by

Tejas Purohit

MFA Transportation Design

In Collaboration with NIO

UMEÅ INSTITUTE OF DESIGN
UMEÅ UNIVERSITY
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Acknowledgements</td>
</tr>
<tr>
<td>6</td>
<td>Abstract</td>
</tr>
<tr>
<td>8</td>
<td>Introduction</td>
</tr>
<tr>
<td>10</td>
<td>Relevance</td>
</tr>
<tr>
<td>12</td>
<td>Process</td>
</tr>
<tr>
<td></td>
<td>Context</td>
</tr>
<tr>
<td></td>
<td>Multi-modal transportation</td>
</tr>
<tr>
<td></td>
<td>Commuting in the cities</td>
</tr>
<tr>
<td></td>
<td>Advantages of urban flight</td>
</tr>
<tr>
<td></td>
<td>Role of A.I.</td>
</tr>
<tr>
<td></td>
<td>Future user</td>
</tr>
<tr>
<td></td>
<td>Clean air mobility</td>
</tr>
<tr>
<td></td>
<td>Types of eVTOL</td>
</tr>
<tr>
<td></td>
<td>Examples of Propulsion methods</td>
</tr>
<tr>
<td></td>
<td>Benchmarking</td>
</tr>
<tr>
<td></td>
<td>Speed, range &amp; Battery swapping</td>
</tr>
<tr>
<td></td>
<td>Take off and landing</td>
</tr>
<tr>
<td></td>
<td>Challenges</td>
</tr>
<tr>
<td></td>
<td>NIO</td>
</tr>
<tr>
<td>32</td>
<td>Research Conclusion</td>
</tr>
<tr>
<td>34</td>
<td>Design Brief</td>
</tr>
<tr>
<td>36</td>
<td>Creative process</td>
</tr>
<tr>
<td>38</td>
<td>First Sketches</td>
</tr>
<tr>
<td>40</td>
<td>Architecture exploration</td>
</tr>
<tr>
<td>42</td>
<td>Rear seat development</td>
</tr>
<tr>
<td>44</td>
<td>Front seat development</td>
</tr>
<tr>
<td>46</td>
<td>Architecture development</td>
</tr>
<tr>
<td>48</td>
<td>Final Surface Data</td>
</tr>
<tr>
<td>50</td>
<td>Size &amp; Dimensions</td>
</tr>
<tr>
<td>52</td>
<td>Results</td>
</tr>
<tr>
<td>62</td>
<td>Conclusion</td>
</tr>
<tr>
<td>64</td>
<td>References</td>
</tr>
<tr>
<td>66</td>
<td>Appendix</td>
</tr>
</tbody>
</table>
THANK YOU!

This project is a result of support and guidance of a lot of people, and I would love to take an opportunity to thank them all.

First and foremost my parents for being motivated and as enthusiastic throughout my journey and keeping me on my toes.

I would like to thank Demian Horst and Jonas Sandström for all the support and encouragement for new ideas & problem solving. And giving a very strong guidance throughout the entire masters programme.

A massive appreciation towards NIO interior design team for believing in my project and supporting it ideologically and financially. I would particularly like to thank Jochen Paesen & Philip Gillman, who made several things in the collaboration a possible. A big thanks also to Julien Cueff, Song Wei, Oliver Prouvst, Adam Philips, Philip Fromme, Tyler Macdonald for all the feedback and support. I would also like to thank Bart, Florian and Anders from the CAS team for their huge assistance.

One of the key motivational factors in the project is my UID colleagues who, in one way or another have influenced bits and pieces of the project in a nice way!

Special Thanks to Philipp Seeger for Familiarizing me with the world of aviation and specifically giving me insight into technicalities of VTOLs.
Looking at clean and faster ways of moving

What if future air travel was highly sustainable and appealing? What if you could hop from building rooftop to rooftop or better, from a city to an island without the worries of ground congestion and gridlocks? And how would it look like if NIO decided to take this opportunity and broaden their product offerings? These were some of the initial question that guided the project towards a mode of mobility which is new and challenging to realise. Admittedly it was also exciting to imagine what would future of autonomy look like in something other than a car and to see if A.I. driven technologies and fresh architecture ideas could enhance this experience. And remove the safety and social acceptance stigmas from this type of mobility. Furthermore to see how the design would be influenced by specific target user group & their needs.

