

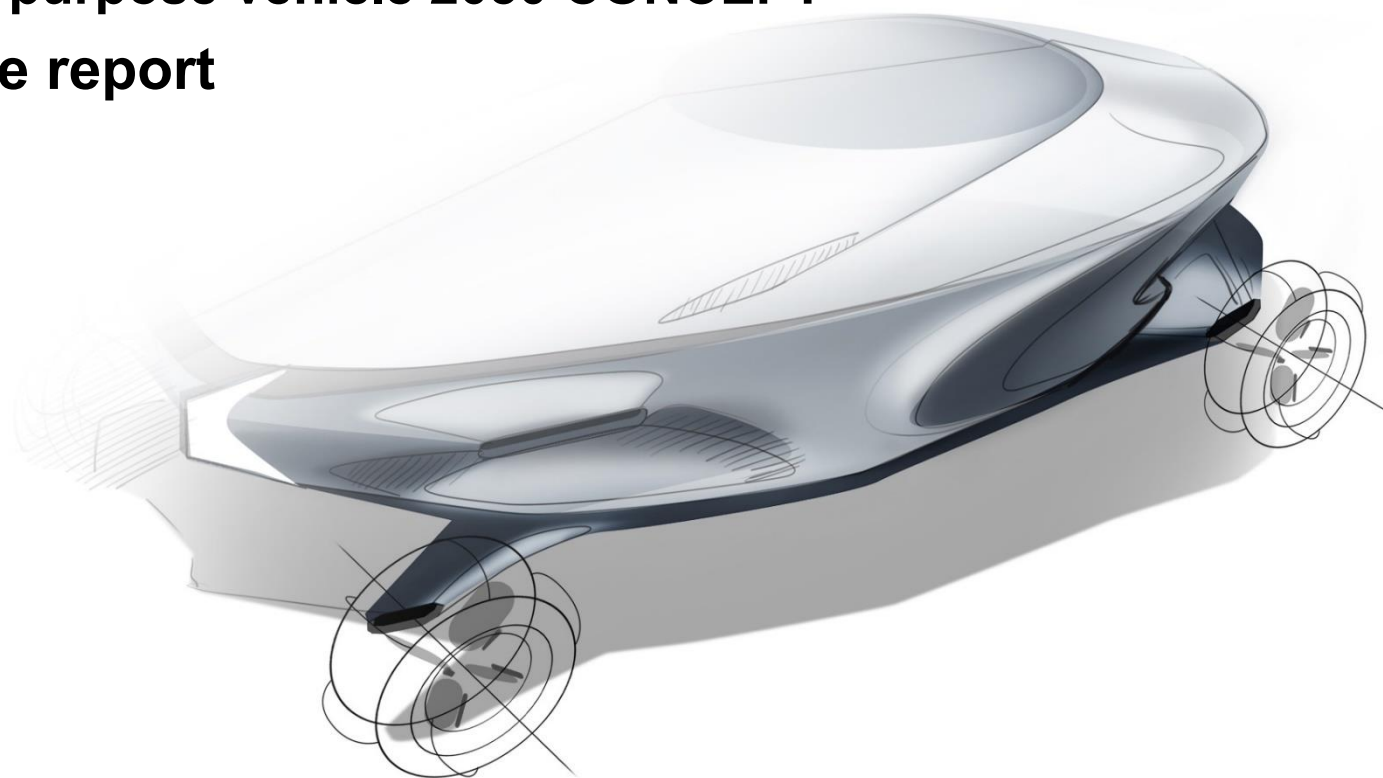
BMW *NEXT MODE*

Amphibious multi-purpose vehicle 2050 CONCEPT

Research module report

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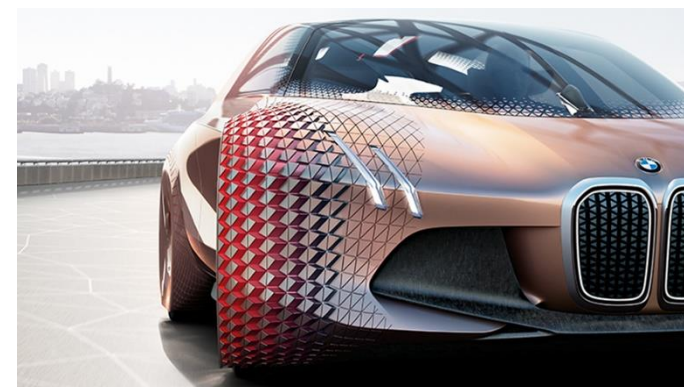
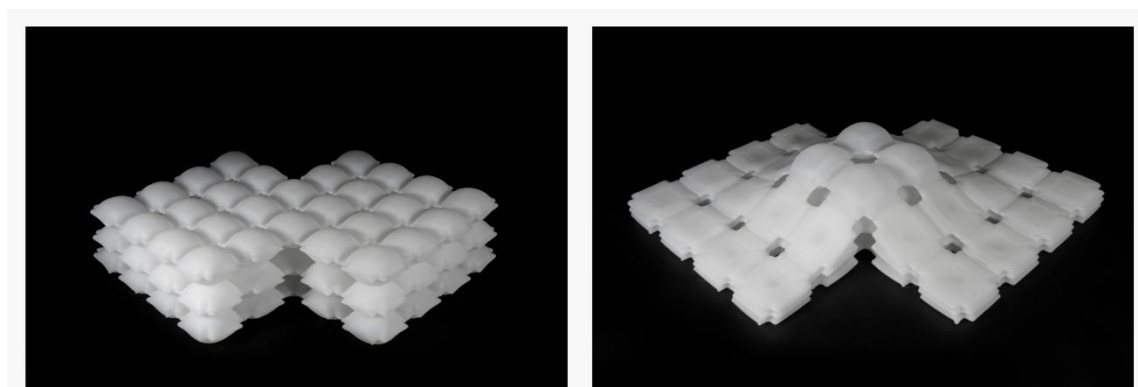
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ABSTRACT

This report aims to demonstrate my research for the final year's MA project at Coventry University. The concept is one hypothesis for future BMW. This brand always focus on futuristic design and cutting-edge technologies. In 2008, the BMW GINA concept challenged the conventional perception of people in the automobile industry revolution and thinking about the future. GINA is the first 'live' car produced by artificial fabric skin that replaced the conventional metal plates outside of a car. In 2016, the company introduced the concept car Vision next 100 to the world. More recently, BMW teamed up with MIT to develop a pneumatic smart material system. This project started from future scenarios and is based on future city forecasts from experts in different fields. The main secondary data are about 4D printing technology, future population, climate change and, car sales data in specific countries. Finally, the analyze by using a matrix of the relationship between vehicle wading depth and vehicle types helps me located the target market. All the research processes are highly coherence. It illustrates my thinking process during nearly two months from starting point of the scenario to the final concept.

INTRODUCTION

3D printing is no more a mysterious technology. The 3D printing relevant manufacturing has been applied in various products. Based on 3D technology, there are an increasing number of new additive manufacturing technology that has been developed and researched by scientists and cutting-edge companies in the world. 4D Printing is a new technology coming to all kinds of industries in recent years. Based on 3D printing technology, 4D printing will change the shape of the material printed. Just as a computer follows the code, these materials can be stimulated by external stimuli to change shape, color, size, the way they move, etc. (Carlota, 2019). One example in the automotive industry is from BMW. BMW and MIT Self-Assembly Lab collaboratively invented a new pneumatic material that can relies on self-transform from. The form of it can be change from one state to another. "The collaboration has created the first fully printed inflatable product that can be customized to any size or shape. These silicone printed objects can change shape depending on the amount of air pressure in the system." (Self-assemble lab, 2018). The liquid printed pneumatic material was regarded as a potential material for concept interior to realize self-adaptable intelligent interior in the future. However, the liquid pneumatic stuff is not the earliest 4D printing concept of BMW. In 2016, BMW had begun to propagandize their concept car Vision next 100, which was given 4D printing concept to change the shape of the wheel arch in response to air flows.



FUTURE SCENARIO

The world in 2050

Scenario is a very interesting tool for people to explore and research what will happen in the future. The future will be never be determined easily, since there will be abundant uncertain elements. From completely different starting point to forecast the future, we can get an antipodal conclusion to draw the future blueprint. However, experts from various fields have many same propositions in terms of global environmental trends and technology trends. According to researchers from Cambridge University, there might be four different situations that will happen in future 30 years, which all based on statistics of society, politics, technology, and environment, etc. Take the scenario 'Zero generation' as an example. In the city, production equipment with numerous automated machineries, and a low dependency ratio are the main characteristics of the society. Our urban architecture is being radically transformed, with wood-based structures gradually replacing reinforced concrete glass and steel (Gürdür Broo et al., 2020). Trees are growing every year around the world, but a great deal of them has been irrevocably lost, while global warming is still wreaking havoc on the climate, and extreme weather in this period of global warming can cause problems for vulnerable people, including the elderly people (Gürdür Broo et al., 2020).



