IDC School of Design
अभिकल्प विद्यालय

IIT Bombay

Fuel Cell Powered Luxury Road trip Vehicle 2040

Mobility and Vehicle Design Project III
DEP703

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PHASE I

The first phase phase of this project was all about finding an inspiration to start with, and doing research in that field to ultimately develop a vehicle design possibility within it. Here, Hydrogen fuel cell was one such field on which extensive research was conducted. Another topic was Golden Quadrilateral Indian highway, which ultimately became the primary context for the vehicle.

Inspiration

The genesis of the vehicle design project stems from a profound source of inspiration, one that arises from the dynamic and rapidly evolving landscape of transportation in India. Witnessing the advent of the fast-developing superhighways across the country served as a catalyst for conceptualizing a vehicle design that could harness the potential of these expansive road networks. The vision was to create a vehicle that seamlessly integrates with the evolving infrastructure, offering a remarkable travel experience.

Another significant factor that fueled this inspiration was the growing popularity and advancements in hydrogen fuel cell technology. The recognition of hydrogen as a clean and sustainable energy source for vehicles captured the imagination and prompted a deep dive into its possibilities. The concept of utilizing hydrogen fuel cells in the vehicle design project not only aligns with the global shift towards eco-friendly transportation but also offers a glimpse into a future where zero-emission vehicles become the norm.

Inspiration also emerged from the realm of high-speed vehicles. Witnessing the agility and efficiency of these machines as they navigate through the superhighways left a lasting impression. The idea of designing a vehicle capable of traversing these roads with ease, akin to the speed and precision of high-performance vehicles, became a central aspiration.

The aviation industry served as a further wellspring of inspiration for the project. The similarities between the fast-paced nature of air travel and the high-speed on-road experience sparked the idea of infusing the vehicle design with elements reminiscent of private jets.

The goal was to create an ambiance and feel that would evoke a sense of luxury, exclusivity, and sophistication akin to the experience of flying in a private aircraft.This amalgamation of inspirations from the superhighways of India, the potential of hydrogen fuel cell technology, the allure of high-speed vehicles, and the sophistication of the aviation industry laid the foundation for a vehicle design project that aimed to revolutionize the road travel experience. It sought to combine the cutting-edge advancements in technology, the vast infrastructure of Indian superhighways, and the desire for a seamless blend of comfort, efficiency, and elegance.

By leveraging these diverse sources of inspiration, the project strived to go beyond conventional transportation paradigms and create a vehicle concept that would transcend boundaries, offering an unprecedented level of exhilaration and satisfaction.

Research Plan

The aim of this research plan is to guide a vehicle design project focusing on three key areas: hydrogen fuel cell technology, the Indian Golden Quadrilateral, and smart vehicle technology of 2040. The project will begin with a PESTLE analysis, followed by keyword identification and trend analysis. The information gathered will then be shared with industry experts from relevant fields to identify important and uncertain factors. Based on this analysis, four scenarios will be created using a 4-quadrant plot, and one scenario will be selected for further development. The selected scenario will serve as the foundation for developing vehicle design ideas through storyboards, sketches, and other relevant techniques.

1. PESTLE Analysis:
a. Hydrogen Fuel Cell Technology:
Analyze the political, economic, social, technological, legal, and environmental factors impacting the adoption and development of hydrogen fuel cell technology.

b. Indian Golden Quadrilateral:
Conduct a PESTLE analysis focusing on the political, economic, social, technological, legal, and environmental factors related to the Indian Golden Quadrilateral project.

c. Smart Vehicle Technology of 2040:
Investigate the PESTLE factors shaping the future of smart vehicle technology, considering the political, economic, social, technological, legal, and environmental aspects.

2. Keyword Identification and Trend Analysis:
Identify and compile keywords and trends from the PESTLE analysis in each area. Analyze the importance and uncertainty of these keywords and trends with the input of industry experts.Categorize the identified factors as important or uncertain based on expert opinions.

3. Scenario Creation and Selection:
Develop four scenarios using a 4-quadrant plot, incorporating the important and uncertain factors from the previous analysis. Evaluate each scenario's potential impact on vehicle design and performance. Select one scenario for further development based on its feasibility, desirability, and potential impact on the target audience.

4. Vehicle Design Idea Development:
Utilize storyboards, sketches, and other visual aids to conceptualize vehicle design ideas based on the selected scenario. Conduct iterative design sessions with project guides to refine and enhance the chosen concepts. Evaluate the feasibility and practicality of the design ideas, considering experiential, and technical aspects.

Introduction

In the quest for sustainable transportation solutions, the convergence of emerging technologies and infrastructure advancements has opened up a world of possibilities. This speculative study delves into the realm of vehicle design, envisioning the future of transportation by examining the interplay between hydrogen fuel cell technology, the Indian super highways, and smart vehicle technology in the year 2040.

To undertake this study, a PESTLE analysis serves as the foundation, examining the political, economic, social, technological, legal, and environmental factors that shape the landscape surrounding these key areas. By dissecting these factors, we gain invaluable insights into the potential opportunities and challenges that lie ahead for the design and development of vehicles in this futuristic context.

Hydrogen fuel cell technology represents a promising alternative to traditional fossil fuel-based power systems. Through a PESTLE analysis, we explore the political will and regulatory frameworks driving the adoption of hydrogen fuel cells, the economic viability of hydrogen production and infrastructure, the social acceptance and awareness of this technology, the technological advancements and efficiency improvements, as well as the legal and environmental considerations associated with its implementation.

Simultaneously, we examine the Indian super highways, focusing on the political commitment and investment in infrastructure development, the economic impact on trade and transportation, the social implications for mobility and connectivity, the technological integration required to support smart highways, the legal framework governing their operation, and the environmental sustainability measures associated with their construction and operation.

Moreover, the study delves into the evolution of smart vehicle technology in the context of 2040. By analyzing the political landscape, economic incentives, social expectations, technological advancements, legal considerations, and environmental imperatives, we gain a comprehensive understanding of the potential for intelligent and connected vehicles to revolutionize the way we travel, interact, and experience mobility.

By combining the insights derived from this PESTLE analysis, we embark on a speculative journey, imagining the possible futures that may emerge from the convergence of hydrogen fuel cell technology, the Indian super highways, and smart vehicle technology in 2040. Through creative ideation and design thinking, we aim to generate visionary concepts that push the boundaries of what transportation can be, offering sustainable, efficient, and intelligent solutions for a future world on the move.This speculative study sets the stage for a transformative vehicle design project, where the boundaries of imagination and innovation are stretched to create tangible designs that pave the way for a sustainable and connected future of mobility.

1. Hydrogen Fuel Cell: 2040 Scenario

1.1 Green Hydrogen

Green hydrogen, produced through electrolysis using renewable energy sources, is a game-changer in the quest for sustainability. As a carbon-neutral alternative, it offers zero greenhouse gas emissions during production and utilization. Its versatility makes it valuable in transportation, industrial processes, and energy storage, providing clean fuel, reducing emissions, and enhancing grid stability. Green hydrogen holds immense potential to revolutionize our energy landscape, promoting a low-carbon future, energy security, and economic growth. Overcoming technological, economic, and infrastructural challenges is crucial for its widespread adoption. With collaborative efforts and a commitment to sustainability, green hydrogen has the power to transform our energy systems, paving the way towards a cleaner and more prosperous world.

Rather than using fossil fuels, green hydrogen is made by using a process called electrolysis to split water into hydrogen and oxygen. If that process is powered by a renewable energy source, such as wind or solar power, then the hydrogen is referred to as being green.

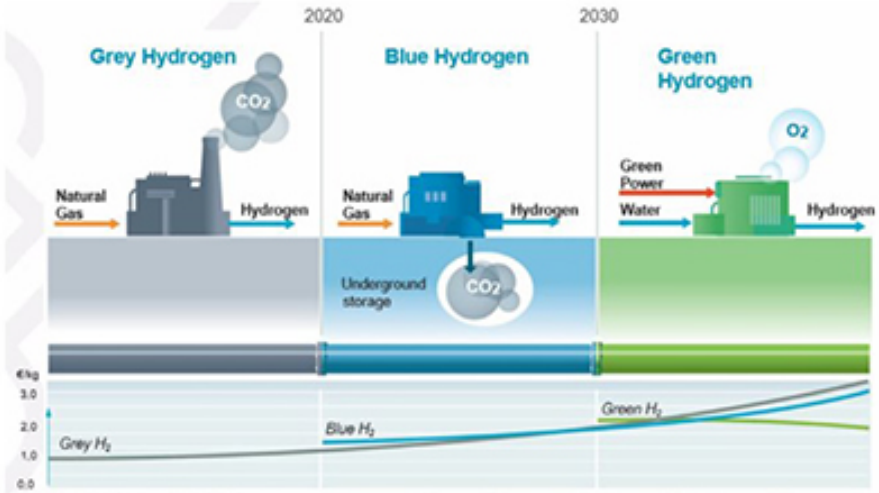


Image 1.1 Basic Difference between Grey, Blue and Green Hydrogen[1]

1.2 Challenges

- Technology: Green hydrogen needs`rs to be built on a scale larger than we've yet seen.
- Transportation and Storage: Either very high pressures or very high temperatures are required, both with their own technical difficulties.
- Electricity: Creating green hydrogen needs a huge amount of electricity, which means a mind-blowing increase in the amount of wind and solar power to meet global targets.

Some current estimates are that that we need to install more offshore wind capacity than in the previous 20 years, every year for the next 30 years.

Details about green Hydrogen

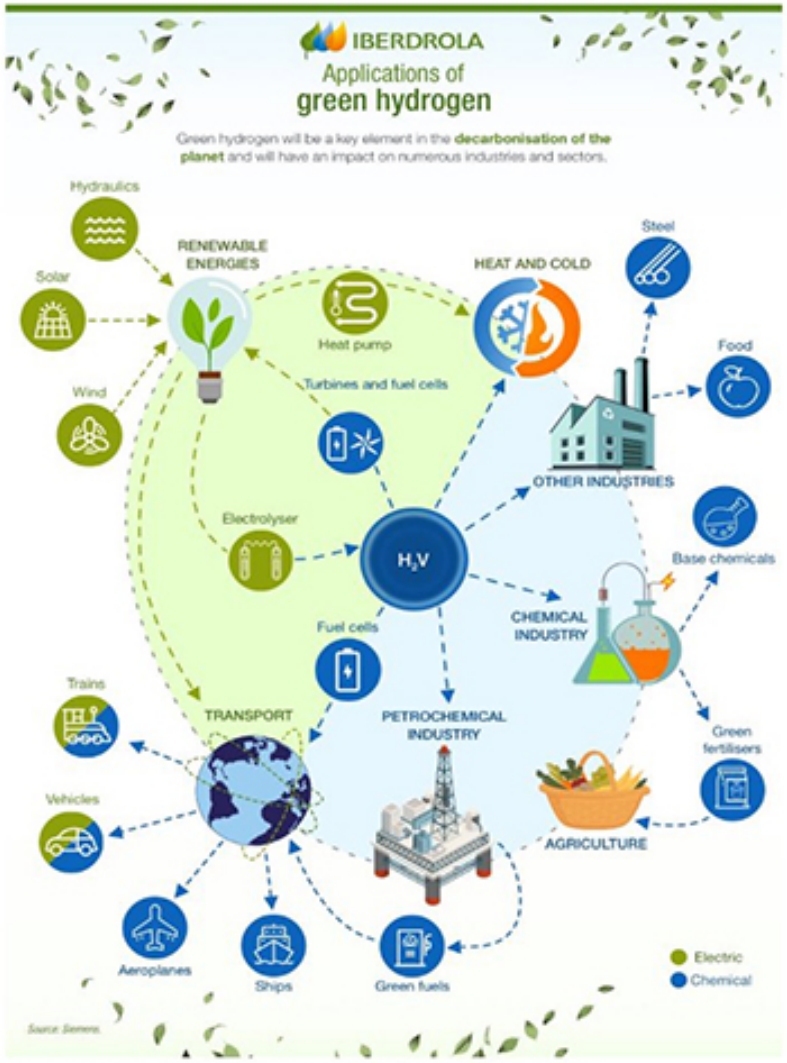


Image 1.2 Industrial applications of Green Hydrogen

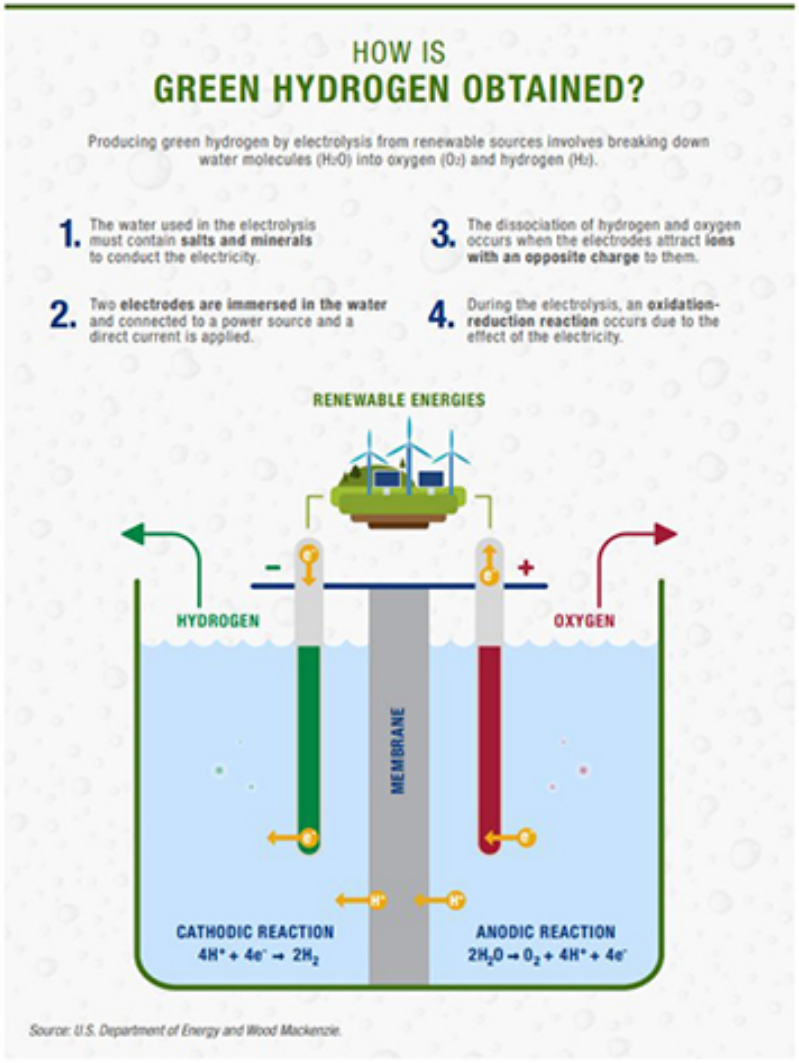


Image 1.3 Chemical preparation of Green Hydrogen

1.3 Automotive Requirements of Fuel Cell

Battery (auxiliary): In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.

Battery pack: This high-voltage battery stores energy generated from regenerative braking and provides supplemental power to the electric traction motor.

DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Electric traction motor (FCEV): Using power from the fuel cell and the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

Fuel cell stack: An assembly of individual membrane electrodes that use hydrogen and oxygen to produce electricity.

Fuel filler: A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.

Fuel tank (hydrogen): Stores hydrogen gas onboard the vehicle until it's needed by the fuel cell.

Power electronics controller (FCEV): This unit manages the flow of electrical energy delivered by the fuel cell and the traction battery, controlling the speed of the electric traction motor and the torque it produces.

Thermal system (cooling) - (FCEV): This system maintains a proper operating temperature range of the fuel cell, electric motor, power electronics, and other components.

Transmission (electric): The transmission transfers mechanical power from the electric traction motor to drive the wheels.

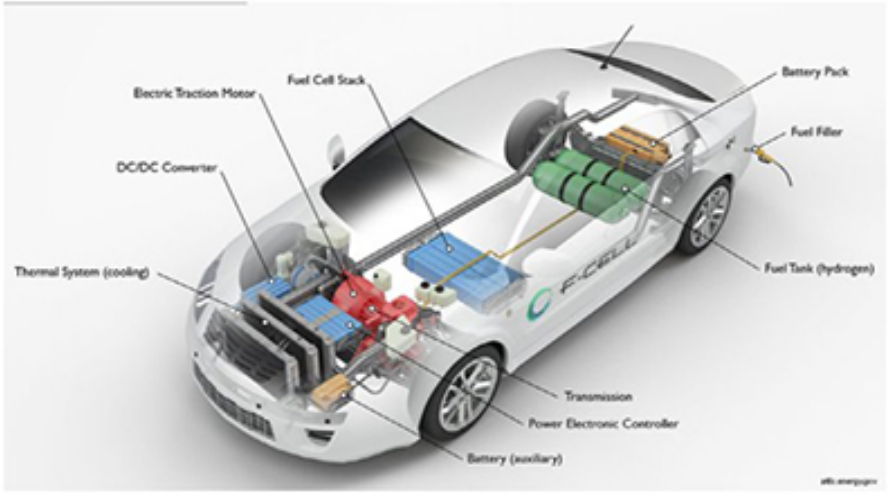


Image 1.4 Schematic showing the powertrain of a Fuel cell powered car

2. India's Green Hydrogen Ambition

Green hydrogen and its derivatives are expected to play a critical role in the world for decarbonisation at scale owing to its versatility enabling its use in many applications. Green hydrogen will also aid the decarbonisation of hard to abate sectors.

Currently, more than 95 percent2 of the world's hydrogen is fossil fuel based, produced via Steam Methane Reforming (SMR) or coal gasification. Production of hydrogen emits 9-10 kg CO2/kg of hydrogen via SMR process3 , and emits 4.1-5.2 kg CO2/kg via subbituminous coal gasification process, even with sequestration of CO2. 4 Through renewable energy-powered electrolysis, net emissions would be minimal.
Indai is one of the largest consumer of hydrogen in the world with a demand of 8.7 MTPA which comprises 7-8 per cent of the global hydrogen demand. Hydrogen is used in India, mainly as an industrial feedstock in the creation of ammonia based fertilisers and in refineries.[1]

Using this model, the cost of green hydrogen production is estimated to be around INR 320-330 per kg (KPMG India Estimates). Cost of transmission typically constituted about 25-35 per cent of the cost of green hydrogen (pre-policy situation). Currently, the focus of India's present policy is largely around the electricity transmission ecosystem. The policy provides for free and easy open access to the inter-state transmission system (ISTS), for 25 years for capacity installed by June 2025 for green hydrogen/green ammonia (GH/ GA) production.

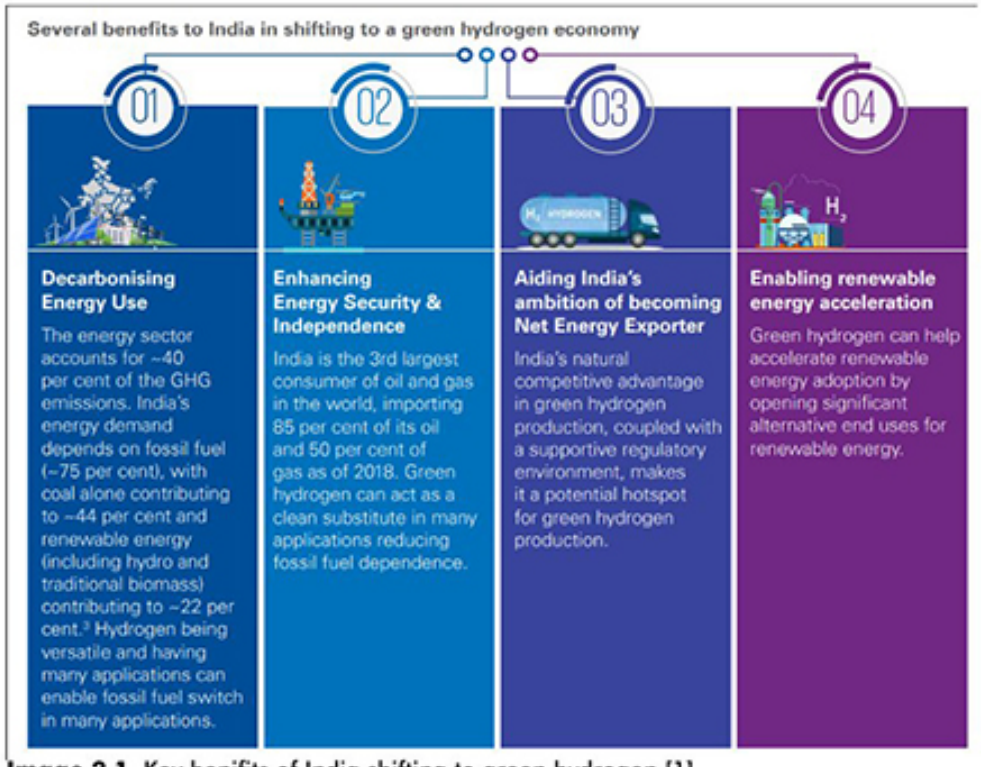


Image 2.1 Key benifits of India shifting to green hydrogen [1]

"In our estimates, the gap between green hydrogen and fossil fuel based Grey hydrogen may close significantly to 25-30 per cent, supported by policy measures as well as rising input Natural Gas costs (approx 10-13.MMBTU or even higher depending on source) driing costs of Grey Hydrogen upwards in the immediate team." [1]

2.1 Reduction in electrolyser Cost: 2040 Scenario[3]

By 2040, India is poised to witness a significant reduction in electrolyser costs, paving the way for the widespread adoption of green hydrogen and catalyzing the growth of hydrogen fuel cell vehicles. Several factors contribute to this optimistic outlook.

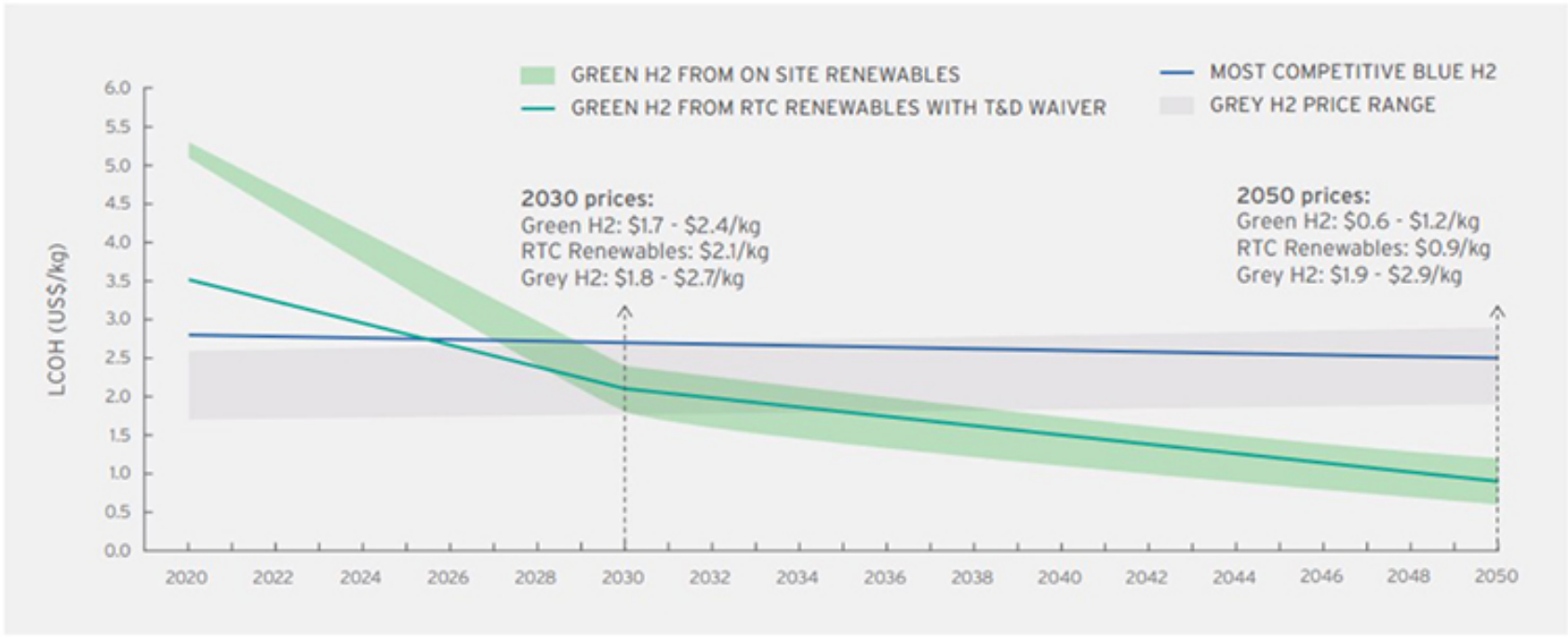
Firstly, technological advancements and economies of scale are expected to drive down the costs of electrolyser technologies. As research and development efforts continue, improvements in electrolysis efficiency, durability, and materials will lead to more cost-effective and reliable systems. Additionally, increased manufacturing capacity and competition in the market will drive down production costs, making electrolyser units more affordable for commercial and residential applications.

Furthermore, the rapidly expanding renewable energy sector in India will play a crucial role in cost reduction. As the country continues to invest in renewable energy infrastructure, the availability of low-cost solar and wind power will enable cheaper electricity for green hydrogen production. Leveraging abundant renewable resources, India can capitalize on its potential for large-scale green hydrogen production at competitive costs

The reduction in electrolyser costs is pivotal for the growth of hydrogen fuel cell vehicles in India. With affordable green hydrogen, the operating costs of hydrogen fuel cell vehicles will decrease significantly, enhancing their competitiveness compared to traditional internal combustion engine vehicles. This cost advantage, combined with the environmental benefits of zero emissions, will incentivize the adoption of hydrogen fuel cell vehicles across various sectors, including transportation, logistics, and public services.The growth of hydrogen fuel cell vehicles will, in turn, create a positive feedback loop for the hydrogen economy. Increased demand for hydrogen fuel cell vehicles will drive investments in hydrogen refueling infrastructure, creating a comprehensive network that further supports the adoption of these vehicles. As the scale of production and usage increases, economies of scale will continue to reduce costs, making green hydrogen an increasingly attractive and viable option for the automotive industry and beyond.

In conclusion, the projected reduction in electrolyser costs in India by 2040 holds immense potential for the growth of hydrogen fuel cell vehicles, powered by green hydrogen. Technological advancements, economies of scale, and the availability of low-cost renewable energy sources will combine to make electrolyser technologies more affordable. This cost reduction will make green hydrogen a competitive and sustainable alternative for the transportation sector, driving the adoption of hydrogen fuel cell vehicles and fostering the development of a robust hydrogen ecosystem in India.

2.2 Speculative Charts predicting Cost reduction by 2040

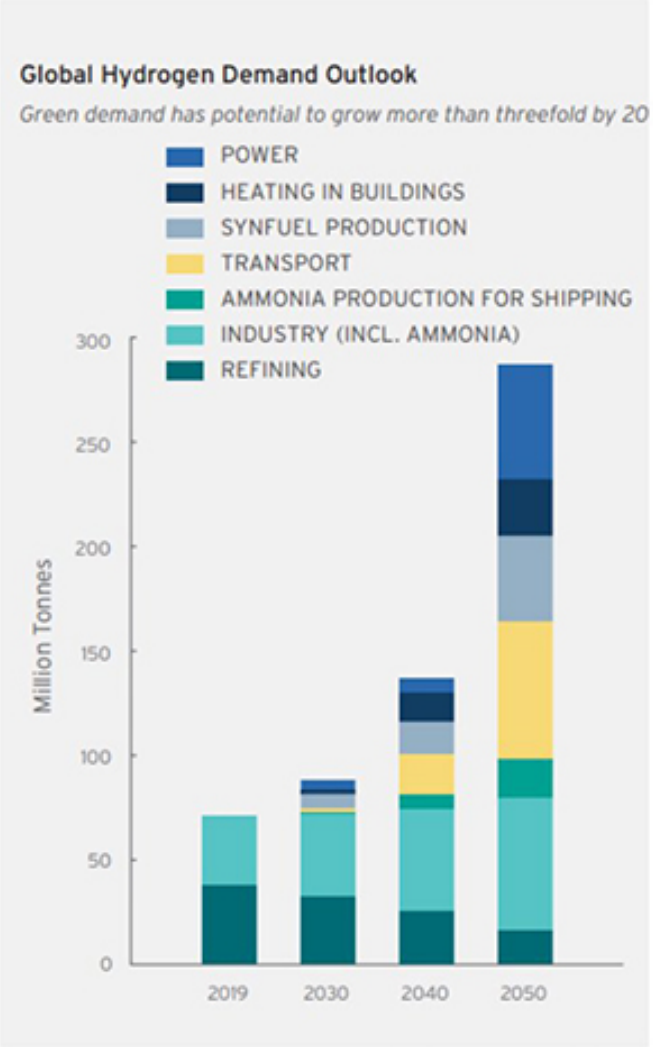


Source: IEA, BNEF, TERI, SECI, RMI Analysis | **Currency conversion:** $1 = ₹72

Image 2.2 Projected price trajectory of solar-green hydrogen production based on decline in electrolyser and renewable costs[2]

Image sourced from NITI Aayog report on' HArnessing GREEN HYDROGEN' report[2]

2.2 Charts predicting Increase in Demand leading to cost reduction



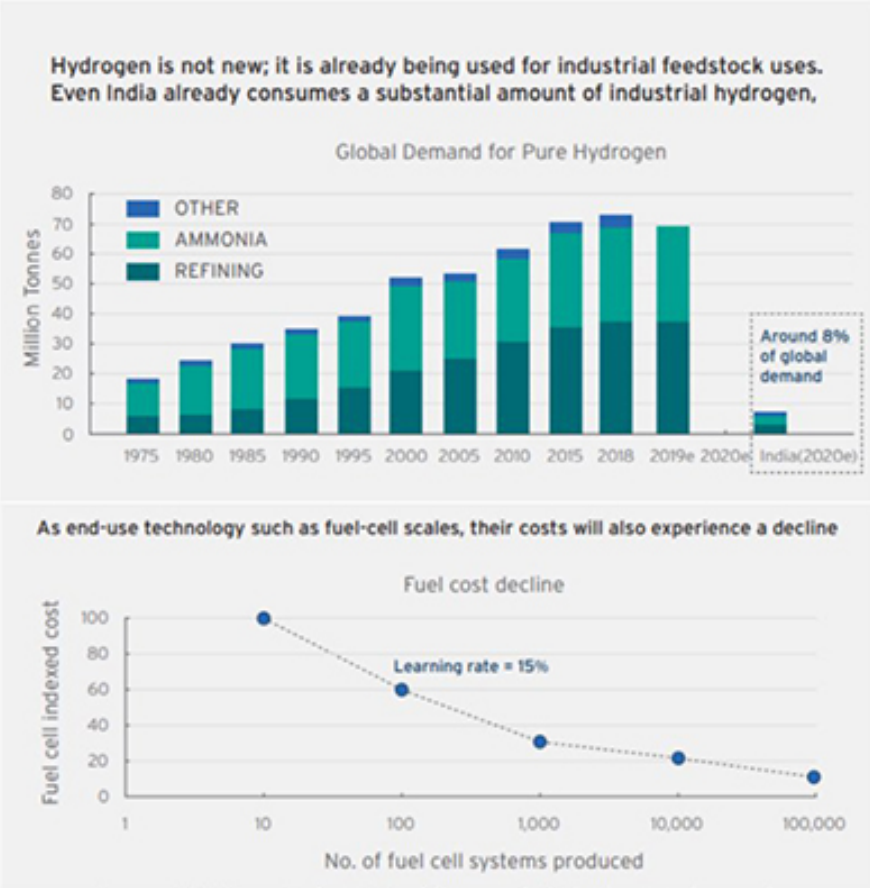


Image 2.3 Expected sustainable growth in hydrogen demand

Note: Image sourced from NITI Aayog report on' HArnessing GREEN HYDROGEN' report[2]

2.3 Renewable Energy in India: Scenario 2040

India boasts a vast and diverse range of renewable energy sources, positioning it as a potential leader in the future development of a green hydrogen economy and fuel cell vehicles. The country's abundant renewable resources include solar, wind, hydro, biomass, and geothermal energy, presenting a significant opportunity for sustainable energy generation.

