An *Innovation* Approach Towards Sustainable Mobility in 2035

Master Thesis
Strategic Product Design
Melanie Rumpf

EMBRAER

TU Delft

„A new, more accessible and more democratic way of getting around will change the world – for the better.“

- Antonio Campello, CEO EmbraerX -

An Innovation Approach Towards Sustainable Mobility in 2035

CREATING A STRATEGY FOR EMBRAER

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Author
Melanie Rumpf
Strategic Product Design (MSc)
M.Rumpf@student.tudelft.nl

Supervisory Team

Chair
Prof. dr. Hultink, H.J.
Professor of New Product Marketing
H.J.Hultink@tudelft.nl

Mentor
Ir. Tassoul, M.
Specialization in Creative Facilitation
m.tassoul@tudelft.nl

Company Mentor
Luciana Ribeiro Monteiro
R&D Analyst
luciana.monteiro@embraer.com.br

Company
Embraer
Av. Brigadeiro Faria Lima 2170
São José dos Campos - SP 12227-901
Brazil
www.embraer.com

Delft University of Technology
Faculty of Industrial Design Engineering
Landbergstraat 15
2628 CE Delft
The Netherlands
www.tudelft.nl

Preface

ACKNOWLEDGEMENTS

In front of you you can find my final graduation report of my master studies ‘Strategic Product Design’. The master thesis was a collaboration with the Brazilian aircraft manufacturer Embraer on the topic of sustainable mobility.

Throughout this 5 month journey several people accompanied me and helped me with advice and their support and added a great value to the master thesis. I am grateful for everyone of you.

Thank you Luciana you did several things, which can’t be taken for granted for a supervisor. I was really grateful especially for your support at the business challenge. Also, your feedback on my work was really valuable as well as connecting me to further employees from Embraer like Carlos for example.

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Thanks to Gabi, who also quickly helped me when needing information about the mobility habits in the US.

Guillermo, thank you for your support and that I always could talk to you. It really helped me to relax and see things more clear.

Executive **Summary**

THE THESIS IN A NUTSHELL

The world is facing its limits in terms of climate change, scarcity of resources, and pollution. While there is a rising population with a rising demand for mobility, the limits of nature affecting society need to be considered. Avoiding mobility completely seems to be challenging considering a more globalized world, where everything is connected. For this reason, creating a strategy for sustainable mobility is relevant.

For creating an innovation strategy several fields were considered and analyzed. Sustainability implications were made and the issues of mobility in terms of sustainability were found out. Since greenhouse gases is the most severe problem it was looked more deeply into different kinds of fuels, which can solve the issue of greenhouse gases. Furthermore, it was looked into strengths and unique characteristics of Embraer, its current situation and brand DNA. An analysis of stakeholders in aviation revealed current barriers that make it difficult for the aviation industry to act sustainably. Also, competitors and their innovation and sustainability strategy were considered. Mapping the context of sustainable mobility helped in identifying major opportunities and threats for Embraer and create trend scenarios that demonstrate possible future developments. Based on the analysis results search fields and a future vision were created. Within a one-day business case, the Embraer Business Challenge, 14 students generated ideas, that were later developed by experts.

The final solution proposes to collaborate with a bus manufacturer, that produces hydrogen fuel cell busses. Through the collaboration, Embraer can learn about the technology of hydrogen fuel cells, which helps Embraer to launch its first hydrogen fuel cell 30-seater airplane in 2035. Also, creating and launching a prototype in the time frame between 2025 and 2034 supports Embraer in gaining more experience with hydrogen fuel cells and to convince stakeholders regarding the technology. While preparing the launch of the hydrogen airplane, Embraer uses the collaboration with the bus manufacturer to further invest into busses. Improving the entertainment offer, and connecting the bus experience to further modes of transport makes the offer of the bus more attractive to consumers. Through connecting the different mobility experiences, and offering using several modes of transport through a subscription, Embraer goes into the growing market of mobility-as-a-service. In 2035 Embraer can embed its hydrogen airplane in the MaaS system and promote the airplane through the established system in a better way.

The strategic roadmap has been elaborated with several experts to validate the feasibility and desirability of the roadmap solution.

Reading **Guide**

FACILITATING THE READING PROCESS

The reading guide supports a quick understanding of the most important insights of the master thesis. On the right an overview is given about the content of the different chapters and how the chapters relate to the design process.
At the beginning of each chapter an overview about the content of the chapter is given. A summary of the most important key insights of the chapter can be found at the end of each chapter.

Some information is in blue to point out its importance.

To dig deeper into the topic or to illustrate examples, links and videos were integrated into the report with a QR code.

These QR codes will ask you to scan them to find out more information about a certain topic.

GOOD TO KNOW

In these boxes additional interesting insights are mentioned to get to know more context information.

ABBREVIATIONS

B2B = business to business
B2C = business to consumer
Bn = billion
CAGR = compound annual growth rate
CEO = chief executive officer
CO2 = carbon dioxide
DOE= US Department of Energy
IDE = Industrial Design Engineering
IRS = Internal Revenue Service
ITC = Business Energy Investment Tax Credit
LCA = life cycle assessment
MaaS = mobility-as-a-service
PSS = product service system
R&D = Research & Development
TU = technical university
US/ USA = United States of America

Explore & Understand

1) INTRODUCTION
>> The relevance of sustainable mobility is explained as well as the project objective.

2) THE ESSENCE OF SUSTAINABLE MOBILITY
>> Issues of mobility are described and a fuel analysis was made to enable addressing the most significant issue of mobility triggering climate change.

3) ABOUT EMBRAER
>> Most important information and insights about Embraer are mentioned.

4) STAKEHOLDERS IN AVIATION & INNOVATION
>> Stakeholders of the aviation industry and competitors of Embraer are mapped.

5)THE CONTEXT OF SUSTAINABLE MOBILITY
>> Important market opportunities and threats are revealed here. Through context information and major threats trend scenarios were created.

Define

6) A NEW INNOVATION DIRECTION FOR EMBRAER
>> Search fields and a future vision for Embraer can be found in this chapter.

Deliver & Develop

7) FROM BUSSES TO AIRPLANES
>> The conduction of the idea generation is described in this chapter. Also the final roadmap solution is described here.

8) EVALUATION OF FEASIBILITY & SUSTAINABILITY
>> In this chapter the final solution is validated and evaluated.

9) FINAL REMARKS
>> Core values for stakeholders are pointed out, the research question is answered, and final recommendations are made.

01

INTRODUCTION

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1

INTRODUCTION

GETTING AN OVERVIEW

To set the project in a context the relevance of the topic of ‘sustainable mobility’ is explained and main stakeholders of the project are introduced in this chapter. Furthermore, project scope and aim are described to set a project focus. The mentioned process structure and a guideline how to read the report guide through the report structure.

1.1

General **Introduction**

PROJECT CONTEXT

The topic 'sustainable mobility' is getting more and more relevant due to the amount of consumption and sustainability issues of mobility. Within a collaboration between the innovation department of the Brazilian aircraft manufacturer Embraer and TU Delft the topic of 'sustainable mobility' is dealt with.

RELEVANCE OF THE TOPIC

On May 31 2019 there were more than 3 billion consumers, 1 billion tons of waste was produced, we had 13 billion tons of CO2 emissions in 2019 so far, and 356,979 people died from air pollution this year according to the world counts (2019). Continuing this lifestyle would mean a need of 1.7 earths. It's probably easy understandable that this way of living will not going to work out on a long term. The world is facing its limits: scarcity of resources that limit consumption and growth (Barnett & Morse, 2013), plastic contamination in the ocean endangering marine organisms (Jambeck et al., 2015), air pollution causing health issues (Brunekreef & Holgate, 2002), and rising temperatures resulting in a change of climate and ecosystems that puts food supply and human security into risk (Masson-Delmotte et al., 2018). While the current way of living and acting apparently causes environmental problems, it is necessary to change our way of thinking and enable business models, products, and concepts that allow a way of living "without compromising the ability of future generations to meet their own needs. " (Brundtland Commission of the United Nations, 1987). Not only that the current way of living harms and endangers the environment and living beings, but we also face the challenge of meeting the needs of a growing population (Lutz, 2017) in the coming years.

3 billion consumers & 13 billion tons of CO2 emssions in 2019

Interested in the live count of environmental statistics? Scan The QR code. :)

Talking about sustainability it is easy to say to avoid a product. Avoiding mobility would not only solve a waste problem (Bocken & Short, 2016), but also the emission problem. However, there is a clear trend of a growing mobility demand. There were 947,080 passenger cars and 335,190 commercial vehicles in use worldwide in 2015 (statista, 2017), and 38.1 million flights in 2018 with a tendency of a rising trend (statista, 2018). According to Barr and Prillwitz (2011) even consumers with the most environmental friendly mindset often don't doubt using airplanes for travelling, which is currently the form of transport with the highest amount of CO2 per passenger kilometre (European Environment Agency, 2014). Furthermore, considering the globalized world with vast amounts of opportunities to travel, there is a need to commute from home to work, the wish to see a family member or a friend that is living in another country, or the need of politicians connecting globally to arrange global agreements. It is barely imaginable that avoiding transportation completely is even possible. So it might not be possible to avoid transportation completely. But it is possible to make it more sustainable and that's what this thesis is about. Sustainable mobility.

EMBRAER & INNOVATION

The master thesis is a collaboration with the Brazilian aircraft manufacturer Embraer. The company was founded in 1969 and concentrates on the fields of commercial, executive, and agricultural aviation, defense & security, and offers services and support to its business clients. It is globally operating and B2B acting as the company sells its aircrafts and offers its services to companies such as American Airlines, KLM, and TUI fly for example to mention only a few of its clients. According to the client Embraer uses the 70-20-10 rule for innovation (figure 1). This model is based on a study of Lombardo and Eichinger (1996), and was later developed for business innovation by Eric Schmidt and Google in 2005. Based on the innovation model, 70% of the companies resources should be used to sustain innovation, meaning enhancing current products and services of the company. 20% should be invested in adjacent markets, meaning new product categories for the company, but already existing categories on the market. 10% of investments remain for completely new not even existing forms of innovation. As the risk rises from 70 to 20 to 10, the less the company is acquainted to the market, the less resources are invested in the strategy in order to keep the risk for the whole company low.
Within Embraer, EmbraerX is responsible to come up with disruptive innovation ideas, considering more adjacent or completely new markets. The division of Embraer, EmbraerX, was established by the company in the recent two years. The CEO of the division is Antonio Campello, who leads teams in Sillicon Valley and Boston in the US.
In order to innovate EmbraerX seeks for collaboration partners, e.g. Uber, startups, or universities like the Delft University of Technology.

TU DELFT

The master thesis part of a collaborative program between Embraer and TU Delft. In particular it is a 2 year collaboration with the department 'people in transit' from the Faculty of Industrial Design Engineering. This master thesis marks the beginning of the collaboration. Parallel to this thesis Frederic Kindervater, a student from the Master studies 'Design for Interaction' at the faculty of Industrial Design Engineering (IDE), will write his Master thesis as well in collaboration with Embraer. He has the same project scope, but will focus on the method 'Vision in Product Design'. After the end of the master theses the concepts will be further developed and prototyped by students from the Master studies 'Integrated Product Design'. at IDE.

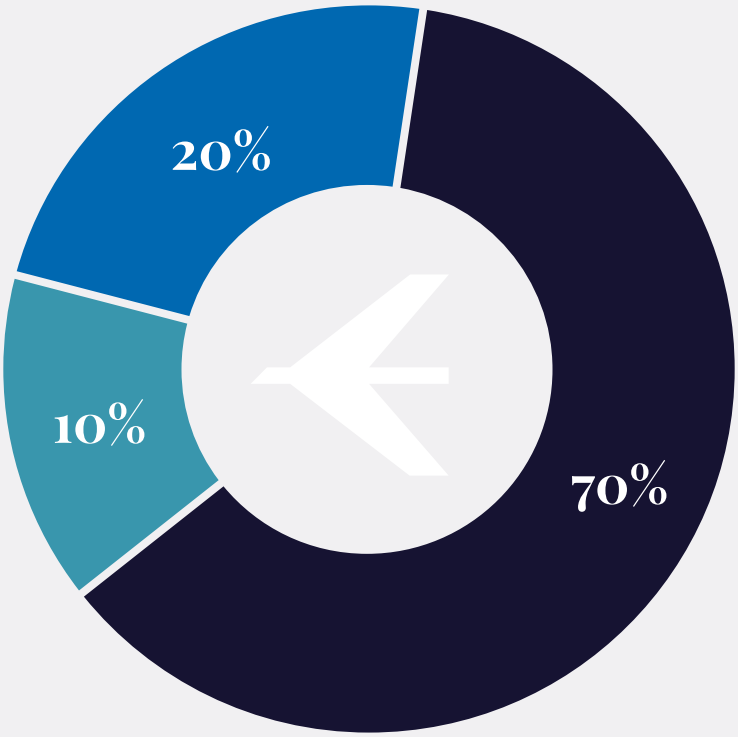


Figure 1: Embraer is acting according to the 70-20-10 rule. 70% of investments are done to sustain innovation, 20% of investments go into adjacent markets, and 10% into completely new forms of innovation.

1.2

Project **Objective**

& APPROACH

As a project collaboration between Embraer and TU Delft the thesis uses the approach roadmapping to spot future innovation opportunities. Through a structured and iterative process based on the creative diamonds the project creates an innovation strategy for Embraer.

PROJECT SCOPE

The project scope is defined by the following factors:

EmbraerX & TU Delft
The thesis is part of a collaboration between Embraer, in particular EmbraerX and TU Delft. Since EmbraerX focus is mainly on adjacent or completely new markets the master thesis can also be positioned in this field.

Mobility
Although Embraer is an aircraft manufacturer the focus is not on aircraft. All kind of forms of mobility that transport a passenger from point A to B can be explored.

Sustainability
Speaking about sustainability different types of concepts will be taken into account. Examples of sustainable definitions and frameworks were for example made by Elkington, Geißendörfer et al., and McMichael et al. .
In 1997, Elkington created the concept of the triple bottom line, which defines three aspects of sustainability: people, planet, and profit. Geißendörfer et al. (2016) extended this definition of sustainability, defining it as „the balanced and systemic integration of intra and intergenerational economic, social, and environmental performance“.
McMichael et al. (2003) argues that to truly understand sustainability it is relevant to look into several aspects and its intercorrelation like “demography, economics, ecology, and epidemiology”. In his paper he refers to the interaction of population, health, the environment, and acting behaviour that all have an impact on sustainability.

PROJECT AIM

The goal of this project is to explore the field of sustainable mobility and to create a strategy for Embraer on sustainable mobility towards 2035. An illustrated roadmap communicates the strategy and helps in understanding and implementing the strategy towards the vision in 2035.

RESEARCH QUESTION

In order to have a guidance throughout the project the following research question was phrased:

How can Embraer embrace sustainable mobility in an innovative and strategic way in the coming 15 years?

APPROACH & METHODS

For the project the method ‘Roadmapping’ based on the book ‘Design Roadmapping’ by Lianne Simonse (2017) was suggested by the client. This approach includes a creative trend research that serves to create a strategic future vision for the company. Based on the trend research, a scouting for technology, and a time-pacing analysis, an innovation strategy can be created. The innovation strategy is finally visualized and mapped on a timeline and leads within three horizons to the future vision.

Figure 2: In order to understand future developments and context factors of sustainable mobility better six expert interviews were conducted. The following experts were interviewed:

Luciana Ribeiro Monteiro is an R&D analyst at Embraer in São José dos Campo and currently working in the Netherlands. She is also one of the supervisors of this project. Ms. Ribeiro Monteiro was in particularly interviewed in order to get to know more about the perspective of Embraer on sustainable mobility and future developments.

Paul Peeters is an associate professor for sustainable transport and tourism at Breda University of Applied Sciences his main subjects are climate change, transportation, and aviation. He was picked as an expert due to his knowledge about sustainable mobility in particular about the aviation industry, different types of fuels and his background as an aircraft engineer.

Jaap Vleugel is a trained economist and senior researcher at the Delft University of Technology. Mr. Vleugel was interviewed in order to get apart from the aviation industry a further view on sustainable mobility since he also was involved in projects related to transport infrastructure in cities and railways. His expertise is especially on transport issues and the triple bottom line.

Derk-Jan van Heerden is the CEO of the company 'AELS - Aircraft End-of-Life Solutions'. His expertise about recycling, in particular in the aviation industry, seemed to be a valuable contribution in order to also cover the topic of recycling.

Tim Vleeshouwer does his Master degree in 'Transport, Infrastructures & Logistics' at the Delft University of Technology. During his Bachelor degree he did his minor in 'Airport of the Future'. As a lead of the full scale department of Delft Hyperloop he could give information about the future development and outlook of the Hyperloop. The Hyperloop seemed to be a particular interesting development to look into due to its potential competition as a sustainable form of transportation in comparison to short haul flights.

Additionally, an anonymous contributor from the aviation industry was interviewed to understand the context of aviation and airlines in a better way.

The relevance of roadmapping - Roadmapping is a future oriented strategy that is especially useful for design innovation or disruptive innovation to sustain a company and prepare it for the future. Spotting future innovation opportunities is essential to stay competitive on a long term and already adapt in time to invest research and resources in innovation before it might be too late, and competitors already are far ahead. Failing to innovate in time can have devastating consequences as the common example of the company Nokia (Bouwman et al., 2014) shows.
The methodology of roadmapping is also relevant to get consumers acquainted and adapted to a disruptive innovation over time. Taking autonomous vehicles as an example, the relevance for the future is taken seriously by several automotive companies. Though, the consumer acceptance and trust in the technology is established over time (Kyu Choi & Gu Ji, 2015).
Within the company a visualization of a roadmap can facilitate the communication of the strategy to the management or executing stakeholders of the strategy like engineers for example.

The gaps of roadmapping - Although roadmapping has several advantages, it also contains its gaps, which can also be compensated through additional methodologies. A roadmap for example does not consider the financial feasibility of the project. The roadmap strategy should also no be taken as a strategy set in stone, but it is important that it needs to be adapted over time due to unforeseen events for example.
Furthermore, the roadmapping methodology developed by Lianne Simonse currently does not include the aspect of 'sustainability'. The method of roadmapping will need to be extended in order to integrate this aspect.

To add further value other methodologies were considered as well. The full approach was classified into different stages , and can be found visualized in figure 3. The following text describes the process:

Explore & Understand
It first was important to explore all relevant aspects for the project. Therefore, expert interviews, a literature review, and a secondary data research was conducted. The list of experts can be found in figure 2. Generative research tools were used for the interviews in order to reveal latent knowledge.
For the analysis it was looked into the strengths and weaknesses of Embraer in relation to its competitors, sustainability and innovation strategies of competitors, consumers and further stakeholders, and context factors through the DESTEP analysis. Furthermore, it was relevant to understand sustainability problems of mobility in a better way in order to be able to frame the desired sustainable future vision later on. Woodcock et al. states that common methods that "predict" needs and trends, and "provide" the relevant product without considering environmental factors hinder a sustainable way of living (Woodcock et al., 2007). A technology scouting was also conducted prior to the vision creation, which is usually uncommon in the approach 'Roadmapping'. The technology scouting helped to create a realistic vision that is feasible and viable in the future.

Define
Insights from the exploration phase were collected to create search fields within a co-creation session and during an individual brainstorming session of the thesis author. One search field was chosen and was the base of creating a future vision for Embraer.

Develop
In the next step ideas were generated with participants, who were given a concrete business case during a business challenge. Also, additional ideas were generated to decide on one concept in the end.

Deliver
Discussions with experts helped in validating and further develop the concept. The discussions were hold with aerospace engineers, and clients.

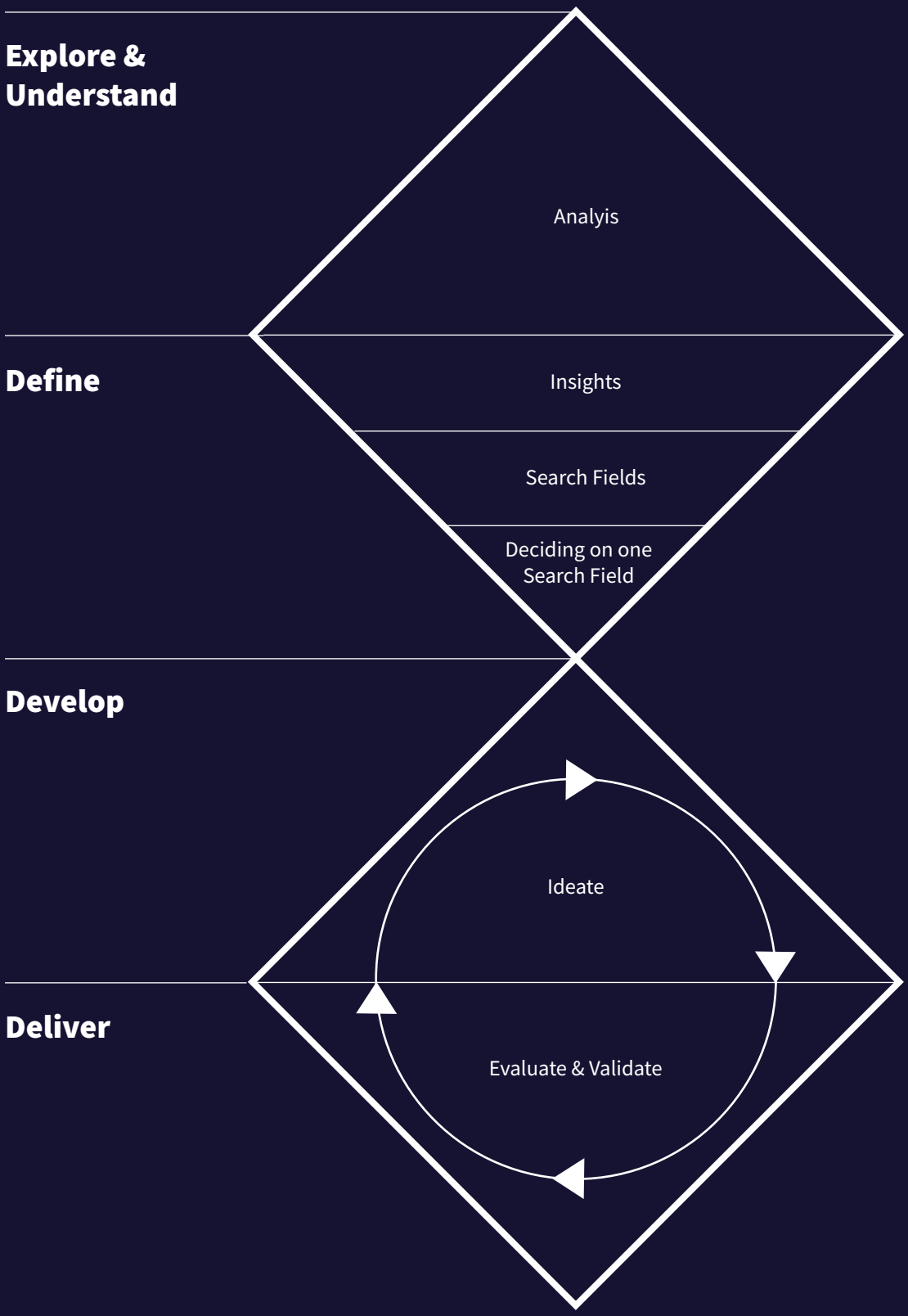


Figure 3: Process structure

2

THE ESSENCE OF SUSTAINABLE MOBILITY

SETTING SUSTAINABILITY CRITERIA

To know how to address a strategy about sustainable mobility the sustainability issues of mobility are defined in this chapter. As the greenhouse gases of mobility are one of the main issues of mobility a technology scouting was conducted to find out more about the feasibility of sustainable fuels that can solve the emission problem.

2.1

What is **Sustainable** Mobility?

DEFINITION & ISSUES OF MOBILITY

Sustainable mobility takes the needs of future generations into account and considers amongst others to sustain environmental, societal, and business development. Mobility currently is not necessarily sustainable and has several issues that this subchapter explains.

METHOD

In order to approach a sustainable concept for Embraer it is necessary to understand what sustainability and in particular sustainable mobility means. Furthermore, it is relevant to be aware of aspects that make mobility currently unsustainable. This way sustainability issues can be easier addressed later in a concept.
For capturing the concept of sustainable mobility and understanding sustainability issues of mobility, the following research questions were phrased:
What is sustainable mobility?
What are problems of mobility in terms of sustainability?
To answer the research questions a literature review was conducted.

DEFINING SUSTAINABLE MOBILITY

The term 'sustainability' can often be really ambiguous (Stirling, 2009). Considering that there are approximately 300 definitions of sustainability (Johnston et al., 2007) makes grasping the true meaning of the term difficult. However, one of the most accepted definitions of sustainable development was made by the Brundtland Commission of the United Nations in 1987, saying "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. ". Instead of referring to needs, the University of Alberta (2010) referred to "physical, natural and social resources" that need to be sustained. Whereas Robinson (2004) includes in the description of sustainability that it is about the "relationship between humanity and nature".
Another concept often mentioned while defining sustainability is the concept of the triple bottom line created by Elkington in 1997. In his framework Elkington approaches sustainability of businesses including three key dimensions that need to be considered: people, planet, and profit, including with these terms social, environmental, and the economic sustainability of a business. In 2016 Geißdörfer et al. defined sustainability based on the concept of Elkington adding the relevance to sustain not only intergenerational like mentioned in the definition of the Brundtland Commission, but also intragenerational.

Defining the term mobility the Cambridge (2014) and Oxford (2019) dictionary, define both mobility by actively moving or passively being moved easily. In this thesis the focus lays in particular from moving from one spot to another.

Sustainable mobility considers societal and environmental health, and is based on a renewable system.

Besides, several definitions of the combination of both terms meaning 'sustainable mobility' or 'sustainable transportation' were made in literature.
In 2007, Woodcock et al. referred in terms of sustainable mobility in particular to the health of living beings and claims a purified and healthy environment. An earlier definition by an OECD (1996) project

also points out that sustainable mobility should no affect societal or environmental health and be based on a renewable system. One of the most accepted definitions of sustainable mobility origins from the council of the EU (2001). According to the council sustainable mobility "Allows the basic access and development needs of individuals, companies and societies to be
met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations; Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development; Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable". Reflecting on the different definitions of sustainable mobility it becomes noticeable that the definitions often focus about harmful effects and problems of mobility on humans and environment that need to be avoided. With the following section the thesis will concentrate on the harmful effects of mobility to find out factors that can be addressed to achieve sustainability in transport.

ISSUES OF MOBILITY

Through the literature review several problems and issues of mobility could be identified. Some of the mentioned problems are more severe than others. The most striking problems, which were noticeable through its emphasis in literature and the amount of times they were mentioned, were 'climate change' and 'air pollution', which are correlated to each other.
The different types of problems are listed below.

Climate Change
(Gössling et al., 2018; Barr, & Prillwitz, 2012; Woodcock et al., 2007; Peeters, 2017)
Climate change is one of the most mentioned negative impacts of mobility. Gössling et al. (2018) even states that acting against climate change is a "non-negotiable, central condition of a desirable transport future", other types of problems caused by transportation would rather be secondary. Greenhouse gas emissions cause climate change. In fact, according to the European Environment Agency (2018) 27% of greenhouse gases are from the transport sector, primarily from fossil fuels, and there is trend of an increasement of emissions. In comparison to 1990 greenhouse gas emissions from aviation rose by +114% in 2015, from shipping by +33%, and from road transport by +22%. Currently, road transport is responsible for 72,1% of emissions from transport, the maritime sector contributes with 13.6% to the emissions, and aviation with 13.3%, the remaining 1% is caused by railways, and other forms of transport.

Sustainable mobility should limit greenhouse gases due to its effects on climate change.

