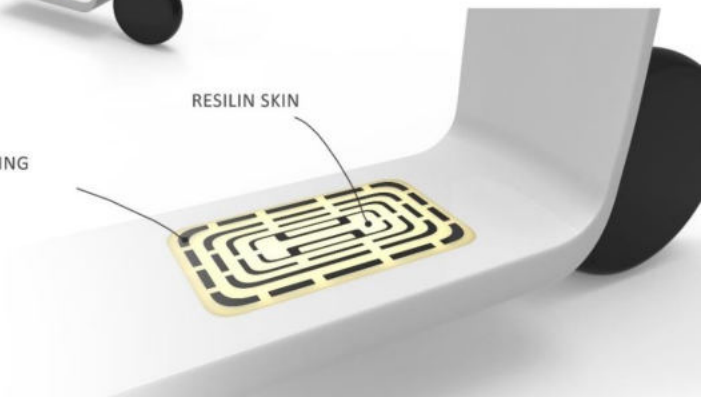
FOR DAILY USE LIKE DELIVERING
NEWSPAPER,
VEGETABLES,
PIZZA/E SHOPEE DELIVERY ETC.

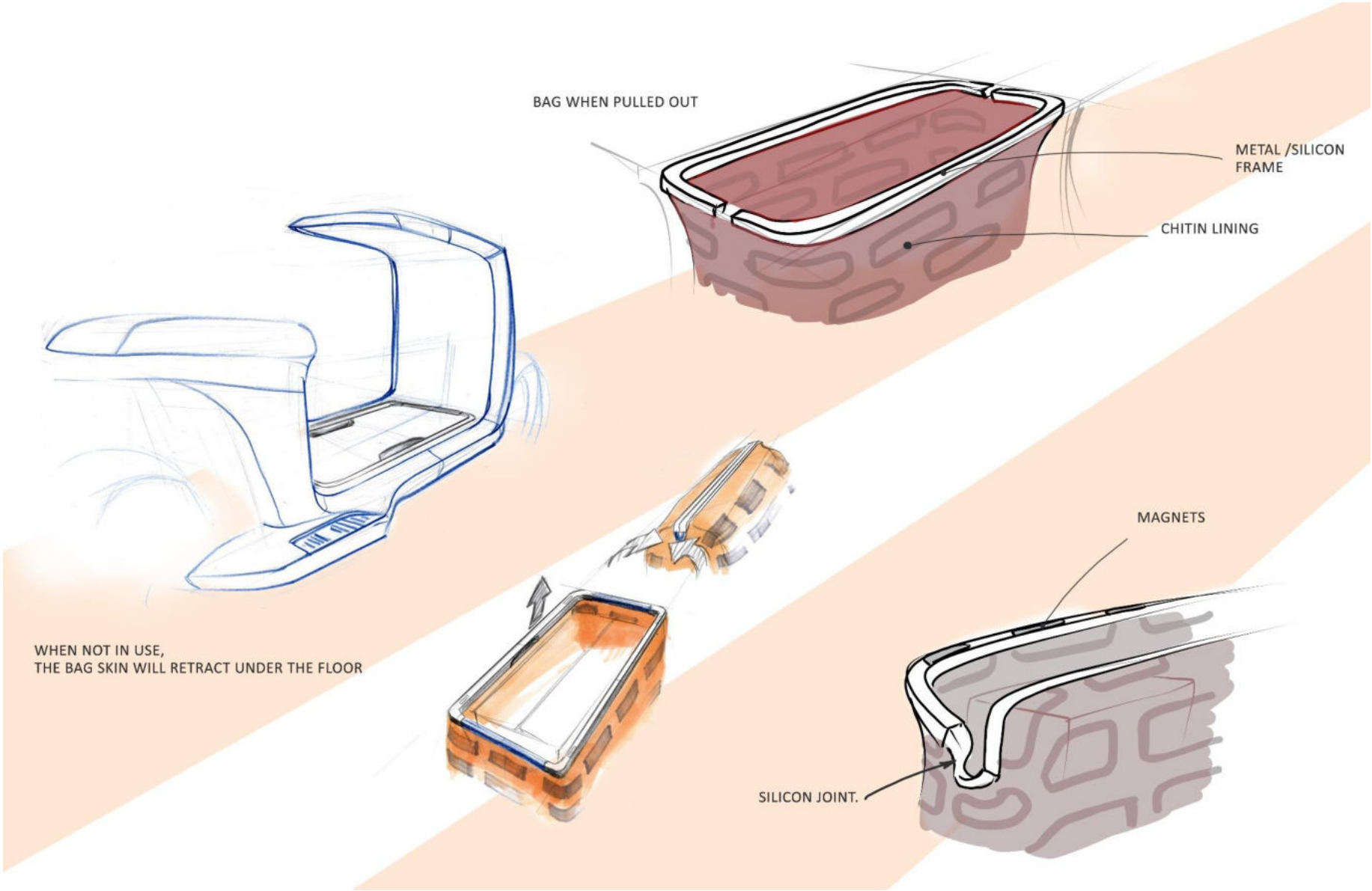


THE BAG SKIN WILL BE FLUSHED IN FLOOR

TWO HANDLES AR PROVIDED IN CHITIN SKIN TO PULL THE BAG





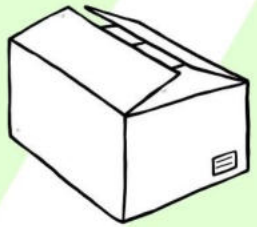

BAG WHEN PULLED OUT
METAL /SILICON FRAME
CHITIN LINING
MAGNETS
SILICON JOINT.