Vertical city space

The growing number of populations is putting great pressure on cities. By 2050, the world population will reach 9 billion people. There will be 70% of these people live in cities. The number of private vehicles is expected to reach 3 billion by 2050 (Indigo group, 2019). In the future, it is difficult for the urban territory to bear the huge demand for space use, especially the parking problem, which will become a huge challenge for future cities. This fact will become a negative circulation where the population will extremely accelerate the growing of vehicle demand and the number of parking structures. On the contrary, the comfortable urban living environment that is constantly being satisfied will accelerate growth of the population.

BY 2050
the world population will reach
9 billion people.

70% of these people
live in cities.

This represents more than
2 billion customers.

The Future transportation volume



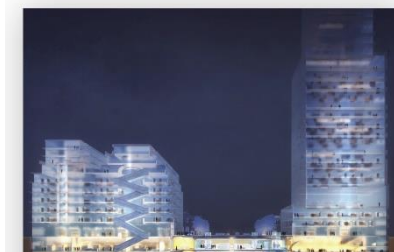
In response, some cities have begun to develop vertical parking lots to meet the demand of citizens for parking space. The construction of underground space in the city optimizes the overall utilization of space, which makes it there is no more necessary to encumber the surface space with a larger horizontal extension of the building structure (Indigo group, 2019). Moreover, the utilization of underground space will connect mobility with underground sources' management. The future underground parking lot is not only a vertical box as a storage use, but it will be a part of the underground system that connecting overground facilities and underground space together. For example, the underground parking lot might be jointed with the public subway system or any overground shopping blocks to improve the transportation efficiency of both private cars and public transportation. There are four underground scenarios from experts to optimize future hypothesis. They are all based on current overground facilities.



SCENARIO 1: CAR PARK RETROFIT



SCENARIO 3: DEEP AVENUE



SCENARIO 2: DEEP SQUARE



SCENARIO 4: DEEP GROUND



The Threat of climate change

Although, the underground parking construction herpes to be a future solution for population explosion, the greatest threat will come from flooding that that exist extensively in the areas of coastal cities and tropical regions around the world. Floods tend to occur in densely populated areas, and the construction of buildings and facilities such as driveways and parking lots reduces the ground's ability to absorb rainwater, increasing runoff. For example, the south of China is one of the most victims affected by floods every year in the world. If you are living in cities close to the Changjiang river, you have to be very careful about the forecast of weather information which might help you to avoid huge commercial lost even save your life.



The image below shows a Chinese underground parking lot flooded by deluge. The water coming in from the outside exceeds the height of the tire and the air intake. A large number of vehicles were damaged and some were trapped, unable to leave the underground parking lot.



If climate change is inevitable, human beings have to admit the reality of unpredictable weather and sea-level rise. For living space, we have to learn how to live in a 'water city'. By the end of the century, sea levels are likely to rise by as much as 60cm, and with the effects of extreme weather, the living conditions of about 300 million people will be changed by flooding (Doloresz, 2021). Some low-lying islands in the Pacific are at risk of disappearing, while cities such as Venice and Jakarta are already losing height (Doloresz, 2021). This will take into account the comprehensive factors in the city, such as the people's food, clothing, housing, and transportation are under consideration. Because of the uncertainty of the environment, this requires our infrastructure to be more adaptable. For example, today's street weather is sunny, but tomorrow's road may suddenly become a river without seawater. All personal and public transport systems also need to be highly interconnected in these weather changes. This requires scientists, designers, and urban planners to think about urban ecosystems and urban life in a new way. In terms of personal transportation, we may need amphibious vehicles to be able to adapt to such conditions. It could also dramatically change travel choices.



Because of climate change, many experts have proposed the idea of building cities on the sea, and examples of people living on the water go back a long way. As early as the last century, indigenous people in southeast Asia and elsewhere have started to live on the water by building in the water, forming stable and historic fishing villages. There are also some typical examples of floating houses in modern society. “The Japanese Metabolists put forward incredible projects such as Kenzo Tange’s 1960 Tokyo Bay Plan and the marine city proposals of Kikutake and Kurokawa” (Brydon, 2019). A more typical example is the City of Venice. The Venetians have long lived in an environment of alternating land and water. Venice has both public transport facilities on the road and water buses, all of which form a complete system. When you want to get to a destination, your route will inevitably include land and water, but you can still get there in the quickest time with high efficiency. The fly in the ointment is that there is fewer amphibious vehicles for people switch over from land to water at liberty. On the other hand, the water and land environment of Venice is quite fixed, the water and land environment are distinct, so there is a relatively fixed transportation system. This is different from the changeable climate of river basins, sometimes flooded by water, but sometimes hot and dry.

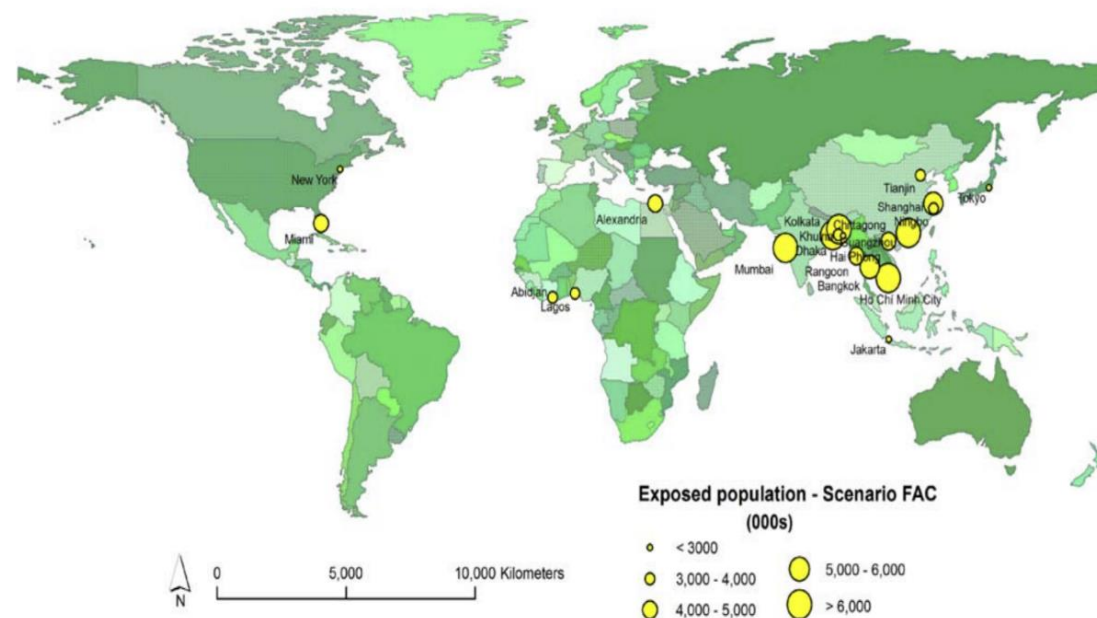


TARGET USER & MARKET

The Global climate risk index

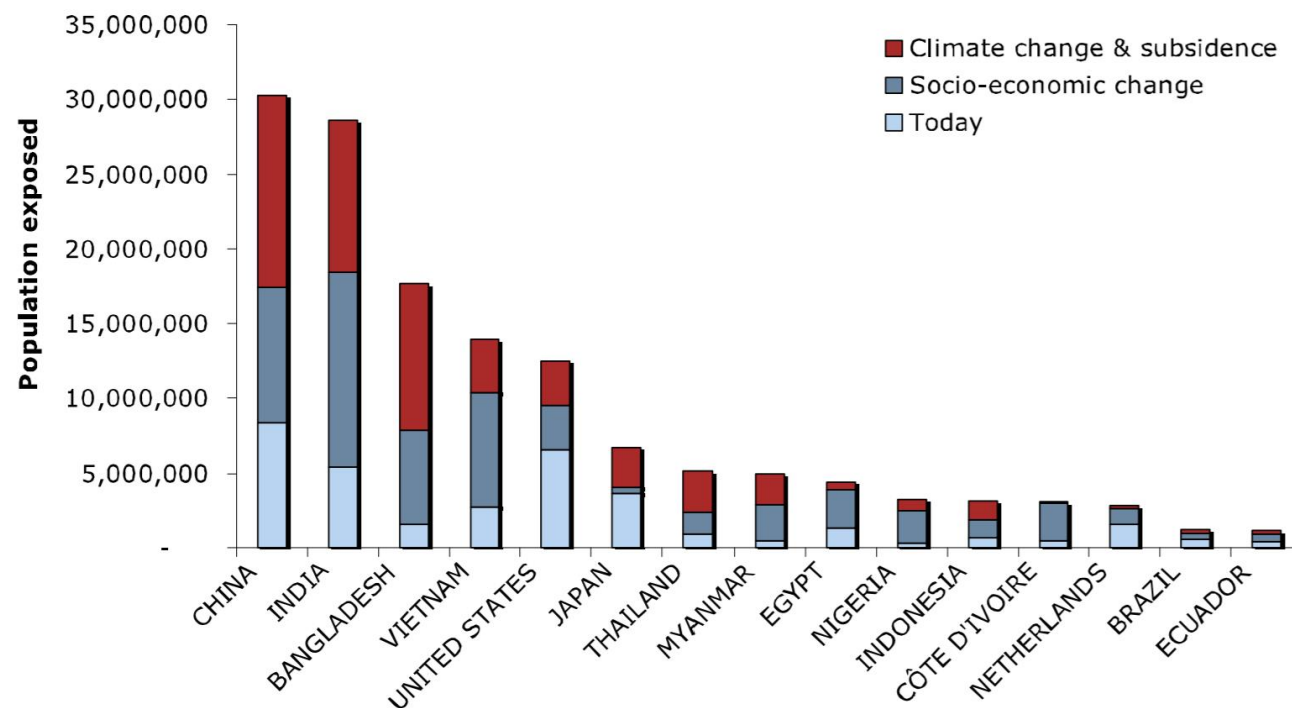
There is no denying that people around the world are all facing climate change wherever you live. Climate change has been not only an element affecting people's life, but in some areas, it has caused massive property damage and casualties. In the period from 2000 to 2019, more than 11,000 extreme weather events occurred around the world, resulting in 275,000 deaths and \$2,56 trillion in property damage (David, 2021). Experts predict that by 2070, around 150 million people will be severely affected by climate change. Asset exposure could soar to \$350m, which would account for around 9% of GDP, ten times its current level (Nicholls, et al, 2007). If we focus on the regions of the world with the greatest climate fluctuations, we can find that these regions and cities are concentrated in river basins and coastal areas, which are densely populated areas, which themselves have relatively poor drainage capacity in cities. Moreover, they are often accompanied by heavy rains.

