

IDC School of Design
अभिकल्प विद्यालय

Design Project 2

Designing Adventure vehicle for snowy terrain using biomimicry

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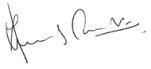
Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated any idea/data in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited of from whom proper permission has not been taken when needed.

Signature: 

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The Mobility and Vehicle design project report entitled 'Designing adventure vehicle for snowy terrain using biomimicry' by Piyush Tanwar is approved in partial fulfilment of the requirement for Master of Design degree in Mobility and Vehicle Design.

Guide: Prof. Sridhar Mahadevan and Prof. Sugandh Malhotra

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1.0 Introduction

Winter landscapes hold a captivating beauty, beckoning us to explore their pristine expanses. However, current snow vehicles often sacrifice agility and environmental impact for speed. This project aims to revolutionize the winter adventure scene by developing a snow vehicle.

Drawing inspiration from the movement and adaptability of nature's marvels, this vehicle will redefine how we experience the snow. Imagine a machine as graceful as a penguin, gliding effortlessly across the terrain. Think of manoeuvrability inspired by snow rabbits, adeptly navigating through deep snowdrifts.

This project is not just about creating a thrill ride. It's about fostering a deeper connection with winter wonderlands while minimizing our environmental footprint. The goal is to develop a vehicle that is both efficient and exhilarating, allowing us to explore the beauty of snow in a more sustainable way.

By combining biomimicry with innovative design principles, this project has the potential to redefine winter adventures, opening up unexplored possibilities for exploration and enjoyment.

1.1 What is Adventure?

Adventure is like a super cool trip, but with an extra dose of bravery mixed in! It's all about doing something totally new and different that makes your heart beat a little faster and puts a big smile on your face.

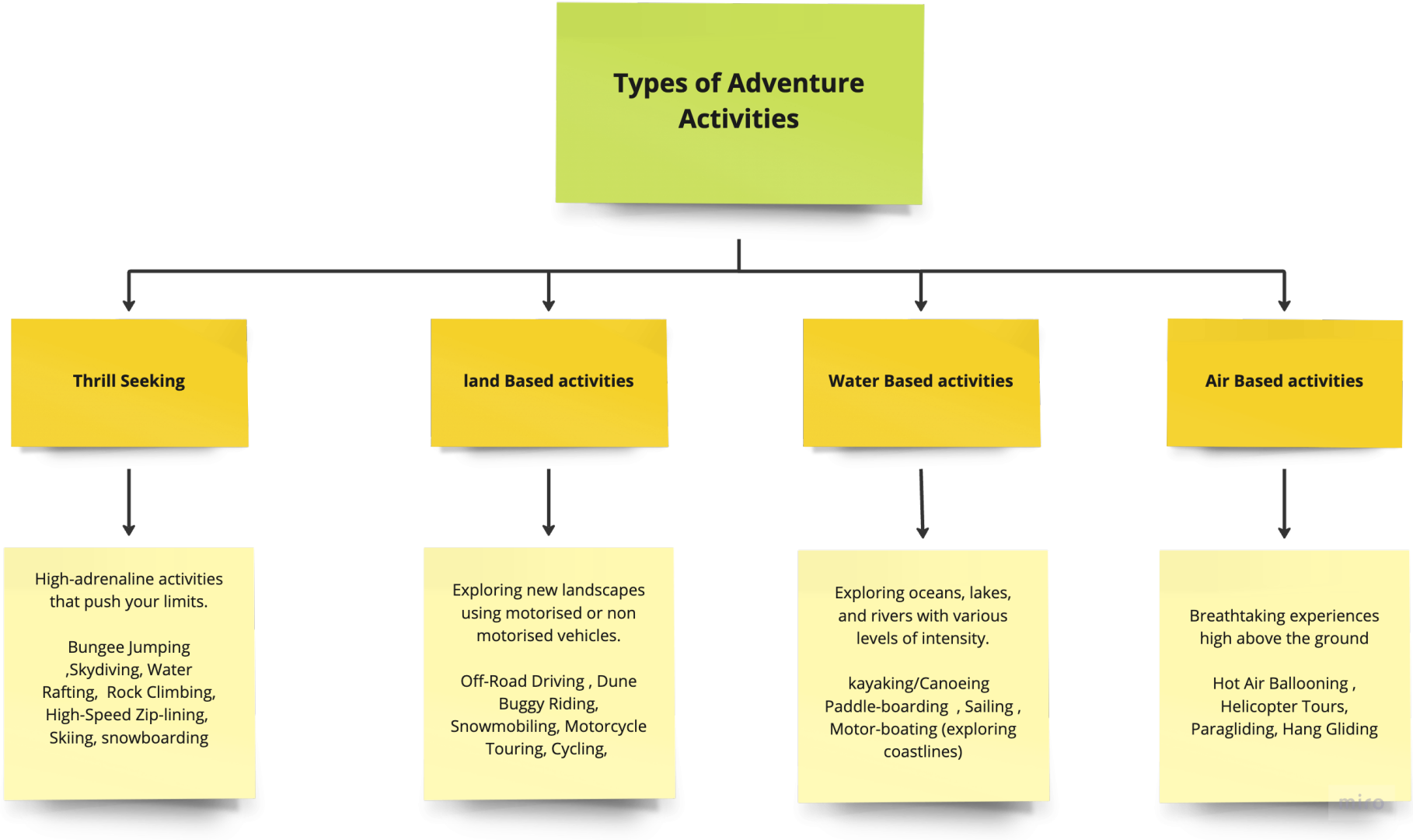
Imagine yourself on a regular trip, but then suddenly you get to try something that makes you say "wow!" Maybe it's a little scary at first, like jumping out of a plane with a parachute on your back (that's called skydiving!) or climbing a mountain so high it touches the clouds. These adventures get your adrenaline pumping and make you feel super alive!

But adventures aren't always about being scared. Sometimes, it's just about exploring new places that make you feel like you're in a whole different world. Think about going to a country where people speak a different language and the food tastes amazing! Or maybe you go on a camping trip and sleep under a million twinkling stars. These adventures open your eyes to new things and make you feel like a real explorer.

The best part about adventures is that there are so many reasons to go on them! Sometimes, you just want to have a ton of fun and try something exciting you've never done before. Other times, you might want to learn something new about a different culture or place. Maybe you even have a special goal in mind, like reaching the top of a mountain or completing a challenging hike.



1.2 Types of Adventure Activities



1.2.1 Thrill Seeking activities

Thrill-seeking activities are all about pushing your limits and experiencing a rush of excitement, often by engaging in activities that involve some degree of risk. They're designed to get your heart racing and adrenaline pumping, leaving you with a sense of accomplishment and a story to tell.









1.2.2 Land based adventure activities

Land-based vehicle adventure activities are all about exploring new places and having thrilling experiences using motorized or non-motorized vehicles on land. They offer a unique blend of adventure, exploration, and sometimes even a bit of self-sufficiency.



1.2.3 Water based adventure Activity

Water-based adventure activities are all about exploring the wonders of oceans, lakes, and rivers, with a good dose of excitement and challenge thrown in! They offer something for everyone, from tranquil exploration to heart-pounding thrills.



1.2.4 Air based Adventure Activity

Air-based adventure activities take you off the ground and into the sky for breath-taking views and exhilarating experiences! Imagine soaring high above the clouds like a bird, feeling the wind in your hair and the world miniaturized below.

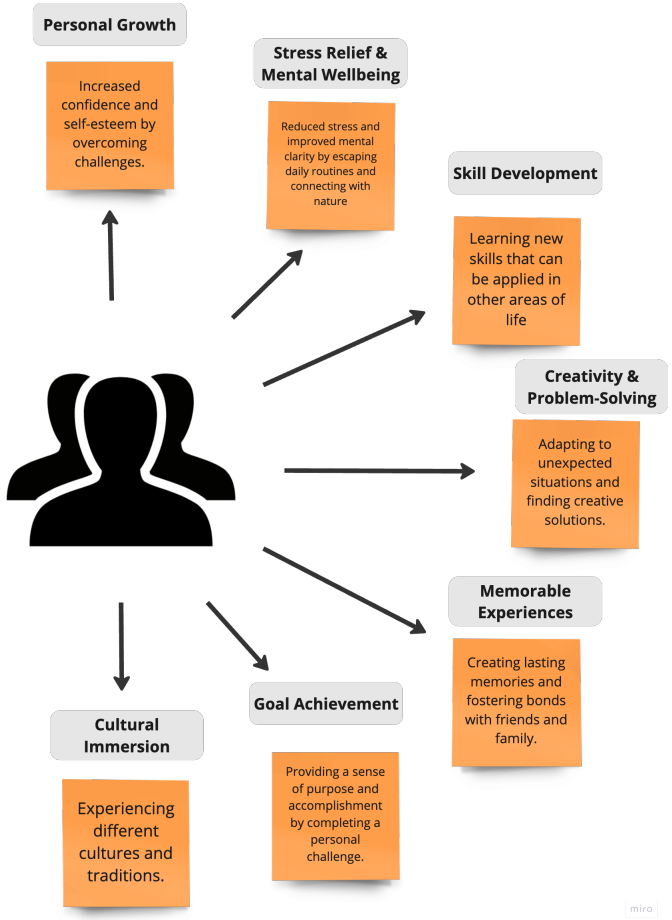








1.3 People’s aspirations and adventure activities



Adventure activities add value to user aspirations in a multitude of ways, both internally and externally

Internal Benefits:

- **Personal Growth:** Stepping outside your comfort zone and challenging yourself through adventure activities can boost your confidence and self-esteem. Overcoming obstacles and achieving goals, big or small, during an adventure can be incredibly empowering.
- **Stress Relief & Mental Wellbeing:** Adventure activities can be a fantastic way to escape the daily grind and clear your head. Immersing yourself in nature, focusing on the present moment, and getting your adrenaline pumping can all contribute to stress reduction and improved mental clarity.
- **Skill Development:** Many adventure activities require learning new skills, like rock climbing, navigating rapids, or using survival techniques. This not only helps you conquer the adventure itself but also equips you with valuable skills that can be useful in other aspects of life.
- **Creativity & Problem-Solving:** Adventures often involve unexpected situations and require quick thinking and creative problem-solving skills. Navigating unfamiliar terrain, overcoming challenges, and adapting to new situations can boost your creativity and resourcefulness.

External Benefits:

- **Memorable Experiences:** Adventure activities create lasting memories that you'll cherish for years to come. The shared experiences, breath taking sights, and sense of accomplishment can forge strong bonds with friends and family.
- **Cultural Immersion:** Some adventures involve cultural experiences, allowing you to learn about different ways of life, traditions, and customs. This can broaden your perspective and understanding of the world.
- **Goal Achievement:** Adventure activities can be a fantastic way to achieve personal goals. Whether it's reaching the summit of a mountain, learning to surf, or completing a long-distance bike ride, adventures can provide a sense of purpose and accomplishment.

1.4 Thrill-Seeker Vehicles:

- **Off-Road Motorcycles & ATVs (All-Terrain Vehicles):** These conquer challenging trails, letting you carve your own path through mud, dirt, and rocks.
- **Rock Crawlers:** Built for extreme rock climbing and technical terrain, these modified vehicles tackle near-vertical inclines and obstacles that would leave other vehicles stranded.

- **Dune Buggies:** Imagine yourself racing across vast sand dunes in a lightweight, open-air buggy. These desert speedsters are like roller coasters on sand, offering an exhilarating ride with the wind whipping through your hair.
- **Snowmobiles:** Snowmobiles turn snowy landscapes into your personal racetrack. Speed across a frozen wonderland, feeling the rush of cold air as you carve through pristine white fields.

- **Jet Skis:**! Jet skis propel across the water's surface at high speeds, offering a thrilling feeling of gliding and manoeuvring..



1.5 Exploring the Outdoors:

- **Jeeps and 4WD Trucks:** Jeeps and 4WD trucks are renowned for their ruggedness and ability to tackle challenging terrain. Whether it's traversing rocky paths, navigating through mud, or climbing steep inclines, these vehicles excel in off-road environments.
- **Overland Vehicles:** Overland vehicles are designed to be self-sufficient, offering all the comforts of home in a compact and rugged package. Equipped with amenities like rooftop tents, built-in kitchens, refrigerators, and ample storage, they allow adventurers to embark on extended journeys without sacrificing comfort.
- **Side-by-Side UTVs:** Side-by-side UTVs are perfect for exploring trails with friends or family, offering seating for multiple passengers in a compact and agile vehicle. Whether it's a leisurely scenic ride or an adrenaline-pumping off-road excursion, UTVs provide a fun and social way to experience the outdoors together.
- **Mountain Bikes:** Embark on an eco-friendly adventure exploring trails and immersing yourself in nature. Mountain bikes come in various styles depending on the terrain you want to tackle.



1.6 Area of Interest

As winter sports continue to captivate enthusiasts worldwide, there arises a growing demand for vehicles that can enhance and complement these exhilarating experiences. From the adrenaline rush of skiing down pristine slopes to the serene beauty of ice fishing on frozen lakes, the allure of winter activities knows no bounds. However, existing transportation options often fall short in meeting the unique demands of navigating snowy terrains with ease and efficiency. This presents a niche market with immense potential for innovation, where vehicles are designed specifically for snow exploration can revolutionize the winter sports industry. By addressing the limited exploration of vehicles tailored for snow, we can unlock new realms of adventure and excitement for winter sports enthusiasts, providing them with the means to embark on unforgettable journeys amidst the winter wonderland.





Research.

2.1 Winter Wonderland: Unveiling Snow Adventures in India

While India is known for its vibrant culture and scorching summers, it also boasts a surprising winter wonderland in the Himalayas. The mighty Himalayas transform into a snowy paradise during winter, offering unique experiences for adventure enthusiasts. Here's a glimpse into winter tourism in India and the exciting snow activities you can partake in:











2.2 Physical location

India boasts several picturesque destinations for winter activities, especially in the northern regions where the Himalayas dominate the landscape. Here's an overview of the physical locations of the mentioned destinations:

Himachal Pradesh

Manali: is a hub for winter sports such as skiing, snowboarding, and ice skating. The nearby Solang Valley and Rohtang Pass are particularly popular for their excellent skiing conditions and breath-taking panoramic views.

Shimla : is famous for its colonial architecture, scenic hills, and vibrant winter festivities. Kufri, a small hill station near Shimla, is renowned for its ski slopes and picturesque landscape.

Auli : is known for its pristine snow-covered slopes and offers a perfect setting for skiing and other winter sports. The panoramic view of the Nanda Devi and Nar Parvat mountains enhances the appeal of Auli for both adventure enthusiasts and nature lovers.

Jammu and Kashmir

Gulmarg : is one of India's premier ski resorts, featuring the Gulmarg Gondola, one of the highest cable cars in the world, which transports skiers to the slopes of Mt. Apharwat. The region's natural beauty and powdery snow make it a winter sports paradise

Pahalgam : is a charming town known for its picturesque landscapes and as a starting point for the annual Amarnath Yatra. In winter, Pahalgam transforms into a serene snowy retreat, ideal for activities like skiing and sledging.

Sonmarg : is Surrounded by glaciers and serene lakes, Sonmarg offers magnificent trekking routes and is a gateway to the famous Zoji La pass. The region is covered in a blanket of snow during winter, providing a spectacular setting for snow activities.

Uttarakhand

Nainital : Nainital town is surrounded by mountains, the highest being Naina Peak, providing ample opportunities for snow trekking and enjoying the scenic beauty of snow-covered landscapes. Snowfall here adds a magical charm to the already picturesque town.

Binsar: is a less commercialized but equally beautiful winter destination. Known for the Binsar Wildlife Sanctuary, this area offers stunning views of the Himalayan peaks like Nanda Devi, Kedarnath, and Panchachuli. The snowfall in Binsar creates a tranquil and captivating atmosphere, perfect for winter hiking and bird watching.

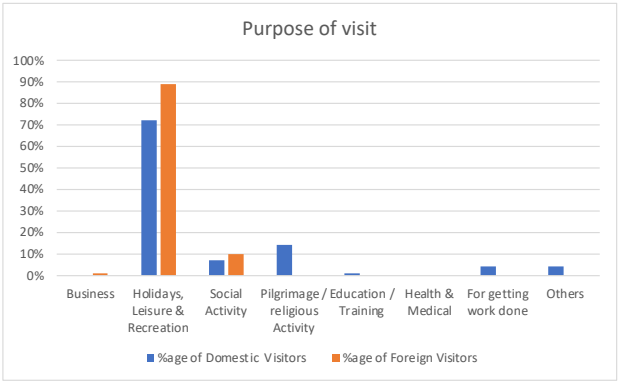


2.3 Tourist Report: Jammu and Kashmir, Himachal Pradesh, and Uttarakhand

2.3.1 Himachal Pradesh

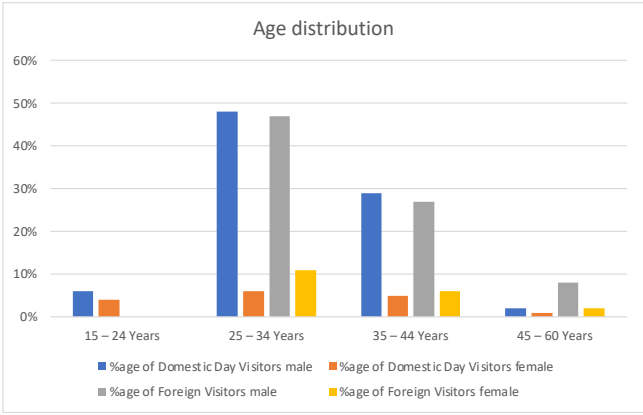
1.Purpose of visit of tourists in state of Himachal Pradesh

Purpose	%age of Domestic Visitors	%age of Foreign Visitors
Business	0%	1%
Holidays, Leisure & Recreation	72%	89%
Social Activity	7%	10%
Pilgrimage / religious Activity	14%	0%
Education / Training	1%	0%
Health & Medical	0%	0%
For getting work done	4%	0%
Others	4%	0%
Total	100%	100%



2. Age distribution of tourists in state of Himachal Pradesh

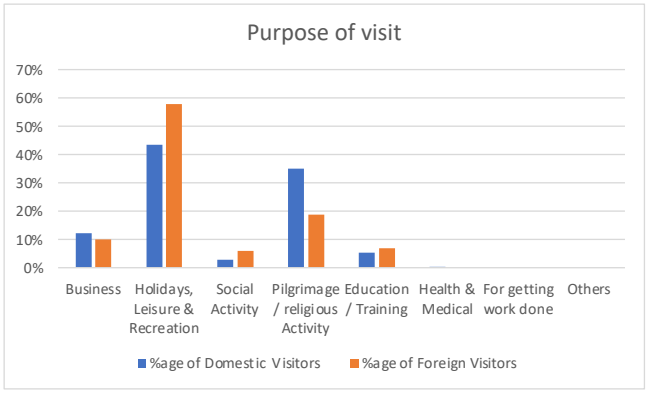
	%age of Domestic Day Visitors		%age of Foreign Visitors	
Age group	male	female	male	female
15 – 24 Years	6%	4%	0%	0%
25 – 34 Years	48%	6%	47%	11%
35 – 44 Years	29%	5%	27%	6%
45 – 60 Years	2%	1%	8%	2%
Total	84%	16%	81%	19%



2.3.2 Uttarakhand

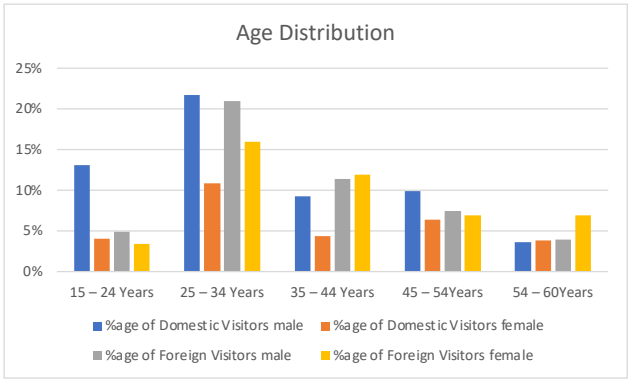
1.Purpose of visit of tourists in state of Uttarakhand

Purpose	%age of Domestic Visitors	%age of Foreign Visitors
Business	12%	10%
Holidays, Leisure & Recreation	44%	58%
Social Activity	3%	6%
Pilgrimage / religious Activity	35%	19%
Education / Training	6%	7%
Health & Medical	0%	0%
For getting work done	0%	0%
Others	0%	0%
Total	100%	100%



2.Age distribution of tourists in state of Uttarakhand

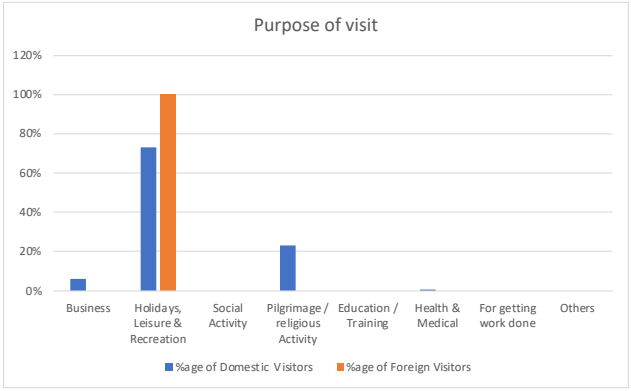
	%age of Domestic Visitors		%age of Foreign Visitors	
Age group	male	female	male	female
15 – 24 Years	13%	4%	5%	3%
25 – 34 Years	22%	11%	21%	16%
35 – 44 Years	9%	4%	11%	12%
45 – 54Years	10%	6%	7%	7%
54 – 60Years	4%	4%	4%	7%
Total	65%	16%	53%	47%



2.3.3 Jammu And Kashmir

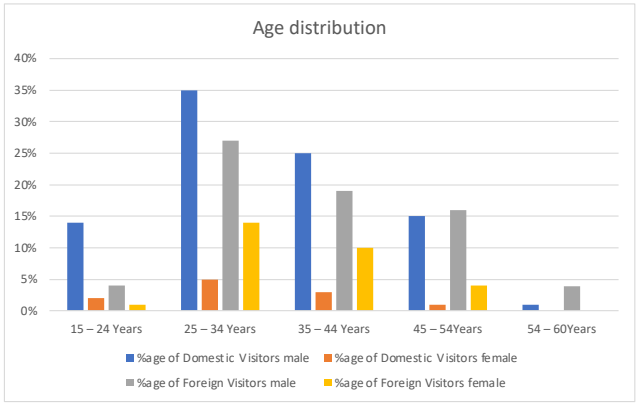
1.Purpose of visit of tourists in state of Jammu and Kashmir

Purpose	%age of Domestic Visitors	%age of Foreign Visitors
Business	6%	0%
Holidays, Leisure & Recreation	73%	100%
Social Activity	0%	0%
Pilgrimage / religious Activity	23%	0%
Education / Training	0%	0%
Health & Medical	0%	0%
For getting work done	0%	0%
Others	0%	0%
Total	100%	100%



2.Age distribution of tourists in state of Jammu and Kashmir

	%age of Domestic Visitors		%age of Foreign Visitors	
Age group	male	female	male	female
15 – 24 Years	14%	2%	4%	1%
25 – 34 Years	35%	5%	27%	14%
35 – 44 Years	25%	3%	19%	10%
45 – 54Years	15%	1%	16%	4%
54 – 60Years	1%	0%	4%	0%
Total	90%	10%	70%	30%



2.4 Thrilling snow activity in India:



India offers a variety of snow activities due to its diverse landscape, ranging from the Himalayas in the north to hill stations in the south. Here are some popular snow activities in India:

Skiing: The Himalayan region, especially in states like Himachal Pradesh, Uttarakhand, and Jammu and Kashmir, offers excellent skiing opportunities. Destinations like Gulmarg, Auli, Manali, and Solang Nala are known for their ski resorts and slopes.

Snowboarding: Similar to skiing, snowboarding is gaining popularity in India. Places like Gulmarg and Auli have facilities and terrains suitable for snowboarding enthusiasts.

Snow Trekking: Trekking through snow-covered landscapes is a thrilling adventure. Popular trekking routes include Chadar Trek in Ladakh, Kedarkantha Trek in Uttarakhand, and Roopkund Trek in Uttarakhand.

Snowshoeing: Snowshoeing involves walking over snow with the help of snowshoes, which distribute the weight over a larger area, preventing sinking. It's a great way to explore snowy landscapes, especially in regions like Himachal Pradesh and Uttarakhand.

Snow Camping: Camping in the snow can be an unforgettable experience. Many trekking routes offer camping opportunities in snowy landscapes, allowing travellers to experience the beauty of winter nights under the stars.

Sledding: India has many places with stunning snow-covered views (Manali), making it perfect for sledging. Sledging is a fun winter activity where you slide down snowy slopes on a sled. You don't need any special skills for it. Just sit on the sled and slide down, laughing and enjoying the chilly air. It's a simple but wonderful winter sport that everyone should experience.

Ice Climbing: For the adventurous souls, ice climbing in frozen waterfalls or ice walls is an exhilarating activity. Locations like Manali and Spiti Valley offer ice climbing opportunities during the winter months.

Snowmobile Riding: Some resorts in snow-prone areas Gulmarg in Jammu and Kashmir offer snowmobile rides, providing an exciting way to explore snowy terrains.

Ice Skating: In places like Shimla and Gulmarg, ice skating rinks are set up during the winter months, allowing visitors to enjoy this classic winter activity.

2.5 Activity List



Snow Climbing



Snowmobile



Sledding



Skiing



Snowboarding



Snow Trekking



Snow camping



Ice Skating

2.6 Motivation for Designing a New Amateur-Friendly Snow vehicle

- **Expand winter adventure opportunities:** By creating an amateur-friendly snow vehicle, we can open up new avenues for winter adventure. This vehicle could enable individuals who are not experienced in traditional winter sports to explore and enjoy snowy landscapes in a safe and accessible manner**.**
- **Enhance accessibility and safety** : By prioritizing safety features and user-friendly design, we can empower people of all ages to participate in winter sports and exploration.
- **Embrace new winter experiences:** Introducing a new snow vehicle with aesthetic designs can encourage people to step out of their comfort zones and try something new.
- **Spark a love for winter exploration:** By providing an easy-to-use and enjoyable means of navigating snowy terrain, the new snow vehicle can ignite a passion for winter exploration in individuals who may have previously been hesitant to venture out in the cold.



2.7 Types of Snow vehicle

Across the world, various types of snow vehicles are used for transportation, recreation, and specialized tasks in snowy and icy conditions. Here are some common types:



Off-road trucks: are heavy-duty vehicles designed to navigate rough terrain. They are often equipped with large, rugged tires, high ground clearance, and powerful engines.
Uses: Off-road trucks are used for transportation, hauling, and utility work in snow-covered areas where traditional vehicles may struggle to operate.



4x4 vehicles: 4x4 also known as four-wheel-drive vehicles, have power delivered to all four wheels simultaneously. This provides better traction and control, making them suitable for driving in snow and ice.
Uses: 4x4 vehicles are versatile and used for transportation, recreational activities, and off-road exploration in snowy conditions.

ATVs : ATVs are small, open-air vehicles with handlebars for steering and straddling seats for riders. They typically have four wheels and are designed for off-road use.
Uses: ATVs are commonly used for recreational riding, transportation in remote areas, and performing tasks such as ploughing snow.

:





Snow cats: snow cats also known as snow groomers are tracked vehicles equipped with a front blade for pushing snow and a rear tiller for smoothing and compacting snow surfaces.
Uses: Snow cats are primarily used for grooming ski slopes, maintaining winter sports facilities, and performing snow removal operations.

Snowmobiles: Snowmobile also called sleds or snow machines, are motorized vehicles designed to travel over snow and ice. They typically feature skis at the front for steering and a track system at the rear for propulsion.
Uses: Snowmobiles are used for recreational purposes, transportation in remote areas, and by emergency services for search and rescue operations.

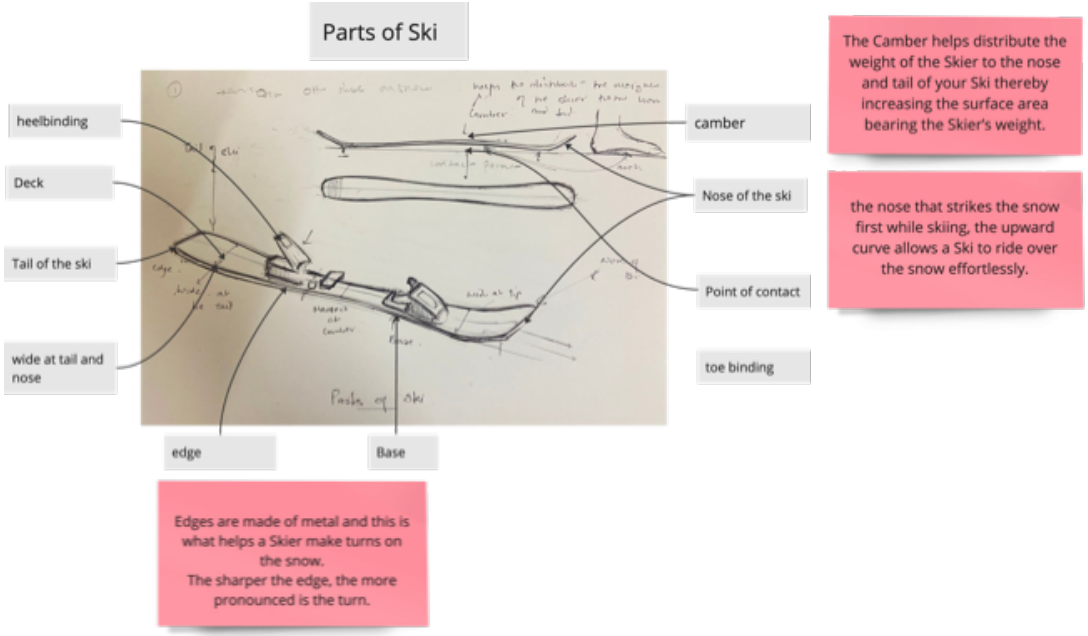
Tracked vehicle : Tracked vehicles are vehicles with continuous tracks instead of wheels. They are designed to distribute weight over a larger surface area, providing traction and flotation in snow and soft terrain.
Uses: Tracked vehicles have various uses, including transportation, exploration, military operations, and utility work in snow-covered regions

2.8 Benchmarking the vehicles and their features

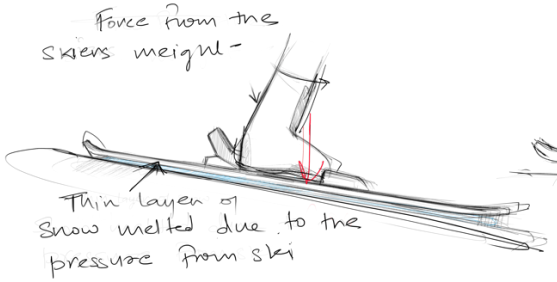


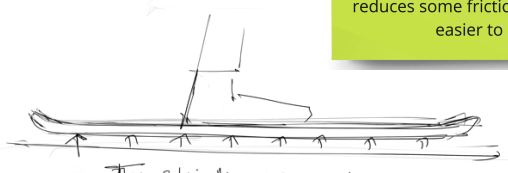
Skis

Skis are long, narrow things you wear on your feet to slide over snow. You wear ski boots with them, and they attach with bindings. Skis usually come in pairs. Some bindings let your heel move freely, some lock it in place, and some only partially secure it. To climb uphill, you can attach ski skins made of synthetic materials to the bottom of the ski.