WHEN NOT IN USE,
THE BAG SKIN WILL RETRACT UNDER THE FLOOR

DAILY VEGETABLE DELIVERY

VEGETABLES HAVE TO BE TRANSPORTED IN SOFT BAGS.

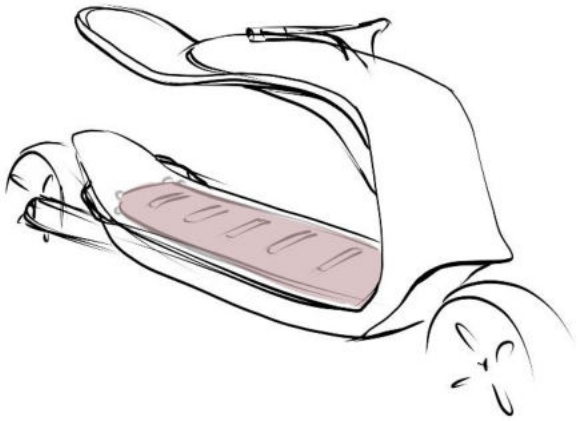
SHIPMENT DELIVERY

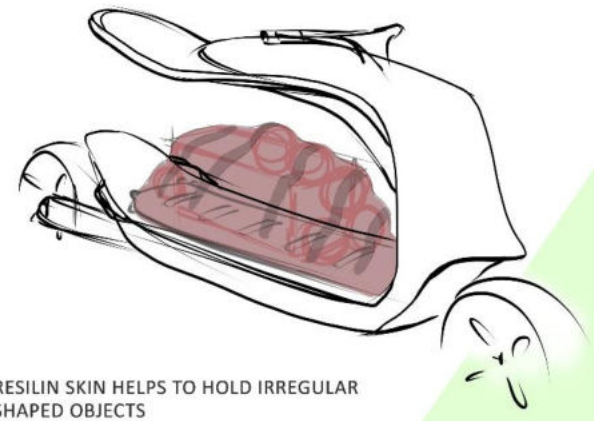
OFTEN LARNGE IN NUMBER, AND VARIABLE IN SIZE



NEWSPAPER SUPPLY

DIFFERENT NEWSPAPERS WITH VARIABLE QUANTITY, NEEDED TO BE DELIVERD DAILY DOOR TO DOOR.