From Post-it ideation to Alias mock-up and Virtual reality software to validate ideas, the process saw use of several tools. Initial stage included several basic CAS layout proposals which allowed for fresh ideas which were translated into detailed sketches on paper and in Photoshop. Two loops of mid-level detailed CAS were generated and then through combination of both, and additional analogue material the final loop of Alias was completed and then handed to In-house CAS team for refinement and physical prototyping support. Throughout the process there were several check points with the mentor, interior director & university tutors which gave valuable input & direction to the project.
RESULT

Sustainable autonomous air travel

The final outcome is a Vertical take off landing vehicle which shows a holistic idea of how future NIO products could look like. A small fleet and a shared model make this realistic and accessible mode of mobility. Passengers are welcomed to a NIO house which also acts as a sky-deck for the vehicle. Open interior layout of the vehicle poses unique and exciting possibilities for either enjoying personal time or a dialogue during the journey. Key functions such as ambient air, music or photo-chromatic glass can be activated by interacting with the two A.I. units placed on top of each seating zone. Use of recycled & vegan materials and lightweight construction of the seats allow for a bigger surface area but optimized weight. The overall welcoming gesture of the interior space aims for attracting a wide group of passengers.
We are living in times when our planet might be at its most fragile state. The smallest lifestyle and resource consumption choices made by the current and future generation will shape the eco system in either good or disastrous way. The common belief though is that with shift to the renewable energy and A.I. embedded technologies a lot the future problems could be tackled in a clever manner.

One of the biggest luxuries has been time & thus being able to arrive from point A to B in the quickest way. In big cities of developing countries like China or India major gridlocks can account for a lot inefficient time spending. This also puts unnecessary pressure on the infrastructure.

The author himself being brought up in similar circumstances, believes this can be good challenge to take on through creative thinking. Answers could be found by looking at a hypothetical scenario of a future city where urban transportation is multi-modal. Recent developments in the field of services driven by AI, though experimental have given us a glimpse of what is to come. Amazon drone delivery, Kroger & Dominos delivering food via completely autonomously driven vehicles are just a few examples of how AI will be crucial for future service models.

This project will be a collaboration with one such company which has AI & user experience at its core called “NIO”. Through its all eco friendly & user centric approach NIO is gaining fast popularity in its country of inception China. The company is trying to challenge other

The author with his professional and intern experience in the field of transportation design wants to explore alternatives to urban transportation which would be piloted by AI. A fresh way of looking at efficient commuting within mega-cities, would provide flexibility to future users. Author finds inspiration from helicopters and drones which provide high manoeuvrability because their vertical take off and landing capabilities (VTOL).

The project will look at potentials of carbon free aerial transportation and how a unique interior design adhering to NIO design standards can provide a seamless user experience before during and after the journey. Author hopes that NIO being a progressive company can show its capabilities not only though ground based but other modes of traveling.

One of the other important aspect the project is to promote sustainability & vision for mobility in the coming years. Though this project can only be tested on an individual level, author hopes it can serve as a brand ambassador for some of the UN sustainable development goals which are blueprints for achieving better future for
Investments in infrastructure – transport, irrigation, energy and information and communication technology – are crucial to achieving sustainable development and empowering communities in many countries. It has long been recognized that growth in productivity and incomes, and improvements in health and education outcomes require investment in infrastructure. The project aims to develop an urban mobility solution which would fit seamlessly in the future connected cities and offer on demand fast commuting solution which will be accessible for a huge community.

Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. With the number of people living within cities projected to rise to 5 billion people by 2030.

Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty. The project will consider use of recycled & light weight materials and energy efficient solutions. (United nations 2014)

it’s important that efficient urban planning and management practices are in place to deal with the challenges brought by urbanization. Urban air travel will serve as an alternate mode of traveling, and thus alleviating stress on the overall system. Making use of carbon free sources of energy the VTOLs could connect cities in a sustainable manner.
The project looks at finding motivation for designing an alternate mode of mobility in the near future and wishes to tap into a segment which would potentially have value for the collaborating partner. The author hopes the process will also enlighten him on a previously unexplored design topic.

The project first digs deep into the nature of mobility in the developing mega-cities of the future. Then peeks into trends in A.i. technologies, Sustainable lifestyle and the upcoming generation of user community. After understanding multi-modal transpiration model in the mega-cities, the project investigates the pros and cons of carbon free air based mobility which includes vehicles such as multicopters or flying cars.

After confirming the benefits of EVTOL for future users and cities, the research focuses on understanding basics of flying such a vehicle. Benchmarking the competition vehicles for their design and services helps to conclude the project goals.

Through ideation using 2d and 3d tools and different stages of visualisation the project will try to reach a viable design solution and then justify all the aesthetic choices made during the process.

Though the project is at a conceptual level, the author wishes the learnings from this project could perhaps inspire ideas in other modes of transportation, be a tester of design philosophy for the sponsor and raise questions whether people are ready and willing to commit to an autonomous future.
URBANISATION

More than half of the world's population resides in urban areas today, and millions of people are added to the global urban population every week. Statistics suggest most of this population growth might take place primarily in African and Asian countries, which will result in high demand for infrastructure, services, climate, and environment. But on the positive side, this scenario shows an increase in the kind of opportunities too, where big emerging cities act as a development tool. By 2030, the world could witness more than 40 mega-cities with population numbers of 10 million or more. This will shoot up the number of vehicles either shared or privately owned. With increasing middle class in a lot of emerging cities, keeping up with the demands for infrastructural needs will be one of the bigger challenges in the near future. (United Nations 2014)

Kenneth King, co-author of “Vertical City: A Solution for Sustainable Living” and the brains behind the organization, predicts future vertical cities will be entirely self-sufficient. Vertical cities can, for example, theoretically provide countless unobstructed surfaces for solar panels. (Robinson 2016)

Mega-cities in Asia and Africa have shown a trend of growing vertically. China adopted this trend in order to sustain its population. China has the largest number of skyscrapers in the world today, more than a thousand buildings surpassing the heights of 150 meters or more. (Block 2019)

“Given the rate of urbanisation seen in the world – and that we must build the equivalent of a new city of one million people every week to accommodate this growth – it is not surprising that the pace of tall building construction continues,” said CTBUH chief Antony Wood.