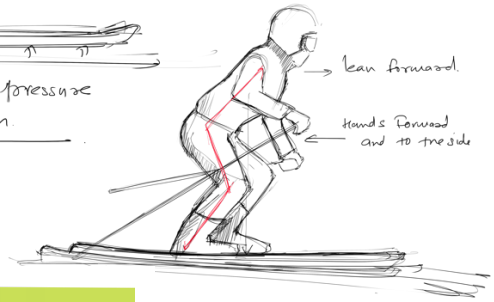


2.8.1 Working





Due to friction, energy dissipates in the form of heat. As a result, it melts the snow below it.
Wax is water repellent. However this reduces some friction and makes it easier to slide



The skies are long and flat aslong flat skies increase the area of contact, which decreases the pressure on the snow. This enables the skier to slide over the snow easily.



In downhill skiing, as your skis push against the ice or snow, kinetic friction occurs which transfers some kinetic energy into thermal energy. Kinetic energy comes from the act of moving and pushing yourself down the slope; the thermal energy is the heat that exudes from where your skis and snow rub together. The more friction, the more heat you generate instead of speed, and the slower you go down the slope



Pros and cons	Insights	Keywords

PROS
1.Great exercise: Provides a full-body workout..
2.Suitable for groomed slopes, powder snow, and backcountry exploration with proper skills.
3.Versatile: Different types of skis for various terrains
4. Glide down mountains and enjoy breathtaking panoramas
5.Best suited for gentle slopes and hills.
6.Highly portable (lightweight, easy to transport)
7.Thrilling downhill rides

Cons
1.Requires skill and practice: Can be difficult to learn initially, especially for beginners.
2.Risk of injury: Falls are common, especially while learning.
3.Requires good balance and stamina.
4.Weather dependent: Requires ideal snow conditions
5Limited terrain:
6:Not ideal for those seeking a thrill ride.

The more friction when you ski, the slower you will be on the course.

Skiers wax the bottom of their skis to reduce friction as they go down the slope.

Skiers can reduce drag by performing an effective tuck, C shape body

No much Mechanism needed

physical activity

versatile usecases

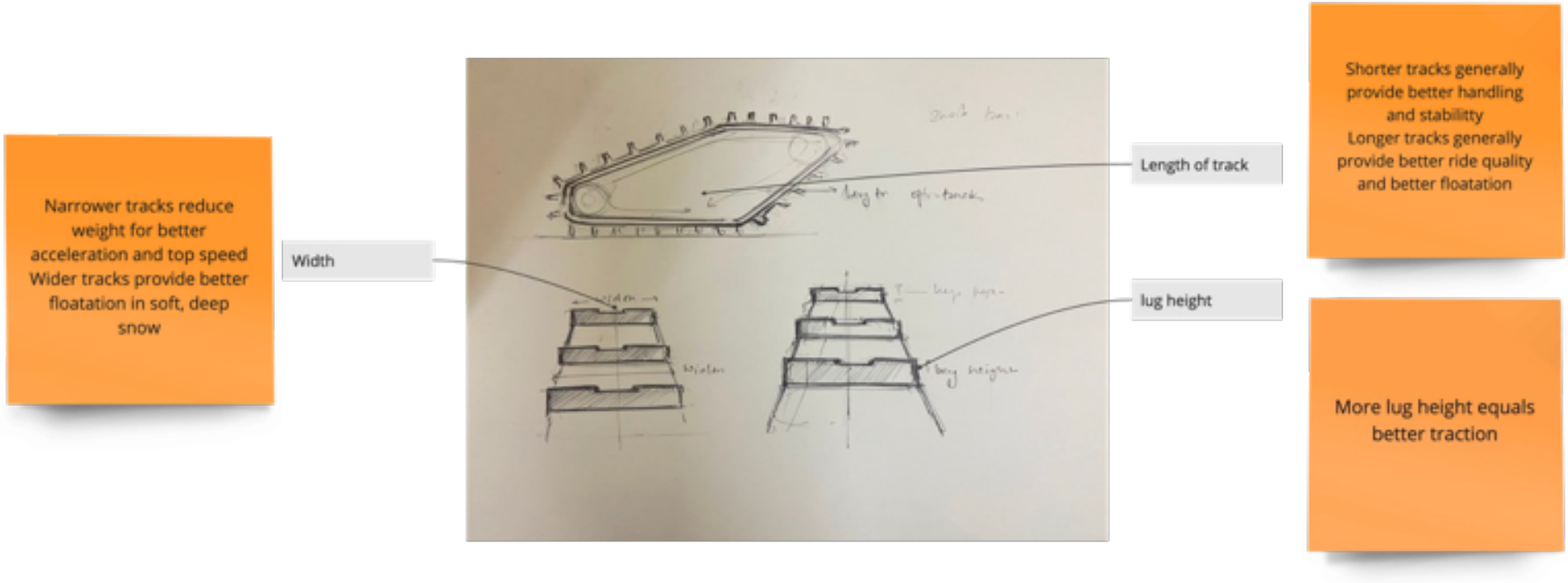
high learning curve

maneuver -ability

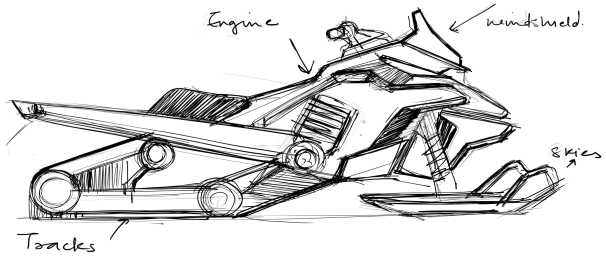
2.8.2 Snowmobile



A snowmobile is like a special vehicle for snow. It's made for traveling and having fun in winter on snow and ice. You can ride it where there are no roads or paths, but usually, people drive them on open snowy areas or marked trails. Snowmobiling is a popular hobby for lots of folks who love winter sports.



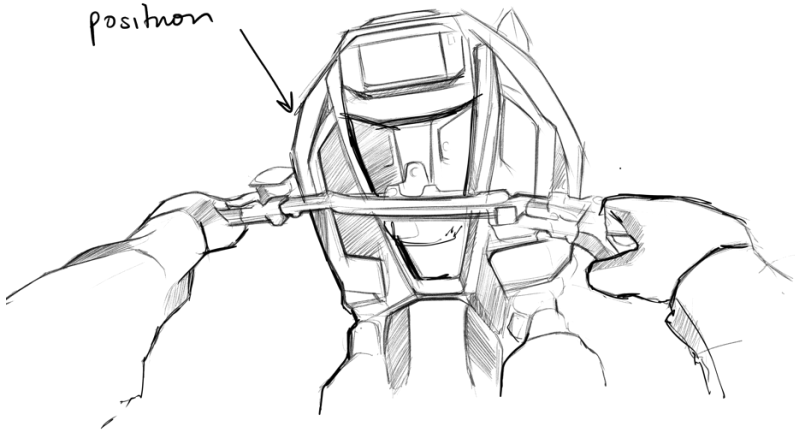
2.8.3 Working





To ride uphill the rider needs to shift his body position towards the rear side and lean forward.

Turning the handlebars turn the Ski's in the same direction, with sharper turns as the handle bars turn s farther from the centre.



Rider need to shift his position for the sharper turns.



Placing more body weight on the inside running board and leaning into the turn.

Pros and cons

PROS

1.Fast and exciting: Thrilling ride across snowy landscapes.
2.Covers large areas: Explore vast expanses of snow.
3.Can carry passengers and even tow supplies.
4. moderate surface area good for stability
5.Best suited for all type of terrain .
6.Multiple people (depending on size)

Cons

1.Requires skill and practice: Can be difficult to learn
2.Risk of injury: Falls are common.
3.Weather dependent: Requires ideal snow conditions
4.Environmental impact: Concerns about noise pollution and emissions.
5:Expensive: Snowmobile rentals and maintenance can be costly.
6.Noisy - disrupts wildlife and other winter enthusiasts
7: difficult to meneuver

Insights

track spread the vehicle weight over a greater surface area, allowing it to move on soft, slippery or unstable terrain

Tracks keep a heavy snowmobile from sinking in soft snow

Turning from the edges

Drivers weight play major role in riding the snowmobile

Keywords

adaptability

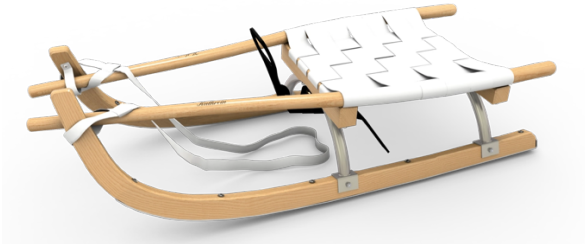
High speed

off-road capability

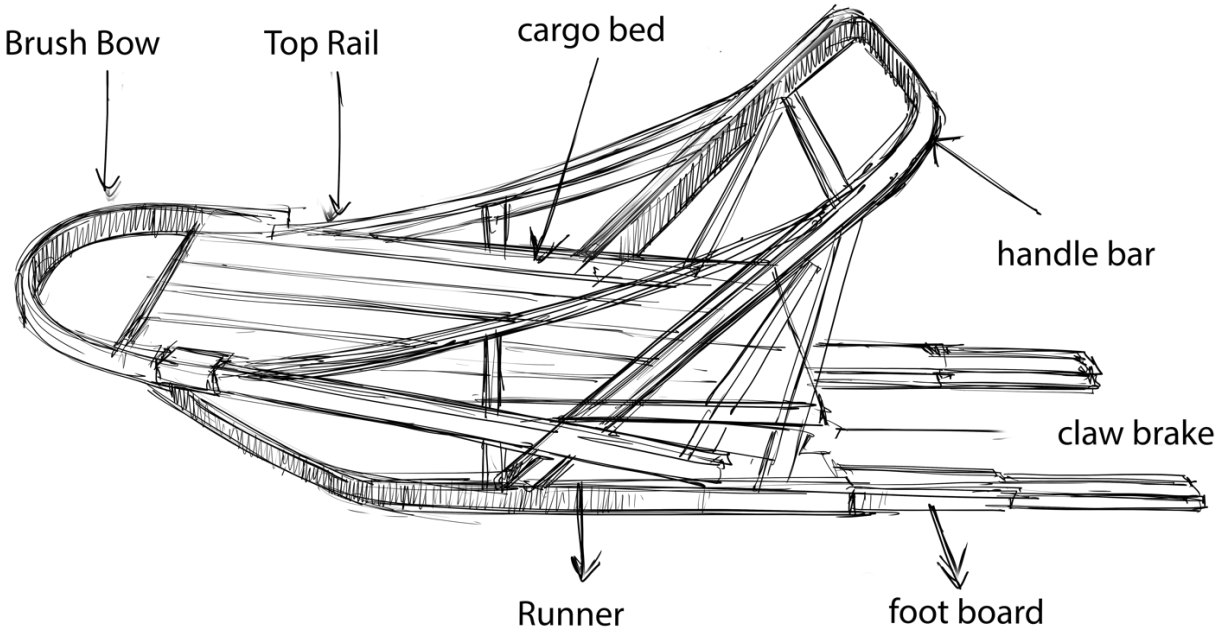
balance and stability

Storage and capacity

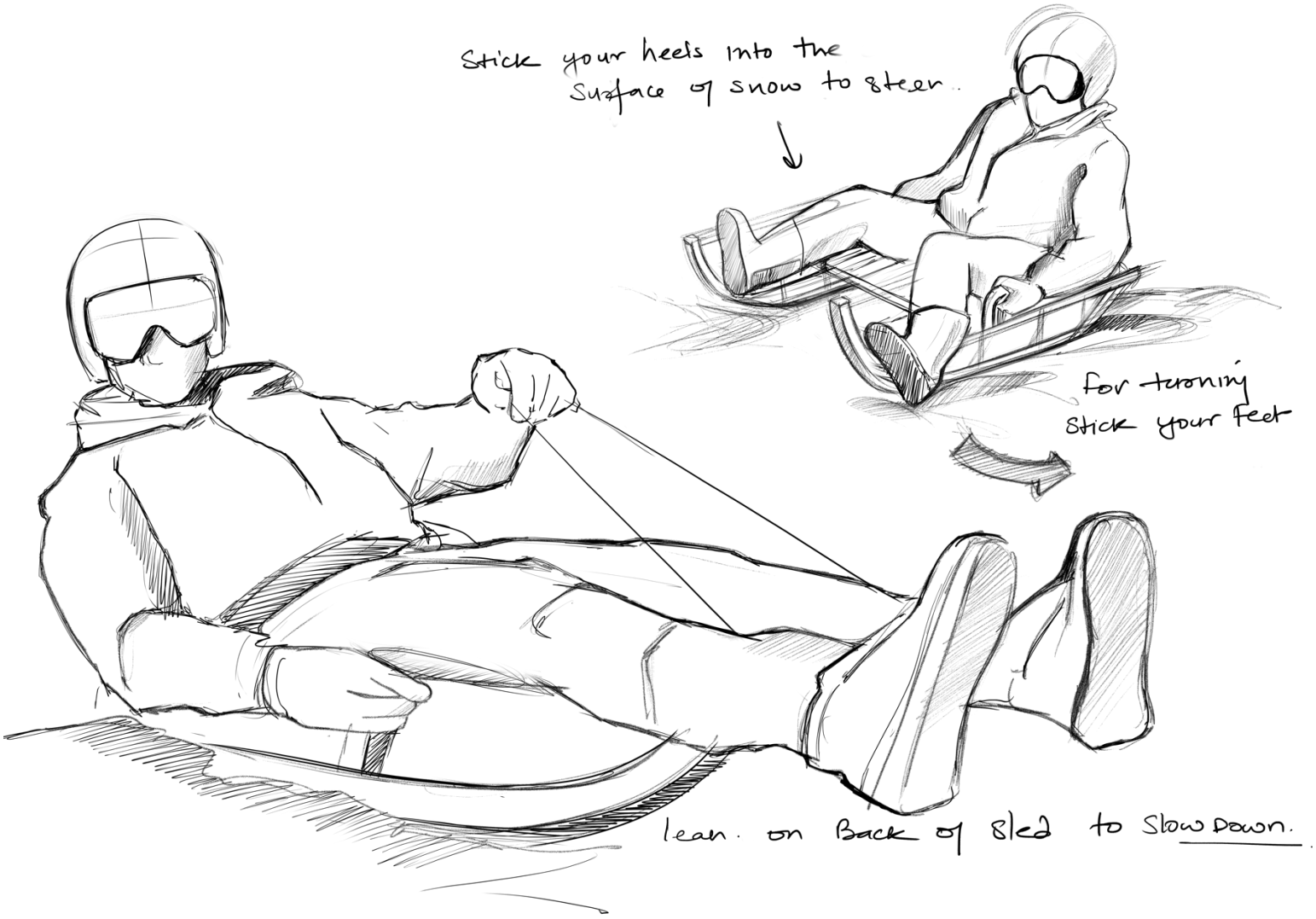
2.8.4 Sledge



A sled, sledge is a fun vehicle used on snow or ice. It slides smoothly because of its smooth bottom or separate body supported by long runners, like skis. This reduces friction, making it easier to carry heavy things.



2.8.4Working


Stick your heels into the
Surface of snow to steer.
for turning
Stick your feet
lean on Back of sled to slow down.

Pros and cons

Pros

1.Fun for all ages: Easy for anyone to enjoy, from kids to adults.
2.Relatively inexpensive compared to other snow activities.
3No prior experience or special skills needed.
4. Large surface area good for stability
5.Best suited for gentle slopes and hills.
6.Multiple people (depending on size)
7.Highly portable (lightweight, easy to transport)
8.Thrilling downhill rides

Cons

1.Difficult to steer or manoeuver easily.
2.Slower than other options
3.Not ideal for covering long distances.
4.Weather dependent: Requires ideal snow conditions
5Limited terrain:
6:Not ideal for those seeking a thrill ride.

Insights

sledge are fun to ride there is no complex mechanism to learn

can be used for all age groups (mostly children's)

because of lightweight it is easy to turn as well as it is highly portable

not very comfortable, can be used for very short distances

Keywords

compact

optimal handling and control

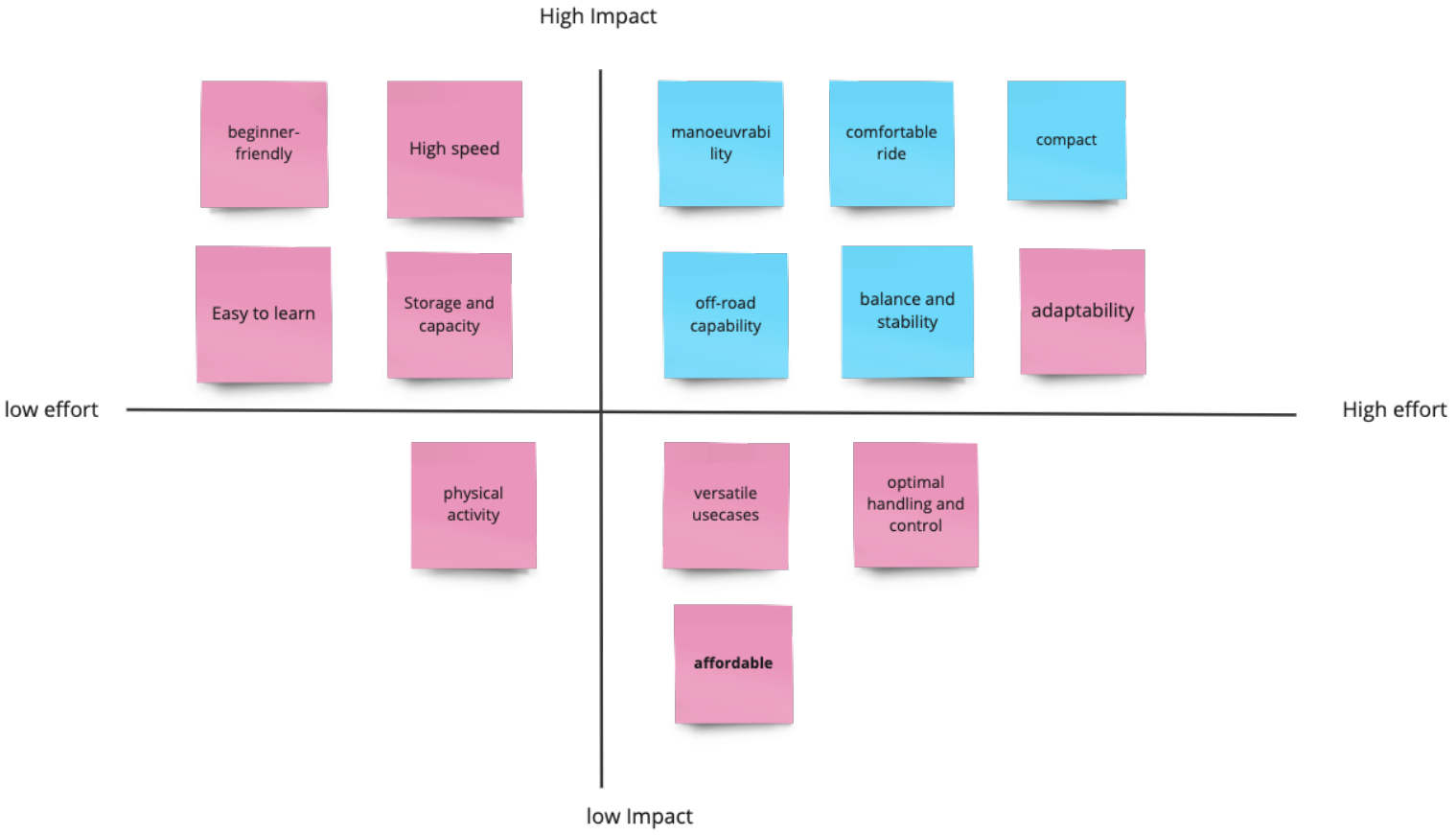
Easy to learn

beginner-friendly

affordable

2.9 Impact Vs Effort graph

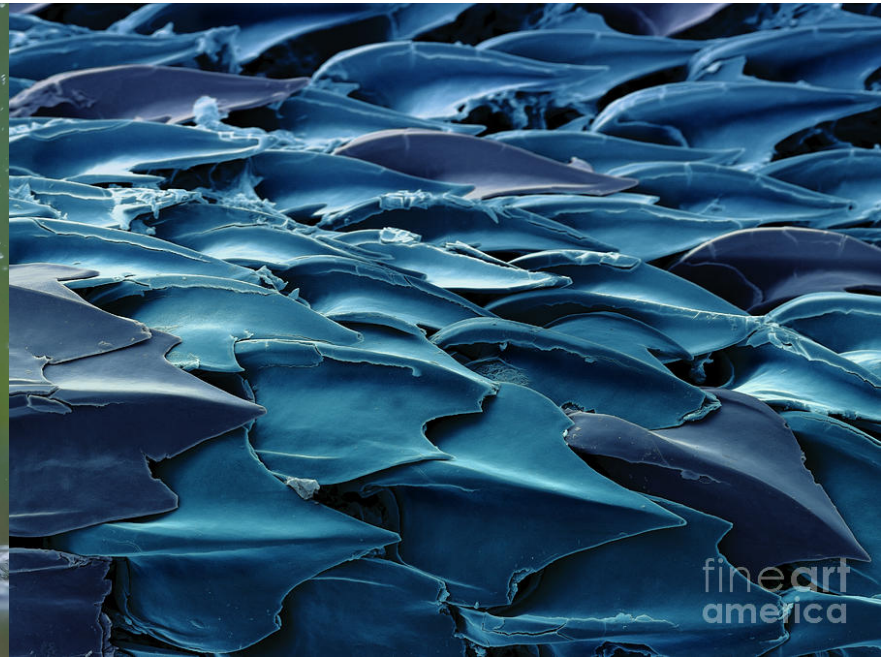
In the realm of design, an "impact vs effort" graph is a visual representation used to evaluate and prioritize design decisions based on the potential impact they will have versus the amount of effort required to implement them. Here's how it works



Biomimicry

3.1 Why Take Inspiration from Nature in Design?





Nature, through millions of years of evolution, has developed solutions that are incredibly efficient, sustainable, and innovative. By studying and emulating natural designs, we can create products and systems that are better adapted to our needs and the environment. Here are key reasons to take inspiration from nature in design:

Efficiency and Adaptation: Nature's designs are optimized for efficiency and adaptability. For example shark skin has inspired surface textures in the automotive industry that reduce drag and improve fuel efficiency. The tiny, tooth-like structures called denticles on shark skin minimize resistance, which has been applied to car surfaces for better aerodynamic performance.

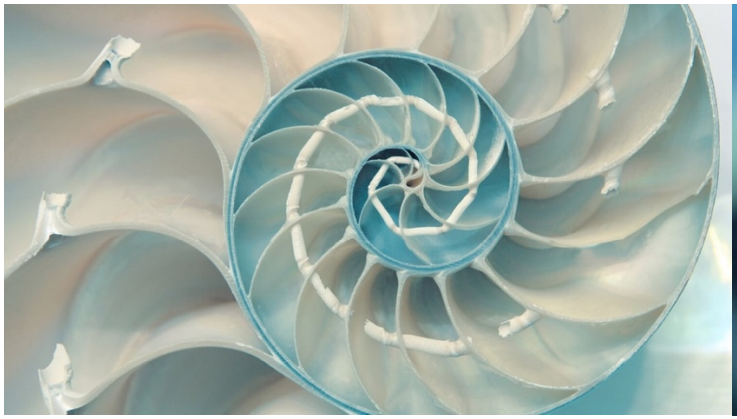
Sustainability: Natural systems are inherently sustainable, using resources judiciously and minimizing waste. By mimicking these systems, we can develop sustainable solutions that reduce environmental impact. Trees, for instance, are masters of resource management, using sunlight,

water, and nutrients efficiently. By studying natural resource management in trees, we can create more efficient water and nutrient distribution systems in urban landscapes, reducing waste and enhancing sustainability.

Innovation: Nature inspires innovative solutions to complex problems. Many modern inventions have been inspired by natural phenomena. Velcro, for instance, was invented after studying how burrs stick to animal fur. This principle of biomimicry leads to creative and practical design innovations. The streamlined shape of the kingfisher's beak influenced the design of the Shinkansen bullet train in Japan. This adaptation reduced air resistance and noise while increasing speed and energy efficiency, solving engineering challenges with nature-inspired innovation.

Functionality and Aesthetics: Natural forms combine functionality with aesthetics. Designs inspired by nature not only work well but also have an inherent beauty. Bird wings, for instance, are both efficient for flight and elegantly shaped, providing inspiration for aerodynamic and attractive designs.

Resilience and Versatility: Nature's designs are resilient, capable of withstanding diverse and changing environments. For example, cacti have adapted to thrive in arid conditions by developing water-storing capabilities and protective features. Learning from such resilience can lead to robust and versatile design solutions.





3.2 Why Study Locomotion in Nature for Design Solutions?

Studying locomotion in nature provides invaluable insights for designing efficient, sustainable, and innovative products. Nature has perfected various modes of movement through millions of years of evolution, and understanding these mechanisms can inspire ground-breaking advancements in technology and design. Here are key reasons to study locomotion in nature:

Efficiency: over millions of years, evolution has honed creatures' movement for their environments. Animals like Sidewinder Snake have become incredibly efficient at moving through sand, using minimal energy..

Manoeuvrability: Nature provides a vast array of movement solutions. From the agility of a mountain goat to the swimming prowess of a dolphin, animals can handle complex terrain and obstacles with ease.

Adaptability: Many creatures can adjust their locomotion based on conditions. Penguins, for example, switch between swimming, sliding, and waddling depending on the terrain.

Innovation and Unique Mechanisms: Nature employs unique and sophisticated mechanisms for movement, such as the flapping of bird wings or the undulating motion of snakes. These can inspire novel engineering solutions.





3.3 Types of Locomotion

Nature exhibits a variety of locomotion strategies that animals use to navigate snowy environments. Here are some of the most common types:

1. Sliding: Penguins use their bellies to slide across the snow, a behaviour known as tobogganing. This allows them to travel faster and with less effort compared to walking.

2. Walking and Running: Moving one foot in front of the other, often with specialized adaptations to prevent sinking into the snow, Arctic Wolves: These animals have long legs and large paws that help them walk and run on snow without sinking too deeply.

3. Hopping and Bounding: Description: Moving in leaps or bounds to cover uneven or soft snowy surfaces, Snowshoe hares use their large hind legs to hop across the snow, which allows them to move quickly and avoid predators.

4. Digging and Tunnelling: Creating pathways or tunnels through the snow to move and find food, Arctic Foxes: These foxes dig through the snow to hunt for lemmings and other small animals hidden beneath.

5. Climbing and Scaling: Moving vertically on snowy or icy surfaces, Mountain Goats are Adapted for climbing steep, snowy slopes with their specialized hooves that provide grip and stability. Snow Leopards: These big cats are skilled climbers and can navigate rocky, snowy terrain with ease.

6. Rolling: Description: Using body momentum to roll over snow, often for play or to remove parasites. For example Polar Bears: Polar bears are known to roll in the snow, which can help to clean their fur and keep them cool.

7. Crawling and Dragging: Moving with the body close to the ground, often dragging oneself through the snow. On land, seals often drag their bodies across the snow to reach the water. Their blubber and streamlined shape aid in this movement.



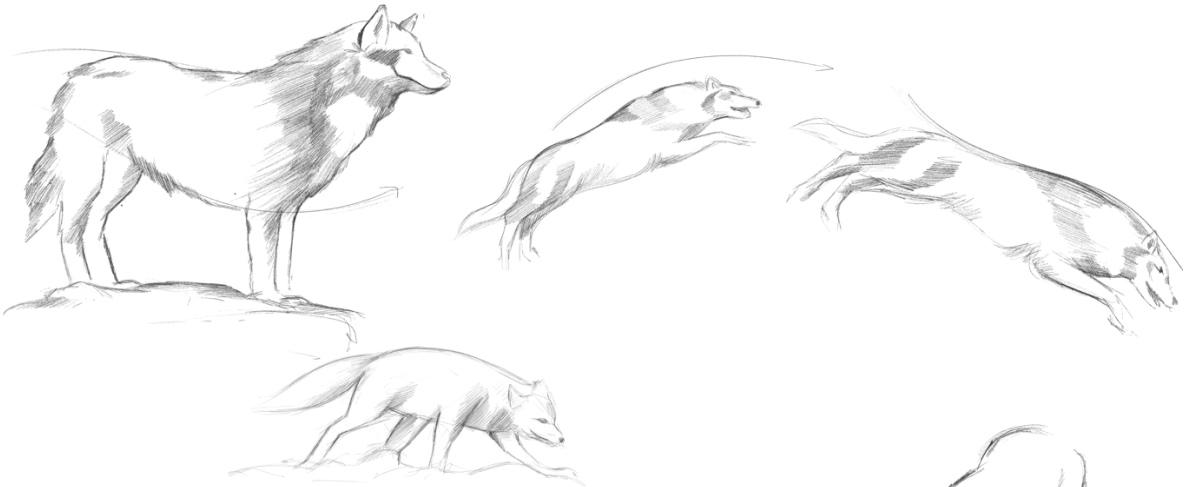




3.4 Artic Fox



Arctic foxes is known as masters of the snowy plains, sport broad paws that act like natural snowshoes, allowing them to glide effortlessly across the wintery landscape. The can easily balances themselves in air as well. and they land aggressively. Their body is covered with hair which protects them from cold and few cm thick fat under their skin.