RESILIN SKIN HELPS TO HOLD IRREGULAR SHAPED OBJECTS

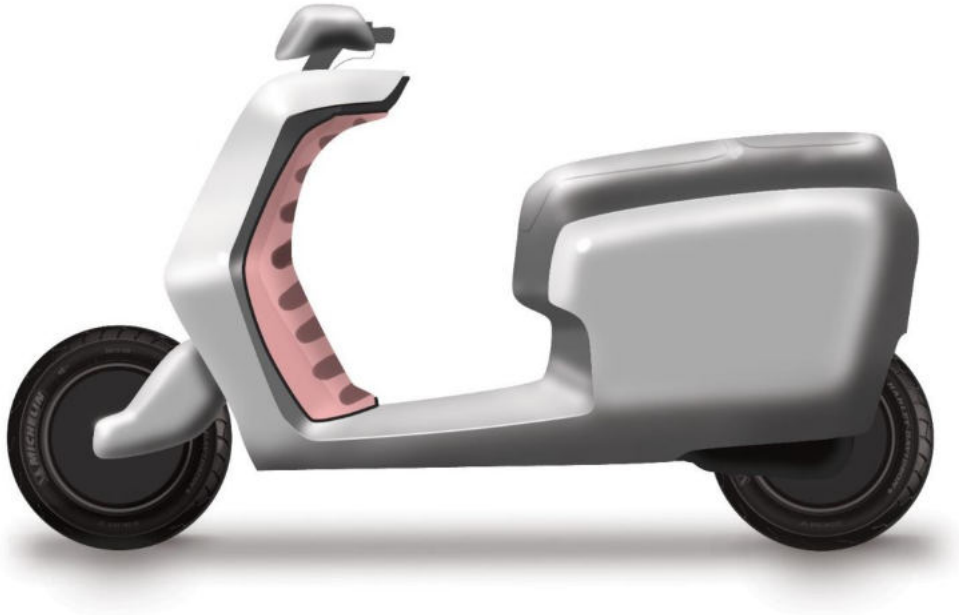
MOPED WITH LARGE STORAGE SPACE.

CAN BE USED FOR DELIVERY PURPOSES

12 Concepts

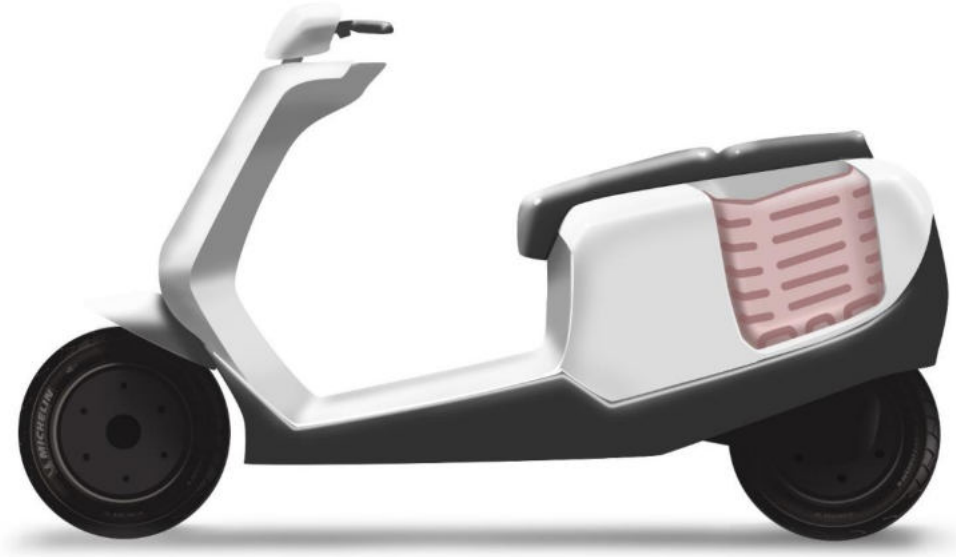
Considering the possibilities of the use of chitin-resilin skin, 6 concepts were generated. The concepts are intended to solve goods carrying problem on 2 wheeler. At the same time, the bike can also be used as full time delivery vehicle for delivering goods. Concepts include modification of current bike form as well as redefining the bike form for carrying goods.