Mobility is a complicated system which is developing at a much faster speed than any time before this. Soon to be accessible technologies ranging from drone taxis to autonomous vehicles to just name a few, will be enablers of new business models and mobility services which will have to adapt to ever changing customer preferences. The enterprises & the policy makers trying to counter the challenges in the field of mobility will be the future winner in this ecosystem. (M.I.T. 2019)
MULTI MODAL TRANSPORTATION

Opportunities for solving sustainable & accessible mobility will be very relevant for the future Mega-cities. An interesting approach towards smarter infrastructure will be Multi-modal transportation. In a Multi-modal system various modes of transportation are used in a connected manner to achieve a highly efficient network. The following illustration created by ‘Porsche consulting’ shows how a potential future city with as many as 5 modes of transportation used in harmony to keep the infrastructural network balanced.
COMMUTING IN FUTURE CITIES

The millennials in the coming decade will reach age of 35-50 which will make them the dominating group in the population. This means there might be noticeable changes in the workplace standards or travel habits. This means sooner or later they will most likely show interest in big numbers in alternative travel methods compared to previous generations. Major cities in the next ten years will likely see fully autonomous vehicles well integrated with the system in mega-cities and the people will be familiar with them. Outside big cities the need for autonomous vehicles will be decided mainly by the private sector. (Cooper, Rainwater 2015)

SHARING or OWNERSHIP

Trends shows a steady increase in shared mobility market in China, Europe and U.S. and this is predicted to continue. China and the United States being the bigger ones compared to Europe. Europe’s market shows tendency of car sharing which is regulated by individual cities and the business model being more asset heavy. Both optimistic or least aggressive scenario point towards a growing demand for shared mobility services. (Ophoff, Hausler, Heineke, and Möller 2017)

ADVANTAGES OF URBAN FLIGHT

Shared flight services show a positive impact, drastically affecting how we move in the cities and save people a lot of lost travel hours. Urban air transportation can utilise the unused three dimensional airspace to reduce stress on the ground transportation systems. (Holden, 2016) Compact electric vertical take off landing vehicles not only have the potential to connect suburbs and cities but also one city roof top to another.

Investing in infrastructure to sustain urban VTOL network will have lesser cost compared to investing in railway bridges, tunnels. Its evident that its possible to re-purpose parking lot rooftops, helipads and unused land surrounding the highways and be used as take off & landing hubs. VTOLs will not require to follow fixed paths like other ground based public transportation services which are limited by pre-made routes, which can cause delays in the cases of even single interruption. VTOLs can reach destination independently without following fixed route reducing the possibility of congestion or delays. (Holden, 2016)
Artificial intelligence and particularly automation will benefit economy. A.I. developments would also contribute in solving challenges such as climate change, poverty, education, health & well being to name a few. Looking at the rate of progress in field of automation, soon machines will be able to handle even some of the most skilful tasks and outperform humans. This will result in a change in the nature of some of the occupations & diminishment in the case of others. (Manyika, Sneader 2018)

The upshot of this will be human machine collaboration which can lead to number of good and bad outcomes.

Today’s teenagers represent 30 percent of the world’s population in many countries. By 2020 they will represent close to 2 billion people globally. These people can be better described as digital natives since they exist in the age of internet. They are smarter, mature and entrepreneurial and have a conscious awareness of the problems in the world, and poised to make a positive change. The internet is well integrated part of their lives and it shapes even their thinking and behaviour. Since these centennial are still being born, since an early age their lives are impacted by aspects such as climate change, autonomous vehicles and mass produced virtual reality devices. A good example of the progressive nature of this generation will be they will not need to learn driving skills as they will be driven around by autonomous vehicles. This means they will be more independent and engage in different activities. (Tal, 2018)
Technology for flying cars and drones seems to be steadily progressing. A variety of prototypes have been made tested since the 1980s, with most of them able to take off vertically. A VTOL aircraft can take off vertically, hovers and lands, without requiring a run way. Even though traditional helicopter possess similar capabilities, they are highly energy in-efficient. Electric and hybrid power-train for such aircraft therefore is seen as a focus for a lot companies. These vehicles are designed to host from two to five passengers and equal cargo weight, be zero emission and quieter than a helicopter, and thus more sustainable for city infrastructure.