The balance their body in air before landing

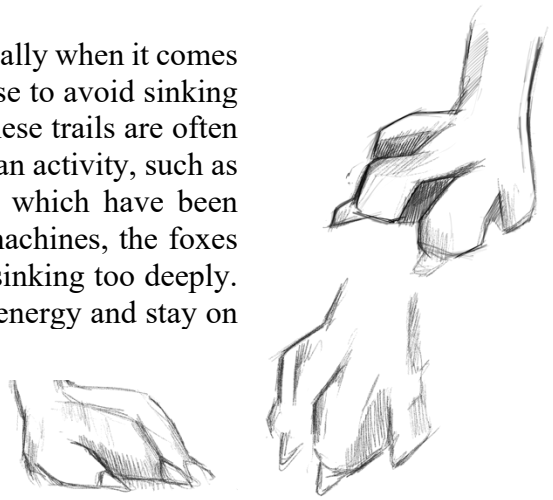


Arctic foxes often use a hopping gait. This minimizes the time each paw spends in contact with the snow, reducing wasted energy from sinking and pulling out. They take a series of small jumps propelling them forward with minimal effort.

3.4.1 Artic fox feet study

Arctic foxes are incredibly clever animals, especially when it comes to navigating their snowy environments. They use to avoid sinking into deep snow is to follow established trails. These trails are often created by larger animals like caribou or by human activity, such as snowmobile tracks. By sticking to these trails, which have been packed down by the weight of the animals or machines, the foxes can move more easily across the snow without sinking too deeply. It's a smart adaptation that helps them conserve energy and stay on the move in their harsh Arctic habitats.





Even distribution of weight





Individual toes can be squeezed together and lean on one another as sideways force is applied



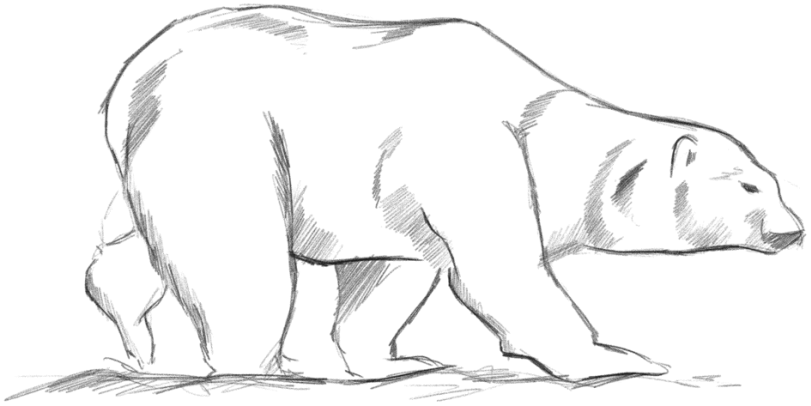
Wolves have webbed feet



toes are individual so they can be flexible on there own

3.5 Polar Bear

Polar bears roam the Arctic ice sheets and swim in that region's coastal waters. They are very strong swimmers, and their large front paws, which they use to paddle, are slightly webbed. Some polar bears have been seen swimming hundreds of miles from land—though they probably cover most of that distance by floating on sheets of ice.



Polar bear have huge feet which act as snow shoes, distributing their weights evenly on ice

Large paws for large surface area

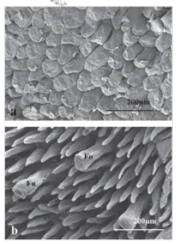






Papillae





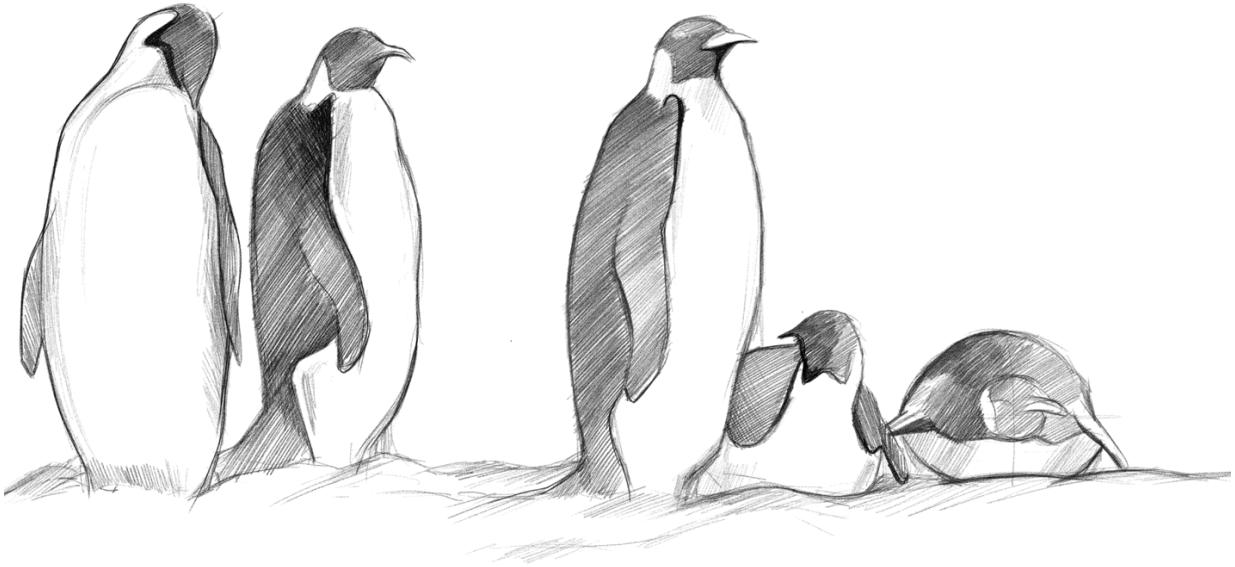
Small pads at the bottom is known as Papillae, it is used to grip on ice and prevent them from slipping

3.6 Penguins



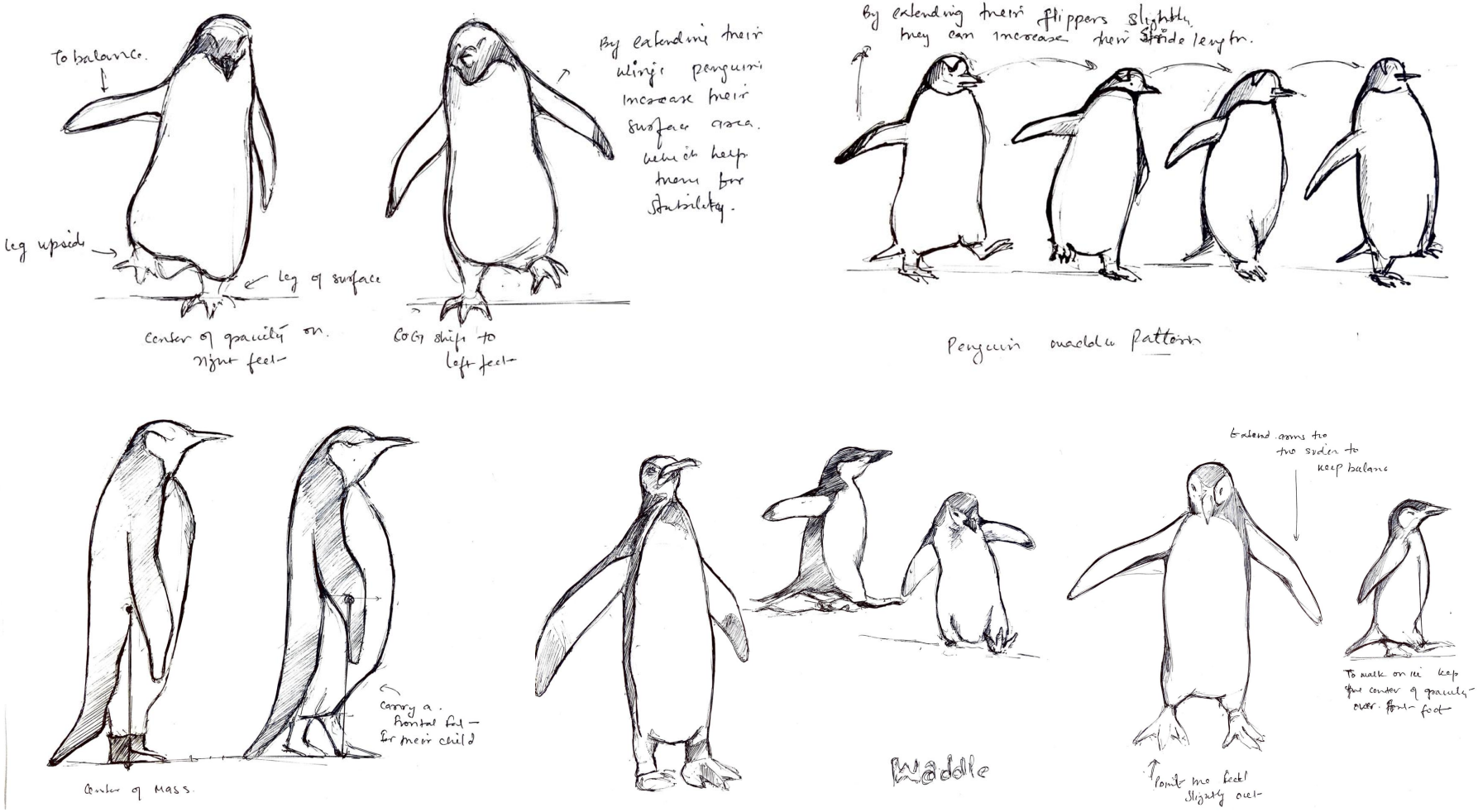
Penguins are special birds that can't fly and love swimming in the ocean. They mostly live in the southern part of the world, except for one type found near the Equator called the Galápagos penguin. Penguins are great swimmers because they have dark and white feathers that help them hide from predators, and their wings are like flippers for gliding through the water.

Penguins have a unique way of getting around: they can't fly, but they're expert swimmers, using their wings to glide gracefully through the water. On land, their waddle might seem clumsy, but it's actually quite efficient for covering short distances. And here's the fun part - some penguin species enjoy sliding on their bellies across ice and snow, almost like they're having their own winter fun!



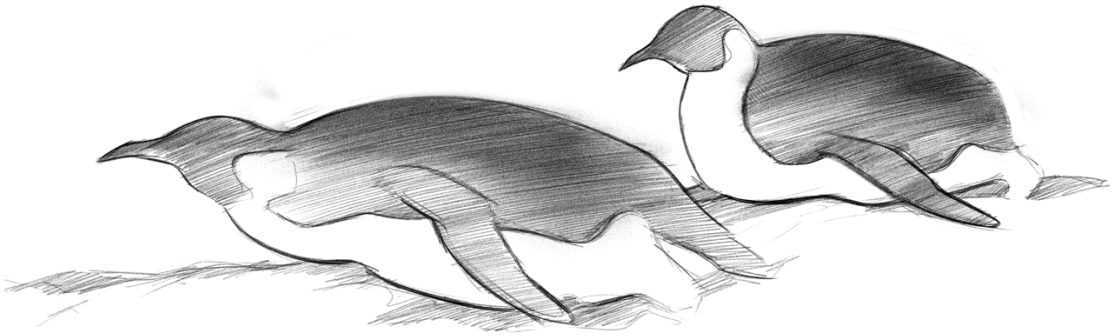
3.6.1 Penguin locomotion study

On land, penguins have a funny walk called waddling. Their bodies are built for swimming, not walking, so they waddle from side to side as they move. It might not be the most graceful walk, but it gets them where they need to go on land, like to their nesting areas or to find food.

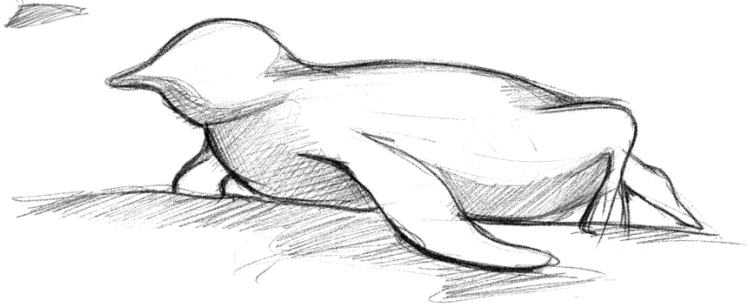


3.6.2 Tobogganing locomotion

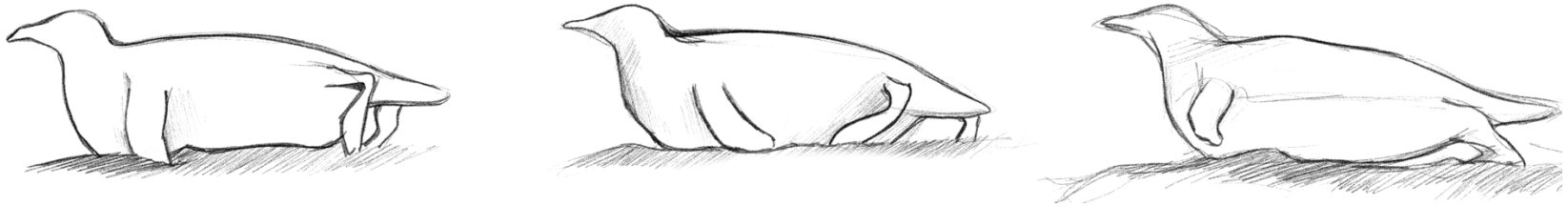
penguins are known for sliding on their bellies across the ice or snow. This fun and speedy way of getting around helps them conserve energy and move quickly across the slippery surface. It's also a playful way for penguin chicks to have fun and learn important skills for survival.



Penguin going quad pedal movement

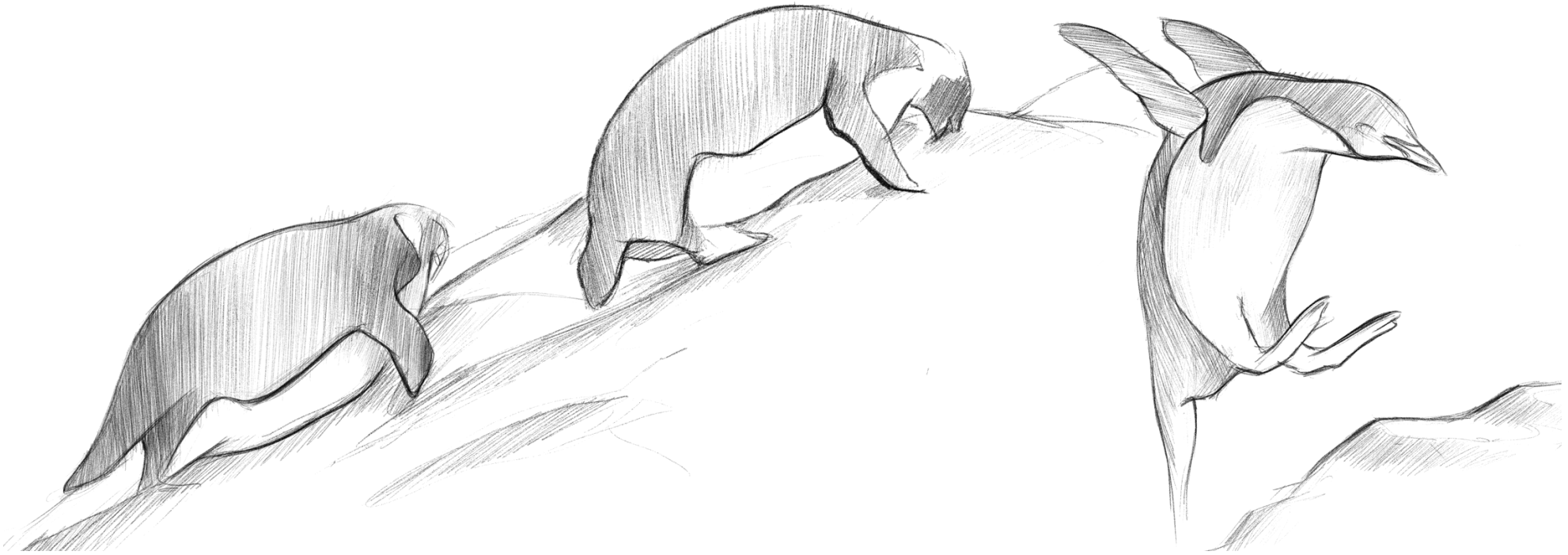


emperor penguin tobogganing on hard snow in the first, it pushes back with its left flipper and bends its left leg; in the second, the flipper finishes pushing, and the leg stretches out; in the last, the flipper moves forward as the leg finishes pushing back.



Rhythmic and playful movement

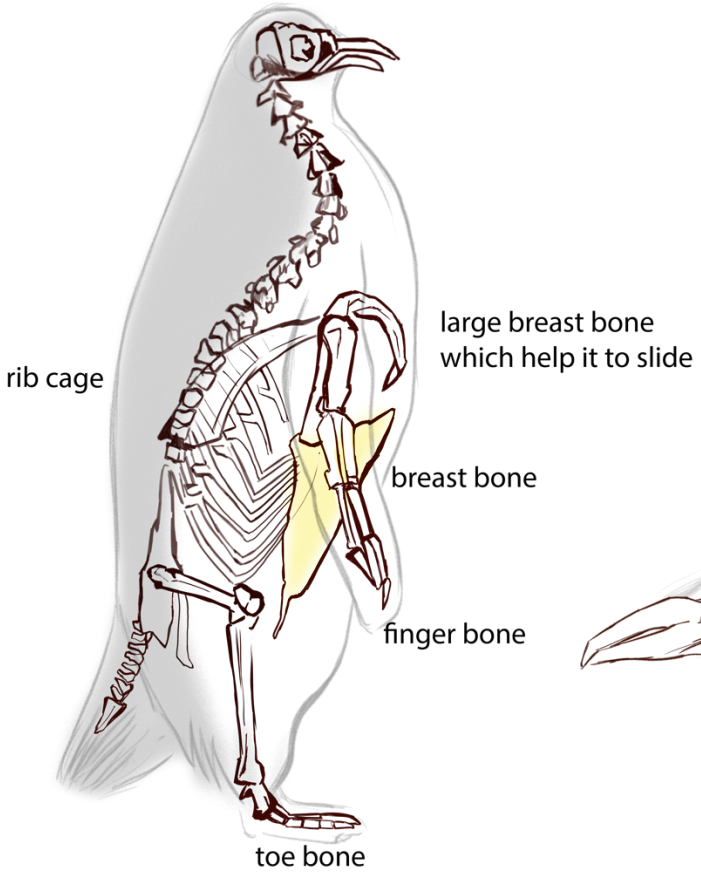
Penguins can navigate steep and rocky terrain by using a combination of their flippers and bellies. They may use their flippers for balance and support, extending them out to help stabilize themselves as they climb. Additionally, penguins are known for their ability to "belly slide" or scoot along on their bellies, which allows them to move smoothly over uneven surfaces. By using their flippers to propel themselves forward and their bellies to glide over rocks and obstacles, penguins can navigate steep and rocky terrain with surprising agility and efficiency



Penguins perform small jumps or hops, particularly when navigating obstacles or during playful interactions. However, these jumps are typically not very high or prolonged Instead, their strength lies in their remarkable swimming skills and their ability to propel themselves efficiently through the water using their flipper-like wings and webbed feet.

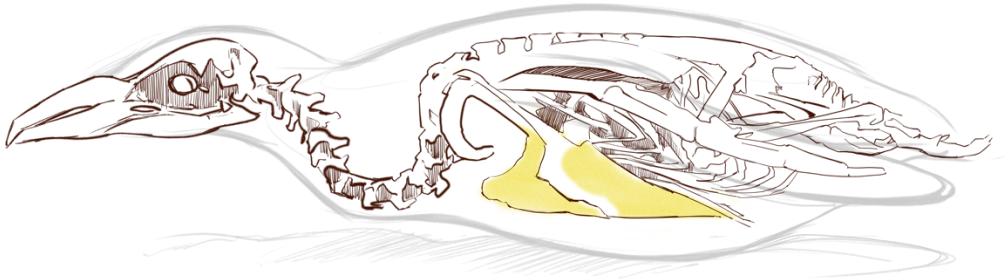
3.6.3 What makes Penguins special?

Penguins are uniquely adapted to sliding across ice and snow with the help of their body structure. Their streamlined bodies and flat, paddle-like flippers reduce resistance, allowing them to move smoothly over slick surfaces. Additionally, their flexible spines and lightweight bones enable them to bend and manoeuvre easily while sliding, providing both stability and agility. By using their body skeleton in tandem with their muscles, penguins can execute precise movements and control their speed while sliding, making it an efficient and enjoyable mode of transportation in their icy habitats.

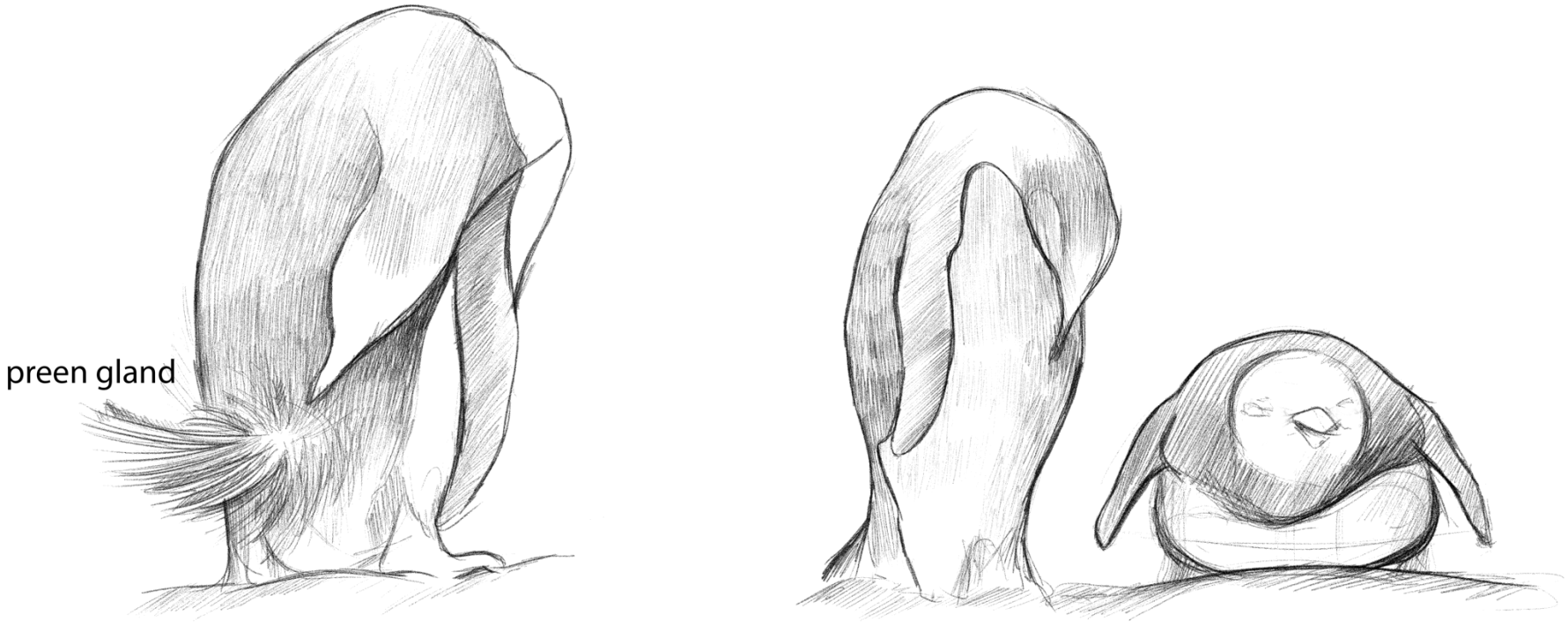


Penguins have a sturdy rib cage structure that protects their vital organs while sliding. This robust framework helps absorb impact and provides structural integrity, allowing penguins to slide confidently without fear of injury

The breastbone, or sternum, plays a crucial role in sliding for penguins. It serves as an anchor point for the powerful muscles that control the movement of their flippers and facilitate sliding across icy surfaces. Additionally, the breastbone provides structural support and stability to the penguin's body during sliding, helping to distribute the forces generated by pushing off and gliding



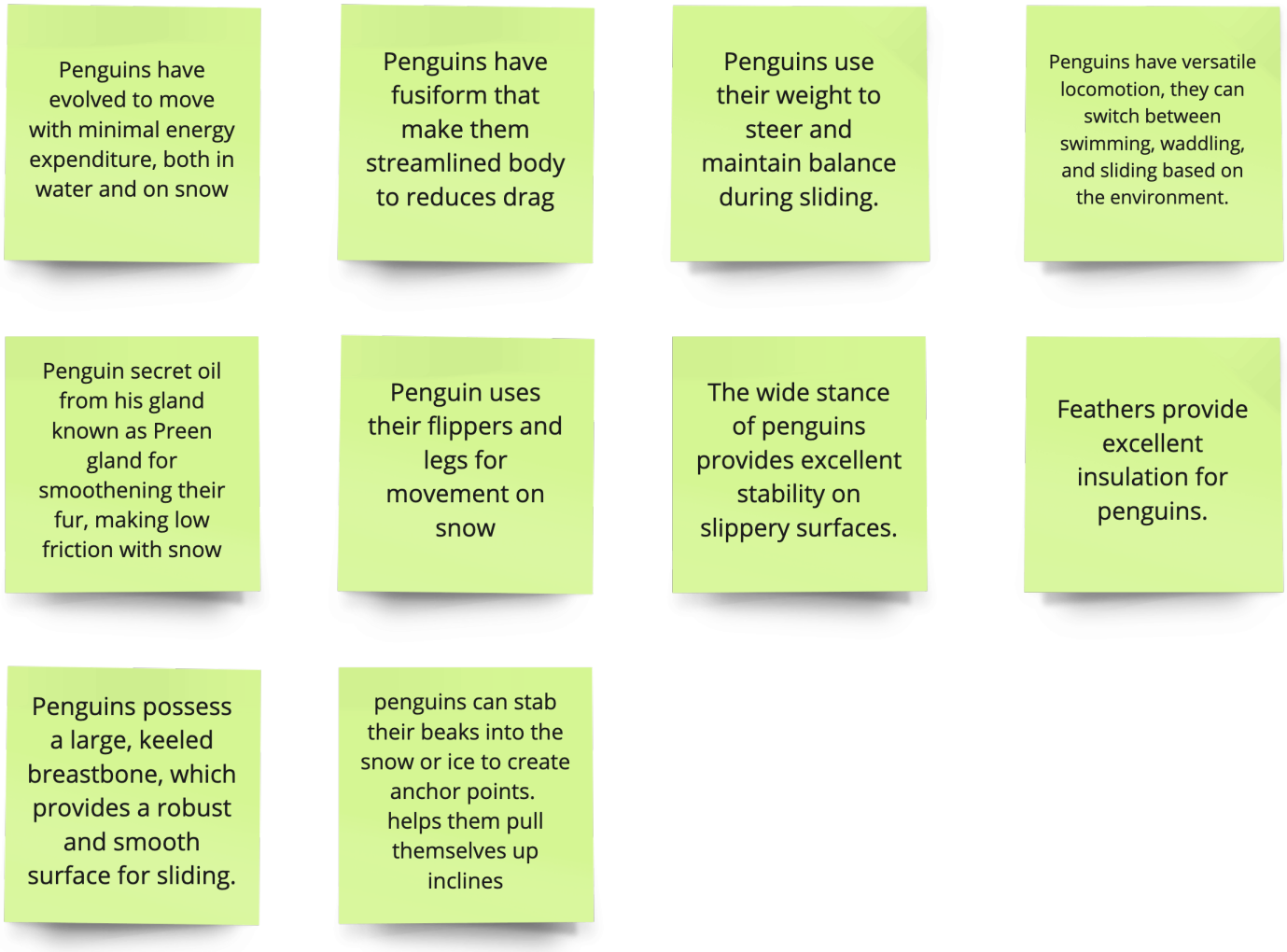
A fun fact about penguins is that they have a special gland located near the base of their tail called the preen gland, also known as the uropygial gland. This gland produces an oil that penguins use to coat their feathers. This oil serves multiple purposes, one of which is to generate a low friction surface on their feathers. When penguins slide on their bellies, this oil reduces friction with the ice or snow, allowing them to glide more smoothly and efficiently. It's like having their own built-in lubrication system for sliding!



The penguin used to oil its feather with the help of its beak to generate low friction during sliding.

3.6.4 Insights

In my research, I have gathered several interesting insights from studying penguins



3.7 Why choosing penguins?

These are the main reasons why chosen penguins as inspiration for new vehicle design

Short, Stiff Tail: A compact, wedge-shaped tail enhances stability and control.

Flipper and Feet Control: Using flipper-like mechanisms for speed and direction control improves maneuverability.

Modified Flippers: Incorporate flattened, paddle-like flippers for efficient propulsion and movement.

Adjustable Center of Gravity: Ability to shift center of gravity aids in easy maneuvering on uneven surfaces.

Upright Posture: Design with legs and webbed feet positioned for a stable, upright stance.

Low-Friction : Utilize a fusiform of penguins to reduce friction and enhance sliding efficiency.