India is blessed with ample sunshine throughout the year, making solar energy a particularly promising resource. With vast expanses of land and a favorable geographical location, India has the potential to harness solar power on a large scale. Additionally, the country's long coastline provides ample opportunities for offshore wind energy generation, while its varied terrain allows for the development of small and large-scale hydropower projects. Moreover, India has a rich agricultural sector, which can be leveraged for biomass energy production, further diversifying the renewable energy mix.

The availability of such a wide range of renewable energy sources is crucial for the future development of a green hydrogen economy and fuel cell vehicles in India. Renewable energy serves as the foundation for producing green hydrogen through electrolysis, ensuring a clean and sustainable source of hydrogen fuel. The scalability of renewable energy sources allows for large-scale green hydrogen production, catering to the growing demand for fuel cell vehicles in the transportation sector.

The availability of such a wide range of renewable energy sources is crucial for the future development of a green hydrogen economy and fuel cell vehicles in India. Renewable energy serves as the foundation for producing green hydrogen through electrolysis, ensuring a clean and sustainable source of hydrogen fuel. The scalability of renewable energy sources allows for large-scale green hydrogen production, catering to the growing demand for fuel cell vehicles in the transportation sector.

Furthermore, strategically developing renewable energy sources around highways like the Golden Quadrilateral and connecting important tourist destinations presents additional benefits. By installing solar panels along highways, India can tap into the abundant solar energy potential while utilizing land efficiently. These solar installations can generate clean electricity to power hydrogen production facilities, enabling the production of green hydrogen locally. This localized energy production can lead to reduced transmission losses and provide a reliable and decentralized source of fuel for fuel cell vehicles.Moreover, incorporating renewable energy infrastructure along highways can serve as a catalyst for sustainable tourism. Visitors traveling along these routes can witness India's commitment to clean energy and experience the benefits of fuel cell vehicles powered by green hydrogen. The development of renewable energy sources in tourist destinations can further promote sustainable practices and contribute to the overall environmental consciousness of the tourism industry.

In conclusion, India's wide range and expanse of renewable energy sources, including solar, wind, hydro, biomass, and geothermal energy, create a favorable environment for the future development of a green hydrogen economy and fuel cell vehicles. Leveraging these resources, particularly around highways like the Golden Quadrilateral and important tourist destinations, can accelerate the adoption of renewable energy, foster local green hydrogen production, and promote sustainable tourism practices. India's commitment to renewable energy not only supports its energy transition but also contributes to a greener and more sustainable future.

2.3 Renewable Energy in India: Predictive Plots

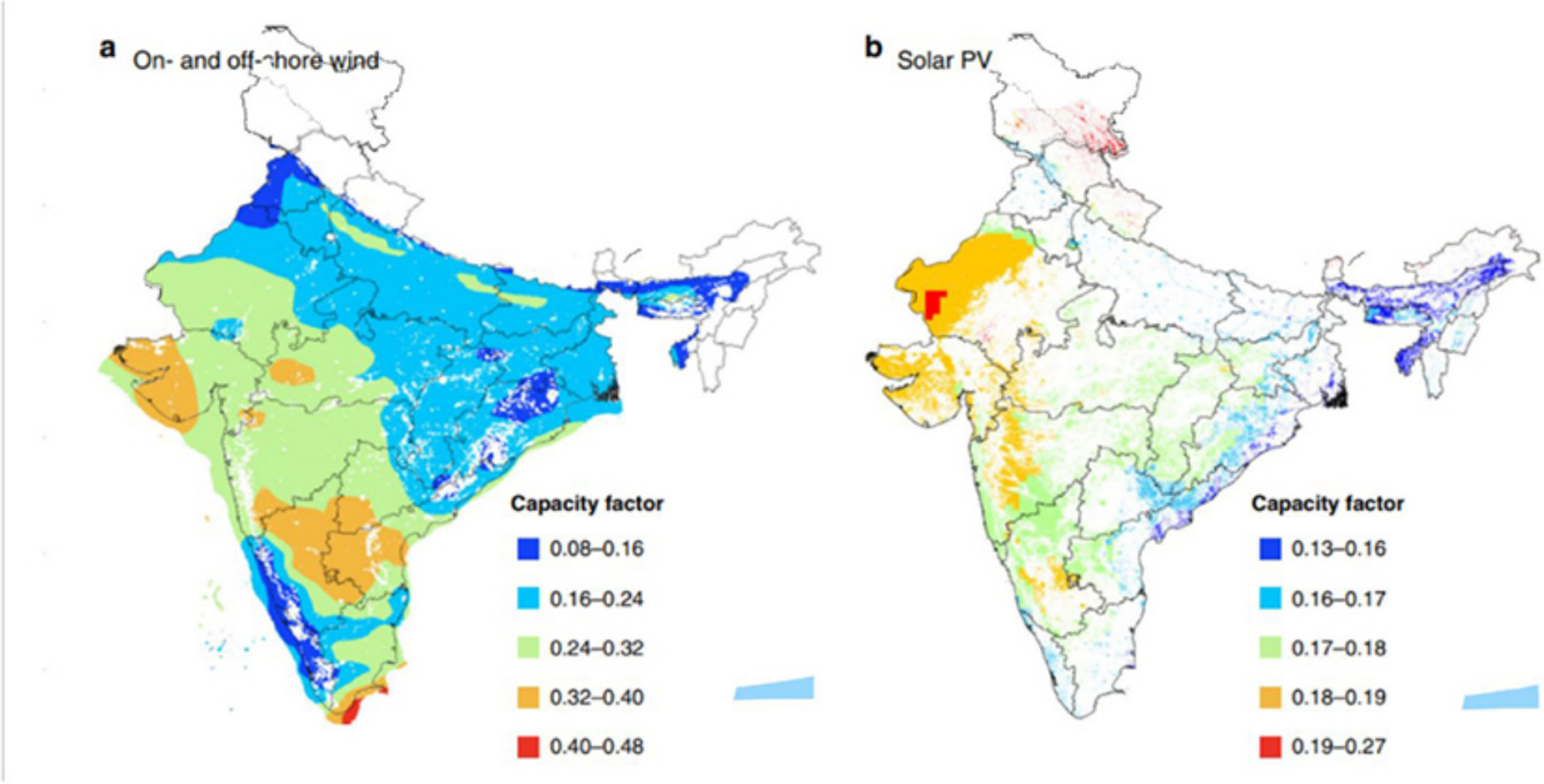


Image 2.4 Reneable capacity factors. Spatial distribution of mean annual capacitfactors for **a** on- and off shore wind and **b** solar PV constructed based on meteorological output.[3]

3. Smart Vehicles 2040

In the year 2040, Indian roads are set to witness a remarkable transformation with the widespread adoption of autonomous vehicles and IoT-based smart vehicles across various sectors. This paradigm shift will revolutionize transportation, enhancing efficiency, safety, and sustainability. These vehicles will leverage renewable energy sources, primarily hydrogen fuel cells, for their propulsion, further contributing to a greener and more sustainable future.

Autonomous vehicles will be a common sight on Indian roads by 2040, bringing about a significant shift in mobility. These vehicles will utilize advanced technologies such as artificial intelligence, machine learning, and sensor systems to navigate and operate without human intervention. With enhanced precision, autonomous vehicles will optimize traffic flow, reduce congestion, and minimize accidents, thereby improving overall road safety and efficiency.

IoT-based smart vehicles will also become prevalent in 2040, connecting vehicles to the internet and enabling seamless communication between vehicles, infrastructure, and the surrounding environment. Through real-time data exchange, smart vehicles will provide valuable insights on traffic patterns, road conditions, and predictive maintenance requirements, facilitating smoother and more efficient journeys.

Hydrogen fuel cells can be easily integrated into autonomous and smart vehicles, providing a reliable and clean power source. These vehicles will harness renewable energy, such as solar and wind power, to produce green hydrogen through electrolysis. This green hydrogen will then be utilized in fuel cells to generate electricity,

Hydrogen fuel cells can be easily integrated into autonomous and smart vehicles, providing a reliable and clean power source. These vehicles will harness renewable energy, such as solar and wind power, to produce green hydrogen through electrolysis. This green hydrogen will then be utilized in fuel cells to generate electricity, powering the vehicles' electric motors and ensuring long-range capability without harmful emissions.

3.1 Futuristic Trends in Vehicles: 2040

In the year 2040, autonomous and IoT-based smart vehicles in India will be equipped with an array of advanced features that enhance convenience, safety, and connectivity. These smart features will revolutionize the driving experience and contribute to a more efficient and intelligent transportation system. Some notable smart features of these vehicles include:

1. Connectivity and Communication: Smart vehicles will be connected to the internet, allowing seamless communication with other vehicles, infrastructure, and the surrounding environment. This connectivity enables real-time data exchange, providing valuable information on traffic conditions, road hazards, and navigation updates.

2. Advanced Driver Assistance Systems (ADAS): These vehicles will be equipped with sophisticated ADAS technologies, including adaptive cruise control, lane-keeping assist, automatic emergency braking, and blind-spot detection. These systems enhance safety by assisting drivers in various situations, reducing the risk of accidents.

3. Predictive Maintenance: Smart vehicles will employ IoT sensors and predictive analytics to monitor their health and performance in real-time. This enables proactive maintenance scheduling, identifying potential issues before they lead to breakdowns and optimizing the lifespan of vehicle components.

4. Intelligent Navigation: Integrated GPS and mapping systems will provide real-time traffic updates, suggesting optimal routes to drivers and considering factors such as congestion, road conditions, and weather. Additionally, smart vehicles will have the ability to communicate with traffic management systems, optimizing traffic flow and reducing congestion.

5. Voice and Gesture Control: Smart vehicles will feature advanced human-machine interfaces, allowing drivers and passengers to interact with the vehicle using voice commands and gestures. This hands-free operation enhances safety and convenience while reducing distractions.

6. Enhanced Entertainment and Connectivity: These vehicles will offer advanced infotainment systems, allowing passengers to access a range of multimedia content, streaming services, and connectivity options. Passengers will be able to stay connected, work, or entertain themselves during their journeys.

7. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Communication: Smart vehicles will communicate with each other and with surrounding infrastructure, sharing information on speed, location, and road conditions. This facilitates cooperative driving, collision avoidance, and traffic management optimization.

8. Energy Efficiency Optimization: Smart vehicles will employ advanced algorithms and machine learning to optimize energy usage, extending the range of electric and hydrogen fuel cell-powered vehicles. These systems will adjust power output, route selection, and charging patterns to maximize efficiency.

4. Driving force and Key Trends

A PESTLE analysis is a valuable tool for understanding the driving forces and key trends that shape the external environment of an organization or industry. By examining the political, economic, social, technological, legal, and environmental factors, a PESTLE analysis provides insights into the opportunities and challenges that can impact business strategies and decision-making.

The driving forces identified through a PESTLE analysis highlight the major factors that exert influence on the industry or organization. These forces can include political stability, economic growth, social attitudes and demographics, technological advancements, legal regulations, and environmental sustainability. Understanding these driving forces helps organizations anticipate and respond to changes in the external environment, positioning them for success.

Key trends identified through a PESTLE analysis reflect the patterns and shifts that are shaping the industry or market. These trends can include emerging technologies, changes in consumer behavior, regulatory shifts, socioeconomic shifts, or environmental concerns. The following list of Driving forces and key trends where presented to industry experts to rate them on a scale of 1-5 based on its importance and certainity.

4.1 Political

UN COP26, Glasgow
EU investments
Agenda 2030 for sustainable development
UN Sustainable Development Goals
Nation Hydrogen energy road map
Green Hydrogen Policy (February 2022)
India's EV Vision
FAME II policy (faster adoption & manufacturing of Electric Vehicles-Phase II)
Hydrogen pipeline networking policies
India as global Hydrogen hub
International Cooperation - IEA, IPHE
Implemenation Agreements - HIA, AFCIA
Short term strategy with low economic disadvantage
Long term strategy for fuel cells
CO2 Emission standards
Refill station incentives
EV Fiscal Incentives
Energy economy modelling
Multi modal Logistic policy
Highway expansion poicies
Highway contractors renegotiation
trade agreements
geopilitics
Strong leaders
Low emmision zones (LEZ) regulation

4.2 Economics

Electrolyser Cost
Operating cost
Fiscal incentives for electrolyser
electricity duty
Raw material cost - Electrode, Catalyst
Cross subsidy surcharge
domestic manufacture of Electrolyser
Brownfield and greenfield investment interplays
Hydrogen Corpus Fund (HCF)
Total cost of ownership (TCO)
Financial Incentives
Purchase and Scrapping Incentives
Global Internet Traffic
National Integrity
New employment creation
Public investments
Low-carbon economy
LCOE(Levelized cost of electricity) for renewable energy
Smooth Material transportation
Access to small towns along the highway
Decarbonisation in commercial vehicles sector
Smart cities

4.3 Social

ISTS- Inter state transmission system
Maintenance of road surface and signs
public outreach programmes
private charging port - policy & implementation
Hyper individual mobility
Fusion of art and Technology
Place of escape
shared mobility
Hyper connected society
Acceptance in society
Social status
Aspirational product
Affordability
safety concerns among users
Population density
tangible value
Access Anxiety in AVs
risks to non-auto travelers
vehicle repair costs
Average number of connected devices, per person
Accessibility
Standardization
Virtual human interaction
Cognitive overdose of technology
Quality of Experience (QoE)
9 billion population
Aging population (over 65s)

4.4 Technological

Green hydrogen
Electrolyser R&D
Hydrogen Transportation
Hydrogen storage methods
Biomass Gasification - H2 production
Power grid upgradation
Embrittlement in transport pipelines
Life Cycle Assesment
RTC Renewables
Innovation in Electrolysers: Photoelectrolysis
Proton exchange membrane (PEM) electrolyser
Corrossion resistant fuel cell
Reduction of precious metal concentration in fuel cell
Alkaline electrolyser
Photocatalyst
Plant-scale-compatible photobiological water splitting
Direct air electrolyser
Direct solar water splitting
Biochemical (Algae) Hydrogen production
Green hydrogen
Big Data management
Biological & Emotional based signals/feedbacks
gesture control
voice control
core multimedia centre
OTA Updates
Vehicle centralised zone oriented architecture
IoV Internet of vehicles
IoE Interconnection of Everything
Multi Access Edge computing (MEC)

3D object recognition
V2X (Vehicle to Everything)
V2P (vehicle to pedestrian)
Intersection Movement Assist (IMA)
Forward Collision Warning (FCW)
infrastructure-to-vehicle (I2V) communication
Stationary vehicle warning (SVW)
Emergency electronic brake light (EEBL) warning
Eco-ICM Decision Support System
Dynamic Eco-Routing
CV-enabled Turning Movement & Intersection Analysis
EMTRAC Emergency Vehicle Preemption (EVP)
Space-Air-griund-sea interated network
Energy conversion efficiency
Platooning risks
Deployment of IPv6
Sensor energy - nanogenerator
SMart wireless charging of vehicles
Blockchain for vehicular edge computing
Centralised and distributed AI
Full Automation
Conditional-High Automation

4.5 Legal

FAME II policy (faster adoption & manufacturing of Electric Vehicles- Phase II)
International Cooperation - IEA, IPHE
Implemenation Agreements - HIA, AFCIA
single legislative framework
hydrogen purchase obligation (HPO)
renewable purchase obligation (RPO)
CAFE - Corporate average fuel economy
carbon credit certificates
resettlement after land aquisition
compensation - (for required scenario shift)
mandate Public, private charging port
End to End data encrytion
Hydrogen Leakage prevention
National Certifications
Crash regulations
pedestrian safety regulations
Hydrogen pipeline regulations
recylable materials
emission standards
Data rights
data privacy
location information
Malicious hacking
Blockchain and FL data protection technology
Model state insformation (MSI)
Incentive bsed data transfer and sharing
Control area netwrok (CAN) - communication protocol
Encryption and Authentication
Vehicle Environmental perception range

4.6 Environmental

Hydrogen economy
circular economy
Decarbonaisation
Energy efficiency
Life cycle Analysis (LCA)
water sourcing
Rain water harvesting
recylable materials
Ecology concern
carbon footprint
Waste disposal
product life cycle
GHGs and Aerosol emmision
Mining and extraction of Platinum (for fuel cells)
Multi wall carbon nanaotube(cheaper and effective) replacing Platinum
Research on earth abundant / carbon based Electrocatalyst
Eco-Smart Parking
Land aquisition
Abiotic depletion impacts
Global temperature rise
Fossil fuel exhaustion
Deforestation
Loss of biodiversity
Hydrogen storage risks (Invisible/highy flammable/explosion potential)
Sea water electrolysis (Renewable H2 production method)
Freshwater eutrophication

5. Importance vs Uncertainity plot

In a PESTLE analysis, the uncertainty vs. importance graph is a useful visual tool that helps identify and prioritize the key factors influencing an organization or project. The graph plots the level of uncertainty (how unpredictable or uncertain a factor is) against its importance (how significant or impactful it is) on a two-dimensional grid.

Factors falling in the high uncertainty, high importance quadrant indicate critical areas where in-depth analysis and further study are necessary. These factors are characterized by their potential to significantly impact this design project, but with considerable uncertainty surrounding their future developments.

To determine which factors should be selected for further study and use in a vehicle design project, the high uncertainty, high importance quadrant of the graph is particularly valuable. This section highlights the key drivers and trends that have the potential to shape the project's success or failure.

Expert opinions played a vital role in predicting the trends and driving forces for 2040 in the context of the vehicle design project. Industry experts possess specialized knowledge and insights that can help identify emerging technologies, regulatory shifts, social changes, and other factors that will influence the automotive industry in the future. By consulting these experts, several valuable perspectives were gained and it helped in the predictions ofthe potential trajectory of the industry, enabling to make informed decisions and develop strategies that align with future trends.

In summary, the uncertainty vs. importance graph in a PESTLE analysis provides a visual representation of the factors that carry significant importance but are surrounded by uncertainty. By focusing on the high uncertainty, high importance quadrant and seeking expert opinions, the vehicle design project can effectively identify and address the critical drivers and trends that will shape the industry in 2040.

5.1 Importance vs Uncertainity plot

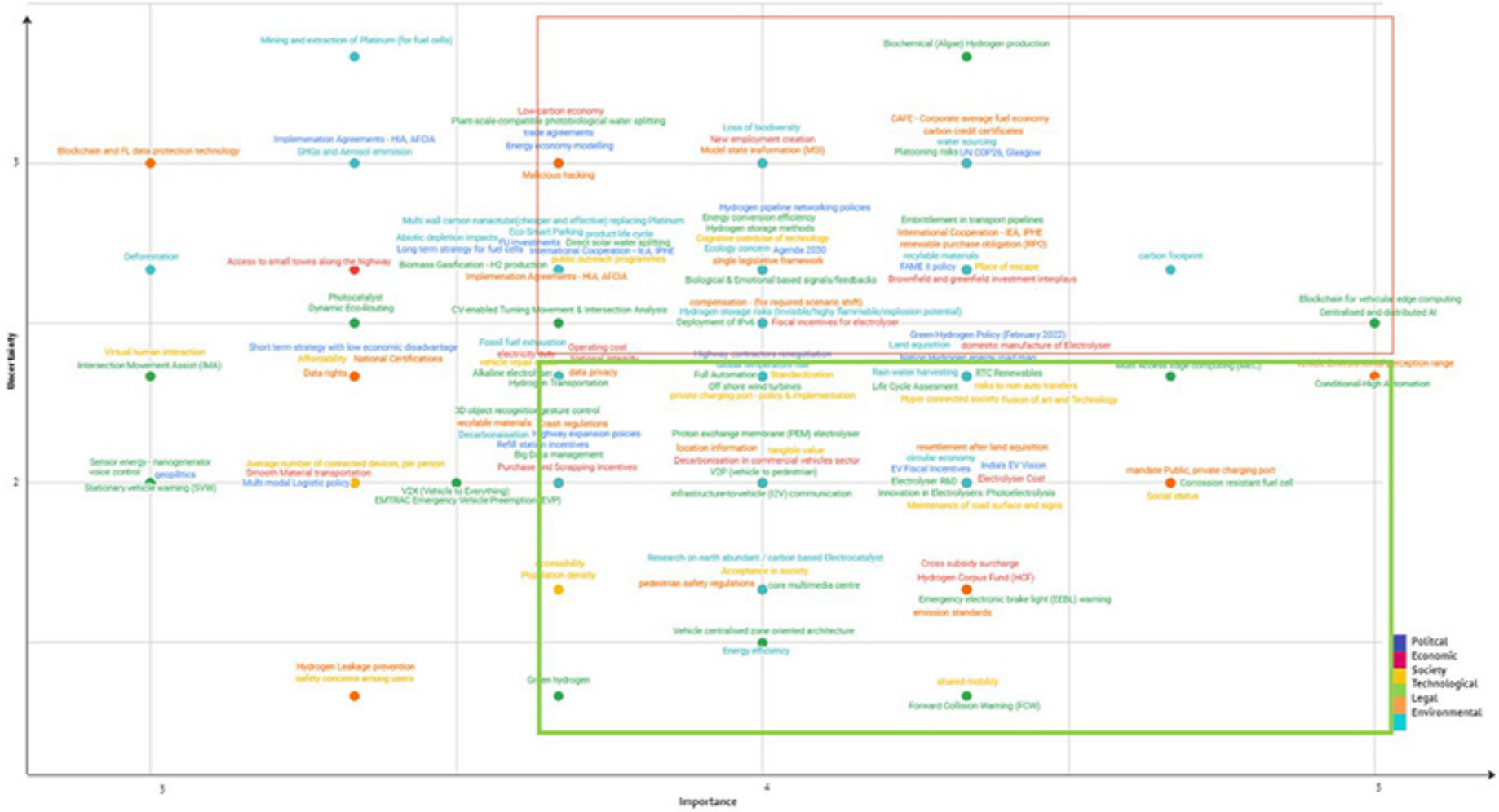


Image 5.1 Importance Vs Uncertainity plot based on PESTLE analysis

6. Future Scenario Building

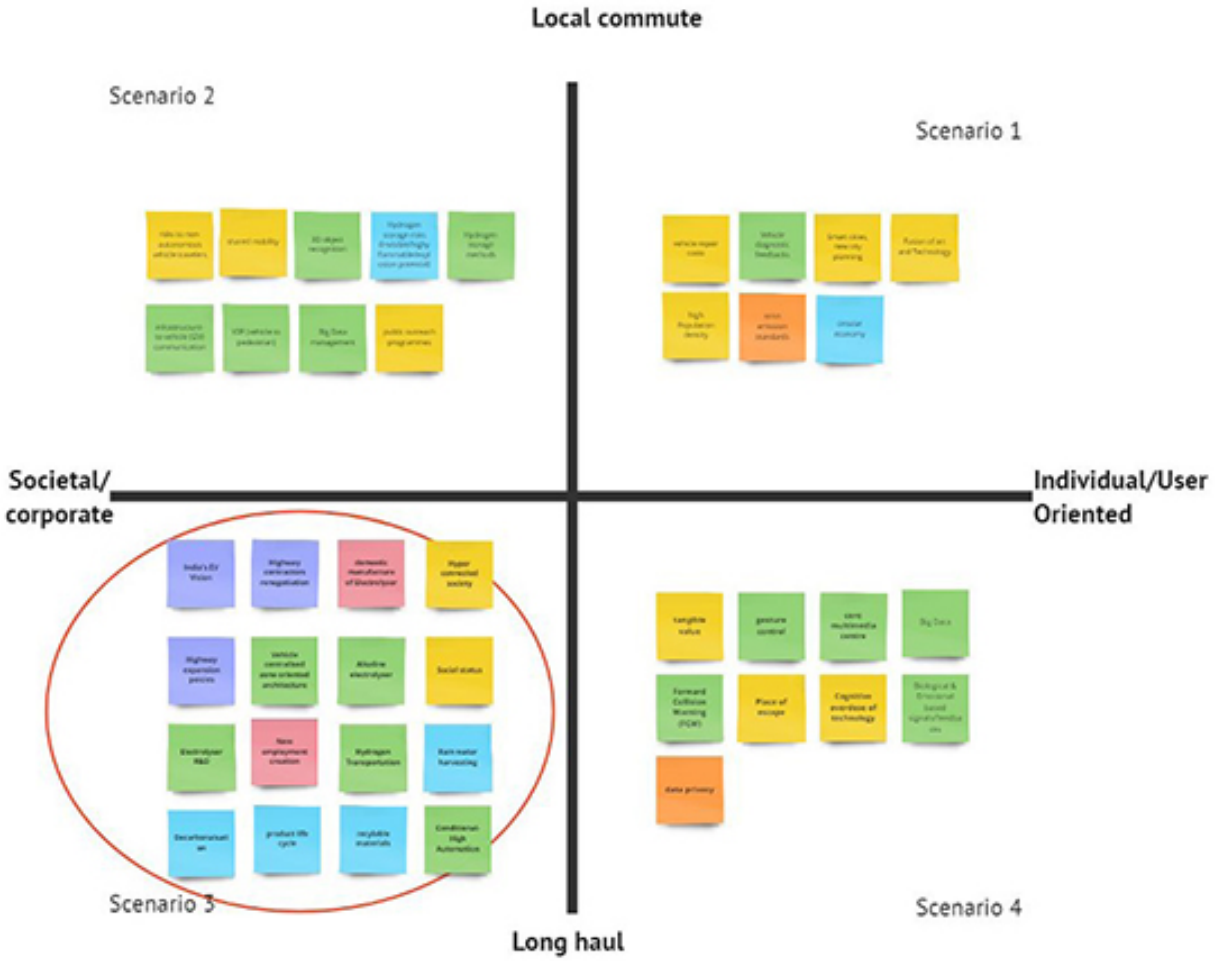


Image 5.2 Four quadrant plot showing 4 scenarios different scenarios of 2040 based on PESTLE analysis.

6.1 Scenario 1: User/Individual Oriented, Local commute scenario

In the year 2040, a user/individual-oriented system design has become the norm for local commutes. One of the key features of this system is the availability of real-time vehicle diagnostic feedback. This allows individuals to monitor the health of their vehicles and identify potential issues before they become major problems. This feedback is integrated with a circular economy model, where parts and materials are recycled and reused, reducing waste and minimizing the environmental impact of the system.

To accommodate the high population density in urban areas, the system relies heavily on public transportation and shared vehicles. The vehicles used in the system are designed with strict emission standards in mind, utilizing hybrid and electric technology to minimize their carbon footprint. The fusion of art and technology is evident in the city's design, with public art installations and interactive technology incorporated into public spaces. These cities prioritize walkability, bikeability, and public transportation, making it easy for individuals to navigate the city without relying on personal vehicles.

By prioritizing shared vehicles and public transportation, reducing vehicle repair costs through predictive maintenance, and incorporating circular economy principles, this system is able to provide a reliable and environmentally friendly solution to local commuting.

6.2 Scenario 2: Societal/ Corporate Oriented, Local commute scenario

In the year 2040, society has shifted towards a corporate-oriented system design, where shared mobility has become the norm. The risks associated with non-autonomous vehicle travel have been recognized, and the majority of vehicles on the road are now autonomous.

One of the key technological advancements that have enabled this shift is the development of 3D object recognition systems. These systems have greatly improved the accuracy and reliability of autonomous vehicles, allowing them to navigate through crowded streets with ease.
However, there are still risks associated with the storage of hydrogen, which is commonly used as a fuel source for autonomous vehicles. These risks include its invisibility, highly flammable nature, and potential for explosions. As a result, new hydrogen storage methods have been developed, which prioritize safety over efficiency.

To ensure the safety of all road users, infrastructure-to-vehicle (I2V) communication has become standard practice. This system allows autonomous vehicles to communicate with traffic lights, road signs, and other infrastructure, enabling them to make more informed decisions and avoid accidents.
Another key development has been the introduction of vehicle-to-pedestrian (V2P) communication. This system allows autonomous vehicles to communicate with pedestrians, warning them of their presence and ensuring their safety.
The management of big data has become increasingly important in this new system design. The vast amounts of data generated by autonomous vehicles and their associated infrastructure require sophisticated management systems to ensure they are processed efficiently and effectively.