The map illustrated top population of 20 cities exposed under the future climate change in 2070.



Where do floods occur most frequently?

Top 15 countries influenced by climate change.

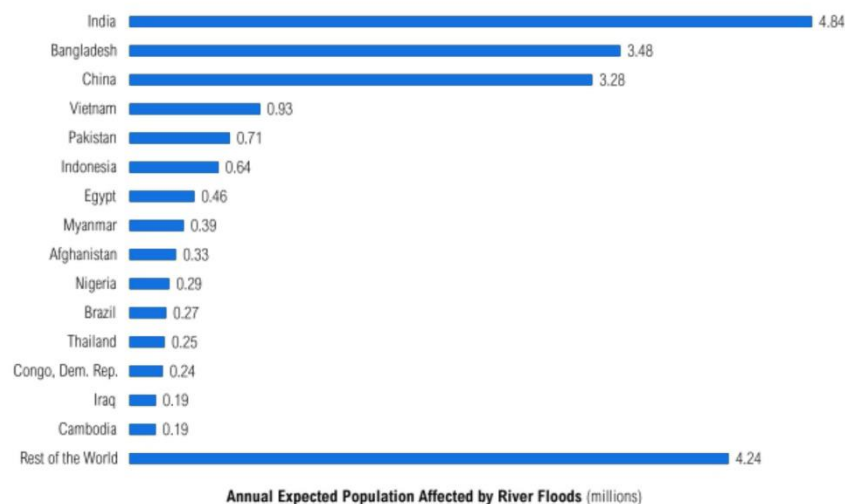


Top 15 countries by population exposed today and in the 2070s, showing the influence of future climate change vs. socioeconomic change
(Source: Nicholls et al (2007), OECD, Paris)

The bar chart on left from Southampton University demonstrates the top 15 countries where there are most populations exposed to climate change both today and in the future. The chart also has a construction of social-economic change between different countries. The number of China and India account for the most parts in the world, which indicates that there are a great number of people are suffering from extreme weather and climate. It is not hard to understand that China and Indian have the most population of the world. What's more important is that there are some biggest rivers of the world in China and Indian that make the people living by those rivers stand under a higher flooding risk. Bangladesh and Vietnam are also regarded as very high-risk countries, especially in the future.

Research from the University of Southampton details how climate will affect the world by 2070, with coastal cities in particular constantly exposed to flooding and subsidence. The study involved 136 cities with a population of almost a million or more. The vast majority of these cities are concentrated in Asia, accounting for 38 percent of the total. Twenty-seven percent of the cities surveyed are located in river deltas, which are also concentrated in Asia. The reason for this is the low altitude of these areas and their tendency to sink year by year. The table at the bottom right shows some of the cities whose city assets are most exposed to flooding. Nineteen of these cities are located in river deltas, and as the chart shows, the most affected cities include Miami, Guangzhou, New York-Newark, Kolkata, Shanghai, Mumbai, Tianjin, Tokyo, Hong Kong. Moreover, in the top 20 cities, there are 6 Chinese cities accounting for 30%. If we imagine the future 30-50 years' scenario of China and Indian, people might have to dealt with the effects of weather, such as floods, by adapting to their frequent occurrence.

15 Countries Account for 80% of Population Exposed to River Flood Risk Worldwide



Rank	Country	Urban Agglomeration	Exposed Assets Current (\$Billion)	Exposed Assets Future (\$Billion)
1	USA	Miami	416.29	3,513.04
2	CHINA	Guangzhou	84.17	3,357.72
3	USA	New York-Newark	320.20	2,147.35
4	INDIA	Kolkata (Calcutta)	31.99	1,961.44
5	CHINA	Shanghai	72.86	1,771.17
6	INDIA	Mumbai	46.20	1,598.05
7	CHINA	Tianjin	29.62	1,231.48
8	JAPAN	Tokyo	174.29	1,207.07
9	CHINA,	Hong Kong	35.94	1,163.89
10	THAILAND	Bangkok	38.72	1,117.54
11	CHINA	Ningbo	9.26	1,073.93
12	USA	New Orleans	233.69	1,013.45
13	JAPAN	Osaka-Kobe	215.62	968.96
14	NETHERLANDS	Amsterdam	128.33	843.70
15	NETHERLANDS	Rotterdam	114.89	825.68
16	VIETNAM	Ho Chi Minh City	26.86	652.82
17	JAPAN	Nagoya	109.22	623.42
18	CHINA	Qingdao	2.72	601.59
19	USA	Virginia Beach	84.64	581.69
20	EGYPT	Alexandria	28.46	563.28

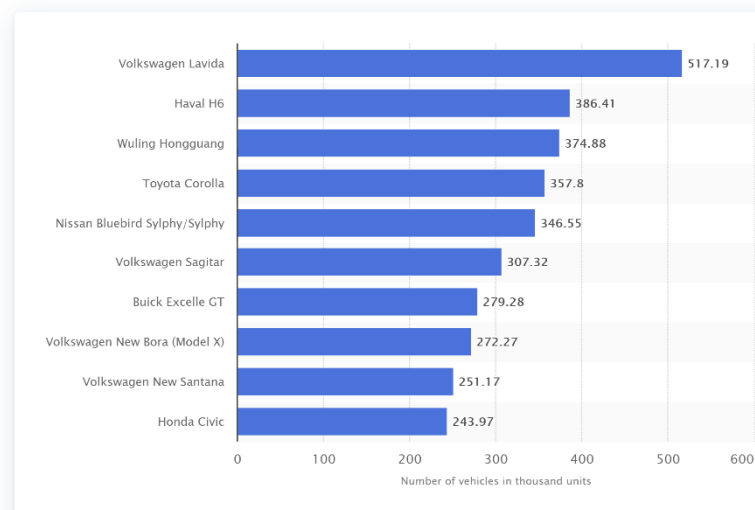
Top 20 cities ranked in terms of assets exposed to coastal flooding in the 2070s (including both climate change and socioeconomic change) and showing present-day exposure (Source: Nicholls et al (2007), OECD, Paris)

China & Indian car market

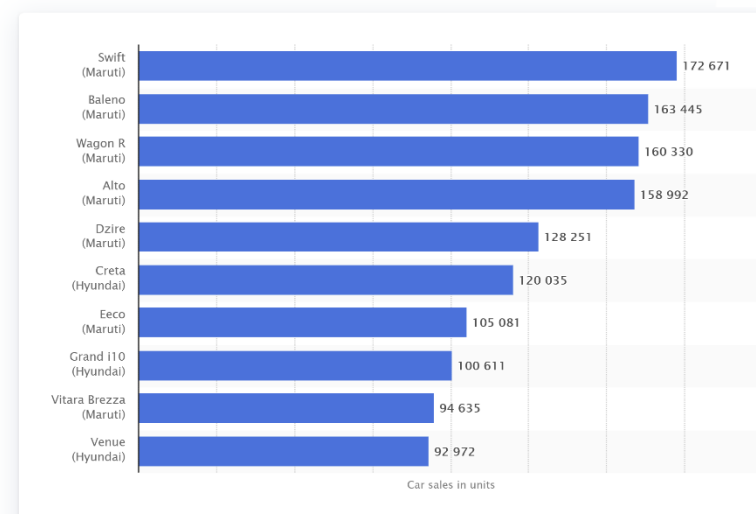
Considering that China and India will be very possible to be in the future specific scenario of water city. I researched the statistics of best-selling cars in these two countries respectively. The data below from the statistics website indicated the most popular cars account for the total number in China and India. Seeing that the research aims to find what is the popular types of vehicles, the models below are mainly different in terms of function and usability. For example, in China market, the top 3 models are Volkswagen Lavida (Sedan), Haval H6 (SUV), Wuling Hongguang (MPV). This indicates people would like to pay for a big car as family utility. When it comes to the Indian market, the best-selling cars are almost from Maruti (hatchback) with a smaller size which accommodates around four occupants. The statistics below are from the 'STATISTICS' website.