These vehicles can help solve urban gridlocks, by transporting people through three dimensional urban airspace. Unlike tunnel digging which can be slower, this system of mobility can be faster to implement and take people from short to long distances, scalable and with comparatively lower cost. The factors impacting life-cycle emissions for transportation include not only emissions of the energy source, but also the inherent vehicle energy required per mile per person. (Lineberger, Hussain, Mehra, Pankratz, 2018)

Due to electric motors being approximately three to four times more efficient than either internal combustion or small turbo-shaft engines, the actual vehicle energy used is substantially decreased compared to existing small aircraft and helicopters. The integration freedom of electric motors provides additional energy use reductions of a similar three times magnitude compared to helicopters (i.e. the ability to achieve a high Lift/Drag ratio by using a fixed wing VTOL approach along with synergistic aerodynamic integration benefits). (Holden, Goel 2016)

Automobile companies are utilizing their experience from the hybrid electric and autonomous vehicle operations to enter this space. For example, Toyota entered into the flying car market by founding the start up Cartivator, which is developing a flying car named Sky Drive. Geely acquired a flying car start up called Terrafugia in November 2017. (Lineberger, Hussain, Mehra, Pankratz, 2018)
**Kitty Hawk (Google)**

- VECTORED THRUST
- LIFT & CRUISE PROVIDED BY SEPARATE SOURCES
- SPEED 150-200 km/h
- Intracity & City to City
- Carries up-to 2 passengers

**Bell Nexus**

- LIFT + CRUISE
- TILTING THE WINGS/ROTORS OR TILT DUCT METHOD
- SPEED 150-300 km/h
- Intracity & City to City
- Carries up-to 5 passengers
- Partial autonomy possible

**Surefly**

- WINGLESS (MULTI-COPTER)
- ROTORS AS MAIN METHOD
- SPEED 70-120 km/h
- Intracity
- Carries 2 passengers
- Partial autonomy possible

**Volta**

- ELECTRIC HELICOPTER
- ELECTRIC PROPULSION METHOD
- SPEED 70-120 km/h
- City to City
- Carries 1 person
- Only piloted
Example of fixed rotors against vectored thrust

**Pros -**
- Small footprint
- Fly at lower altitude
- High agility
- Quicker certification

**Cons -**
- Payload limitations
- Short range

**Pros -**
- Redundancies due to multiple rotors
- Solid range
- Flying at high altitudes
- Decent payload capacity

**Cons -**
- Big footprint
- Slow certification
To better understand the developments and challenges to this specific genre of mobility, the author of this thesis looked into the existing and future concepts from other manufacturers, and the services they offer to ease the use for the customers. Following are the observations found during this study.

INTERIOR DESIGN

Focus seems on business commute
Full autonomy planned in most cases
Use case intra city or city to city
30km to 850km travel rage depending on VTOL type
Seating from 2 to 6 person
Lightweight aesthetics for weight reduction
Designed for fixed seating, not multi-tasking
Functional but cold appeal

SERVICES OFFERED

Battery Swap service shows potential for efficiency & convenience
Companies tend to design brand experience centre or lounge for customers before boarding to enhance the experience
Apps include detailed information about the journey including in some cases weather updates, rotor speed, altitude.
VTOLs over time will be available in many different categories similar to automotive ride-sharing services. They will be likely categorised by their speed and range capability. Long range VTOLs will need to reach a higher speed compared to the short range ones, which would travel at a slower speed. Ideal use case for operations will be commuters wanting to travel an average distance between 80-100 miles each way. This would mean the vehicles will have to be able to fly longer distances with some sort of range extender, to do more than one trip. But as battery technology improves this would change. Studies shows a range like this can be achieved in next 5 years. This means VTOLs that can achieve a lift/drag ratio of 10 or higher. Electric VTOLs will likely use 140 Kph battery packs for an aircraft capable of carrying 4 person. In most cases, charging of the vehicles will take place overnight or during an extended stop. (Uber elevate Holden, Goel 2016)

Battery swapping is an option to help increase operations productivity. Tesla, and recently NIO have invested in Various automated battery swap system which can replace within seconds. Confirming overall safety of the vehicle, after swapping a new battery will be an additional challenge.

**AUTONOMY**

Like autonomous cars, autonomous VTOLs can improve safety by reducing number of potential accidents. As people and authorities become familiarised over time full autonomy can be implemented. Safe operation even during component failure will be also an important aspect of autonomy. Over time autonomy can provide high reliability at a lower cost than current models. And in these cases the role of pilot can be seen more as on-ground controller, where they can operate only during emergencies and improve productivity of the system. These on-ground pilots with time would be able to manage a Fleet instead of just one aircraft. (Uber elevate Holden, Goel 2016)
Volocopter battery swapping visualisation