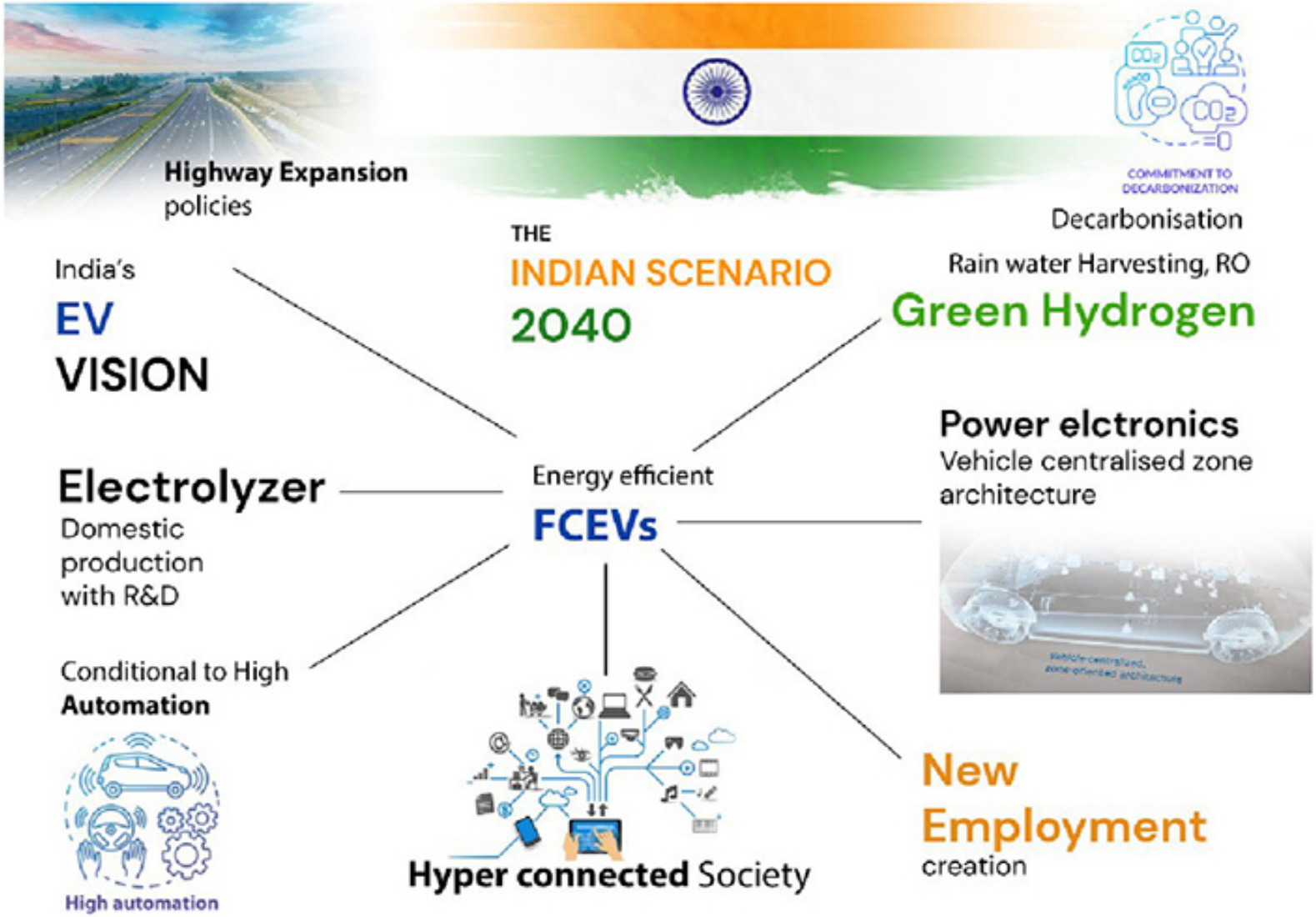
Finally, public outreach programs have played a crucial role in the adoption of this new system design. Through education and outreach efforts, the public has become more aware of the benefits of shared mobility, autonomous vehicles, and the importance of safety. As a result, society has embraced this new corporate-oriented system design, leading to a safer, more efficient, and sustainable transportation system.

6.3 Scenario 3: Societal/ CorporateOriented, Long Haul scenario

In 2040, India has made significant progress in its EV vision, with the government actively promoting the use of electric vehicles to reduce carbon emissions. As a result, the vehicle design project for the Golden Quadrilateral focuses on creating a sustainable and eco-friendly transport system.

The government has also incentivized the domestic manufacture of electrolyzers to produce green hydrogen. The use of alkaline electrolyzers and rain water harvesting is preferred as they have a lower carbon footprint compared to traditional methods of hydrogen production.
The society has become hyper-connected, and the new vehicle design concept caters to this by incorporating advanced connectivity features. The social status of owning a clean and eco-friendly vehicle has also increased, leading to a surge in demand for such vehicles.
The vehicle's centralised zone-oriented architecture is designed to optimise data transfer and optimise the information processing.
The highway expansion policies also prioritize the creation of dedicated lanes for EVs and hydrogen-powered vehicles. The project has also created new employment opportunities, including R&D for electrolyzers and hydrogen transportation.
The vehicle's product life cycle is also taken into consideration, and the use of recyclable materials is preferred. Conditional-high automation features have been incorporated to promote safety and reduce accidents.
Overall, the project is geared towards decarbonization, with a focus on sustainable and eco-friendly transportation.

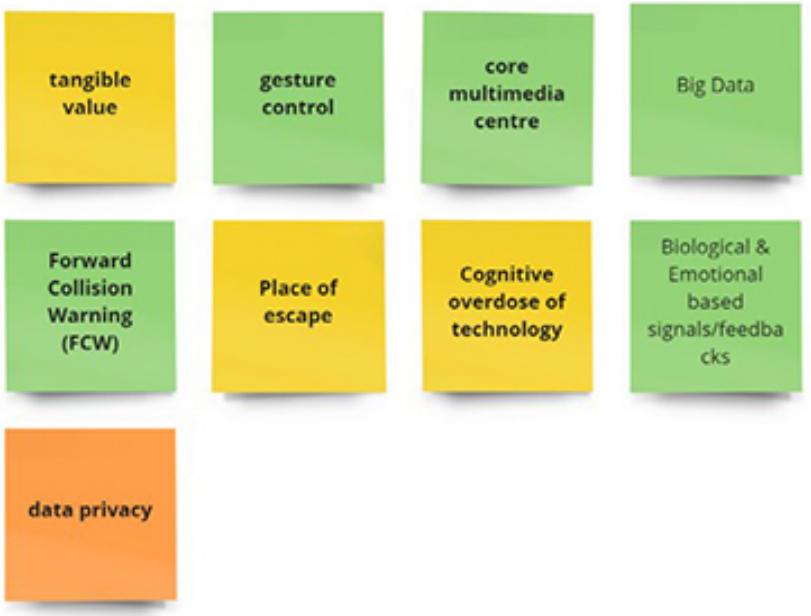
6.3.1 Visual Representation of Scenario 3



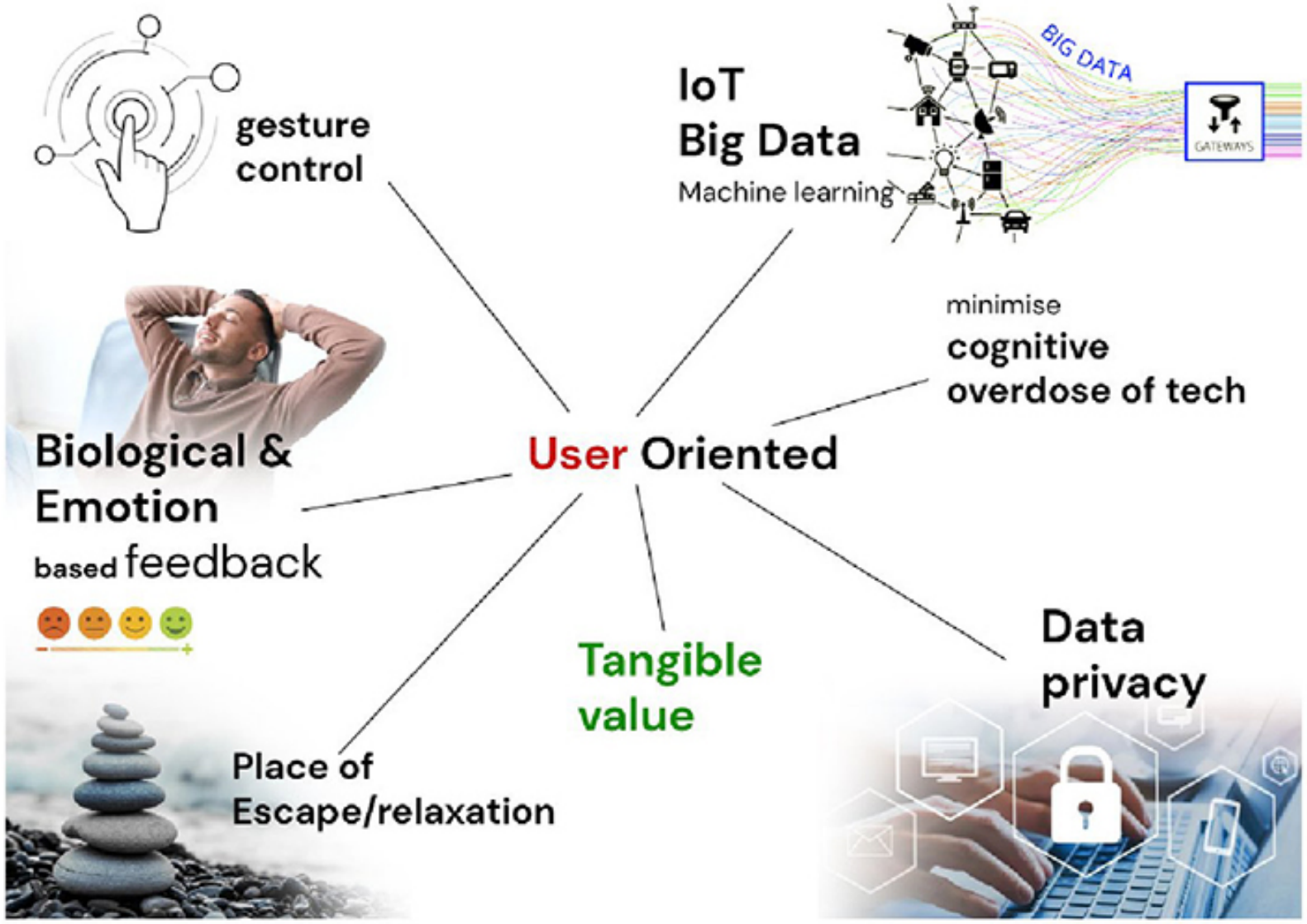
6.4 Scenario 4:

In the year 2040, a new user-oriented system design has been introduced that revolutionizes the way people interact with technology. The system utilizes IOT and Big Data with interactions like gesture control, and a core multimedia centre to provide tangible value to users, while also prioritizing safety, comfort, and privacy.
The core of the system is the multimedia centre, which acts as a hub for all interactions. Using gesture control technology, users can access a range of services, including entertainment, communication, and information. The system is designed to avoid cognitive overload by limiting the amount of technology used in the user interface, making it easy for people to navigate and use the system. The system continuosly takes feedback and through machine learning understands user preferneces and improve over time.

The scenario has well developed next gen ADAS, with 3d Object recognition and state of the art safety systems. The system is also designed to promote relaxation and well being. The system includes a "place of escape/relaxing" where users can unwind and recharge. This concept may include comfortable seating, ambient lighting, and calming sounds to help users de-stress and relax. The system also utilizes biological and emotional-based signals/ feedbacks to provide users with a more personalized experience. For instance, the system can adjust the lighting and temperature based on users' emotional state to provide a more comfortable environment.Data privacy is a critical consideration in the system's design. All data collected is anonymized, and users have control over the data they share with the system. The system is designed to be transparent and user-friendly, so users can understand how their data is being used and have the option to opt-out of data collection if they wish. Overall, the user-oriented system design provides tangible value to users by prioritizing safety, relaxation, and privacy.



6.4.1 Visual Representation of Scenario 4



6.5 Selected Scenario & Justification

Scenario 3 was selected and studied further for developing a vehicle design project within it. The scenario in 2040 is a societal/corporate oriented one, which means the aspects under consideration are at a corporal/central level. This mainly includes policies for green hydrogen and fuel cell vehicles. A scenario where the society is fully equipped to handle fuel cell powered vehicles with a lot of smart technologies like High to conditional Autonomy, and vehicles which make use of latest power electronics and new packaging methods for better processing of data and efficient route planning methods.

Further, scenario 4 was also considered to bring out the human/ user aspect into the project. Scenario 4 is an individual/local oriented one with lot of points regarding how humans will evolve by 2040. Their likes and dislikes, preferences, technology in use etc. So, by 2040 humans would be using technology helping them to stay connected with one another at a much higher level than now in 2023. With the cognitive overdose of technology, people would love to have a place of escape/relaxation.

7.1 Stories based on selected scenario

A group of bright-eyed and adventure-seeking students from IIT embarked on a much-awaited road trip. Their spirits were high, and their hearts filled with the excitement of exploration. With a map in hand and a playlist of their favorite tunes, they set off on a journey filled with endless possibilities.

Their road trip wasn't just about reaching a destination; it was a quest for unforgettable experiences. They took detours to scenic spots, discovering hidden gems along the way. With tents and camping gear, they embraced the freedom of overnight stays under the starry sky, sharing laughter and stories around a crackling bonfire.

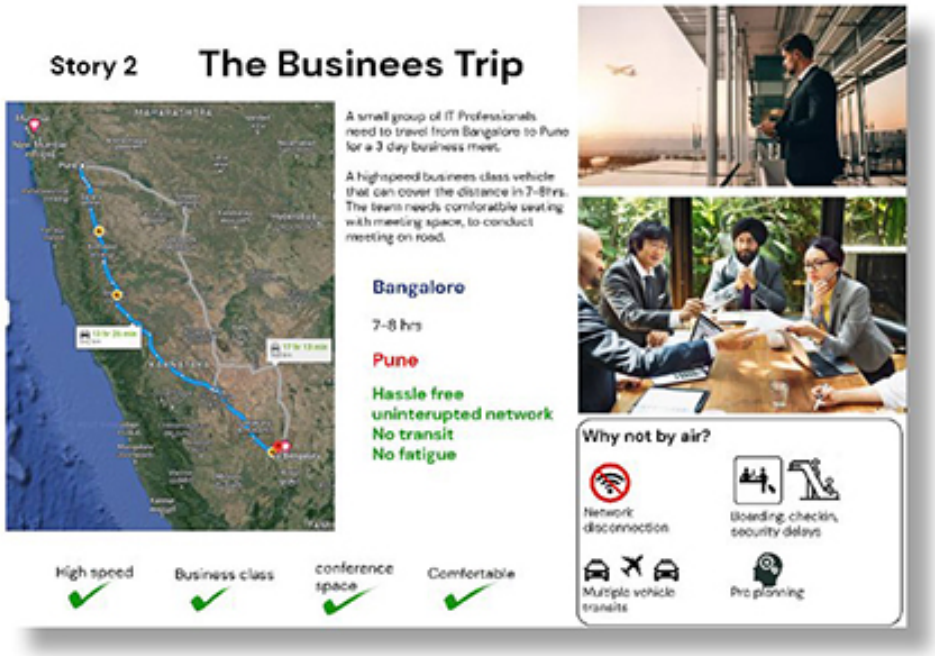
But it wasn't just the natural beauty that captivated them. The latest technology they had at their fingertips added an extra layer of enjoyment to their journey. They relied on smart navigation systems to find the best routes, capturing stunning landscapes with their high-resolution cameras. In their sleek and futuristic vehicle, they experienced the thrill of highway cruises, feeling the wind in their hair and the freedom of the open road.

Amidst all the adventure, they found time to relax and cherish the moments of togetherness. Whether it was playing road trip games, singing along to their favorite tunes, or experimenting with the latest gadgets, laughter filled the air. Their road trip was a perfect blend of relaxation, fun, and exploration—a testament to the spirit of youth and the wonders of technology. As they returned, their hearts brimming with memories and a sense of camaraderie, they knew that this road trip would forever remain etched in their minds as a chapter of freedom and joy.

7.2 Stories based on selected scenario

Opting for a road trip, a multinational corporate executive embarked on a business journey from Bangalore to Pune, seeking a blend of relaxation and speed. They were delighted to experience a hassle-free and uninterrupted network throughout their drive, allowing them to stay connected and attend important video conferences seamlessly. The comfort of a business class environment within the vehicle added to their convenience, providing a conducive space for work. Utilizing the conference area, they efficiently conducted meetings, brainstormed ideas, and collaborated with their team, maximizing productivity on the go.

Upon arriving in Pune, the executive felt a sense of renewal and rejuvenation. The stress and frustrations typically associated with air travel were absent, replaced by a feeling of accomplishment and satisfaction. This experience led them to recognize the untapped potential of road trips as an alternative to traditional business travel. From that point forward, the concept of a relaxed and high-speed business trip gained traction, transforming the way companies approached corporate travel. The emphasis on comfort, connectivity, and inspiration led to a reimagined travel experience, fostering productivity and well-being for executives on the move.



7.3 Stories based on selected scenario

A group of diverse individuals from different parts of the world embarked on an extraordinary road trip across India, akin to an intercontinental cruise ship journey. Their aim was to immerse themselves in the vibrant tapestry of Indian cultures and indulge in the vast array of delectable cuisine that the country had to offer.

As they set off on their epic adventure, they discovered the rich diversity of India's cultural heritage. Throughout their journey, they encountered locals who warmly welcomed them into their communities. They partook in traditional dances, joined in local festivities, and learned about the customs and rituals that shaped Indian life. Every interaction revealed a deeper connection to the diverse tapestry of humanity.

8. Luxurious road trip vehicle: The story

The final vehicle design idea was selected based on understanding each of the stories mentioned above. The project focusses on creating a new and rejuvenating user experience for a long road trip across India. Being a country of immense cultural varieties and layers to its name, an intimate and immersive road trip is the only way to know her prestigious culture.

The vehicle project is proposed for the year 2040, with all the previosly mentioned technological advancement in place. The vehicle project will involve a whole system design supporting it along the road trip. The user experience will be charted out and predefined, but could also adapt and improve over time, thanks to the machine learning and IOT based tech surrounding the whole system.

Image 8.1 The primary context: Indian Super Highways

8.1 An insight into the essense of the project

In 2040, India has become a popular destination for cultural and food tourism. With the rise of technology, entertainment, and society, there is a growing demand for unique and immersive experiences that combine culture and cuisine. With the growing industry of information technology, people's lifes are fully connected like never before. People have started to find free time from daily jobs and their need to live the life to its fullest have increased manifold. The awareness about the importance of spending time with loved ones and creating memories has spread among the citizens.

This vehicle project focusses on this very concept of exploring the large and multi cultured nation of India. A highly connected and immersive travel experience for users. The experience is predesigned, and multiple trip ideas and itineraries will be laid out Infront of potential customers. The customers decide the travel plan and set out on a multi-day exploratory road trip. The trip will be mainly focussed on superhighways, and adjoining destinations. The vehicle must provide an experience similar to that of a private jet , but on road.

9. Secondary User Research

Families

Families are here to enjoy their precious time together and they demand privacy and comfort. They may carry several items for personal care, for kids etc., which must be securely kept in vehicle. They would prefer a very sociable and vibrant ambience perfect for their state of mind being a family on a very long trip across India.

Couples

Families are here to enjoy their precious time together and they demand privacy and comfort. They may carry several items for personal care, for kids etc., which must be securely kept in vehicle. They would prefer a very sociable and vibrant ambience perfect for their state of mind being a family on a very long trip across India.

Friends groups

Families are here to enjoy their precious time together and they demand privacy and comfort. They may carry several items for personal care, for kids etc., which must be securely kept in vehicle. They would prefer a very sociable and vibrant ambience perfect for their state of mind being a family on a very long trip across India.

Travel vloggers

They want to capture each moment in its beauty, and they prefer window seat with mounting option of camera and other equipment. vloggers also wish to get all journey related information at his/her fingertips

Research related people

These people may travel solo or as group. They may be PhD scholars, researchers learning about Indian culture and traditions. They need persona space with working ability, comfortable seating and bedding

Foreigners

Foreign tourists need a welcoming a warm cabin with international standards. They like good visibility and a hassle fee seating/bedding for a comfortable travel experience.

Note: Images shown just for representational purposes. All images sourced from the internet. All rights belong to the respective owners

9.1 User Interview

During the user interviews, several key points were highlighted regarding the desired features and preferences for a vehicle design project. The main focus was on providing a re-energizing comfort and convenience within the vehicle. Users expressed the need for infotainment systems that are large, easy to use, and provide ample information about the journey, social media, and other relevant content.

Additionally, users suggested having a limited number of passengers onboard to avoid congestion and ensure a luxurious journey. They emphasized the importance of having sufficient space to work and keep personal equipment safe. Privacy was also a significant concern, particularly for families of four, who desired a sense of privacy during their travels.

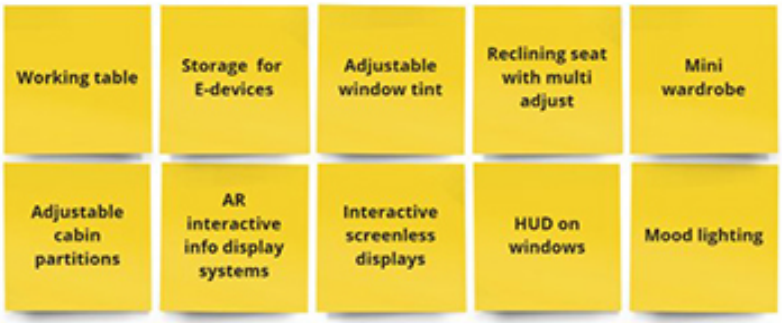
Easy access to luggage bags and cargo bay inside the vehicle was deemed essential by the users. They expected all basic amenities to be provided, ensuring a comfortable experience. Onboard WiFi connectivity was considered crucial, as it would facilitate various activities during the journey.

Moreover, users emphasized the desire for an unconventional experience, emphasizing the need for the vehicle to stand out and not be perceived as just another bus. It was also highlighted that the vehicle should be designed with easy ingress and egress, allowing passengers to walk in and out effortlessly. Taking into account these user preferences and requirements, the vehicle design should prioritize home-like comfort, spaciousness, privacy, ample amenities, onboard WiFi, an unconventional experience, and easy access for passengers.

9.2 Key User Insights

A cultural and food tourism experience across India may last for many weeks, in that case a very comfortable and luxurious hassle free journey must be ensured for the passengers. For this, The vehicle should not be overcrowded, rather must provide sensation of space and peace for the lucky travelers on board for such a demanding and immersive travel experience.

Also, multiple vehicles will be in operation behind one another, ensuring passenger numbers are taken cared of. Therefore, a single vehicle may have 4-5 seats. This will help reduce the footprint to an optimum, so that the vehicle can traverse across small village roads and tourist destinations if necessary. The size of the vehicle may be larger than that of a standard mini bus to accommodate luxurious features such as reclining seats, personal entertainment systems, and private lounges. A larger size would also provide more space for passengers to move around and enjoy the luxurious amenities.



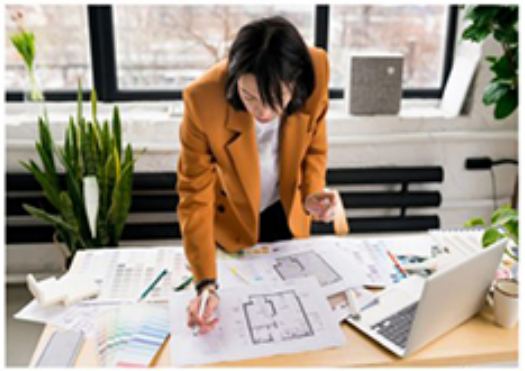
Based on the user interaction and keeping in mind the predicted future trends, a rough idea of the vehicle experience and its footprint was estimated. The vehicle would incorporate the highlighted features and would seat around 4-5 passengers (A family). The vehicle would provide multiple use case modes, such as: On road cruise mode, Movie mode, Camping mode, short break mode. Inshort, the vehicle has a versatile interior space maximising the utilities for a very xtensive and immersive road trip.

10. Persona

Aswin Prasad | 40
Software engineer | Bengaluru

Passion
Latest technology
Travelling

Goals
To travel around the world with family



Aparna Babu | 38
Interior Designer | Bengaluru

Passion
Latest design trends, interior decor
Travelling

Goals
To explore new cultures and places with family

The family

Aswin's and Aparna are very much alike has a lot in common, they are passionate travellers, and wants to explore new cultures and cuisines.

Kids, Manu and Bhanu are also very fond of travelling. They have done several multi day road trips and has always been well behaved.

Passionate travellers

Fond of new tech

Exploratory mindset

11. Design Brief

‘To design a road trip/vacation vehicle for a family of 4, providing a re-energizing and immersive experience. The vehicle can be used as a mini camper with versatile living space to stretch out and relax.’

More details

The vehicle should feel like a private jet for the roads. The vehicle should provide an exclusive living space for the family by having plenty of interactive and infotainment displays, storage spaces and whatever is needed for a long trip. The cabin should feel spacious and airy for all occupants at all scenarios. The vehicle may be used primarily on highways and must provide great visibility outside. The vehicle running on green hydrogen emits nothing, but water and oxygen must be easy to refill and should have partial autonomy driving capabilities as well. The vehicle should provide options for camping, at a small level, example: providing a setting for serving snacks/tea/coffee. Overall, the vehicle must be a fully equipped private living room capable of cruising at national speed limit with ease.

Who uses the vehicle and How?

The road trip luxury vehicle can be rented/leased for a fixed period of time by users and the vehicle must be a part of large governmnetal/private organisation handling the project. Users can customise the interior features as per their requirements. The vehicle runs primarily on smooth highways, but can also do occasional rough road excursions.

12. Inspiration: Aviation Industry

Image 12.1 Interior design of SWISS first class

Image 12.2 Interior design Qatar Airways

Image 12.3 Interior design of Singapore Airlines

With the premise of the project being a long-distance road trip cruiser, the aviation industry with its luxurious and plush business and first-class cabins came as an inspiration. The aviation industry deals with passengers travelling long haul (10-20hours) spending time in a vehicle cabin. The only difference here is medium of travel. The airplanes first class cabins have large expansive seats and storage areas with a clean and modern design language. The ambient lighting also plays a major role in airplane interiors to set the mood and maintain a calm aura during the long-haul flights. These aspects of air-travel was taken as inspiration and was benchmarked as the dream experience a customer wants from this design project.

13. Benchmarking

Image 13.1 Mercedes V class details

Image 13.2 Toyota Velfire details

13.1.1 Mercedes V class

Mercedes V class is a 4.9m long, 2.2m wide van with option of 4 or 6 seats. It is positioned as a luxurious van with plenty of storage and interior space for passengers. It is commonly used as luxury airport transit vans, VIP escorts and by other businessmen and women. It does not allow passengers to stand up straight due to its 1.9 m total height.

13.1.2 Toyota Velfire

Toyota Velfire is also a luxury van which is again 4.9m long, almost 2m wide and 1.9m high. This vehicle also has 4 or 6 seater options based on customer requirements. It is used by film stars and businessmen needing hassle free transit from point A to B. Both these vehicles are more business oriented and has onboard working facility, in the form of tables and privacy windows. These vehicles are position specifically for business purposes and accordingly has that reflected in their design language and feature list.

13. Benchmarking

Wheel base (mm)	3350	3615	4400
Length (mm)	5440	6225	7010
Width (mm)	2095	2095	2095
Height (mm)	2550	2550	2550
GVW (Kg)	3625	4135	4610
Seating Capacity (Excl. Driver)	10	13	17
Front Suspension	Independent	Independent	Rigid
Air Bag for Driver & Co Driver	Yes	Yes	Optional

Image 13.3 Force Urbania details

Model	Seater	Sleeper
Length(mm)	15000	15000
Height(mm)	3800	4000
Width(mm)	2600	2600
Wheelbase(mm)	8350	8350
Permitted GVW	22200 kg	22200 kg

Image 13.4 Volvo 9600 Details

13.1.3 Force Urbania

Force Urbania is an economy style people carrier. It is positioned as a tourist vehicle for a large group of people. This vehicle is mainly rented in India. It lacks luxury and exclusivity. The design is very utilitarian and does its job very well, that is to carry people in economy comfort. It is available in 3 different dimensions: All have a width of 2.1m but the length and wheelbase varies as 5.4m-7m (length) and 3.6-4.6m(wheelbase)

13.1.4 Volvo 9600

Volvo 9600 is a full size premium economy style Sleeper/executive class bus. It is purely a people mover, which travels long distances connecting major cities in India.

13.2 Powertrain Benchmark

	Vehicle	Tank capacity	Range	Power
	Toyota Mirai2	5.6kg	650km	184hp
	Hyundai Nexo	6.33kg	756km	163hp
	Mercedes GLC Fcell	4.4kg	478km	211hp
	Honda Clarity Fcell	5 kg	589km	176hp
	Hyundai ix35	5.64kg	594km	136hp
	Citroen e Jumpy Hydrogen Peugeot e expert Hydrogen Open Vivaro e Hydrogen	4.4kg	400km	134hp

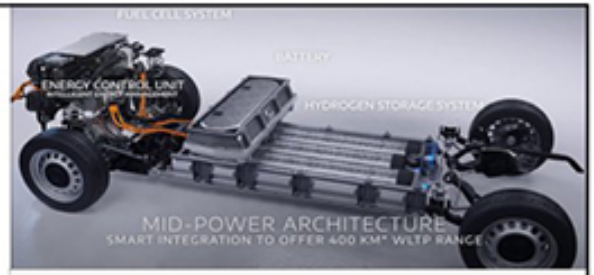


Image 13.5 Powertrain of Stellantis and Toyota (fuel cell)

Various present-generation fuel cell vehicles were studied in terms of its powertrain details. The passenger vehicles have more range and hydrogen storage capacity than the commercial one from Stellantis. After looking at the present scenarios and with the insights gained during the interaction with experts from fuel cell industry, the hydrogen tank size will reduce in future due to increase in holding pressure and more efficiency can be achieved. Also, because the proposed vehicle will travel across remote destinations and long highways, it is important to have sufficient range for any un-necessary worry (range anxiety). With all these points under consideration, the final powertrain details are as follows:

13.2.1 Final Powertrain details

Rear wheel driven, single Indusction motor
260kW Fuel cell output (350hp)

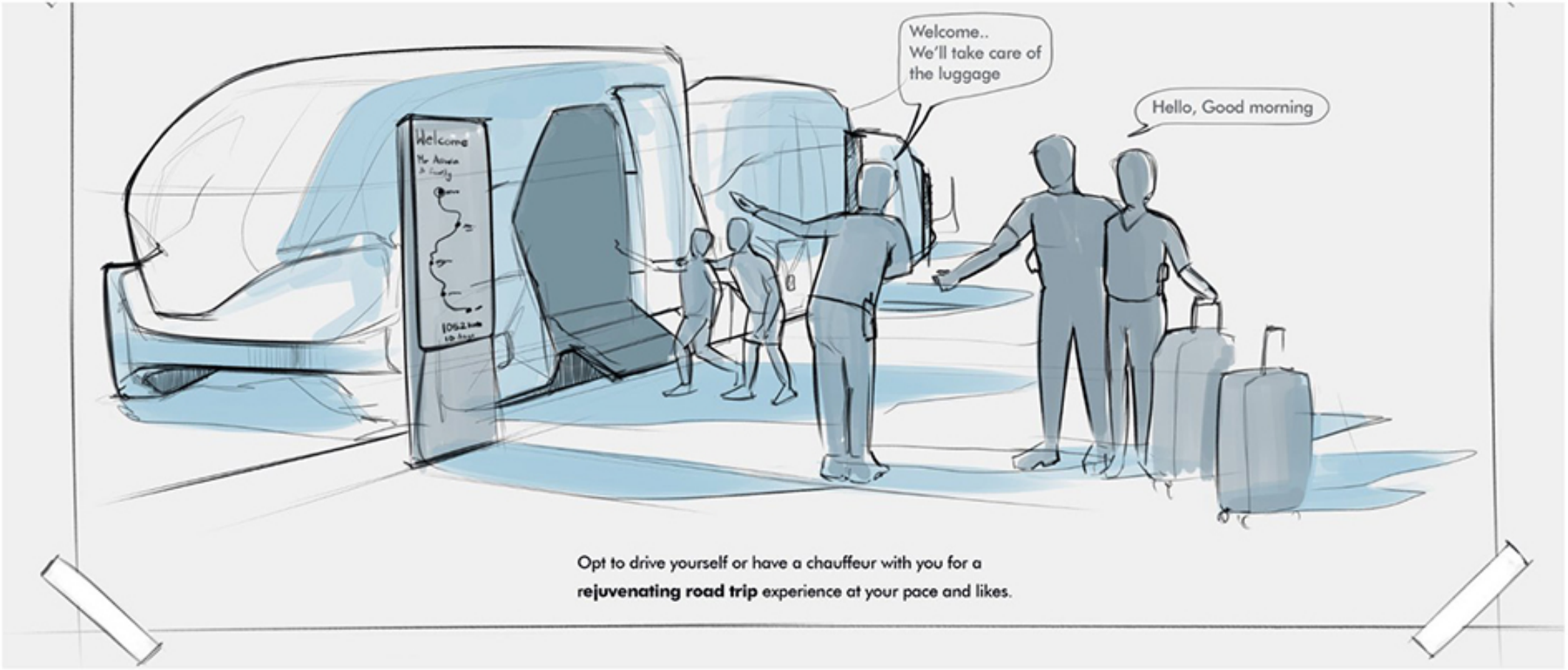
6kg Hydrogen storage (Centrally-longitudinally mounted)
3 hydrogen tanks at 70Mpa (10,000psi) carrying a total of 180L Hydrogen
Gross weight of tanks will be 100kg.