Concept 1



Concept 2

Concept 3



Concept 4

Concept 5

Concept 6

14 Final Design

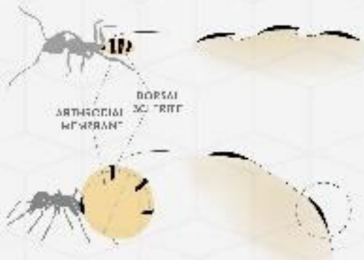
INSPIRATION

CAMPONOTUS INFLATUS

AMONGST THE CAMPONOTUS INFLATUS "REPLETES" ARE THE ANTS WHICH CAN STORE HONEY

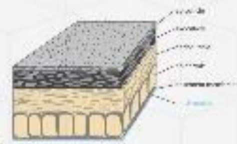
THE ABILITY OF REPLETES TO INFLATE THEIR GASTER IS EXPLAINED HERE.

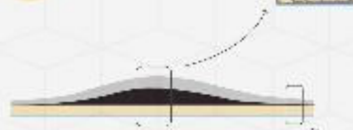
HONEYPOT ANTS- NORMAL STATE

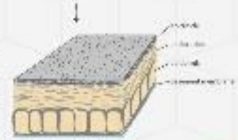


HONEYPOT ANTS- ELASTIC STATE

CUTICLE LAYER DENSITIES







FOLDING AND UNFOLDING

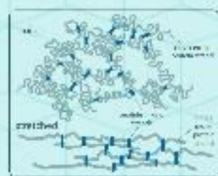
mesh matrix against epidermis cells

cuticle cells - normal state

cuticle cells - stretched

HONEYPOT ANT GASTER

ELASTIC STRUCTURES



RESILIN FIBRES

PROTEIN FIBRES

elastic scaffolding of mesh matrix

Resilin

Chitin

IDEATION

HONEYPOT ANTS- NORMAL STATE

One Directional, 2D object stretching

One Directional, 3D object Stretching

Two Directional, 3D object Stretching

The Carrier Boxes for Bikes have very less space inside. An average size box can have less than 10 liter volume.

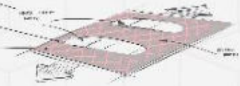
The containers are made of Hard materials and can only accomodate object of specific size.

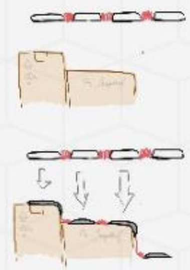
These Boxes are Hard attched to the bike with bolts and fixtures. Often People prefer soft bags over these containers, compromising the locking fascility.

Hard Patch- representing Chitin Strength

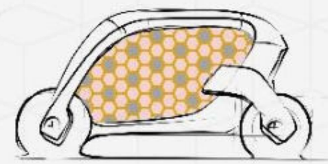
Elastic Fibres- representing Protein mesh

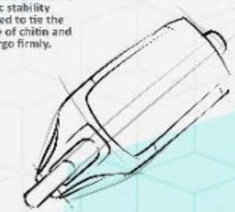
Skin- representing the cuticle cells.





Automated delivery vehicle which is balanced by gyroscopic stability assist and does not need to tie the cargo as the skin made of chitin and resilin can hold the cargo firmly.