Sales volume of the leading car models in China in 2019

(in 1,000s)

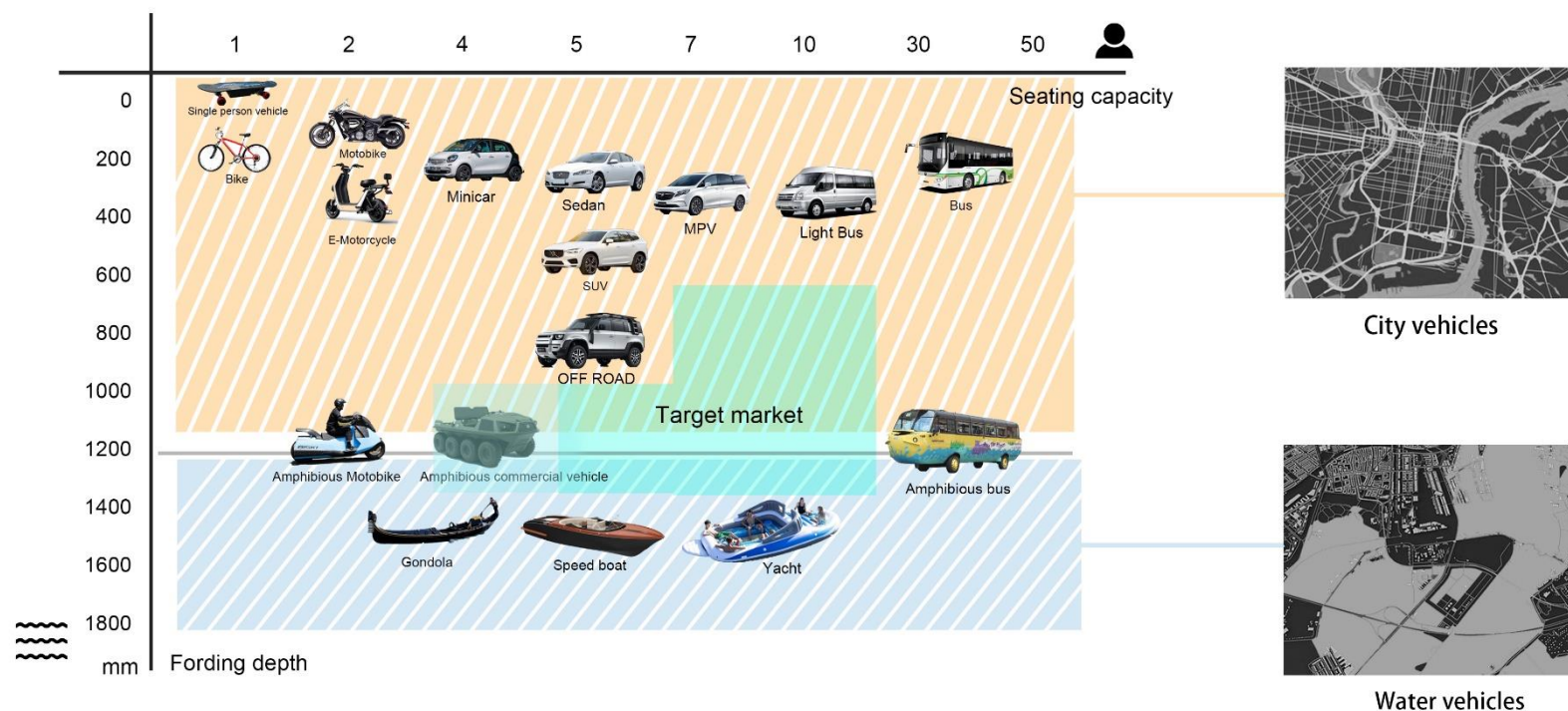


Best-selling cars across India in financial year 2021,



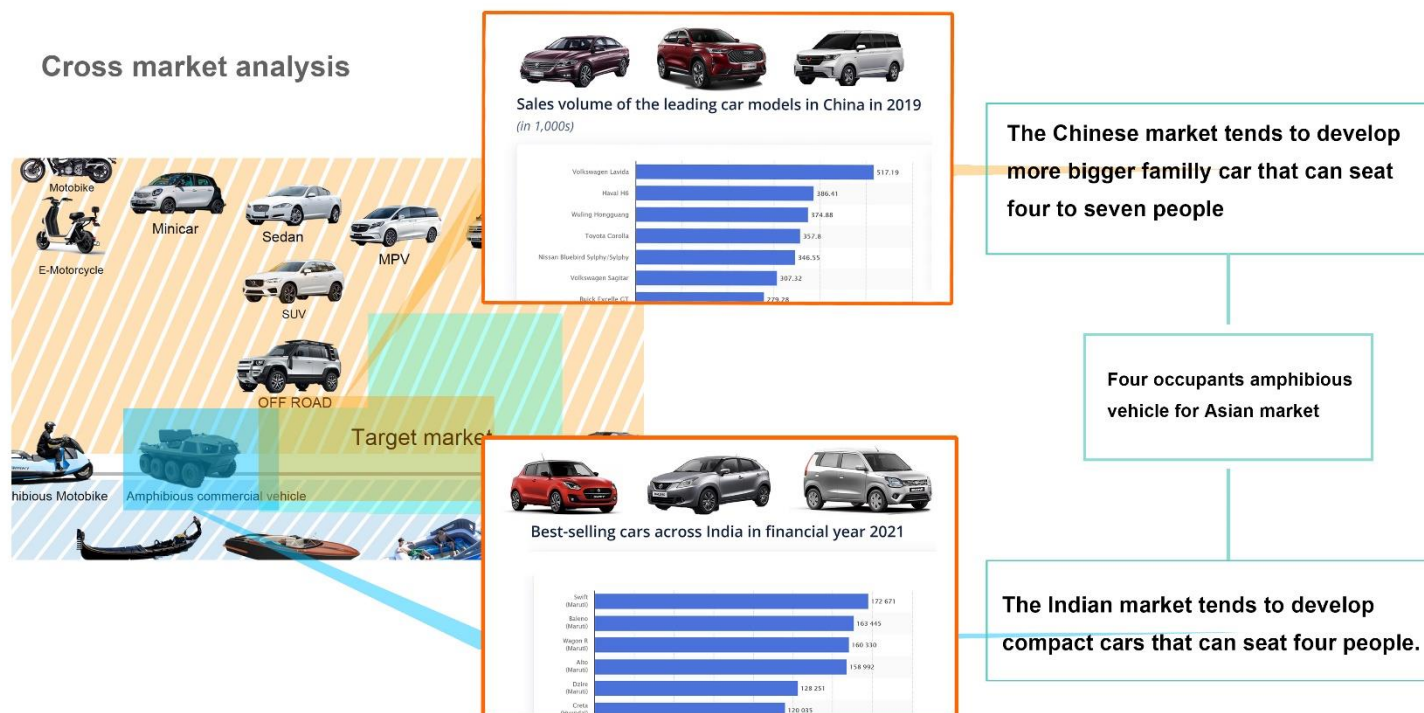
Target Market

The matrix below illustrated how I located the target market which is amphibious passenger vehicles to adapt the future city scenario. The vertical axis represents the maximum wading depth of the vehicle, and the horizontal axis represents the number of passengers the vehicle can carry.



Market: Amphibious passenger vehicle for 4-10 people in the future city where there are Frequent rainfall and future water city.

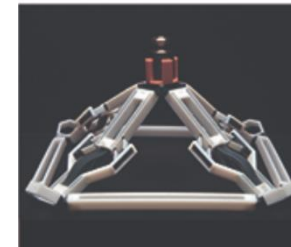
I listed some key representative vehicles, from skateboards to public buses, to compare the wading capacity of different types of vehicles. The top half of the chart represents the vehicles in the city on land and the bottom half represents the vehicles on water. I also found some amphibious vehicles that some of them are used as a public vehicle. One kind of vehicle with four people capacity is used as commercial transportation in some complex terrain. The conclusion is the market blank between four people and 10 people amphibious vehicle is the opportunity for future scenario. The final target market and users can be obtained by combining the survey results of the previous part of the vehicle market with the analysis results of the market gap in this part. In China, it's a larger amphibious vehicle that can ride at least four to seven people. In the Indian market, the target is a two-stage vehicle for four people. Therefore, the final target is a four-person amphibious vehicle designed for the Asian market.



TECHNOLOGY

4D printing programable material

One of the characteristics of 4D printing material is that the shape can be transformed when it is stimulated by external stimulus. The fourth dimension of 4D printing is time, which allows the appearance to change over time after an external stimulus. Currently, the technology is closely integrated with 3D printing, and researchers use smart materials, mathematical modeling, and machine learning algorithms. (ABB review, 2020). For example, the planiform 2D printed sheet can transform to a 3D shape programmed beforehand when it is stimulated by water. This material has three characteristics. The first is self-assembly. Some printed materials can be self-assembled into different structures in the characteristic environment, thus omitting human and mechanical, and electronic involvement. The second feature is adaptive. In the future, it can be driven by internal sensors, so it does not need the help of external mechanical structures and motors, which greatly improves the self-seeking cost and maintenance convenience of the product. The third is its ability to repair itself. The material can repair itself to some extent in the event of local external damage.