Design

4.1 Design Brief

Designing an engaging tourist experience for traversing icy and snowy terrains using biomimicry of penguins. This vehicle should prioritise user comfort, safety, and environmental responsibility while offering a unique and dynamic mode of transportation.

Functional Requirements

Design that mimics the penguin's streamlined body for efficient movement .

Comfortable seating/standing accommodation for both adults and children.

Easy manoeuvrability and control over the vehicle, allowing for a playful and engaging experience.

Biomimicry design inspired by penguin flippers for efficient propulsion on ice and snow.

Options for electric or human-powered propulsion to minimize environmental impact.

Vehicle Dimensions

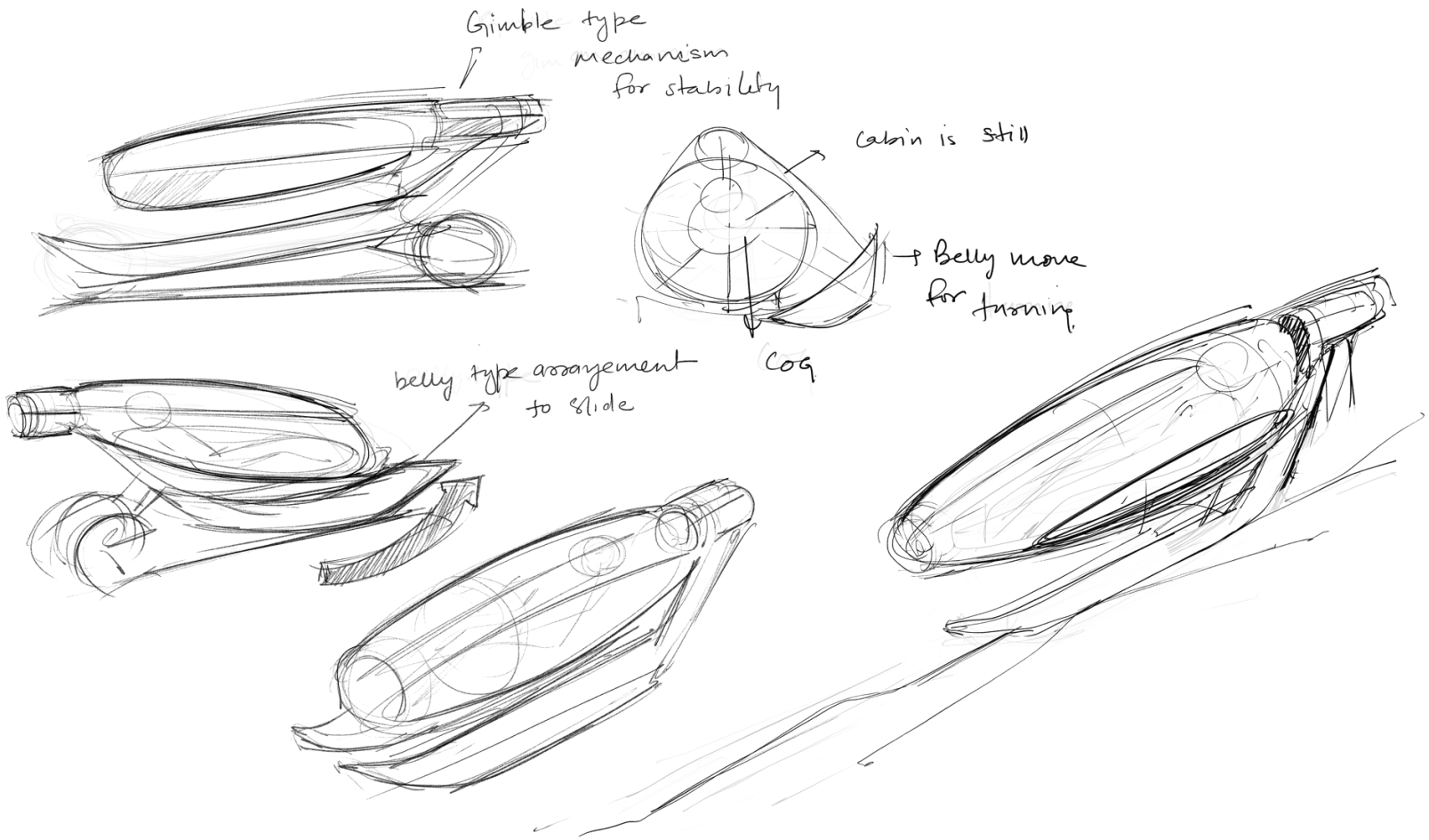
Length: 3188 mm

Width: 1080 mm

Height: 1200 mm

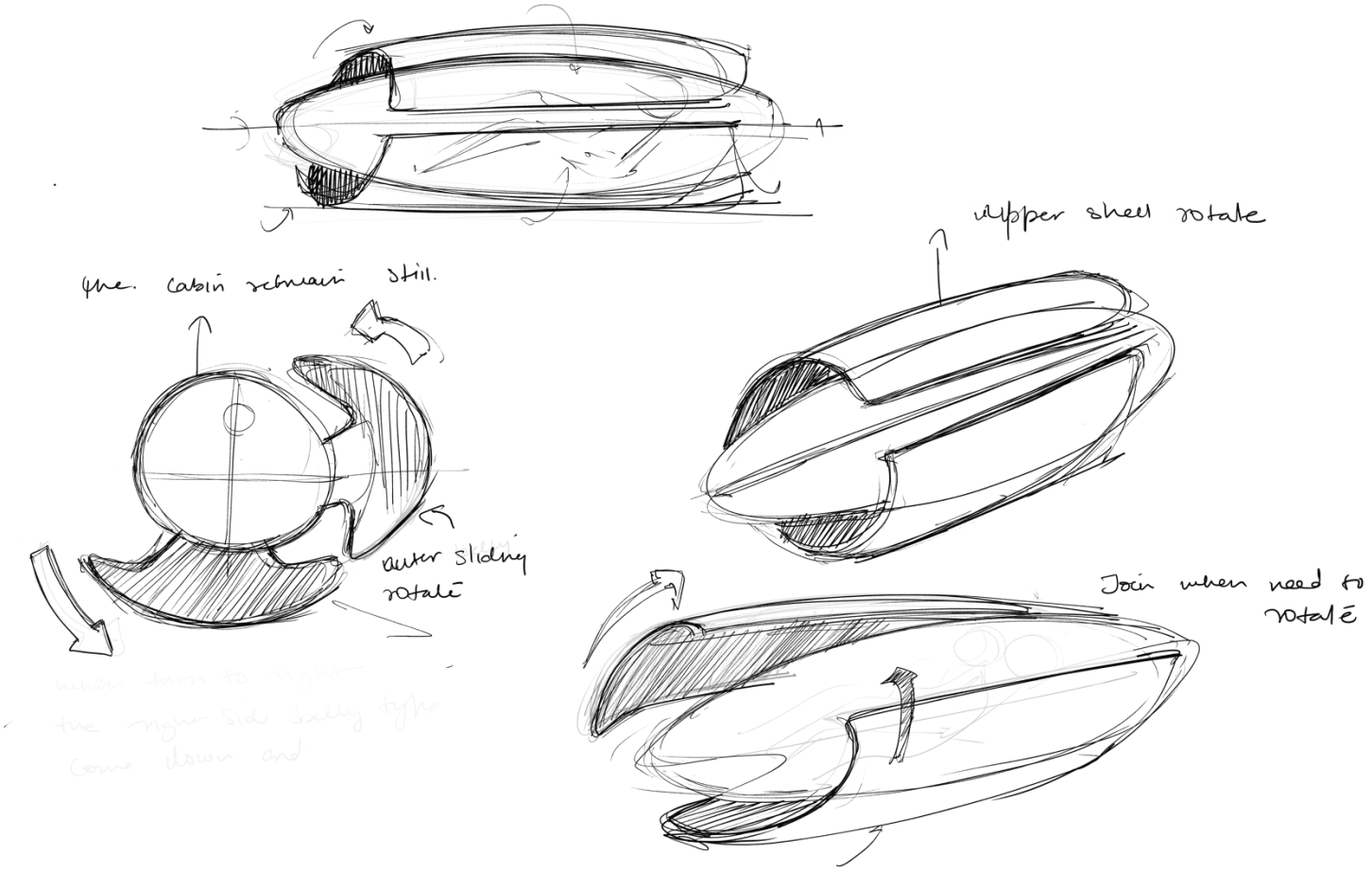
4.2 Concepts 1

In Concept 1, the vehicle incorporates a sliding arrangement reminiscent of penguins' movement, connected to a gimbal mechanism. This setup enables the vehicle to slide smoothly, akin to the motion of penguins, while the gimbal ensures that the driver's cockpit remains stable and properly oriented, regardless of the direction of sliding or turning.



4.3 Concept 2

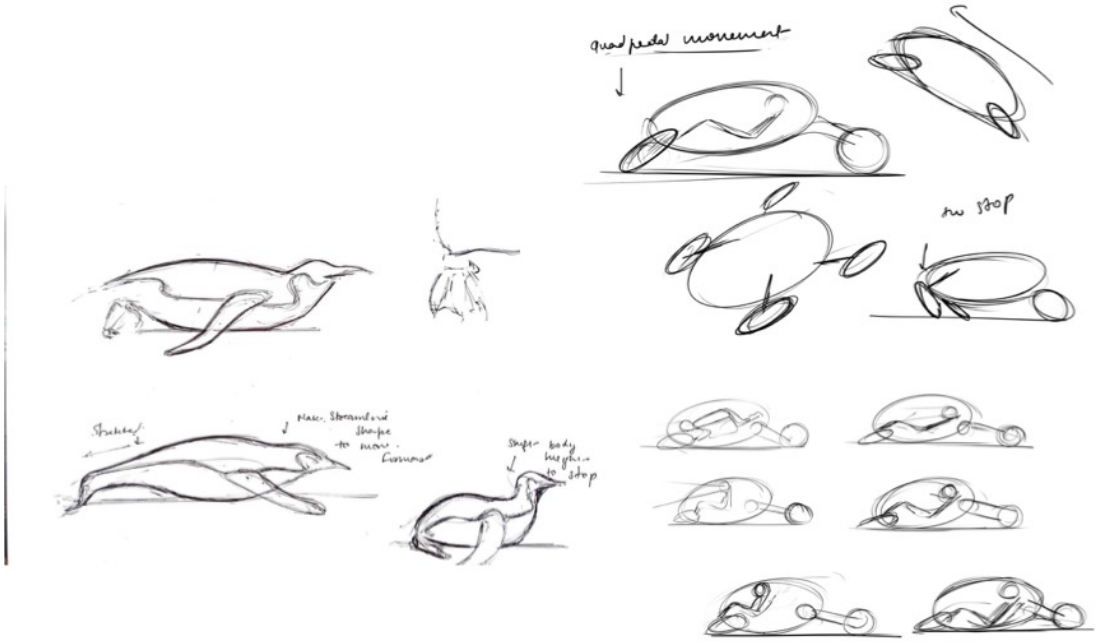
In Concept 2, there's a rider cockpit that remains stationary while an external surface moves or rotates in any desired direction. This external surface serves as a platform for movement, rotating as needed. Additionally, the outer slider expands to provide stability when required.

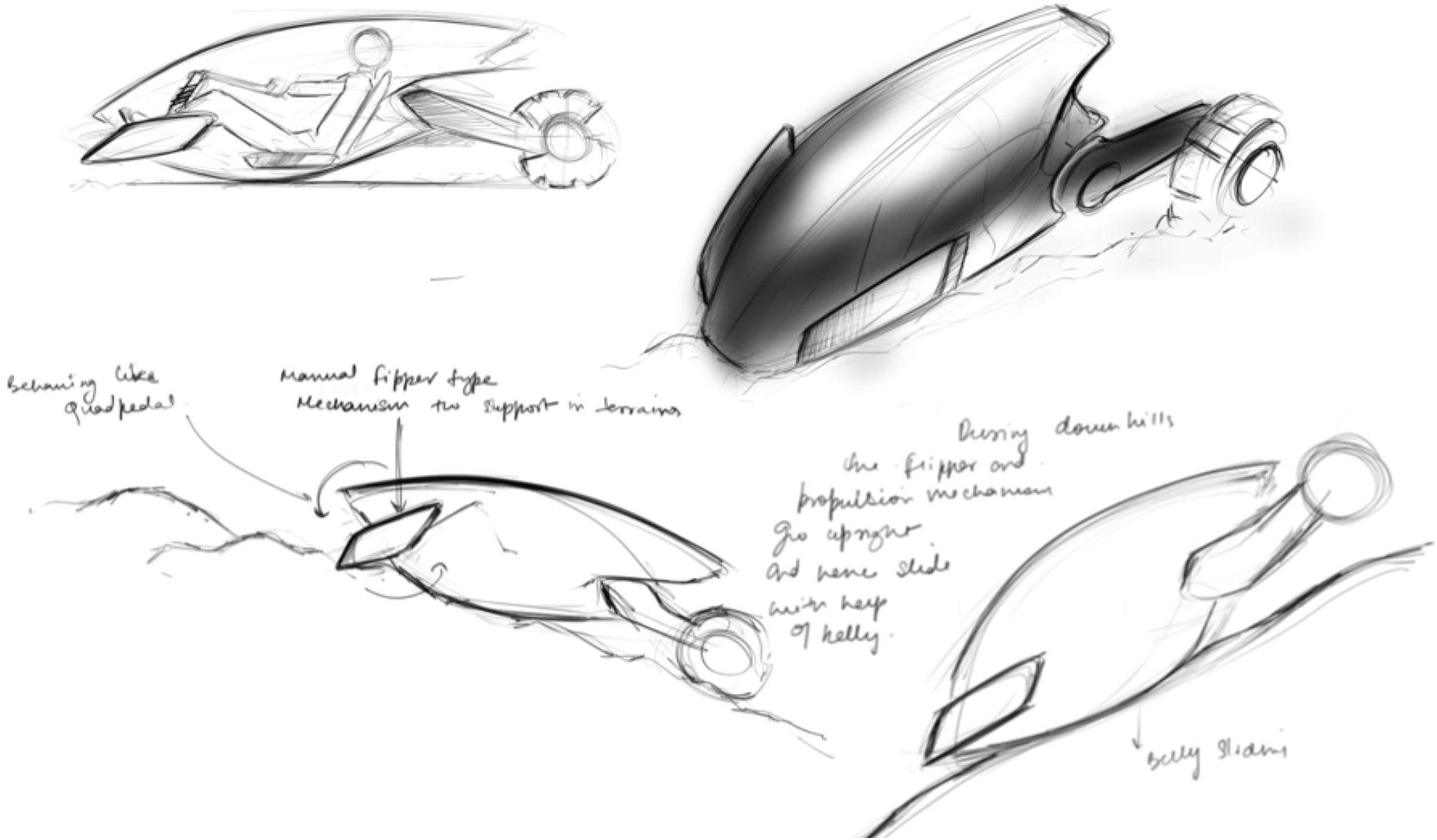


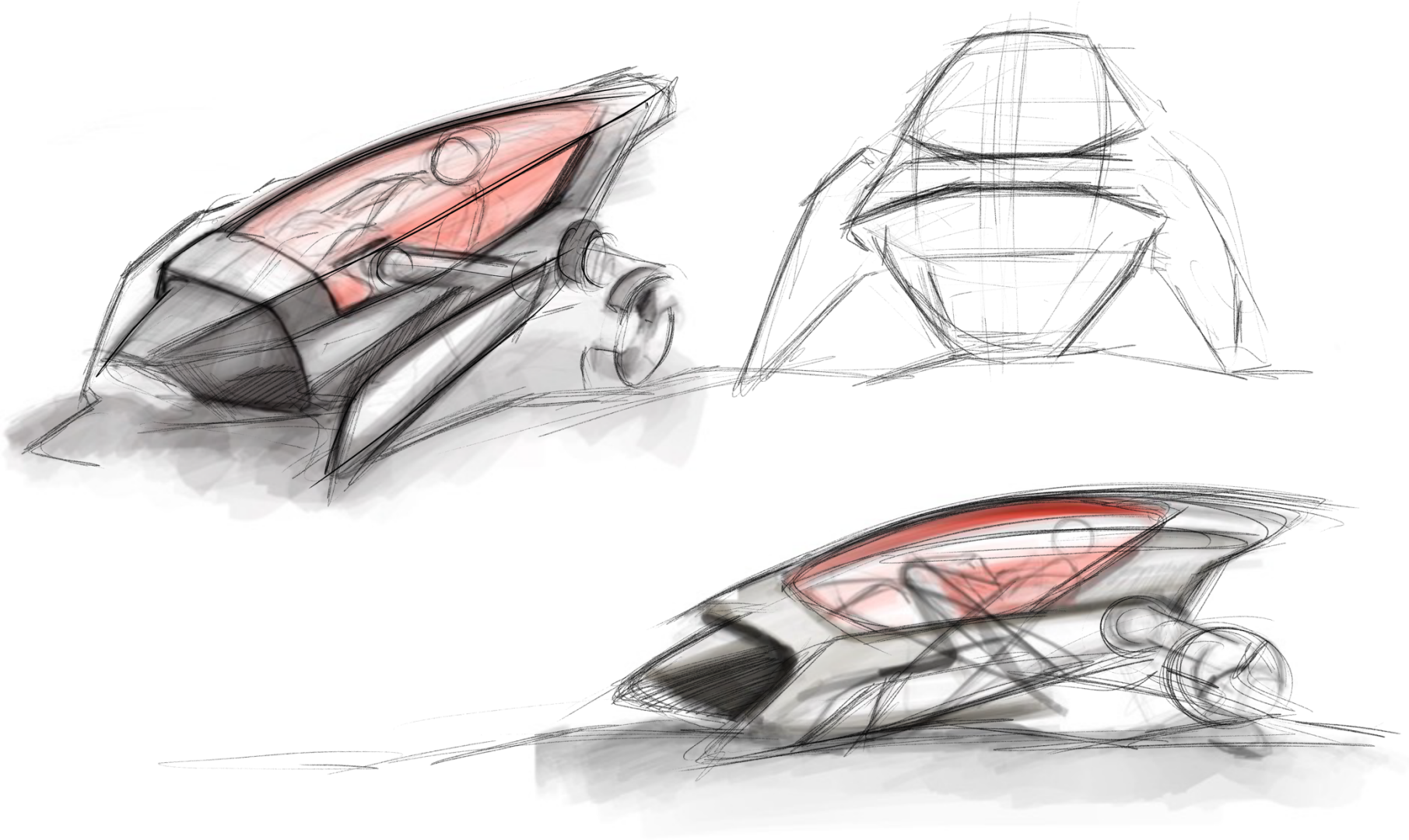
4.3 Concept 3

In Concept 3, the vehicle employs a flipper-type arrangement for propulsion, inspired by the movement of penguins. This setup enables the vehicle to execute a quad-pedal movement akin to that of penguins. Additionally, there's a belly-type arrangement beneath the vehicle, facilitating sliding motion.

To steer the vehicle, the driver tilts it to change the centre of gravity, mimicking the way penguins adjust their posture for directional changes.

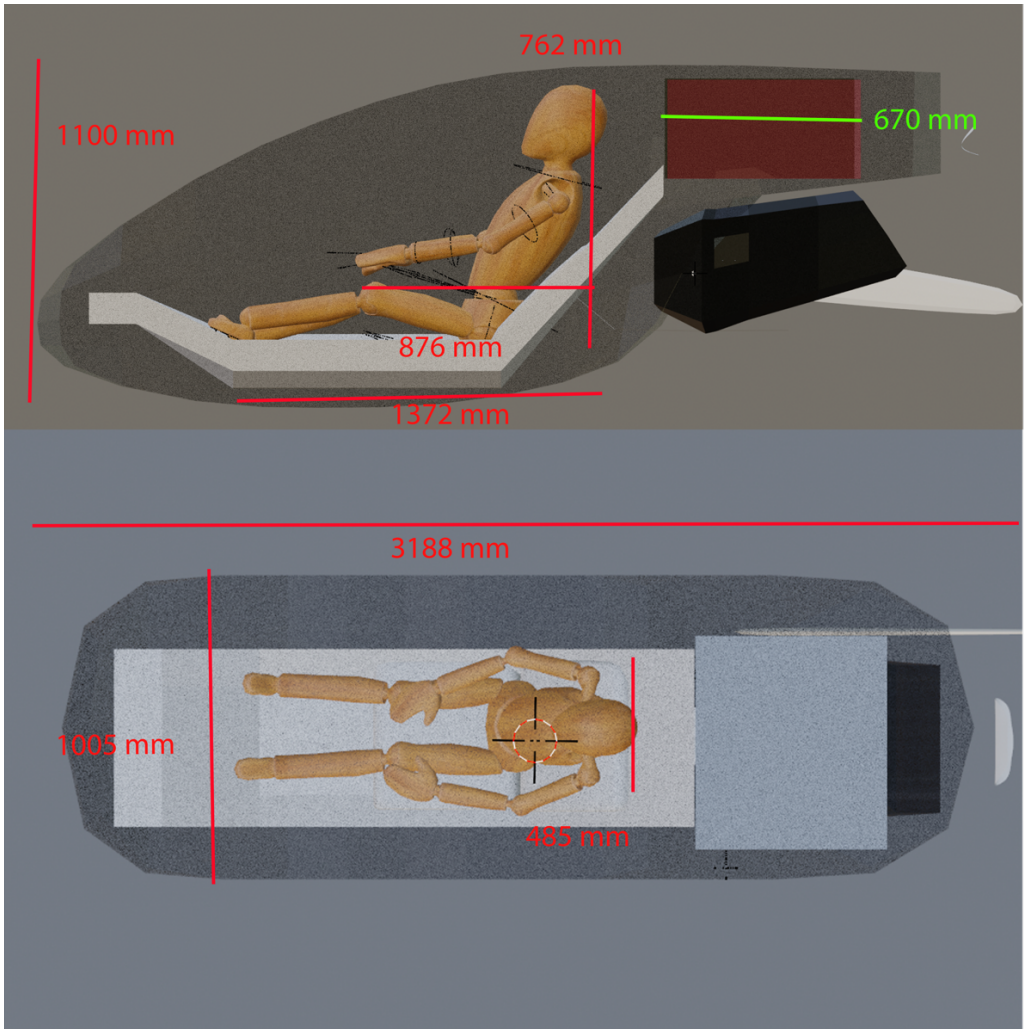



Manual flipper type
Mechanism for support in terrains
During downhills
the flipper and
propulsion mechanism
go upright
and hence slide
with help
of belly.
belly slides



4.4 Occupant Packaging

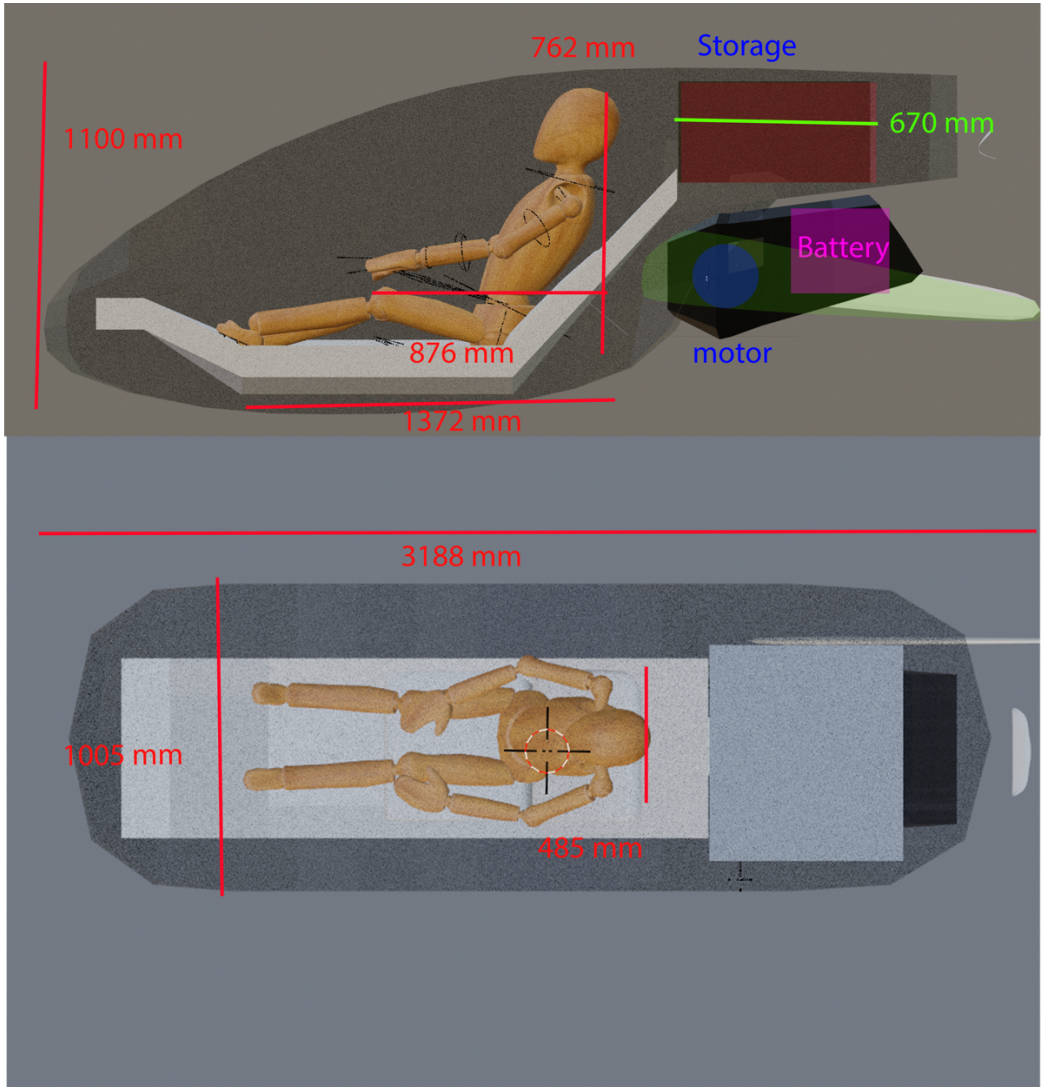
I found inspiration from old snowmobiles, After looking into it more, I came up with a new type of packaging.. The packaging is designed to be more efficient and safe.



Occupant Packaging:

After incorporating the dimensions of the seat for one passenger, which includes a seat base measuring 519mm x 490mm and a seat back measuring 786mm x 490mm, along with a storage compartment measuring 350mm x 690mm, the overall dimensions of the vehicle would be 3188mm x 1005mm x 1100mm.

4.4.1Technical Packaging:

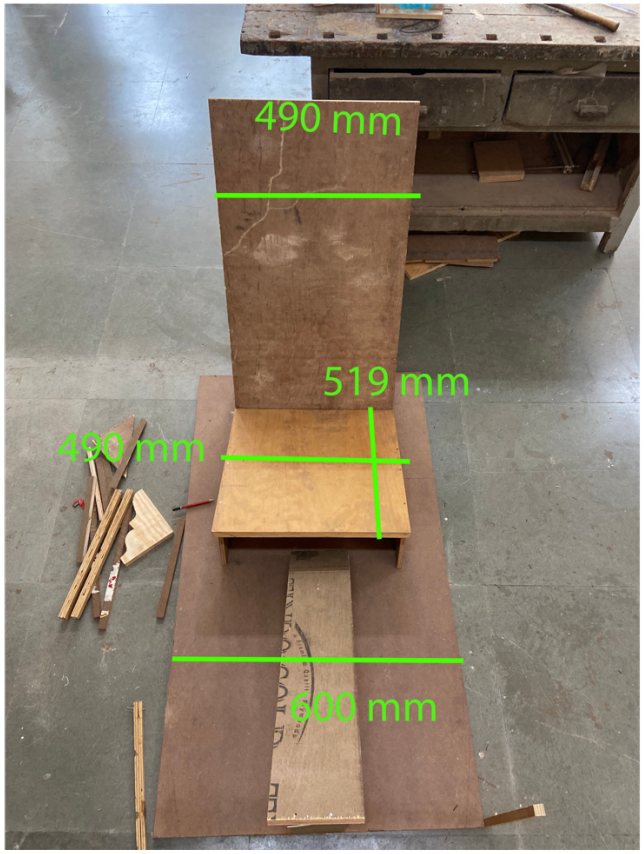


In my technical packaging, there would be a motor responsible for propelling the vehicle forward. It is positioned at the rear of the seat. Adjacent to the motor, there would be a battery. Additionally, there is a storage compartment situated above the mechanical compartment.