Air Pollution
(Gössling et al., 2018; Gabrielli et al., 2014; Banister, 2008; Woodcock et al., 2007; Chan et al., 2009)
The earlier mentioned greenhouse gases, mainly resulting from fossil fuels, are the reason for air pollution. While various sectors already could reduce their emissions, the transport sector can not claim the same (European Commission, n.d.). There is even the risk of a permanent grey sky, when fossil fuels are continued to be used (Chan et al., 2009). The increasing global warming might even worsen the situation of air pollution (Patz, & Kovats, 2002). However, the most dangerous effects of air pollution are on health. The gases cause "asthma, bronchitis, leukaemia, and lung disease" (Banister 2008), also, allergies, cancer, cardiovascular diseases, which can cause premature deaths (O'Neill MS, 2005). Tens of thousand of deaths are associated in fact with emissions from the transport sector (Lipfert, 2004).

Environmental Issues
(Gössling et al., 2018)
Environmental issues are standing in relation to air pollution and climate change, that cause this type of problem. Emissions don't only harm the health of humans, but also of the environment and all living beings.

Noise
(Gössling et al., 2018; Hoogma et al., 2005; Woodcock et al., 2007).
Especially, residents living nearby roads or airports are affected by the problem of noise. Noise is related to diseases caused by stress (Gössling et al., 2018).

Safety & Security
(Gössling et al., 2018; Budd, Griggs, & Howarth, 2013)
Accidents, or intentional acts like terrorism can cause injuries and death.

Congestion
(Gössling et al., 2018)
Congestions are related to safety issues, and lead to inefficient usage of fuel that result in higher air pollution. Furthermore, there is a higher risk to be exposed to air pollution in traffic jams.

Physical Inactivity
(Pucher, & Dijkstra, 2003; Woodcock et al., 2007)
According to literature passive forms of transportation support physical inactivity, and therefore is also a factor contributing to obesity.

Unsustainable Resource Usage
(Gössling et al. 2018)
While it is often common for products to look at the sustainability of materials, production methods, energy used for the production, maintenance (Vogtländer, 2017), it becomes significant that this is only a minor concern in the mobility sector. More significance is attributed to air pollution and climate change.

Social Inequality
(Budd, Griggs, & Howarth, 2013; Woodcock et al., 2007)
Passive forms of mobility are often only used by the most wealthy part of the world, while for the majority of the population several forms of transportation, especially flying, is not accessible. Nevertheless, although a great amount of the population does not contribute to the problems

GOOD TO KNOW

Imagine you would invite 10 people and this is the portion you would serve to each of them. The portion is equivalent to the amount of CO2 emissions emited by the population. While the most rich 10% emit 49%, the most poor 10% emit 1%. Mobility is also only financially accessible to a limited amount of people, who are mostly responsible for the CO2 emissions.

Figure 3: Illustration shows how much different population parts are resposinsible for CO2 emissions. Each plate stands for the amount of CO2 emissions of 10% of the population, beginning with the richest 10% (left) and ending with the poorest 10% (right). (Oxfam, 2015)

of transportation they experience their negative effects.

Land Usage
(Köhler et al., 2009; Hoogma et al., 2005)
Great amounts of land is used for the infrastructure of mobility, which is criticized by literature.

Spread of diseases
(Hufnagel, Brockmann, & Geisel, 2004)
In particular aviation, contributes to the spread of diseases through mobility between different countries and continents.

LIMITATIONS OF THE RESEARCH

Although various papers were used for the literature review there might still be other issues that can be addressed for a sustainable mobility concept. Having the example of food consumption in airplanes one might come up for example with improving the packaging waste.

CONCLUSION

The main focus of a sustainable transport strategy should focus on the core issue to prevent air pollution and resulting climate changing effects of air pollution. Other issues are rather secondary, but also should be addressed as much as possible. As over time developments might change further sustainability issues might arise. Also, the main problem of air pollution might be solved in some decades and other mobility issues might get more relevant.

Figure 4: Issues of sustainability found out through the literature review.

2.2

Sustainable Fuels

TECHNOLOGY SCOUTING

In the previous literature research the core issue of air pollution and its effect on climate change was found out as an issue of mobility.
Fossil fuels are the main cause for air pollution. Köhler et al. (2009) even argue that "our world would come to a standstill" if fossil fuels are continuously used. Therefore, several types of alternative fuels were scouted to find out advantages and disadvantages of the different types of alternative fuels and its possible application for different types of transport.
For finding out more about sustainable fuels a literature review was conducted and information from the expert interviews was extracted. To get a focus the three most relevant sustainable fuels especially for the aviation industry, but also in general for the transportation sector, mentioned during the expert interviews were examined more closely. The most relevant sustainable fuels are biofuels, electric and hydrogen propulsion.
The following questions help as a guideline for the research:
What kind of sustainable fuels exist?
What are the advantages and disadvantages for the type of this type of fuel?

BIOFUELS

Biofuels are plant based and are often blended with gasoline or diesel. There are different types of biofuel, e.g. bioethanol, which is based on sugar cane, corn, wheat and sugar beets or biodiesel, which comes from vegetable oils, rapeseed, soybean and palm (BusinessEurope, 2018). Currently the most used biofuel is biodiesel with approximately 66%, bioethanol is the second most common form of biofuel (Raboni, Viotti, & Capodaglio, 2015). According to Raboni, Viotti, & Capodaglio (2015) biofuels still contribute to emissions, but can reduce emissions ranging from 40.1% - 84.1%. However, the aviation sector only makes limited use of biofuel at the moment. Boeing for example reduces its emissions with biofuel by 14-30% (Boeing, 2018). Currently, rather reductions of 40% are possible, reductions of 80% will rather be possible towards 2050 (BusinessEurope, 2018). In road transportation biofuel makes 3.3% of all fuels (Raboni, Viotti, & Capodaglio, 2015).

Emission reductions of 40% are possible now. In 2050 reductions of 80% can be achieved.

Advantages of biofuel
Biofuel is already used in the transportation sector, especially in aviation, and doesn't require a change of infrastructure in comparison to other types of alternative fuels (Köhler et al., 2009). Also,

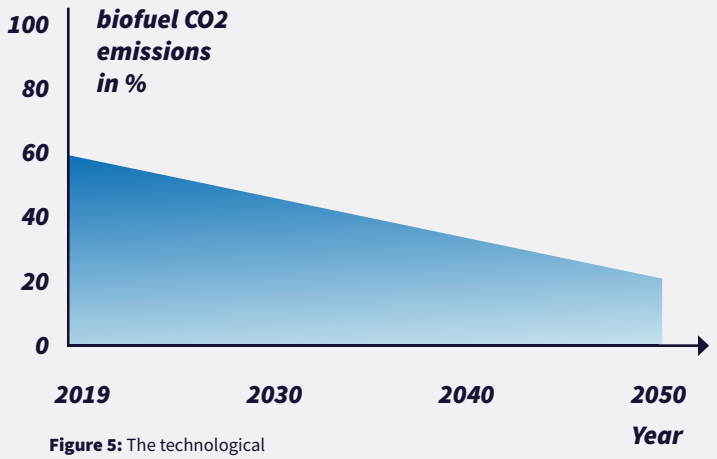


Figure 5: The technological advancement of biofuels and its emissions on a timeline.

there would be enough land to produce biofuel for projected aviation growth (Gössling & Upham, 2009). Especially, subsidies and CO2 penalties by the government as well as a rise of oil prices might benefit the growth of biofuel (Klein-Marcuschamer et al. 2013). In fact, it has a chance to take over fossil fuels completely.

Disadvantages of biofuel
Due to a better market competitiveness of fossil fuels and current energy policies, biofuels are only used limitededly in the aviation industry (BusinessEurope, 2018). Biofuel seems to be one of the best alternatives for sustainable fuels at the moment and will definitely contribute to reduce aviation emissions. However, biofuels won't achieve zero emissions and will still pollute the air and environment. Therefore, Klein-Marcuschamer et al. (2013) argue that biofuels won't be the ultimate and only solution against air pollution, although they might play a role in reducing emissions. Also, the United Nations Energy Committee (2007) argues that biofuels should rather be used for heat and power, than for mobility purposes. Furthermore, Busse, Brümmer, & Ihle (2010) examined the correlation between biofuel and food prices and found out that the alternative fuel rises prices of rapeseed oil, and soy oil. These rises in price are criticized by Raboni, Viotti, & Capodaglio (2015), who point out the particular negative impact on the population at the bottom of the pyramid, and possible difficulties of accessibility of food due to biofuel production.

ELECTRICITY

To be sustainable electric energy should preferably come from renewable sources e.g. such as wind and solar energy. Especially, the source of nuclear energy is highly discussed as Bickerstaff et al. (2008) indicate. While nuclear energy has issues of harmful radioactive waste (Woodcock, 2007), it still could support a change towards a low emission future (Chu & Majumdar, 2012). In fact, transportation fueled by electricity has local zero emissions (Köhler, et al, 2009). However, also hybrid electric vehicles are possible, which reduce emissions.

Advantages of electricity
Electric powered transportation is one option for zero-emission-mobility, that also doesn't rely on oil (Köhler et al., 2009), and is probably the best option for achieving sustainability in the next few years. On long-term other sustainable fuel options probably will rise (Köhler et al, 2009). According to Paul Peeters (2019) trains are one of the most sustainable way of transportation and is fueled in the Netherlands by electric wind energy. In Europe, the amount of electricity fueled trains is 60% (BusinessEurope, 2018). Furthermore, an advantage of trains is the already existing infrastructure. Therefore, trains will play a significant role in sustainable transportation in the next decades (Köhler et al., 2009). In aviation electrical vertical take-offs (eVTOLs) will influence the aviation industry. EVTOLs are already working and were tested amongst others by NASA (Kivits, Charles, & Ryan, 2010). Kasliwal et al. (2019), point out that eVTOLs will have a small role in a sustainable transportation system. In their study they state that eVTOLs might outperform ICEs and ground vehicles at distances up to 35 km. However, it should be considered that ground vehicles are usually used for distances around 17 km on average (Oak Ridge National Laboratory, 2017).

Disadvantages of electricity
Although electric mobility can contribute to an emission free future Banister (2005) points out the problematic amount of energy consumption and resource use during the products life cycle that should be considered in order to create a true sustainable form of transportation. Current limita-

Electric mobility can achieve zero emissions. However, electric mobility is limited by the battery capacity and the resources.

tions of electric vehicles are for example relatively high purchase costs, charging issues (infrastructure and the capacity of the
battery), and warranty issues (Chan et al., 2009). The experts Jaap Vleugel and Paul Peeters (2019) especially point out the issues of the battery. Batteries are currently produced from really scarce material. Turning the whole transportation sector electric could reallocate problems from air pollution to scarcity of resources. Especially Paul Peeters (2019) sees the problem of the batteries needing a lot of space in the aircraft and not being leight-weighted, which can be a problem for electric aircraft. Due to the battery capacity electric planes or VTOLs can only have a limited amount of passengers and a limited flight range. However, over time it can be expected that technology will improve and electric aircraft will be able to transport more passengers on a flight longer range.

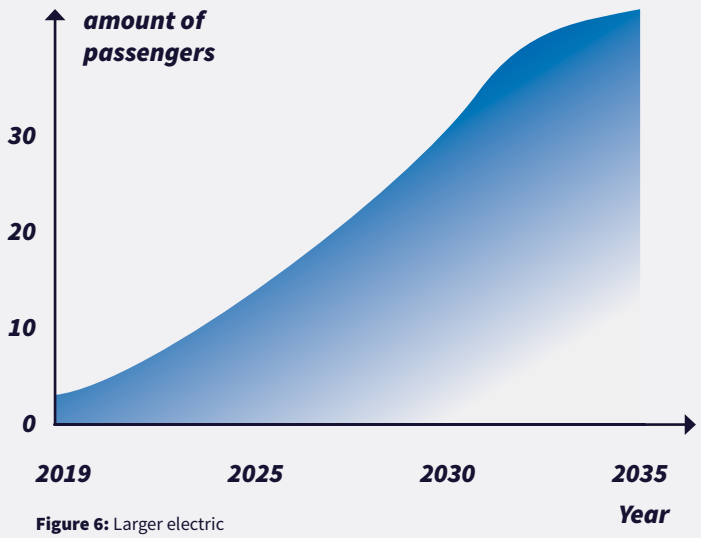


Figure 6: Larger electric aircrafts with more passengers will be feasible over time (NASA/ Misra, 2017)

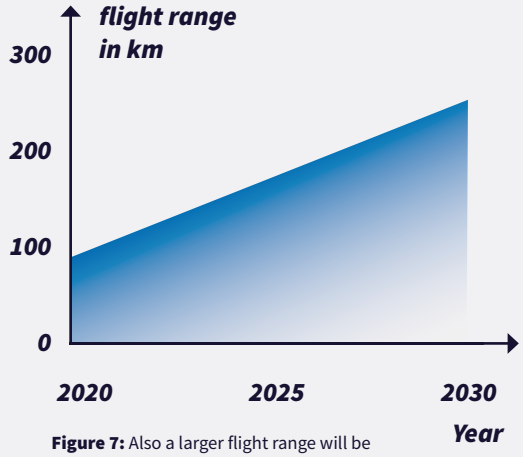


Figure 7: Also a larger flight range will be feasible over the years. The example shows the increasing flight range of a 4 passenger VTOL. (NASA/ Misra, 2017)

GOOD TO KNOW

$6,25 This might be the price for an eVTOL per passenger mile in the future (Booz Allen Hamilton & TSRC, 2018). Converted this would mean 3,49€ per km.

HYDROGEN

Part of a zero emission future will be hydrogen. The fuel can be produced for example from water, biomass, natural gas or coal (Turner, 2004). Hydrogen can also be used for fuel cells, which convert the energy into electricity for the propulsion system (Extern, 2006). Therefore, when talking about fuel cells powered through hydrogen electric propulsion is meant. In contrast, when talking about electricity as a fuel considering advantages and disadvantages previously, electricity powered through batteries was meant.

Advantages of hydrogen
Hydrogen is one of the most widely available resources in the universe (Campen, Mondal, & Wiltowski, 2008), and even seen by scientist as some kind of ideal and desirable fuel (Balat, 2008; Agarwal, 2012). The fuel does not harm the environment, and is also easily usable during changes of temperature e.g. in winter (Ma, et al., 2003). Further advantages of hydrogen are its lightweight, and its energy-efficiency in comparison to fossil fuels (Balat, 2008) and electricity. Because of its lightweight attribute hydrogen fueled vehicles can reach longer distances than battery electricity or kerosene (Verstraete, 2013) and can be easily stored inside an aircraft. Furthermore, it is possible to refuel hydrogen vehicles quickly (Gim & Yoon, 2012).
Dependent on the technological development an aircraft for 30 passengers can already be feasible for 30 passengers in 2035 according to the expert Paul Peeters (2019). In the future hydrogen airplanes even with 800 passengers are expected (Carrington, 2015). Although hydrogen is currently more expensive than kerosene, it is expected that hydrogen will be cheaper in the future than kerosene (Khandelwal et al., 2013).

Disadvantages of hydrogen
Due to relatively high manufacturing costs of hydrogen it is unlikely that hydrogen aircraft will be introduced before 2030 (Köhler, et al., 2009) although the technology already will be feasible at this point. Hydrogen and its possible applications and introductions in the transportation industry can be seen in figure 8.

DISCUSSION AND CONCLUSION

Different types of fuels were discussed. While all different types of fuels can be applied at various modes of transport, about the alternative fuel usage of the aviation industry the following can be said:
Biofuels reduce emissions and can be applied at large airplanes. Electric fuels have due to the battery capacity a limited flight range and are over the years rather be applicable for smaller aircraft. Hydrogen is seen as an ideal fuel for the future of aviation. Through its lightweight and can be well stored. The first hydrogen aircraft could already be introduced in the next years. However, due to the competition with kerosene hydrogen airplanes might only be introduced later according to the expert Paul Peeters (2019). While in 2035 a hydrogen airplane of 30 passengers will be feasible, in the future a hydrogen airplane of more passengers will be possible. Comparing to electric aircraft, electric aircraft will rather be limited in the flight range and amount of passengers.
While aviation still has issues with sustainable fuels also due to the infrastructure that would be needed to be established and the technological development of the different kinds of fuels, there are also sustainable forms of mobility, which don't have these issues: trains and busses fuelled by sustainable energy.
Figure 5, 6, 7, and 8 estimate the technological development of the different kind of fuels. During the validation of the project it was found out that the expert Paul Peeters (2019) doubted the introduction of a full electric aircraft in 2030 as can be seen in figure 6. The data of the figures were retrieved from reliable sources amongst others like Nasa for example. However, for confirmation more experts should be asked about the estimated introduction date of the various types of fuels.

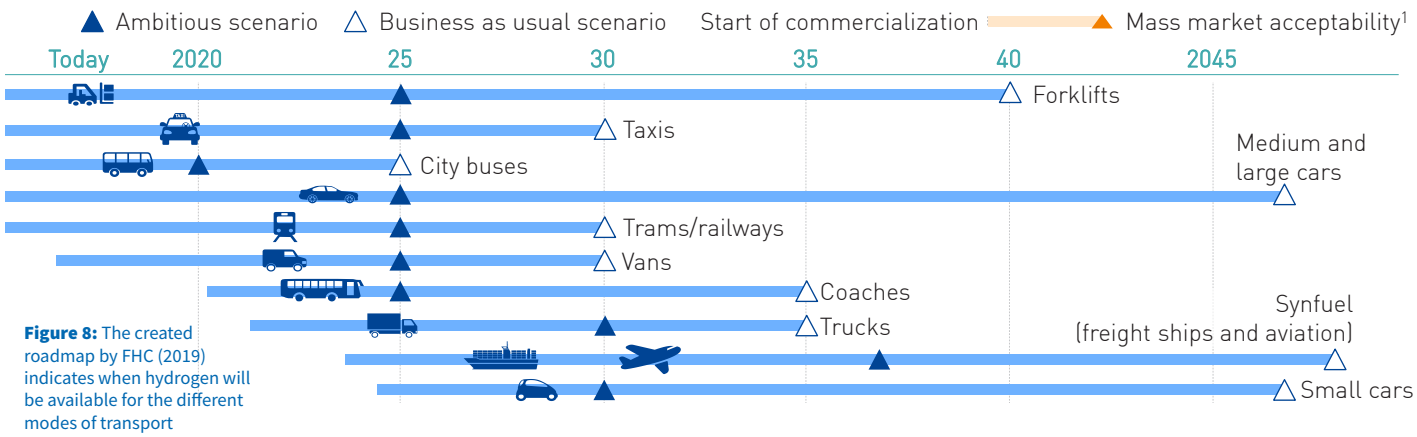


Figure 8: The created roadmap by FHC (2019) indicates when hydrogen will be available for the different modes of transport

Key Insights

THE ESSENCE OF SUSTAINABLE MOBILITY

DEFINITION OF SUSTAINABLE MOBILITY

Sustainable mobility considers societal and environmental health, e.g. by limiting emissions, and waste or using renewable resources. It is safe, created fairly, and efficient on resources and emissions.
While being limited on resource consumption and emissions, sustainable mobility should also still allow accessibility and development.

KEY ISSUES OF MOBILITY

For several reasons mobility is often not sustainable. A concept of sustainable mobility should focus on the core issue to tackle the problem of air pollution. Other problems are secondary, but should also be considered. Further issues are for example: environmental issues, noise, safety & security, congestion, physical inactivity, unsustainable resource usage, land usage, social inequality, or spread of diseases.

SUSTAINABLE FUELS

Biofuels can reduce emissions of aircrafts by 40% now and probably by 80% in 2050. This type of fuel is especially useful for large airplanes, but is often not applied due to economic competitive reasons.

Electricity can achieve zero emissions, and is especially an opportunity for smaller aircrafts/ eVTOLs. Due to issues with the battery it is not applied for large airplanes. Small electrical airplanes are already flying, and might get bigger in the future with coming technical improvement in the battery capacity.

Also, hydrogen is part of a zero emission future and is considered by some experts as an ideal sustainable fuel. However, also here a lot of technical improvements need to be done. While it is realistic to create small hydrogen airplanes now, the first commercial 30-seater airplane will be possible in 2035, and a higher amount of passengers will be feasible in the future.

Sustainable fuels in aviation are partly already existing and can be applied now (e.g. biofuels), but also still need to be developed and made commercially (biofuels, electricity, hydrogen). Applying sustainable fuels now is currently easier with other forms of transportation such as trains or busses.

The next chapter will introduce insights about Embraer. In chapter 4, more about stakeholders in the aviation industry can be found out and the current application of for example biofuels in the industry.

3

ABOUT EMBRAER

A STRONG BRAZILIAN EXPORTER

In this chapter the history of Embraer is described as well as current market areas and developments of the company to introduce general information about Embraer. The brand identity of Embraer and its innovation subsidy EmbraerX can be retrieved in this chapter to adapt the final innovation strategy also to Embraers brand. Additionally, strengths and weaknesses of Embraer were found out. Strengths can be used to support a strategy, weaknesses should be either avoided in a strategy, or strengthened.

3.1

Embraer
Then & Now

ACHIEVEMENTS & PITFALLS

Embraer has its roots in the Brazilian government. Currently, the aircraft manufacturer produces commercial, executive, and defense and security aircrafts. Through EmbraerX Embraer sparks innovation, this is done especially at the moment through an eVTOL.
The current joint venture of Embraer with Boeing can mean new opportunities, but also new threats to keep being relevant as an aircraft manufacturer.

EMBRAERS HISTORY - A GOVERNMENTAL COMPANY

Embraer was founded in 1969 by the Brazilian government in order to support the military through the supply of manufactured aircrafts. In its early years the company was named Empresa Brasileira de Aeronautica SA and had its headquarter since the beginning in Sao José dos Campos. Due to Embraers Brazilian heritage the company first focussed mainly on the Brazilian and Latin American market. Deeply connected with the Brazilian government, the government owned 51% of the companies voting share.
While first only focussed on military aircrafts Embraer changed its strategy during the mid 90s and expanded to commercial aircrafts and executive jets. During the early 90s Embraer was facing first several issues due to bankruptcy, which resulted in a privatization enacted by the Brazilian government in order to save the company. During the years the company recovered and became in 1998 Brazilians 2nd largest exporter and the 4th largest aircraft manufacturer worldwide.

Today the company mainly operates in commercial aviation, defense & security, and executive jets. Besides, Embraer also manufactures aircrafts that apply for example pesticides for the agricultural sector. For all operational areas service and support is provided, e.g. amongst others maintenance on aircrafts or modification wishes.

EMBRAERX - SPARKING INNOVATION

EmbraerX is the sparking innovation department within Embraer. The department exists since 2017 and is leaded by its president Antonio Campello in Silicon Valley. Through disruptive innovation and a human-centered design approach EmbraerX aims to enhance people‘s lives.
In May 2018 EmbraerX released in collaboration with Uber a concept of an electrical vertical take-off for ride sharing in urban areas that is safe, and quiet (see figure 9). The first passenger test of the eVTOL is set for 2020. In 2023 the collaborational partners hope to get the certificate for the electric aircraft. Throughout the years the eVTOL will become more and more autonomous. Furthermore, EmbraerX initiated a business platform called Beacon to engage stakeholders in the aviation industry to foster innovation.

Interested in Embraers eVTOL? Scan The QR code. :)

Figure 9: Embraers concept of an eVTOL. (Cook, 2019)

101 **Commercial Aviation**

109 **Executive Jets**

Figure 10: Aircraft deliveries of Embraer in 2017

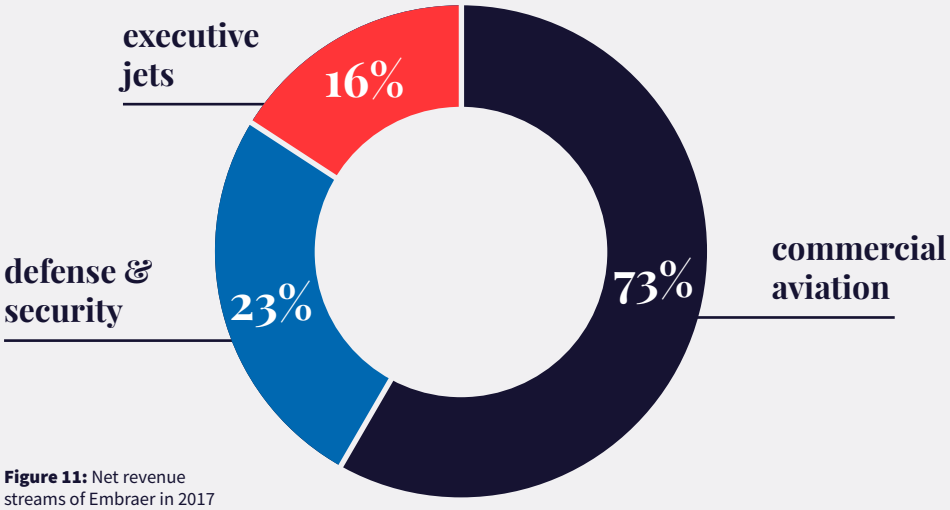


Figure 11: Net revenue streams of Embraer in 2017

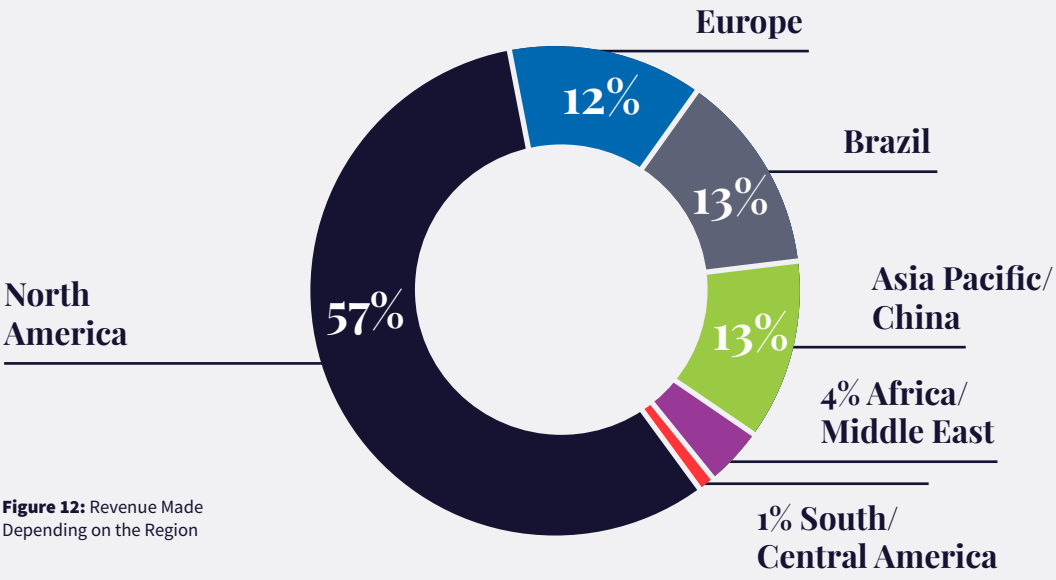


Figure 12: Revenue Made Depending on the Region

COMPETITOR OR ALLY? - JOINT VENTURE BOEING & EMBRAER

After Airbus bought a part of Bombardier in 2018, Embraer was set under the pressure of a highly competitive environment with Bombardier in the field of commercial aviation. Facing Airbus as a strong competitor led to a strategic partnership with Boeing. The joint venture with Boeing includes Embraers sector of commercial aircrafts and services (80% belonging to Boeing and 20% to Embraer), and Embraers military aircraft KC-390 (49% Boeing, and 51% Embraer).