What is an IP rating?

If dust or water enters the electronic device, the device will malfunction and be damaged. Therefore, we use the IP value to classify the protection capability of the device shell. In general, an IP rating will consist of two digits, occasionally followed by a letter denoting specific materials, hazards or testing scenarios. The most common way you will see such a rating given will be in the format IP43, IP67, or similar. The first digit will be a number between 0-6, and indicates the degree of protection from ingress of solid objects (the user themselves, and other potentially harmful particulates such as dust or dirt). The second digit in an IP rating will be a number between 0-9, denoting the quality of resistance to moisture ingress at varying intensities, angles, depths, and pressures of exposure or immersion. (RS, 2021).

There are various products that the IP level have reached IP69 or higher water resistance ability, such as the H20 Ninja Mask and JBL Charge Speaker.



BRIGADE®	
IP 	
SOLIDS	LIQUIDS
1 Protection from objects greater than 50mm in diameter e.g. a hand 	1 Protection from condensation 
2 Protection from objects greater than 12mm in diameter but no greater than 80mm e.g. fingers 	2 Protection against water droplets 
3 Protection from entry by objects with a diameter of 2.5 mm or more e.g. tools 	3 Protected against spraying water 
4 Protection against foreign bodies larger than 1mm e.g. fine tools 	4 Protected against water spray and splashes 
5 Limited ingress of dust 	5 Protection against low pressure water jets 
6 Completely dust tight 	6 Protection against high pressure water jets 
Product Example A Brigade Backsense® Radar is rated at IP69, and therefore is completely dust tight as represented by the '6'. It is also protected against close range, powerful and high temperature water jets as represented by the '9'.	
	7 Protection against temporary immersion in water 
	8 Protection against immersion in water over long periods 
	9 Protection against close range, powerful and high temperature water jets 

Future all-road tire

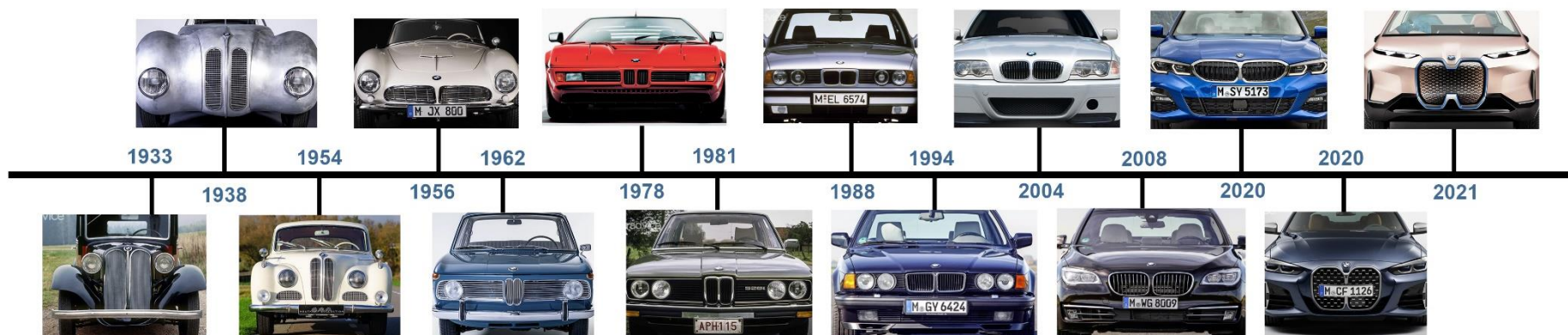
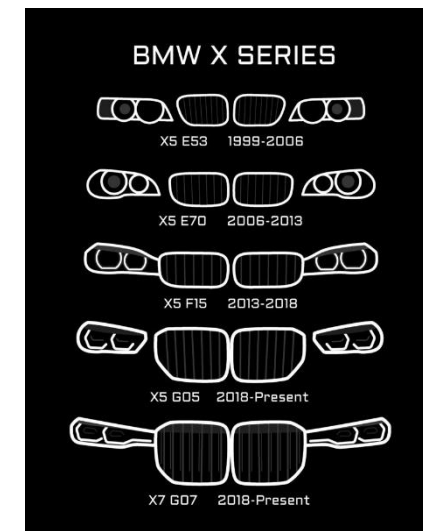
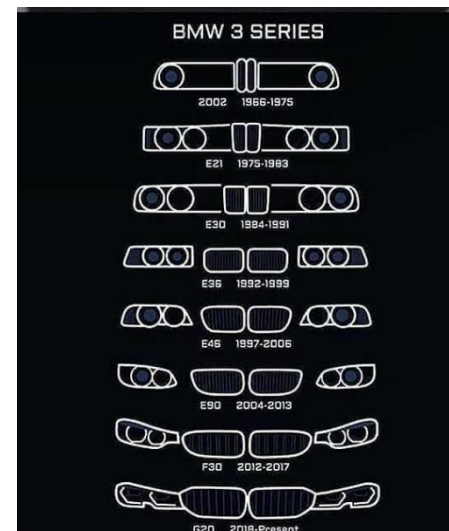
Hankook tire has demonstrated its concept design for future tires. The concept of a car tire has not changed much in a hundred years, and a tire can simply be understood as a sheet of rubber wrapped around a metal hub. Hankook Tire has gone beyond engineering exploration and released three concept tires that can change the shape of the wheel. These tires can improve performance by rapidly changing shape to suit the terrain. The surface of the mountain tire is composed of hexagonal blocks. When entering special terrain, its outer surface can be expanded and expanded, thus changing the surface friction, strengthening traction and grip on the ground. Cars with these tires can be driven on steep mountain roads or in the desert. Moreover, the water-driven tire with a hub made up of turbine blades that generate thrust in the water when it spins.



VISUAL LANGUAGE

BMW's grille evolution

BMW double-grid design is one of the most iconic elements of BMW. This element has been around for more than 90 years. But over the course of this long period of time, there have been many changes in details such as grille proportions. From the earliest vertical layout gradually evolved to the later horizontal layout. At the same time, the grille seems to be getting bigger. This is especially true in SUVs. But on the latest concept car, the grille seems to be evolving towards a vertical arrangement back to where it started.



Concave curvature language

4D printing technology may involve the use of some soft materials, such as artificial skin specially designed for cars. Back in 2008, BMW introduced its GINA model, which used a similar concept. Instead of a hard steel surface, the car had only artificial skin. This kind of material application produces a lot of concave surfaces rather than the kind of bulging surfaces that we prefer today.



RESEARCH QUESTION & PROJECT BRIEF SUMMARY

Question: How will future 4D printing technologies influence the automobile and improve user experience (UX) in the future water cities?

Scenario: Future life of human are going to be sample and efficient. The use of large amounts of timber structure will make the architectural style and aesthetics lighter. Climate change will be the biggest problem for humanity. The project aims to design for future 2050 cities where climate change brings a lot of intense fall weather. The city will be in a transition between flood and sunny days. The blocks are going to switch over between dry streets and watercourses frequently during the year.

Target user: People living in these delta basins and coastlines will face great challenges in the future. The challenges of climate and flooding are more evident in densely populated cities with well-developed vertical Spaces. Many cities in India and China, in particular, will face such challenges in the future. The project aims to design a family vehicle for these countries.