4.4.2 Packaging Mock-up

I have developed an actual 1:1 vehicle interior packaging mock up to physically visualize the dimensions of the vehicle. This model also aids in determining the overall ergonomics of the vehicle, including how the rider will enter and exit, as well as other factor

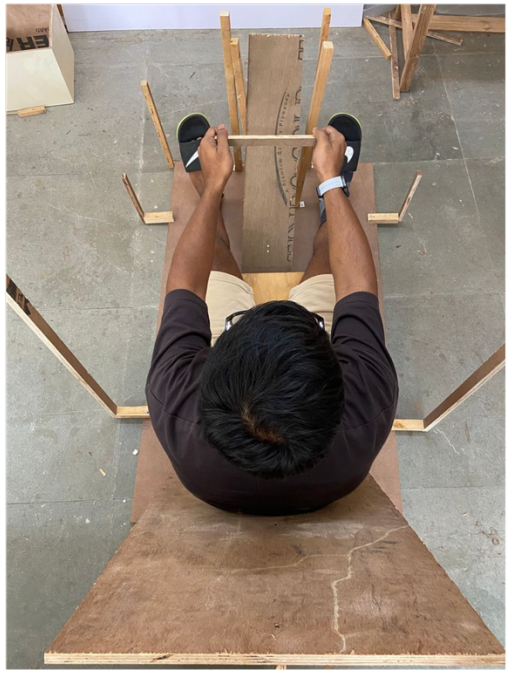




4.4.3 User testing :















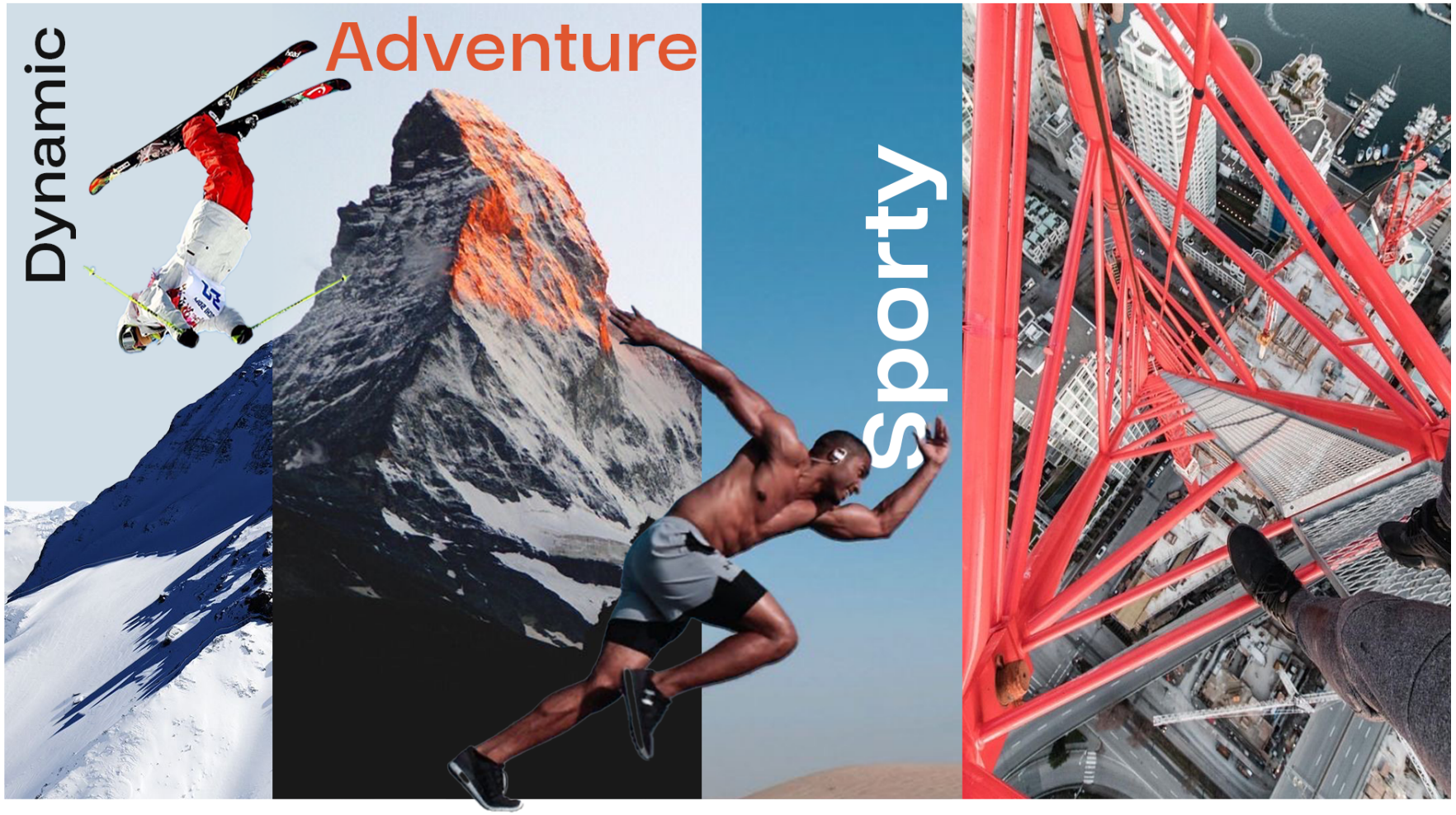








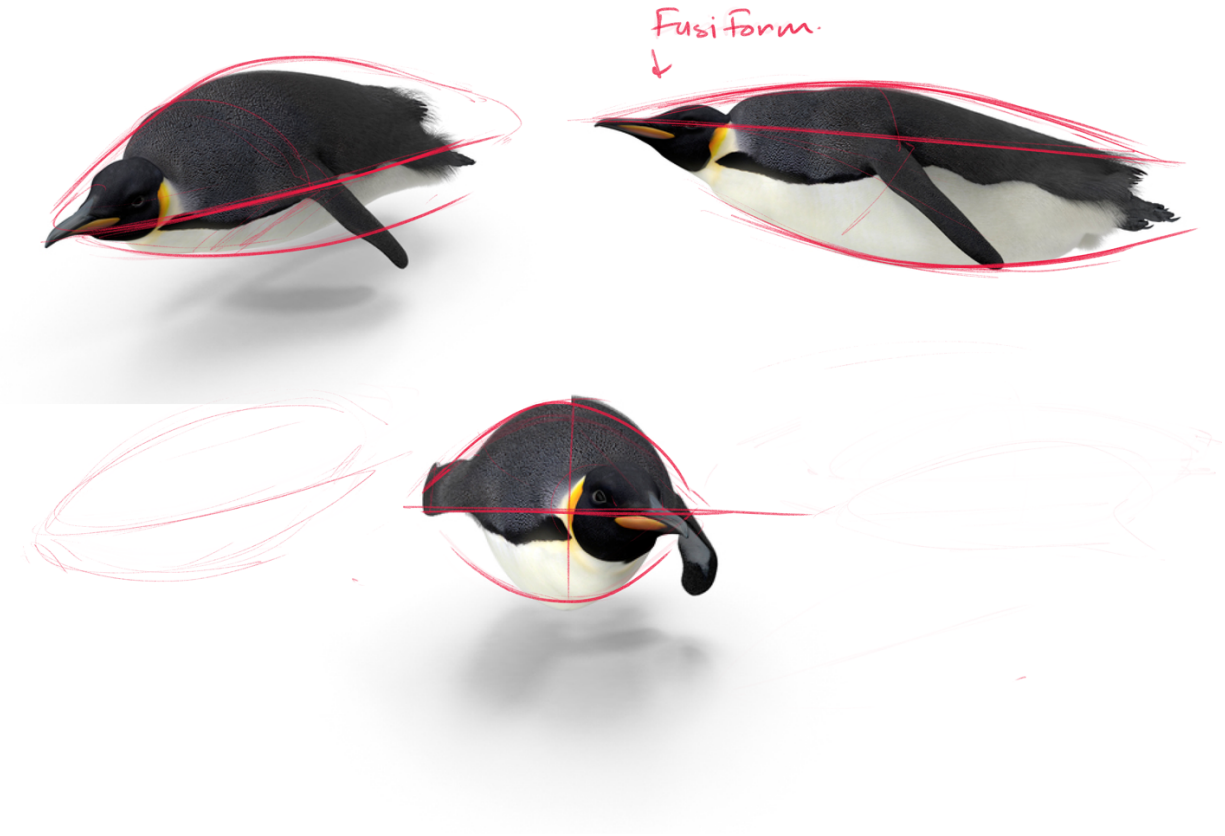
4.5 Mood board



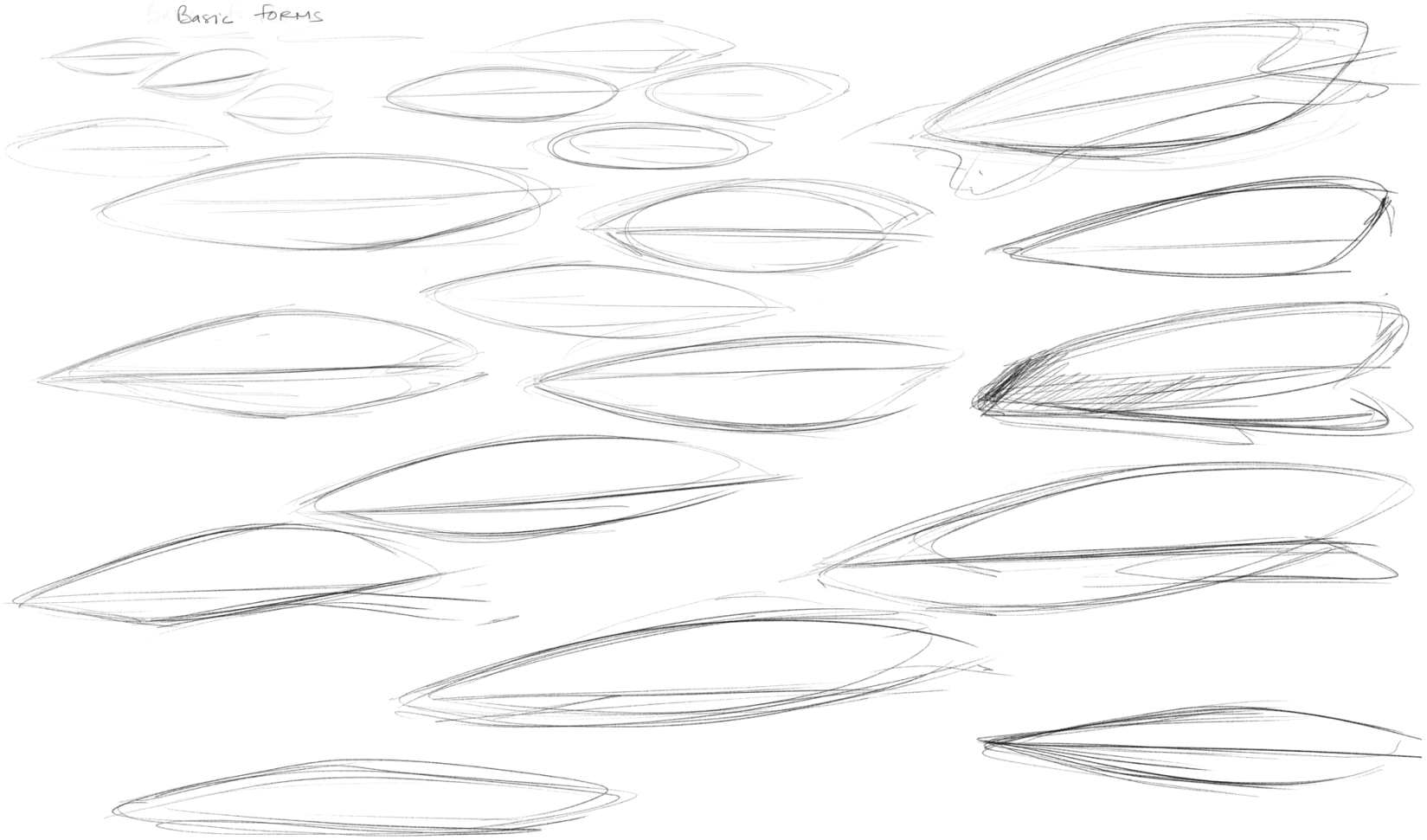
Sporty, Dynamic and Adventure

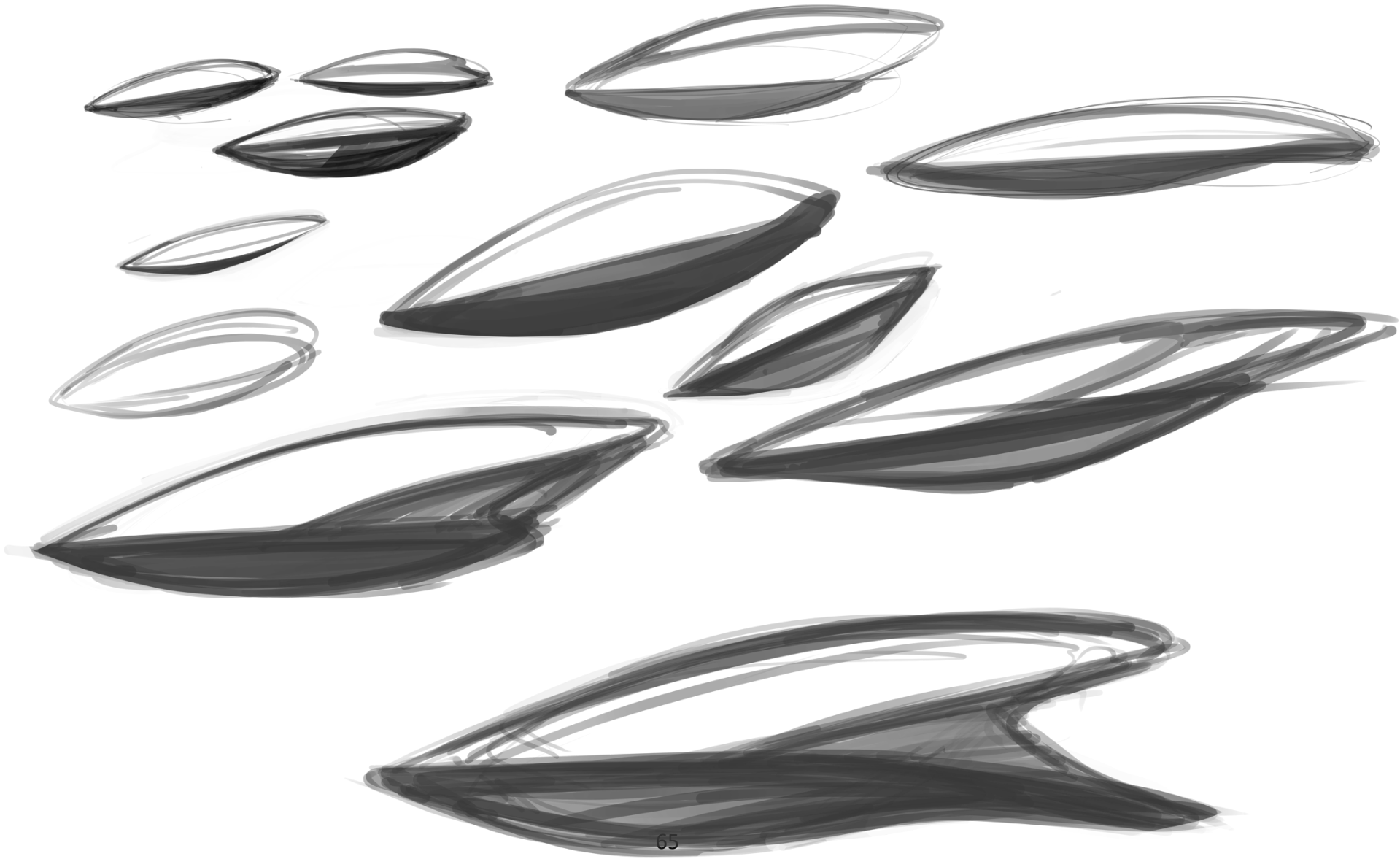
4.6 Forms study

Penguins possess a remarkable fusiform body shape, perfectly adapted for their aquatic lifestyle. This streamlined form is crucial for efficient swimming, enabling them to navigate through water with minimal resistance. Penguin's fusiform body shape is primarily optimized for efficient swimming in water, it also offers advantages when it comes to sliding on snow, ice, or even rocky terrain. The streamlined, torpedo-like shape of penguins reduces air resistance, allowing them to slide effortlessly over snow which minimizes friction, enabling penguins to maintain momentum and glide farther distances with each slide.