NIO battery swapping station visualisation
Payload weight and number of passengers determine the overall size of the vehicle. For an acceptable economical model an average payload of 1.3 to 1.7 will make sense. Therefore the capacity of 2-4 passengers including the pilot if there one, would be ideal for these aircraft. This capacity will permit on-demand operations with eventual autonomous flights. Increased number of passengers will provide better economics and efficiency. The amount of lift generated by the rotors will need to exceed the overall weight of the vehicle including the passengers, to allow take off and manoeuvring. The centre of the weight needs to be balanced with the centre of lift. For smaller VTOLs these aspects will be more critical as the passengers represent majority of the total weight. The flights will also be affected by trip altitude or external temperature. Initially pilot might have to assess the weight of the passengers and distribute them to achieve the right balance. With technology maturity sensors might be able to take care of this automatically, particularly when during ride-sharing. Analysis shows over time, in autonomous flights the cost will reduce from the initial high anticipated numbers. A fleet of VTOLs will require a mixture of both small and large stations with fast charging capacity and boarding or de-boarding facilities for the passengers. (Uber elevate, Holden, Goel 2016)

Big stops would host a fleet where as smaller stops would take care of single aircraft, where they can quickly drop off and pick up passengers without extended stops. An example of this would be small helipads on top of downtown buildings. A way of reducing pollution and noise in the city, floating stations can be proposed in coastal areas. Example of such stations already can be seen in New York and Vancouver. To have big number of flight operations this category of stops. Tall parking lots offer a good opportunity of utilising the space as take off landing stops. Initially this mode of mobility is unlikely to carry passengers from door to door, but instead from one stop to another. But in time, depending of the location and regulations the VTOLs could take off or land from private residences. The locations will have to analysed and registered for such operations. (Uber elevate, Holden, Goel 2016)

SAFETY

For acceptance of passenger drones which are manned or autonomous, they would have to show a clean safety record in both the technology side as well as the operations. As seen with the autonomous cars, any small incidence can see a notable attention and can slow the process. Operations of VTOLS in suburban areas could be seen as an infrastructural challenge. (Uber elevate, Holden, Goel 2016)
Tokyo Helipad

Ehang 148 1 person drone
SOCIAL ACCEPTANCE

Getting a wide acceptance for using eVTOL aircraft will require solving several issues related to safety and security. Having these seamlessly integrated with the city infrastructure being one of the key aspects of the big picture. These vehicles will also have to prove they will benefit all parts of the society not only the wealthy. Experts expect the noise profile of a VTOL to be one fourth that of a helicopter at a 300feet altitude. The objective then will be to assess the personal benefits against the mass suitability and decide how to best achieve quality & comfort for this mode of mobility. The public opinion about urban air mobility vary from country to country covering the broad spectrum of enthusiasm to scepticism. The first implementation of such technology will therefore take place where public might be more open, such as Dubai, Singapore & China. The first implementations and results will define the perception of safety and security concerns and offer solutions for dealing with visual and noise pollution. (Uber elevate, Holden, Goel 2016)

INFRASTRUCTURE

The key aspects of vertical mobility include infrastructural needs such as take off, landing stations, charging options and serviceability. While there is ample of airspace available, integration with the pre-existing transportation will be a necessity. Size, number and location will be a determining factor for the EVTOL ecosystem. The key resources required will be number of take off landing and charging options along with air traffic control set up. Urban EVTOL infrastructure needs to balance out the pros and cons such as defining proper use of take off landing spaces. Many cities have helipads which can therefore sustain the initial infrastructure. The number of these take off landing sites will have to multiply with time. In advance phase, mega-cities will large population will need 100 or more of such sites in order to provide a strong network. (Uber elevate Holden, Goel 2016)
MARKET

China, being the place of birth and the biggest current and near future car market, is the current focus for NIO cars. Recently NIO has contributed towards installation of several charging and battery swap stations along some of the major highways in the country. The brand slowly plans to expand in the U.S and EU market in the future.

PAST & PRESENT

NIO was born as a global start up in 2014. One of the key figures & founder William Li (Li Bin) dubbed as the Elon Musk of China, mentions company is focused on providing premium user experience to all its customers and make them feel proud about owning a car again. The company focuses on passenger electric vehicles and also participates in the Formula E under the same name showing its extreme performance capabilities.

“Performance for living” is how the Design Vice president Kris Tomasson describes the NIO design philosophy. The first production SUV ES8 demonstrates design theme of “Open Solidity” in both interior & exterior communicating a progressive but premium design with almost a hand crafted feel to the way its executed.

NOMI is the interactive AI unit which sits proudly on dash of each NIO vehicle. Its an integration of AI in the interior of a vehicle similar to having ALEXA or SIRI in a smart home. From taking voice commands to selfies its an ideal companion particularly for solo journeys.

NIO house is a collaborative space which offers variety of areas including living room, library, cafe, theatre, gallery(Car showcase space) and more. NIO houses are spread across major cities in China, and plan to expand in newer cities. These spaces can be shared amongst the user community. They bring people together and give a taste of what NIO lifestyle is like.

MARKET

China, being the place of birth and the biggest current and near future car market, is the current focus for NIO cars. Recently NIO has contributed towards installation of several charging and battery swap stations along some of the major highways in the country. The brand slowly plans to expand in the U.S and EU market in the future.
NIO Nomi A.I. Unit

NIO Eve concept
CONTEXT

Urbanisation points towards increasing need for on-demand travel services. Interconnected transportation systems with the help of A.I. can level the playing field.