While Boeing paid Embraer $4.2 billion for this partnership, Embraer does not expect to make revenue from commercial aviation during the next 5 years, which used to be the main revenue stream of the company. This means a high uncertainty for Embraer during the next years. Getting no additional revenue from commercial aviation during the next years, means for Embraer that the company needs to explore further opportunities. These opportunities can also be supported through the help of the joint venture. First, in terms that the capital that Boeing paid can be used for strengthening sectors like executive and agricultural aviation, or defense & security. However, there is also an opportunity to explore new market and revenue streams. Having a bigger product portfolio can mean for example distributing risks, in case one stream might face problems.
While the joint venture can mean an opportunity for Embraer to get support to explore further markets, Embraer should mainly focus to create its own revenue stream. Being too dependent on Boeing in the future could mean getting overtaken by Boeing.

3.2

Father & Son

BRAND IDENTITY EMBRAER & EMBRAER X

In order to create a strategy for Embraer it is essential to understand the companies brand to know how the company sees itself, and how it wants to act. Therefore, the brand of Embraer, and EmbraerX were analyzed and compared. For capturing the brand identity it was made use of the strategic brand triangle considering the purpose, positioning, and personality of the brands. Figure 13 illustrates the brand triangle of Embraer and EmbraerX.

PURPOSE

Embraer states that the company is mainly focussed to reduce "distances between people". While EmbraerX concentrates more on the purpose of "transforming businesses" and solving the most relevant issues of humanity to "empower people".

POSITIONING

The Brazilian aircraft manufacturer makes a clear statement and aims to be "one of the leading forces in the global aerospace and defense and security industries", and strives for "excellence". Also EmbraerX aims for a leading position, but adds additionally its ambition for "disruptive innovation, autonomy, and urban mobility". The subsidy wants to design for "everybody" and shows a connection to everyday people. In contrast Embraer also has exclusive target groups, e.g. in the segment of executive jets. Besides, EmbraerX values collaboration and "co-creation".

PERSONALITY

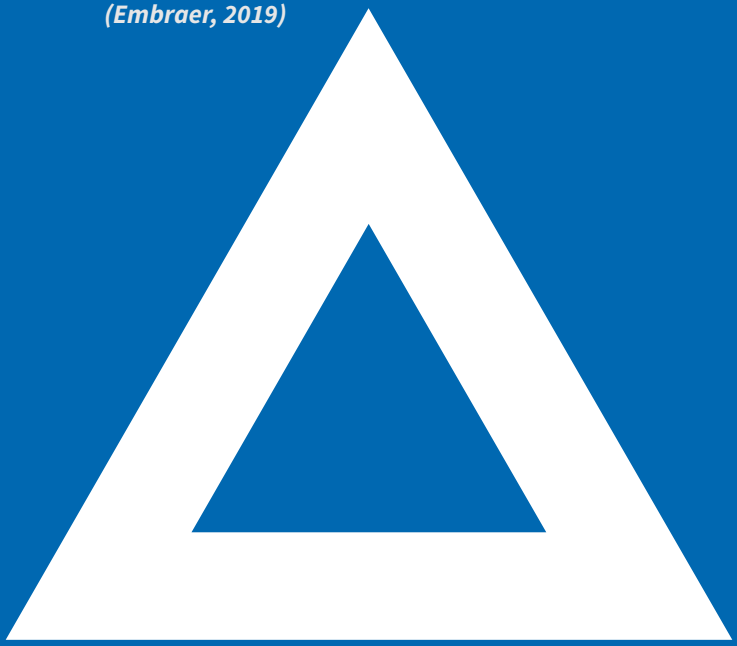
The brand personality considers how the brand acts and was analyzed in respect to the brand dimensions of Aaker (1997), and the brand archetypes of Jung (1938).
Embraer presenting itself prominent in terms of competence and reliability can be derived from the leading position it wants to take and its ambition for excellence. It underlines its reliability through videos of renowned clients, in particular in the field of executive aviation, that reason their choice for Embraer.
Furthermore, the company wants to excel through leading technology, and especially through EmbraerX as a "disruptive innovator".
Looking at Jung's archetypes another really essential factor of Embraers brand can be revealed: Embraer as a caregiver. The aircraft manufacturer clearly states its commitment to sustainability, including social and environmental sustainability. and wants to contribute in "enhancing everyone's lives" as especially EmbraerX mentions. Designing an innovative strategy in which 'sustainability' takes a leading role can strengthen Embraers societal caring personality. EmbraerX supports the core values of Embraer, but goes further in its personality. The market accelerator shows itself with a startup mentality and can be positioned according to Aaker's brand dimensions as an exciting brand.
Taking Jung's archetypes into account EmbraerX also can be seen as a creator that revolutionizes, disrupts, and is deeply connected to everyday people. Furthermore, Embraer points out its Brazilian heritage, while EmbraerX rather stresses its internationality.

While Embraer has a more calm personality, EmbraerX appears to be more young and works as a disruptive innovator within Embraer.

PURPOSE

„Reducing distances between people“ (Embraer, 2019)

„Empowering people, transforming business“ (Embraer, 2019)



POSITIONING

„Embraer will further consolidate its position as one of the leading forces in the global aerospace and defense and security industries. Embraer is a market leader in the segments in which it operates and commands a reputation for excellence.“ (Embraer, 2019)

EmbraerX aims for a leading position and has an ambition for disruptive innovation, autonomy, and urban mobility. Embraer X has a conncetion to everyday people and values collaboration and co-creation.

PERSONALITY

competent, reliable, caregiver, based on Brazilian heritage

competent, reliable, caregiver, disruptive innovator, market accelerator with a startup mentality, exciting, creator, international

Figure 13: Brand triangle of Embraer and EmbraerX. The dark text stands for the brand triangle of Embraer, and the white text indicates the one from EmbraerX.

3.3

Unique Characteristics & **Improvable** Elements

OF EMBRAER

Several strengths and weaknesses of Embraer were found out. While Embraer has a strength in the field of commercial aviation, the company needs to catch up with innovation projects.

Unique characteristics and improvable elements of Embraer were extracted during the company analysis. The elements also stand in comparison to Embraers competitors, which will be discussed in another chapter. Strategies generally should be build on the companies strengths. However, a strategy can also be about establishing new strengths and unique elements of the company.
Weaknesses of the company can be avoided for creating a strategy or even strengthened. While Embraers competitors released more innovative concepts, Embraer can catch up with this during the coming years. Furthermore, it was mentioned that Embraer used to be strong in commercial aviation. The past tense was used because of the changes in the area that the joint venture with Boeing might cause.
To have a better and quicker overview of the strengths and weaknesses of Embraer bullets points were written.

STRENGTHS & UNIQUE CHARACTERISTICS

- Brazilian heritage and connection to the Brazilian government
- Used to be the third largest aircraft manufacturer for commercial aviation
- Used to be market leader in commercial aviation up to 150 seats, in particular E175 to 195
- Especially a strong market of commercial aviation in the US
- KLM is the strongest user of Embraer airplanes in Europe
- Embraer has less suppliers to choose from than Boeing or Airbus. This way the Brazilian aircraft manufacturer eases the process and can produce faster and cheaper than Airbus or Boeing.
- Joint venture with Boeing
- High satisfaction of customer experience of product and services of executive jets
- Understanding and managing complex systems with different stakeholders (aircraft parts, suppliers)

WEAKNESSES

- Rather small in comparison to Boeing and Airbus
- Difficulties in the executive jets market (market is stagnating/ decreasing)
- Following with similar innovation strategies like competitors (eVTOL)
- Small amount of innovations in comparison to competitors

GOOD TO KNOW

Did you know that Embraers CEO Francisco Gomes Neto is also connected to other forms of transportation? Gomes Neto used to be chief executive of the bus manufacturer Marcopolo SA (Mandl, Rochabrun, & Arend Laier). Marcopolo SA already could gain amongst others experience with electric and hydrogen busses (Barrett, 2009).

Key Insights

ABOUT EMBRAER

EMBRAER THEN & NOW

Embraer was founded in 1969 by the Brazilian government for military purposes, and is still connected with the Brazilian government. The company operates in commercial aviation, defense & security, executive jets, and offers additional services and support. EmbraerX is the innovation subsidy of Embraer since 2017 and released a concept of an eVTOL in 2018. Currently changes are going on inside the company due to the joint venture with Boeing. The two company collaborate in the field of commercial aviation. Embraer got paid $4.2 billion and won't make revenue from commercial aviation during the coming 5 years. 80% of the joint venture belong to Boeing, while 20% belong to Embraer.

FATHER & SON

The core brand characteristics of Embraer are its aim for a leadership position, and the company showing reliability and caring elements. Embraer brands itself caring about people and the environment. The main goal of the company is to bring people closer to each other. EmbraerX has the same core elements like Embraer, but points out more its young startup characteristics, internationality, and its connection to people, e.g. through a human-centered design approach. The innovation subsidy is an innovative disruptor that strives for changes to improve people's lives.

UNIQUE CHARACTERISTICS & IMPROVABLE ELEMENTS

Embraer was especially really strong in the field of commercial aviation. In this field Embraer had its strongest markets in the US. In Europe KLM is the strongest user of Embraer aircrafts. The strength of Embraer in the sector of commercial aviation is now unsure due to the joint venture with Boeing.

There is potential to strengthen Embraer's innovation abilities. Weaknesses of Embraer are in the field of executive jets, and Embraer is rather small in comparison to Boeing and Airbus. Furthermore, interestingly Embraers CEO is a former chief executive from the bus manufacturer Marcopolo SA, a company that already looked into the development of hydrogen and electric vehicles.

The next chapter is about the stakeholders in the aviation industry, to see in which context Embraer is surrounded. Also, it becomes more clear how many innovation projects Embraer has in comparison to its competitors.

1

STAKEHOLDERS IN AVIATION & INNOVATION

WHY IT IS DIFFICULT TO BE COMPLETELY SUSTAINABLE IN THE AVIATION INDUSTRY

In this chapters the different stakeholders around Embraer are mapped to understand the situation in the aviation sector in a better way. Stakeholders, who could help in a sustainable development are mentioned as well as current barriers of a sustainable development.
Furthermore, the sustainability and innovation strategy of Embraers competitors are described to get an overview of current market innovations and to be able to create a differentiation strategy for Embraer.

4.1

General
Stakeholders
& VALUE FLOW

Sustainable development in the aviation industry is not always easy. Depending on low prices due to consumers, companies create and use rather unsustainable forms of transportation. However, stakeholders often do have an open mindset about sustainable development. Governmental institutions could make a big contribution to support the aviation industry to enable a sustainable mobility future.

The stakeholder analysis was done in combination with a value mapping. Mapping the current stakeholders provides an overview about the stakeholders of Embraer. It is important to know about the stakeholder needs and the value flow to identify potential value gaps, unmet needs, and opportunity areas. A visual overview of all stakeholders can be found in figure 14. In the following text stakeholders are listed and described:

AIRLINES

Stakeholder need: The needs of and additional information about commercial airlines are derived from the anonymous expert interview (2019). Main concerns of commercial airlines are to make profit through creating a value to its customers: passengers of aircraft. Sustainability is considered in the operation of the airlines. However, the aspect of sustainability is rather a side criteria and criteria like creating comfort for customers or offering low prices are considered as more important to the airlines. Offering low prices is one aspect of staying competitive on the market. Currently, sustainable fuels are more expensive than kerosene and hinder offering low prices. Because kerosene makes ⅓ of the flight prices it seems relevant to the airlines to reduce kerosene consumption. This is for example done through weight reduction of aircrafts. Furthermore, ticket prices are kept low by a high passenger density in aircrafts to reduce the cost per unit. Although sustainable fuels like biofuels are only barely used at the moment the aviation set a goal to introduce biofuels step by step in the future (ICAO, 2016).
Considering the current growth of air travel the goal of airlines is to transport as much people as possible.
Value for Embraer: Embraer used to make most of its revenue through selling commercial aircraft. In the next five years Embraer doesn't expect to make revenue form that stream due to the joint venture with Boeing. However, Embraer is still allowed to produce commercial aircraft up to 50 seats.
Value given by Embraer: The Brazilian manufacturer produces aircraft for commercial airlines and creates value to the end-consumer of airlines, e.g. through passenger comfort of seats.

END-CONSUMER AIRLINES

Stakeholder need: During the anonymous expert interview it could be retrieved on which kind of customers commercial airlines focus and which kind of target groups they have.
Business travellers are frequent flyers and therefore important to commercial airlines. A growing part of business travellers are Millennials. Millennials often tend more to have an interest on environmental and societal issues. While they are concerned about sustainability they also like travelling, which often doesn't align with sustainability goals. Apart from business travellers, Millennials also often value having a low price offer for commercial flights.
The aging population values especially the aspect of comfort and is willing to pay more for comfort.
In general, customers value seamless travel expe-

Figure 14: Stakeholder map: In the first circle around Embraer current clients and partners are visible of direct businesses. The second circle shows innovation and further partners of the company. Around are further stakeholder with which Embraer is not directly in touch with, but who are also important to consider like government, society, etc. .

riences.
Value for Embraer: If the end-consumer is satisfied with the Embraer product it has a positive impact on airlines buying aircrafts from Embraer.
Value given by Embraer: The value is given through the manufacturing of the aircraft and considering aspects like comfort or sustainability in the aircraft concept.

SOCIETY

Stakeholder need: The needs of society can be derived from Maslow's hierarchy of needs (1943). Maslow differentiates between three different types of needs. Needs down in the hierarchy need to be fulfilled before one aims for a higher need. Basic needs (physiological and safety needs) are down in the hierarchy, followed by psychological needs (belongingness and love needs), and self-fulfillment needs (self-actualization). Current societal trends and needs can be derived from the 'context/ trend map' in chapter 4.
Value for Embraer: B2B clients and the end-users of Embraer aircraft and services are part of society. Therefore, it is important how society perceives Embraer.
Value given by Embraer: Embraer aims to take care of the environment e.g. through the sustainability committee within the company, creating a zero emission electric VTOL, including biofuel into consideration while building aircraft and further environmental strategies.

GOVERNMENT

Stakeholder need: Through the expert interviews current needs and actions of government and politics could be identified. Politicians regulate the mobility environment. Unsustainable ways of mobility get limited through the government. CO2 penalties on flights exist, but don't have a big impact on the amount of flights according to the expert interview of Paul Peeters. These penalties do rather have an impact on the price of short haul than of long haul flights. Furthermore, the government controls the safety of mobility, aims to reduce noise pollution, and bans high CO2 emitting vehicles in cities. While some politicians are in favour of sustainability others negate climate change. During the context analysis in chapter 5 it was found out that governments supports sustainable forms of transportation with subsidies.
Value for Embraer: The government does not give a direct value to Embraer. But the company should consider the government due to the regulation impact of politics on mobility. A potential direct value could be given through subsidies supporting Embraer in a sustainable development.
Value given by Embraer: Embraer fulfills the mobility need of society through manufacturing aircraft.

BOEING

More information about Boeing can be found in the competitor analysis.

UBER

Stakeholder need: Uber provides different types of mobility services, e.g. ridesharing, bike sharing scheme, or food delivery to satisfy mobility needs of consumers. Currently, Uber partners up with Embraer and further mobility partners to create an eVTOL to shape the future of future urban air travel. The interest of Uber is mainly commercial.
Value for Embraer: Uber buys the eVTOL from Embraer and makes revenue through providing a service.
Value given by Embraer: Embraer manufactures the aircraft and makes profit.

Further stakeholders are innovation partnerships for example with universities and startups, suppliers supplying Embraer with material/ products to manufacture the aircraft, or shareholders. Further collaborations exist for example with the UN Global Compact to reach certain societal and environmental goals. The world and its resources and limitations also needs to be taken into account.

4.2

The **Competitive** Field of **Innovation**

CREATING A DIFFRENTIATING STRATEGY

To cover sustainability companies often try to create more eco-efficient airplanes. Further concepts are in development e.g. electric aircraft or are a vision of a potential future in the next 50 to 100 years such as train planes.

When looking at the competitive environment it often is common to differentiate between product form, product category, generic, and budget competition. In case a new direction is determined there is no concrete product to compare with. However, still it is interesting to look at the competitive environment, and in particular the most direct competitors offering similar products like Embraer.
For the competitor analysis it was looked into
what the competitor offers,
how the competitor differentiates itself in terms of its sustainability and innovation strategy, and
in general what kind of sustainable strategies are followed.
This way information could be derived about what kind of products an aircraft manufacturer is able to produce, to get inspiration about interesting innovative directions, how it is possible to deal with the topic of sustainability, and learn what the competitors are doing to create a strategy for differentiation.
Further developments in the mobility industry were covered through the trend and context analysis.

BOEING - COMPETITOR & ALLY

The company currently operates amongst others in the area of commercial aviation, defense, and space operations. Sean Newsum, director of commercial airplanes environmental strategy, sees Boeing as one of the leader of sustainable aviation. Currently, Boeing aircrafts focus on eco-efficiency by reducing weight of aircrafts and using biofuels. In Boeing's 'Environment Report Executive Summary from 2015 the company pointed out a 14-30% CO_2 reduction of their current aircrafts. Furthermore, Boeing researches into electric, solar, and fuel cell power and also looks into recycling of materials. Interestingly, Boeing even states on their website the possibility to avoid travel e.g. by using video calls or virtual reality as an employee as an alternative to travel.
With Aurora Flight Sciences, a Boeing company,

Figure 15: Collaborational project of Airbus, Rolls-Royce, and Siemens about creating a hybrid-electric commercial aircraft (Caujolle, 2017)

Figure 16: Bionic 3D printed airplane structure by Airbus (Kunze, 2015)

Boeing looks into several types of innovation, e.g. an eVTOL, the automated remote controlled aircraft centaur, or aircrafts manufactured through additive manufacturing.

AIRBUS

Airbus is mainly active in the fields of commercial aircrafts, helicopters, defense, and space. Also, Airbus concentrates on eco-efficiency with its vision: "Develop collaborative frameworks with airlines to establish the best eco-efficient solutions." Here, the company looks into efficiency of alternative fuels such as biofuels, and reduces materials and waste. Electric fueled aircrafts are examined by Airbus. However, only smaller aircrafts are currently able to fly. Also, eVTOLs (electric vertical take-offs) are developed by the company. While Embraer currently still is in the development phase of its eVTOL, Airbus already hopes to fly its first eVTOL this year (Chuanren, 2019). Furthermore, Airbus has innovation concepts of a hydrogen airplane or a futuristic bionic structured aircraft (figure 16) to reduce weight. The company teamed-up with Rolls-Royce, and Siemens to create a hybrid electric aircraft (figure 15).

LOCKHEED MARTIN

According to Lockheed Martin the company is in particular a market leader in the field of aerospace and defense, and operates in commercial aviation, defense, services, space, helicopters, and maritime systems. While other competitors often mention at least to have an ambition regarding sustainable fuels, the company doesn't mention this topic, but emphasizes its ambition for efficiency. For example waste and water efficiency are part of the companies sustainability operations. In the field of innovation Lockheed Martin stands out through an innovative form language reminding of a ray flying in the air, and its technology innovations regarding autonomous flight and intelligent AI systems.

BOMBARDIER

Bombardier creates business and commercial aircraft. Apart from the other mentioned competitors the company also develops and produces trains. In terms of sustainability Bombardier refers to the triple bottom line by Elkington (1997) mentioning first economic, followed by environmental and social sustainability. Similar to Boeing, Airbus and Lockheed Martin also Bombardier focusses on eco-efficiency, and underlines particularly the sustainability of railway transport.

DASSAULT AVIATION

Operational areas of Dassault aviation are civil aviation, defense, offering services, and space. Eco-efficiency strategies are conducted e.g. by the reduction of fuel or weight reduction, or reducing energy and water within the company. Innovation focus mainly on research projects, which are for example about hydrogen airplanes and reducing air pollution.

LILIUM

Lilium focuses on the development of an eVTOL and might therefore be a competitor of Embraer in the future since Embraer also created a concept of an eVTOL. The German company aims to create a zero-emission form of transportation and wants the eVTOL to be bookable in 2025.

NASA

Nasa is especially well-known for its space operations, but also in general investigates and operates in the aeronautic field. Also, Nasa looks into eco-efficiency to reduce aircraft noise or weight, the latter one to reduce emissions. The agency especially stands out from other companies in terms of sustainability and innovation due to its

visual material, e.g. using a completely new shape for its aircrafts for noise and emission reduction (figure 17) or an electric personal air vehicle (figure 18). This might be due to its focus on research that develops new innovations.
Furthermore, just like Embraer, Nasa collaborates with Uber to develop an eVTOL.

DISCUSSION

Especially, eco-efficiency is the main strategy to reduce emissions of aircrafts and reduce noise. Eco-efficiency is achieved e.g. by reducing weight of the airplane or using biofuels. Recently, especially companies, who are in particular strong in the field of commercial aviation, are looking into electric air vehicles like the eVTOL. All companies often seem to have similar strategies by applying eco-efficiency and creating an eVTOL. Creating an eVTOL is the only real innovation currently in the field of sustainable fuels. Other projects on sustainable fuels concentrate for example on hydrogen airplanes or hybrid electric airplanes. While there is research done in the field of hydrogen barely prototypes are created.
The expert Paul Peeters criticized that in particular Airbus collaboration with Rolls-Royce, and Siemens about creating a hybrid-electric airplane might be more for demonstrating the willingness to be sustainable instead of actually acting sustainably. Not really acting sustainably, but only showing the willingness to be sustainable through eco-efficiency strategies can also be applied for other companies. The issue might be in the end, that sustainable fueled aircraft are barely bought by airlines as found out during the anonymous expert interview and the lunch lecture of KLM, because consumers are not willing to pay significantly more for sustainable engined aircraft flights. It would be rather about making a trade-off for consumers and not about paying significantly more as several times mentioned during the expert interviews.
In the field of innovation especially Nasa stands out through its research projects and especially visual material as can be seen amongst others in figure 19. Also, Airbus has several innovative concepts, e.g. a bionic structured aircraft (figure 16). Boeing was the only company that made a bold statement with stating the option to avoid travel by using VR. Further innovation lie for example in hydrogen fueled air taxis created by Alaka'i Technologies, and Designworks, a design agency owned by BMW (Wiggers, 2019), or the combination of trains and airplanes. Looking into the combination of trains and airplanes is currently rather missed by the competition (Hawkins, 2016; Metcalfe, 2018). Train planes are rather a concept for the next 50 to 100 years. Visions of train planes can be seen in figure 21 and 22.
Bombardier is currently the only aircraft manufacturer that also produces trains. However, the company does not combine

Interested in more innovative airplane concepts? Scan The QR code. :)

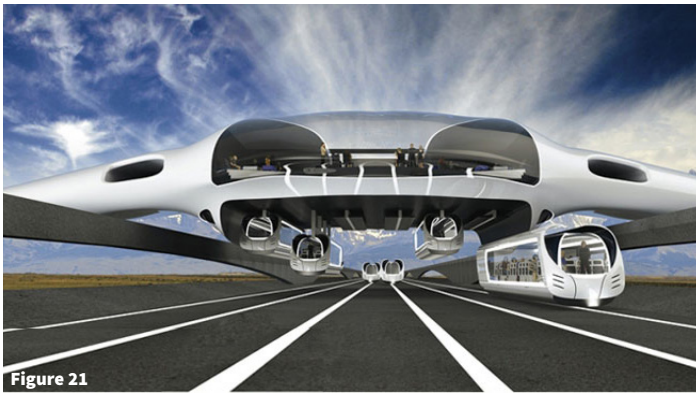


Figure 17: Innovative plane form to reduce emissions and noise ba Nasa (Gipson, 2013)
Figure 18: Personal air vehicle by Nasa (Barnstorff, 2010)
Figure 19: Various airplane innovations by Nasa (Congressman, 2017)
Figure 20: Supersonic aircraft by Nasa (Gourley, 2015)
Figure 21: Combining airplanes and trains (Grozdanic, 2014)
Figure 22: Plane-train (Hawkins, 2016)

	EMBRAER	BOEING	AIRBUS	LOCKHEED MARTIN	BOMBARDIER	DASSAULT AVIATION	Lilium
FIELD OF OPERATION	Commercial aviation	Commercial aviation	Commercial aviation	Commercial aviation	Commercial aviation	Civil	
	Executive aviation				Business aircraft		
	Defense & security	Defense	Defense	Defense		Defense	
	Agricultural aviation						
	Services & support	Services	Services	Services	Services	Services	Services
		Space	Space			Space	Space
			Helicopters	Helicopters			
					Specialized aircraft		
					Railway/ trains		
				Maritime systems			
FIELDS OF INNOVATION	eVTOL	eVTOL	eVTOL				eVTOL
		hydrogen airplane	hydrogen research			Research on hydrogen airplanes	
		hybrid electric aircraft	hybrid electric aircraft				
FURTHER INNOVATION			bionic airplane structure and concept cabin, future combat aircraft system			e.g. research projects: clean sky, SESAR, Alpha-BIRD	

Figure 23: Overview of the operational areas of companies in the field of aviation and their innovation strategies. Nasa is not mentioned in the table, due to its focus on research.

Key Insights

STAKEHOLDERS IN AVIATION & INNOVATION

GENERAL STAKEHOLDERS

Different kind of stakeholders influence Embraer as well as Embraer influences its environment. Relevant stakeholders are for example, airlines that purchase Embraer aircrafts, end-consumers of those aircrafts, society, politics, or collaborating partners like Uber or Boeing.
While airlines do try to be sustainable, they currently don't make use of sustainable fuels. Sustainable fuels would rise the ticket price and might be a competitive disadvantage for airlines. At the moment consumers strongly take the price into account when choosing a mode of transportation or choosing an airline. Due to reasons of comfort especially the older generation is willing to pay more. Millennials are in favour of sustainability. However, this generation enjoys travelling, which does not align completely with their wish to be sustainable.
Politicians currently barely limit the aviation industry using kerosene as a fuel. Once politicians would decide on having an impact on the usage of kerosene change might come quickly. Also, politicians sometimes subsidies sustainable forms of transportation.

THE COMPETITIVE FIELD OF INNOVATION

Companies in the aviation sector mainly focus on eco-efficiency strategies. Because more in the field of sustainable aviation is possible through sustainable fuels this can be interpreted as not actually acting sustainably, but more showing to be sustainable as it also was found out during the expert interviews. EVTOLs are a common innovation strategy in particular for airlines, which focus on commercial aviation. Furthermore, different aviation companies conduct research especially in electric and hydrogen-fueled aircraft. However, **while there is research done in the field of hydrogen barely prototypes are created.** The most innovative concepts come in particular from Nasa, and Airbus. While several innovation fields are covered, aviation companies don't or barely seem to look currently in innovation strategies related to the combination of ground and air transportation.

More context about sustainable mobility is given in the next chapter. Especially, opportunities and threats for Embraer derived from the context factors were analyzed.

5

THE CONTEXT OF SUSTAINABLE MOBILITY

OPPORTUNITIES & THREATS

In this chapter an overview of the context factors will be given. The context factors give an overview about the current landscape of sustainable mobility. Furthermore, potential market opportunities and threats were derived from the context factors. Opportunities show Embraer which potential markets might be interesting to look into. Out of high uncertainties future scenarios were created to explore potential futures and to be able to prepare for these futures.

5.1

Context /Trend Map

INTRODUCTION

The context map on the following 4 pages gives an overview of the current context factors in the field of sustainable mobility.

Several expert interviews and secondary data research were conducted in order to frame the general context. Therefore, the DESTEP method was used as criteria to cover different kind of fields.

The context and trend map on the following pages shows an overview of the context and trend factors found out. Figure 24 shows a small version of the context map, which aids in understanding how to read the context map. All factors were clustered and major trends and context factors were derived, which can be seen in the inner circle of the map. Within the major trends subcategories can be seen with a red headline and white context/ trend factors. The map should be read clockwise, starting with the red headline and followed by the white written context factors. To facilitate the reading the white thin inner circle line indicates which factors belong together.
All factors were evaluated by its uncertainty and the impact it might have, when Embraer does continue with its current operations. Factors which are especially relevant for Embraer, e.g. because they tend to have a high impact on Embraer and are rather uncertain, were marked with bigger dots than factors, which are less relevant for Embraer. Based on the colour of the dot next to the factor it can be derived if it is a demographic, economic, societal/ cultural, technological, environmental, or political factor.