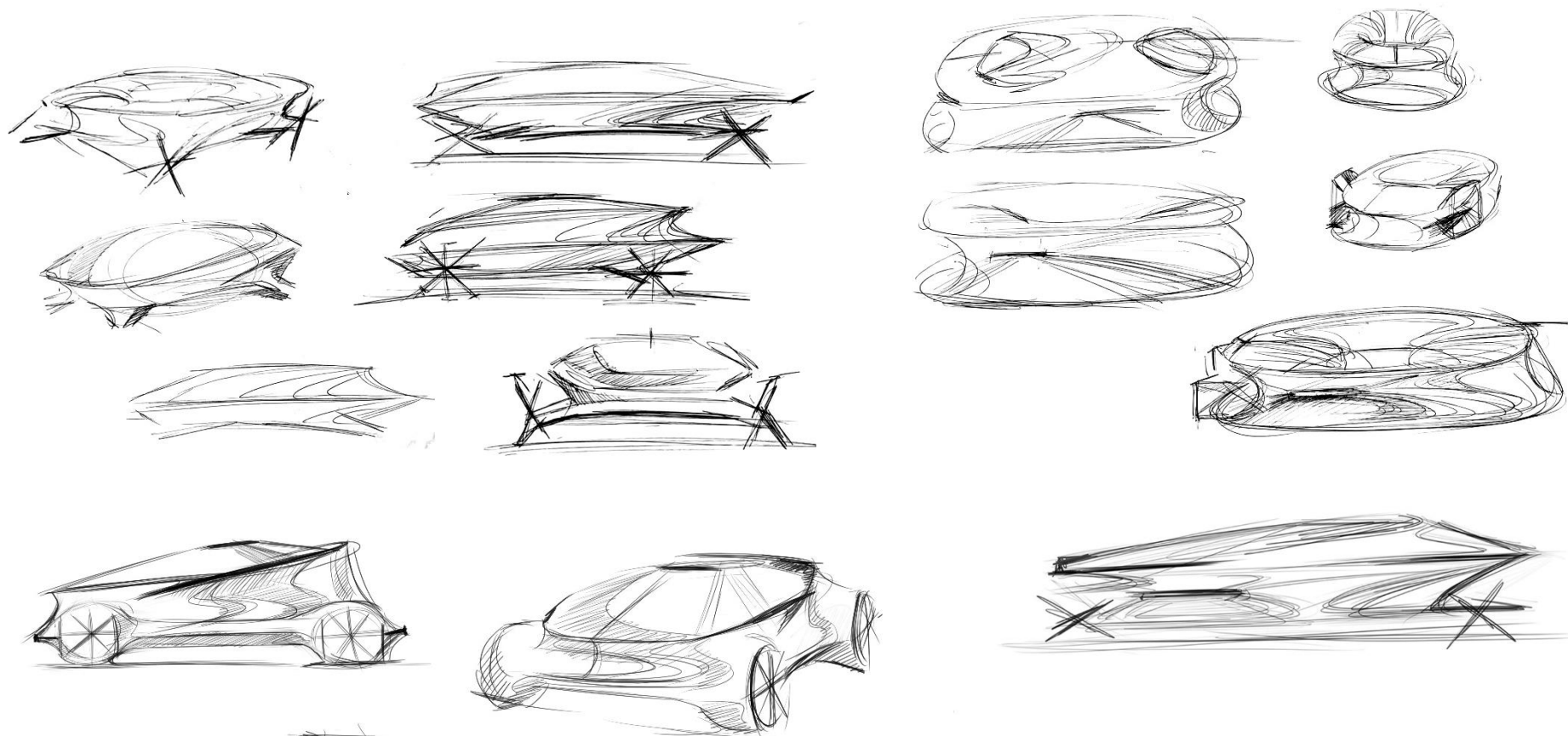
Target market: Through the comparison of vehicles with different wading capacities, a market for amphibious vehicles that can ride four to eight people is obtained. In these two countries, a four-person transportation market is obtained after a comprehensive comparison.

Technology: 4D printing materials that can transform it from a car to a boat by stimulus of water.

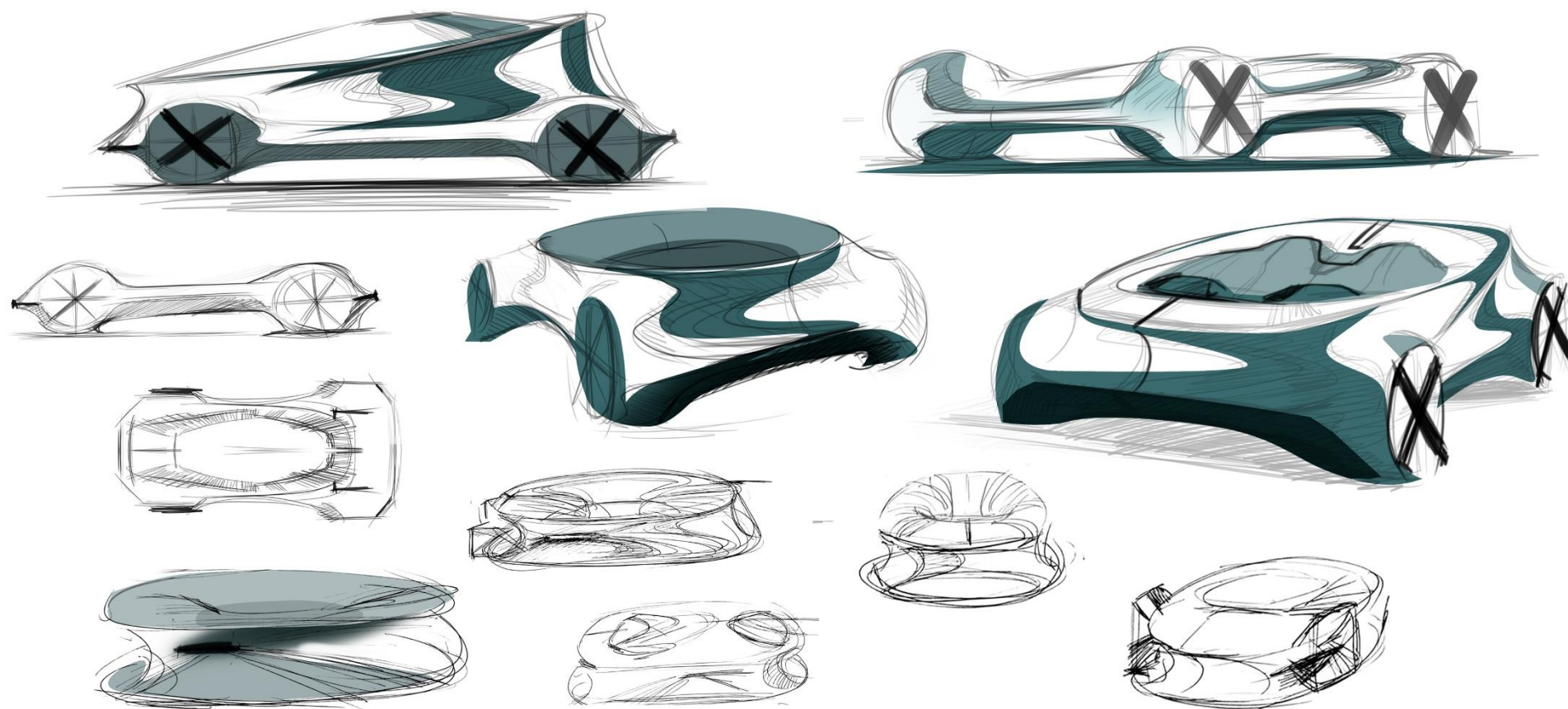
Design language: BMW's front grille has gone from vertical to horizontal and is now moving from horizontal to vertical. Replacing the metal shell with a soft material will result in a concave surface.