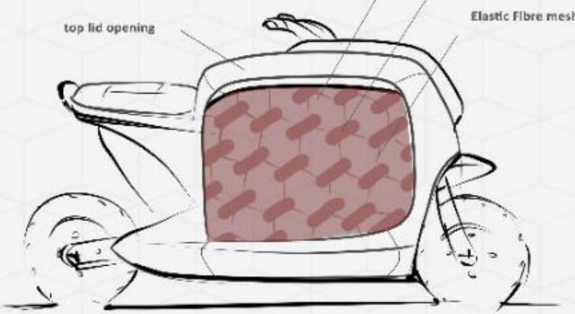


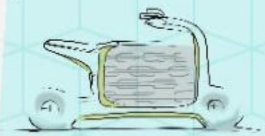
Non-tearable skin

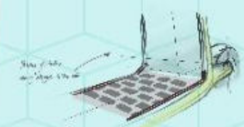
Hard Skin [semi-stretchable]

Elastic Fibre mesh

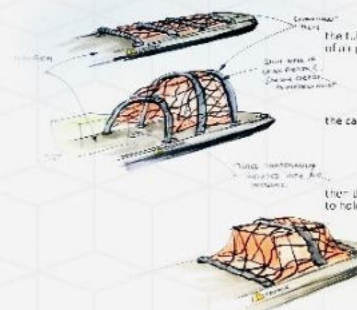
top lid opening







The exploration shows a bike with Front storage space.



the tubes can expand with help of air pressure and make space

the cargo can be slided in

then the pressure can be released to hold cargo firmly

Carrying things over two wheeler is a tough task for people like Paperwala, Dabbewala, E-shopee Delivery boys etc. The main reason is that a bike is not designed for such purpose and thus it does not have space to store such volume of cargo.

There's a need to introduce a bike that can help in such tasks and can accomodate the variable volume of cargo.



A delivery boy have to take collect the parcels respective to his predefined route/region.

The route length can vary anywhere between 5 to 30km and takes up to 6 Hrs.

Total weight of the shipments can vary between 10 to 25kg.

Generally parcels come with bubble wrap or foam packing. But few parcels come with specific handling in-

Mostly at places like office zones, shops, colleges etc. delivery boys can meet a person at some landmark and handover the parcel from their bags. Thus he don't have to leave his bike.

At places like Apartments or commercial complex, he have to park his bike and carry the parcel to respective floor.

While doing so, he have to carry all his parcels with him

In addition to these, he have to maintain documents of delivery confirmation, cash on delivery records, payment slips and return pickup invoice.

He've to carry mobile, EDC machine, invoice list and

Mopeds have enough space in front to keep things and thus one need not to tie the bag to the bike.

USER STUDY

People prefer carrying load on bike as it is easy. But in many cases the load is either large in volume, delicate or odd in shape. Thus it becomes difficult to carry it.

observations shows the different practices of carrying things on bike.

whereas the conventional bikes dont have space to keep the bags and thus people attach extra metal hooks to hang the bags.

Both of these images show the bikes with load that is daily delivered to the shops. in such cases, the volume is very large and its very difficult to tie and un-tie that load everytime.

Often people have a leather bag attached to bike but as it is not sufficient, they have to use extra bag, which then they tie to the support hook.

Some people use thier motorbikes or bicycles to travel place to place. They cary thier tools with them. e.g. sheet metal technician, Plumber etc.

Some people carry handmade cloth woven bags with them to carry vegetables.