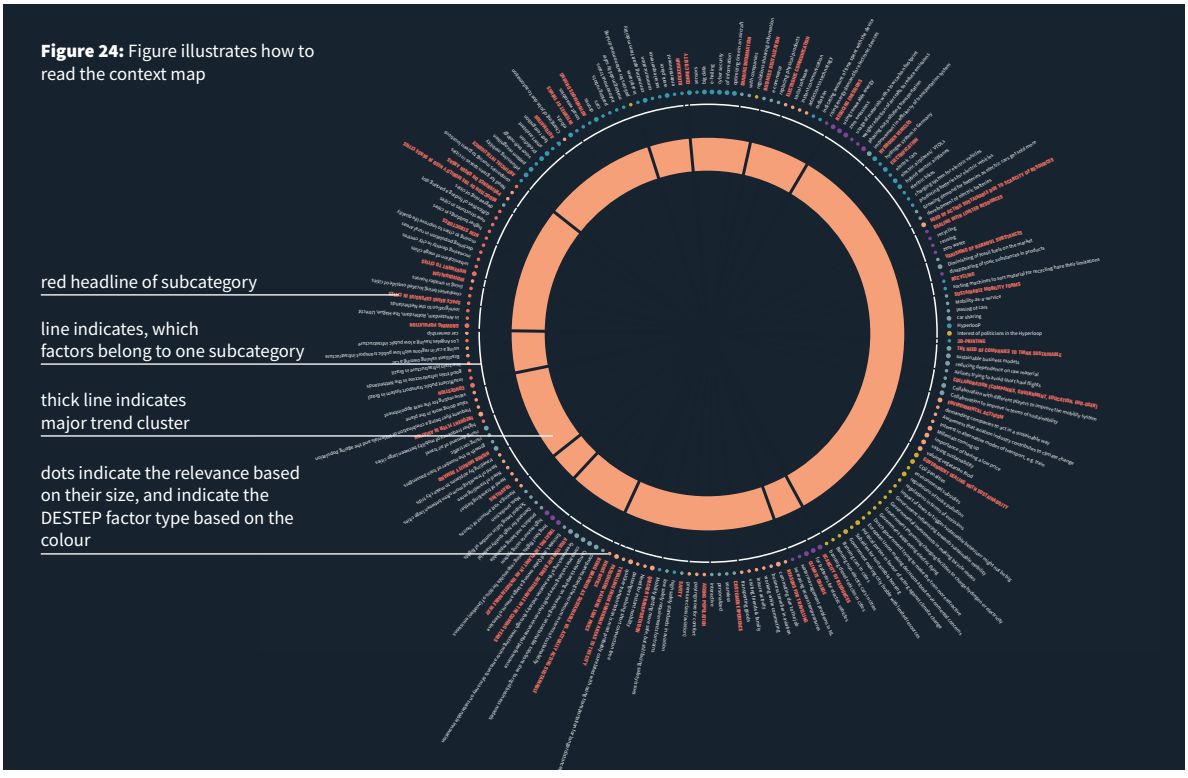
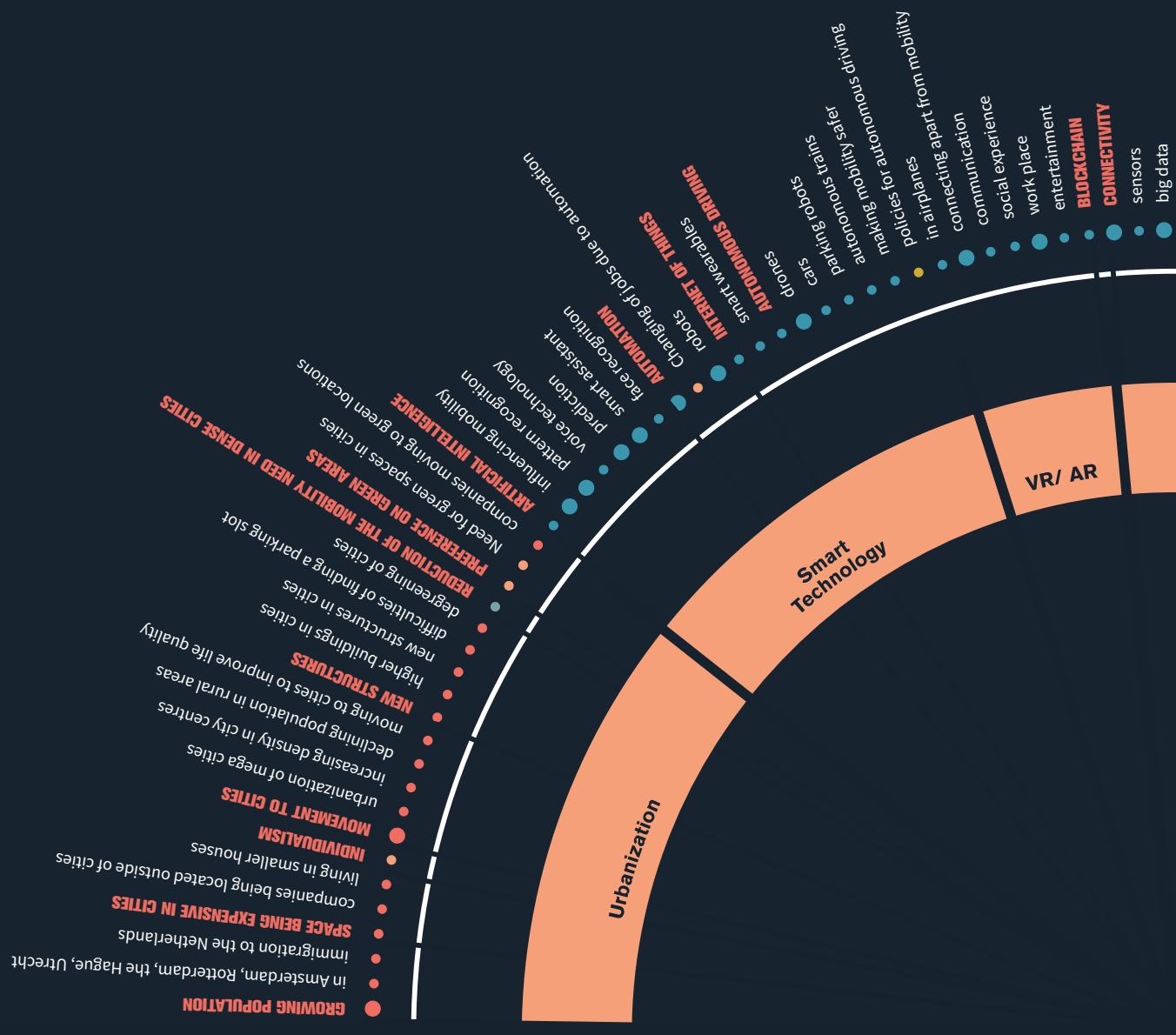


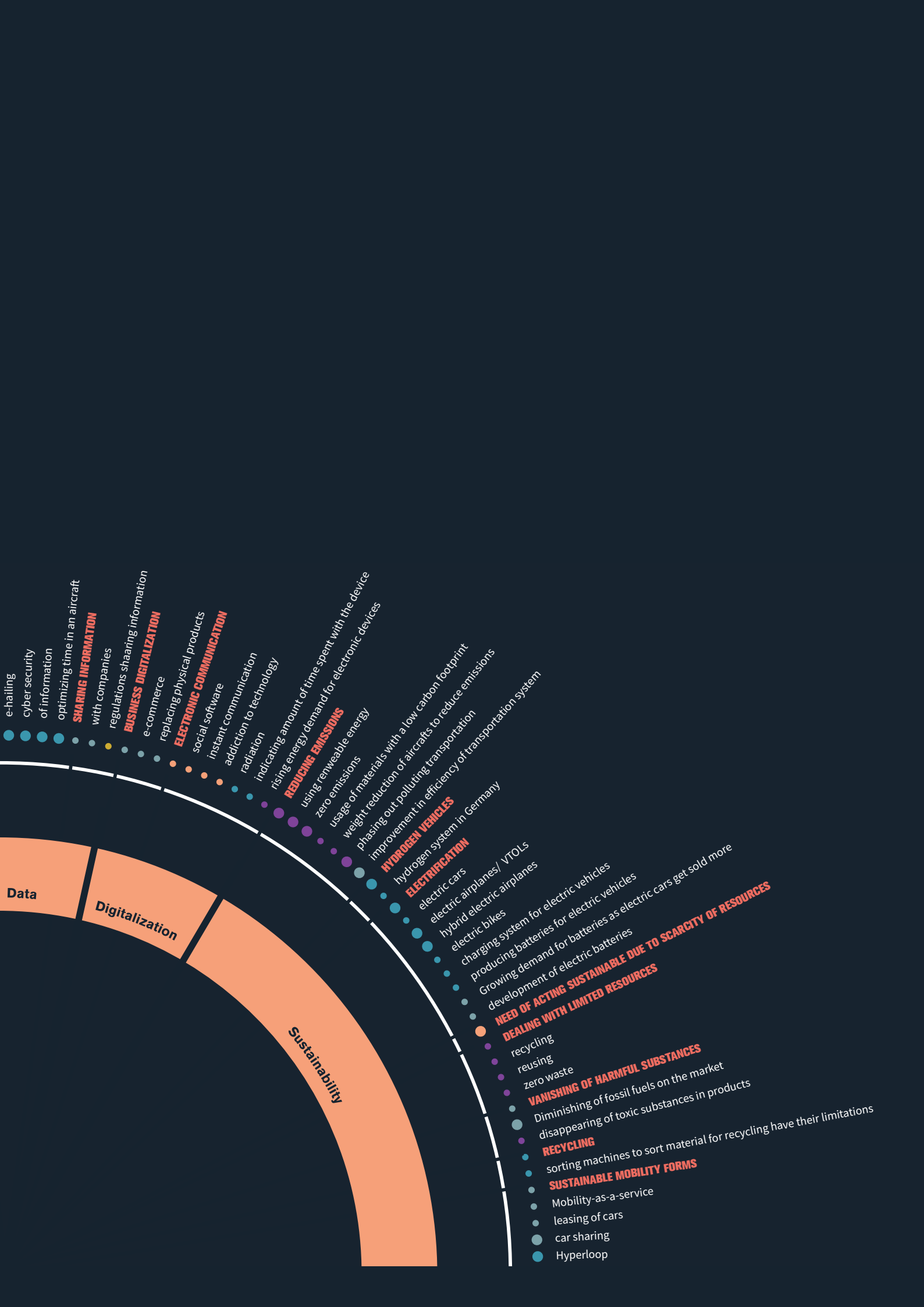
Figure 24: Figure illustrates how to read the context map

Context/ Trend Map

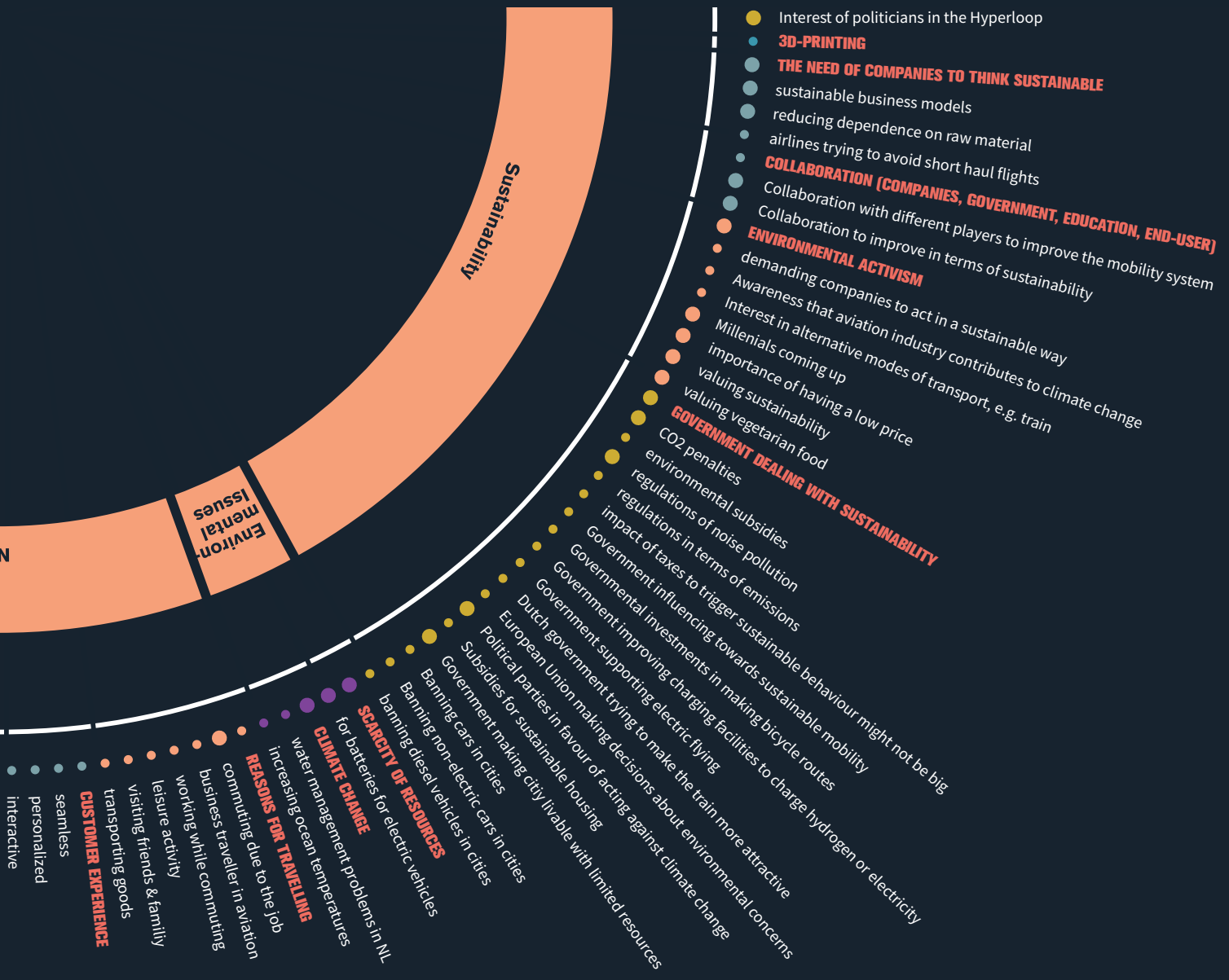
DATA VISUALIZATION

- Demography
- Economy
- Society & Culture
- Technology
- Environment
- Politics




Data
Digitalization
Sustainability
e-hailing
cyber security
of information
optimizing time in an aircraft
SHARING INFORMATION
with companies
regulations shaaring information
BUSINESS DIGITALIZATION
e-commerce
replacing physical products
ELECTRONIC COMMUNICATION
social software
instant communication
addiction to technology
radiation
indicating amount of time spent with the device
rising energy demand for electronic devices
REDUCING EMISSIONS
using renweable energy
zero emissions
usage of materials with a low carbon footprint
weight reduction of aircrafts to reduce emissions
phasing out polluting transportation
improvement in efficiency of transportation system
HYDROGEN VEHICLES
hydrogen system in Germany
ELECTRIFICATION
electric cars
electric airplanes/ VTOLs
hybrid electric airplanes
electric bikes
charging system for electric vehicles
producing batteries for electric vehicles
Growing demand for batteries as electric cars get sold more
development of electric batteries
NEED OF ACTING SUSTAINABLE DUE TO SCARCITY OF RESOURCES
DEALING WITH LIMITED RESOURCES
recycling
reusing
zero waste
VANISHING OF HARMFUL SUBSTANCES
Diminishing of fossil fuels on the market
disappearing of toxic substances in products
RECYCLING
sorting machines to sort material for recycling have their limitations
SUSTAINABLE MOBILITY FORMS
Mobility-as-a-service
leasing of cars
car sharing
Hyperloop

Infrstructure in different Regions
Increasing Mobility Demand
High consuming System
Acting Unsustainable
eeds
AGEING POPULATION
paying more for comfort
premium class (aviation)
SAFETY
high safety standards in aviation
low safety requirements for trains
Mobility getting more safe, but still facing safety issues
QUICKER TRANSPORTATION
Need for instant mobility
passengers valuing short connection time
TRVALLING FROM SUBURBAN AREAS TO THE CITY
PASSENGERS VALUING LOW PRICE
HOME OFFICE
BEING BRANDED AS SUSTAINABLE VS. ACTUALLY ACTING SUSTAINABLE
Companies doing the minimum in terms of sustainability
Companies keeping on investing in unsustainable solutions due to rigid business models
Greenwashing of the aviation industry through investing minor amounts of money on sustainable innovation
ADUATION NOT BEING SUSTAINABLE IN THE COMING YEARS
TREATING THE PLANET IN AN UNSUSTAINABLE WAY
Emirates, and Qatar owning a large amount of kerosine
long haul flights being responsible for 80% of (aviation) emissions
high resource using system
products not being repairable
Demand for high quality material
Skripol being full in number of flights
Mass production
Having a vast amount of choices
TRAVELLING
Need of travelling further
Need of travelling more
travelling by airplanes to make city trips
Need of travelling more often between large cities
HIGHER MOBILITY DEMAND
growth in the number of train passengers
rising car traffic
rising demand of air travel
higher frequency of mobility between large cities
FREQUENT FLYER IN AVIATION
frequent flyer being a combination of Millenials and the ageing population
value doing work in the plane
value resting for the next appointment
CONGESTION
insufficient public transport system in Brazil
good train infrastructure in the Netherlands
low train infrastructure in Brazil
Brazilians valuing owning a car
using a car in regions with low public transport infrastructure
Los Angeles having a low public infrastructure
car ownership


Sustainability
Environmental issues
N
Interest of politicians in the Hyperloop
3D-PRINTING
THE NEED OF COMPANIES TO THINK SUSTAINABLE
sustainable business models
reducing dependence on raw material
airlines trying to avoid short haul flights
COLLABORATION (COMPANIES, GOVERNMENT, EDUCATION, END-USER)
Collaboration with different players to improve the mobility system
Collaboration to improve in terms of sustainability
ENVIRONMENTAL ACTIVISM
demanding companies to act in a sustainable way
Awareness that aviation industry contributes to climate change
Interest in alternative modes of transport, e.g. train
Millenials coming up
importance of having a low price
valuing sustainability
valuing vegetarian food
GOVERNMENT DEALING WITH SUSTAINABILITY
CO2 penalties
environmental subsidies
regulations of noise pollution
regulations in terms of emissions
impact of taxes to trigger sustainable behaviour might not be big
Government influencing towards sustainable mobility
Governmental investments in making bicycle routes
Government improving charging facilities to charge hydrogen or electricity
Government supporting electric flying
Government trying to make the train more attractive
Dutch government making decisions about environmental concerns
European Union making decisions about environmental concerns
Political parties in favour of acting against climate change
Subsidies for sustainable housing
Government making city livable with limited resources
Banning cars in cities
Banning non-electric cars in cities
banning diesel vehicles in cities
SCARCITY OF RESOURCES
for batteries for electric vehicles
CLIMATE CHANGE
water management problems in NL
increasing ocean temperatures
REASONS FOR TRAVELLING
commuting due to the job
business traveller in aviation
working while commuting
leisure activity
visiting friends & family
transporting goods
CUSTOMER EXPERIENCE
seamless
personalized
interactive

5.2

Market Opportunities

& SUSTAINABLE POTENTIAL AREAS

Sustainable fuels are a rising market for different modes of transportation. Also, mobility-as-a-service offers great opportunities for the mobility sector.

For setting a strategy one should look into growing markets to avoid a high level of competition, and search for potential to make revenue. During the expert interviews it was found out that the mobility market is growing in the future. There is a growing demand for trains, cars, and air travel. Also, further mobility trends like electrification, mobility-as-a-service, and smart technology were found out. Major trends and their size and growth potential were additionally analyzed more into depth through secondary data research.

MOBILITY-AS-A-SERVICE (MaaS)

The increasing demand of mobility as a service shows a tendency towards sustainable mobility since getting away from vehicle ownership is preferable for sustainability because it is less resource demanding. Furthermore, it shows an increasing demand for mobility. According to statista (2017) the MaaS market will grow from 2025 to 7,500 billion dollar worldwide, to 9,200 billion dollar in 2030, to 9,500 billion dollar in 2035. Within MaaS there are several different opportunity areas, e.g. ride hailing, bike sharing, ride sharing, and car sharing. From these mentioned subtopics ride hailing has the most market potential, followed by ride sharing (Grand View Research, 2019). MaaS will be particularly relevant in urban areas (Goodall et al., 2017) to make mobility more seamless (Durand et al., 2018). The major advantage of MaaS is that it connects with different types of mobility and therefore supports a more seamless customer experience.

MaaS is estimated to be 9,500 billion dollar worth in 2035

GOOD TO KNOW

Figure 25: Connection between trains and planes (den Boer, 2018)

Mobility experiences have also been tried to connect during the past. Figure 25 shows an illustration of the connection between the Dutch railway (NS) and airplanes. The connection between trains and airplanes always has been really deeply, MaaS could intensify this connection, but also include further modes of transportation into the mobility system.

SUSTAINABLE FUELS

Hydrogen

During the sustainable fuel analysis it was already found out that experts view hydrogen as one of the ideal fuels especially for aviation in the future. Hydrogen is also a growing market and expected to grow from 2017 from US$ 115.3 Bn in 2017 to US$ 174.2 Bn in 2026 (Maximize market research, 2019). HydrogenEurope (2019) even aims to scale up hydrogen by 25% of the complete energy demand by 2050. Several drivers like economic and political collaboration can lead to scaling up hydrogen more quickly (Want, 2018).

While hydrogen is currently more expensive than kerosene, experts expect the fuel to be cheaper

than kerosene around 2035 (van Zon, n.d.).

Hydrogen has several advantages towards electric mobility forms. Currently, several ground vehicles, like cars and busses are using hydrogen. In the future hydrogen will also be important for the aviation industry. Want to know more? Scan The QR code. :)

Electrification

During the expert interviews different kind of electrification trends were found out, e.g. in the car and aviation industry. Statista (2017) estimates the market growth of electric vehicles as followed: 1,670 billion dollar worldwide in 2025, 1,330 billion dollar in 2030, and 1,420 billion dollar in 2035. Also, electric airplanes are a strong trend, Zunum for example is one company who is currently looking into electric airplanes. However, companies, which are currently looking into this trend often don't have fully electric, but hybrid electric airplanes. According to Paul Peeters (2019) from a sustainability perspective hybrid electric airplanes still might have a lot of carbon emissions. Further secondary sources estimate emission reductions of Zunum airplanes by 40-80% (Lardinois, 2018). Due to the battery capacity hybrid electric airplanes are applied at the short haul flight market.

Want to know more about Zunum and the development of electric flights? Scan the QR code :)

Biofuel

Biofuels are especially for large airplanes an opportunity to reduce emissions. As found out during the stakeholder analysis currently biofuels are not applied much due to competitive reasons. However, to reach the sustainability goals of reducing 50% of net aviation emissions in 2050 in comparison to 2005 (IATA, 2019) there is a need to introduce more bio fueled airplanes. The challenge for the aviation industry will be how to introduce those biofuels while staying competitive. According to Zion Market Research (2019) the biofuel market in aviation will raise from 61 billion dollar in 2018 to 131 billion dollar in 2025. Grand View Research (2017) confirms the growth of biofuels in aviation additionally.

AUTONOMOUS VEHICLES

Autonomous driving will affect the future market and change the customer experience. Instead of driving customers will be able to do other activities inside the vehicle (Clarence-Smith, 2018). Statista predicts a market in that field of 890 billion dollar worldwide in 2025, 900 billion dollar in 2030, and 1,000 billion dollar in 2035. Keeney (2016) even estimates the autonomous MaaS market by 9,000 billion dollar in 2030.

PASSENGER EXPERIENCE

New developments of the mobility industry will influence the customer dramatically as already mentioned. MaaS will make mobility more seamless. Autonomous driving will lead to new possibilities of the experience inside the vehicle and allow leisure activities, or working possibilities. But autonomous driving will also further support social inclusion of people, who are not allowed or cannot drive. Artificial Intelligence and data analytics will further support personalization.

Technological developments and MaaS will lead to new possibilities in passenger experience.

HYPERLOOP

The Hyperloop is a future opportunity for sustainable transportation, but also might replace short haul flights, which might be a threat for aviation. Because the Hyperloop seems to be a high potential field an expert interview was conducted with Tim Vleeshouwer, who is a lead of the full scale department of Delft Hyperloop. According to Vleeshouwer, the Hyperloop can be expected in the next 10 to 15 years. However, currently companies and politics feel uncertain to invest in this area. Market growth might therefore only be moderate regarding the Hyperloop. Establishing an infrastructure and dealing with the different kind of regulations and legislations might be a challenge in the future. For this reason Vleeshouwer rather expects the Hyperloop in countries like China, India, or the United Arab Emirates, where wide ranging land and less regulational barriers can be found than in the EU. Ameri Research Inc. (2017) especially sees an opportunity of the Hyperloop technology in North America. Furthermore, Variant Market Research (2018) sees in the Hyperloop the advantage of needing less land in comparison to other types of transportation and estimates the market size by $6,822 million in 2026 at 46.2% CAGR. Similar estimates has Factor & Equilibrium (2019).
An example of how the Hyperloop and a station of the Hyperloop might look like in the future can be seen in figure 26.

Figure 26: Hyperloop and Hyperloop station concept of Delft Hyperloop (Arnhold, 2019)

Missing infrastructure and legislations make it currently challenging to invest in the Hyperloop.

SUSTAINABLE PUBLIC TRANSPORT

The Hyperloop is a form of high speed rail and in general the high speed rail market is a growing market rising especially in countries such as Germany, Spain, France, and Italy. (Ivanova et al., 2018). Also, in baltic countries the railway network is growing from 4,693 vehicles in 2014 to 17,200 vehicles in 2019 (Baltic Rail AS, 2019).

Furthermore, electric busses are highly on demand, which also includes electric fuel cells powered by hydrogen. Worldwide the market of fuel cell vehicles is estimated to have 583,360 units in 2030. In North America alone there are estimated to be 118,847 units (Leo & Kumar, 2015). Verma & Agarwal (2019) estimate that the market will rise from 830 million dollar in 2018 to 11,600 million dollar in 2024 worldwide.

5.3

Threats & **Uncertainties**

DIFFICULTIES IN THE FUTURE

While on the one hand there is a clear need of acting sustainably, on the other hand it is difficult to act sustainably e.g. due to a growing consumption demand and the demand of a low price.

During the research several factors that might mean a threat to Embraer were. In the following text the threats and uncertainties are discussed that can also be found in the context map.

NATURE LIMITATIONS

Climate change and scarcity of resources show the limitations of earth, and reveal a need to act in a way in a sustainable way to fulfill needs on a long-term. It is uncertain how society, politics and economy will deal with the limitations of earth and what kind of consequences this will have for Embraer. According to IPCC (2018) there are only 11 years left to act against climate change, which makes it more likely that stakeholders actually will act within this timeframe against climate change.

LACK OF CONSUMER TRUST

While the natural limitations are becoming more clear the current system still needs a high amount of resources and has emissions triggering climate change. Companies stick to unsustainable solutions due to rigid business models and do often a minimum in terms of sustainability. The full effects on nature of this way of acting are uncertain as well as it is uncertain of how urgent it will become in the end to actually act sustainable. Because companies often do not have sustainable business models consumers are becoming more critical. Additionally, there is a rising awareness of consumers that the aviation industry triggers emissions and therefore pollution and climate change. This lack of consumer trust could be responsible for avoiding flying and avoiding companies with unsustainable solutions.