INITIAL SKETCH & DIRECTIONS

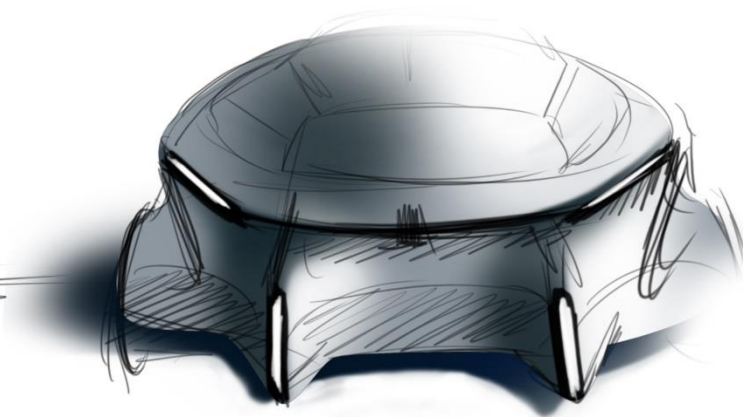
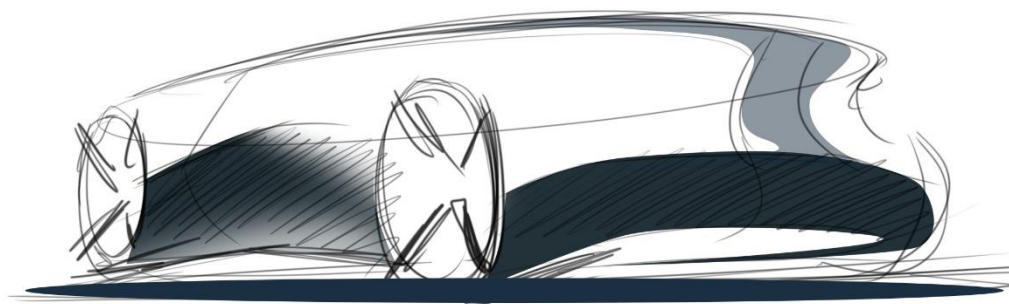
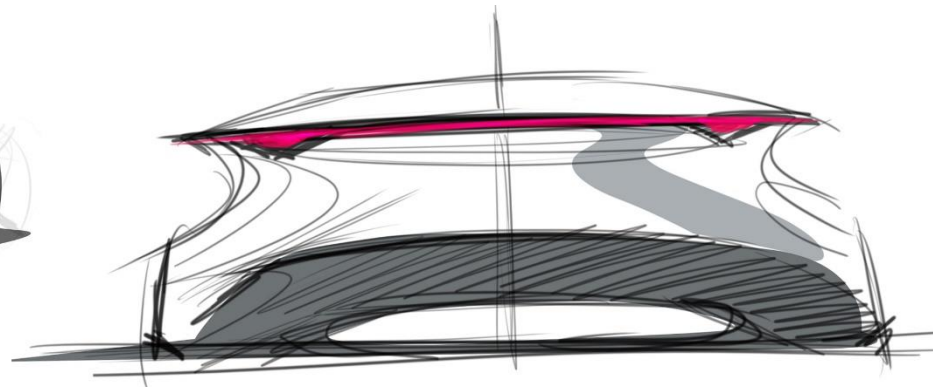
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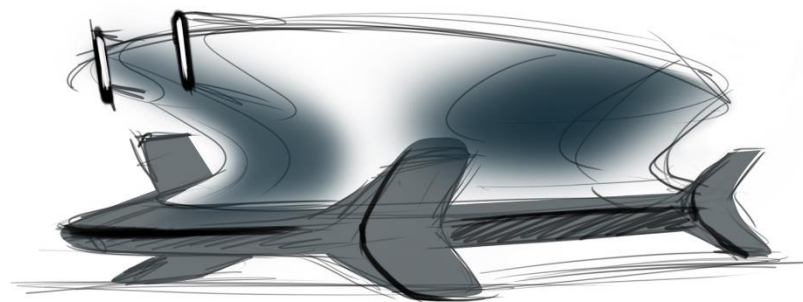
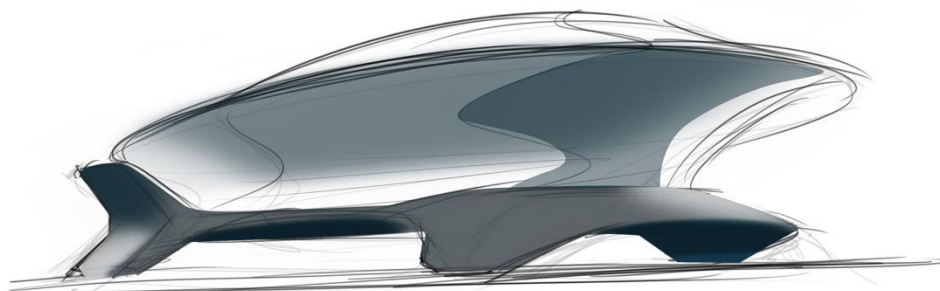
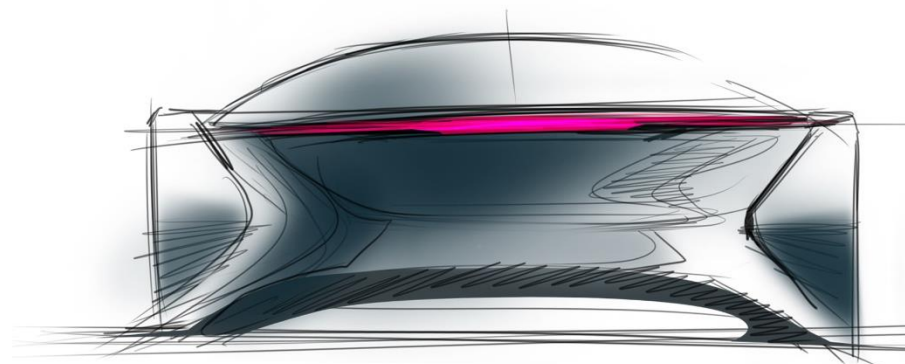
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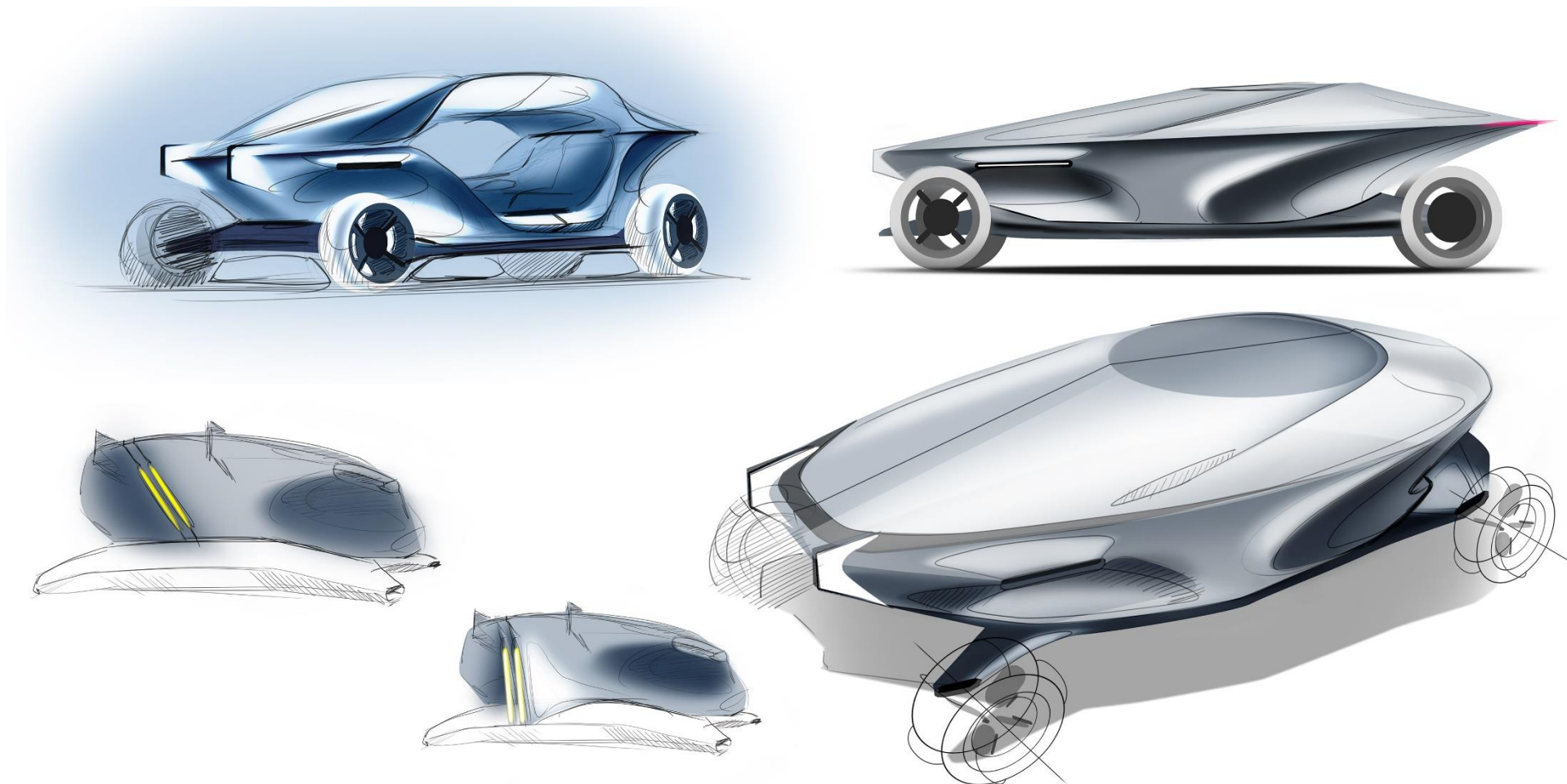
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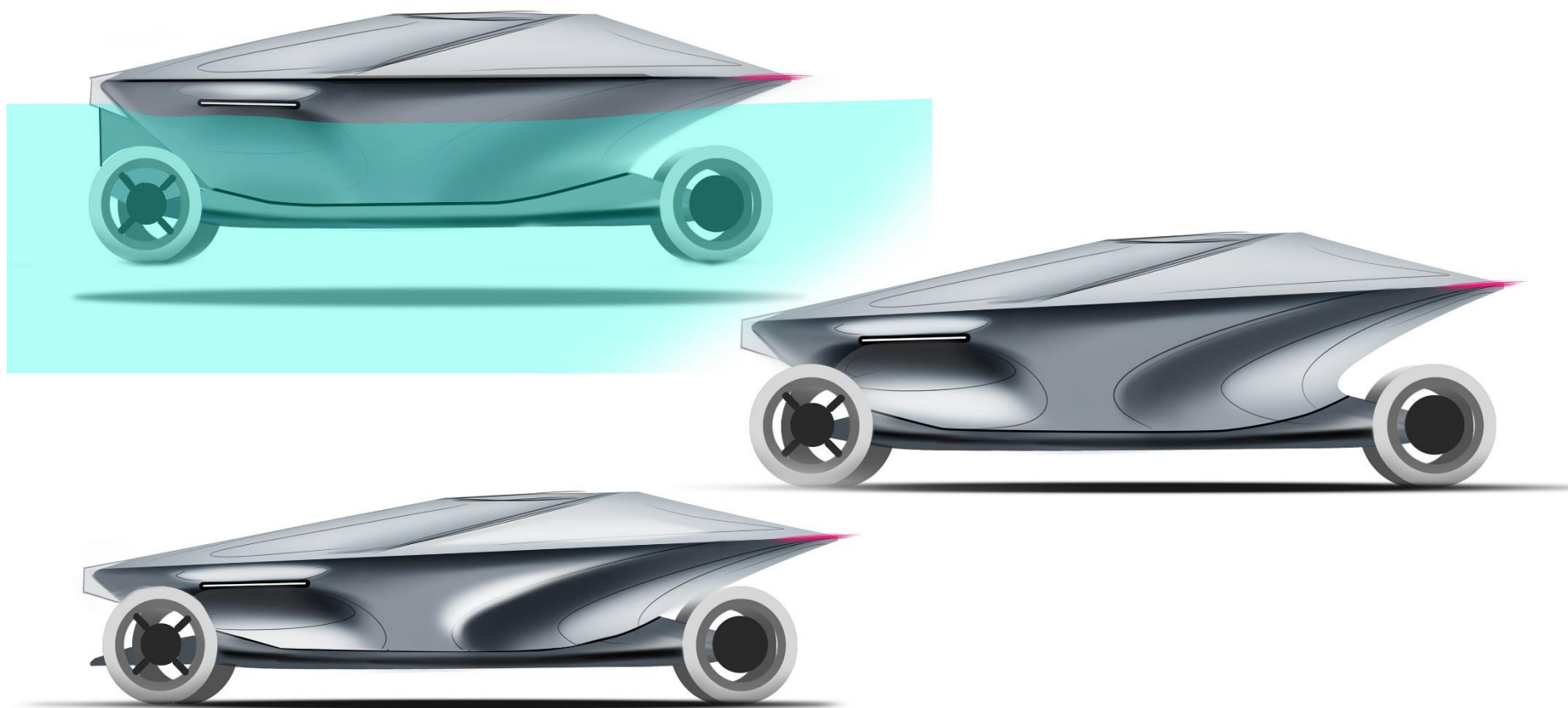
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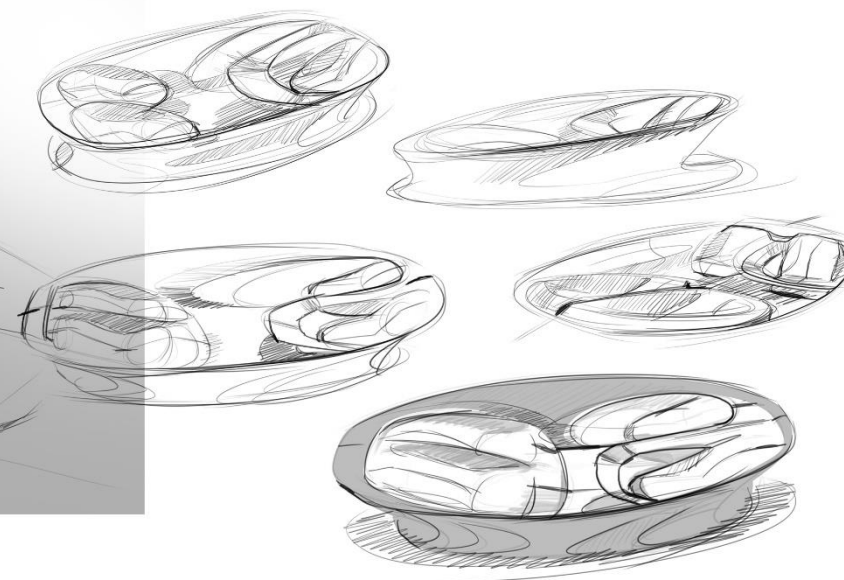
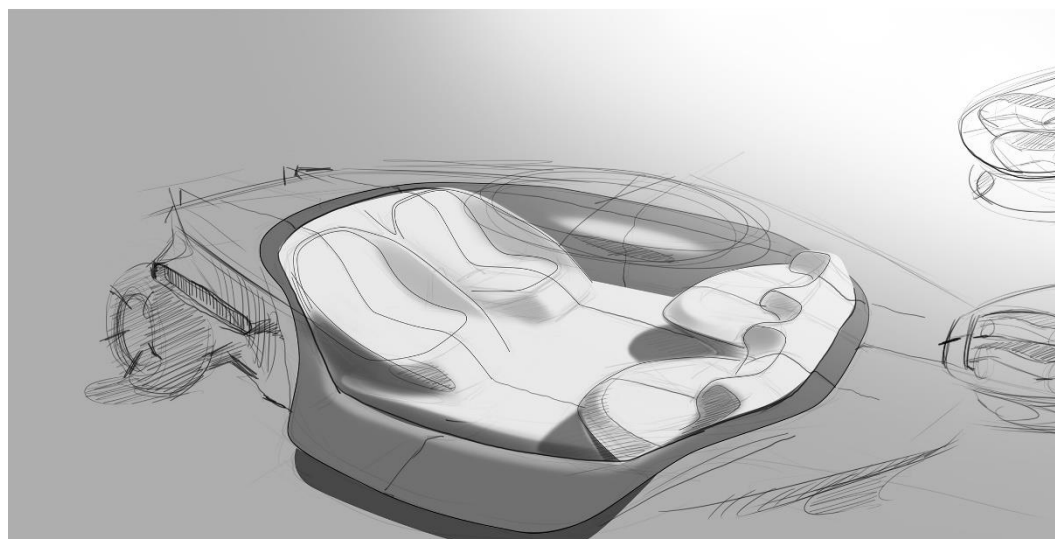
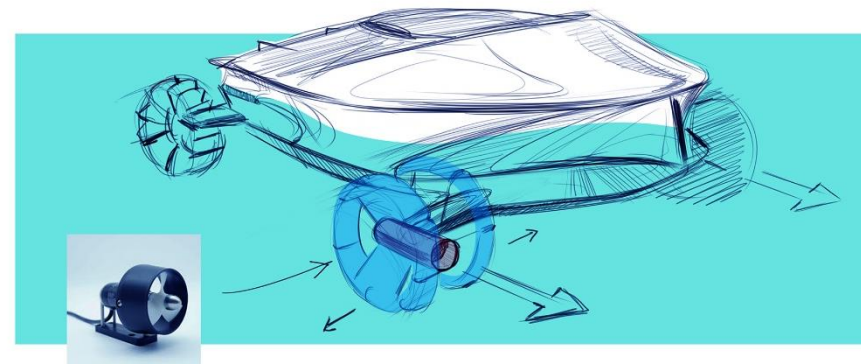
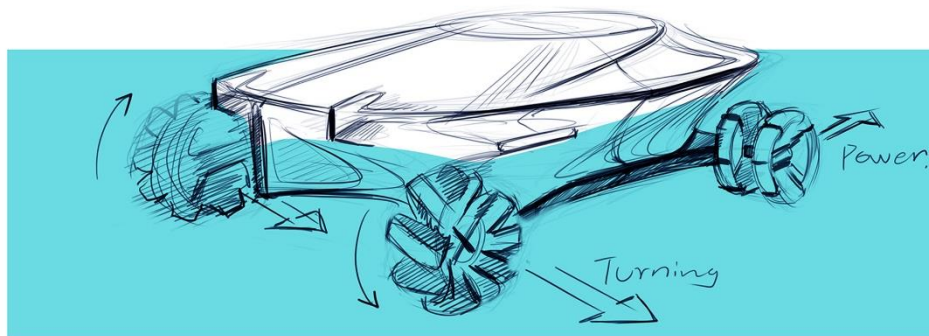