Urban air space in mega-cities is a where eVTOLs can serve as revolutionary vehicles, connecting people in a faster way. The potential passenger market for eVTOLs by 2035 is estimated to be 32 billion USD.

The potential users for autonomous eVTOLS are born in the age of internet & will be accustomed to A.I. as an essential part of their daily lives & experiences. Trend amongst these future users shows interested in shared or leasing services more than ownership of the vehicles.

Nio Through their approach of designing for a premium experience can provide a unique solution for this field of transportation.

VERTICAL MOBILITY

Promising developments in the battery technology & various methods of propulsion shows that eVTOLs are not fiction anymore. Major players actively participating in this field highlights that there is a great demand for radically new ways of connecting people faster than ground based transportation.

A combination of Thrust vectoring & fixed rotors can provide significant range & speed and also allow for higher payload.

Competitors benchmarking shows functional but not warm & welcoming interior design solutions. Trends points towards light weight aesthetics & simplification of interface & infotainment systems in future VTOLs.

Future autonomous flights will first need to overcome hurdles such as social acceptance, safety & range.
Though the scope of the project seems quite wide, the author aspires to meet some of the particular goals and wishes along the process and through the end result.

**GOALS**

Designing a warm & inviting interior concept which should serve as a Vision for future NIO interior Design. Design for optimal visibility through the fuselage to enrich the flight experience. Unconventional interior layout which would allow for travel activities & practical functionalities to support them, which should spark a debate about possibilities in eVTOL interior architecture. Explore the potential evolution of A.I. host NOMI which is a foundation for all NIO products. Conceptualise future NIO house which can serve as Vertistop for eVTOLs. Design a viable Exterior solution. Illustrate the journey experience through high quality images.

**WISHES**

Learn & understand freedom & constrains about designing eVTOLs. Understand & share how alternate sustainable travel system could be as valuable as other modes of transportation. Inspire interior design team at NIO
The type of vehicle this thesis will explore is a vertical take off landing vehicle (VTOL). This will require a combination of fixed rotors and thrust vectoring. To achieve the desired payload and economy, the vehicle will be equipped with fully autonomous flying capabilities and can be taken over by remote pilot in-case of emergency landing situations if needed. The use case which this vehicle will target is city to nearby tourist destinations. The distance and the duration of the journeys this vehicle can offer will be based on the payload and the electric power-train capabilities. One to two hour journeys with a capacity of four people and limited luggage allowance will contribute to a sustainable yet premium business model for NIO. The project will also look at possibilities of connecting this mode of transportation with other ground based modes by using a take off landing station as a transition hub.

The interior design will focus on external visibility which will allow passengers to experience stunning landscapes throughout the journey. The interior layout will be an open one, where passengers can have a dialogue and socialize rather than focus on entertaining themselves. Exploring a combination of different seating will offer passengers different experiences during the journey. Dedicated storage spaces for luggage, coffee or tea table and storage hook for hanging clothes or luggage will be part of problem solving exercise throughout the process.

The interior design will provide experience essentials like ambient lighting, sound and temperature control. The project will investigate integration of an A.I. unit inside the interior (similar to Google home or Alexa) which can be used to control various functions.
Formal inspiration came from soft shapes welcoming colours, and shy tech details. The idea was to create a shape contrast between soft & subtle main forms and honest but simple details which will be aesthetically engaging for the passengers.

Creative phase started with generation of several CAS mock ups to explore new possibilities for the overall architecture of the vehicle. This helped create a better understanding of the interior and exterior connection, the volume and proportions. Important aspect of the interior was having at-least two different seating experiences, in the space but also having a feeling of openness. Through different packaging layouts, it was easier to segregate the ones which solved the interior in a open but new way. Soon by making several proposals by hand and digital sketching several layers of details, materials and colours were explored.

Then two more loops of CAS mocks ups were carried out which would then be combined to achieve the final proposed design. During the process there were a couple of opportunities to place and validate the mock ups in Virtual reality which gave an accurate understanding of the interior space. The chosen end result was detailed out in Alias, and then visualised in 3d rendering tools for final and contextual imagery.

Due the sponsored collaboration with NIO, the Alias model was re-worked rapidly by in-house digital designers and then stitched surface data was then sent out for 1:6 scaled physical prototyping.

Formal inspiration came from soft shapes welcoming colours, and shy tech details. The idea was to create a shape contrast between soft & subtle main forms and honest but simple details which will be aesthetically engaging for the passengers.
FIRST SKETCHES

This page represents an experimental starting point, based on NIO design philosophy the following sketches were exploration of how a living space could be created without getting constrained by a set package.

Functional seat and architectural ideas from this ideation will be later implemented in the complete design proposals in the process.
Initial CAS mock up based on early sketches show this interesting proposal.
The goal here was to explore several architectural possibilities and seating layouts for the passengers.