10kW Auxilliary li-polymer battery (For regen, startup, torque fill) (front transversly mounted)

PHASE II

The phase of Design exploration. Now the whole focus is shifted to thinking creatively and developing the best story for the vehicle. The phase involved constant refer backs to the research phase to keep the exploration grounded and within the scope of the project. An inside out approach was followed to create the vehicle package.

14. Story Board

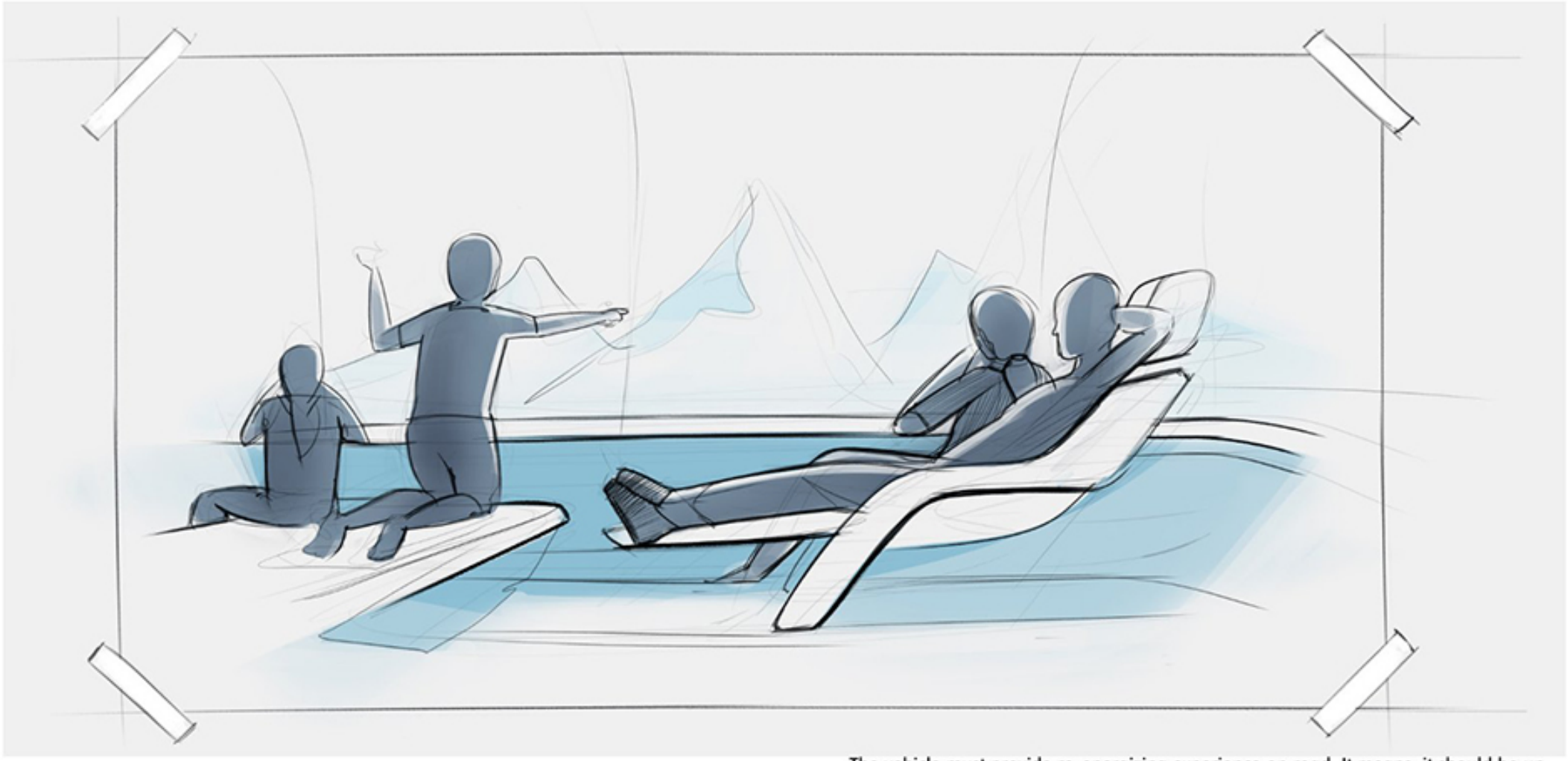


The journey starts eve before boarding the vehicle. The users can lease or rent the vehicle for a road trip and the customised vehicle as per guest preference will be delivered to them. The guest can change the number of seats, optional bed and the number of days they want to use to vehicle for.

Image 14.1 Storyboard sketch 1

Note: Iteration 1 of the storyboard is given in Appendix

Story Board



The vehicle must provide re-energizing experience on road. It means, it should be unlike any other vehicle a family can travel in total privacy.

Image 14.2 Storyboard sketch 2

Story Board

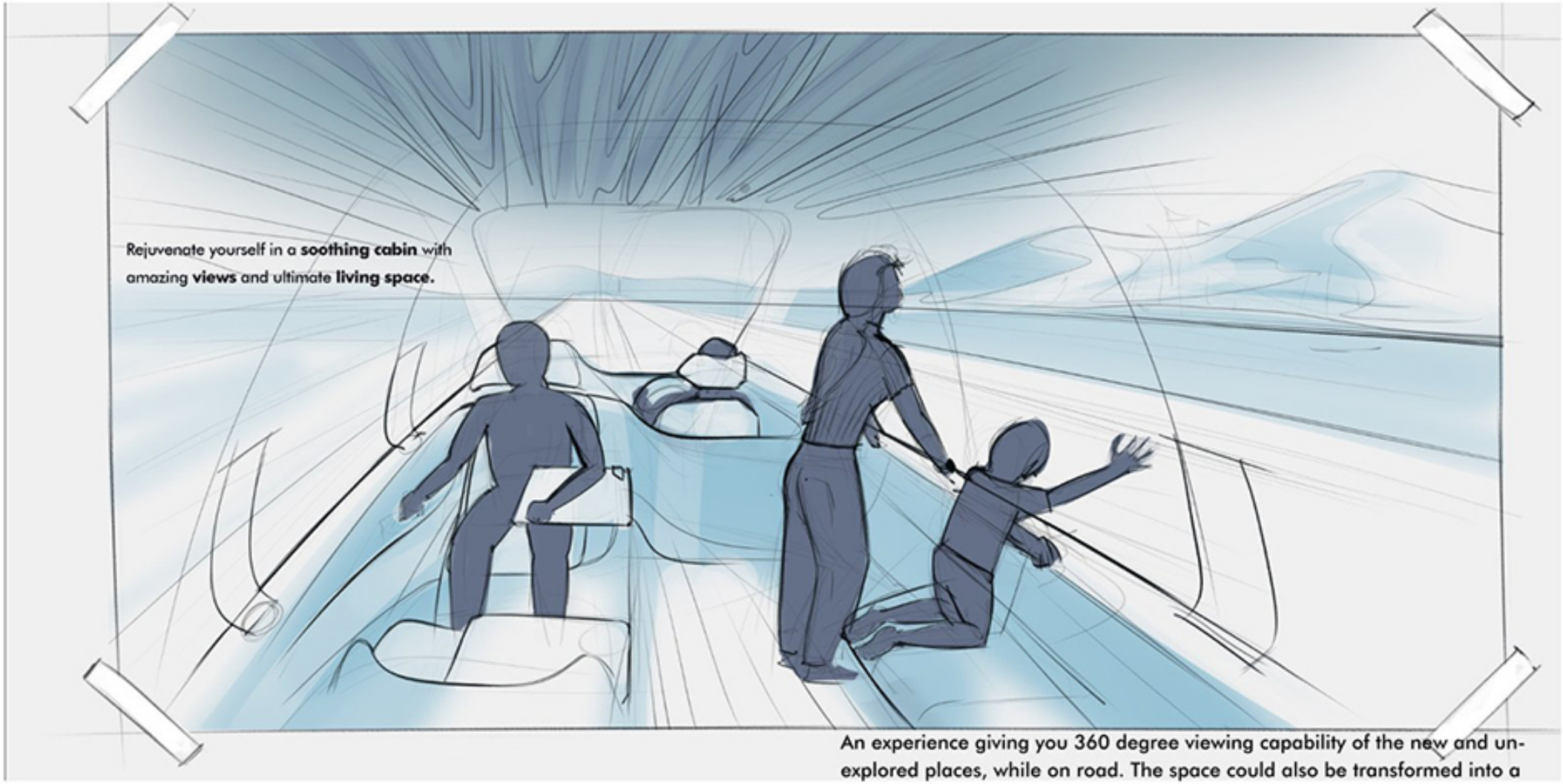
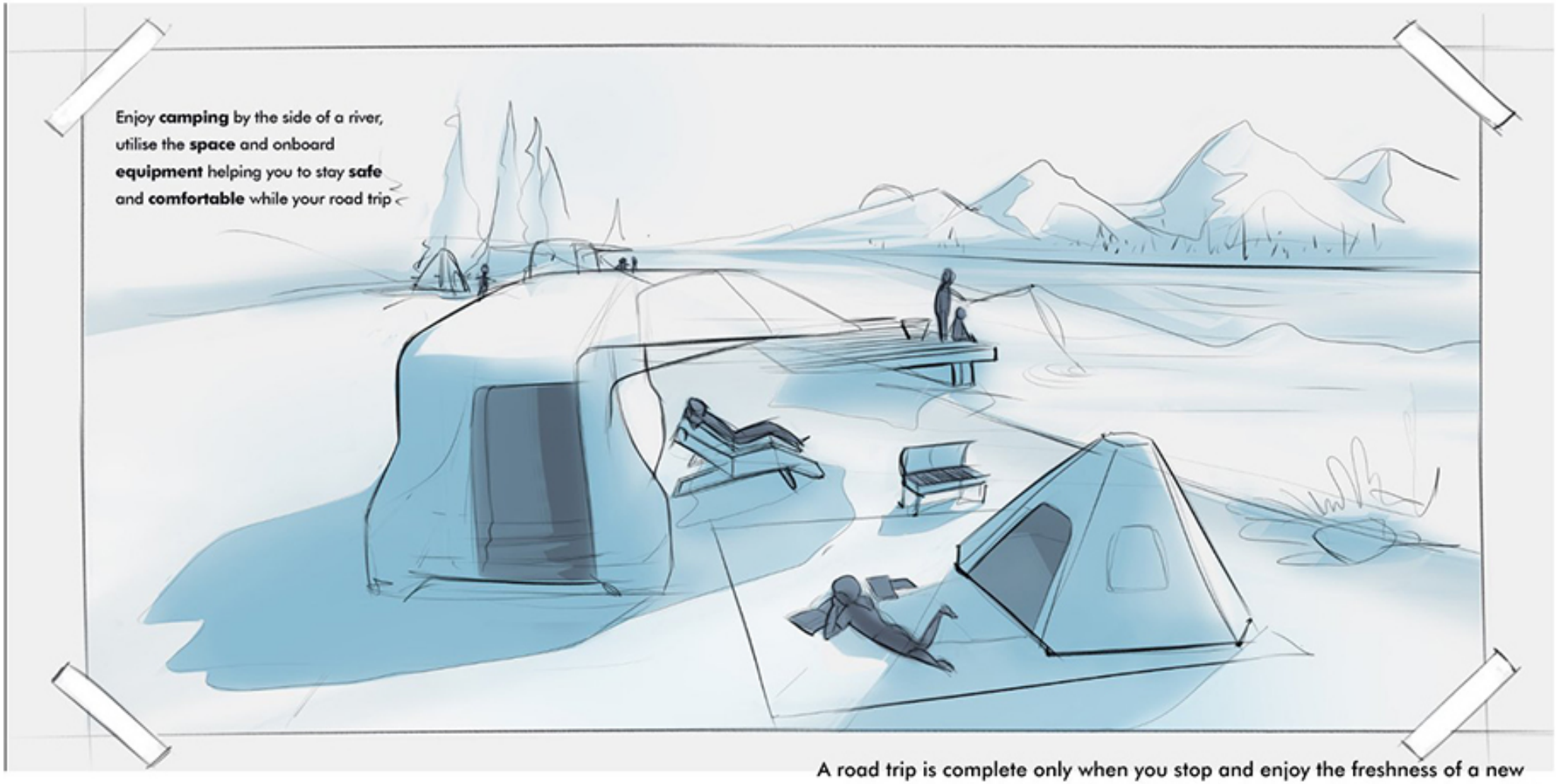


Image 14.3 Storyboard sketch 3

Story Board



A road trip is complete only when you stop and enjoy the freshness of a new unexplored location. The vehicle must provide opportunity to camp on a small scale, to enjoy the hot cofee, and to safely run around a camping site.

Image 14.4 Storyboard sketch 4

15. Interior Trends

Image 15.1 Some of the latest interior trends in the Automotive world

The latest interior trends related to the selected project direction was studies. The latest interior designs have clean and seamless integration of utilities without being too dominant. Use of natural lighting as a means of increasing cabin ambience wss also noted. Use of ambient lighting to create multiple cabin moods is also seen in modern vehicle interior concepts. Usage of bold and newer colour combinations, use of vegan and recycled materials have become a common practice in premium brand like Volvo and Mercedes. Technological innovations like drive by wire and electrochromic windows are gaining popularity and market approval slowly on mainstream cars.

16. Vision Sketches

16.1 Vision Sketches

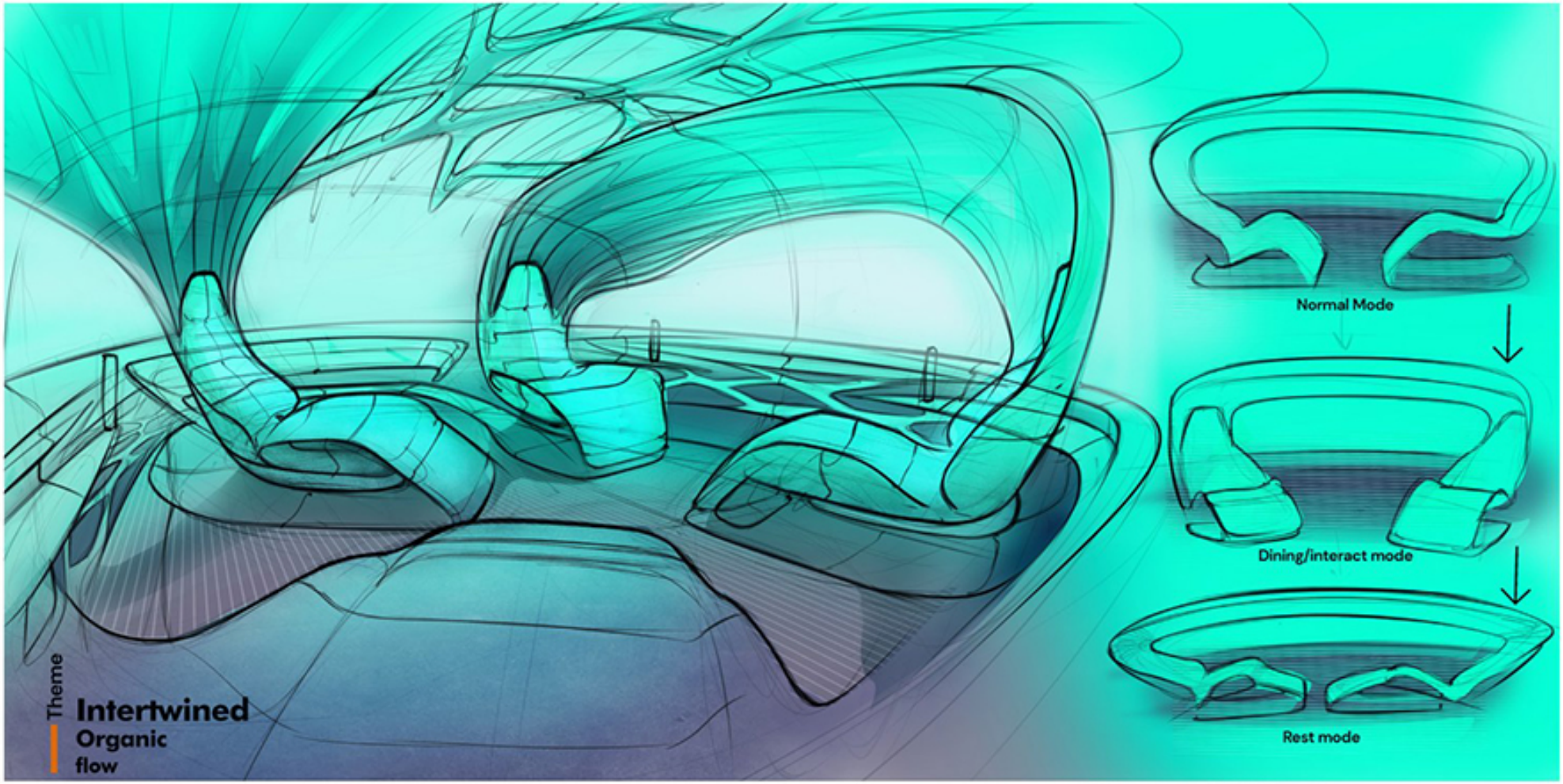


Image 16.1 Vision Sketch 1

The vision was to create a very intimate and futuristic living space with a panoramic DLO.The whole space should feel like a living entity to which the users are getting a part of.

16.2 Vision Sketches

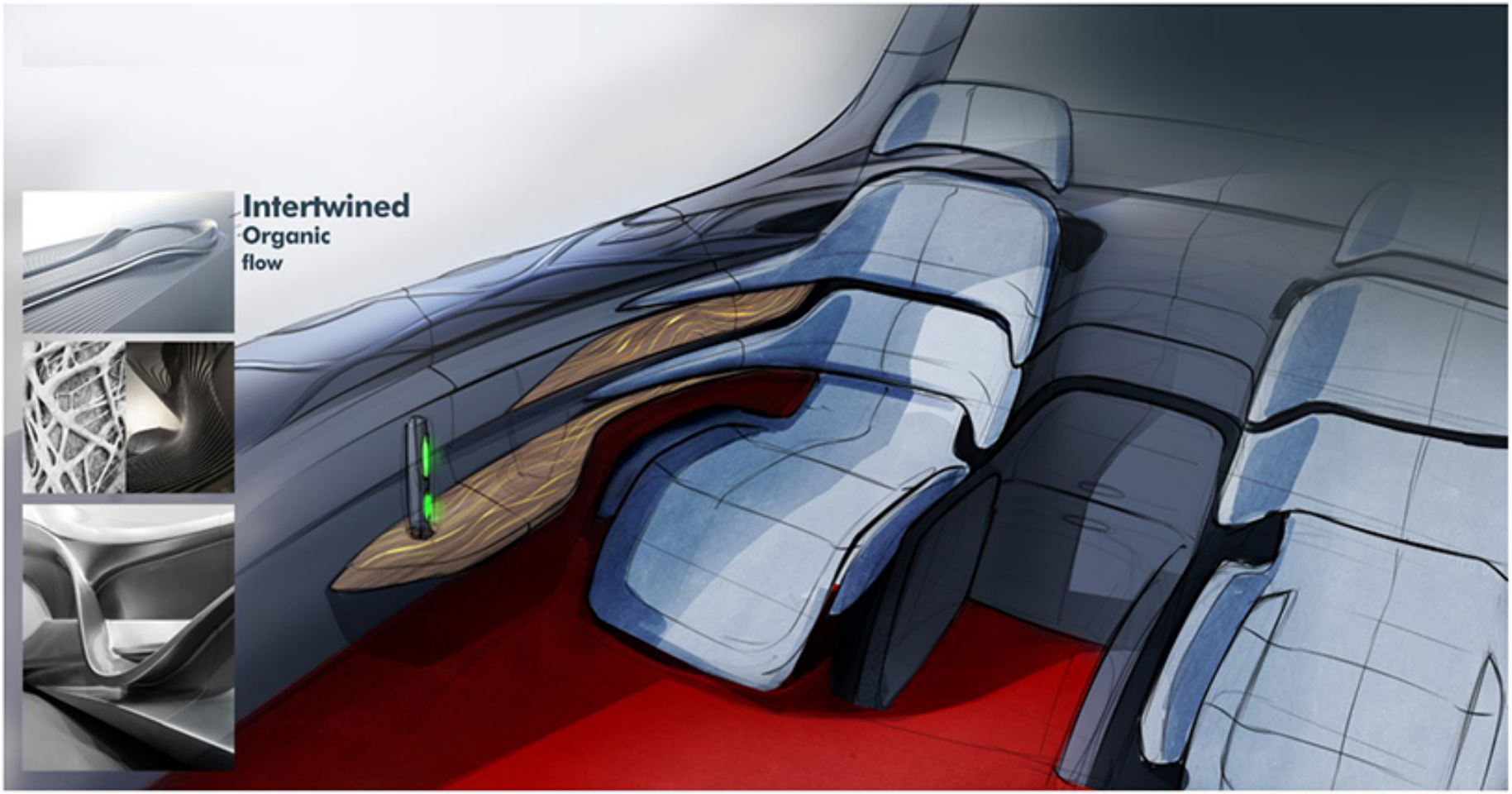


Image 16.2 Vision Sketch 2

This sketch shows a seat concept. The seat is intertwined with the side panels, with possibilities to integrate screens and other features in an integrated fashion .

16.3 Vision Sketch: Seat Concept

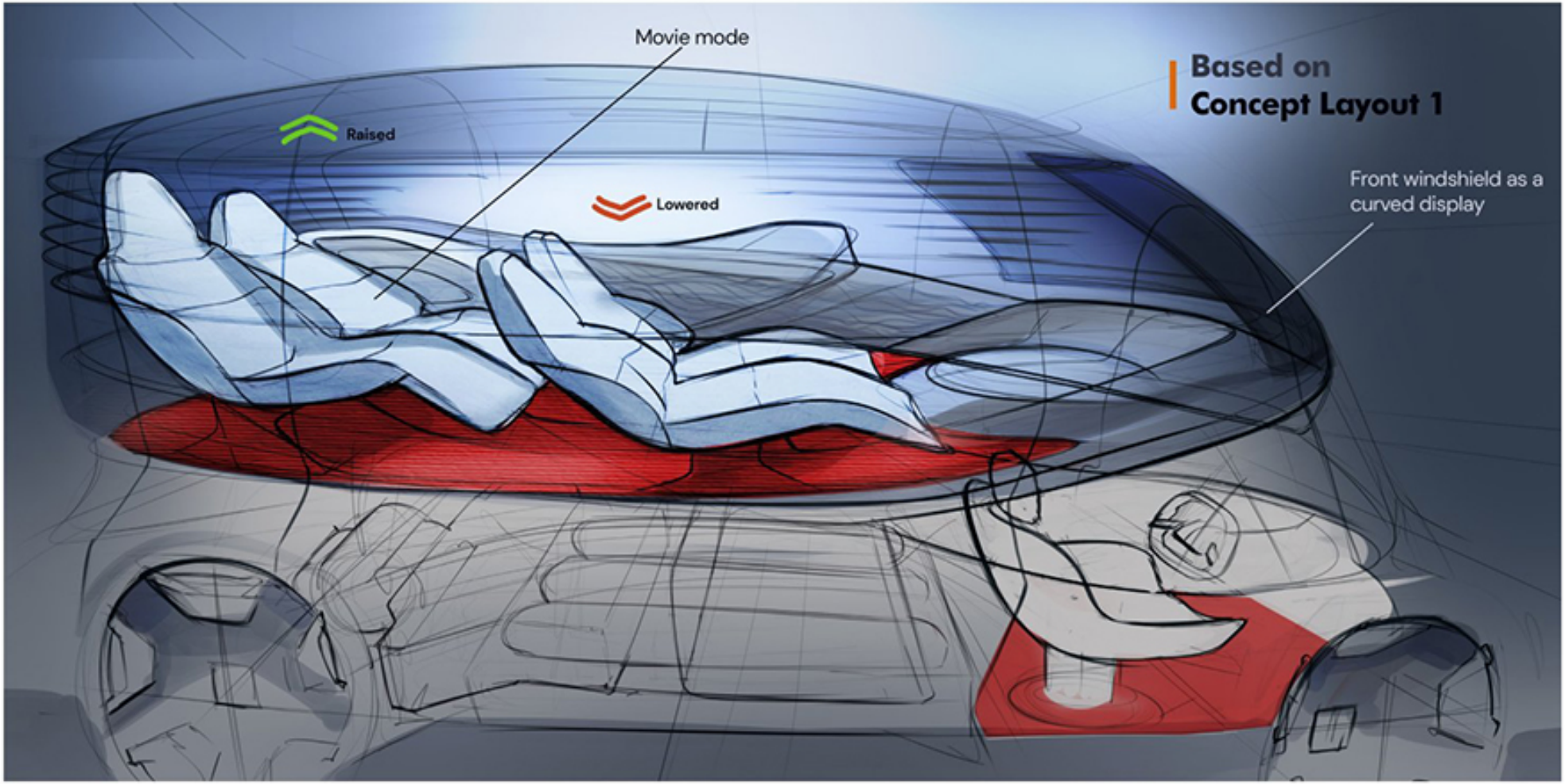


Image 16.3 Vision Sketch 3

A movie mode vision where the rear 2 seats raises and front two seats lower, along with the front windshield becoming a curved movie screen

17. Concept Layouts

17.1 Concept Layout 1

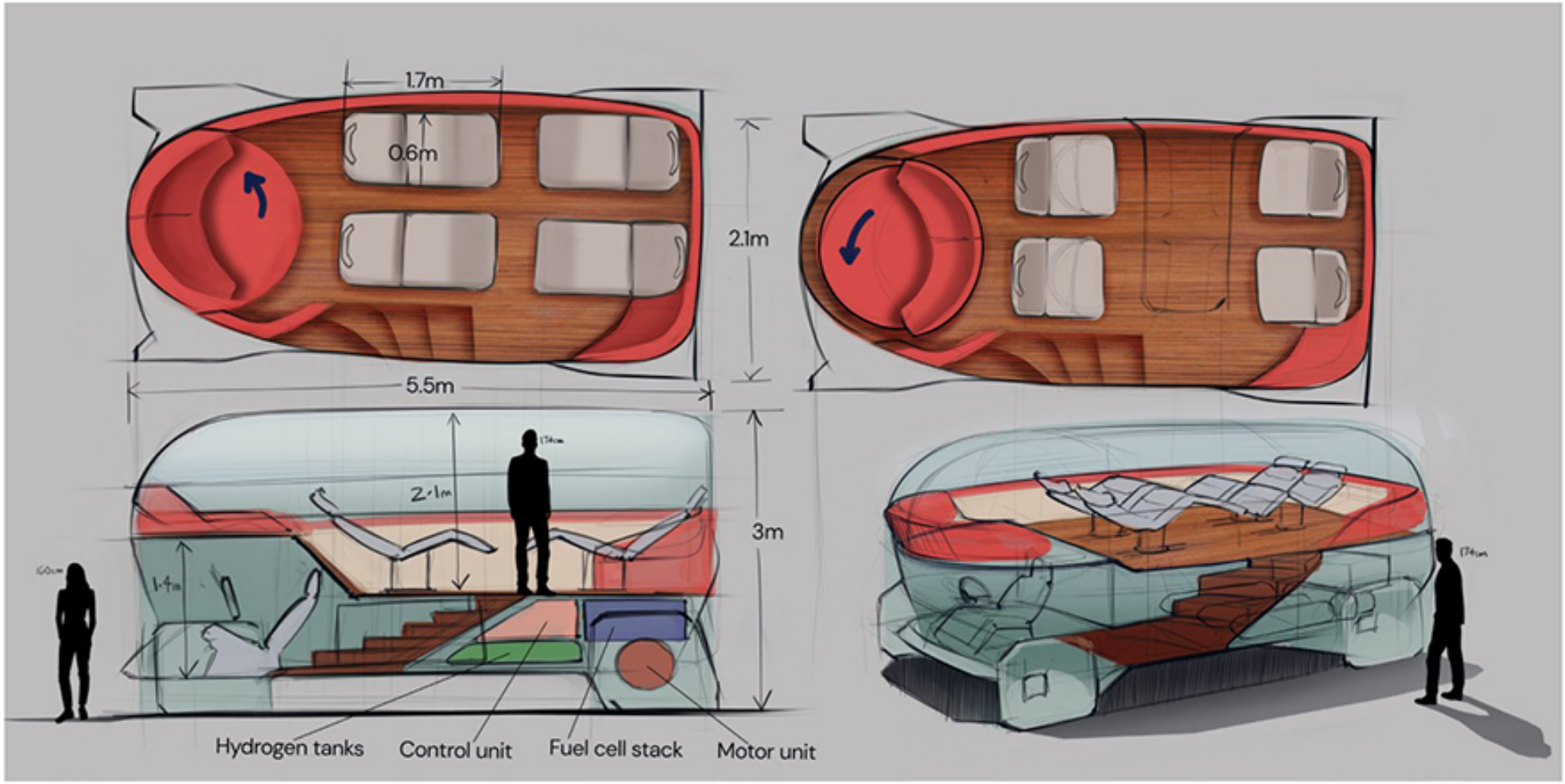


Image 17.1 Concept Layout 1

The concept shows a 5 seater with an elevated passenger cabin, giving them a panoramic outside view. But the driver/chauffeur will not be comfortable in long runs.