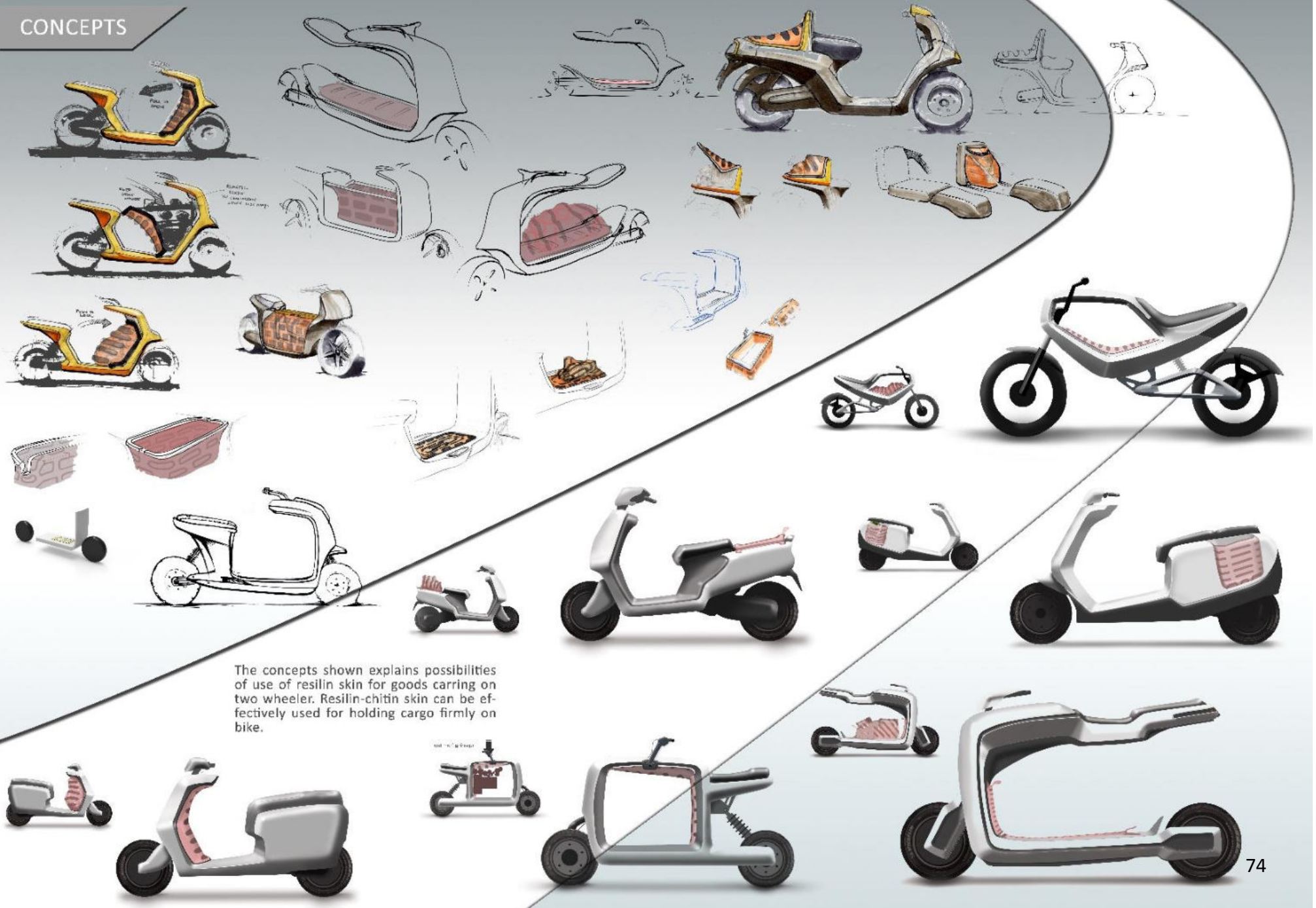
Market is a place where people carry material on bikes as the quantity of load is less. They often attach grills or carrier to help constraining the load.

Observation shows that most of bikes are noticed carrying vegetables from market at time of evening.

Most people visit market after thier job shift and while returning home.

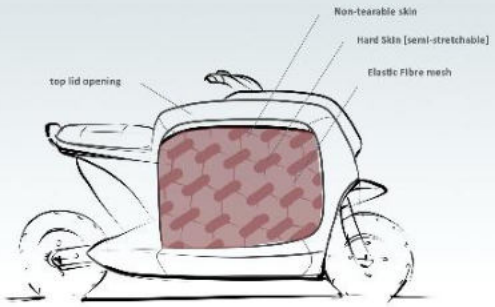
Whereas customer carry bags with them which they tie to side of the bike or rear carrier of bike.