FINAL DIRECTION



As the water level rises, the external sensor material is stimulated to automatically stretch and increase its height, eventually causing the vehicle to float.





CONCLUSION

Overall, 4D printing technology and programmable materials is a very interesting technology, and its characteristics have great possibilities. But for now, most of the research results of this technology are still in the model stage in the laboratory. Some of them are used in concept products, and only a few are mass-produced products. Although 4D printing has been around for several years, it is still quite new to the public. Scientists and researchers may make even greater breakthroughs and different results in this field in the future. In the following process, I will continue to do 2D rendering and detail design as well as 3D modeling. In the whole investigation process, I may ignore some details and reasonable consideration. If I have the opportunity in the future, I will gradually improve the deficiencies in the research and design in the future project design. Thanks to every tutor and professor of Coventry University who help me during the project and inspired me in both the research module and design module.

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The picture on the left of page 5 describes the 4D liquid printing startup device from the SELF-ASSEMBLY LAB website, viewed 24 July 2021, <<https://selfassemblylab.mit.edu/liquid-printed-pneumatics>>

The picture on the bottom of page 8 describing the future underground parking lot is from Indigo group, viewed 25 July 2021, <<https://www.group-indigo.com/wp-content/uploads/2020/03/Dossier-de-presse-Parking-du-Futur-English-version.pdf>. >

The map on the right of page 12 describing the top region influenced by flood is from 'Ranking of the world's cities most exposed to coastal flooding today and in the future', viewed 25 July 2021, <<https://climate-adapt.eea.europa.eu/metadata/publications/ranking-of-the-worlds-cities-to-coastal-flooding/11240357>>

The charts and table on pages 13 and 14 describing the top region influenced by climate change and flooding are from 'Global climate risk index 2021', viewed 25 July 2021, <<https://germanwatch.org/en/19777>>

The charts on page 15 illustrating the best-selling cars in China and India are from the Statistics website, viewed 25 July 2021, <<https://www.statista.com/>>

All the remaining images in this report are from the Google Images website, viewed 26 July 2021, <<https://www.google.cn/imghp?hl=zh-CN&ogbl>>