4.6.1 Form Development





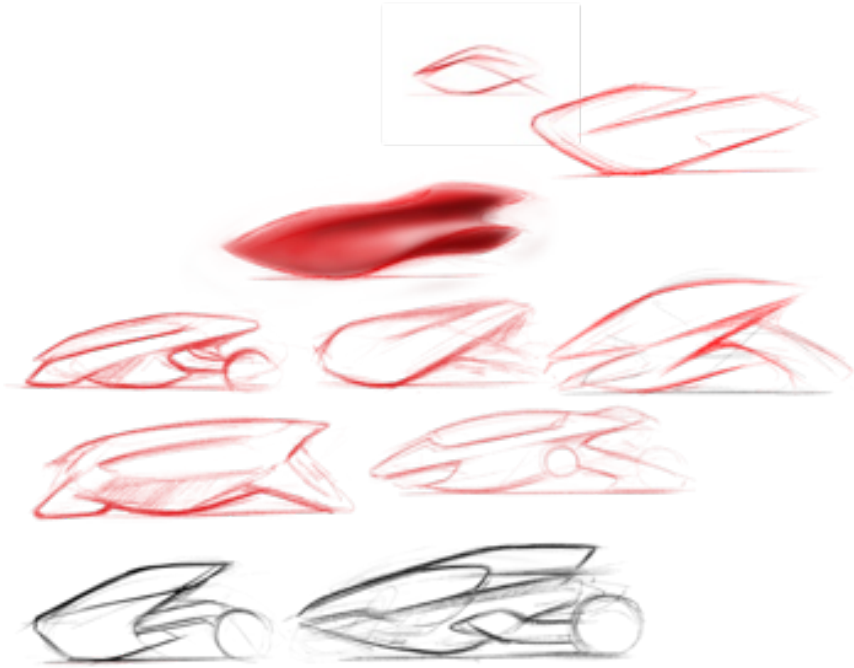
4.6.2 Theme Board









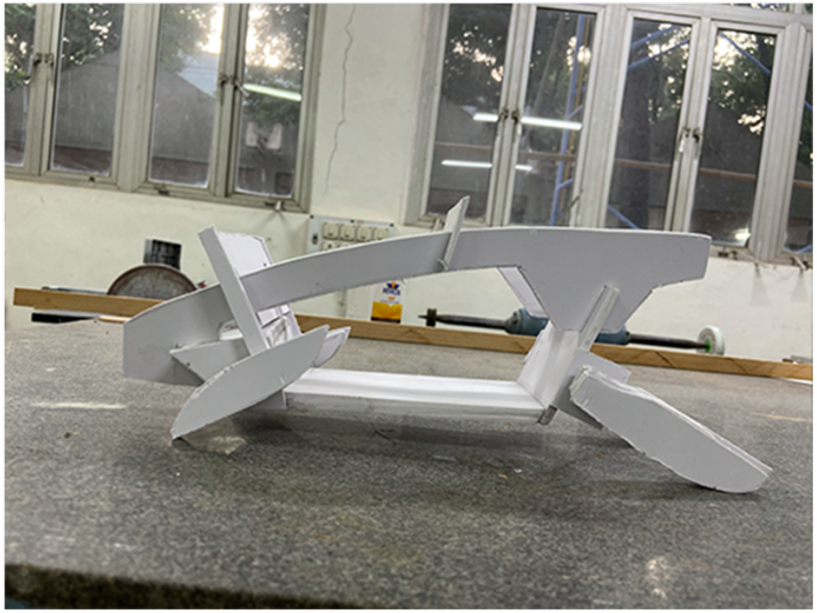


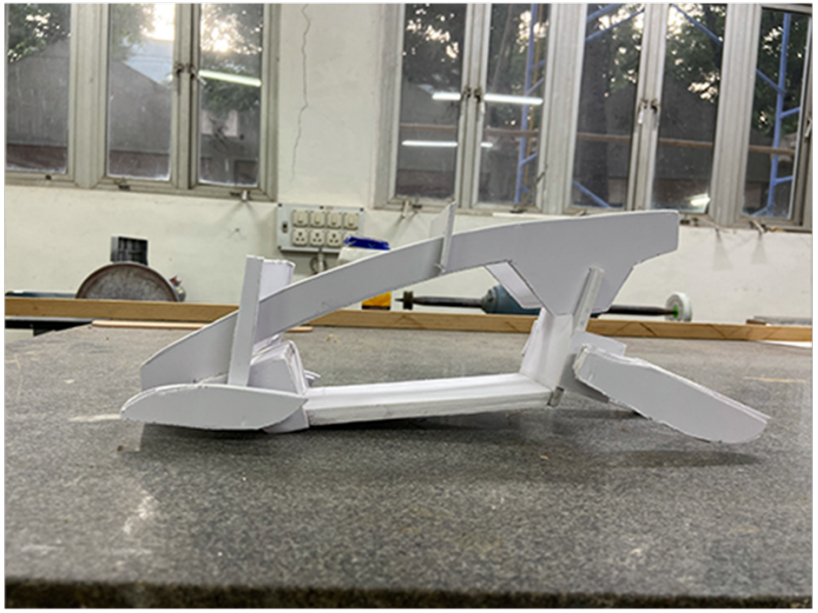
Sporty And Dynamic

4.6.3 Form Mock-ups

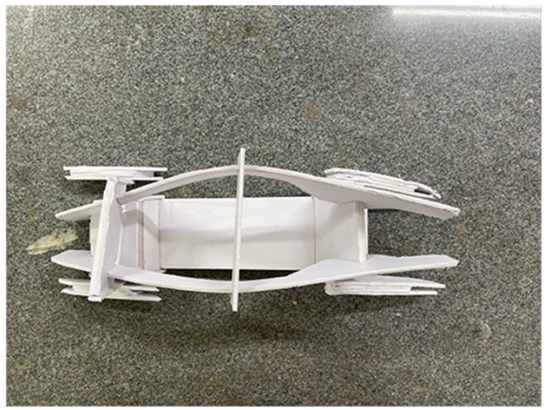


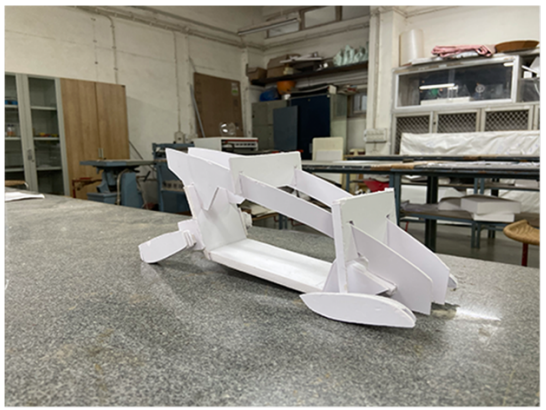
4.6.4 Lo fi Mock-ups





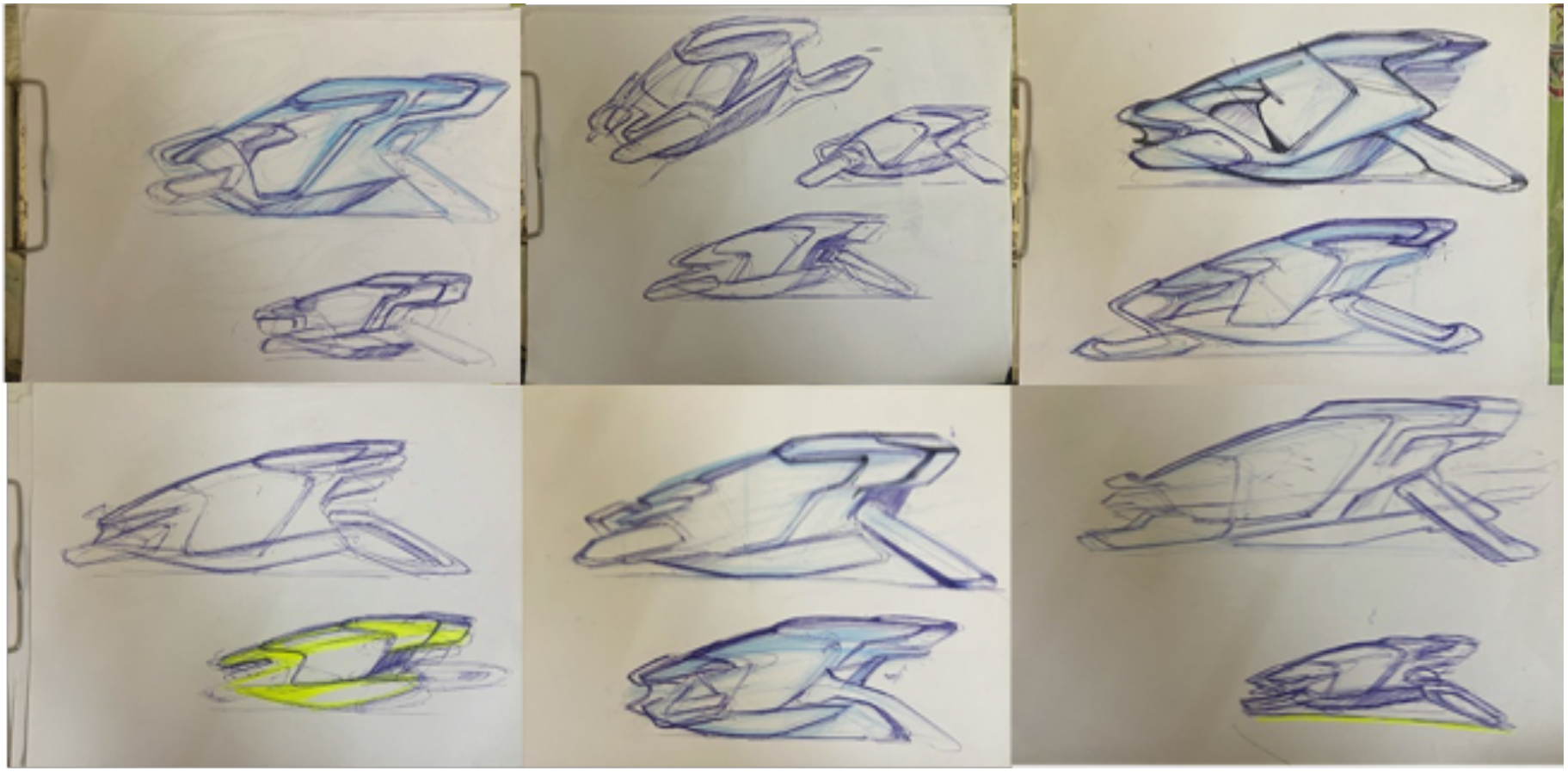




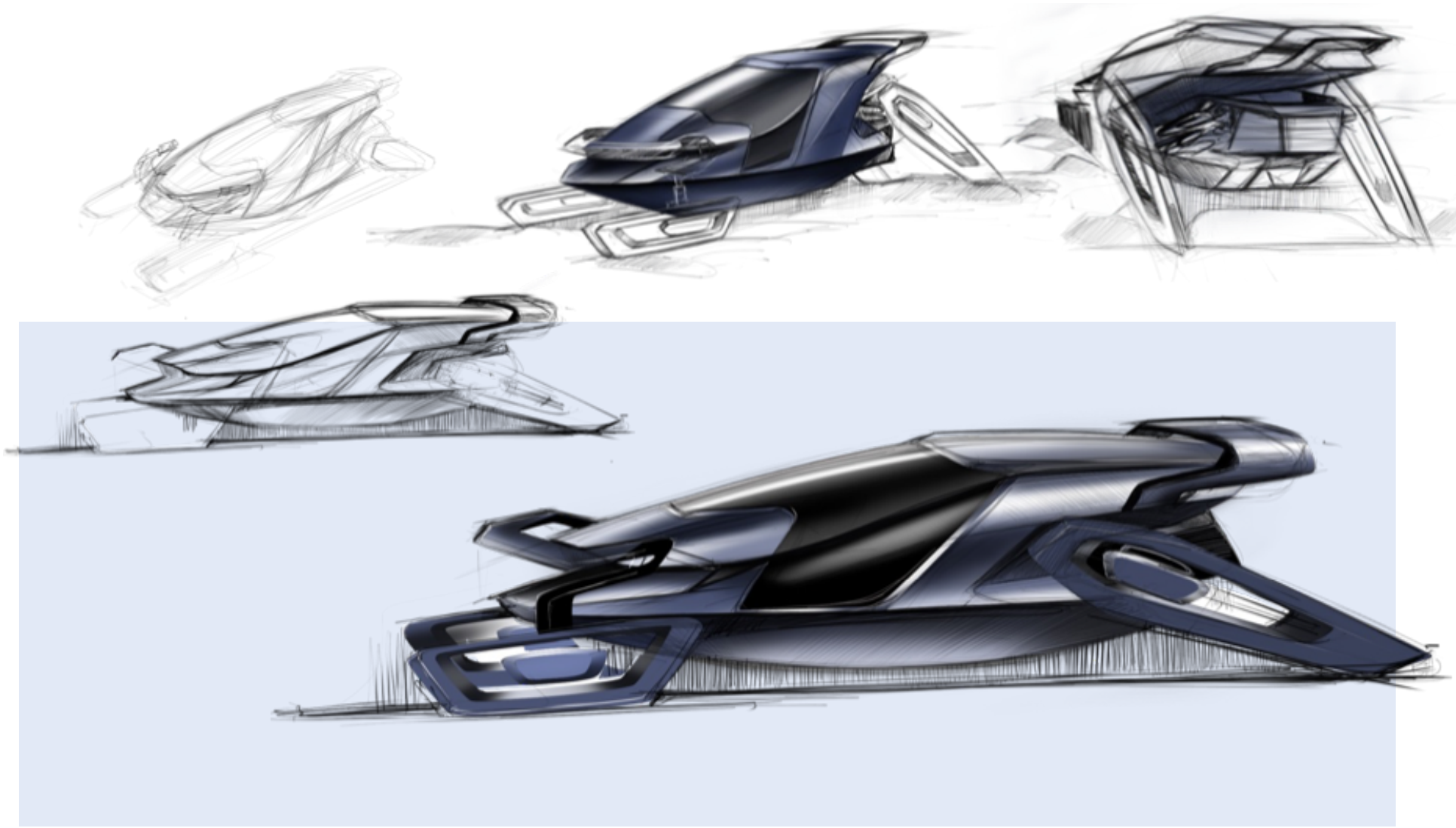


4.7 Ideations

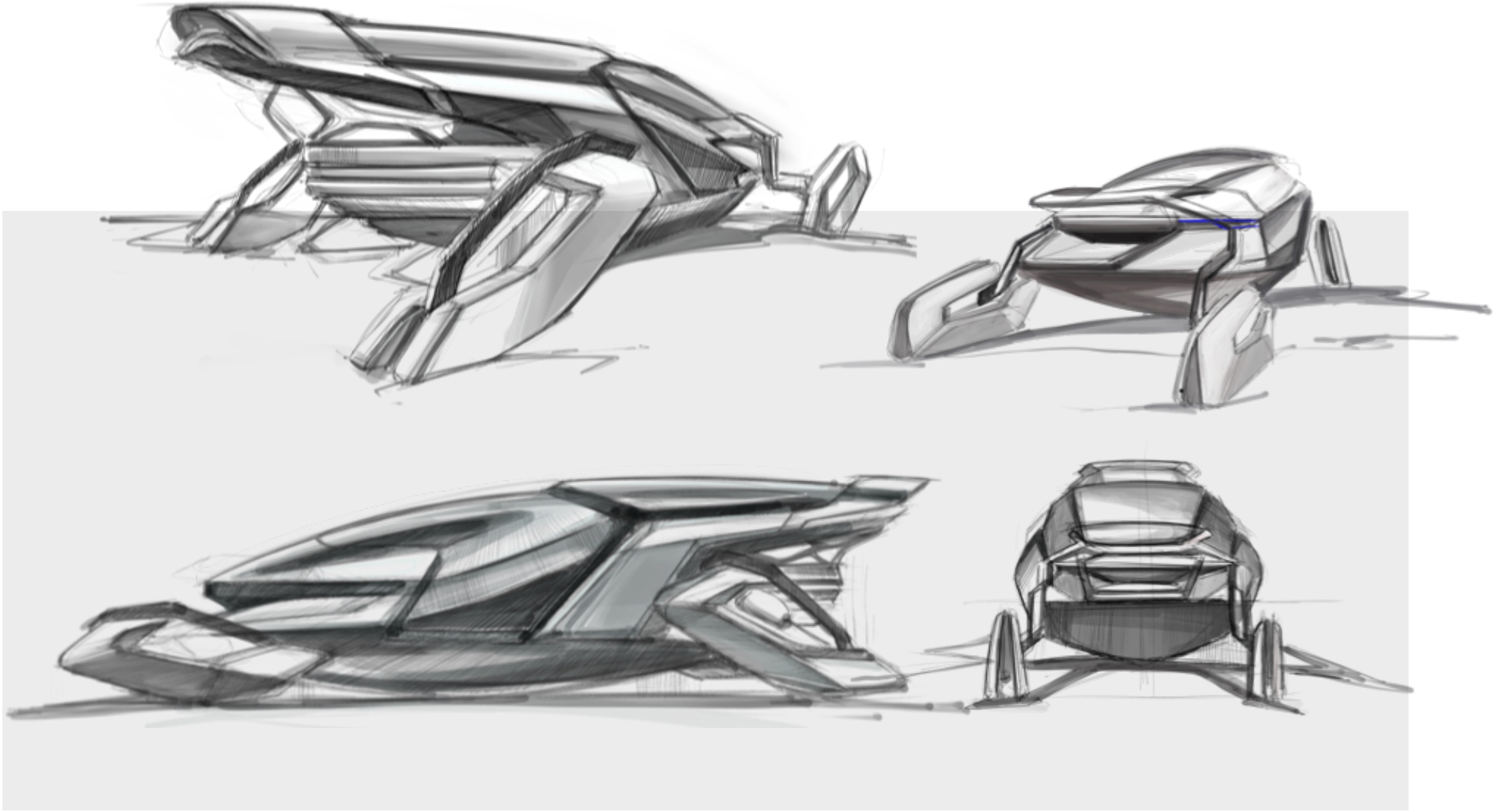




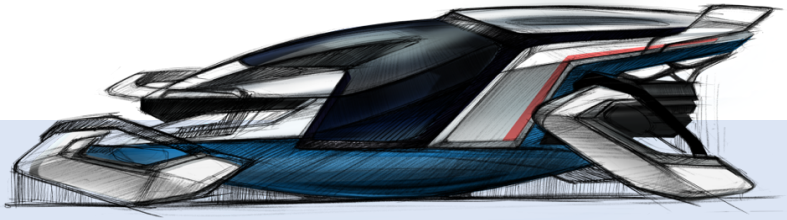
4.7.1 Concept Sketches

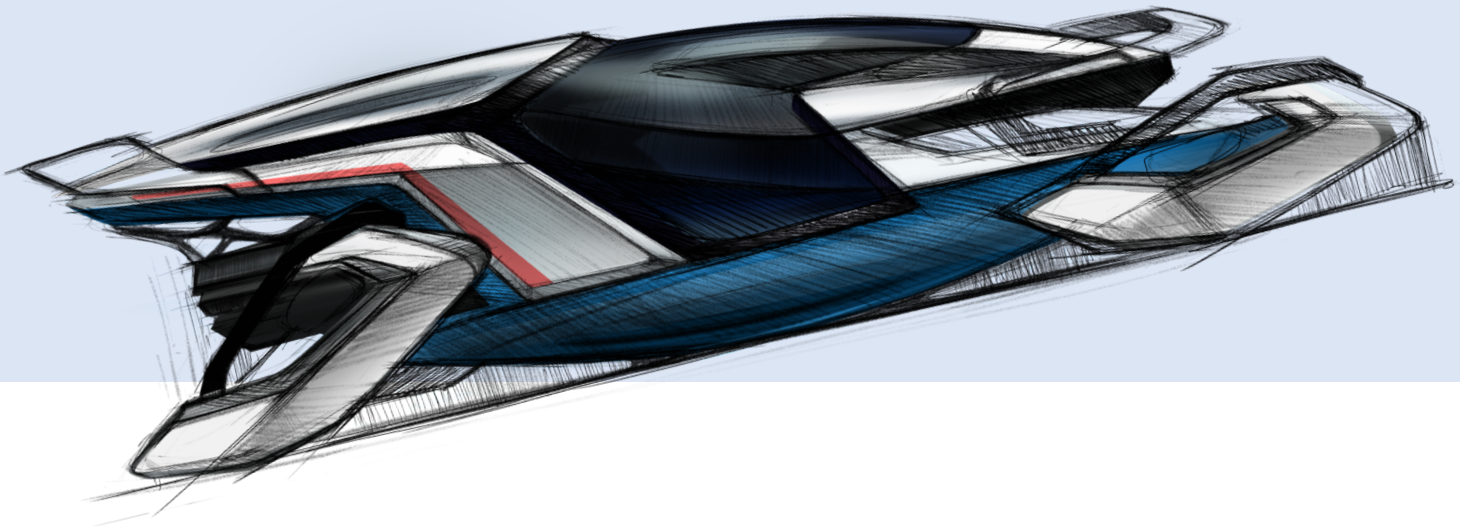


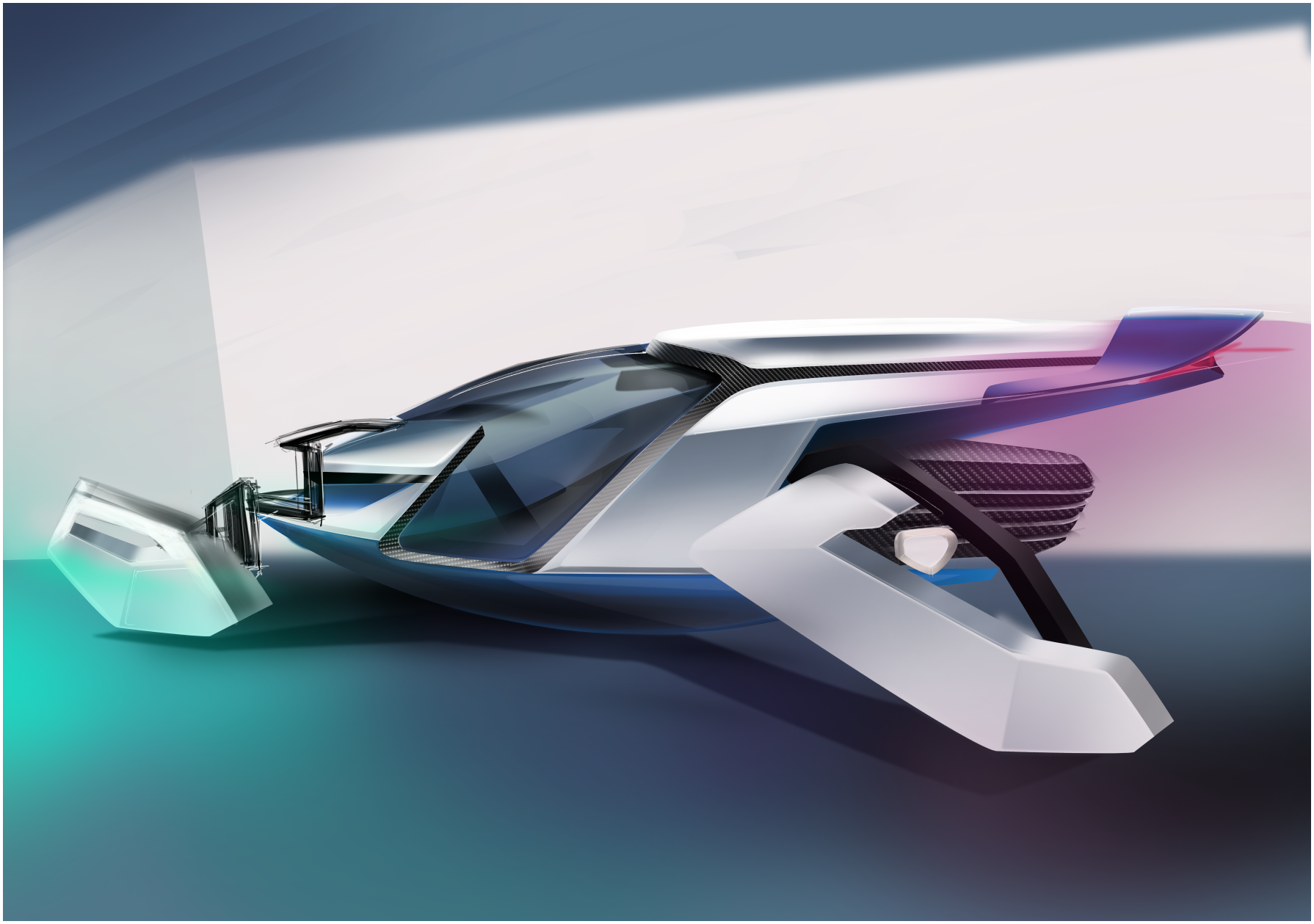
4.7.2 Final Design



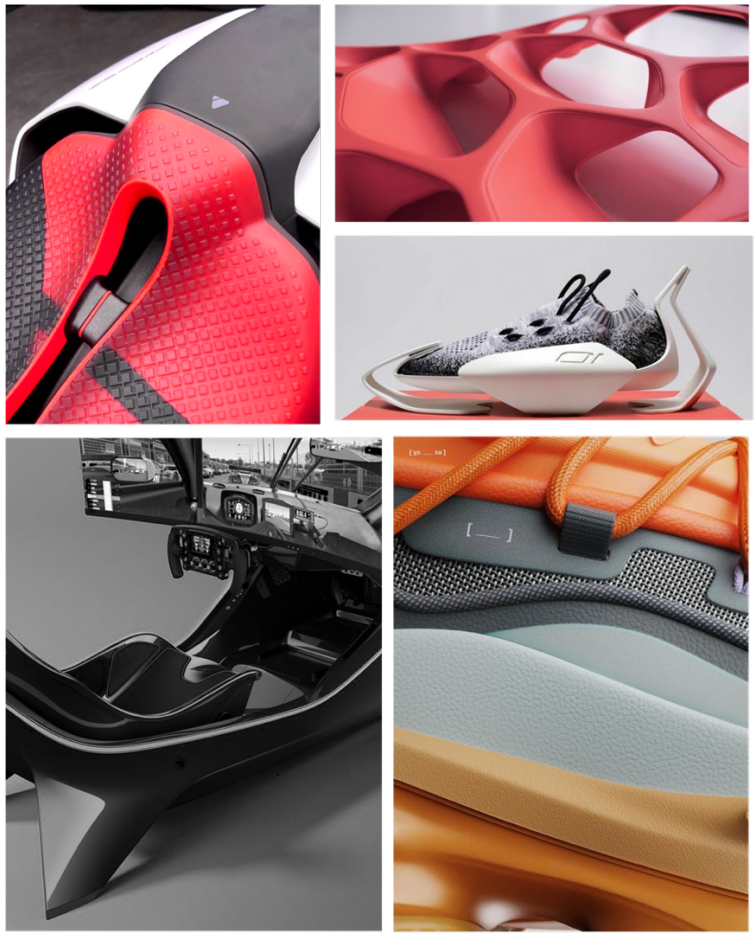
4.7.3 Hand Renders







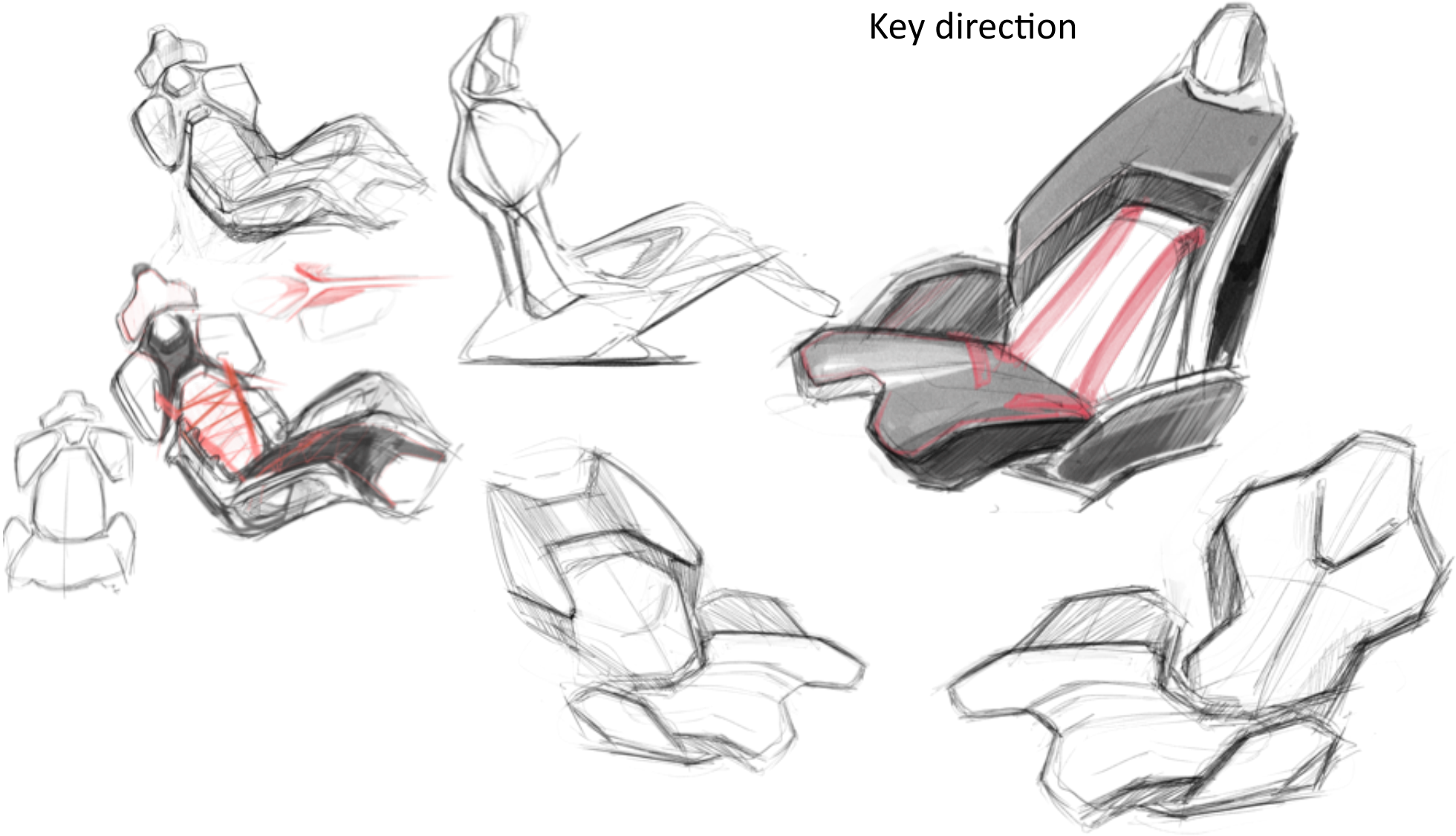
4.7.4 Interior Theme board

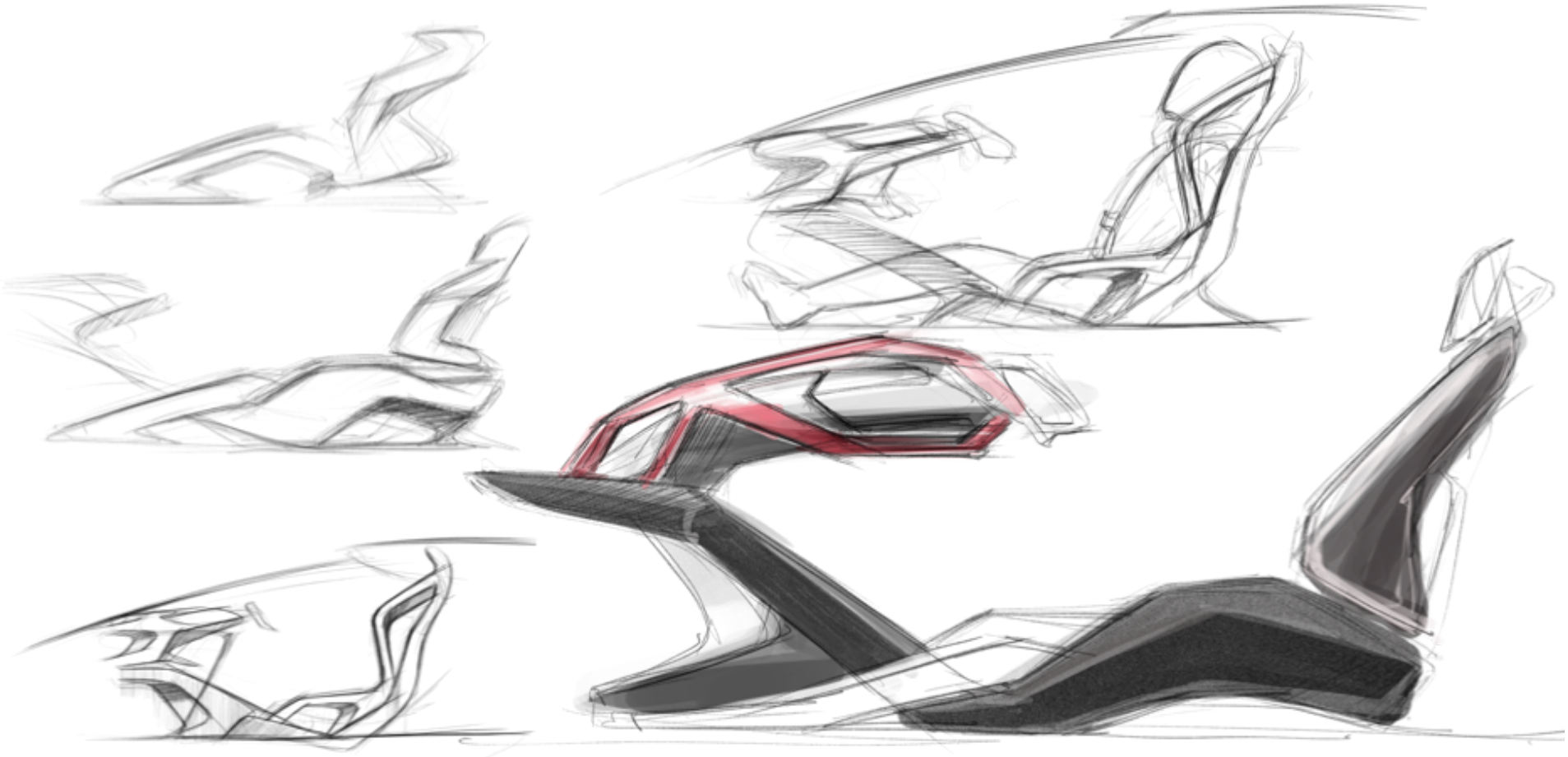




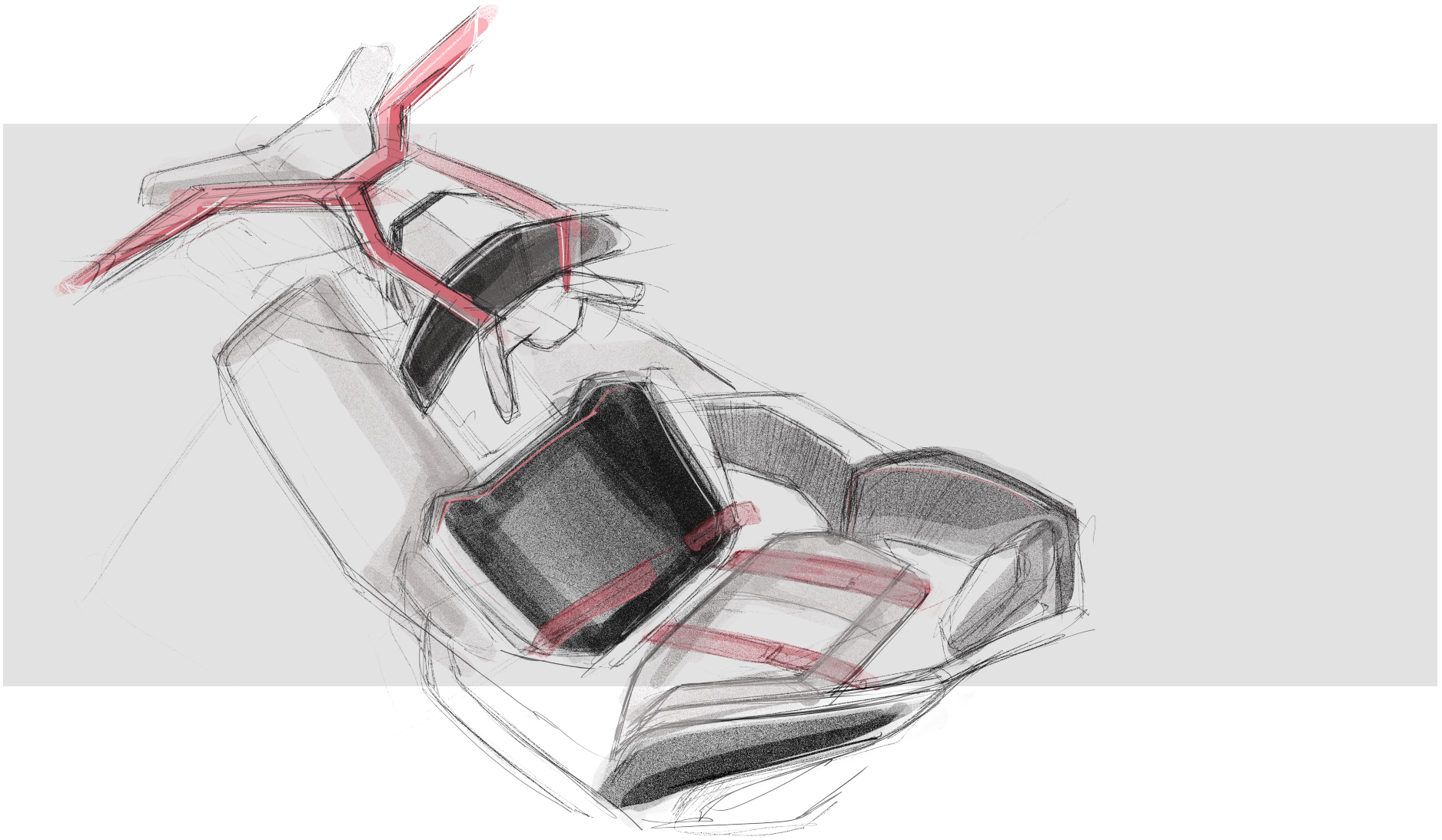
Sporty and Dynamic

Key direction





4.7.5 Final interior design



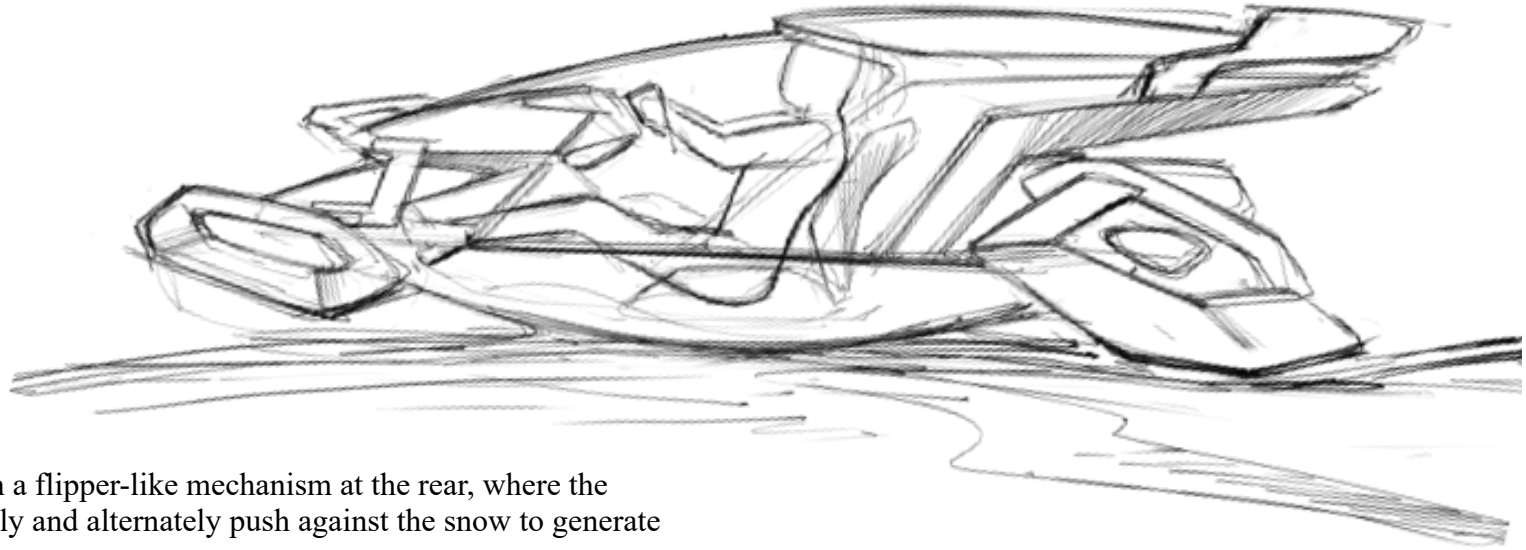
4.8 Vehicle Working



By extending their flippers backward and then pulling them forward, they generate forward thrust.

Penguins lie flat on their bellies, aligning their body parallel to the ground. This position reduces air resistance and provides a stable platform for sliding.

Low profile body for stability

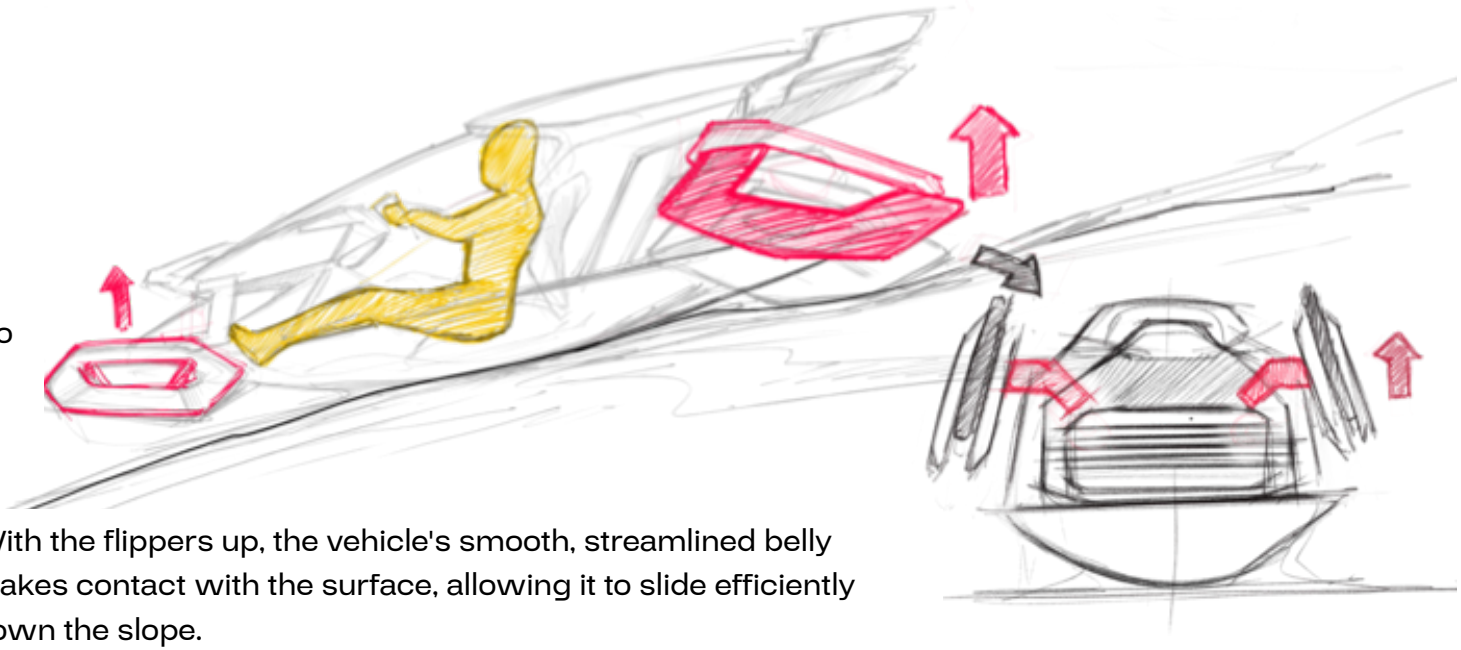


The vehicle is equipped with a flipper-like mechanism at the rear, where the flippers operate independently and alternately push against the snow to generate forward thrust.