Following sketches show asymmetrical package for the interior space and use dynamic form language which uses inside-out approach to make visible use of the supporting external structure.
This sketch page displays a symmetrical seating layout and thematically tries to simulate a yacht deck.
REAR SEAT DEVELOPMENT

Rear seats were meant to offer two distinct modes 1 connect and 2 Independent. This would allow the passengers seating on these independent seats to form a bench in order to share time together, during which the coffee table would slide behind the bench.

When Independent mode in active, the seats rotate 15 degrees away from each other during which the asymmetrical headrest can be used to get a nap and focuses on privacy. During this the controls and storage located between the two zones is more accessible.

Initial ideas for the rear seat
Final design for rear seats

Exploration for the rear seat bench formation concept
FRONT SEAT DEVELOPMENT

Front seat design was challenging. In order to achieve a welcoming gesture as soon as the passenger glance at the space these seats would invite them in with the shape that loops around the rear seats. But it would also serve as a structural member for the fuselage and house the storage shelf and coffee table.

Font seating system is designed to offer a lounge chair like configuration which allows the passenger to either face each other or lean on extended armrest which can also act a back support. This posture can be used only during the flight as the passengers can detach the belts and adjust freely on this big seat.
other seating system concepts

Front seating system final design
X frame which connects the interior and exterior, acts as a structural part of the vehicle. It also houses, key features such as ambient lighting, seat belt locks, storage hooks. One of the main purpose of having this frame was to house the two A.I. voice command units which are housed at the top near the glass roof. The recycled carbon fibre structure is robust but lightweight.
Theme development sketches
As previously mentioned the final design was a combination of ideas from all the different ideation loop. Based on the final theme proposals this surface data saw two loops, one rough cut from my side and second refined loop from the in-house surface designers. For meeting the standards of data delivery for a physical mock up data was made water-tight. There were also a couple of rounds of re-work for making the scaled model fit the budget for the prototyping firm. What is visible here is then a combination of my own surface work and support from the professionals. This data is also valid for final visualisation and V.R. testing, which would play an important role for in the final result.
Final stitched surface data
Passengers enter from the front, for this the nose rotates open and stairs are deployed.
The interior at a first glance gives an impression of a living space, which makes it unmistakably recognizable as a NIO product. The front seats in this particular trim indicate a playful and inviting colour scheme where passengers are invited to experience spectacular views of the landscape or city skylines.

Rear show a relatively serious colour and material choice where passengers can enjoy creature comforts of a business class lounge. The photo-chromatic glass of the cabin can be dimmed or made partially transparent as required by the passengers during the flight. Each seat has a safety seat belt provision integrated in the safety structure.
NOMI integrated near the roof structure on both sides of the interior act as a voice command assistance. Passengers can activate functions such as light, sound and temperature control with this. The storage units and storage hooks are quietly tucked in the background and do not dominate the interior design. Central table hosts a beverage dispenser which can be retracted back inside, if passengers intend to engage in other activities.

The choice of authentic but sustainable materials and the open layout of interior space is intentional and helps create a premium travel experience. The smaller functional components such as button and interfaces are hidden and only appear when required. This is so that the passengers during the journey can have a quality time, and focus either on the view outside or interact with each other, instead of be sucked in by smartphone screens.
Exterior is built mainly from combination of aluminium composite and consists of several carbon fibre components placed in the rotors, under-body and landing legs. The sensors are placed in the roof hub, and batteries are placed in the under-body and the tail of the vehicle in order to achieve a precise centre of thrust.
The experience can be easily booked with an app, where the passengers can browse the nearest sky stop locations and also access critical information such as weight allowance and safety instructions before taking off.
Vehicle is docked at one of the NIO housed for the next passengers to board.
CONCLUSION

The in-depth research made during the beginning of the project helped make it somewhat credible. Thanks to authors networking skills, connecting with industry experts and gaining insights into the basics of a new type of vehicle became a natural part of the process. This laid out a solid groundwork for the things to come.

At the collaborating partner the selected topic was initially met with a slight doubt, but the author soon managed to convince that this project could offer interesting learnings for future products.

It became evident in the research that future cities will undoubtedly look at more than just ground based transportation modes for building a more efficient mobility network. Cities will compete at being more sustainable than one other and acceptance towards a.i. driven technology and autonomy of things would certainly see a growing interest. Important insight was gained by looking at future users who would commit to newer modes of mobility. Deeper study into practicality of EVTOLs gave a broader picture of the overall subject. Benchmarking the competitors and how they plan to strategically introduce these vehicles & services to make them easy to use, gave a valid insight. Once the findings from this research were aligned with the interests & values of NIO as a brand, the ideation process was initiated.

The Author realised during the creative phase that taking on both interior and exterior as a problem solving task will be a major challenge, but as the design later evolved with an inside out element, it became important to highlight that with a hint of what the exterior might look like.

Several loops of ideation, and CAS mock ups were carried out to explore a fair number of concepts. Then selected ones were re-reiterated on both analogue and digital platforms. Early visualisations were made and then presented to the team & tutors for feedback. A decent level of material and colour understanding was gained during the process by having a dialogue with the colour and material finish team at NIO.