CONCEPTS

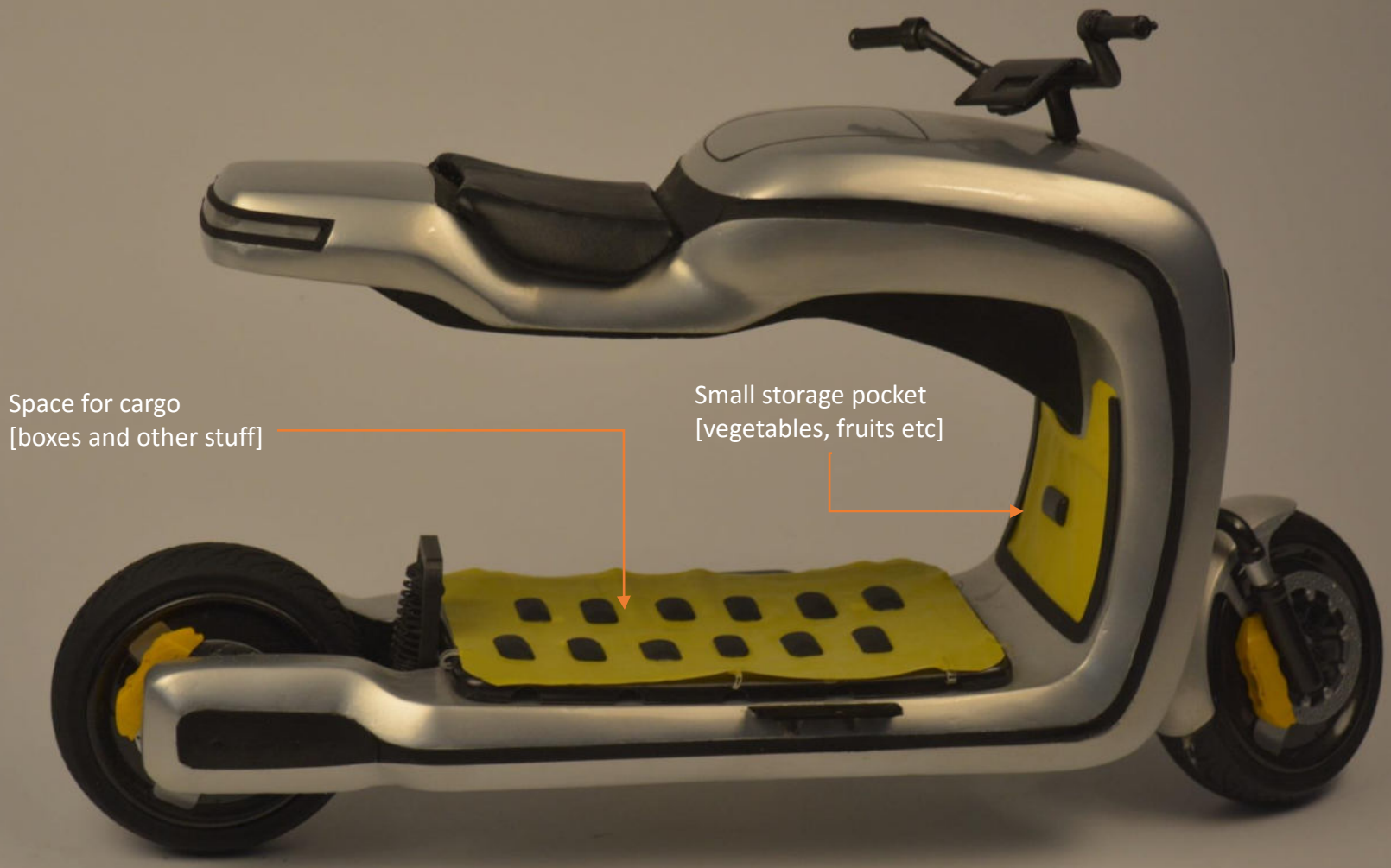


The concepts shown explains possibilities of use of resilin skin for goods carring on two wheeler. Resilin-chitin skin can be effectively used for holding cargo firmly on bike.