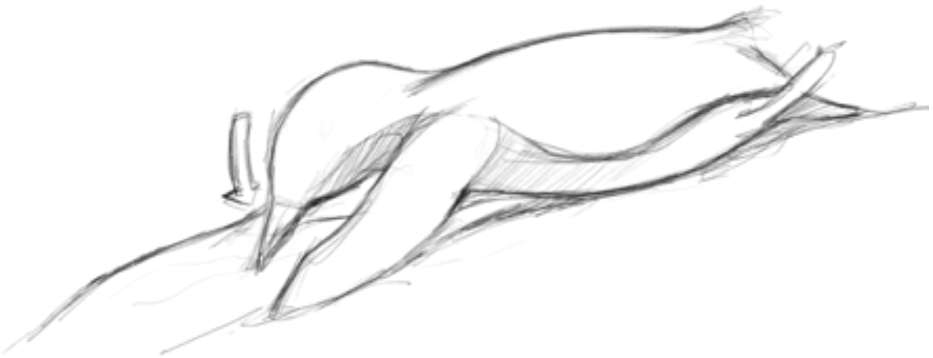


vehicle is designed to slide down slopes in a unique way, As the vehicle begins its descent, sensors detect the downward motion.

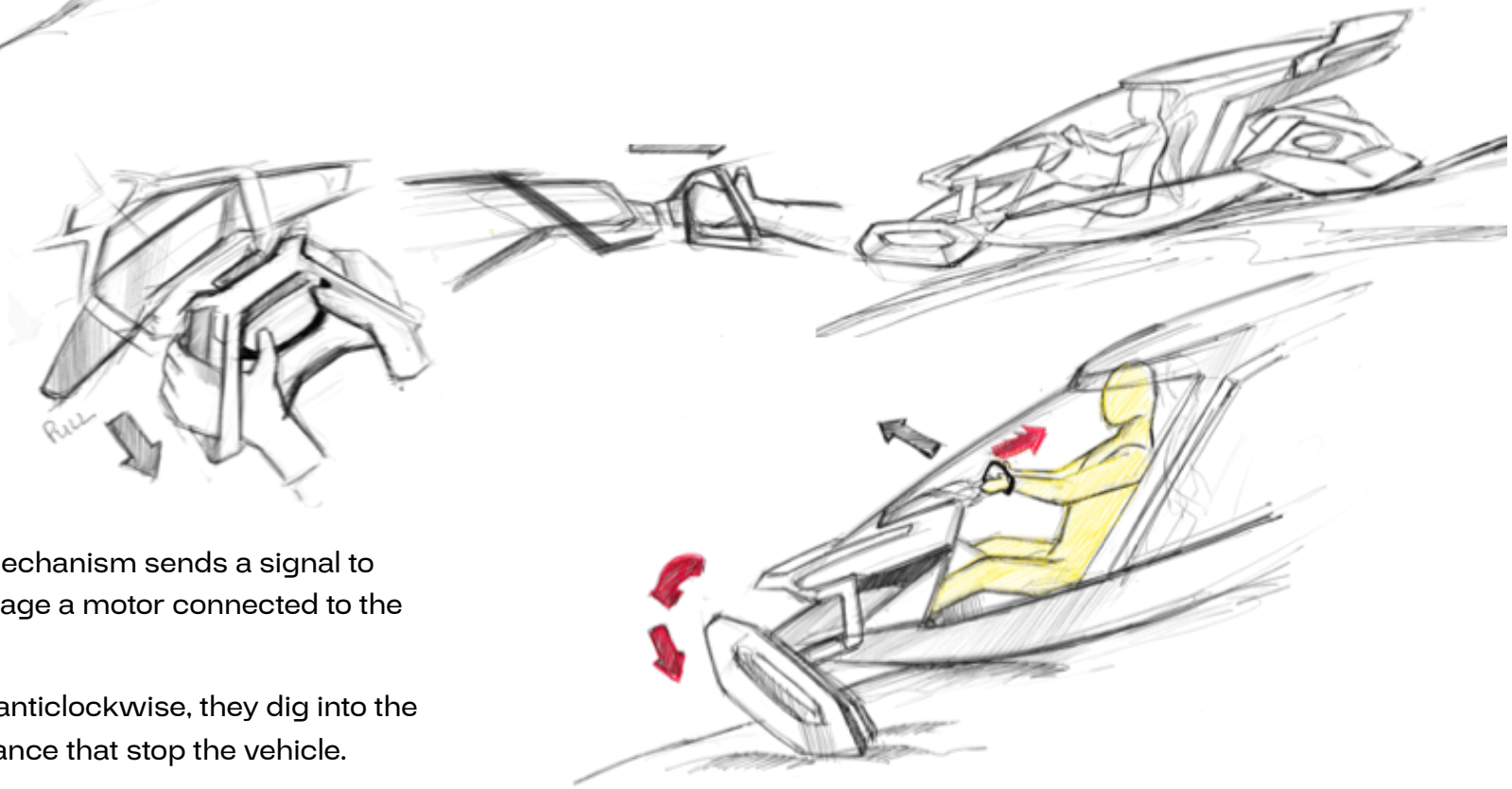
The flippers, attached to the sides of the vehicle, automatically flip upwards to reduce friction and resistance.



With the flippers up, the vehicle's smooth, streamlined belly makes contact with the surface, allowing it to slide efficiently down the slope.



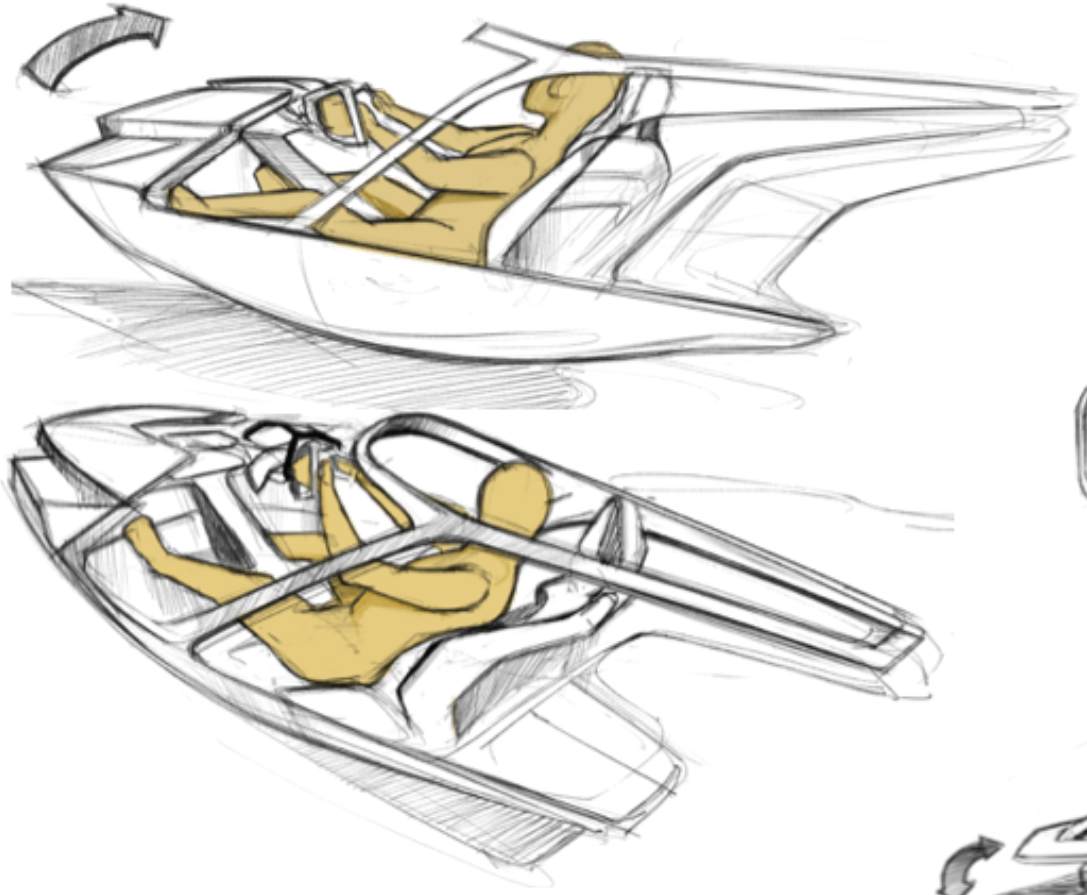
Penguins use their flippers to halt their motion by digging them into the snow, creating resistance that slows them down.



When the rider wants to stop the vehicle, they pull the steering mechanism towards them. This action triggers the brake system.

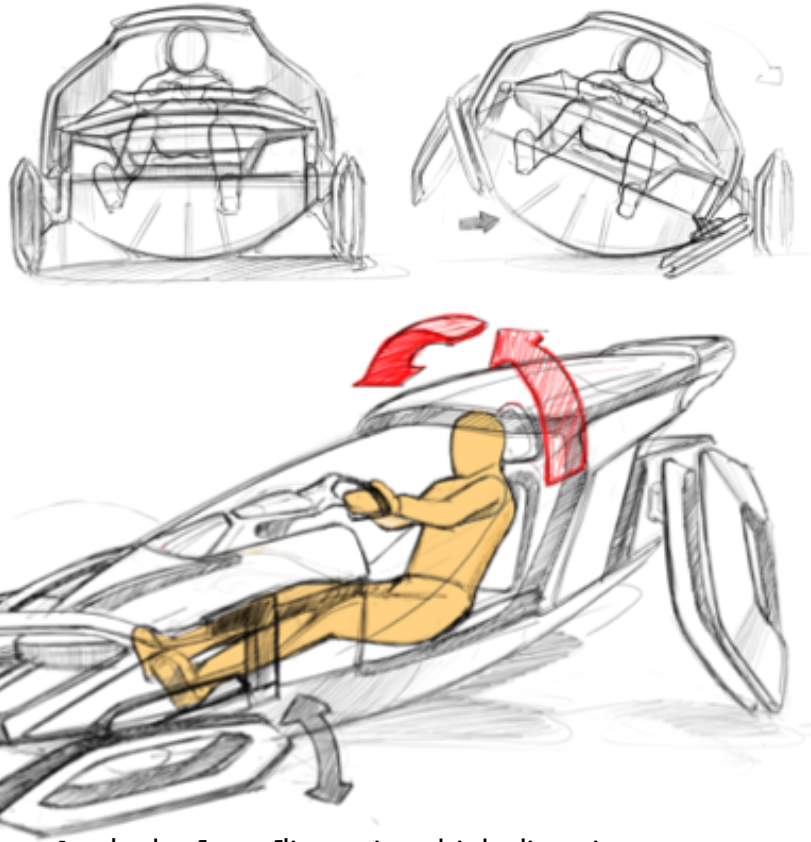
Pulling the steering mechanism sends a signal to control system to engage a motor connected to the

As the flippers rotate anticlockwise, they dig into the snow, creating resistance that stop the vehicle.



The rider need to tilt their bodies slightly to one side or the other to assist with turning and maintaining balance. Just like penguins do.

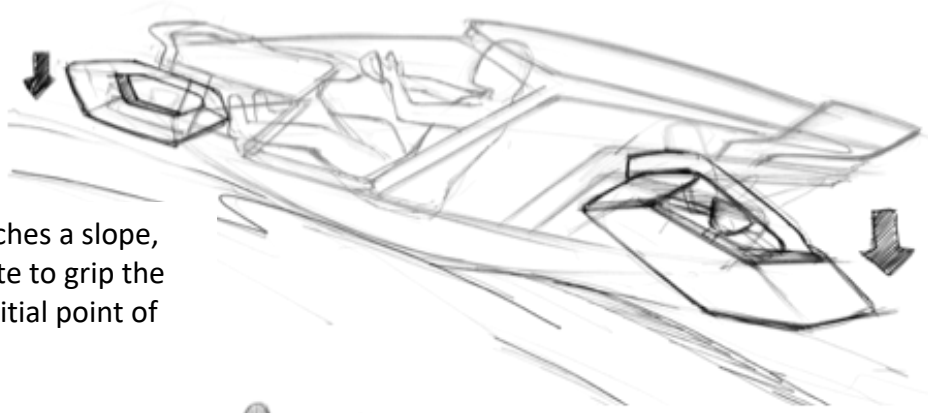
Penguins adjust their flippers to steer. By moving one flipper more than the other, they can change direction smoothly.



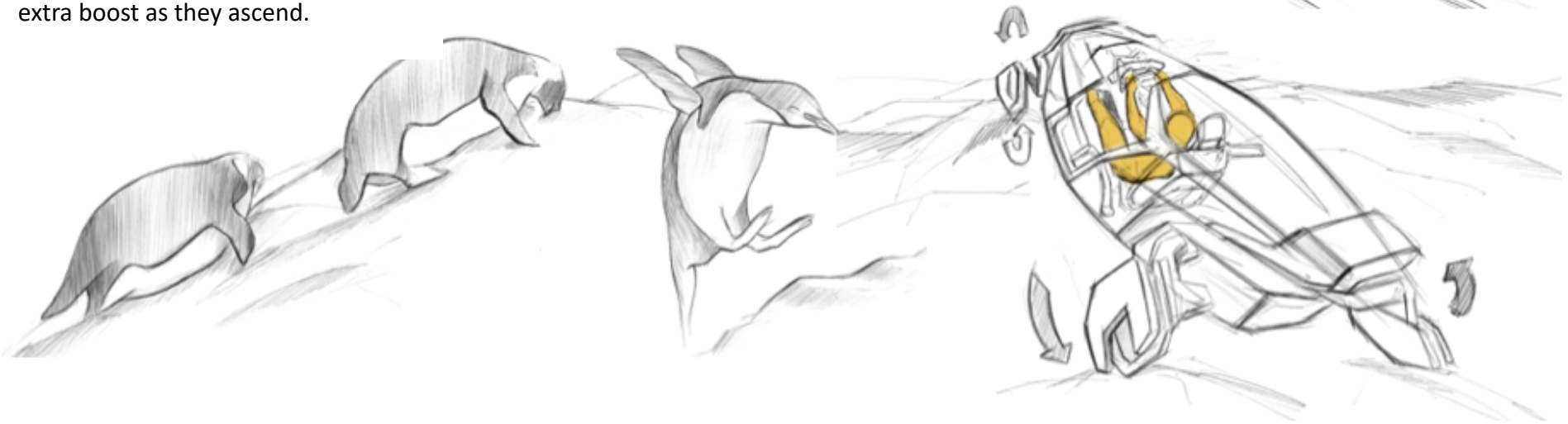
Angle the front flipper in which direction you want to turn

Penguins often use their strong, sharp beaks to grip the ice or rocky surfaces. By pecking and pulling themselves
upwards, they can gain traction and stability.

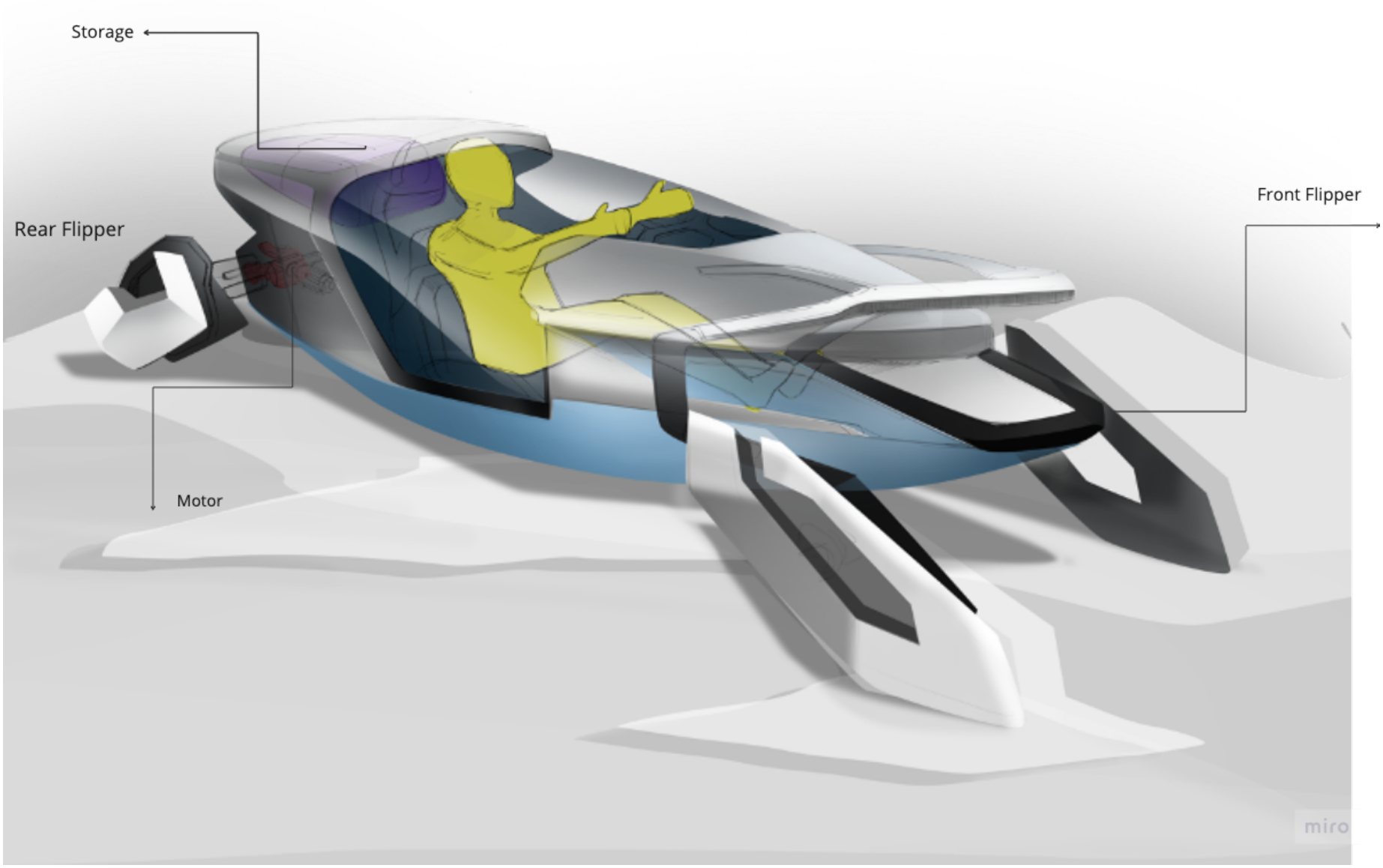
In some cases, penguins use their flippers to push against the ground or the climbing surface, giving them an extra boost as they ascend.



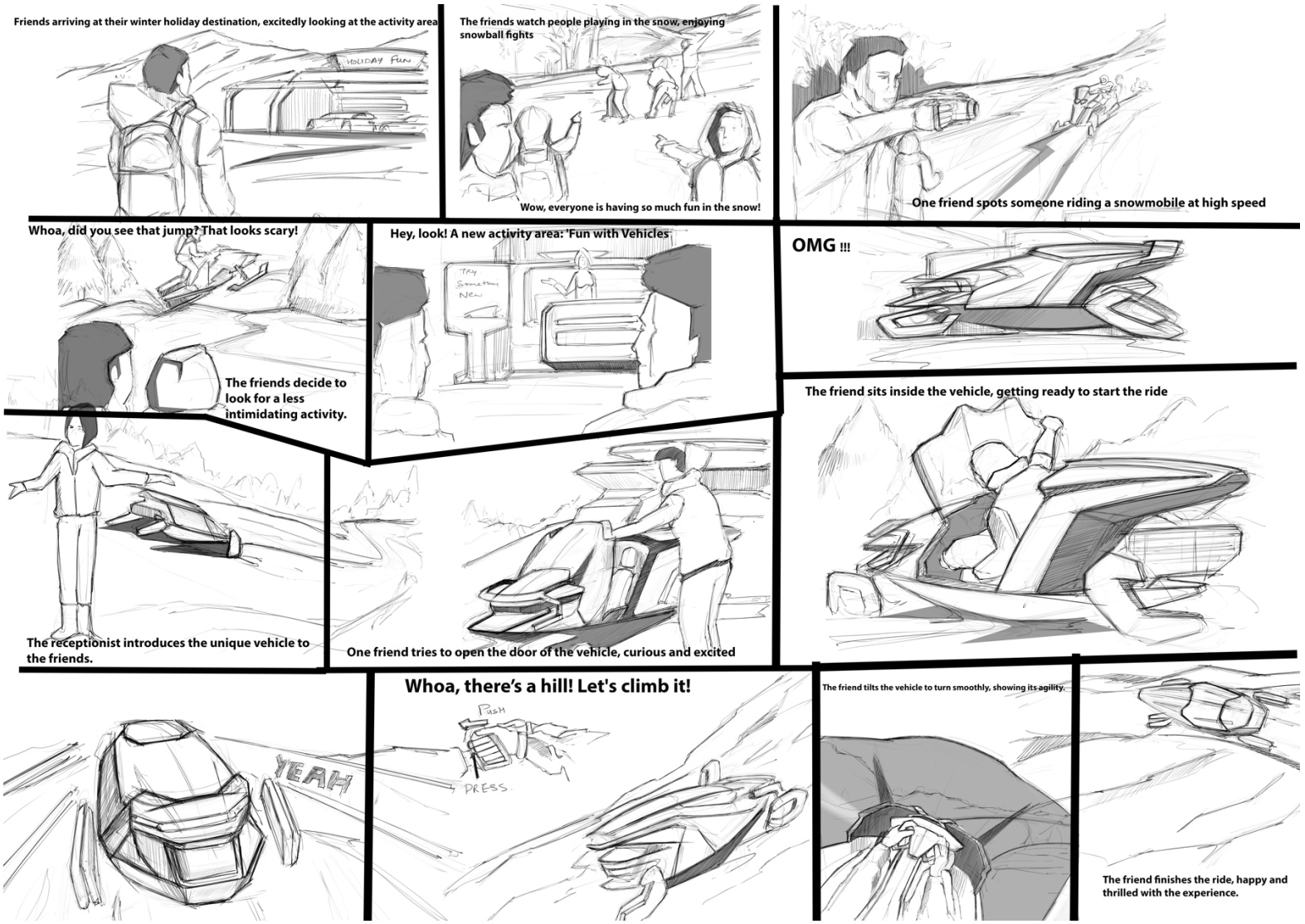
As the vehicle approaches a slope, the front flippers rotate to grip the surface, creating an initial point of contact.



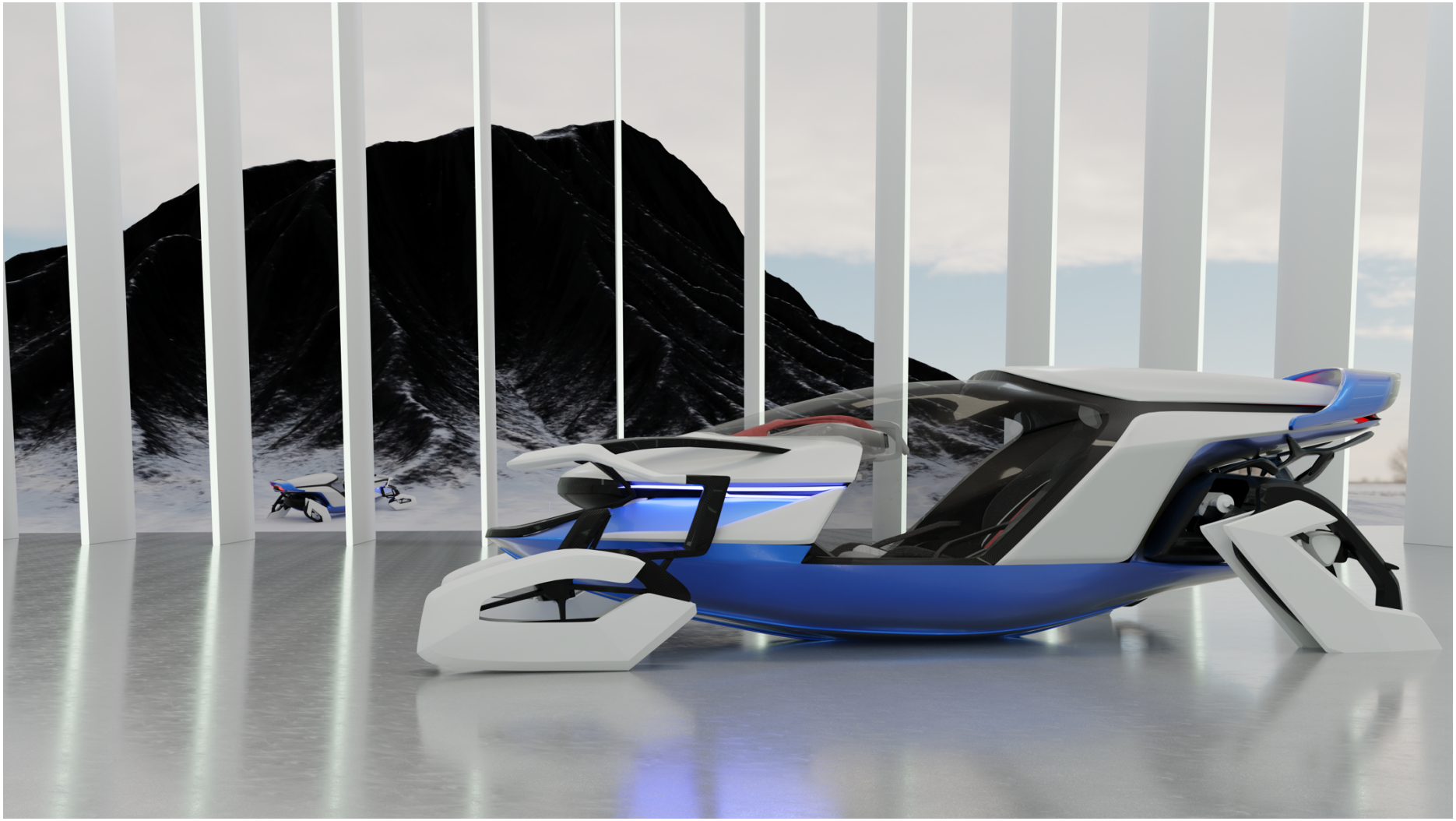
There is a quad pedal type of motion in which The front left flipper rotates forward and pushes against the surface while the rear right flipper does the same, lifting and propelling the vehicle upward. And same with the other flippers.