17.2 Concept Layout 2

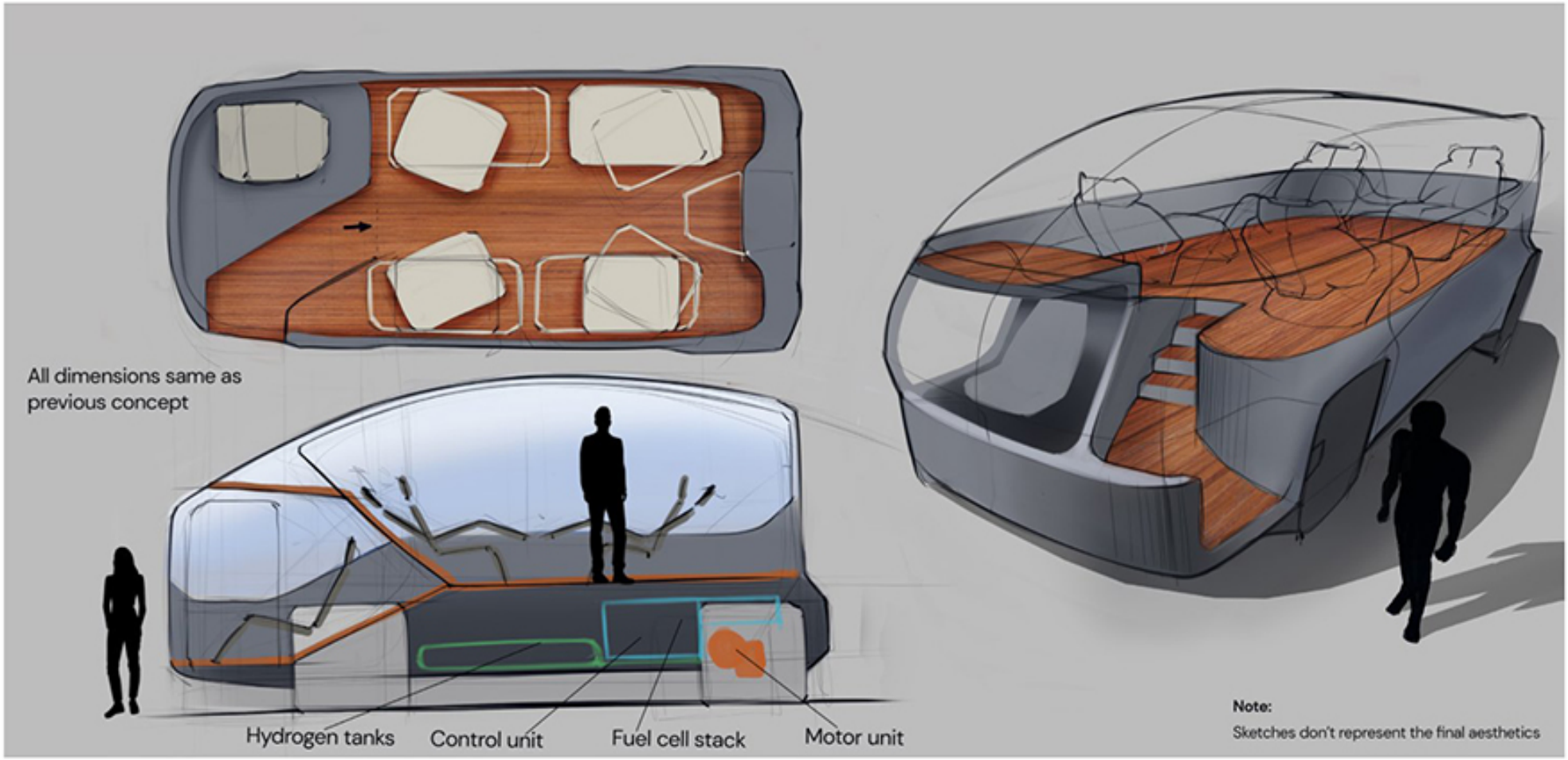


Image 17.2 Concept Layout 2

The concept with semi multi level seating. Similar to layout 1 in terms of chauffeur/driver comfort, only difference being the passenger entry point.

17.3 Concept Layout 3

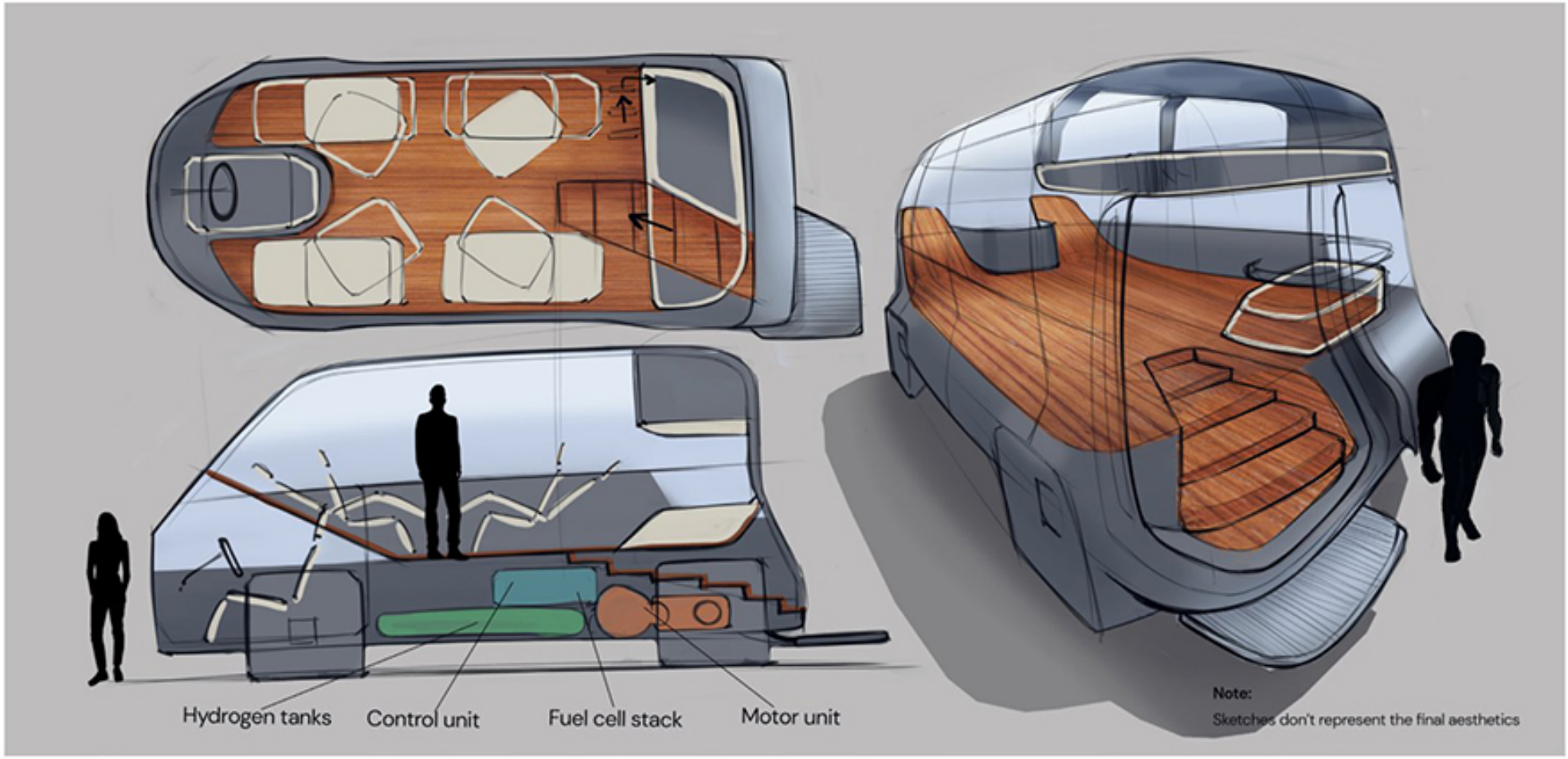


Image 17.3 Concept Layout 3

This concept gives a central driving seat and a rear passenegr entrance, optimising the cabin space to accomodate a transversely placed bed.

17.4 Concept Layout 4

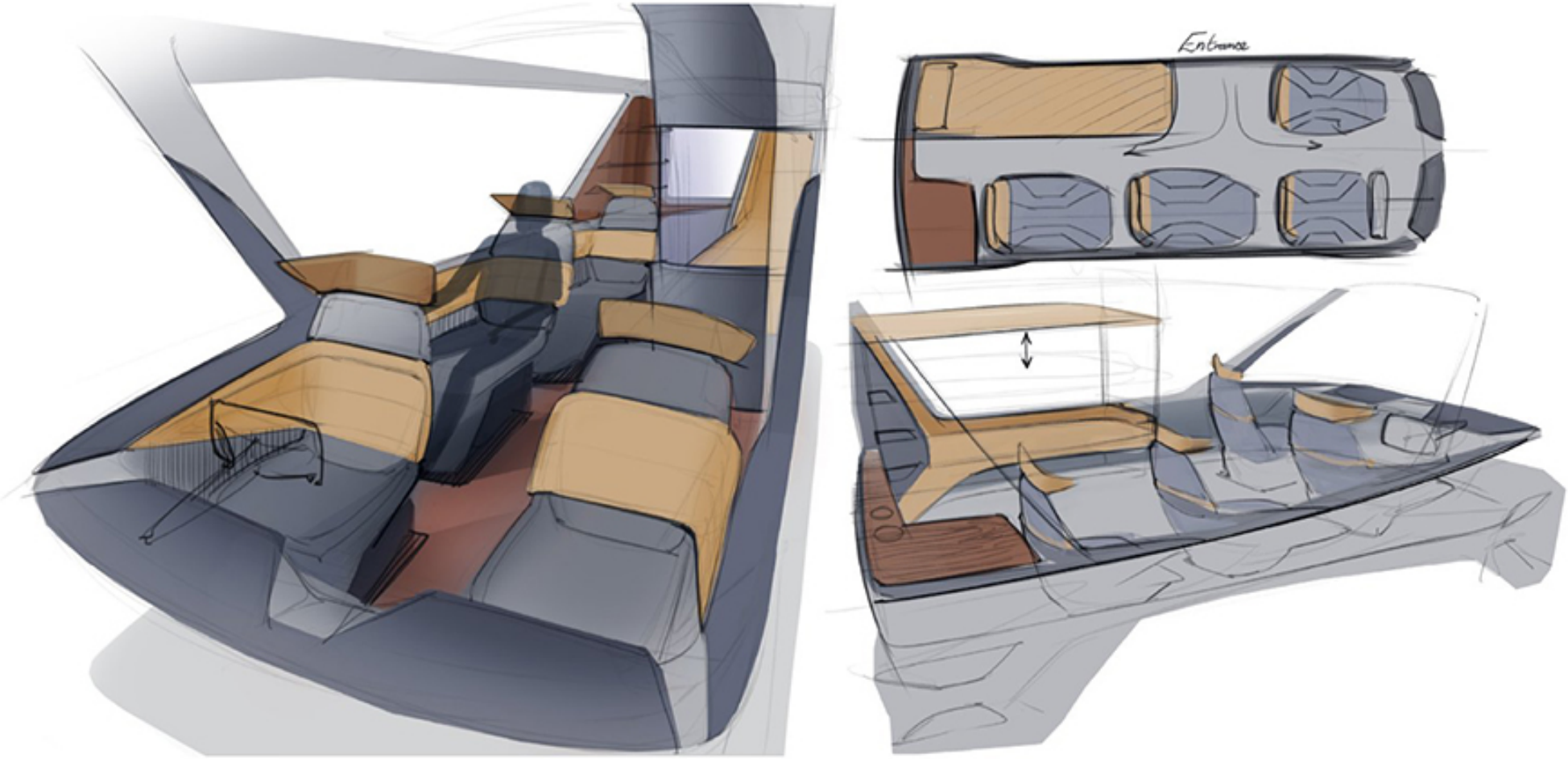
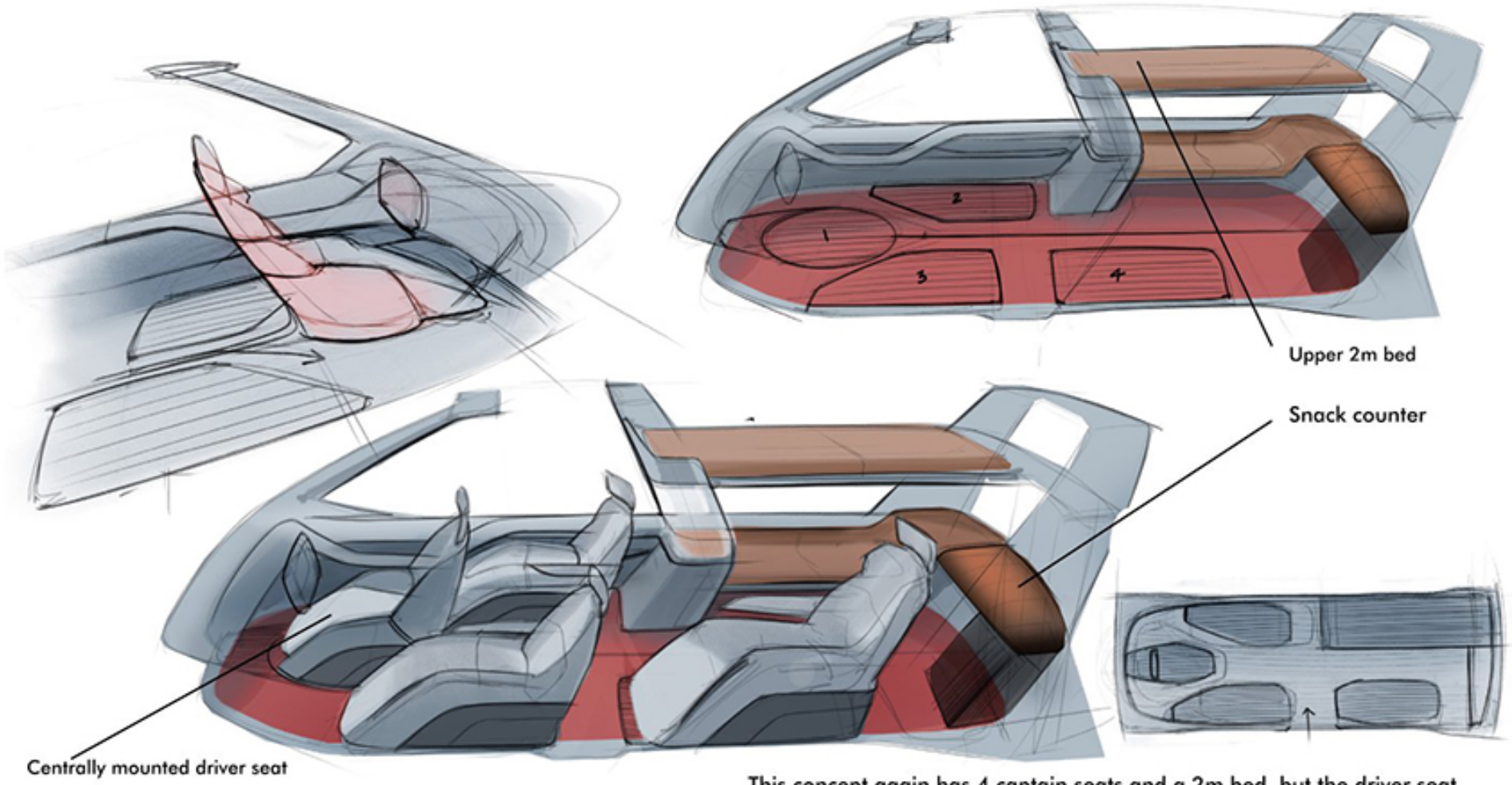


Image 17.4 Concept Layout 4

The multi elevation concept was discarded, along with the idea of having a chauffeur. The vehicle will now be operated by the family(primary user) or whoever is hiring/ renting the vehicle. This concept has 4 captain seats and a 2m bed integrated.

Concept Layout 5



This concept again has 4 captain seats and a 2m bed, but the driver seat is centrally mounted, also the bed is split into a upper 2m bed and a lower lounge/ mini bed. There is also a small snack counter integration at the rear

Image 17.5 Concept Layout 5

18. Themeboards

Aviation Inspired ——— **Seemless integration**

The connection to the world of avaition was to be maintained in the final design. With the users being tech saavy and an interior designer, modern design touches with clever use of materials are required in the cabin design.

Image 18.1 Themeboard showing interior design language

Concept Layout 6

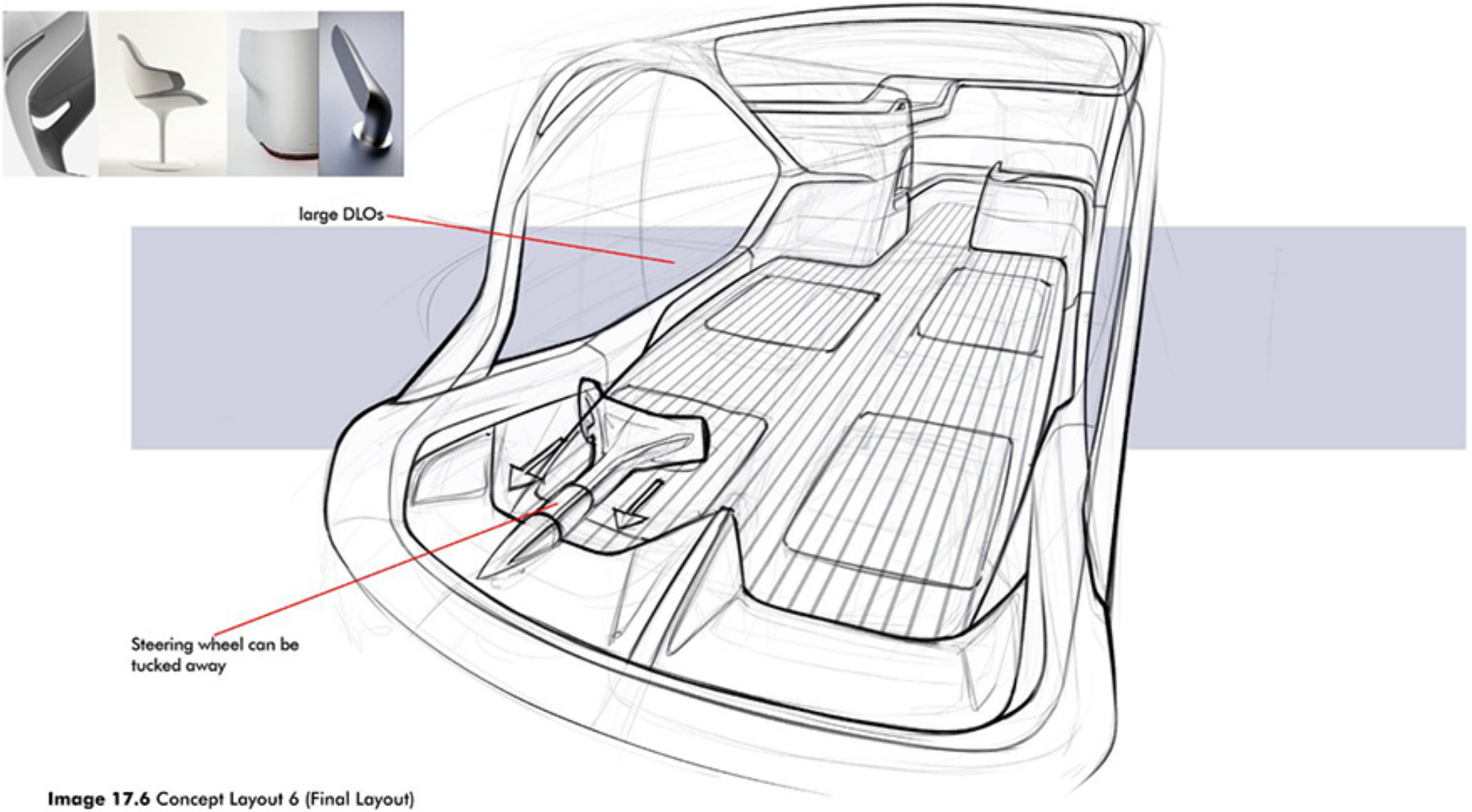


Image 17.6 Concept Layout 6 (Final Layout)

19. Final Direction Ideation

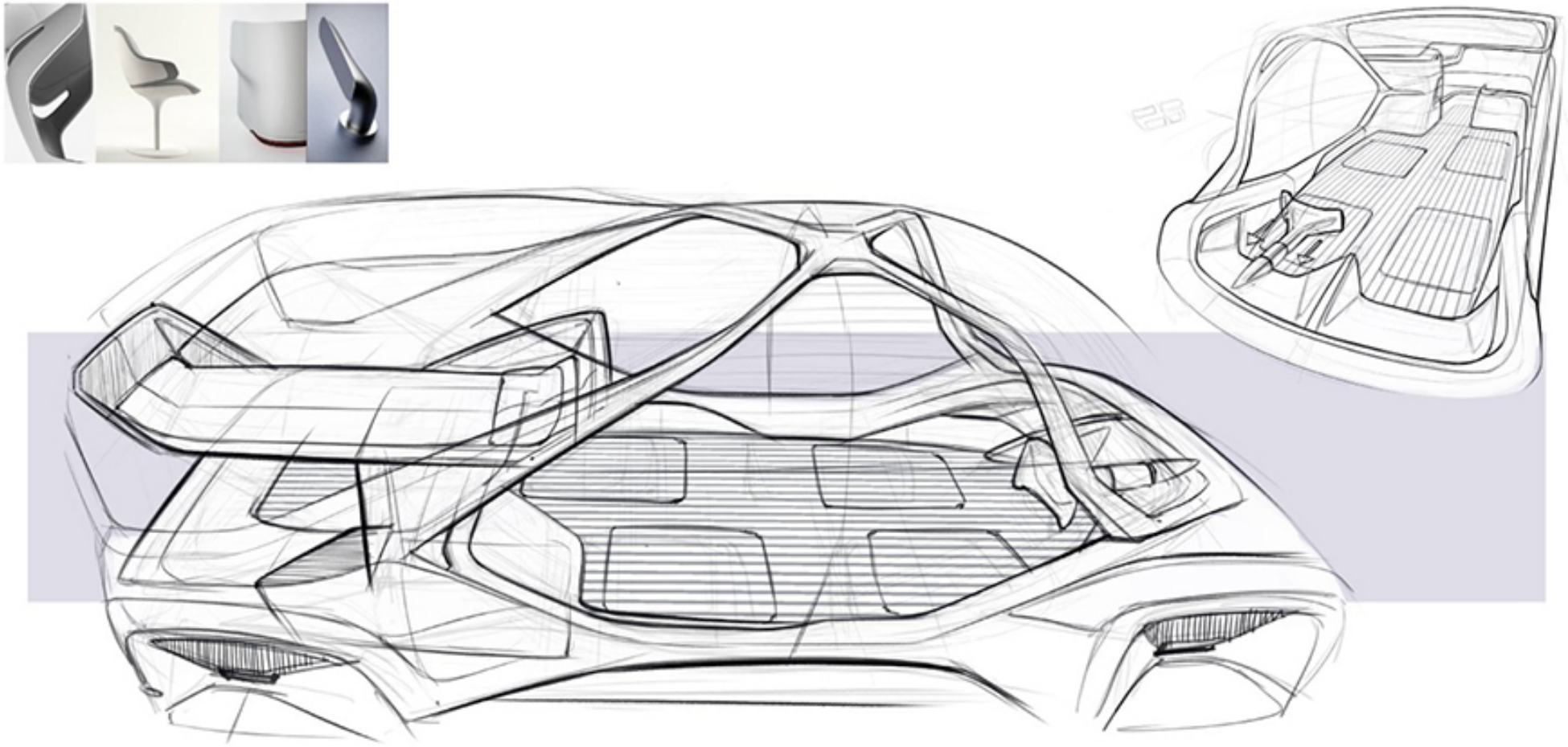


Image 19.1 Interior ideation based on selected layout

The final direction was chosen based on learnings and feddbacks recieved on the previos layouts. This layout accomodates 4 adults in absolute comfort, has space for 2 people to sleep, a snack counter, wardrobe, water dispenser, storage space and trash bin.

Interior Ideations

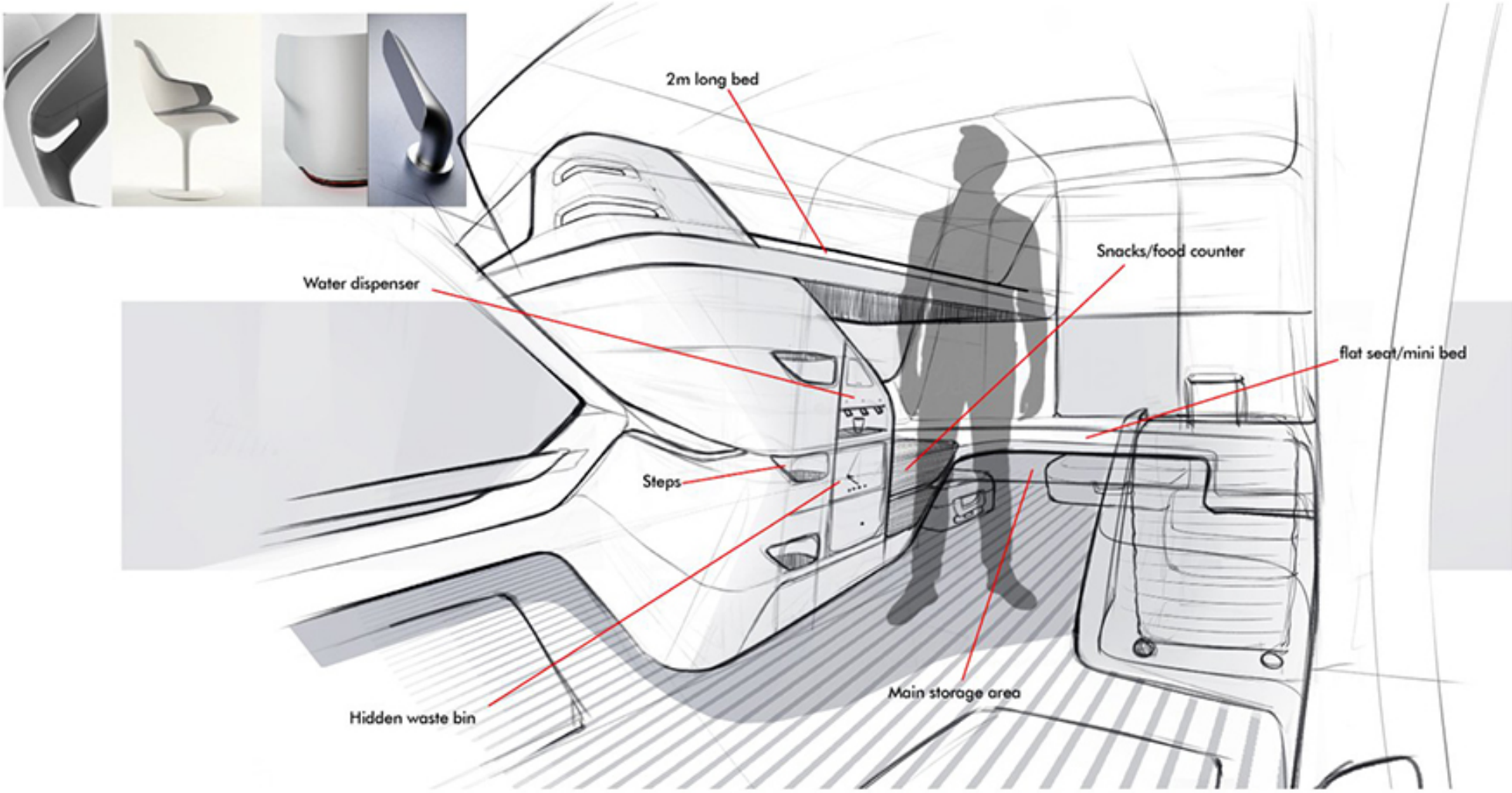


Image 19.2 final Interior ideation: Rear section

Interior Ideations

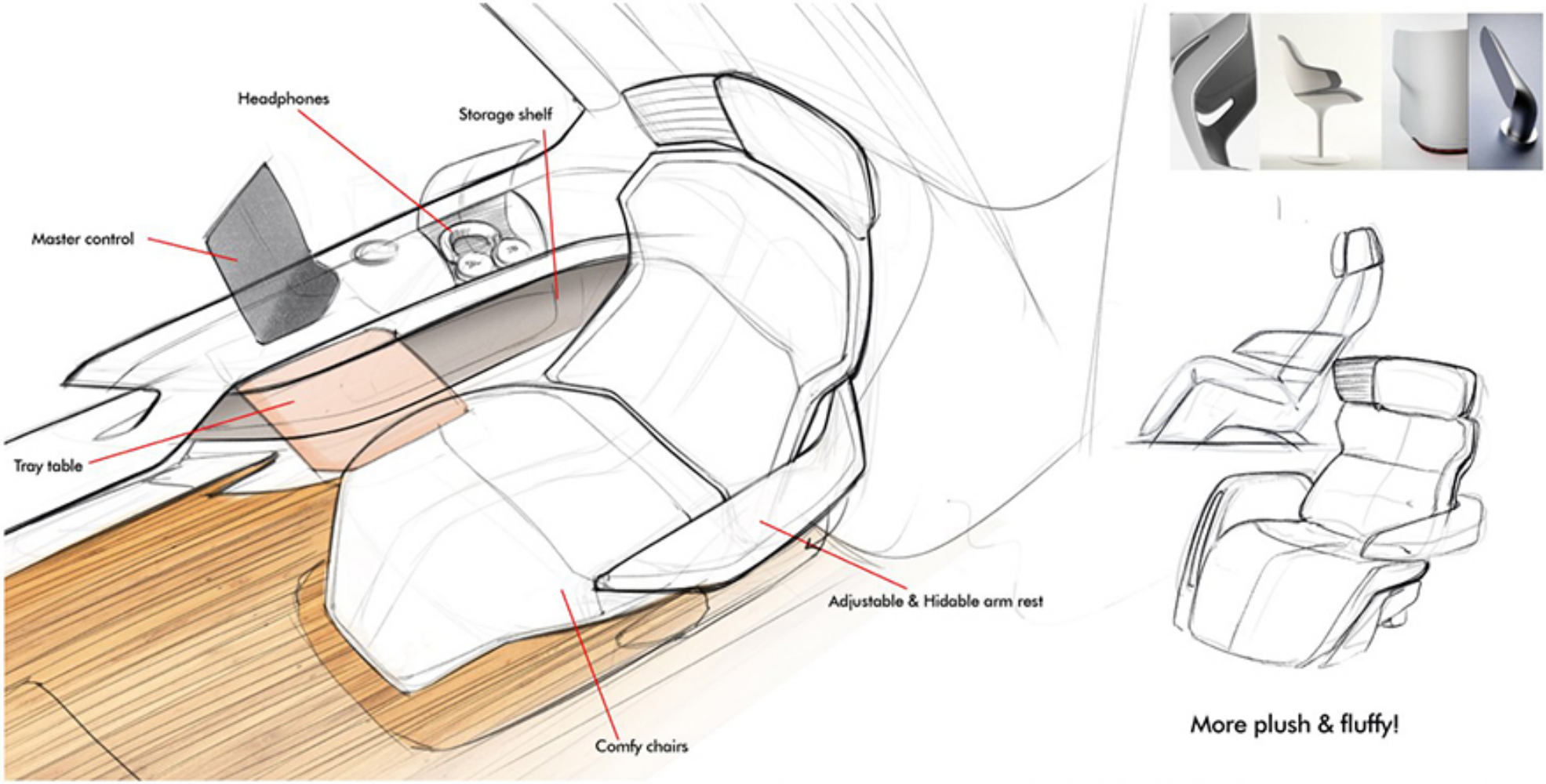


Image 19.3 final Interior ideation: seats

The captain seats are equipped with multiple adjustments option, tray table, under seat storage, reading light, microphone, seat belt holder. This ensures the major utilities needed in a seat is accesible in any seat configuration.