GOOD TO KNOW

„Flygskam“

The word “Flygskam” was introduced in Sweden to make people feel embarrassed about flying. The goal is to avoid flying due to its polluting effects that trigger climate change (Henley, 2019).
system.

DEMAND OF ACTING SUSTAINABLY

Furthermore, a strong sustainability trend is noticeable. Emissions are reduced through renewable energy, biofuels are used, and the most polluting aircrafts are phased out. EVTOLs aim for zero emissions, but still are facing issues like a missing infrastructure or social barriers. Collaborations amongst different stakeholders are fostered to improve in terms of sustainability. Besides, environmental activists demand from companies to act in a more sustainable way.
The trend of acting sustainably proceeds slowly and gradually, but it is there and can be recognized in the various types of developments that were mentioned. The open questions and uncertainties for Embraer are: With what kind of solutions will companies come up with? How will sustainable solutions change the market environment? How strong will be the pressure to act in a sustainable

way? Will consumers prefer in the future more sustainable products or will they stick to unsustainable solutions that they were used to over the years?

ENVIRONMENTAL REGULATIONS

Currently, there are only minor political interventions on the emissions of the aviation industry. However, there is a trend of environmental regulations: CO2 penalties, regulations of noise pollution, and political parties, who are in favour of acting against climate change. Once politics decide to reduce emissions of mobility, change can come quickly and might confront the aviation industry with the challenge of introducing quickly less or non-polluting aircrafts or having difficulties to make revenue due to high taxes on aviation that make flying less affordable.
Figure 27 illustrates this uncertainty.

SUBSTITUTION OF FLYING

Due to reasons of sustainability politics try to nudge citizens to use more sustainable ways of transportation e.g. trains.
A new form of transportation, the Hyperloop, has the potential to substitute short haul flights. It is more sustainable than aircrafts, has a low energy consumption, and is faster than trains. Even airlines are looking into ways to substitute short haul flights as found out during the anonymous expert interview (2019).
Furthermore, the trend of VR/ AR creates new possibilities of virtual collaboration workspaces. Frequent business flyers might use VR/ AR more for international communication, which would make a personal visit irrelevant. Flying would be avoided and substituted by the VR meeting, which has the advantage for the company to save money.

GROWING POPULATION

There is a clear trend of a growing population. The growing population also is correlated with a higher consumption. Especially, in times of climate change, issues due to too many emissions, scarcity of resources, and too much waste it might be difficult to handle this amount of consumption. The question for the mobility industry will be how to handle this amount of people, and satisfy the demand, while not harming the environment.

LOW PRICE MENTALITY

A big amount of the population values low prices. Especially, when product or service choices are made the prices are considered. Not choosing the lowest price might be related to getting an additional offer (e.g. comfort in airplanes) or choosing a sustainable product. However, according to the expert interviews (2019) it is also about making a trade-off. If a product is more expensive to meet better sustainability implications consumers would only go for this choice if it is not extensively more expensive in comparison to other choices.

CONGESTION

A growing population, and a growing mobility demand might stimulate congestion, which is usually an unpleasant experience for users. Due to urbanization there might also be more congestion in cities in the future. On ground congestion might stimulate the usage of eVTOLs in urban areas. But the development of eVTOLs also might bring congestion from the ground additionally to the sky.

TECHNOLOGY SHIFT

There are several technology developments and innovations, e.g. artificial intelligence (pattern recognition, prediction, smart assistants), robots, automation, connectivity, and autonomous driving. It is difficult to predict how much these developments will influence the market in the future. How much will companies make use of these types of technologies? How will consumers embrace these technologies? Will it be accepted or will consumers be sceptical and prefer to use technologies of the past?

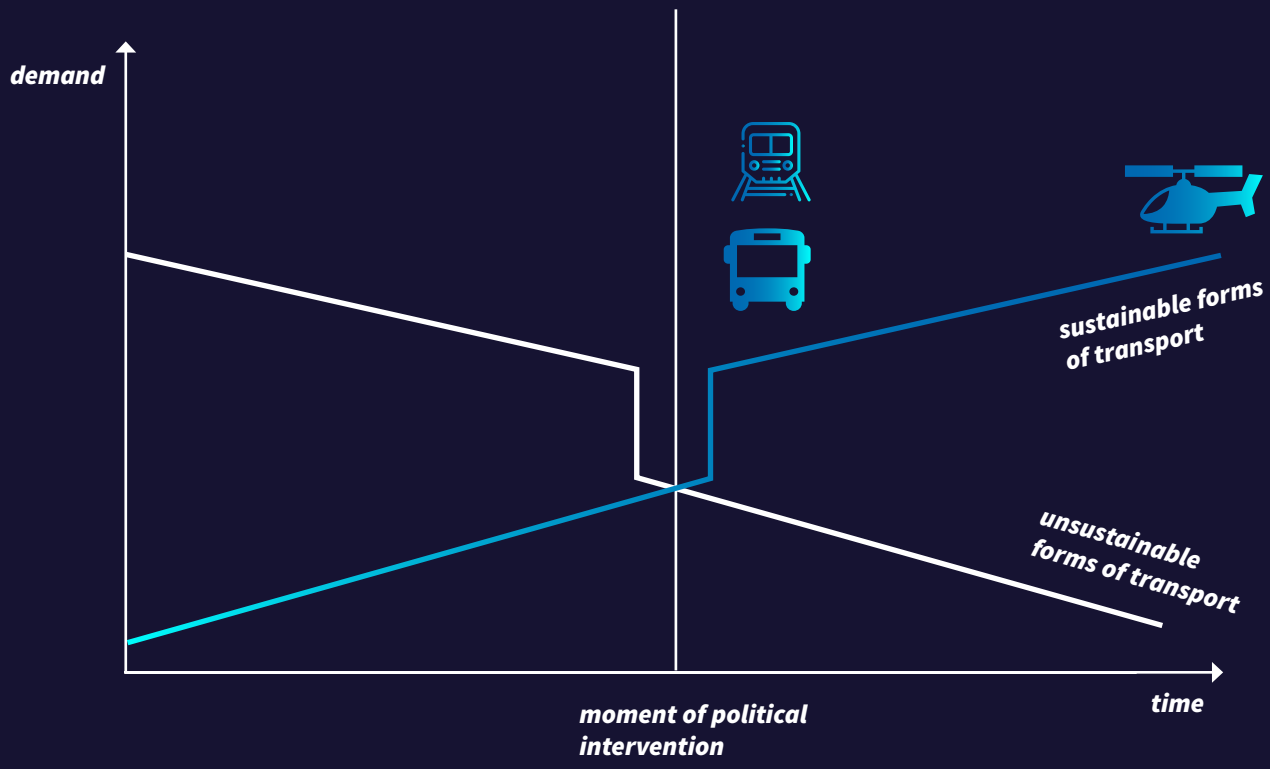


Figure 27: Assumption what might happen in case of a quick change towards sustainable mobility

Change towards sustainable forms of mobility is expected to happen gradually. However, in case of political interventions change can happen quickly as figure 26 illustrates. The assumption of figure 27 is that in case of quick change towards sustainable mobility existing sustainable forms of transport e.g. like electric or hydrogen trains or busses will be rising. Developments of new forms of mobility like VTOLs still will need it's time to evolve e.g. due to a missing infrastructure. The more a company relied on unsustainable and polluting forms of mobility the more challenges it might face in the future.

5.4

Trend Scenarios

POSSIBLE FUTURE

How might tomorrow look like? Maybe we can assume what happens tomorrow, but what happens in 2035 might be more uncertain. For these uncertainties possible futures were explored.

Trend scenarios were created in order to estimate possible directions of the future and to find a strategy on which Embraer can react to critical scenarios.
For the creation of the trend scenarios two critical uncertainties were picked. Its extremes were positioned on two axes in order to create the scenarios as can be seen in figure 28. Based on the expert interviews the critical uncertainty of political interventions on high emission mobility (e.g. aviation) was chosen. Currently, there is a gradual and rather slow change towards sustainability. However, in case politicians decide to intervene, change can happen quickly (Jaap Vleugel, Paul Peeters, 2019) and Embraer might not be prepared for a quick change towards sustainable mobility. Figure 27 illustrates the assumption of having a quick change towards sustainable mobility due to political interventions. The assumption of having a quick change are especially described in the first two scenarios.
Especially, because climate change gives according to research a time limitation to react within 11 years (IPCC, 2018) the scenarios of a quick change are possible in the future. Furthermore, according to the anonymous expert interview (2019) it might be uncertain how the development of AR and VR might influence aviation. These technologies might influence the communication of different stakeholders and might be used to avoid business travel. As a result business travel and the amount of frequent flyers might decrease. The factor of a decreasing demand on mobility stands in contradiction to the trend of a growing demand for mobility. Developments like high speed trains or the Hyperloop might substitute in particular short haul flights, which is a threat. The trend scenarios are described in the following text and additionally visualized. Certain trends overlap in several scenarios. The scenarios were used later to create search fields, the search fields are further described in the next chapter.

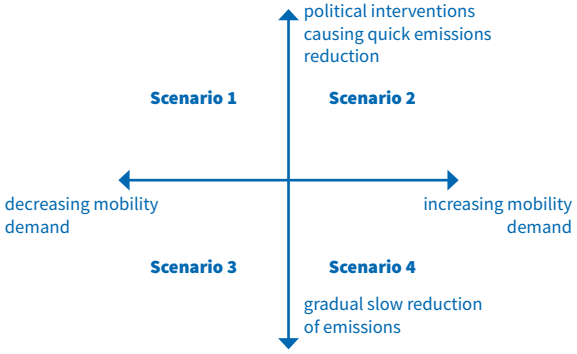


Figure 28: The scenarios and its critical uncertainties mapped on axes.

1) THE POLITICAL INTERVENTION

Demography: There is a growing population.

Economics: The aviation industry is not prepared for a dramatic shift towards sustainability, which threatens the industry and jobs. New collaborations are made to use the knowledge of the aviation industry to create more sustainable forms of transport such as trains. The collaborations create new market possibilities in the sector.

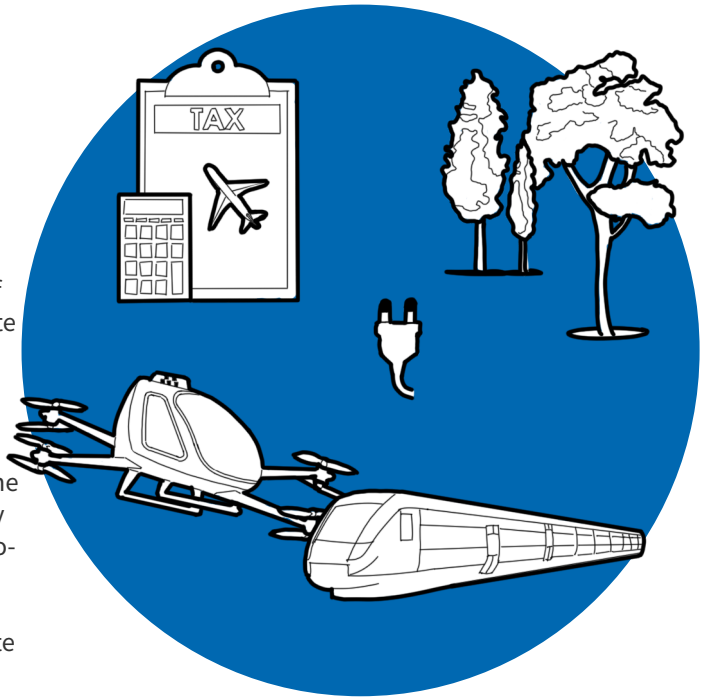
Society & Culture: While environmental activism was first very prominent it decreases after the introduction of new environmental policies. At the time when taxes on flights are introduced society criticizes that flying is only left to the wealthy people of the world.

Technology: Virtual reality is used to communicate with business partners all over the world. This development decreases business travel and the amount of frequent flyers in order to save money.

Environment: Nature and resources are recovering. Still the planet needs to be treated carefully to avoid the coming back of environmental risks.

Politics: Due to the societal development of environmental activism and the risk of climate change politicians involve more and more environmental requirements in political decisions.
Environment is set over economy to prevent natural disasters. Taxes are introduced on fuels that cause emissions. Therefore, taxes also affect biofuels. However, biofuel flights are less affected than kerosene flights. The taxes cause that tickets for flights between Amsterdam and Madrid cost ~1500€ and from Amsterdam to Mexico City 4500€.

2) REPLACEMENT THROUGH ALTERNATIVES



Demography: There is a growing population.

Economics: Because it takes 5 years to manufacture airplanes the aviation industry is struggling with the dramatic shift towards sustainability. New airplanes with new engines need to be developed that allow fuels such as electricity or hydrogen. This development results in a decreasing income.

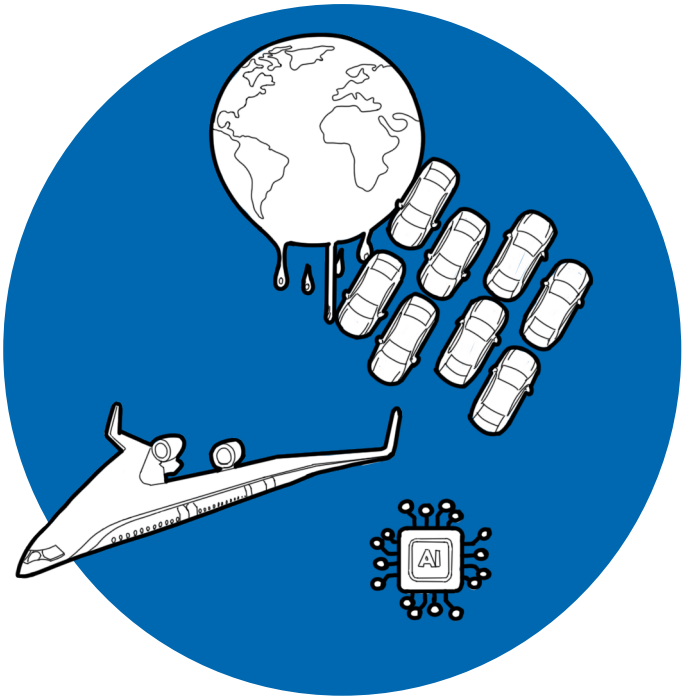
Society & Culture: Business streams such as the usage of VTOLs are rising, but companies face big investments because infrastructures are missing, which challenges the industry.

Technology: Because alternative fuels become more important more research is done in those fields which accelerates the development for example of hydrogen.

Econology: Nature is recovering, but scarcity of resources is still an issue.

Politics: Politicians introduce a concrete action plan to abandon kerosene over the next years. The plan includes policies that force airlines to use more biofuels, electric, and hydrogen airplanes. Furthermore politicians strongly subsidies sustainable forms of transportation e.g. trains, the Hyperloop, or bicycles. Also, VTOLs benefit from this development and additional policies to guarantee safety in VTOLs are introduced.

3) THE COMPETITIVE LANDSCAPE



Demography: There is a growing population.

Economics: Step by step the aviation industry tries to be more sustainable, e.g. by creating more leightweighter airplanes or to improve the infrastructure to save energy and fuels. Biofuels and further sustainable fuels are only introduced slowly in order to stay competitive on the market. The current market characteristics don't really change.
Besides, there is an increasing demand for mobility.

Society & Culture: Society enjoys leisure travel and likes to explore the world.

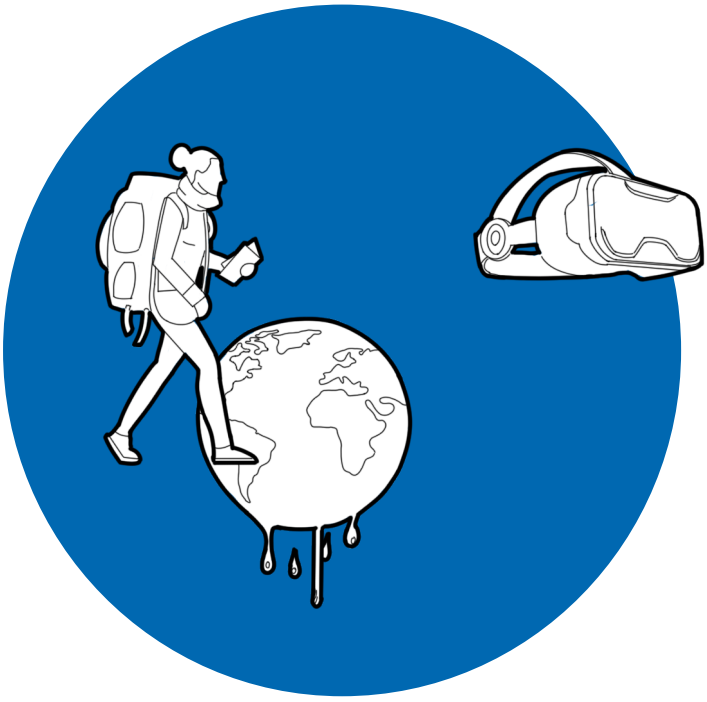
Technology: The world is getting smarter. AI predicts better customer needs and is able to personalize passenger experiences in a better way. Smart

assistants are used in airplanes and on airports now.

Environment: The more it is invested in unsustainable solutions the more noticeable become scarcity of resources or climate change.

Politics: There are only a few small policies that limit emissions, which only have minor consequences on the mobility industry.

4) ENDANGERED BUSINESS TRAVEL



Demography: There is a growing population.

Economics: Because business travel is decreasing companies look into further revenue streams. Leisure travel still seems to be a good revenue stream. Slowly the aviation industry tries to be more sustainable. A few airplanes are fueled by biofuel in 2035.

Society & Culture: Business travel is reduced. But common travelling is still practiced. People want to explore the world and get to know new cultures. However, some parts of society try to reduce travelling for environmental reasons.

Technology: Virtual reality is used to communicate with business partners all over the world. This development decreases business travel and the amount of frequent flyers in order to save money.

Environment: The more it is invested in unsustainable solutions the more noticeable become scarcity of resources or climate change.

Politics: There are only a few small policies that limit emissions, which only have minor consequences on the mobility industry.

RECOMMENDATIONS BASED ON THE SCENARIOS

Avoiding the worst case scenarios of a dramatic shift towards a sustainable system would suggest to use more emission limiting or zero emission mobility. The competition already looks especially into electric, but also hydrogen airplanes. Not looking into this field at all might be risky and mean a competitive disadvantage. Because Embraer doesn't have the current resources for this development and there is a missing infrastructure collaborations will be important that support Embraer to look into the field of sustainable fuels. It is relevant to build step by step this infrastructure of sustainable fuels to avoid a high risk in case of a dramatic shift towards limiting and zero emission mobility.
The competition like Airbus for example looks into different developments and prepares itself for the future by investing into different kinds of startups. This action might be an inspiration for Embraer, but of course other types of collaborations are also

possible.
Before taxes for aviation are introduced it also might be good to search for a dialogue with politicians and find solutions together. Rising taxes of high emission mobility might even mean an opportunity for Embraer and might be a common goal of politicians and Embraer. In the case of rising taxes the demand for electric, biofuel or hydrogen airplanes might rise and mean a new revenue stream for Embraer. In that case, Embraer might not face a challenge, but airlines, who have to buy these new type of airplanes in the future. Therefore, a step by step introduction of these airplanes might be more realistic. For politicians rising taxes for high emission mobility is desirable to prevent the risks of climate change.
Furthermore, it is relevant to find a solution that helps a growing population to be sustainable, which might be difficult, because the more consumers are in the world the more might the demand for consumption rise.
Also, the scenarios indicate, that it might be critical to invest in business travel, although it might be that there will be revenue streams for business travel in the future. There are new opportunities through technologies, such as VR or smart systems for example. These developments might also mean new possibilities, in which also the mobility industry looks into and change the mobility environment. The technological developments need to be considered as well also in order to fall not behind in a competitive environment
Furthermore, it is relevant to use only limited resources to make a big impact. Besides, it is relevant for Embraer to further have a look on developments that might substitute Embrear products such as virtual reality, or the substitution of emission causing short haul flights.

The scenarios were further used to create search fields. More about search fields can be read in the following chapter.

Key Insights

THE CONTEXT OF SUSTAINABLE MOBILITY

Expert interviews and secondary research was conducted to define context factors around the topic of sustainable mobility. The factors were clustered to 12 subtopics, which are urbanization, smart technology, VR/ AR, data, digitalization, sustainability, environmental issues, needs, acting unsustainable, high consuming system, increasing mobility demand, and infrastructures in different regions. Each subtopic contains various subcategories.

MARKET OPPORTUNITIES

Out of the context factors opportunities and threats were described further. Especially, mobility-as-a-service is a growing future market, which is assumed to be 9,500 billion dollar worth in 2035. Further opportunities and growing markets are sustainable fuels (hydrogen, electrification, biofuel), autonomous vehicles, and the hyperloop. Due to technological developments such as autonomous vehicles for example new possibilities in a changing passenger experience arise. Also, sustainable public transport is high on demand, in particular high-speed rail systems, and electric and fuel cell busses.

THREATS & UNCERTAINTIES

It is uncertain how severe nature limitations can get in the future (such as climate change or scarcity of resources). Consumers are sceptical about flying and perceive it as unsustainable. There is a demand for example from environmental activists to act sustainable. Also, policies develop in the direction to limit high emission mobility such as aviation and support rather sustainable trains, busses and bicycles. While environmental challenges are faced it might get difficult to consider these developments because we are also facing a growing population. Furthermore, consumers prefer prices of mobility to be low, which is difficult to align with offering sustainable forms of mobility. Besides, short haul flights might get substituted e.g. by developments like the Hyperloop. There might be more congestion and the influence of new technologies is uncertain in the future.

TREND SCENARIOS

Based on the context factors two critical uncertainties were picked to create 4 trend scenarios. The first critical uncertainty is about political interventions on emission causing mobility. In case of political interventions change towards sustainable mobility might come quickly. If there are no political interventions the development towards sustainable mobility will rather go slowly and gradually. Another critical uncertainty is the substitution of mobility, e.g. communication via VR might substitute business travel and the Hyperloop might serve as a substitution for short haul flights. Also, people might be motivated to use less mobility due to environmental reasons. The trend scenarios were used amongst others to create search fields. In the next chapter more can be read about the search fields.
Recommendations that were made based on the trend scenarios were about looking into sustainable fuels, engage in collaborations, search for dialogue with politicians to, consider technological developments, and take care about developments that might substitute airplanes or short haul flights.

A New Innovation Direction for Embraer

ANALYSIS SYNTHESIS

In this chapter various innovation search fields are described that emerged from the analysis. The search fields are potential market areas that might be interesting for Embraer to look into. Based on the search fields a future vision was created that is explained in this chapter. The vision is a more general direction that can be achieved through various types of concepts. In case over the years the strategy needs to get aligned to new unpredictable developments the vision can help as a general direction for creating new concepts.
Additionally, a target group was defined. Through defining a target groups needs of that group can be better addressed later in the strategy.

6.1

Search Fields

SUSTAINABLE OPPORTUNITY AREAS FOR EMBRAER

New developments and uncertainties also always come with new opportunities. From connecting passenger experiences to new sustainable forms of transport there will be a lot of possibilities for Embraer in the future.

ISSUES & GAPS

Based on the trend scenarios and the previous analysis several gaps and issues could be identified:

There is a need to be sustainable. The scenarios show, that with a gradual change towards sustainable solutions environmental issues will get more severe and make critical scenarios with an urgent change more likely. However, sustainable actions are not conducted due to various reasons that need to be overcome, for example:
- Providing a mobility demand for a large and growing population is currently related to higher emissions and more resource usage.
- Consumers and companies show openness about acting sustainable. However, they don't act sustainable, due to several barriers. In the case of fuels, biofuels would raise the ticket prices. The 'low price mentality' of consumers makes it difficult to introduce sustainable products.
Also, society already has the habit of consumption, and it appears challenging to break this habit towards a more sustainable system.
- Technologies such as electric fueled airplanes have a limited capacity and can rather be used in the coming years for short haul flights. Embraer has not established an infrastructure for electric and hydrogen flights, which might be challenging in the future to create alone. Also, employees would need to be trained to deal with these new technologies.

Additionally, there is the issue that due to the joint venture with Boeing, Embraer decreased in the amount of employees. Embraer needs to strengthen in the future again and create more revenue streams apart from Boeing.

The analysis, trend scenarios, issues and gaps were used in order to create search fields.
A brainstorm was conducted to develop sustainable search fields for Embraer (figure 29). Additionally, search fields were found out during a co-creation session with four students from the Delft University of Technology as can be seen in figure 28. The


Figure 29


Figure 30

Figure 29: Co-creation brainstorm
Figure 30: Brainstorming

co-creation was especially valuable for two reasons. First, research shows that groups outperform individuals (McMahon et al., 2016) during the idea generation. Second, through co-creation the company can learn from consumer needs, and the customer can design for its own needs (Prahalad & Ramaswamy, 2004). The students are potential consumers. Both brainstorms were based on the previous analysis results, and trend scenarios. In the following text the search fields are introduced. Under each introduced search field a description can be found of how the search field relates to different aspects of the SWOT analysis. Furthermore, concerns about each search field are revealed to facilitate a decision making between the search fields.

SUSTAINABLE SHIFT SUPPORT FOR COMMERCIAL AIRLINES

Often airlines avoid introducing biofuels, because it would raise ticket prices and endanger the competitiveness amongst other airlines. Consumers often choose low price tickets and consider the sustainability aspect in a limited way. However, in general airlines and consumer show openness towards sustainable solutions, but are not choosing these options due to the mentioned barriers. There is a potential in supporting commercial airlines to use more biofuels. This support can especially be done with airlines, who have a strong relationship to Embraer like KLM or American Airlines for example.

STRENGTH

- Boeing and Embraer are looking into new applications of biofuel. This knowledge can be used to support the strategy (Chen, 2013; Luxford, 2015). Especially, with Boeing as a strong partner the strategy can be strengthened.
- Embraer has a strength in commercial aviation.
- The aircraft manufacturer has strong relationship to airlines such as KLM and American Airlines and can make use of this influence.

OPPORTUNITY

- There is an opportunity in biofuels since Brazil and the United States are leading countries in biofuel production (Wang, 2019). Especially, in these countries Embraer is strong in the market. Also, Embraer has a connection to the Brazilian government, which might help in the area of biofuels.
- Furthermore, biofuels is a growing market.
- Stakeholder analysis: the aviation industry set the goal to use more biofuels in the future (ICAO, 2016), but currently faces difficulties to actually do it.

Concerns

Looking into the direction of biofuels might be risky since biofuels raise ticket prices and threaten the competitiveness of Embraer. Also, conducting this strategy alone might be difficult for Embraer as a company that is rather small in comparison to Airbus and Boeing. Furthermore, the strategic fit to EmbraerX as innovation department is doubtful.

SUBSTITUTION OF SHORT HAUL FLIGHTS

There is a trend that in the future emission causing short haul flights might get substituted by alternatives like (high-speed) trains or the Hyperloop. Especially, there is a trend of trains getting subsidies. Instead of fearing this trend, Embraer can go with this trend and use its knowledge about customer experiences and needs for these distances. The Hyperloop might be

the new short haul flight. Common trains have the advantage of not needing an additional infrastructure in a lot of areas.

STRENGTH

- The Hyperloop is especially an opportunity area for countries like China for example. Since Embraer is located in the Chinese market the company might have an advantage there.

WEAKNESS

The strategy can be about overcoming the weakness of having similar innovation as the competition. Since the competition is currently not looking into the field of the Hyperloop it is an opportunity to stand out.

OPPORTUNITY

Hyperloop as an opportunity field.

THREAT

Short haul flights might get substituted. It is an opportunity to overcome the treat and make revenue in exactly this field.

Concerns
Several companies and the government do not look into the Hyperloop according to Tim Vleeshouwer, because it might be an uncertain search field. Especially, there are issues of introducing a new infrastructure or dealing with various regulations from different countries that hinder the introduction of the Hyperloop. For trains an infrastructure is already established. However, in some countries like Brazil and the US there is a missing infrastructure for trains.