This was also seen as an important part of process in order to create a more sustainable plan for realising the end product. Once the ideas in the sketches and digital mock ups were evaluated, a detailed surface data was produced which served as a foundation for final visualisation and upcoming physical prototype.

The author was met with a noticeable struggle because of not being able to finish tasks as planned in some stages of the project. This often ate up time from the other stages of the project. These delays often resulted in psychological stress. One of the key learnings from this was to stick to the decisions made and believing in them firmly. The author’s habit of comparing his work with colleagues also contributed to stress during the process, which could have been avoided. In conclusion, the project delivered both positive and negative behavioural insights which can be learned from and applied to the future work.

As an aspiring interior designer, the author’s quest for knowledge on newer topics was fulfilled to an extent with this project. The hope is that this project could at the very least inspire new ideas in the design community, and raise questions about potential existence of such mobility platforms.

As for a young brand like NIO the project Horizon represents a progressive future. And with the family centred approach to design the project tries to bring the brand ideology in the spotlight the.

Sustainable aviation and autonomy remain some of the most debatable topics in the transportation industry today. And while fully autonomous flying vehicles might be a distant future, the Horizon project tries to highlight one of the potential outcomes of combining these technologies. It goes without saying that a project such as this also comes with obvious doubts and concerns like the environmental impact of creating newer products or safety and viability of such vehicles. But in a future where humans aspire to be better connected and cities to be more sustainable, vertical mobility will play a major role period.
WEB REFERENCES

Relevance

Context


A.I

User

Clean air mobility
http://www.foresightguide.com/air-deliveries-and-air-taxis-finally-solving-urban-gridlock/ - authors unknown

Types of VTOL
http://evtol.news/

Speed range and battery technology

Take off and landing

Challenges

NIO
https://www.youtube.com/watch?v=2VI-2McURB Published by NIO Aug 15, 2017
IMAGE REFERENCES

8. https://in.pinterest.com/pin/642537071812423531/ By The collaboration of Irving Penn & Issey Miyake  
11. https://cora.aero/  
17. https://www.bellflight.com/company/innovation/fcx-001  
18. https://liium.com/  
27. 28. https://www.nio.com/visioncar  
32. https://minimalissimo/rifmo  
34. https://www.couchpotatocompany.com/products/frost-chair-1  
35. https://bragliatotraverso.com/pandora  
38. https://designstreet.it/beatle-divano-minimalista-schiene-girevole/  
39. https://contractfurniturestore.co.uk/products/nest-easy-lounge-chair  
**APPENDIX**

**Time-plan**

<table>
<thead>
<tr>
<th>January 2019</th>
<th>February 2019</th>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monday</strong></td>
<td><strong>Monday</strong></td>
<td><strong>Monday</strong></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Tuesday</strong></td>
<td><strong>Tuesday</strong></td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Wednesday</strong></td>
<td><strong>Wednesday</strong></td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td><strong>Thursday</strong></td>
<td><strong>Thursday</strong></td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td><strong>Friday</strong></td>
<td><strong>Friday</strong></td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td><strong>Saturday</strong></td>
<td><strong>Saturday</strong></td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td><strong>IDEATION</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Sunday</strong></td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td><strong>IDEATION &amp; PACKAGE EXPLORATION</strong></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td><strong>IDEATION</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Budget in Euro**

- **Travel**: 2000 flight and accommodation
- **Materials**: 50 transfer stickers, wood vinyl
- **Printing**: 90 double poster printout
- **Model & Exhibition**: Sponsored by NIO GmbH
- **Other**: 700 model delivery to Umea
- **Total**: 2840 €
<table>
<thead>
<tr>
<th>April 2019</th>
<th>May 2019</th>
<th>June 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3D Sketch Modeling &amp; Early Vis</strong></td>
<td><strong>Final 3D for Prototyping</strong></td>
<td><strong>Final 3D for Prototyping (Maya)</strong></td>
</tr>
<tr>
<td>7 8 9 10 11 12 13</td>
<td>5 6 7 8 9 10 11</td>
<td><strong>Design Talks &amp; Degree Show</strong></td>
</tr>
<tr>
<td><strong>Process Gateway</strong></td>
<td><strong>Report Delivery</strong></td>
<td><strong>Final Exam</strong></td>
</tr>
<tr>
<td><strong>Final 3D for Prototyping (Maya)</strong></td>
<td><strong>Show Preparation, Model Final Touches</strong></td>
<td><strong>Final Exam</strong></td>
</tr>
<tr>
<td>21 22 23 24 25 26 27</td>
<td>19 20 21 22 23 24 25</td>
<td><strong>Show Preparation, Model Final Touches</strong></td>
</tr>
<tr>
<td><strong>Final 3D for</strong></td>
<td><strong>Show Preparation, Model Final Touches</strong></td>
<td><strong>Final Exam</strong></td>
</tr>
<tr>
<td>28 29 30</td>
<td></td>
<td><strong>Final Exam</strong></td>
</tr>
</tbody>
</table>