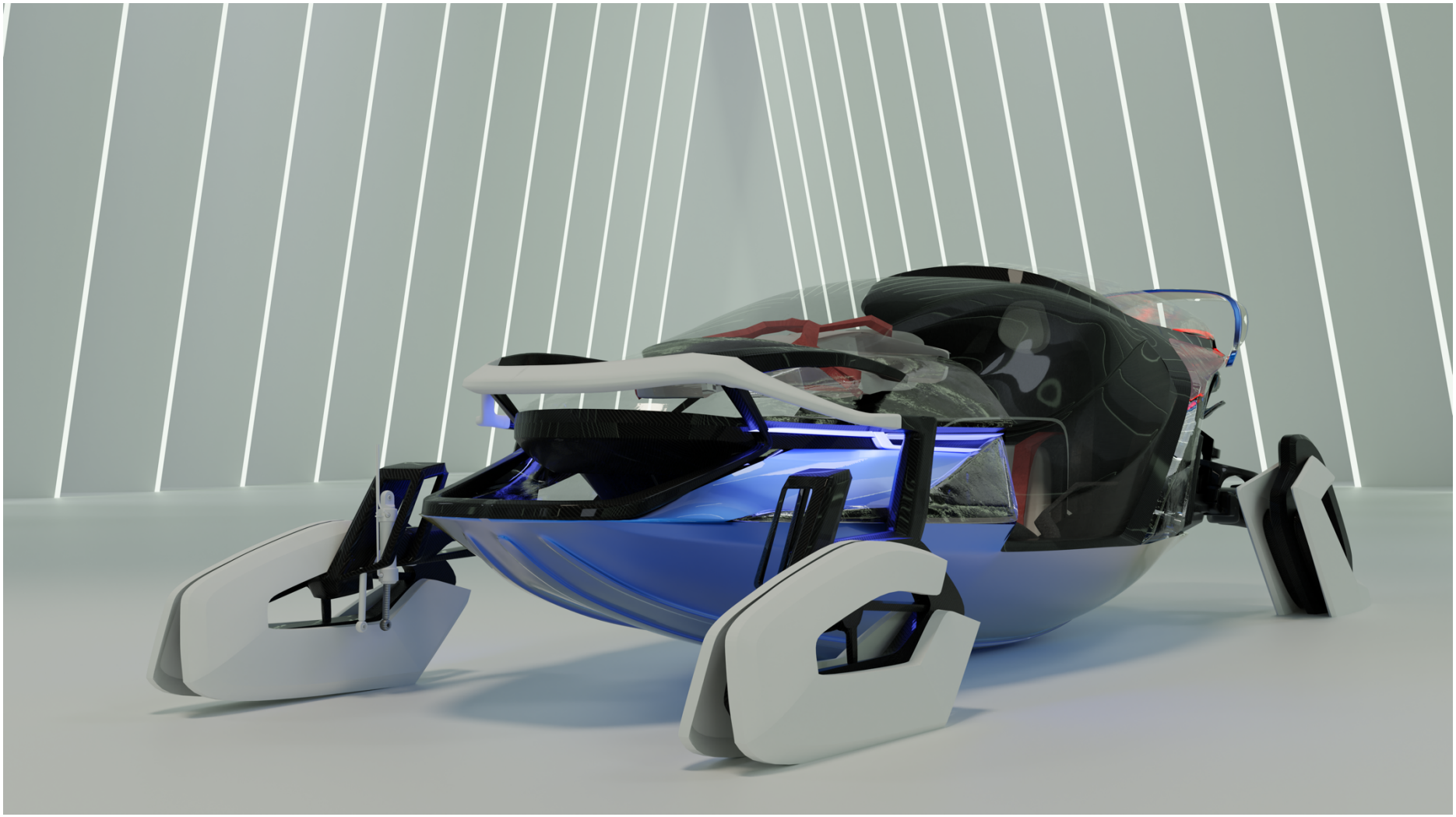

Storage
Rear Flipper
Front Flipper
Motor
miro

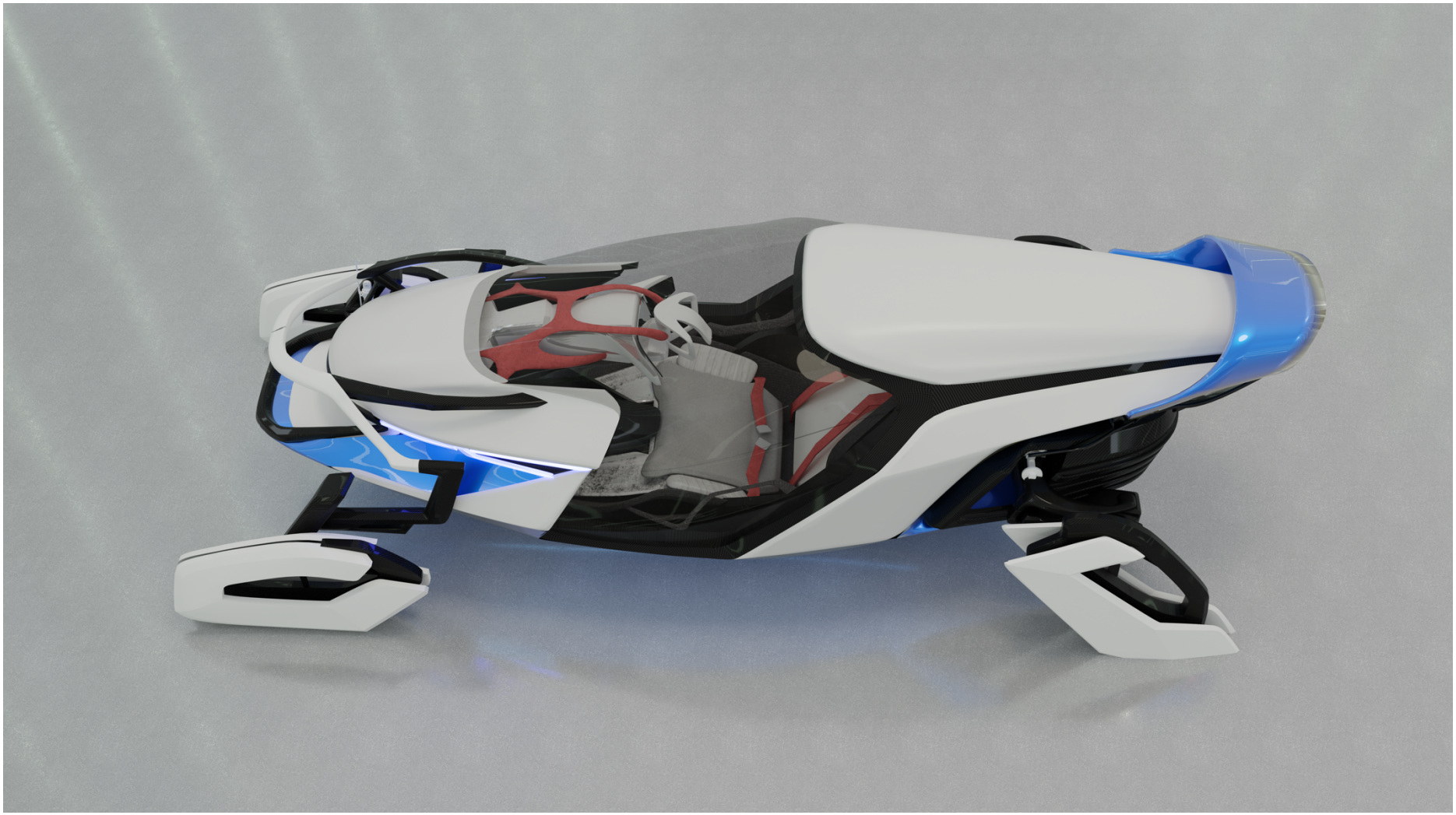
4.9Story board

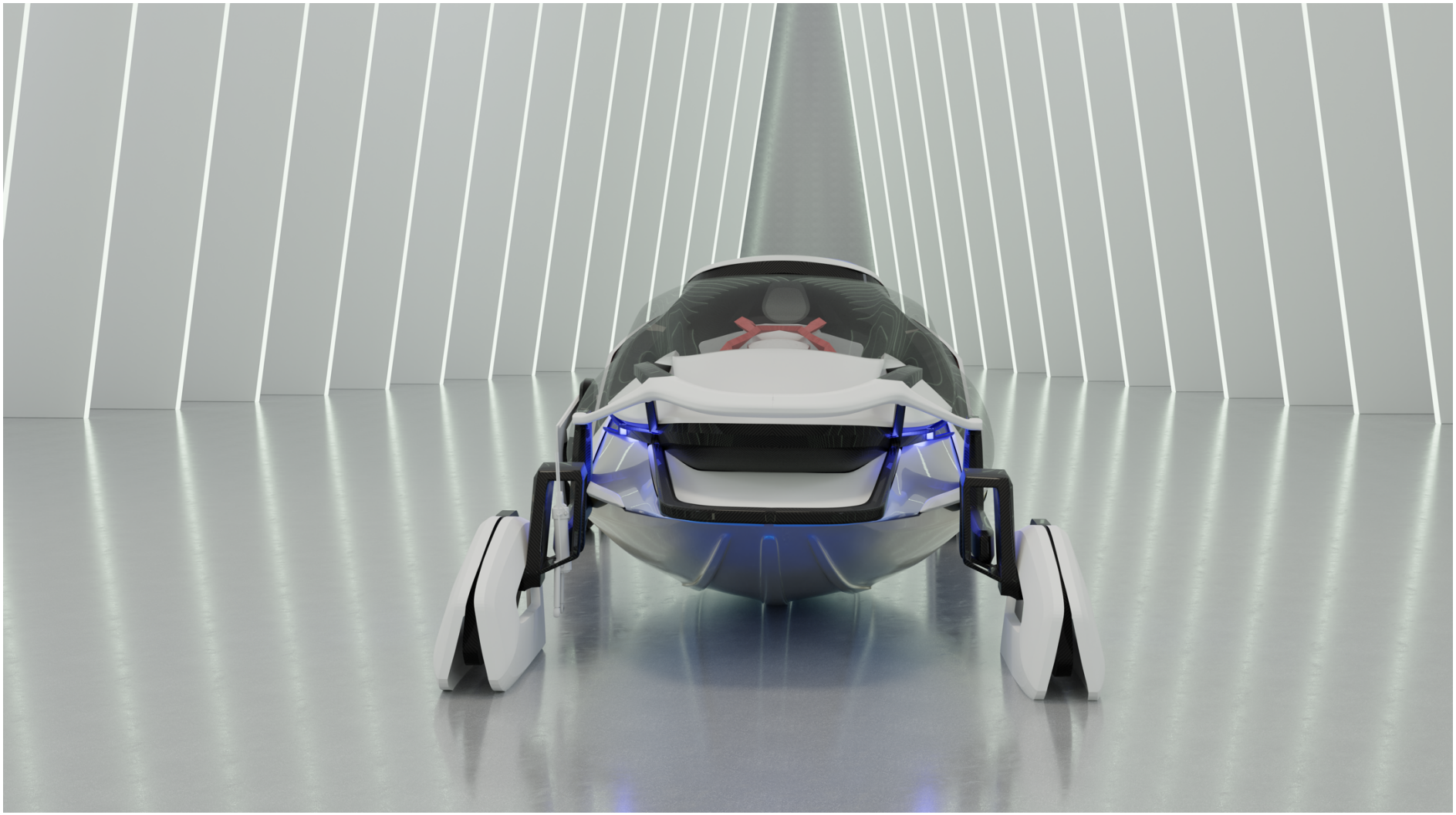


4.10 Final Renders

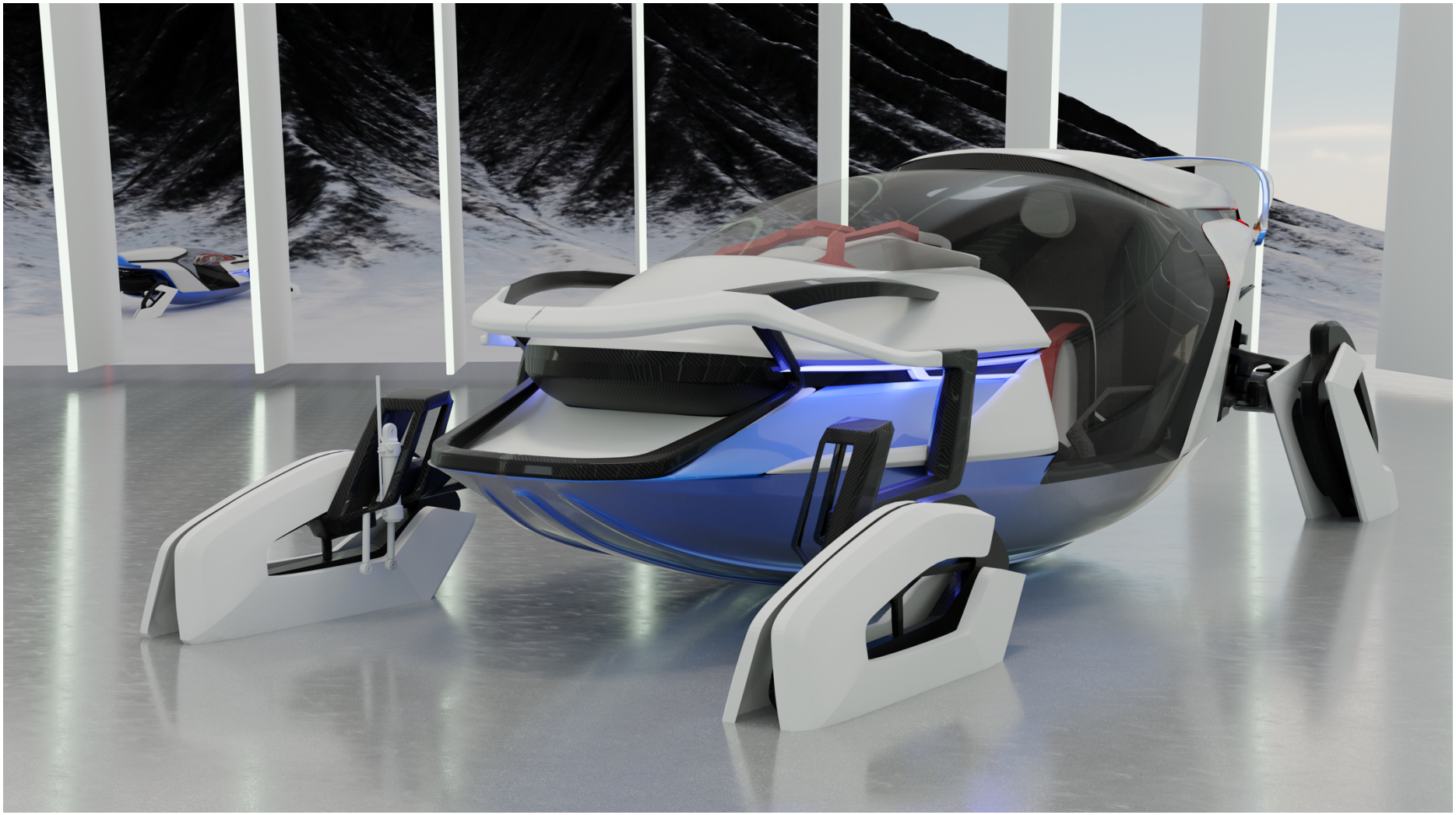




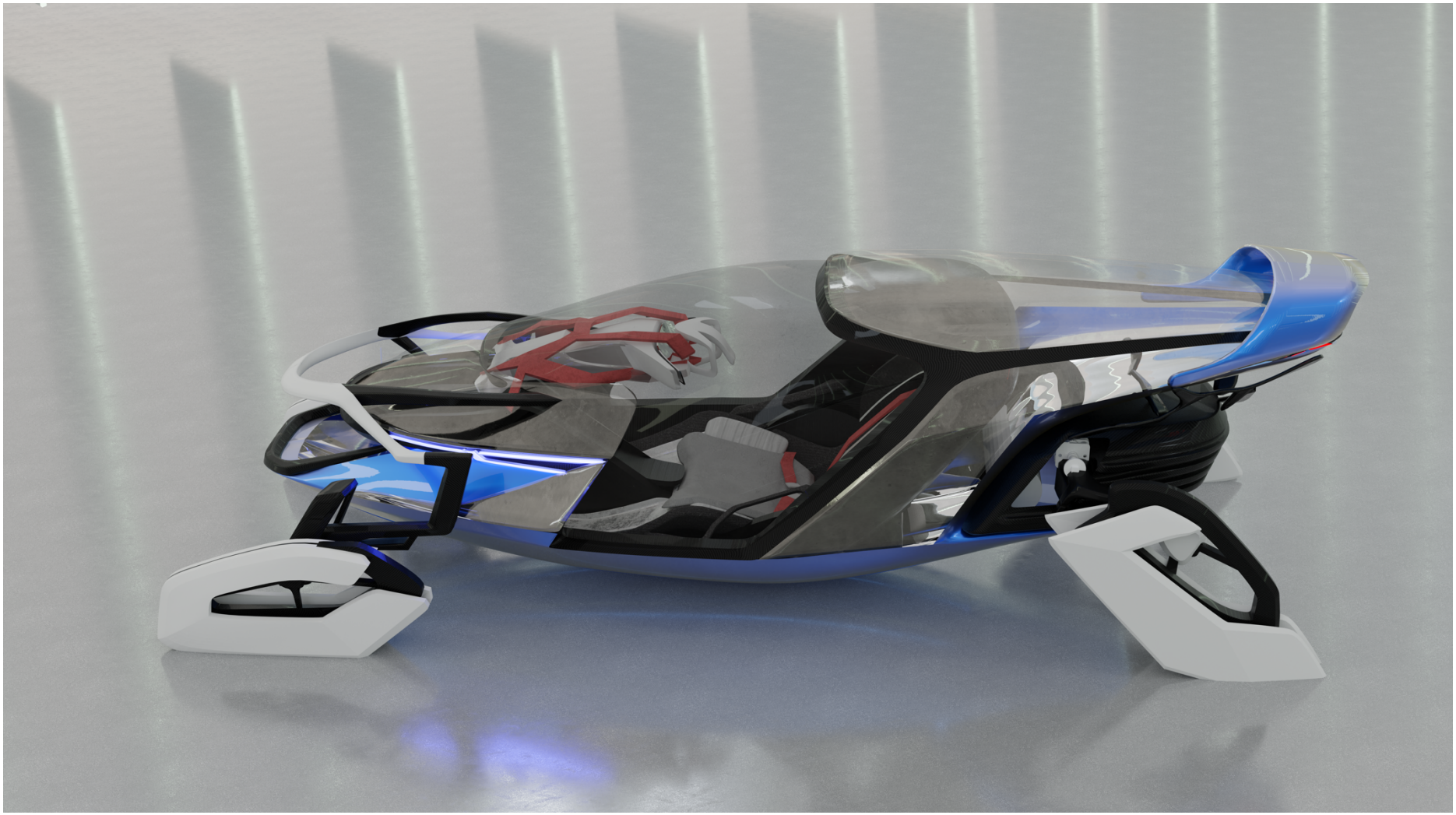


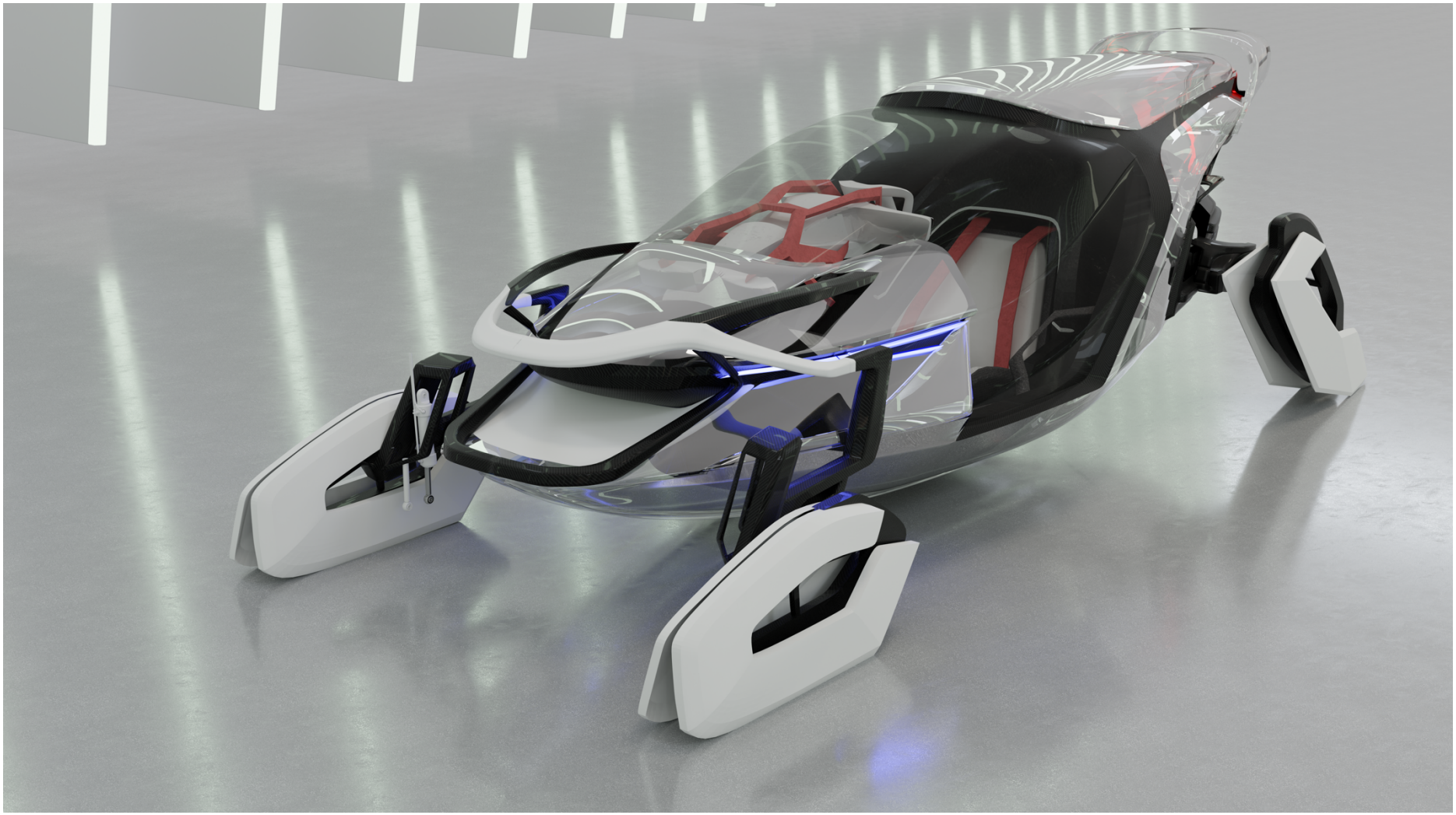


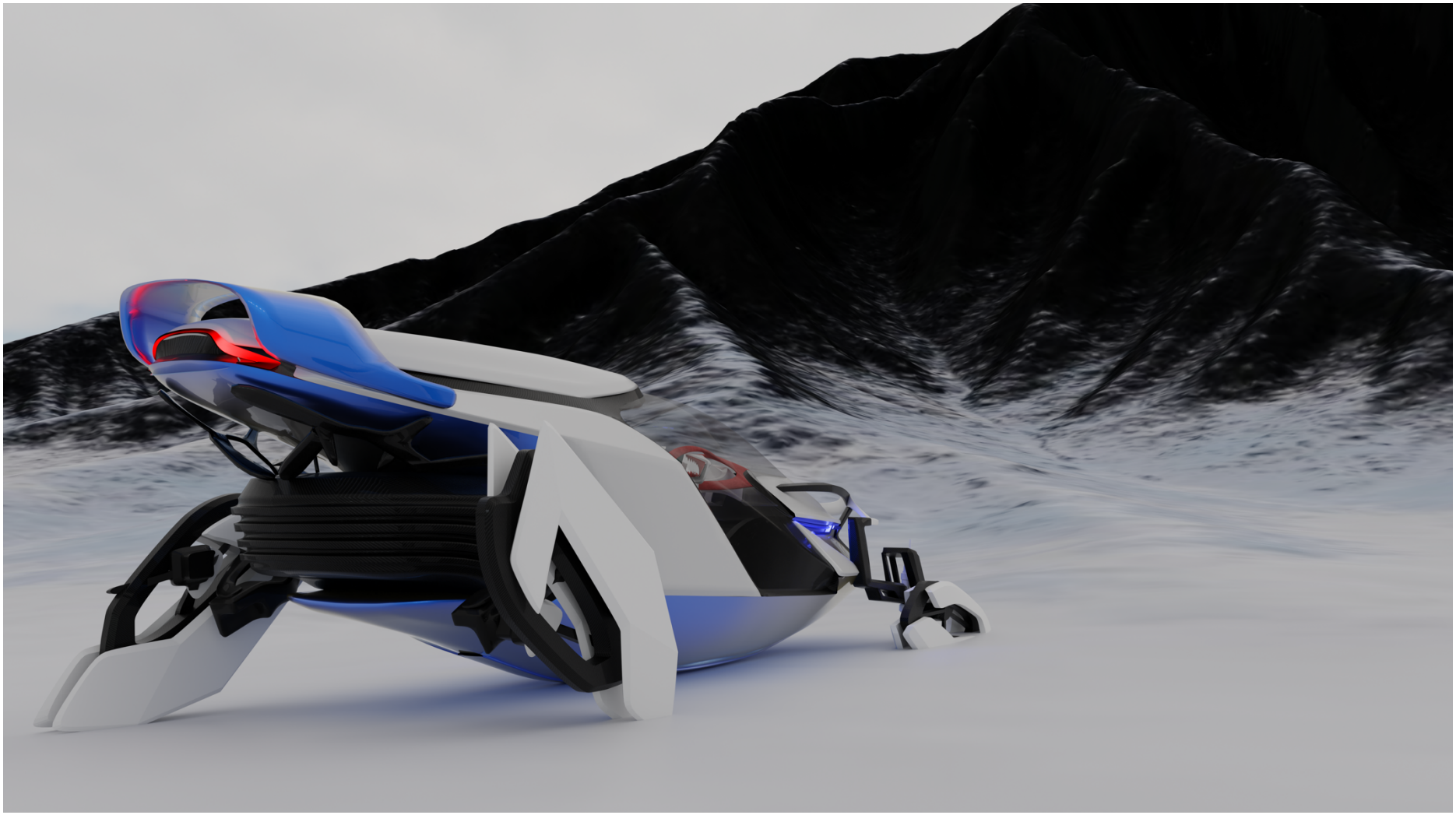


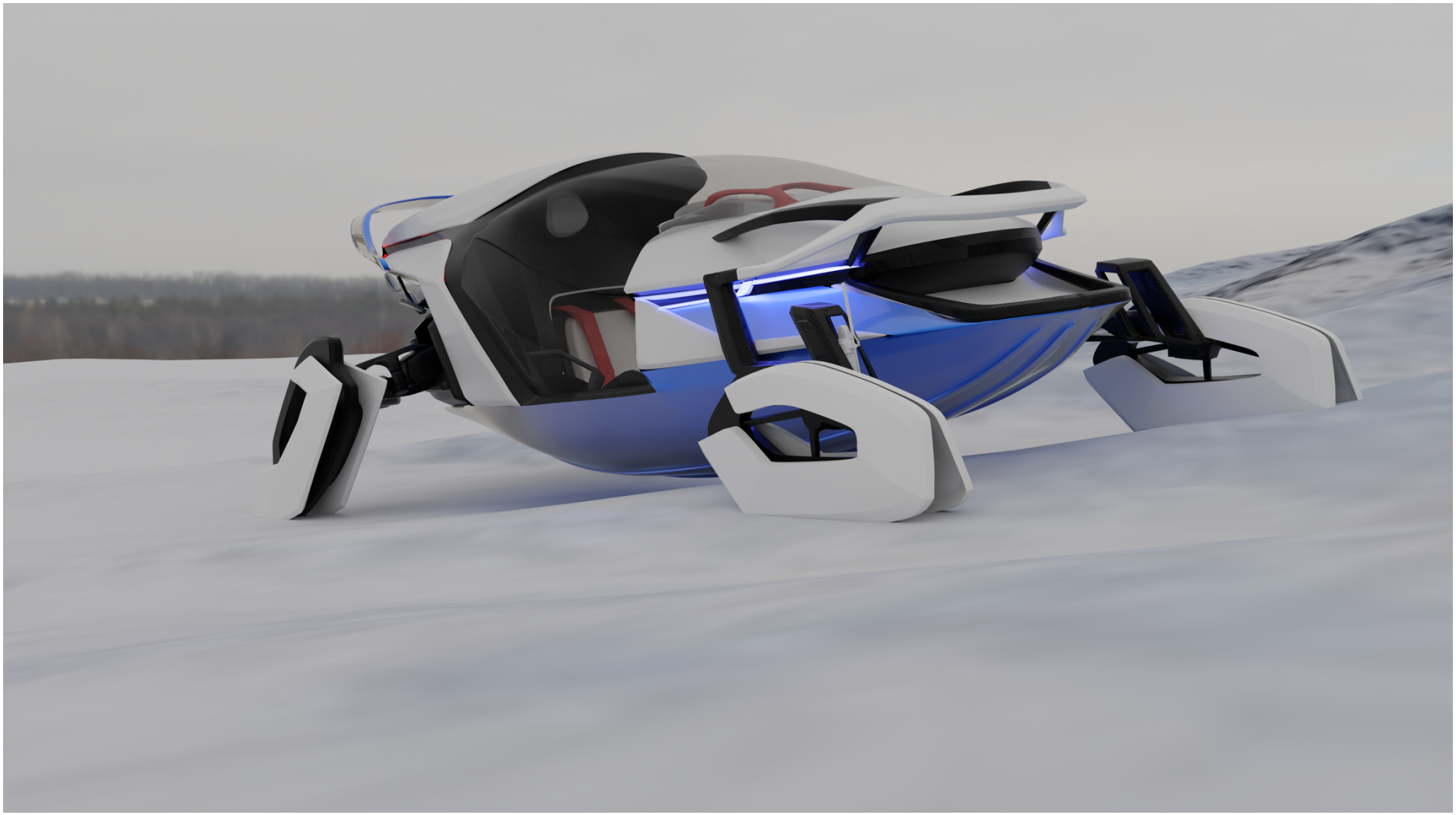




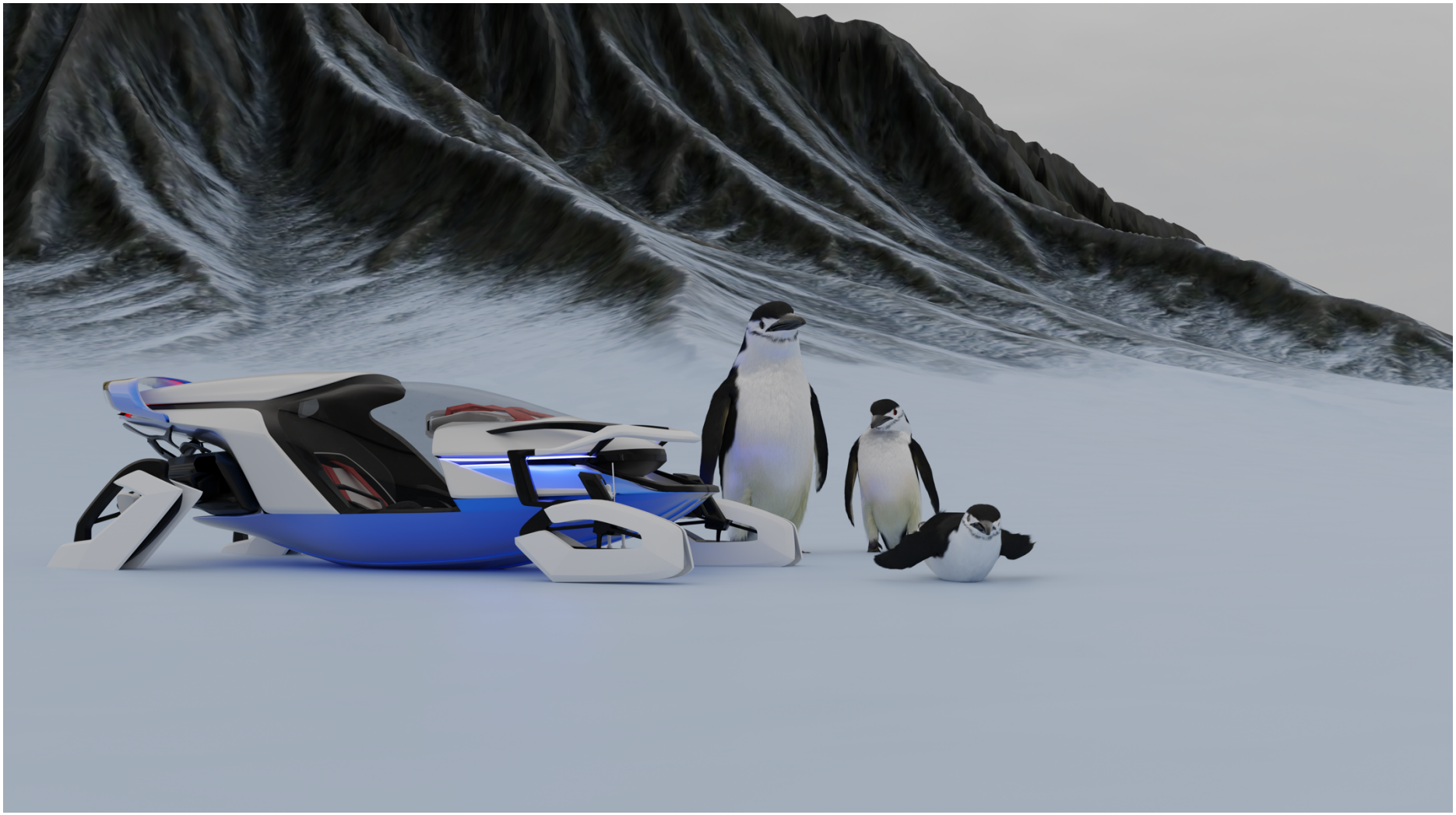














Physical model







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