URBAN MOBILITY SOLUTIONS

Electrical vertical take-offs are a strong opportunity are at the moment in that EmbraerX is looking into. However, the company and the market does not have a lot of experience with this mobility form. Therefore, it is important that Embraer strengthens this field as much as possible and creates new strategies that strengthen the Embraer VTOL.

STRENGTH

Embraer already has the resources regarding VTOLs, and a collaboration with Uber in this area.

OPPORTUNITY

VTOLs are a strong trend and are part of a growing mobility market in the future that will be introduced approximately in 2025.

Concerns
To strengthen the innovation department of Embraer, it might be critical to look into eVTOLs. The competition already looks strongly in this area and Embraer should look furthermore for a strategy to differentiate itself in the future. Besides, urban VTOLs are solutions with only a low number of passengers (3-6). For sustainable requirements it is preferable to have a bigger amount of passengers in order to save energy that would be necessary to fly the passengers separately.

INTEGRATION OF DIVERSE MOBILITY FORMS INTO ONE SEAMLESS SYSTEM

Connecting different modes of transports has the advantage of creating a seamless and more joyful passenger experience. It is a huge and growing market opportunity in the future as called 'Mobility-as-a-Service' (MaaS). Through connecting different modes of transports a system solution can be found that can have a higher sustainability impact than only one mode of transport can have. Furthermore, there is an opportunity to transform this experience to a complete seamless system in the future (e.g. 50-100 years), for example flying airplanes that transform on the ground towards a train and bring the passenger seamlessly to the final destination.

STRENGTH

Embraer can use the commercial airplanes in this strategy and use its strong relationship to commercial airlines.

WEAKNESS

Competitors did not look in the intersection of trains and airplanes or train planes as an innovation strategy, which is an opportunity to differentiate from competitors in the field of innovation and overcoming the weakness of having the same/ similar innovation like the competition.

OPPORTUNITY

- MaaS is a strong growing market.
- Airlines look into trains to create more smooth and seamless passenger experiences.
- There is an innovative trend potential of flying trains in the future.
- Trend potential: flying trains, train plane hybrid
- It is possible for an aircraft manufacturer to manufacture trains as can be seen from the example of Bombardier.
- It is possible for an aircraft manufacturer to manufacture also trains as the example of Bombardier shows.

THREAT

- Looking into trains would make Embraer less vulnerable towards political interventions and a growing scepticism from the consumer side.

Concerns
Combining trains and airplanes completely might be possible in 50 to 100 years, which is out of the scope. However, it is possible to connect the passenger experiences through other opportunities

SUSTAINABLE FUELED 30-SEATER AIRCRAFT

In 2035 Embraer should launch at least its first prototype of a hydrogen fueled airplane in order to be able to compete with the competition in the following years.

The competition Airbus, Boeing, and NASA are already looking into hydrogen airplanes, and it could mean a disadvantage for Embraer not to look at this field at all. Electric VTOLs will only be a niche market in the future, while the future of sustainable aviation fuel might rather be mainly hydrogen. The first flying prototype of a hydrogen airplane is planned for 2025 (Jeung, 2018), it will commercially start

flying probably around 2035 with approximately 30 seats (interview Paul Peeters), and be fully available in 2050 (interview Jaap Vleugel).

Electrical airplanes of 30 seats might already be viable some years earlier around 2025-2030 and create a new sustainable segment opportunity in the future.

STRENGTH

Commercial aviation is a strength of Embraer. Especially, reducing the seat number to 30 seats means having a new segment for Embraer and creating a new opportunity.

WEAKNESS

Embraer is weakened in the amount of revenue streams and had to reduce the amount of employees from 21,000 to 7,000 due to the joint venture with Boeing. The 30 seat segment would mean an independent revenue stream that only Embraer benefits from and not Boeing and would strengthen Embraer.

OPPORTUNITY

Electrification of mobility is a growing market.

Concerns
There are still issues with the technology of hydrogen and electric airplanes. The process of creating hydrogen takes a lot of energy and the fuel is more expensive than kerosene at the moment. Electric batteries in airplanes take a lot of space and are relatively heavy. Furthermore, the capacity of the battery limits the flying distance. Additionally, for hydrogen and for electricity the infrastructure is missing.

CONCLUSION

Comparing the different search fields SWOT elements and potential impact, the search field 'Integration of diverse mobility forms into one seamless system' was chosen.
Because this search field is about a system solution and not only one mode of transport a bigger impact on sustainability can be achieved. It is about system optimization, making everything more fluent, cheaper, and saving energy. Also, car ownership shall be reduced through this solution, which would lead to less vehicles and therefore the usage of less resources.
In case the system uses less resources it is easier to provide a mobility demand for a growing population. Additionally, within the system consumers can be nudged easier towards sustainable solutions.
Another benefit is that a system solution might be cheaper than financing only one mode of transport and would suit the low cost mentality of consumers in a better way. Besides, Embraer would not be alone in building an infrastructure, but further mobility providers could take a part in integrating a better infrastructure.
Additionally, in a system of integrated mobility experiences Embraer can take its individual role with its mobility products. A sustainable 30-seater airplane, which was mentioned as well as a search field and can be the product integrated into this system. Integrating the product into a system has the advantage for example to raise awareness through other modes of transport about the product. The 30-seater can be advertised at the MaaS platform to introduce the experience to passengers. Also, through paying for the whole mobility journey instead of only for the journey with the 30-seater airplane, offering a cheaper ticket price is possible.

A sustainable and cost-efficient solution for a growing population that makes it easy to act in a sustainable way and helps in building a better infrastructure for sustainable forms of transport.

6.2

Envisioning a **Sustainable Future System**

THE FUTUE OF SUSTAINABLE MOBILITY

A sustainable direction considering the environment, the way people feel during the journey and around the mobility experience, but also the needs of Embraer as a company brings new value to Embraer. In the future it will be more about considering the whole journey of the passenger instead of looking at one mode of transport separately.

Based on the search field a vision was developed. In design roadmapping it is a common practice to integrate company stakeholders, who will further work on the project in the vision creation process. Due to the fact that Embraer is in the negotiation process with Boeing, the company employees were not allowed to give any kind of information to further stakeholders, and could not get involved in the vision creation process. Together with Peter Vink a predetermined vision was enhanced to create a shared vision. As an initiator of the project Peter Vink will be involved in the collaboration between TU Delft and Embraer for the coming two years, which makes it relevant to include him as a stakeholder.

The following vision was created:

We envision the vanishing of different modes of transport towards an intelligent seamless one mode transport system. Sustainable impactful and emission limiting mobility will move you to the place, where you need to be, and provides you a passenger experience that supports you in mastering your day.

EXPLANATION OF THE VISION

A concrete product was on purpose not mentioned, because various solutions can lead to the same goal in the end. As in the introduction of this project mentioned there is always the possibility of unforeseen things happening, which might create the need to explore new directions. A roadmap needs to be checked over time and adapted, and the vision supports giving a future direction to the project.

'the vanishing of different modes of transport towards an intelligent seamless one mode transport system'
At the moment the different modes of transport are separated. There are cars, trains, bicycles, airplanes, motorcycles, scooters, and further modes of transportation. Changing the mode of transportation is necessary sometimes to move from A to B. Because there are separated modes of transport, which work separately and not as one system, issues like complicated travel routes, waiting times, infrastructure barriers, and congestion arise. Also, the ownership of mobility of consumers leads to a high resource using system. A system integration of different modes of transport towards one functioning system can avoid issues like waiting times, congestion, and infrastructure barriers, and create a more seamless experience. With MaaS this system integration can be achieved. Smart technologies have the ability to enhance the interaction between the different components and modes of transportation towards one working system.

'sustainable impactful and emission limiting mobility'
In times of climate change, scarcity of resources, and consumers that question the aviation industry in terms of sustainability it is relevant to act

as sustainable as possible. Emission limiting and even zero emission mobility is feasible today, but still has constraints that will improve in the future. Embraer will need to prepare for that coming future of new fuels to be able to stay competitive on the market.

'move you to the place, where you need to be'
There are 7.7 billion people in the world (worldometers, 2019), and the population is growing. Aligning the current consumption with sustainable behaviour is currently an issue and might get more problematic with more people. For this reason it should not be the goal of economy to grow as much as possible, but take the environment into account. Also, more mobility might create more and new issues like congestion or noise pollution. For this reason, it is relevant that people preferably travel, when they really need it. For example, someone suggesting a sustainable mobility solution might easily come up with a bicycle and be against vehicles. But in case of a life threatening emergency, no one would suggest to bring the life threatened patient by bike to the hospital just for the sake of sustainability. To decide, which needs should be preferably fulfilled one can take the hierarchy of user needs by Maslow (1943) as an orientation (see figure 31). Needs at the bottom of the hierarchy are rather preferable to fulfill than needs at the top of the hierarchy like self-fulfillment.

'provides you a passenger experience that supports you in mastering your day'
Mobility is not only about moving, it is also about the experience. While being in an airplane you can read, watch a movie, work, eat or do other activities. An experience can be seamless so you can do activities without interruption or it helps you to relax and puts a smile on your face that helps you mastering your day. Especially, in times of autonomous driving, when it will be less about driving yourself, but doing activities inside the vehicle the passenger experience becomes more relevant.

Figure 31: Hierarchy of user needs might help as an orientation about the urgency to fulfill the user need. Needs at the bottom of the hierarchy are more urgent to fulfill. Self-fulfillment needs related to mobility are for example travelling to explore the world. Basic needs related to mobility are for example to transport of an injured person.

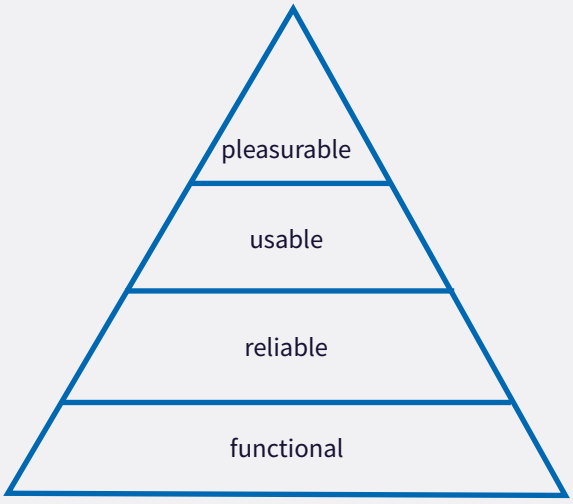


Figure 32: Aarron Walter's hierarchy of user needs. A product/ service should rather be placed in the upper part of the hierarchy.

Aarron Walter developed in his book ‘Designing for Emotion’ (2011) a hierarchy of user needs that indicates the relation of a product/ service to the user. The hierarchy of Aarron Walter can be seen in figure 32. In order to create a high user value the product and/ or service should be in the upper part of the hierarchy, which means it should be preferable pleasurable to the user. Pleasurable can mean, that it creates a valuable experience or even has a personal importance to the user.

Figure 33: Visualized vision

6.3

A Young Sustainable Brand

NARROWING DOWN THE TARGET GROUP

Introducing innovation in the US is easier for Embraer since the company is especially strong in this market. Choosing a young target group of generation Z is suiting for EmbraerX with its young brand personality.

For the idea generation in the next phase it is relevant to define a target group to adjust the idea to the user groups needs. Looking back at the brand analysis of EmbraerX, EmbraerX targets everyday people. The innovation department has a young personality. Suiting to the character of EmbraerX the target group of a young generation was picked.

As a target country the United States was chosen. While analyzing Embraer it was found out that the Brazilian aircraft manufacturer is especially strong in the US market in terms of commercial aviation. Because Embraer is already established in this market it will be easier for the company to enter the US market with further and new innovations.

Concentrating on the younger generation due to the young appearing brand of EmbraerX the generation Z was considered. The generation has the need to be sustainable, while growing up in a globalized world, where everything is connected amongst others through mobility, which often is polluting. Therefore, generation Z wants to be mobile in a sustainable way (Koutsoukos, 2019).

Generation Z (1994 onwards) grew up with different kinds of technologies and therefore people from this generation are often technology savvies. This generation enjoys communicating via social media, and is conscious about sustainability and the environment. In particular, Snapchat is the most popular application used by this generation (Leskin, 2019). Another popular form of entertainment of this generation is Netflix. 71% percent of generation Z have access to a Netflix account and watch it (Claveria, 2019).
Besides, generation Z also grew up in a global context and often has international experience. Work is not a priority for this generation. (Bejtkovský, 2016) Figure 34 shows a summary of what generation z is about.

Generation Z: sustainable conscious, global, technologically skilled, preference on social media, Snapchat, Netflix and internationally mobile

Figure 34: What generation Z is about. Being mobile in a sustainable way is important to this generation

Key Insights

A NEW INNOVATION DIRECTION FOR EMBRAER

SEARCH FIELDS

Current issues and gaps that were found out are providing a sustainable mobility solution for a growing population
- consumers and companies not acting sustainably and consumers often prefer low-cost
- options, while sustainable products often are expensive
- there is a missing infrastructure for sustainable fuels and modes of transport

Based on the analysis results the following search fields were created:
(1) sustainable shift support for commercial airlines, (2) substitution of short haul flights, (3) urban mobility solutions, (4) integration of diverse mobility forms into one seamless system, (5) sustainable fueled 30-seater. While most search fields deal with only one mode of transport, search fields (4) aims for a system solution and can therefore most likely solve the found issues and gaps, and have a high sustainability impact. Therefore, search field (4) was selected.

ENVISIONING A SUSTAINABLE FUTURE SYSTEM

Based on the selected search field a future vision for Embraer was created:

We envision the vanishing of different modes of transport towards an intelligent seamless one mode transport system. Sustainable impactful and emission limiting mobility will move you to the place, where you need to be, and provides you a passenger experience that supports you in mastering your day.

A YOUNG SUSTAINABLE BRAND

As a target market the US was selected since Embraer is especially strong in this market.

Generation Z appears to be a suiting target group for the young brand personality of EmbraerX. The generation has a need for sustainable mobility, is global and technological skilled.

The next chapter provides information about in which concept the search field, and vision was turned into.

7

From Busses To Airplanes

HOW EMBRAER CAN LEARN FROM A BUS MANUFACTURER TO ENABLE SUSTAINABLE AVIATION FUTURES

This chapter provides information about the idea generation of the concept and the final strategic concept itself. Through co-creative sessions ideas were generated. Experts and students supported with their variety of backgrounds to generate a wide range of ideas during the co-creative sessions. The final strategy is divided into three steps that reach the vision in 2035. Furthermore, a business model explains in this chapter how Embraer can generate revenue through the strategy. A target group and market is further described to specify which needs the strategy addresses. Additionally, a visualized strategic and tactical roadmap allow stakeholders to understand the plan and to make decisions about it. Besides, a time pacing strategy explains the time pacing of the strategic plan.

7.1

Co-Creation
With Multidisciplinary Experts

FROM THE EMBRAER BUSINESS CHALLENGE TO THE PEOPLE IN TRANSIT MEETING

A one day business case with engaged students with multiple backgrounds and an idea generation session with experts supported the concept creation.

THE EMBRAER BUSINESS CHALLENGE

The value of co-creation has already been mentioned. Co-creation allows to see ideas and problems from a different perspective. Participatory design can bridge the gap between a company-centric way of thinking, which is amongst others about profitability, to a more customer-centric way of thinking, which reflect users desires, hopes, and wishes (Prahalad & Ramaswamy, 2002). Co-creation is about creating personalized value for consumers that fits to their situation (Prahalad & Ramaswamy, 2004).
EmbraerX already discovered the value of co-creation for themselves and practices this technique. As an EmbraerX project this thesis also practices participatory design. A business challenge was hold on the TU Delft campus. Over several weeks the event got promoted through posters, and Facebook posts. The event reached 3.3k people on Facebook, 40 people responded to the event on Facebook, people engaged with the event, invited friends and commented on the event. 22 students applied for the event and 14 students with different backgrounds participated at the 'Embraer Business Challenge'. The students had the following study backgrounds: Aerospace Engineering, Complex Systems Engineering & Management, Business Economics, Strategic Product Design, Sustainable Energy Technology, Air Transport Operations, and Design for Interaction. Additionally, participants had internship experience at Embraer, Airbus, and Porsche AG. All participants were divided into 4 groups and worked one whole day on an idea, which they presented in the end. Figure 35-41 shows pictures of the business challenge event.

Amongst others, through a participatory business challenge an idea was developed. The business challenge event reached alone on Facebook 3.3k people.

PEOPLE IN TRANSIT MEETING

A further brainstorm to improve the project was done with stakeholders, who are involved in the project: Luciana Ribeiro Monteiro (Embraer), Peter Vink (People in Transit), Suzanne Hiemstra-van Mastrigt (People in Transit), Yu Song (People in Transit), Erik Jan Hultink (supervisor of this master thesis), and Frederic Kindervater (Master student). Also, within this meeting valuable insights could be made, which can be found in the appendix.

Figure 35

Figure 36

Figure 37

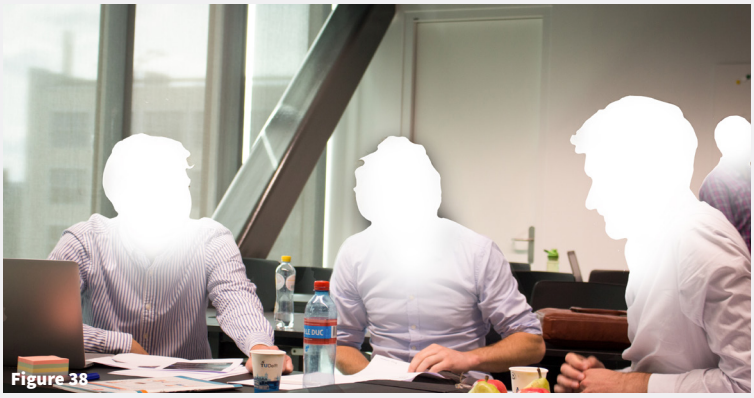


Figure 38

> **This week we had the opportunity to work with Embraer on a Business Challenge for shaping the future of sustainable mobility. With a team of multi disciplinary talents, we envisioned a scenario traveling in 2035 with a seamless journey by incorporating sustainable solutions such as EmbraerX.**
>
> *- Participant engagement on LinkedIn -*

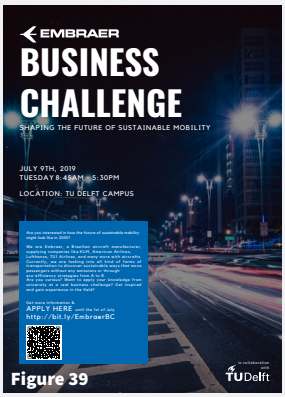
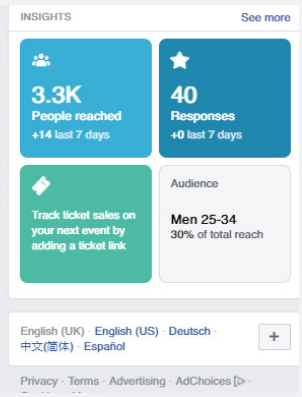


Figure 39

Figure 40



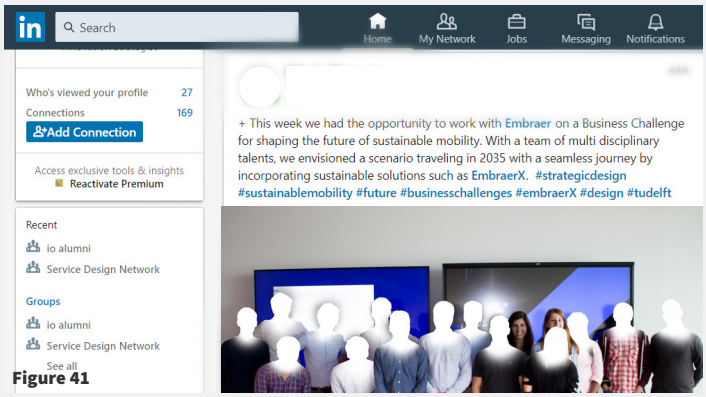


Figure 41

Figure 35: Photo of all participants and the organizers after the Embraer Business Challenge
Figure 36-38: Participants working on the case
Figure 39: Promotion poster to get students interested to participate in the business challenge
Figure 40: The Facebook event reached 3.3K people and received 40 responses
Figure 41: Participant posting about the business challenge on LinkedIn

7.2

Smart Sustainable System Experience

ROADMAP SOLUTION

Investing in sustainable existing forms of transportation like sustainable busses at the moment, can avoid major threats. Sustainable aviation is difficult to realize now, but needs to be prepared to enable sustainable mobility also in the skies in the future.

THE IDEA

The trend scenarios showed that especially the future of unsustainable forms of mobility might be uncertain.
In times of dramatic change towards sustainable mobility due to political interventions society might rely more on existing and established sustainable forms of transportation, e.g. sustainable fueled trains, busses, or bicycles. Sustainable aviation is feasible in the future. However, it will take several years to establish new infrastructures for sustainable fuels, for this reason establishing sustainable airplanes now might be difficult to realize, especially in a competitive environment.
For this reason, it will be relevant for Embraer to count also nowadays more on sustainable forms of transport and even learn from the sustainable fuel technology to establish it later for aviation. Enabling zero emission especially for commercial aviation will also help consumers to regain trust in the aviation industry, that has been damaged through the awareness that the aviation industry is not sufficiently acting sustainably. To act against the trend of avoiding or substituting airplanes, sustainable alternatives need to be introduced. Also, the trend of people travelling and wanting to explore the world became noticeable, which can foster environmental issues and climate change. For this scenario, Embraer might also need to prepare and enable sustainable aviation for long range flights.
A sustainable fuel that has the potential to be zero emission and be used for long ranges is hydrogen.
Figure 42 illustrates that it is safer for Embraer to focus on sustainable ground vehicles now, but that over time when sustainable aviation is feasible Embraer can shift its focus again towards airplanes. The goal of the roadmap is to go step by step towards the vision of a hydrogen airplane for commercial usage, while using a low risk strategy.
Commercial aviation is a strength of Embraer, which the company should continue. However, Embraer only can continue with commercial aircraft up to 50 seats to make independently revenue from Boeing.

The goal of the roadmap is to go step by step towards the vision of a hydrogen airplane for commercial usage embedded into a MaaS system.

Figure 42: While it is easier and safer for Embraer to rely on sustainable ground vehicles now, over the years sustainable aviation will get more important and feasible for Embraer.

Figure 43: Reasons for selecting hydrogen as a fuel, and MaaS and the USA as a market.

Small recap: Why creating a hydrogen airplane?

Hydrogen
… is the most abundant element in the universe (Campen, Mondal, & Wiltowski, 2008) and does not face scarcity of resources, which electric or kerosene fuel might do. Especially electric mobility might face its limitations due to its scarce material (Vleugel, 2019).
… fuel has zero emissions and only emits water vapour (Yilmaz et al., 2012).
… is more lightweight and energy dense than battery electricity or kerosene (Balat, 2008). Therefore, hydrogen mobility can reach longer distances (Verstraete, 2013). In particular, battery electricity is limited in capacity and would rather be suitable for short distances in the aviation industry.
… is estimated to get cheaper over the years and even will be cheaper than kerosene (Khandelwal et al., 2013)
… can be refueled quickly (Gim & Yoon, 2012) and takes less time than refueling electricity.

Small recap: Why MaaS?

MaaS has the ability to connect different modes of transport and make a journey more sustainable. Furthermore, MaaS is about having mobility as a service instead of owning the different types of vehicles yourself, which is from a sustainability perspective preferable. The reduction of vehicle ownership can also lead to a reduction of produced vehicles and provides more space. Due to less produced vehicles and less required space MaaS is a suitable solution for a growing population and also for dense urban areas.
Furthermore, MaaS is a growing future market estimated to be 9,500 billion dollar worth in 2035 (statista, 2017).

Why using the USA as a target market?

- Embraer is already established in the US and has a strength there in the field of commercial aviation.
- The USA is one of the countries with the highest emissions in the world. According to Wang (2017) the US are accountable for 14.58% of global emissions. To achieve a big impact it makes sense to start with a country with high emissions.
- It is possible to receive several governmental incentives for using hydrogen fuel.

Figure 44: Reasons for exploring the bus market.

Why exploring busses?

- Exploring first busses instead of aircraft is a low risk investment. A fuel cell electric bus might cost 650,000€ (Pocard & Reid, 2016). In comparison, the cost of the Embraer passenger plane E195 is around 48 million Euro. Investing in busses is approximately 74 times cheaper than investing in airplanes.
- From all kinds of mobility fuel cells powered by hydrogen can be found most likely in busses (NREL, 2019). For this reason learning from a bus manufacturer is the best way to learn more about hydrogen fuel cell technology.
- Embraers CEO Francisco Gomes Neto used to be a chief executive at the bus manufacturer Marcopolo SA and has experience in the field of busses. No other aircraft manufacturer has the connection to busses as Embraer does.
- Fuel cell vehicles and busses are a growing market. Worldwide the market of fuel cell vehicles is estimated to have 583,360 units in 2030. In North America alone there are estimated to be 118,847 units (Leo & Kumar, 2015). Verma & Agarwal (2019) estimate that the market will rise from 830 million dollar in 2018 to 11,600 million dollar in 2024 worldwide.

In addition, MaaS is a relevant factor of the roadmap. For the strategy the USA was set as a target market. Figure 43 on page 84 gives a clear overview why hydrogen as a fuel, MaaS, and the USA as a target market were selected.
The strategy is divided into 3 horizons that reach step by step towards a hydrogen airplane integrated into a MaaS system. Horizon 1 is a value enhancement of the current product/ service offer. Horizon 2 enables reaching the ideal scenario in the third horizon.

1ST HORIZON - COLLABORATIONS & NETWORKING - KNOWLEDGE SHARING & LEARNING ABOUT HYDROGEN (2020-2024)

In the first horizon the core action is to start a collaboration with a bus manufacturer, which produces fuel cell busses powered by hydrogen. This way Embraer can learn more about fuel cell technology and find out what potential issues of the technology are, and reliabilities. Furthermore, the bus manufacturers can share operational experience and share knowledge about operating fuel cells powered by hydrogen on a commercial level.
The learnings from the field help Embraer to later introduce a fuel cell aircraft powered through hydrogen themselves.
More reasons for looking into busses can be found in figure 44.

Collaborating with a bus manufacturer to learn about fuel cells powered by hydrogen for sustainable aviation futures

As a collaboration the bus manufacturer New Flyer is suitable. New Flyer is part of the NFI group, the largest bus manufacturer of North America with 8,900 employees. Within the NFI Group New Flyer has produced so far 44,000 electric and fuel cell busses. The company has experience with hydrogen fuel cell technology since 1993.

A target market or hydrogen fuel cell vehicles in the US is California. Fuel cell busses have especially been introduced there (Leo & Kumar, 2015) and the state aims to have a zero emission bus fleet by 2040 (P&S market research, 2019).

Want to know more about how New Flyer sees hydrogen fuel cell technology for busses? Scan The QR code. :)

In the US markets for busses are especially school busses, a market that is also expected to grow. North America alone is accountable for approximately 48% of the global school bus market (Research & Markets, 2019). Also, universities and student accommodations can get better connected through busses. For university students it will additionally be important to connect the busses to supermarkets for grocery shopping.

Equipping the busses with wifi that connects to a small entertainment offer for the students would be a value enhancement of the journey. Embraer has experience with entertainment offers through commercial aviation and can bring this value to the bus journey.
As Snapchat and Netflix are one of the most popular entertainment offers for the target group, collaborations with these companies can enrich the entertainment programme and the passenger experience. Furthermore, on the starting page of the entertainment offer the passenger gets informed about the sustainability of the mode of transport in comparison to other modes of transport. This way, awareness and consciousness is raised about the sustainability of mobility. A membership when taking the bus can decrease ticket prices for the passenger. Besides, data will be collected to find out the most desirable traffic points of the students and to position mobility choices at these traffic points.