Interior Ideations

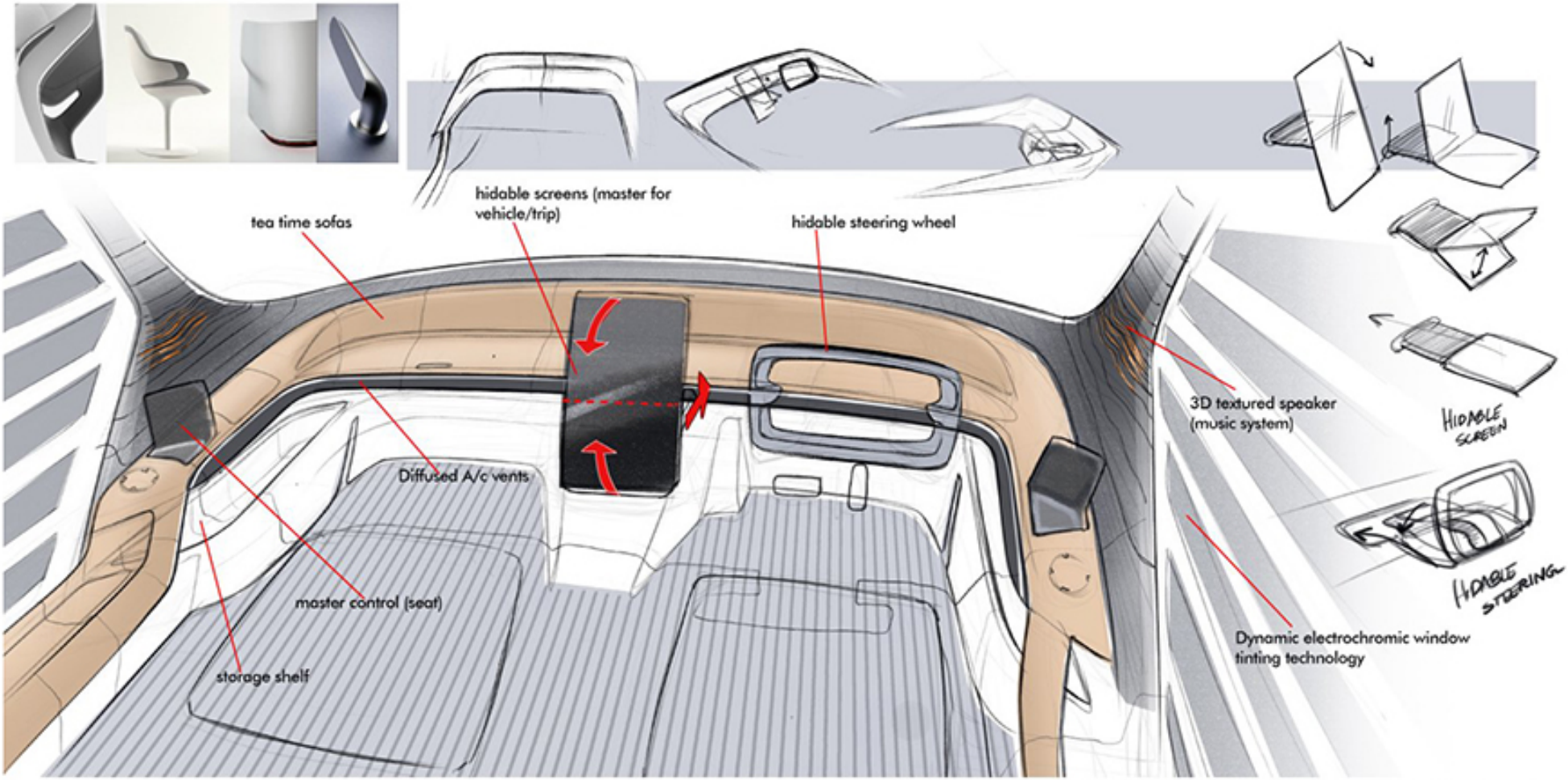
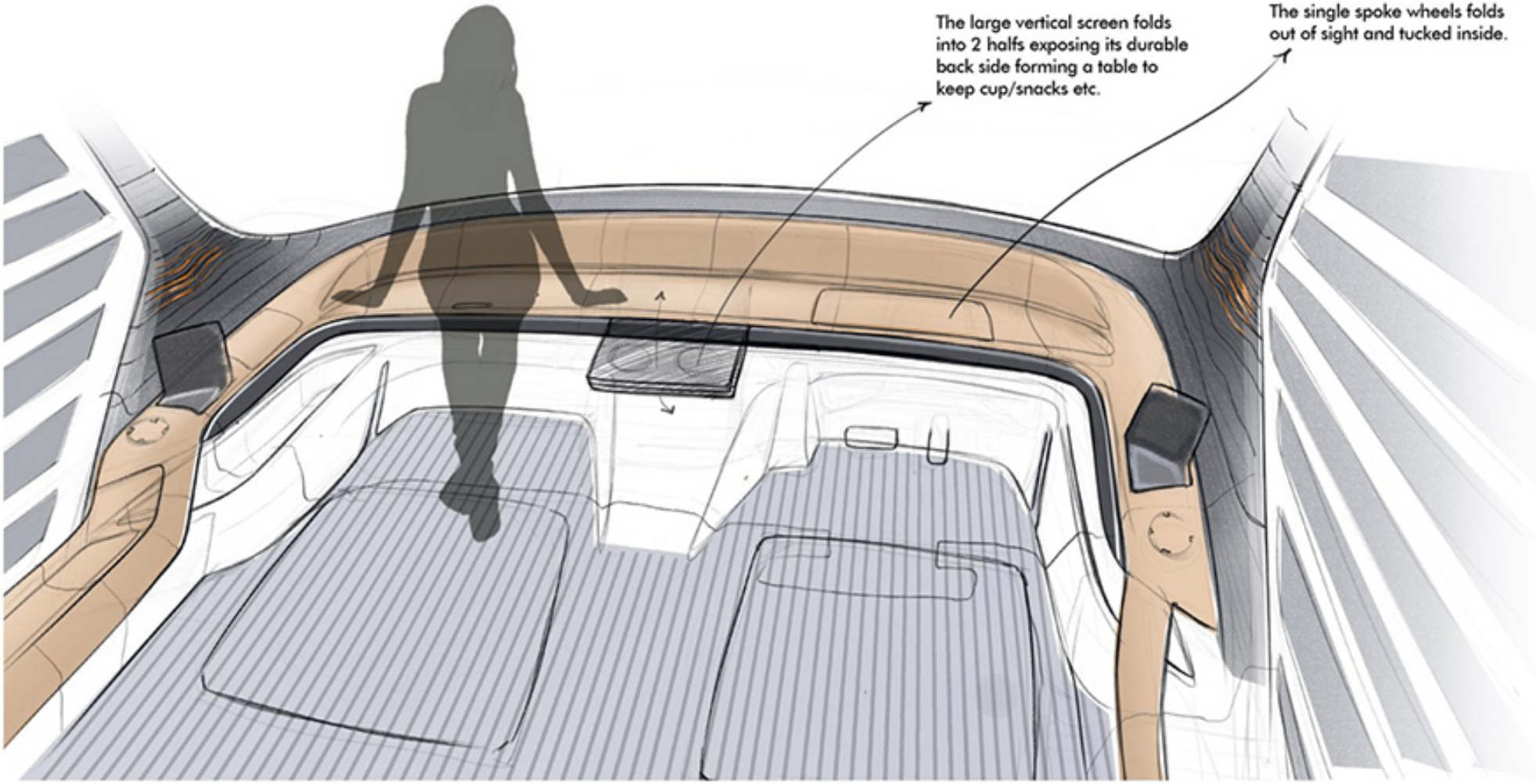


Image 19.4 final Interior ideation: Dashboards

The front dashboard is based on form following function. The whole dash doubles up as a picnic seat, best for sitting together while sipping hot coffee. The central screen folds and hides away into th panel revealing more space.

Tea Break


The large vertical screen folds into 2 halfs exposing its durable back side forming a table to keep cup/snacks etc.
The single spoke wheels folds out of sight and tucked inside.

Interior Ideations

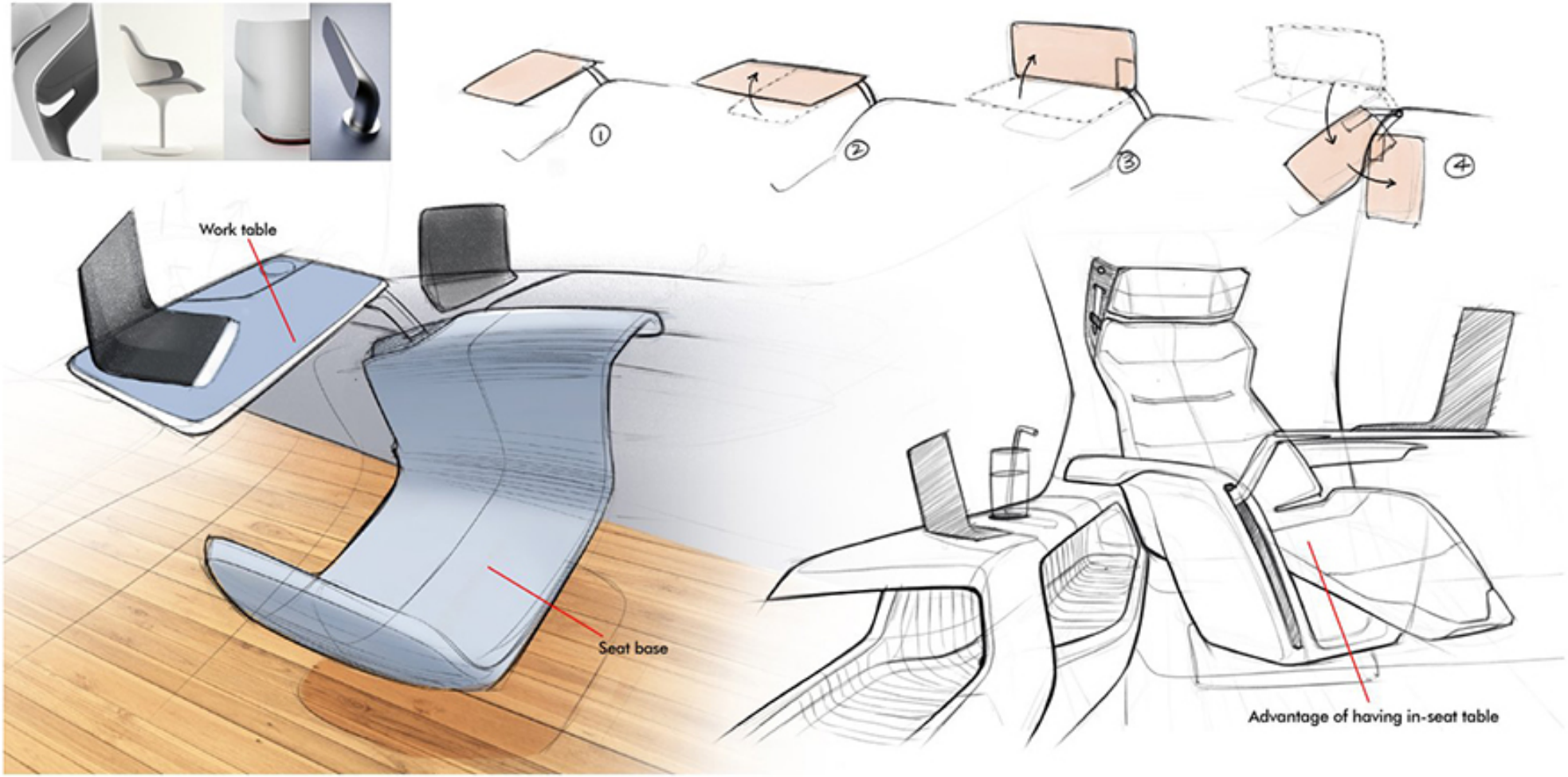


Image 19.5 final Interior ideation: Tray table

The retracting tray table can easily accomodate a laptop (in its future form) and the tray being movable helps in getting in and out of the seat easily.

Interior Ideations

The side panels has most of vehicle controls such as ambient light, seat controls, trip information. The panel also has a shelf like arrangement where users can rest their phones, VR headsets, towels, blankets, just like a table near a bed in most bedrooms.

Image 19.6 final Interior ideation: Side panels

Interior Ideations

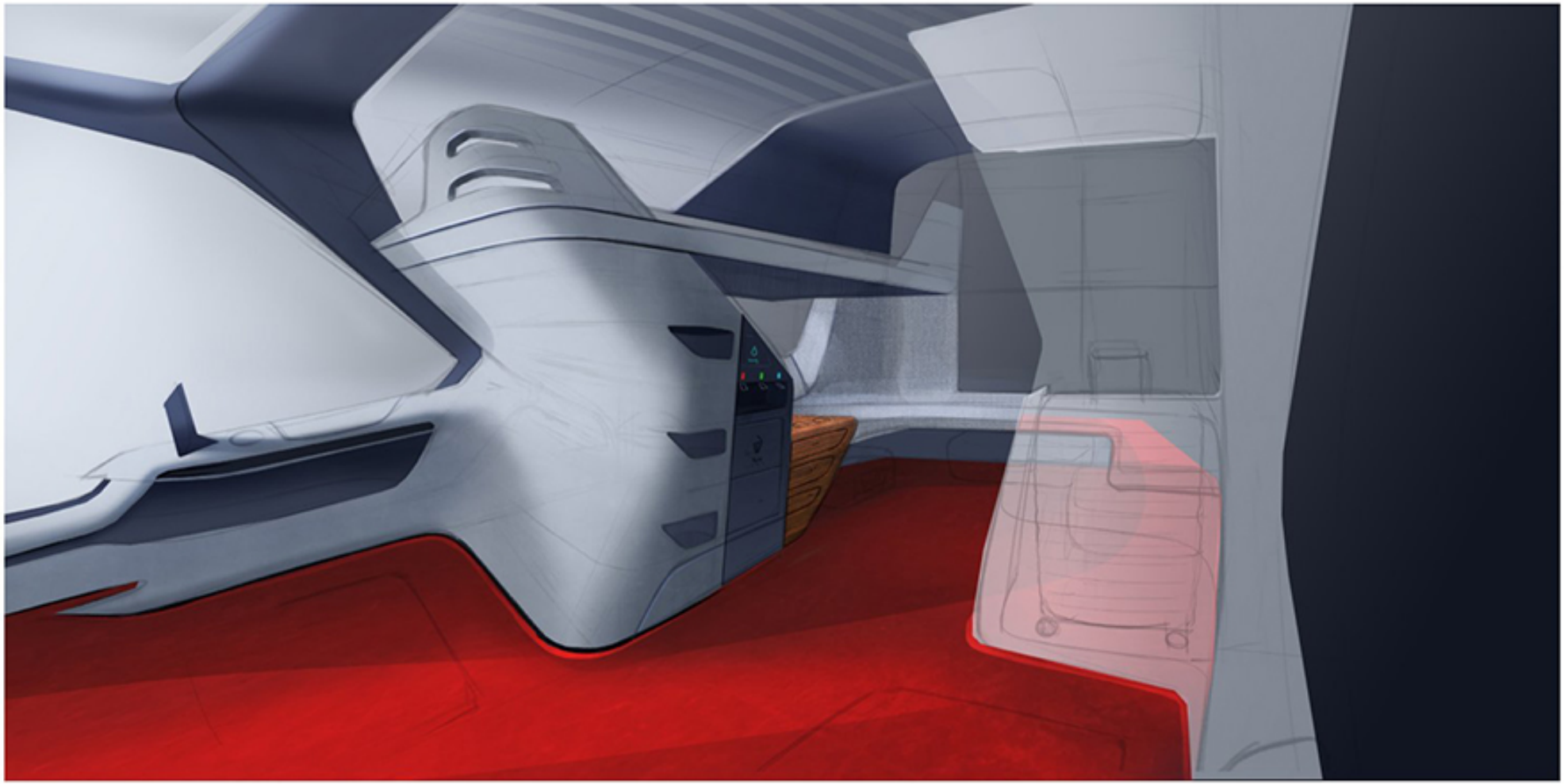


Image 19.7 final Interior ideation:Rear section details

The aviation inspired design language has seemless volumes integrating lot of utilities required for a long road trip. The space utilisation by various equipments also creates a unique interior look, which would ultimately influence the exterior form.

Interior Ideations

An idea where the water dispenser+ trash bin+ snack counter was moved to the other side, keeping the bed separate. This did not work out in 3D revealing a lack of access space in between both the volumes. Hence the previos idea was taken forward.