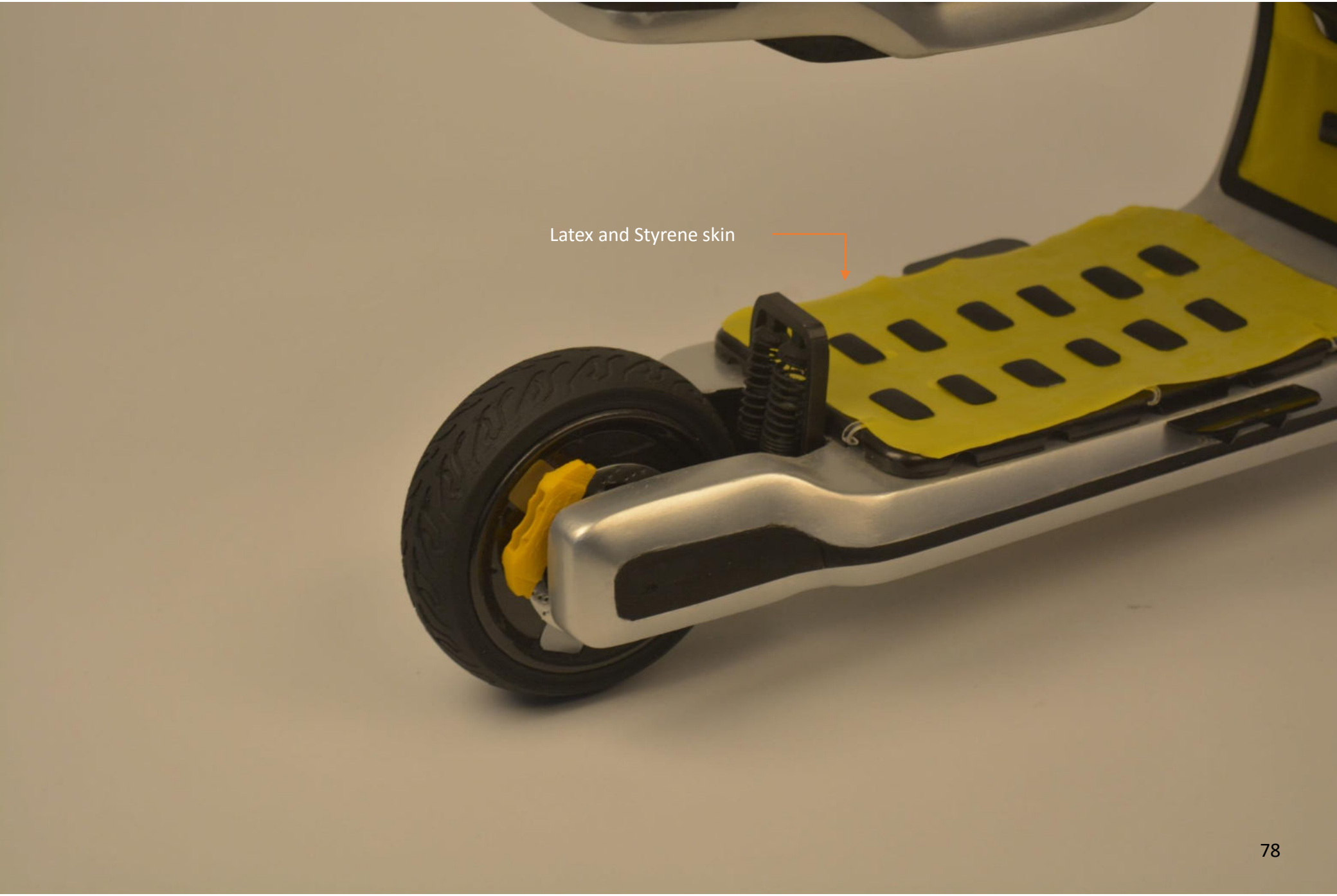
FINAL CONCEPT



Scale model


Space for cargo
[boxes and other stuff]
Small storage pocket
[vegetables, fruits etc]


Locker


Latex and Styrene skin

Auto Expo 2016
Indo-Expo Mart, Greater Noida

Anupam Shukla
Tata Mototrs Design Studio

15 References

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