Figure 45 illustrates the bus experience with its user values and trends

Further Collaborations

The Hydrogen Council
The Hydrogen Council is an industrial collaboration that supports the development of hydrogen. With

joint industrial forces it will be easier for Embraer to gain knowledge in the field of hydrogen and connect to further industrial partners. Want (2018) presents in his article an interesting idea how joint industrial forces can enable a better transition towards hydrogen. Introducing hydrogen as an individual company might be challenging, through collaborations hydrogen can be produced on a mass scale and therefore get cheaper. In particular, Want (2018) suggests to connect different stakeholders digitally, but of course also a connection through the Hydrogen Council is possible.

Political Support
Financial incentives and support to establish hydrogen airplanes and an infrastructure for the coming horizons will be necessary. In the US several governmental institutions support companies through financial incentives, reduced taxes, or subsidies and grants. The US Department of Energy (DOE) for example gives funding to companies looking into hydrogen. Also, the Zero Emission Airport Vehicle and Infrastructure Pilot Program financially supports companies creating a hydrogen infrastructure at airports. Also, exemptions from fuel taxes through the Internal Revenue Service (IRS) are possible as well as financial incentives through the Business Energy Investment Tax Credit (ITC).

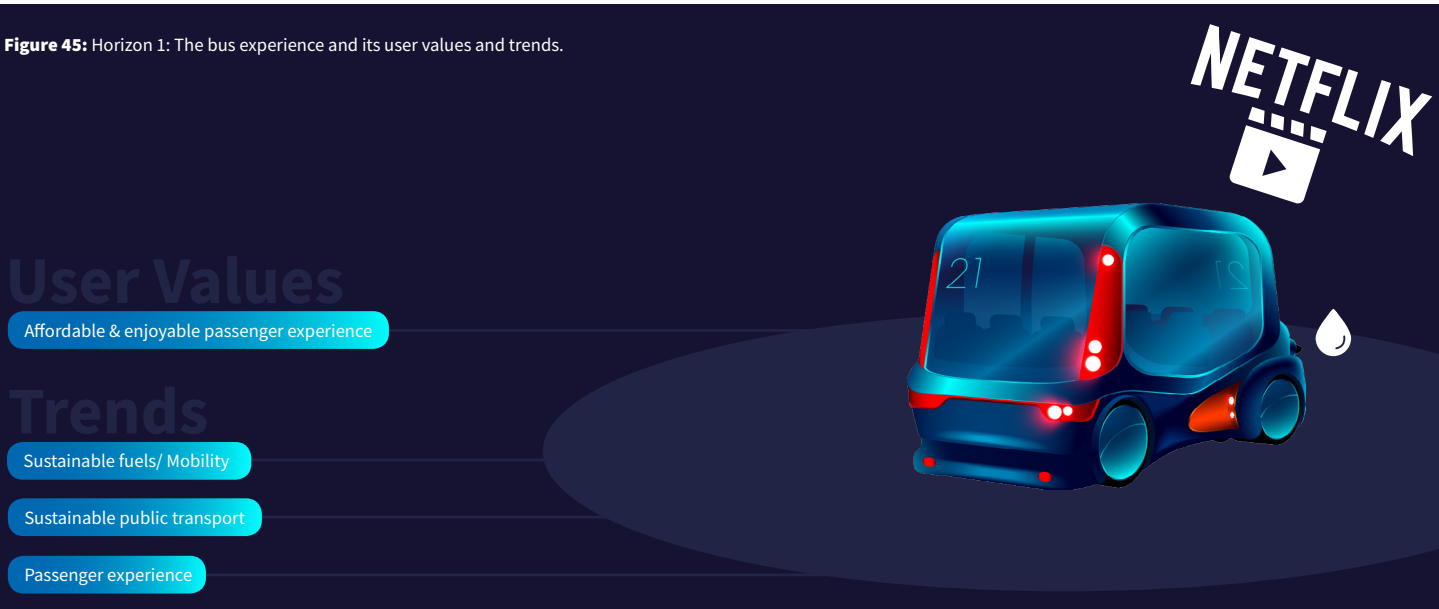
Social & Sustainable Suppliers
Embraer can make use of social and environmental suppliers and sustainable materials to build their airplanes and VTOL to gain experience and apply the materials also later at the hydrogen airplane. The

GOOD TO KNOW

Currently, companies such as Airbus, BMW, Daimler, Honda, Toyota, and more mobility companies are part of the Hydrogen Council and take the development of hydrogen seriously.

AIRBUS BMW DAIMLER HONDA TOYOTA

Figure 45: Horizon 1: The bus experience and its user values and trends.



sustainability impact of the materials can be measured through a life cycle analysis (LCA), and later be used to communicate the sustainability impact towards customers. Through sustainable materials, the risks of scarcity of resources and harmful emissions through low environmental impact materials can be avoided.
Also, recyclability should be considered. It is possible to recycle at least 90% of an aircraft (Delgado Gozalvez et al., 2018). Recommendable companies that recycle are for example AELS (Aircraft End-of-Life Solutions) and the Rotterdam based company VerdraaidGoed.

2ND HORIZON - GAINING EXPERIENCE WITH HYDROGEN & CONVINCING STAKEHOLDERS (2025-2034)

To get closer to the vision of a hydrogen airplane in the second horizon Embraer introduces its first prototype of a hydrogen airplane. For keeping the costs low an existing regional aircraft can be taken and only the propulsion system needs to be changed from a kerosene propulsion to a fuel cell powered by hydrogen. The prototype serves for two purposes: First, to gain more practical experience in the application of hydrogen technology. Second, to convince stakeholders regarding the hydrogen technology. According to experts, that were recruited during the concept development and validation phase the public might have concerns regarding the safety of hydrogen, because hydrogen potentially is inflamable. In fact, hydrogen and kerosene are both inflammable, but kerosene would rise the fire even more than hydrogen. Therefore, kerosene can be considered as more dangerous than hydrogen (Seeckt, 2010). Through testing a prototype in public the trust and confidence of the public in the technology can be gained. Also, the prototype can convince certification authorities regarding the reliability of hydrogen technology.
For distributing risks Embraer can rely on a startup building the prototype. Aerospace students, who worked on the hydrogen fueled aircraft concept "The Greenliner" (Delgado Gosalvez et al., 2018) and students from AeroDelft, a project team that currently is building a hydrogen aircraft prototype, have experience in the field and plan to found a startup startup that explores further the possibilities and opportunities of hydrogen airplanes. The startup can help Embraer building the prototype.

Building a hydrogen airplane prototype to convince stakeholders

While the prototype is under development, Embraer further develops the MaaS system.
Since especially students from university often rely on cars it should be considered to also get in touch with a car sharing service and include bus and car sharing as part of the membership programme. Also, bicycles are often used by students and should be part of the mobility membership, as well as electric or hydrogen cars. However, it needs to be considered that electric and hydrogen cars might not always been taken by the target group to avoid additional costs. Around 2025 Embraer also aims to launch its VTOL, which gets integrated into the system.

In the first horizon the entertainment offer was mainly provided via Wifi. In the second horizon displays get implemented into the different modes of transport belonging to the MaaS system that do not require the passenger to drive, e.g. inside the busses, or the VTOL. The displays will make it easier to access the entertainment offer in case the passenger doesn't have a suitable device to access the offer inside the vehicle. The membership also enables having access to the entertainment offer when not being inside the vehicle, and makes it therefore possible to access the entertainment offer in case the passenger decides to use the car as part of the MaaS system.
Through sustainable milestones the passenger gets rewarded for taking sustainable mobility choices and new entertainment features, e.g. a new series gets opened up to the

Rewarding the passenger for making sustainable mobility choices

passenger, which otherwise would cost additional money.

In 2030 the target group gets scaled. Students, who now left university can continue using the MaaS system. It can be expected that the needs of the target group will change after starting a job, which provides them more money. Therefore, choices like sustainable hydrogen and electric cars will be more attractive in the system.

Figure 46 illustrates the strategy, user values, and trends of horizon 2.

3RD HORIZON - SMART SUSTAINABLE SYSTEM EXPERIENCE (2035)

Due to the preparation in the previous horizons Embraer can now introduce its first commercial hydrogen 30-seater airplane. The airplane can cover regional distances up to 2000 km. This distance covers for example the route from San Francisco to cities such as Seattle, Portland, Denver, or Las Vegas.

The MaaS system is now used by society, and the hydrogen airplane directly can get embedded into the MaaS system, and support a seamless and sustainable passenger experience. Autonomous vehicles and systems will be digitally connected and communicate to achieve a better connection time and a lower congestion rate.

A sketch was made to show how the hydrogen airplane might look like in 2035. The sketch can be found in figure 47. Also user values and trends of the third horizon can be retrieved from figure 47.

Embedding the hydrogen airplane into an integrated and smart MaaS system

Figure 46: Horizon 2: While Embraer builds its hydrogen airplane prototype to convince stakeholders the bus experience gets connected to various modes of transport. Passengers are getting rewarded for taking sustainable mobility choices

User Values

Affordable, enjoyable, seamless & rewarding passenger experience

Trends

Sustainable fuels/ mobility

Sustainable public transport

Passenger experience

Mobility-as-a-service

User Values

Affordable, enjoyable, seamless, rewarding & smart passenger experience

Trends

- Sustainable fuels/ mobility
- Sustainable public transport
- Passenger experience
- Mobility-as-a-service
- Autonomous vehicles
- Connectivity

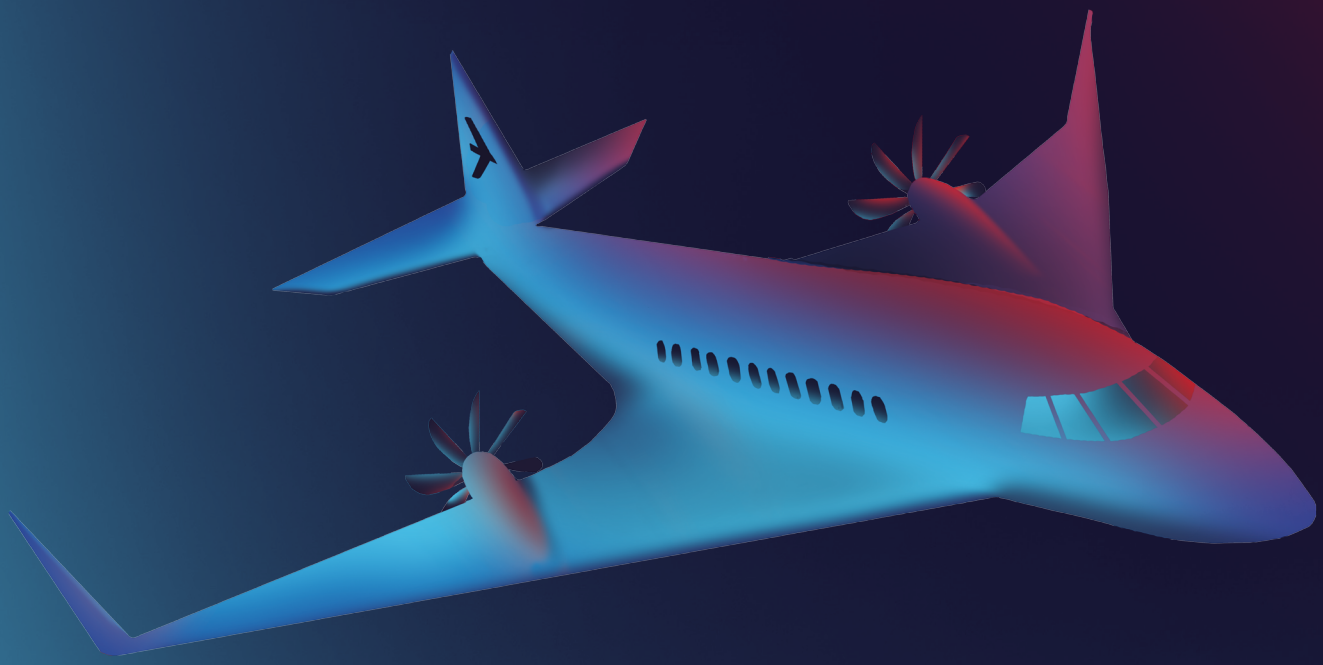


Figure 47: Horizon 3: A sketch of the final hydrogen airplane can be seen. The airplane will be embedded into a smart MaaS system. Also, user values and trends of the third horizon can be seen in the figure.

7.3

The Value Flow of Stakeholders

A SUSTAINABLE BUSINESS MODEL

Knowledge exchange, and providing a sustainable mobility experience with engaging suting entertainment offer for generation z are key values in the business model.

1ST HORIZON

The knowledge exchange between Embraer and the bus manufacturer will be essential in the first horizon. Embraer learns more about the technology of fuel cells powered by hydrogen, reliabilities and operational experience from New Flyer. On the other hand, New Flyer can benefit from Embraers knowledge about aerodynamics. Aerodynamics are not only relevant in aviation, but also can help busses to reduce fuel consumption (Muthuvel et al, 2013; Kanekar, Thakre, & Rajkumar, 2017) and therefore reduce operational costs. Also Embraers knowledge about leightweightness of vehicles can reduce fuel consumption and will be valuable for the bus manufacturer.
While having the knowledge exchange Embraer can also use the connection to New Flyer to start going into the market of mobility-as-a-service to connect mobility experiences. To incentivize passengers to use busses Embraer supports New Flyer in implementing a better passenger experience.
Furthermore, Embraer and the Hydrogen Council support each other in enabling a sustainable hydrogen future.
The government supports Embraer financially in creating a hydrogen airplane to provide for society sustainable mobility. The whole business model and value flow of the first horizon can be retrieved from figure 48.

2ND & 3RD HORIZON

Additionally, to the business model in the first horizon, in the second and third horizon various mobility experiences are getting connected. The connection of mobility experiences provides the passenger a more cost efficient and seamless transport system with lower congestion rates. Through including hydrogen airplanes in the system in 2035 the subscription even enables the passenger to travel longer distances up to 2000 km. The business model and value flow which complement the first horizon can be seen in figure 49.

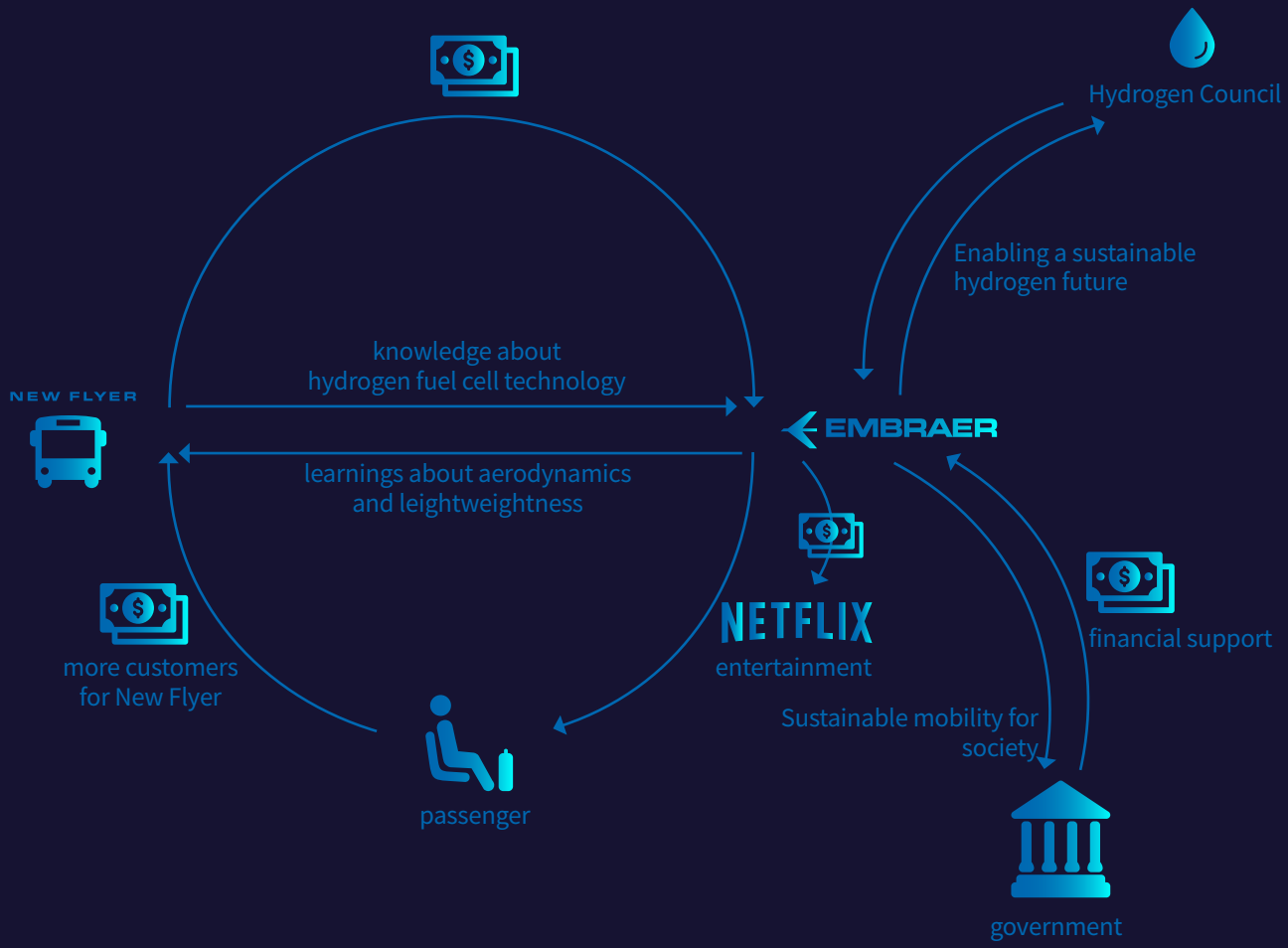


Figure 48: Business model and value flow first horizon

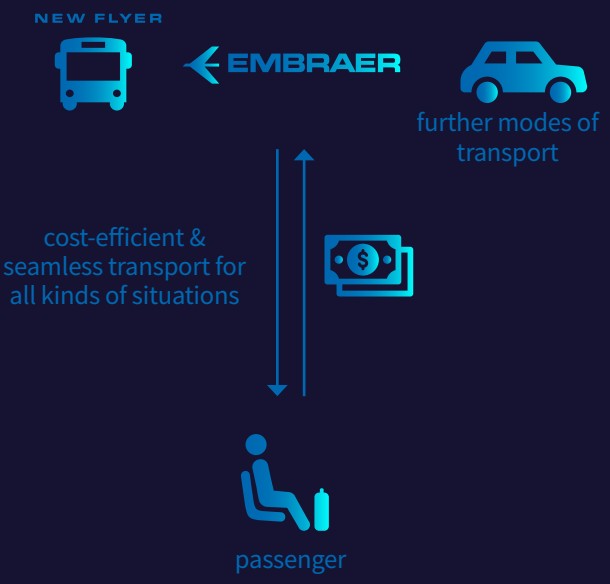


Figure 49: Additional business model and value flow second and third horizon

7.4

Getting Around **in the US**

DEFINING A TARGET GROUP

Busses are a cheap way for students to get around. However, also other types of transport need to be considered when attracting the target group.

Depending on the horizons the target group and also the target groups needs change, because of changing life circumstances over time.

Through secondary research of reports of study experiences in the USA and through interviewing Gabriele Diehl and Frederic Kindervater, who have both lived in the USA for half a year (see figure 50), the mobility needs of the target group has been analyzed.

In horizon 1, the need bringing students from home and student accommodations to the educational institutions and to supermarkets is fulfilled. Therefore, in horizon 1 basic needs are fulfilled as can be seen in figure 51.
In the USA it is common for college students to go by bus to college. Often, university students rely on cars (Detert, 2017; Uni Heidelberg, 2010; Uni Heidelberg 2017) and partly use busses to university or the supermarket (HAW Hamburg, 2012; Uni Heidelberg, 2014). Generally, busses are a more cost effective way to be mobile, which is usually prefered by students (Uni Heidelberg, 2016). However, in the USA several issues need to be overcome to make the bus more attractive than car ownership: more busses with better connections need to be established providing a quick and efficient infrastructure and reliability regarding the schedule as could be retrieved from reports (Uni Heidelberg 2017, Uni Heidelberg 2016). When introducing the first horizon there should rather be a focus on students arriving for their first year at university and international students, since these students usually do not have a vehicle. Changing the habit of students, who already have a vehicle might rather be challenging. As a further incentive for using the bus an entertainment programme is offered inside the bus to make the bus more attractive than the car ownership. Through also addressing college students in the first horizon, it is easier to connect to the target group, when they are starting their studies at university. While the first horizon is about a value enhancement, in the second horizon more advantages are introduced to nudge students to a MaaS system and away from vehicle ownership. Now, different mobility experiences get connected. The target group usually uses car sharing or bicycles , it will be important to also make these forms of mobility available to further create a desirable offer for the target group (Uni Heidelberg, 2014). Bikes are especially popular for students when getting around on the campus . In the first horizon it was mainly about basic needs. Through introducing further modes

Figure 50: Experiences were retrieved amongst others by these two interviewees to find out more about the mobility needs in the US

Gabriele Diehl (28)
German, went for half a year to college in the USA in 2010

Frederic Kindervater (25)
German, internship experience at Mercedes Benz in Silicon Valley in 2018/ 2019

of transport also other needs can be fulfilled by the target group, e.g. the psychological need of visiting friends or relatives (see figure 52). Although it is preferable to address basic needs as mentioned in chapter 6.2, it should be considered that especially university students might use competitive and more unsustainable offers. in case only basic needs are addressed. Therefore, a trade off needs to be done. Also, in the third horizon the need of seeing friends and family is getting addressed as the hydrogen airplane gets introduced. Besides, students are brought from the airport to the campus by bus in this horizon, which is already a practice in the USA (Detert, 2017).

Figure 51: In the first horizon especially basic needs are addressed: using mobility to get to the educational institution or to the supermarket

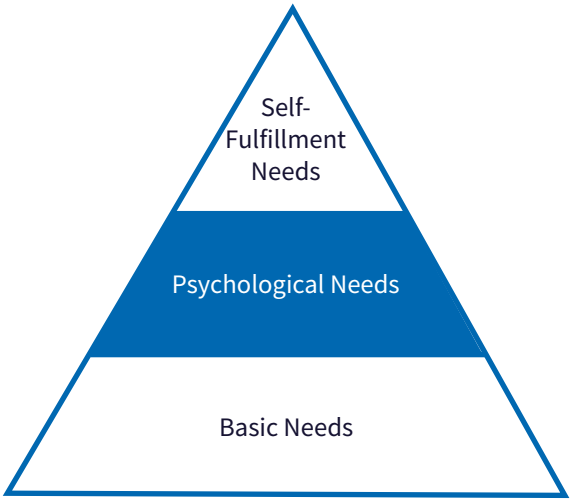


Figure 52: In the second and third horizon also psychological needs are addressed: connecting to friends and relatives.

7.5

Convincing Investors

STRATEGIC ROADMAP

A website engages investors in supporting Embraer with its strategy

Essential for the strategy will be to convince investors to support the strategy. For the approach roadmapping it is common to create a roadmap that shows investors, which actions the company wants to take and how they are connected to user values and trends. Presenting the strategy on an interactive website is one of the most suiting ways to convince potential investors. Therefore, the following website was created:

https://www.melanie-rumpf.com/embraer

Please, open the website preferably as a desktop version.

The website is a prototype of a strategic roadmap, that Embraer can implement on their own website. After an introduction page on the website, the user gets directed to the next page, which tells about goals of Embraer to be global, connect worldwide, and be at the same time sustainable. This wish of wanting to be globally connected and to be sustainable is reflected in the needs of generation z. Furthermore, it is demonstrated that investors are needed to reach a high impact, which is challenging to achieve for one company alone like Embraer. On the next page, the vision is presented. Also, the general idea is introduced to the user. Afterwards, the strategy is explained in more detail. At the end the investor is directed to an opportunity to get in touch with Embraer.

7.6

A Plan For the **Management & Product/ Service Developers**

TACTICAL ROADMAP

The tactical roadmap gives visually an overview of the strategy, how the strategy is connected to different values and trends, and how the plan can get implemented using various resources.

Furthermore, a tactical roadmap was created. The tactical roadmap supports the management and product/ service developers in understanding the strategy, making decisions about it, and implementing the strategy. The full roadmap can be found on the following two pages (figure 53).
Columns divide the different horizons and show the strategy development on a timeline from 2020 towards 2035 leading towards the future vision. Market trends and user values are connected to the product/ service offer of each horizon. Below the product/ service offer on the tactical roadmap, different technologies can be found that are relevant for the PSS system. Relevant technologies are the fuel cells, the development of VTOLs, and autonomous and smart systems. Below the row of technologies, resources can be found. The resources indicate, which team within Embraer will be required to implement the strategy. Additionally, it is shown which partnerships are necessary for realizing the strategy. It is relevant to learn from the bus manufacturer New Flyer about fuel cell technology. Netflix and Snapchat are important to offer an engaging experience inside the vehicle. The Hydrogen Council provides industrial support for brining the technology of hydrogen forward. Since Embraer is B2B oriented, a service provider needs to manage the MaaS system from the second horizon onwards.
Social and sustainable suppliers are integrated to provide the MaaS system and airplanes of Embraer with sustainable resources. During the second horizon a startup supports Embraer in building a prototype of a hydrogen airplane. The MaaS system in the second horizon requires different mobility providers to connect the different mobility experiences with each other. Siemens and Rolls Royce provide the hydrogen propulsion and engine for Embraer. The last row shows the development of the amount of investment that is required for the two modes of transport, busses and aircraft. Drivers and threat indicate why it is relevant to invest into these forms of mobility.