Image 19.8 final Interior ideation: Modified rear section

20. Final Sketch: Interior

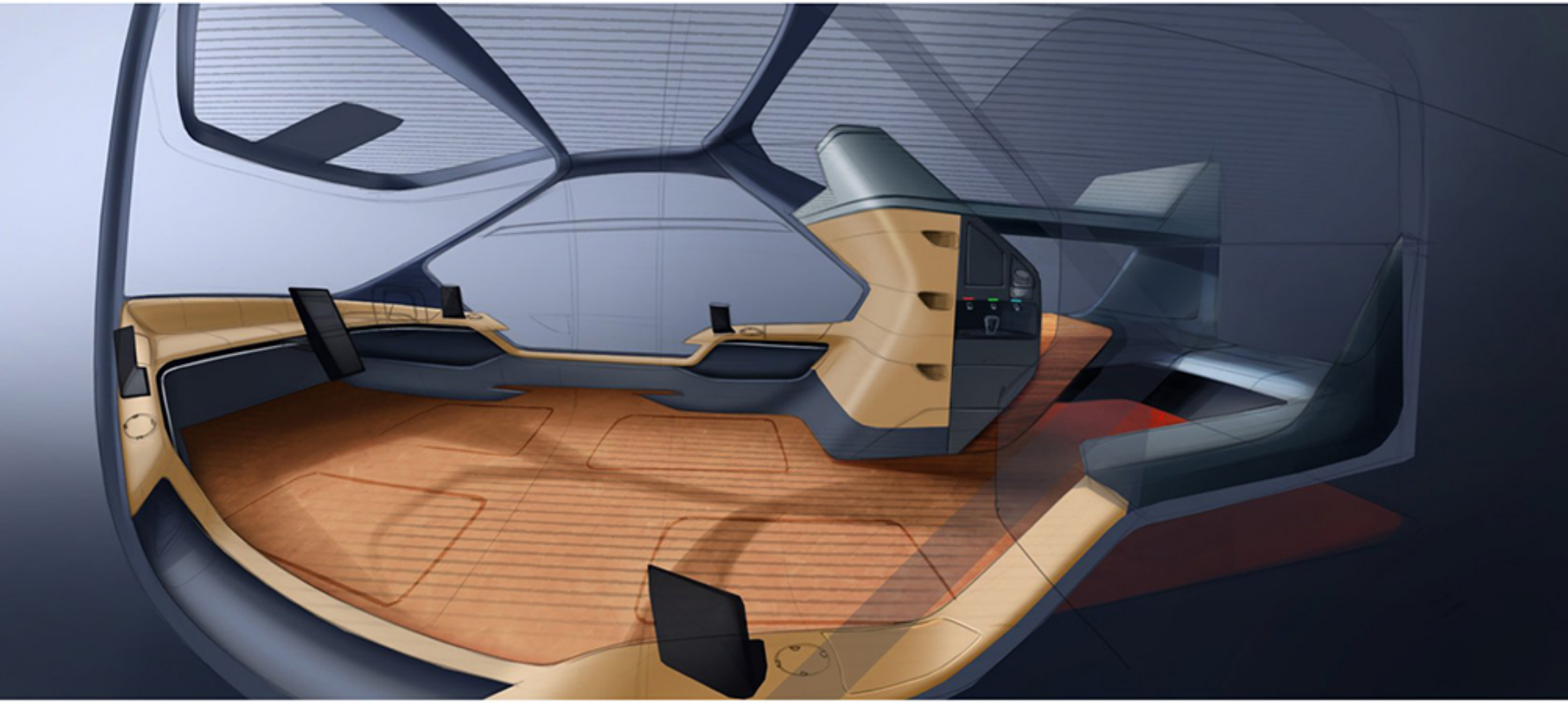


Image 20.1 Final interior sketch without seats

Final Sketch: Interior

Image 20.2 Final interior sketch with seats and other equipments

Final Sketch: Interior

Image 20.3 Final interior sketc: rear part

Note: Refer to Appendix for more interior ideas and features

21. Exterior Ideations

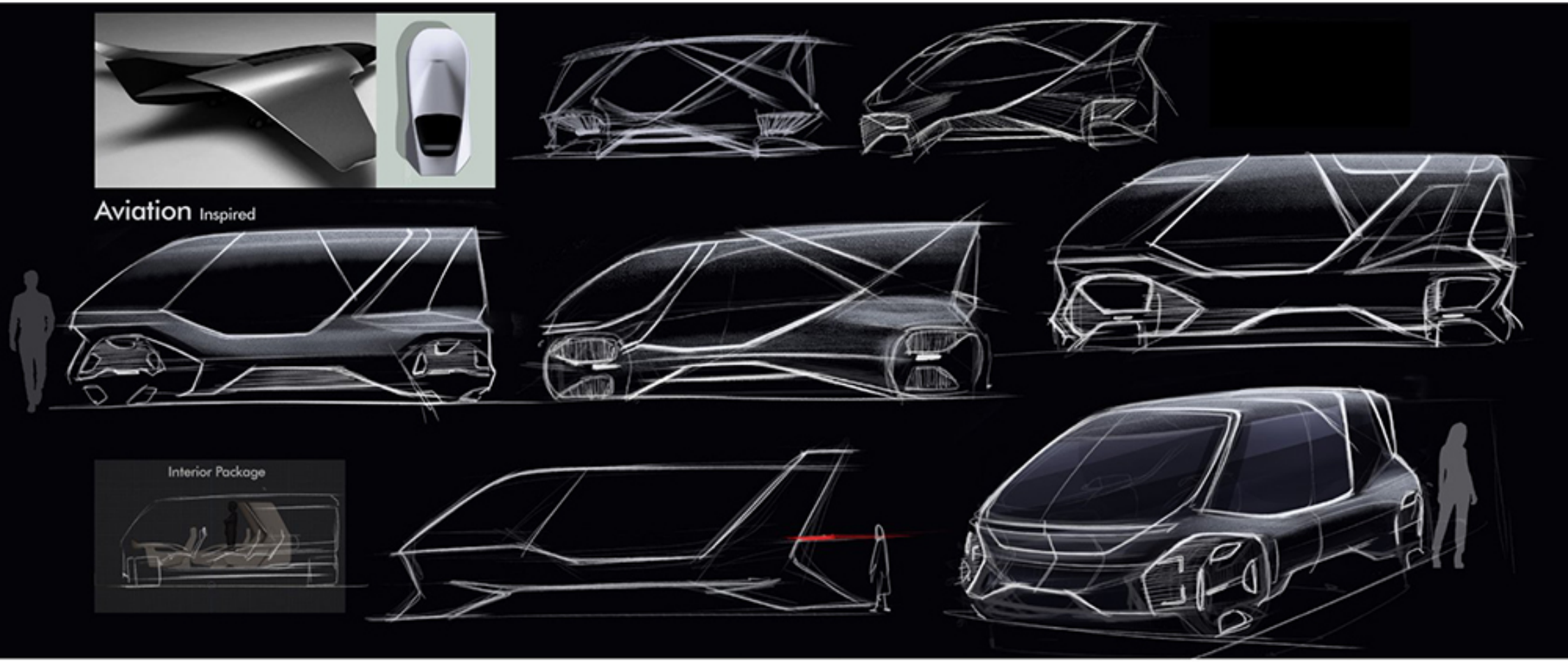


Image 21.1 Exterior ideation 1

Exterior Ideations

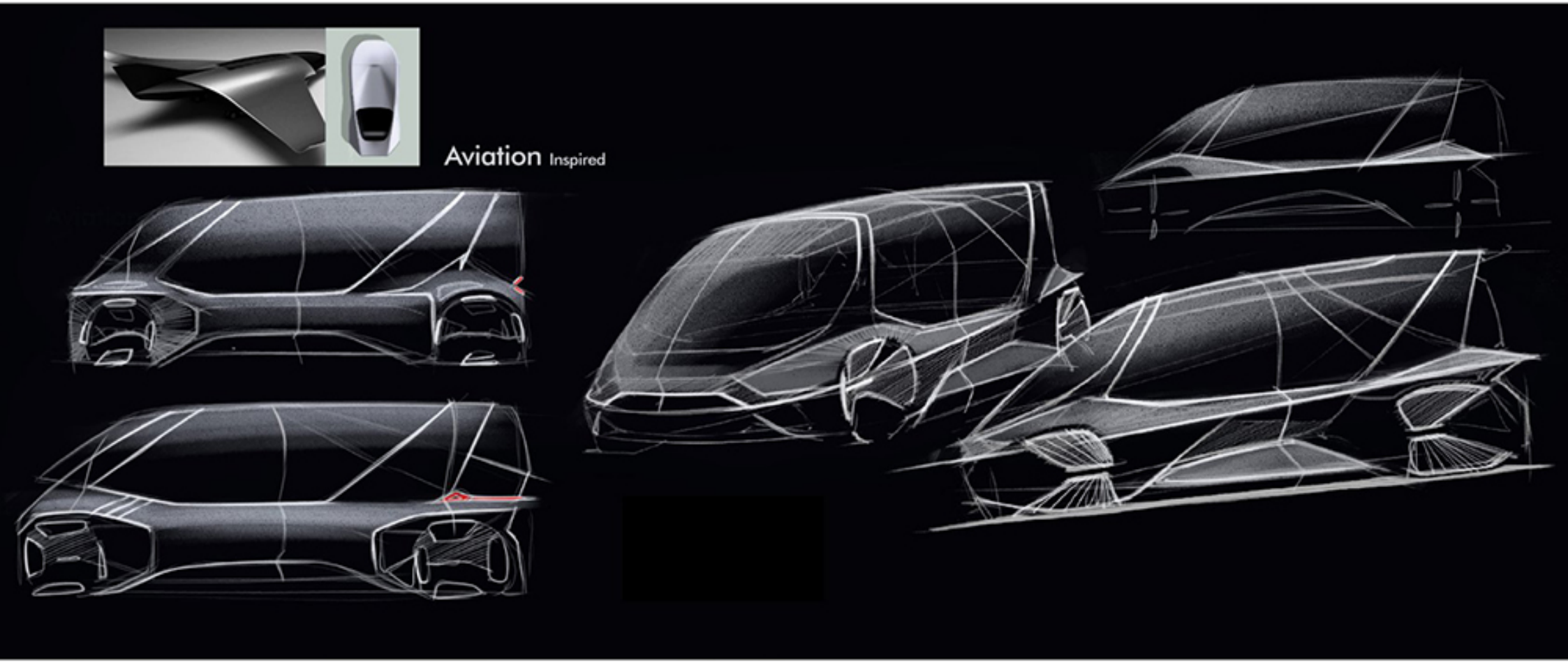


Image 21.2 Exterior ideation 2

Exterior Ideations

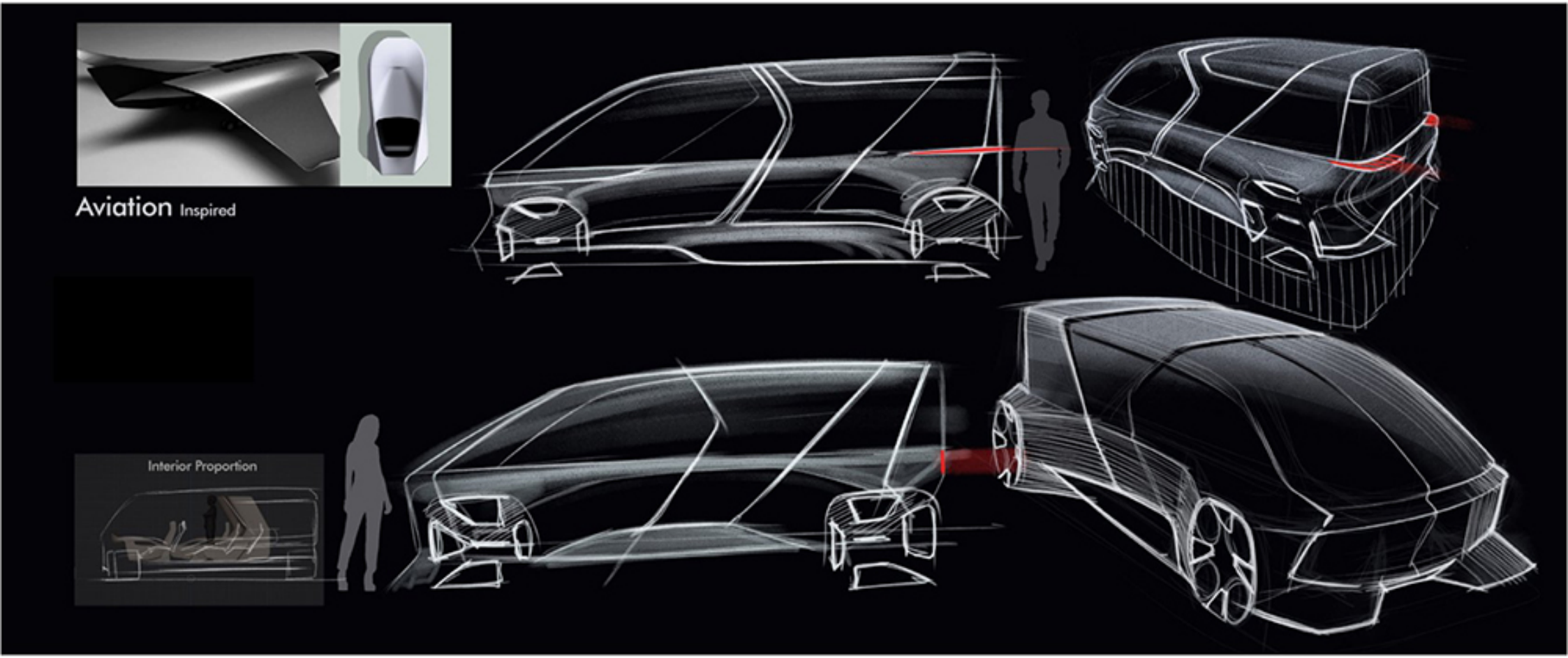


Image 21.3 Exterior ideation 3

Exterior Ideations

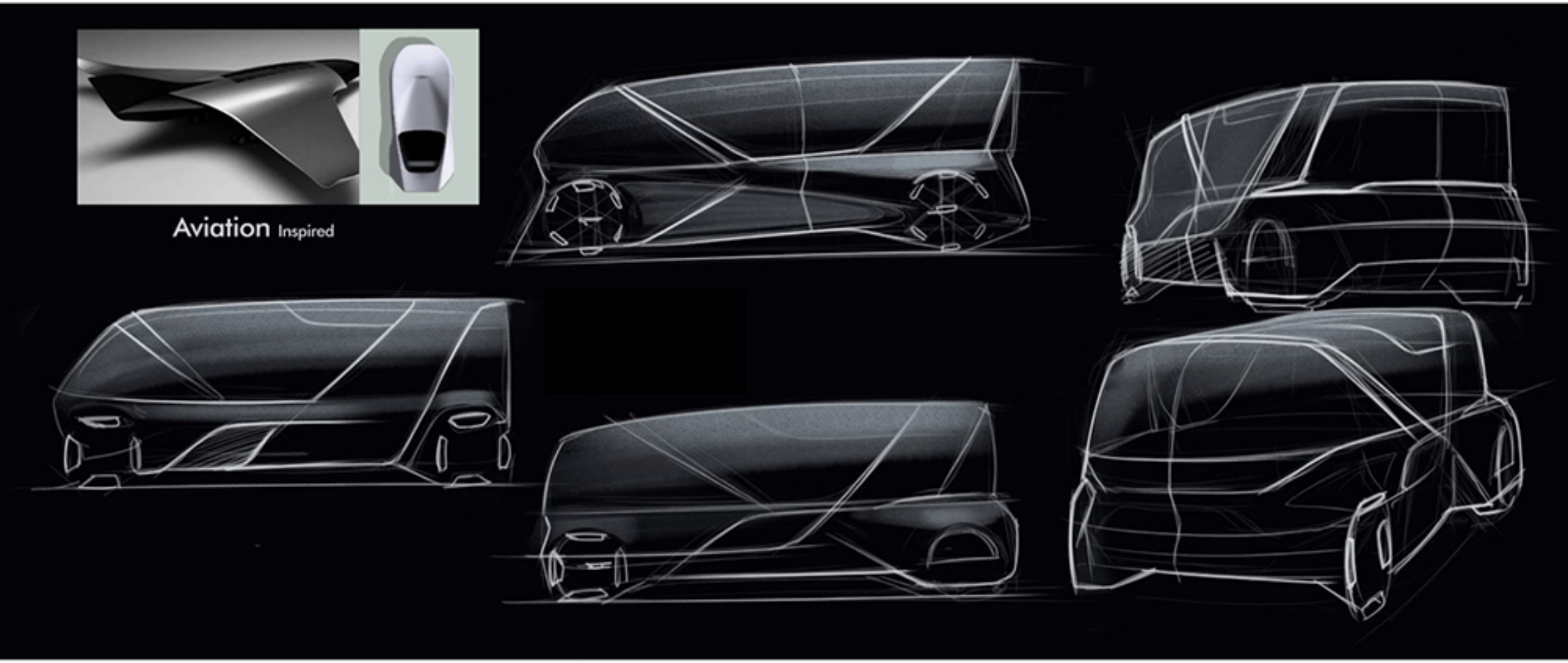
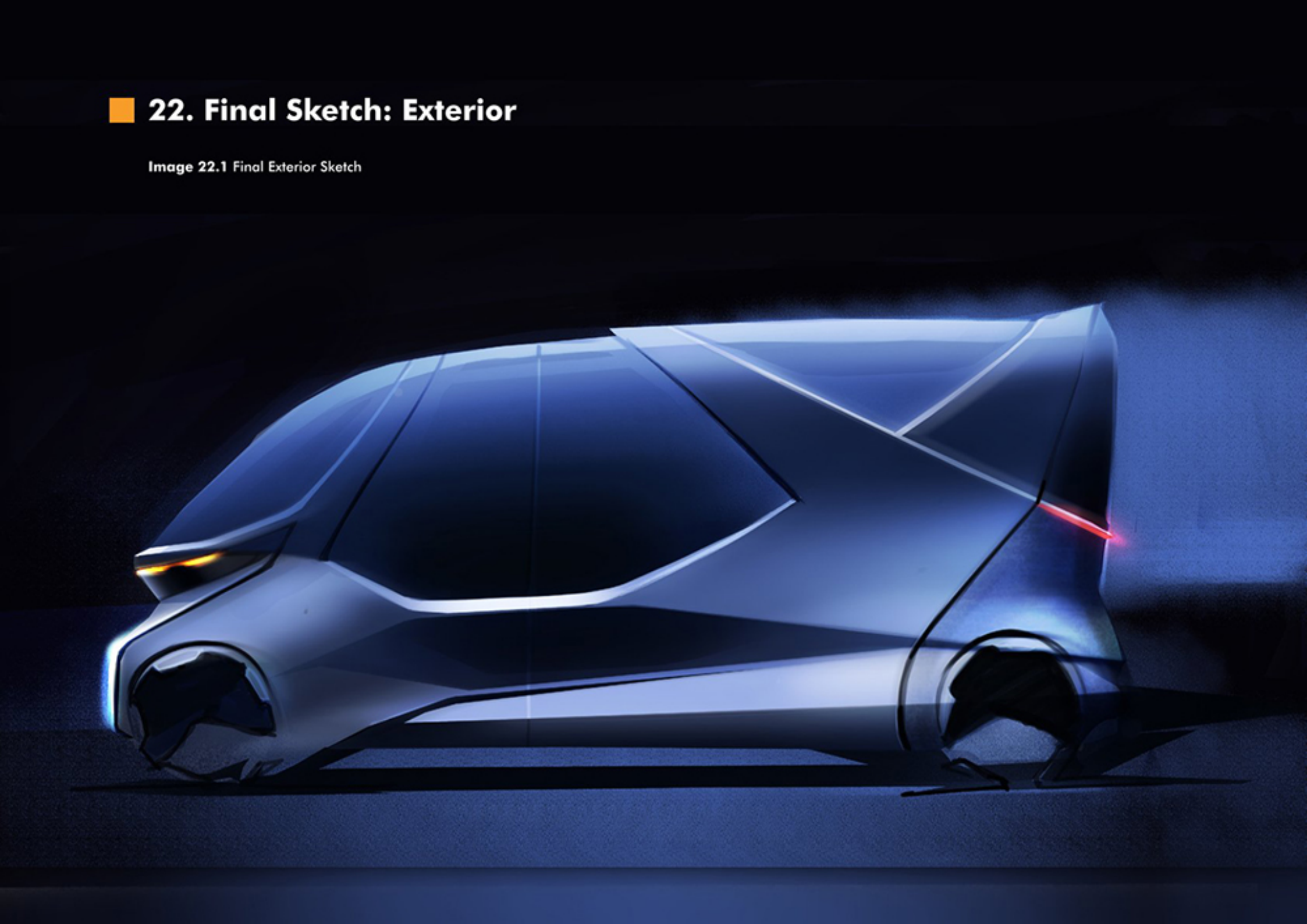


Image 21.4 Exterior ideation 4

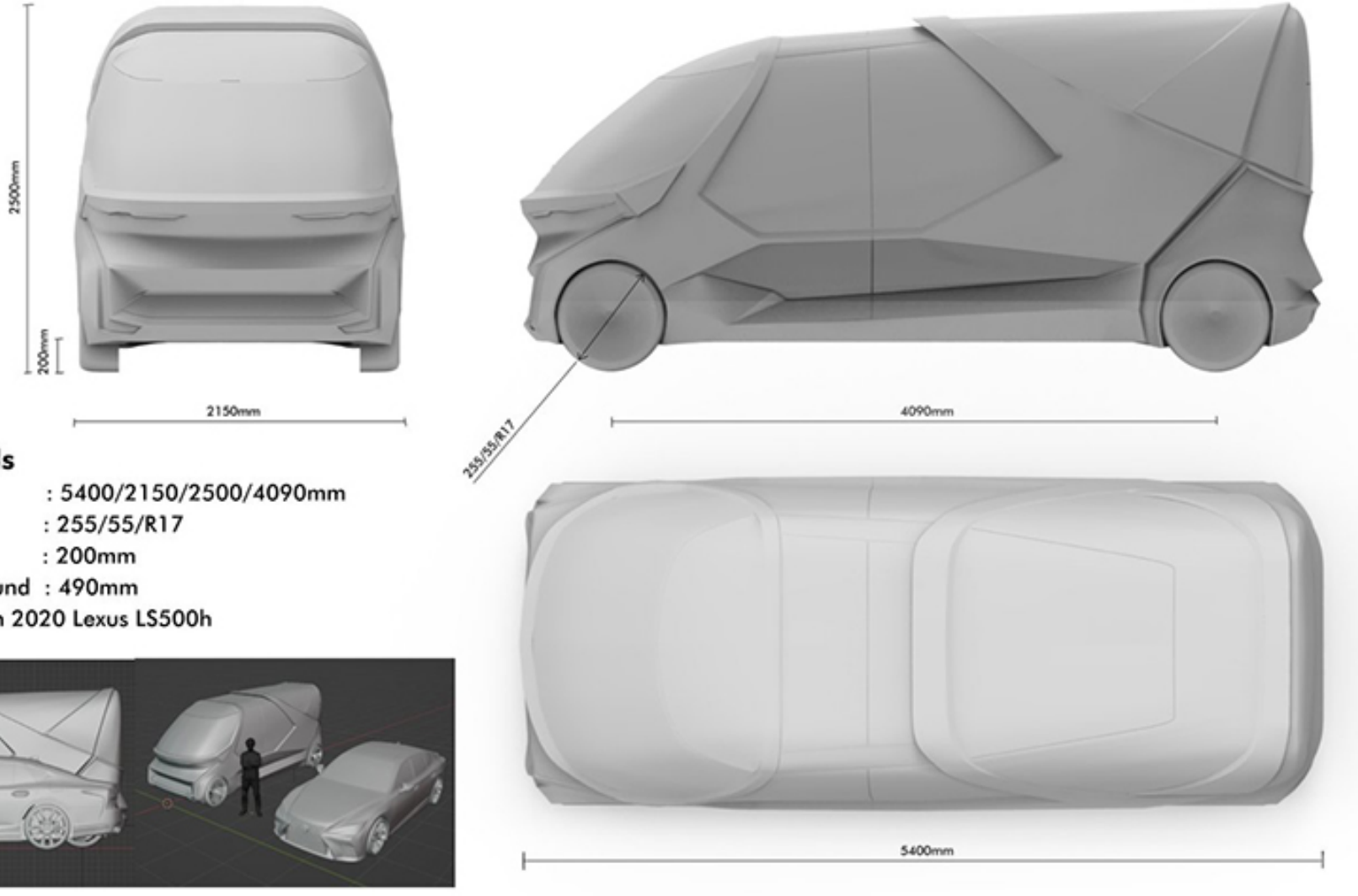
22. Final Sketch: Exterior

Image 22.1 Final Exterior Sketch



23. Vehicle Dimensions

Image 23.1 Vehicle Dimension and comparison with Lexus LS500h

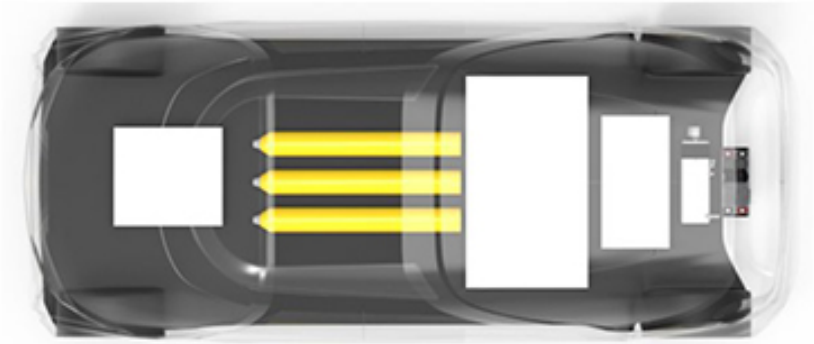


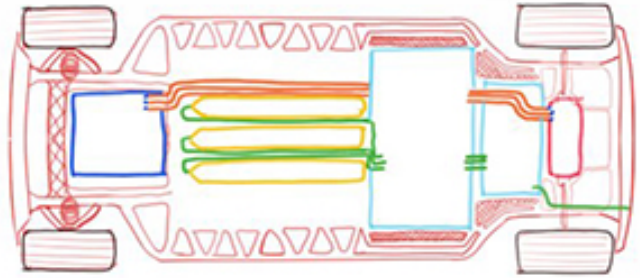
Dimension Details

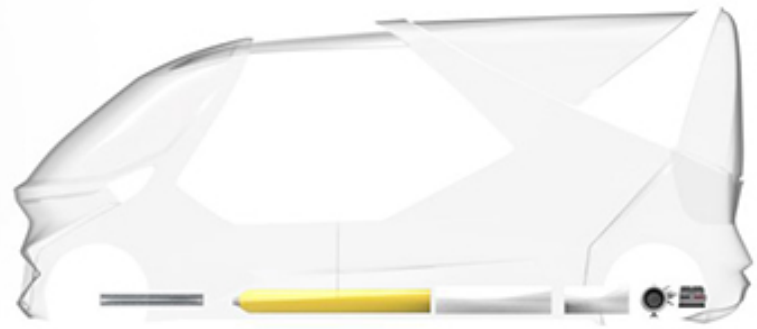
L/W/H/W.B	: 5400/2150/2500/4090mm
Tyre size	: 255/55/R17
Clearance	: 200mm
Floor Height from ground	: 490mm

Visual comparison with 2020 Lexus LS500h

24. Technical Package







Rear wheel driven, single Indusction motor
260kW Fuel cell output (350hp)

6kg Hydrogen storage (Centrally-longitudinally mounted)
3 hydrogen tanks at 70Mpa (10,000psi) carrying a total of 180L Hydrogen
Gross weight of tanks will be 100kg.

10kW Auxilliary li-polymer battery (For regen, startup, torque fill) (front transversly mounted)

Image 24.1 Technical Package

PHASE III

The final phase of the project is all about showcasing the developed interior and exterior design of this unique vehicle. A technical package was developed as soon as final layout was fixed and the whole vehicle was developed on that. The following phase includes renders of the final model.

25. 3D Renders: Interior

Image 25.1 Interior Render: Top overview

Image 25.2 Interior Rende: Rear most view

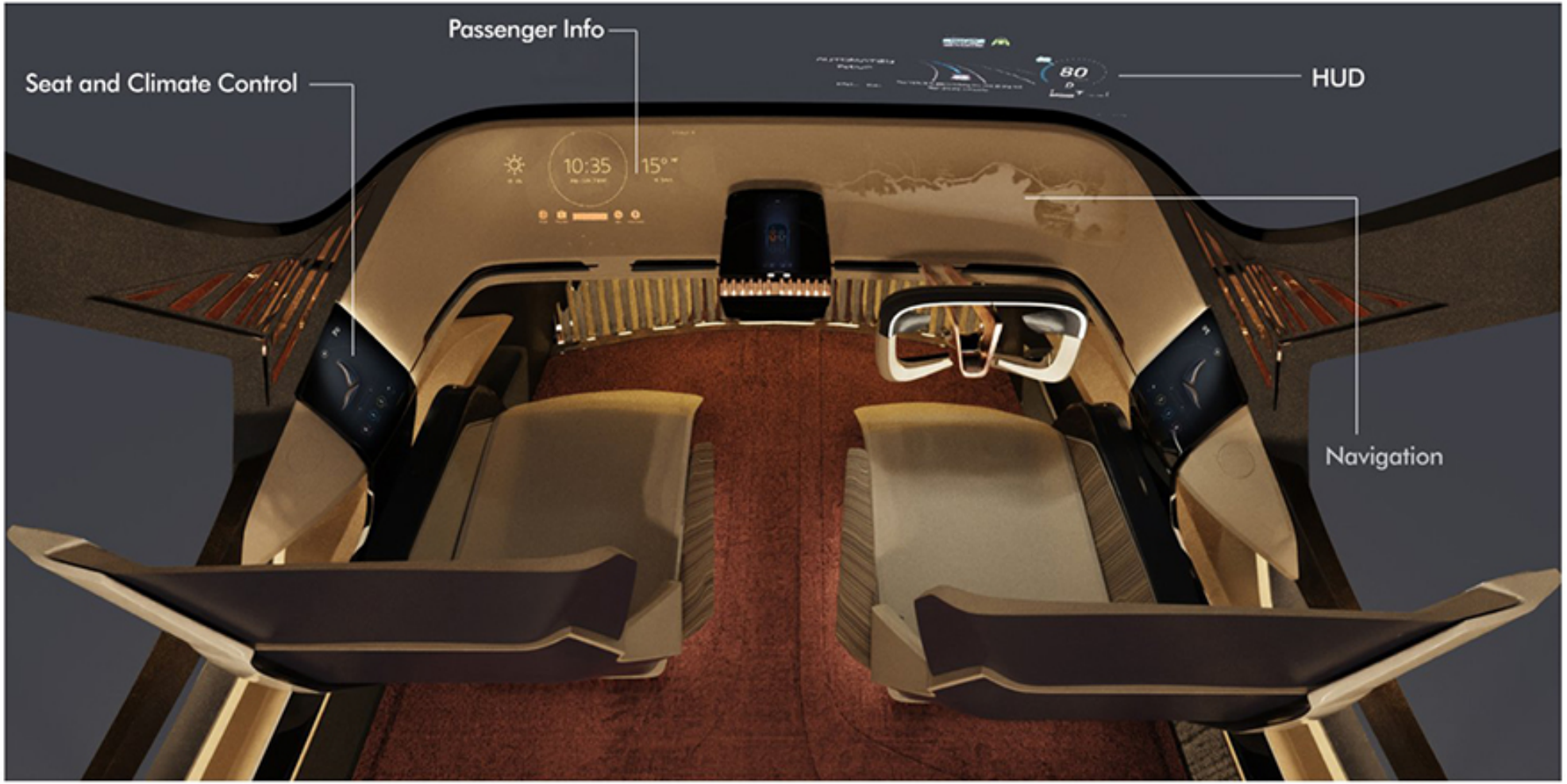
Image 25.3 Interior Render: Front to rear view

Image 25.4 Interior Render: Side panel shelf

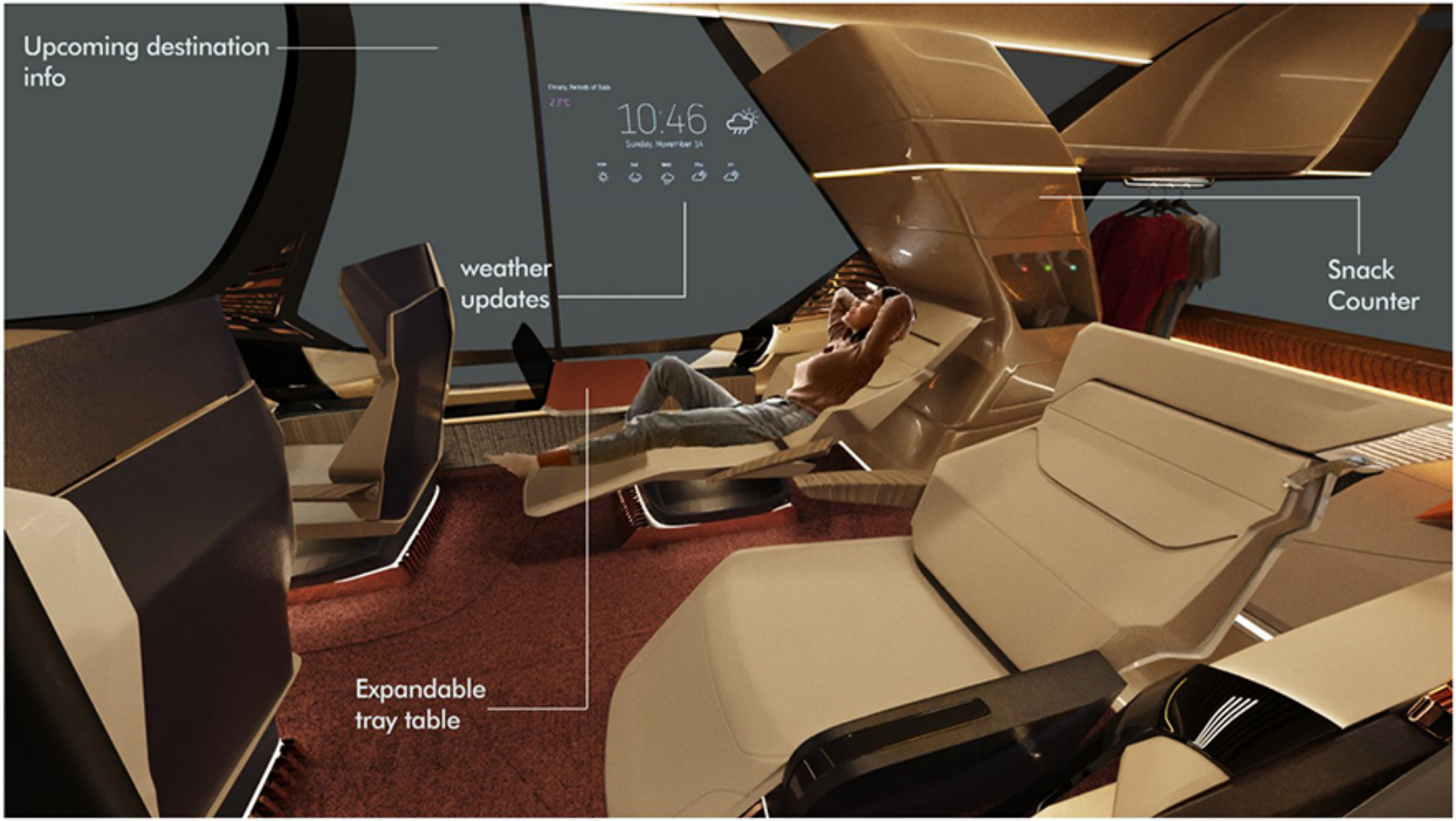
Image 25.4 Interior Render: Rear to front view

Image 25.5 Interior Render: front side view

25.2 3D Renders: Interior Details



25.2.1 3D Renders: Interior Details



26. 3D Renders: Exterior

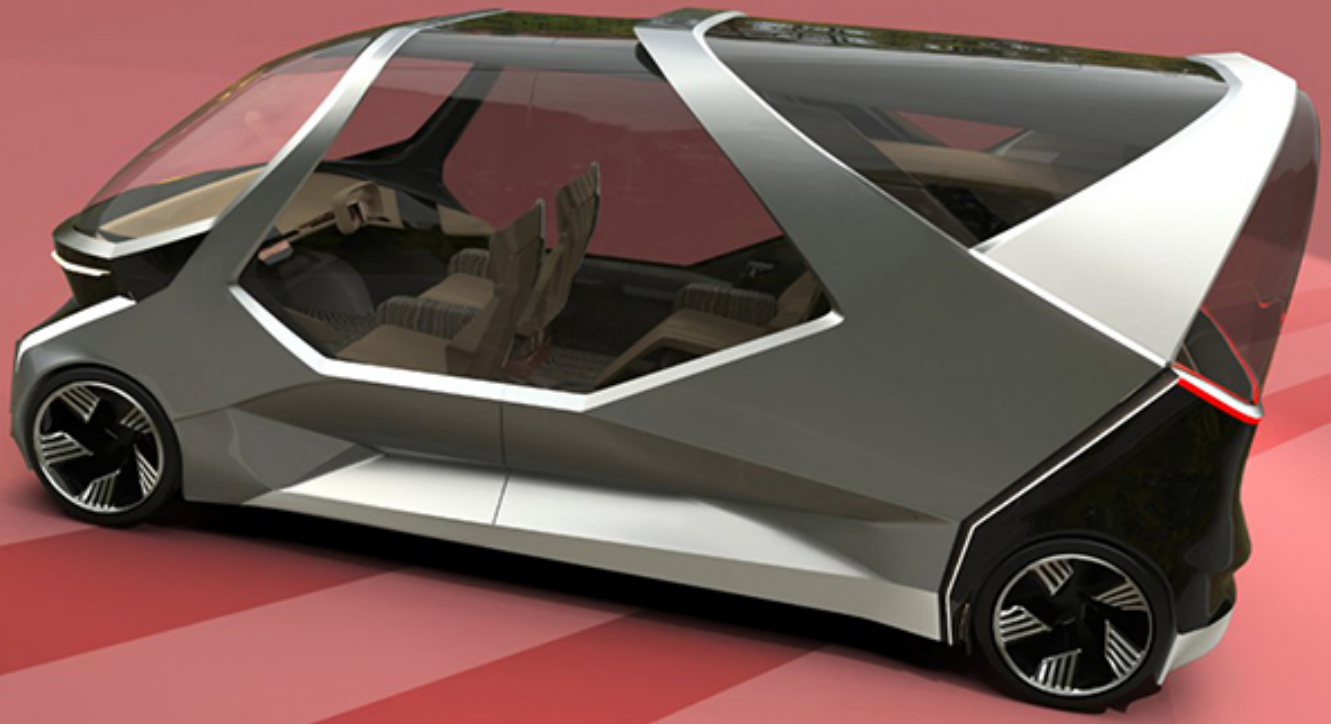


Image 26.1 Exterior Render: Side

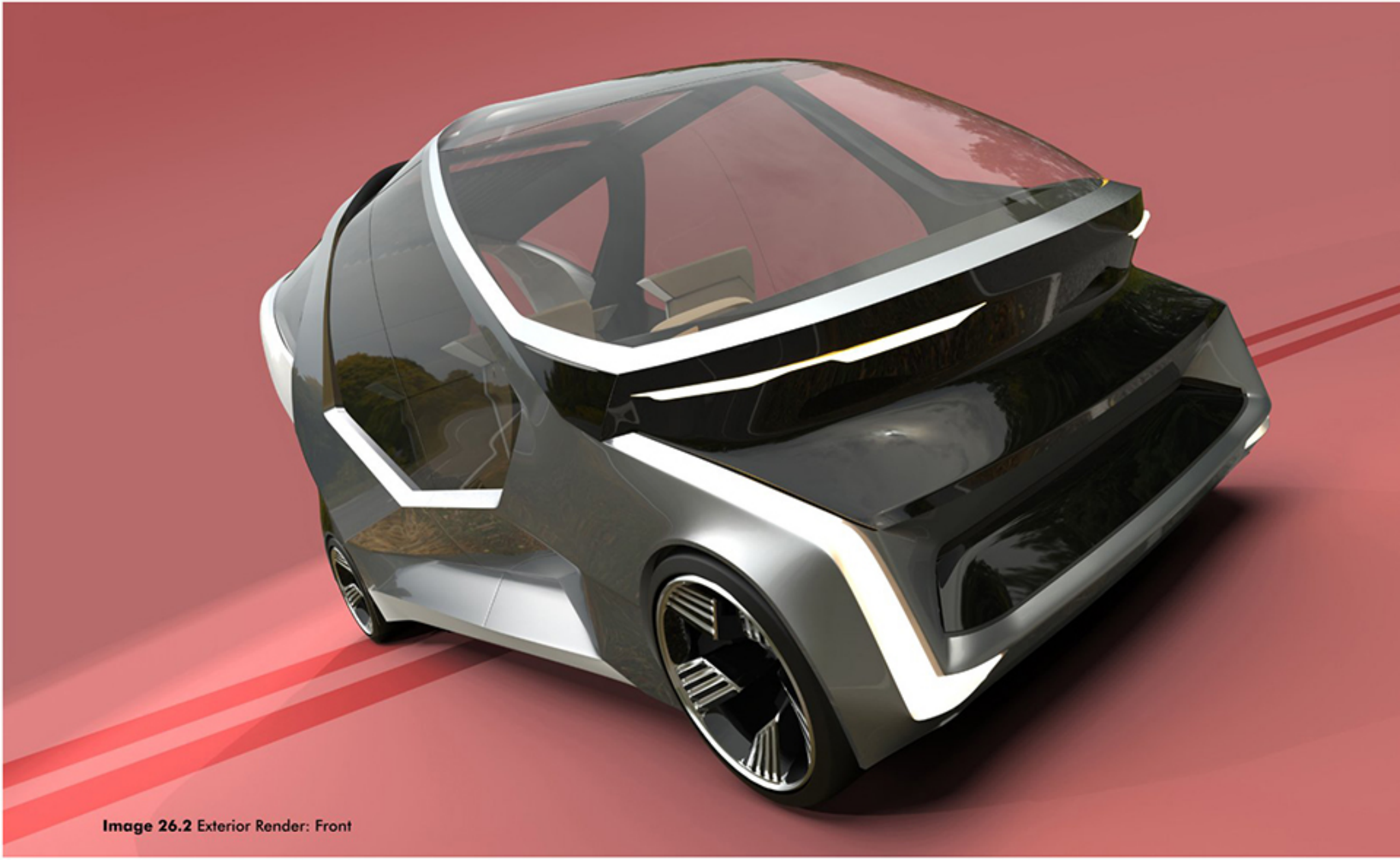


Image 26.2 Exterior Render: Front

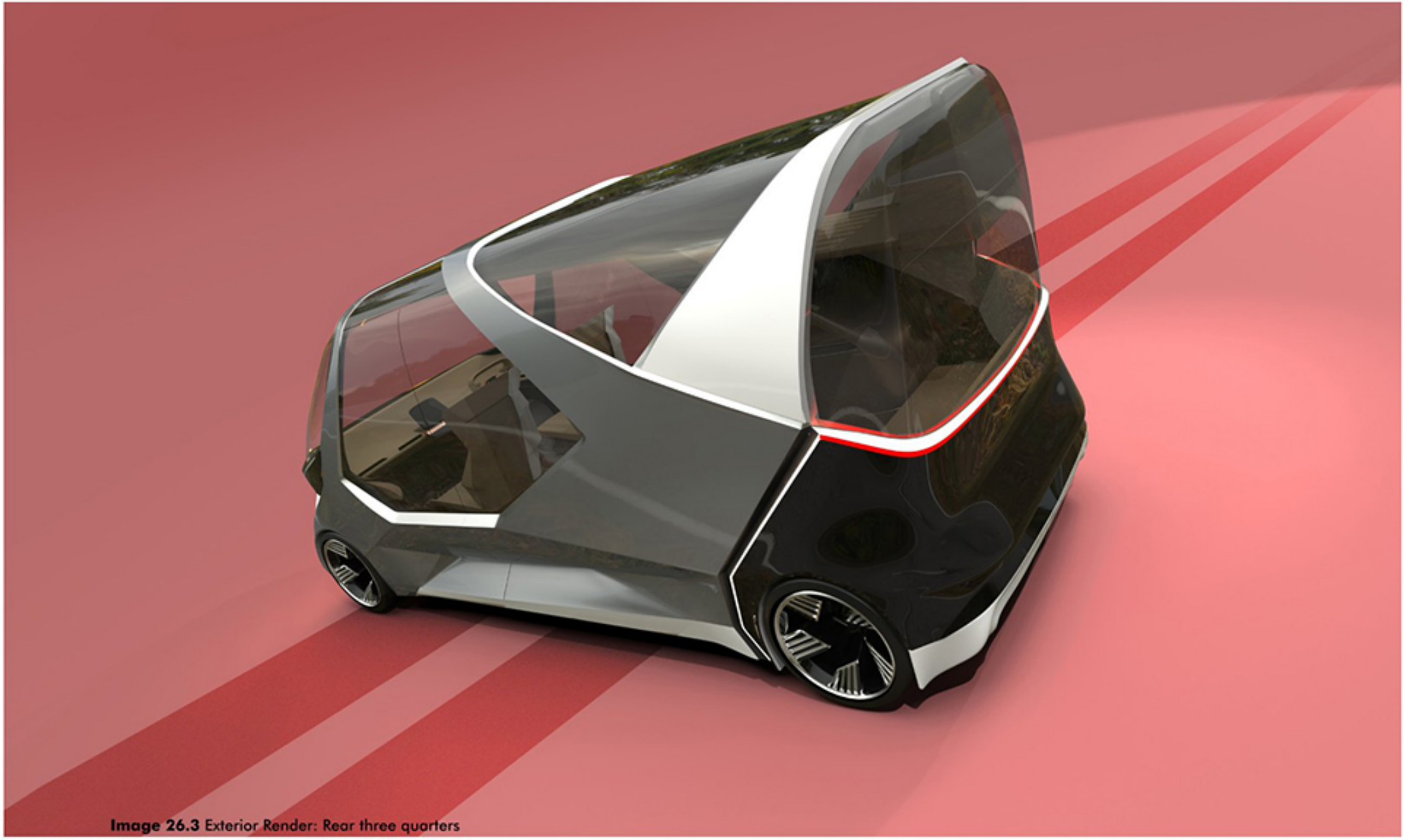


Image 26.3 Exterior Render: Rear three quarters

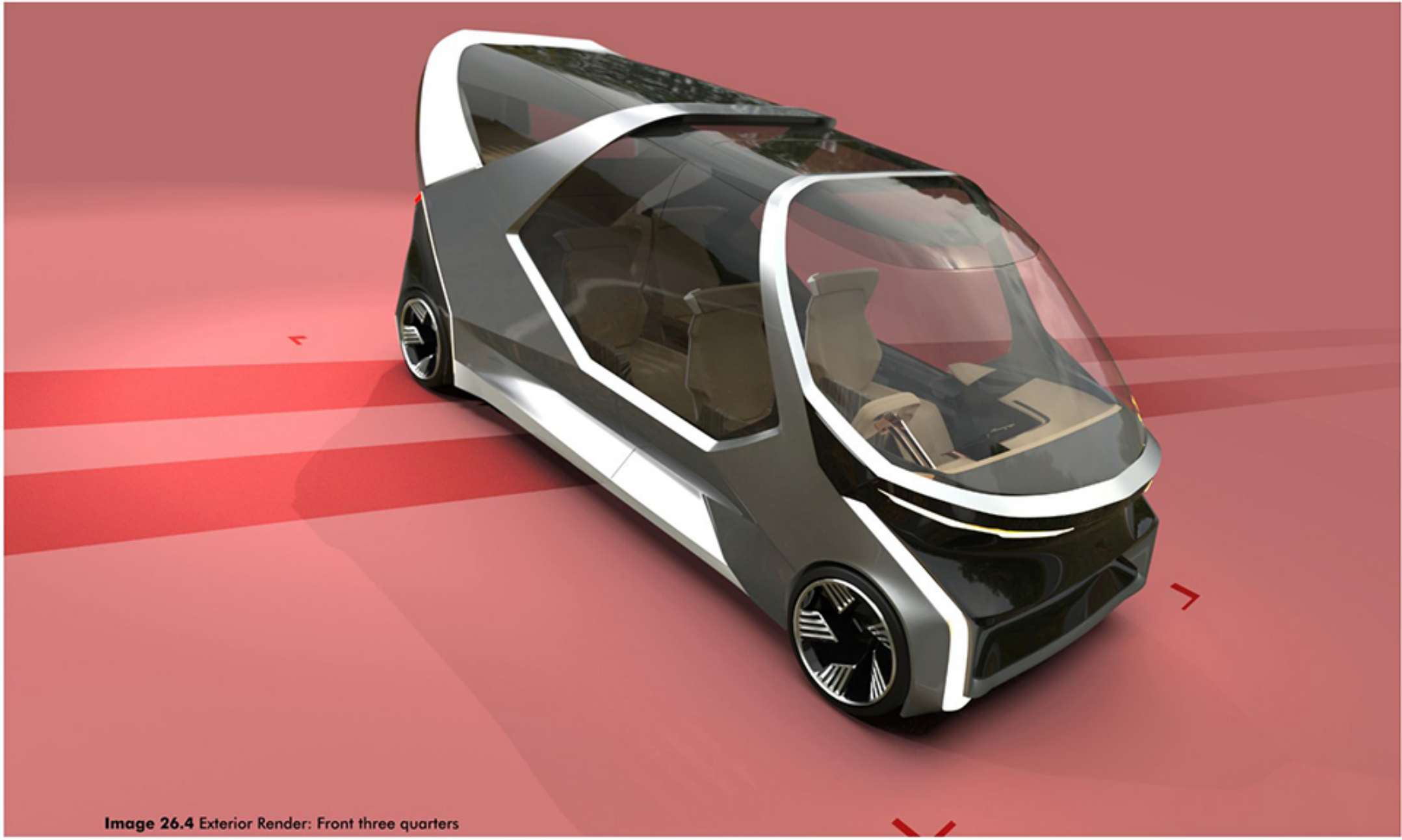


Image 26.4 Exterior Render: Front three quarters

Image 26.5 Exterior Render: Highway

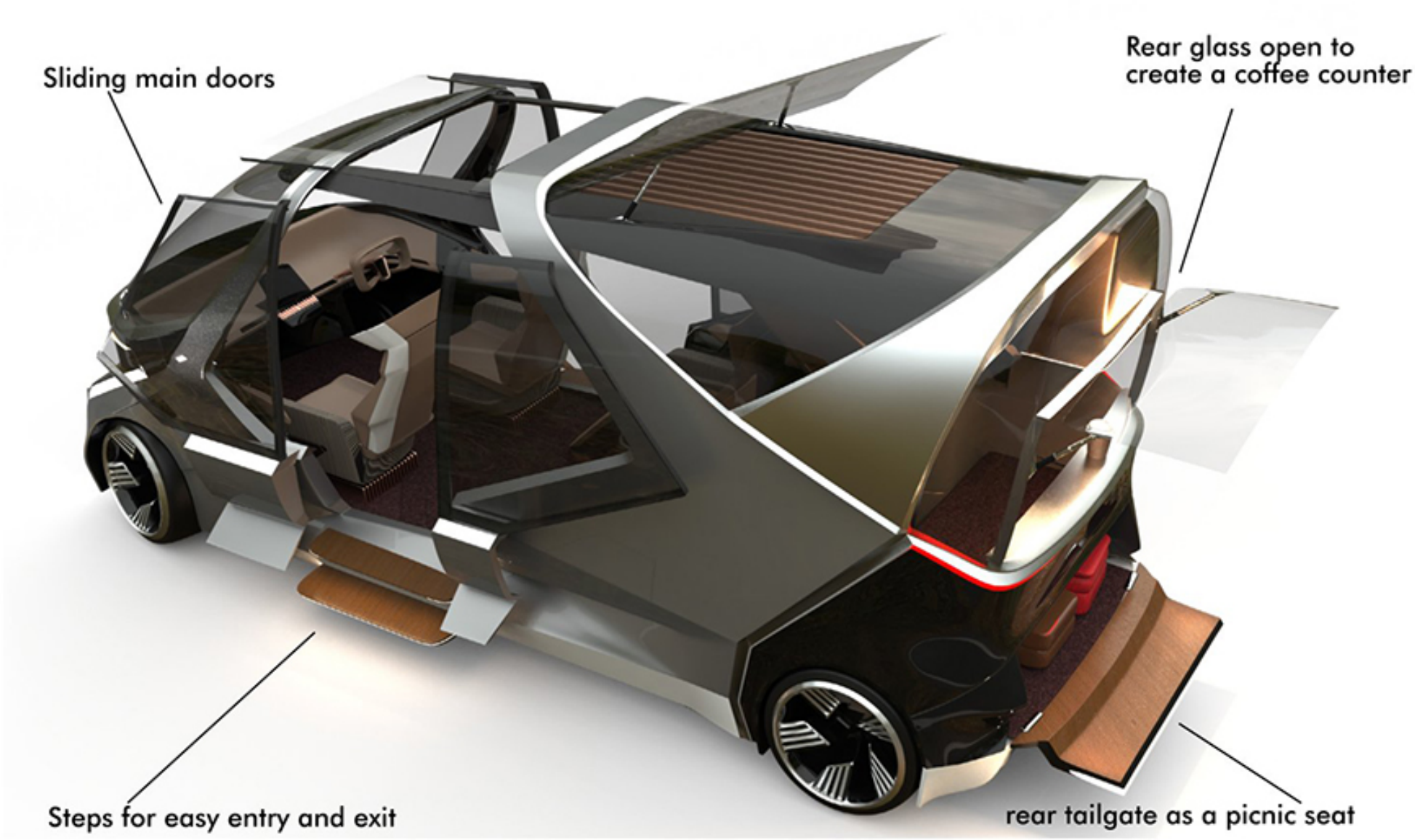
Image 26.6 Exterior Render: Sea side

Image 26.7 Exterior Render: Parked up near a beach

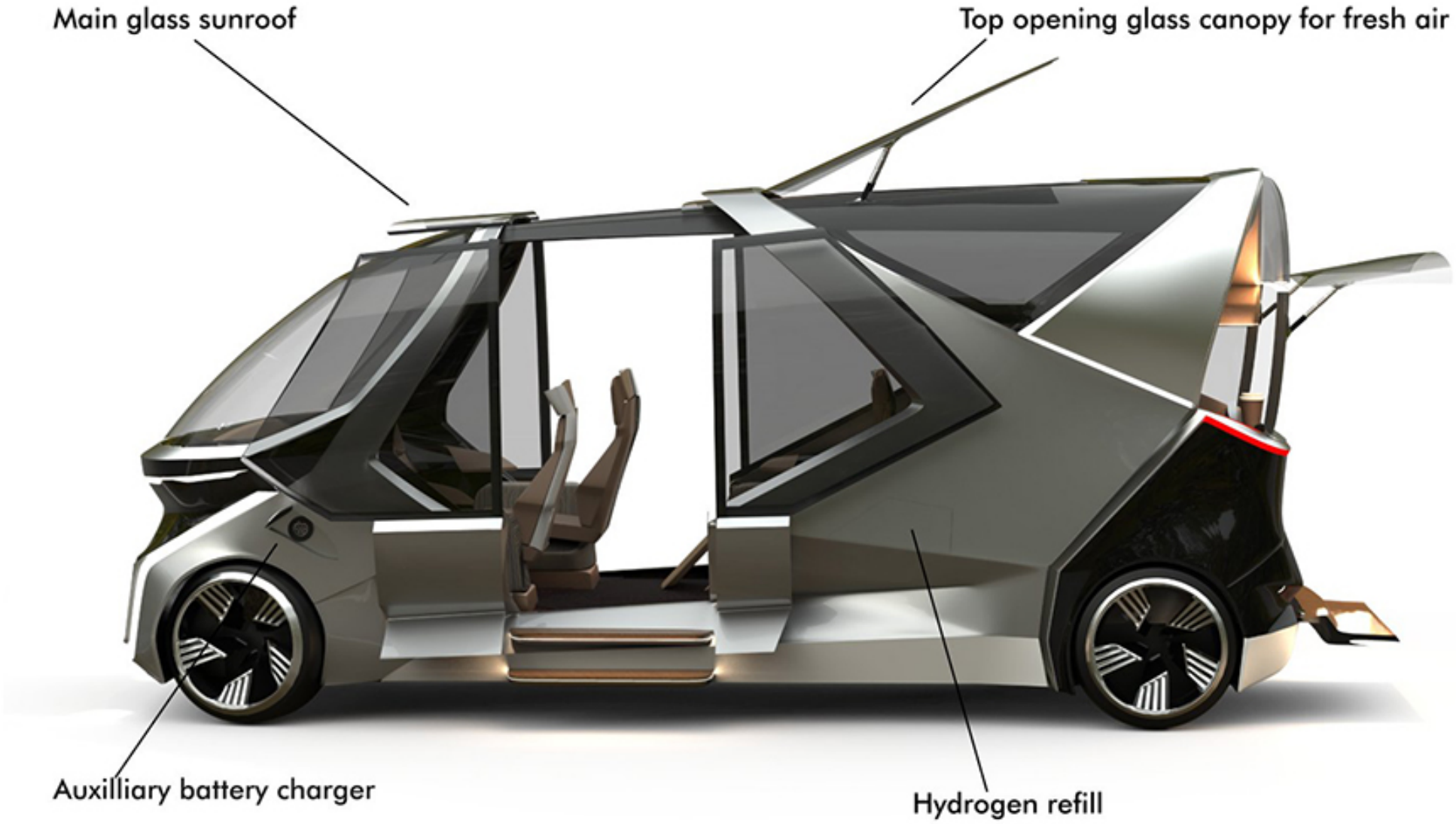
Image 26.8 Exterior Render: Outdoor exploration

Image 26.9 Exterior Render: Studio shot

26.2 3D Renders: Exterior Details

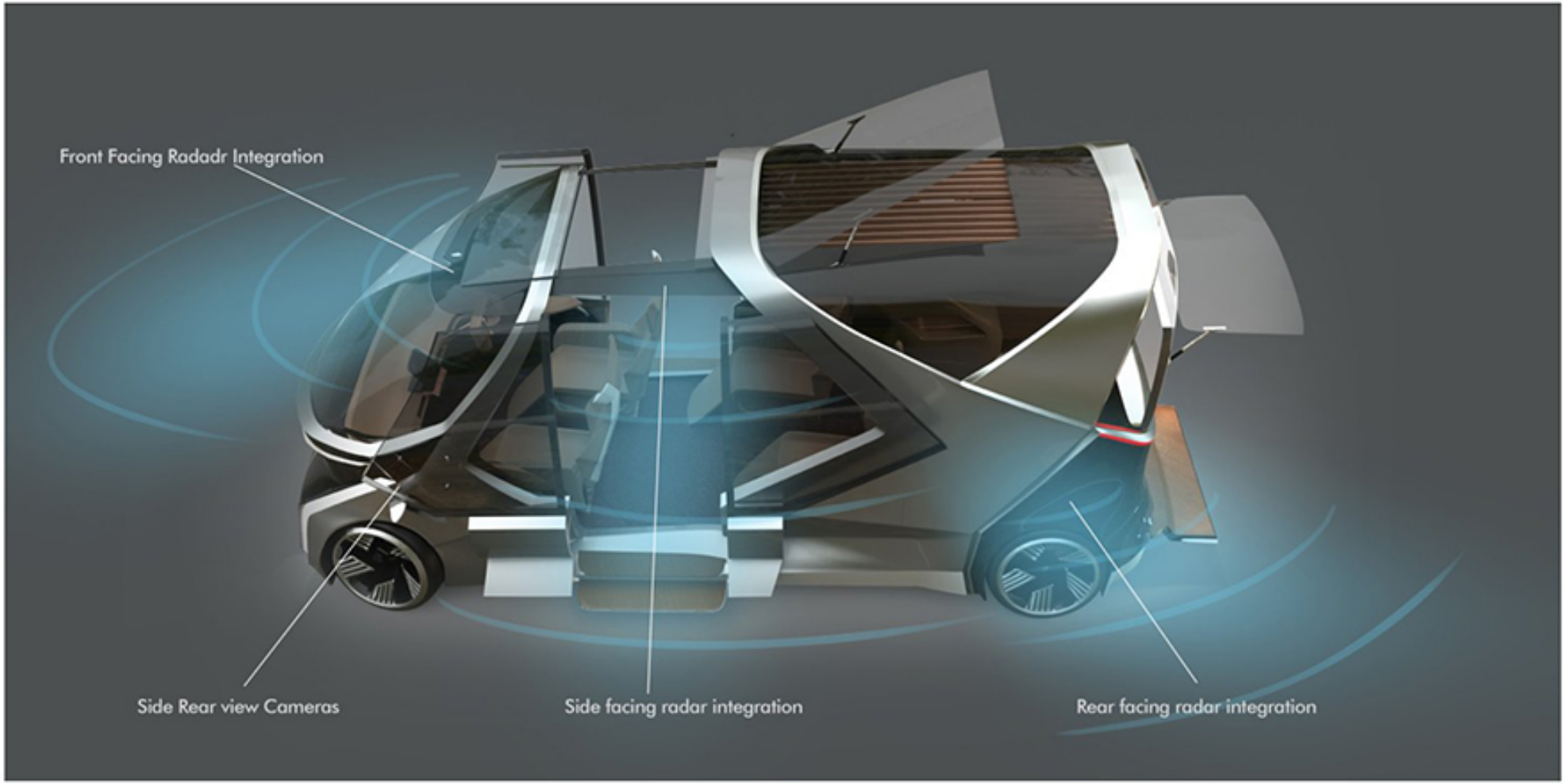


26.2.1 3D Renders: Exterior Details



26.2.2 3D Renders: Exterior Details

26.2.3 3D Renders: Exterior Details



The vehicle is equipped with level 2 autonomous driving capability, enabling driver to take the hands completetly off the wheel and relax for a few minutes. The vehicle also has auto park, auto lane change and smart adaptive cruise control for effortless highway journeys. For this, there are radars placed on all 4 sides of the vehicle, which scans the road all around.

27. Physical Mockup

Images showing the 90% completed model
Scale 1:12
Material: 3D printed PLA

References

Reports:

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https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf (iot)

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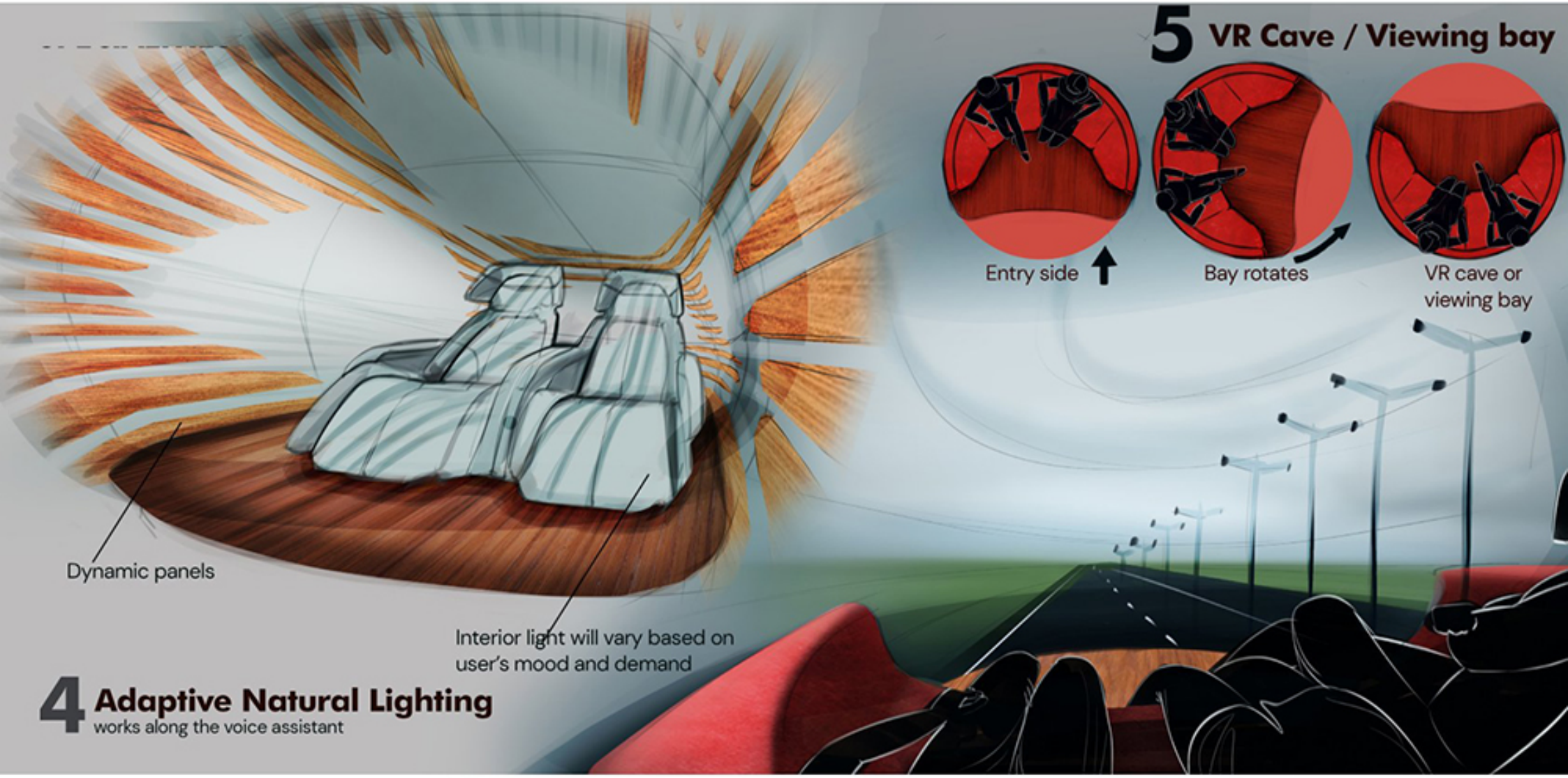
Appendix

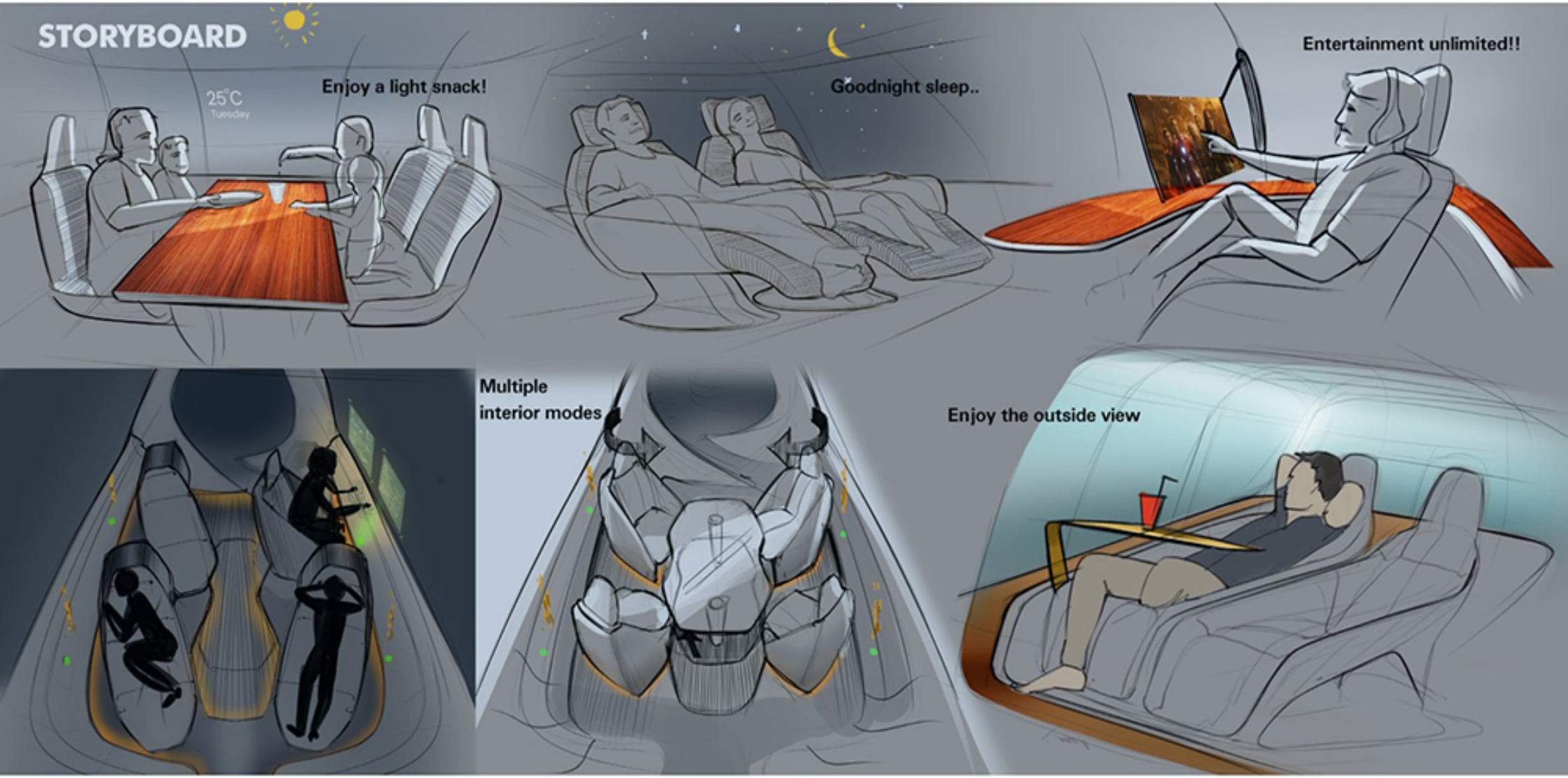

1 Zero g seating
Easy breathing
Reduced stress on heart
"zero stress zone"
Relaxed muscles
Face to face
Airplane like
Sleep mode
Dining mode
2 Multiple Cabin Layouts
Ambient lighting
Climate control
Trip advisory
Music
Cabin mode change
Driver communication
What can I help you with?
Hey....I need a cozy vibe here
Hey.....detail us about the next stoppages
Hey.....What's the food like in New delhi?
3 Personal Assistant / companion

Ideations at a feature level was done along with the main layout explorations. Few of the ideas where converted to final concept



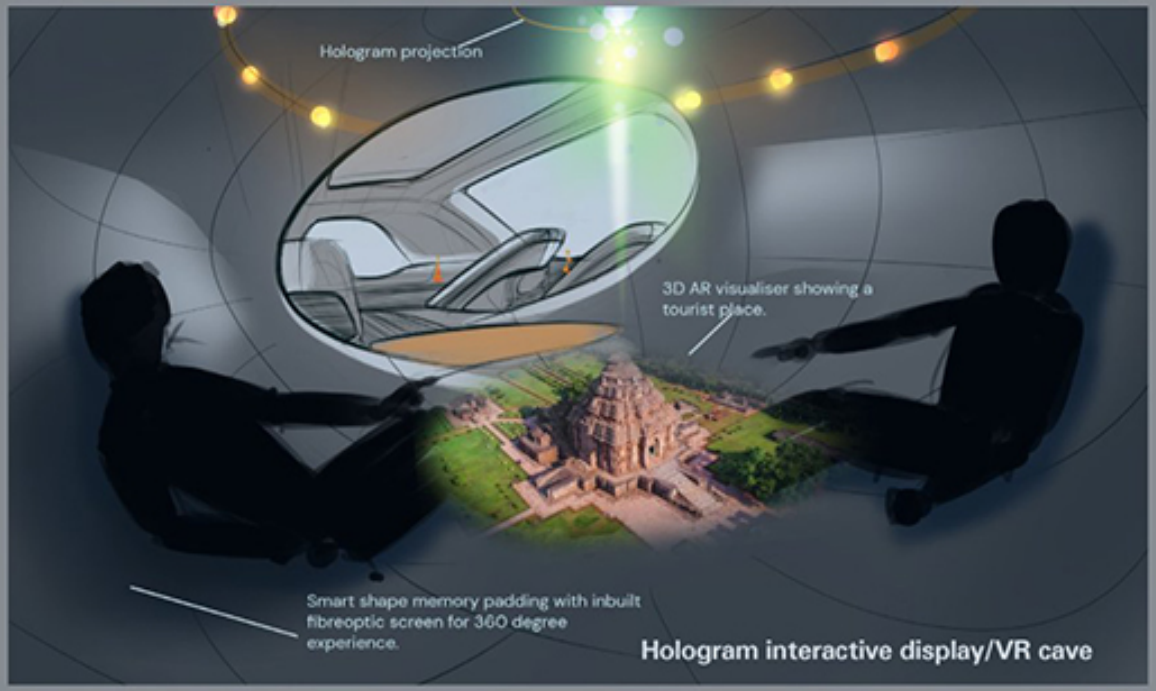
Ideations at a feature level was done along with the main layout explorations. Few of the ideas where converted to final concept

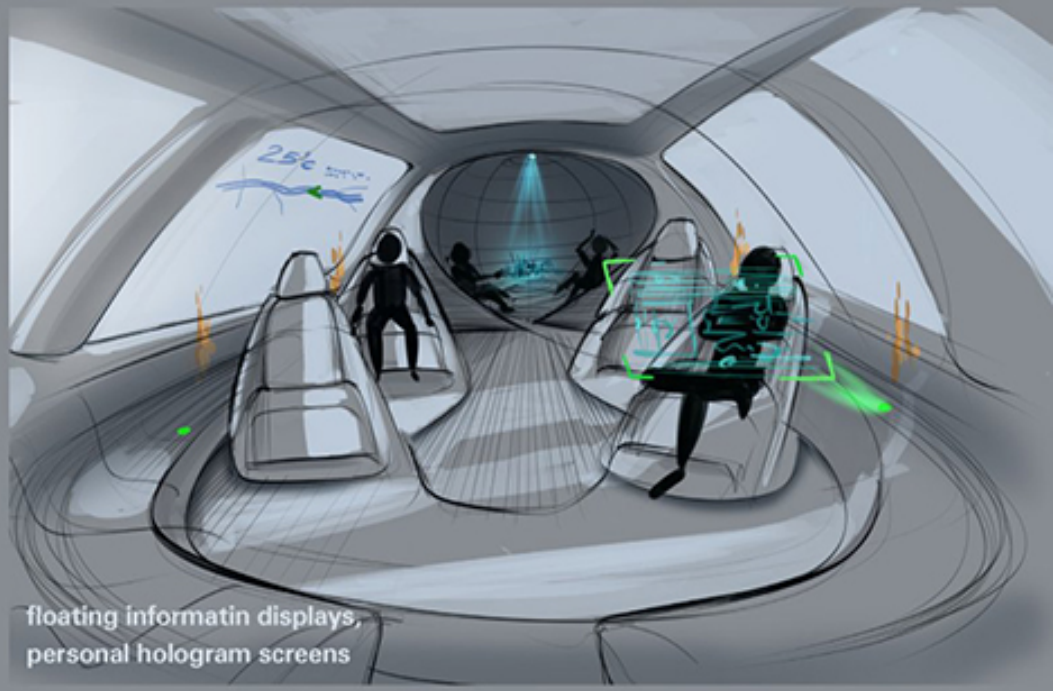
Initial Sory Boards: Modified after feedbacks suggesting to incorporate more user to vehicle experience scenario rather than focussing on specific feature detials and technicalities.

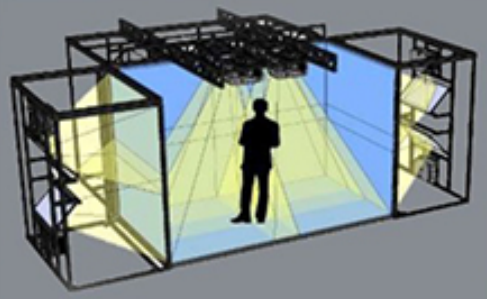


Initial Sory Boards: Modified after feedbacks suggesting to incorporate more user to vehicle experience scenario rather than focussing on specific feature detials and technicalities.

STORYBOARD







THANK YOU