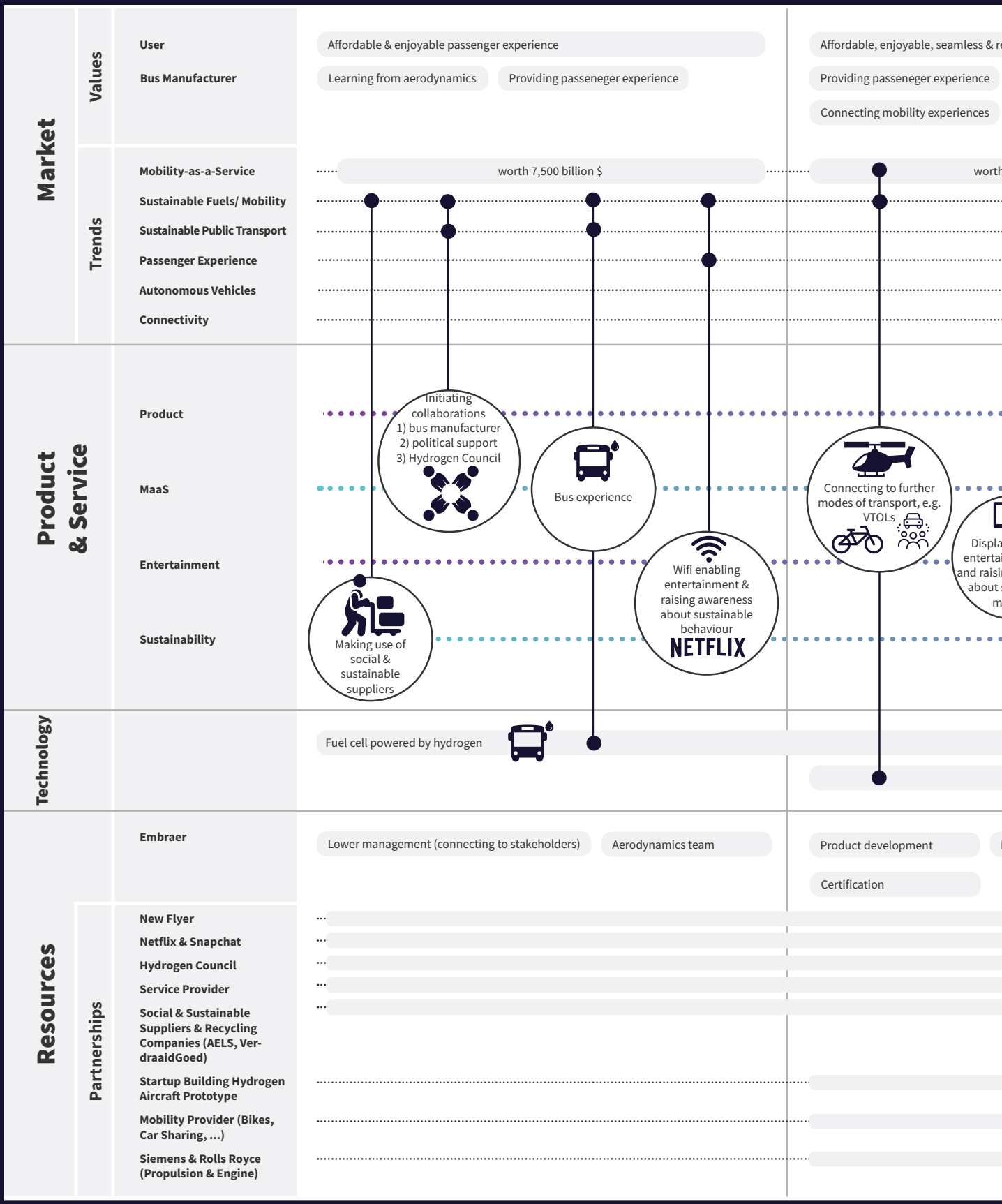
Figure 53: Tactical roadmap

Horizon 1

Collaborations & Networking -
Knowledge Sharing & Learning About Hydrogen

Ho

Gaining Expe
Convin



2020 - 2024

orizon 2

rience With Hydrogen &
cing Stakeholders

Horizon 3

Smart Sustainable System Experience

ewarding passenger experience

Stakeholder management

Affordable, enjoyable, seamless, rewarding & smart passenger experience

Providing passeneger experience

Stakeholder management

Connecting mobility experiences

Bridging long distances

9,200 billion $

worth 9,500 billion $

Prototype: hydrogen aircraft

ys offering
inment offer
ng awareness
sustainable
obility

Membership reward for choosing sustainable mobility forms

Autonomous vehicles

Hydrogen airplane

Digital connection of vehicles in real-time

System efficiency

VTOLs

Autonomous & Smart Systems

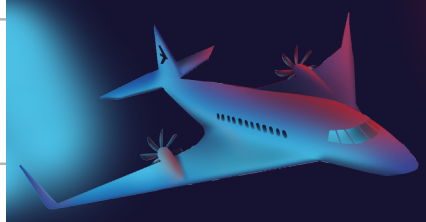
Marketing for product acceptance

Product development

Marketing for product acceptance

Certification

We envision the vanishing of different modes of transport towards an intelligent seamless one mode transport system. Sustainable impactful and emission limiting mobility will move you to the place, where you need to be, and provides you a passenger experience that supports you in mastering your day.



Hydrogen getting cheaper than kerosene

Technological development of hydrogen airplanes

Collaboration to achieve a hydrogen future

Subsidies for future sustainable aviation

Tax incentives for sustainable aviation

Airplanes

EMBRAER

2025- 2034

2035

7.7

Timing
Smartly

TIME PACING STRATEGY

Technological development mainly determines the time pacing strategy. The competitor time pacing makes aware about how often Embraer should release innovation news to the public.

DEPENDING ON THE TECHNOLOGICAL DEVELOPMENT

The time pacing mainly depends on the technological development of the hydrogen airplane. It can be expected that building a prototype in the second horizon requires 3 years. Additionally, the strategic roadmap would need to be accepted by the management of Embraer, which might take around 1 year. Another year can be calculated, in which Embraer learns basic requirements about fuel cells powered by hydrogen from the bus manufacturer. For this reason, the second horizon is expected to start in 2025. Another driver for the year 2025, is the introduction of Embraers VTOL, which will be introduced during that time. In that time the MaaS system supports in connecting mobility experiences with the VTOL.
The first commercial hydrogen 30-seater airplane is expected in 2035 according to Paul Peeters (2019). FHC (2019) sets the date at 2037, Delgado Gozalvez et al. (2018) a 20-seater at 2030, and van Zon (n.d.) estimates the entry of commercial hydrogen airplanes between 2025 and 2040. Building the final hydrogen airplane can take up to 10 years and can be started after the introduction of the first prototype in 2025. Therefore, the year 2035 is set for the launch of the hydrogen airplane. Also, building the airplane while parallel testing on prototypes is feasible.

The MaaS system orientates itself on the technological development of the aviation industry. However, the system requires in horizon 2, two steps. These are the steps of the MaaS system:

2020: Pivot - to test the acceptance level.
2025: Scale the system - to reach a higher impact.
2030: Scale the target group - to reach a higher impact.
2035: Make the system more intelligent and sustainable - to adapt to the technological development and possibilities during this time

Step 3 was added, because around 2030 it is expected that students, who are using the system, graduate and find a job. The target group should not switch to car ownership, but continue using the MaaS system.

DEPENDING ON COMPETITORS

Figure 54 shows the time pacing of the innovation of competitors. Regarding innovations mainly innovative air vehicles were considered. Innovations e.g. such as the usage of VR in aircraft, technological development and the improvement of efficiency were excluded in the diagram.
The competitors Bombardier and Dassault Aviation did not meet these criteria and were therefore not considered in the figure.
In figure 54 it becomes noticeable that especially innovation strong competitors like Airbus and NASA release yearly innovations. However, often the innovations released are not completely new concepts, but developments of previous concepts, e.g. several versions of electric planes or VTOLs. Lockheed Martin constantly improves its helicopters yearly. Boeing seems to launch every three years new innovative aircraft concepts. The company aims to introduce the and electric aircraft with the company Zunum in 2022, which can't be currently seen in the figure. Generally speaking, a higher frequency of innovations can be seen in the figure every three years.

Depending on the competitors Embraer should at least release every 3 years innovation concepts

Therefore, Embraer also should consider the time pacing of the competitors and release news about innovation concepts at least every three years. Releasing innovation concepts every year can increases the innovation potential of the company. Like the competitors Embraer would not need to release completely new concepts, but keep the public up to date about the current development of the collaboration with the bus manufacturer, the MaaS system, prototype and the hydrogen airplane.
A further collaboration with the faculty of Industrial Design Engineering of the Delft University of Technology can furthermore foster releasing innovative renderings about the future vision created in the master thesis or the development of the hydrogen airplane.

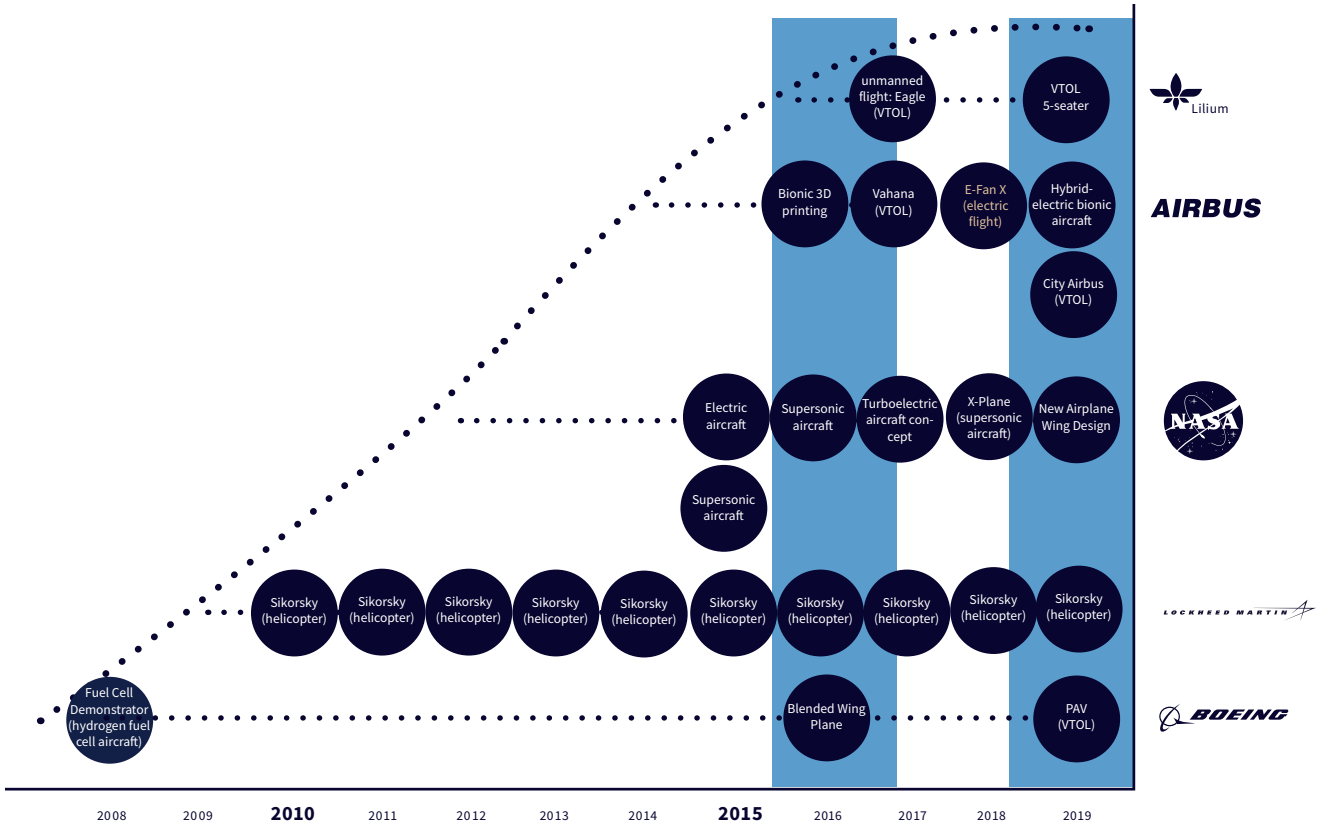


Figure 54: Time pacing of the innovations of competitors

Key Insights

FROM BUSSES TO AIRPLANES

CO-CREATION WITH MULTIDISCIPLINARY EXPERTS

Co-creative idea generation sessions were organized. The Embraer Business Challenge was conducted with 14 students with multidisciplinary background to generate ideas. The event was promoted over several weeks and reached alone on Facebook 3.3k people. One whole day students were working on a business case and presented their final results professionally at the end of the event. Furthermore, ideas were generated with experts, who are involved in the project.

SMART SUSTAINABLE SYSTEM EXPERIENCE

In particular, busses use fuel cells powered by hydrogen, which is a technology that Embraer can learn from to enable sustainable aviation in the future. Hydrogen is desirable since it is the most abundant element in the universe and the only fuel capable of enabling zero emission long haul flights in the future. The strategy is divided into three horizons that explain how Embraer can learn now from busses while making revenue through a mobility-as-a-service system that later is useful to integrate its hydrogen airplane in 2035 into the system.

Horizon 1 (2020-2024)
During the first horizon Embraer connects to various stakeholders to enable a hydrogen aviation future. The Hydrogen Council provides a strong industrial network that supports Embraer in using hydrogen. Political financial support is valuable to realize the strategy with further subsidies. A collaboration with the bus manufacturer New Flyer helps in learning more about fuels cells powered by hydrogen. The collaboration with New Flyer is also used at the same time to start exploring the market of MaaS. During the first horizon the investment into New Flyer enables improving the passenger experience through an entertainment offer. Also, the passenger is made aware about its choice of mobility in terms of sustainability.

Horizon 2 (2025-2034)
In the second horizon a prototype of a hydrogen airplane is created to gain experience with the technology and convince more stakeholders about hydrogen. Besides, the bus experience is getting integrated into a MaaS system providing various forms of mobility. Displays are now inside the vehicles to provide entertainment and nudge passengers towards sustainable mobility choices through a rewarding system.

Horizon 3 (2035)
In 2035 the commercial 30-seater hydrogen airplane is introduced and gets integrated into the MaaS system to connect different mobility experience and make the passenger experience more seamless. Autonomous vehicles are now part of the MaaS system. Additionally, vehicles are connected in real-time to achieve better connection times.

THE VALUE FLOW OF STAKEHOLDERS

This subchapter describes the business model. While Embraer learns from the bus manufacturer about hydrogen fuel cells, Embraer shares its knowledge about aerodynamics that enable the bus manufacturer to reduce operational costs. Furthermore, revenue is gained through providing an engaging passenger experience and connecting the different modes of transport in the MaaS system. Besides, the government supports Embraer financially with enabling a hydrogen aviation future and the MaaS system.

GETTING AROUND IN THE US

The target market of the strategy is the US. Therefore, especially the mobility needs in the US were analyzed. In the first horizon, in particular basic needs such as using transport to reach educational institutions is addressed as well as going to the supermarket. Following the plan needs and target group get expanded over time. The second and third horizon addresses as well the need of travelling for the psychological need of visiting relatives and friends.

CONVINCING INVESTORS

A strategic roadmap was made to convince investors to support Embraer in enabling sustainable hydrogen aviation futures. The roadmap can be seen on the following website: https://www.melanie-rumpf.com/embraer

A PLAN FOR THE MANAGEMENT & PRODUCT/ SERVICE DEVELOPERS

Also, a tactical roadmap was created that support the management and product/ service developers to understand the strategy and make decisions about it.

TIMING SMARTLY

The time pacing is in particular dependent on the technological development. Horizon 1 can start now. In 2025 it is expected to start testing the prototype. Afterwards, 10 years will be needed to develop the hydrogen airplane. Therefore, horizon 3 starts in 2035. The MaaS system orientates itself on the time pacing of the technological development.
Furthermore, the time-pacing strategy of competitors was analyzed. Depending on the time-pacing of competitors Embraer should release information about innovation concepts at least every three years. These news releases should be about the current development of the prototype, the hydrogen airplane, and the MaaS system.

The next chapter provides information about the feasibility of the strategy and evaluates the sustainability of the strategic plan.

6

Evaluation of Feasibility & Sustainability

DEVELOPING AND EVALUATING THE STRATEGY

This chapter supports the evaluation of the feasibility of the strategy. Experts were recruited and gave insights about the possibility of technological and financial implications. Furthermore, the sustainability of the strategy was evaluated to find out in which terms the roadmap solution made an impact.

8.1

Developing & Validating the Concept

IS THE STRATEGY FEASIBLE?

Creating a 30-seater hydrogen airplane is technically and financially feasible through industrial and political collaboration. With experts a low risk strategy was developed.

The presented idea is a result of an iterative idea development and validation process with experts. The experts involved in the process can be retrieved from figure 55.

Several of these experts were already involved in the context analysis (Luciana Ribeiro Monteiro, Jaap Vleugel, Paul Peeters) or the vision creation (Peter Vink).

Technical requirements and feasibility of the concept have been discussed with five aerospace engineers: Paul Peeters, Daniel Juschus, Gerjan Nieuwerth, Jacomijn van Jam, and Marco Delgado Gosalvez. Paul Peeters has published around 130 papers about the topic of transport and sustainability, which were often related to the aviation industry and the issue of emissions. Juschus, Nieuwerth, van Jam, and Delgado Gosalvez were involved in the project "The Greenliner" and proved the financial and technological feasibility of a 19-seater fuel-cell aircraft powered by hydrogen in 2030 (Delgado Gosalvez et al., 2018).

Want to get to know more about the Greenliner? Scan The QR code. :)

Watch Delgado Gosalvez presenting the Greenliner at TEDxDelft and scan the QR code. :)

Figure 55: Experts involved in the concept development and validation

Luciana Ribeiro Monteiro
R&D Analyst at Embraer

Carlos Eduardo de Carvalho
Industrial Designer at Embraer

Peter Vink
Professor of Environmental Ergonomics

Paul Peeters
Professor for Sustainable Transport and Tourism at Breda University of Applied Sciences

Jacomijn van Jam (left), Gerjan Nieuwerth (middle), Daniel Juschus (right), Marco Delgado Gosalvez (had to leave before the picture was taken)
Student of the Faculty of Aerospace Engineering at TU Delft

Jaap Vleugel
Senior Researcher at the Faculty of Civil Engineering at TU Delft

Furthermore, the students have experience through internships at Airbus and through building a hydrogen airplane of a range of 2000 km with the team AeroDelft. In particular, Daniel Juschus is part of the board of AeroDelft.

The experts Vink, Peeters, Juschus, Nieuwerth, Jam, and Delgado Gosalvez (2019) all agreed that a 30-seater hydrogen airplane is technically feasible in 2035 or even earlier. Financially, higher costs might be faced in comparison to a kerosene airplane. These costs can be covered through industrial collaboration, investors and governmental support according to the experts. Nieuwerth (2019) also mentioned that through creating a hydrogen airplane the risk of rising kerosene prices can be avoided. Also, hydrogen prices are expected to get cheaper as Nieuwerth (2019) noted.

As an aerospace engineer, Peeters (2019) confirmed that it is possible to learn from a bus manufacturer about hydrogen fuel cells and use the knowledge for manufacturing an airplane. With Peeters a low risk strategy was developed to get to the vision of an hydrogen airplane. Currently, in the second horizon a prototype of an hydrogen aircraft is suggested. Peeters additionally added, that in case of barriers of creating the hydrogen aircraft prototype, the prototype could be fueled by a kerosene based fuel cell. Basing the propulsion on a kerosene fuel cell could simplify the design and reduce emissions of the prototype by 40-50% in comparison to a usual kerosene aircraft.

Juschus, Nieuwerth, van Jam, and Delgado Gosalvez (2019) pointed out that creating a prototype of a hydrogen airplane is simple to realize and pointed out that even a student team like AeroDelft can do it with a low budget. Taking an existing aircraft and changing the propulsion system could ease up the process of creating a prototype according to the aerospace engineers. Furthermore, Juschus, Nieuwerth, van Jam, and Delgado Gosalvez (2019) emphasized that the technical readiness level of hydrogen airplanes is quite advanced. Steps as research and development, and a demonstration of hydrogen airplanes have already been proved. The only step missing of the technical readiness level is the commercial production. Juschus (2019) advised to create the hydrogen aircraft now and be “ahead of the game” in terms of sustainable mobility before companies are forced to do something, e.g. due to political intervention or scarcity of kerosene and following rising kerosene prices. Furthermore, Juschus (2019) confirmed the possibility that the hydrogen airplane can have a range of 2000 km and be used as a regional aircraft.

Additionally, Jaap Vleugel, professor at the faculty of Civil Engineering at TU Delft, was consulted. His knowledge about public transportation and infrastructure added value to the concept development phase. Vleugel (2019) is convinced about the feasibility of mobility-as-a-service. However, he also mentioned that Embraer first should do pivots of the MaaS concept and then scale the actual system to keep risks low. Regarding the hydrogen airplane solution, industrial collaborations will be useful to introduce hydrogen on a large scale and lower down costs according to Vleugel (2019).

The concept about looking first into busses to enable a future of hydrogen airplanes was presented and discussed with Luciana Ribeiro Monteiro, Carlos Eduardo de Carvalho, and Peter Vink to test the satisfaction of the concept to the clients.
The clients gave positive feedback on the concept. Looking into busses to learn about hydrogen and going step by step towards a future of hydrogen airplanes appeared possible and feasible to the clients. De Carvalho (2019) even pointed out that the CEO of Embraer used to work at a company that manufactures busses.

Besides, through the Embraer Business Challenge, Luciana Ribeiro Monteiro from Embraer was involved in the concept selection of the presented concepts by the participants. Here, it was found out that amongst others a solution is desired that also involves existing mobility solutions with an existing infrastructure in a MaaS system, which can be found in the final concept. The concept involves to connect mobility solutions such as busses, car sharing, bicycles, and airplanes.

8.2

Sustainable
Impact Evaluation

MAPPING SUSTAINABLE MOBILITY

The strategy addressed several issues of mobility and could improve these issues.

For evaluating the strategy it was looked into the issues of mobility, which were found out in chapter 2.1. The issues of mobility are mapped in figure 56. The wheel in figure 56 is orientated on the EcoDesign strategy wheel by Brezet and Hemel (1997). Outer circles of the wheel indicate a high sustainable achievement in the category as the inner circle shows a low achievement in the category. The light blue map indicates the existing mobility system while the dark blue indicates the elaborated strategy of the thesis. Evaluations were rather subjective. An explanation of the improvements of each category can be found in the following text. Some categories were summarized, e.g. climate change, air pollution, and environmental issues, because they are caused by the same issue, namely greenhouse gases.

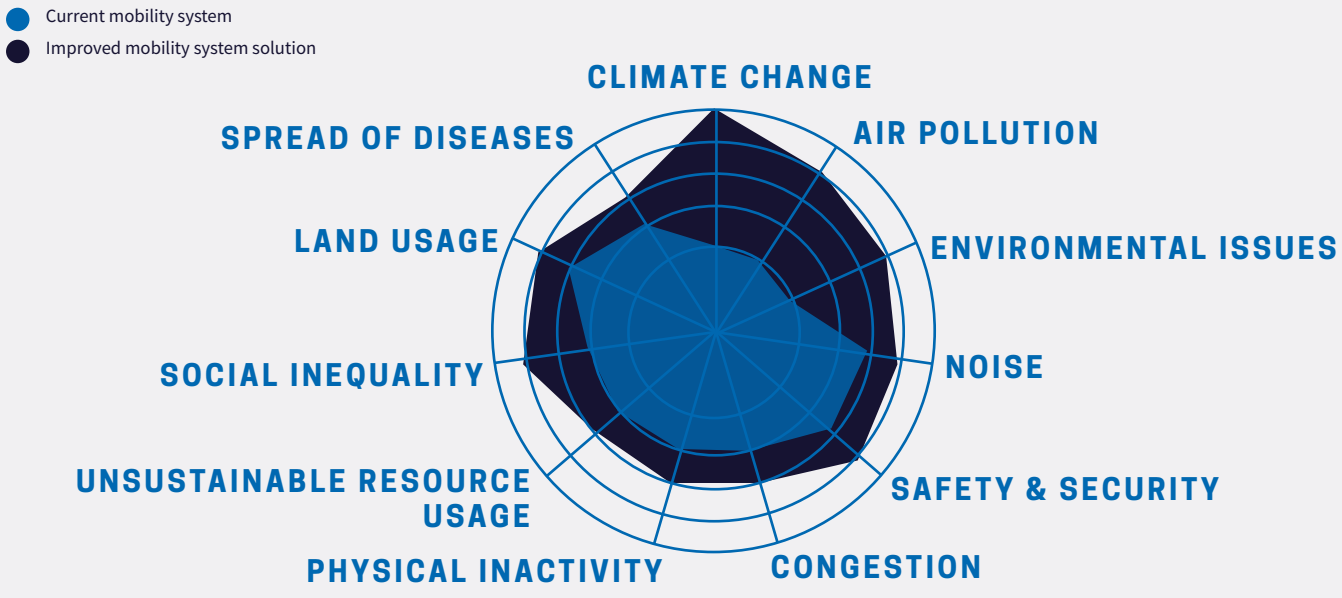
CLIMATE CHANGE, AIR POLLUTION, ENVIRONMENTAL ISSUES

The hydrogen airplane and the bus have zero emissions, only water vapour gets emitted. Therefore, the emissions during usage do not trigger climate change, air pollution, or environmental issues.

NOISE

Since hydrogen is lighter than kerosene the final hydrogen fuel cell airplane will weight less than a common kerosene airplane of the same size. The decrease of weight causes a reduction of noise of the hydrogen airplane (Seeckt, 2010). Furthermore, the MaaS system reduces traffic by acting against vehicle ownership, making the system more efficient, and addressing only basic and psychological needs. Through reduced traffic also noise gets reduced.

Figure 56: Evaluation of the final strategy mapped. Light blue indicates the current system, dark blue indicates the improved mobility solution.



SAFETY & SECURITY

Kerosene has a higher explosive volume than hydrogen (Seeckt, 2010). For this reason, hydrogen is safer than kerosene. Additionally, the MaaS system reduces congestion, which is correlated to accidents. With less congestion more safety is expected.

CONGESTION

As already mentioned congestion is reduced, first due to the smartness of the system making traffic more efficient and due to the reduction of vehicle ownership. Also, addressing only basic and psychological needs reduces the usage of mobility, because less temptation to use mobility for self-fulfillment needs is given, e.g. leisure travel.

PHYSICAL INACTIVITY

Bikes are included in the MaaS system and promote physical activity.

UNSUSTAINABLE RESOURCE USAGE

Social and sustainable suppliers are included in the strategy. Especially, the companies Verdraaid-Goed and AELS can give further advice about using recycled resources or how to recycle the bus or the airplane.

SOCIAL INEQUALITY

The strategy is currently suiting to the target market of the USA, which is rather a wealthy country. Especially, busses are often used in developing countries, because they require a low infrastructure and have low maintenance costs. Therefore, a strategy concerning busses is easy to implement in a developing country and promotes social equality. However, it needs to be considered that currently the price of hydrogen is more expensive than the one of kerosene. But since hydrogen is expected to get cheaper than kerosene, a hydrogen bus will be more affordable for developing countries in the future. Besides, through governmental subsidies the hydrogen airplane gets more affordable.

LAND USAGE

Due to the reduction of vehicle ownership and the efficiency of the MaaS system less infrastructure and land is required.

SPREAD OF DISEASES

Reducing the spread of diseases is currently not considered in the strategy, because a higher emphasis to the reduction of emissions is given. Currently, the strategy is also more about covering regional distances. Therefore, the spread of diseases is not a high risk. However, after 2035 it is expected that hydrogen airplanes also replace long haul flights. At the moment policy makers regulate the spread of diseases, e.g. by prohibiting transporting meat from one country to another.

Key Insights

EVALUATION OF FEASIBILITY & SUSTAINABILITY

DEVELOPING & VALIDATING THE CONCEPT

Several experts were recruited to develop and validate the strategic plan. Building a hydrogen airplane is from a technological point of view feasible. In terms of financial feasibility support through further stakeholder, e.g. political institutions is required. Furthermore, it is confirmed that it is possible to learn from a bus manufacturer more about hydrogen fuel cells. Also, building a prototype in the second horizon is a feasible solution since only the propulsion system of an existing airplane needs to be changed. Besides, clients gave positive feedback on the strategy.

SUSTAINABLE IMPACT EVALUATION

The strategy was evaluated based on the found out issues of mobility mentioned in chapter 2.1. Almost in all categories the strategy could improve the sustainability in comparison towards the existing mobility system. A special emphasis was given to the reduction of greenhouse gases. For this reason, the solution scored high in particular in the categories ‘climate change’, ‘air pollution’, and ‘environmental issues’.

While this chapter validated and evaluated the concept, the next chapter points out which kind of value the strategic plan brings to different types of stakeholders. The research question is answered, limitations are mentioned and a personal reflection is given.

9

Final Remarks

DISCUSSION & CONCLUSION

This chapter points out the core value of the strategic roadmap for stakeholders involved in the project, and stakeholders, which are part of the strategic plan. The research question is answered and points out how the strategy proposed relates to strategic and innovation tools. Furthermore, limitations of the roadmap solution are mentioned and recommendations are followed up by the limitations. Finally, a personal reflection about the project and learning objectives is given.

9.1

Conclusion

CORE VALUES & RESEARCH QUESTION

The strategic plan enables Embraer to avoid major threats through a low risk strategy. TU Delft will be able to further embody the hydrogen airplane and/ or the vision of this master thesis. Furthermore, the research question has been answered considering several strategic and innovation tools.

CORE VALUES FOR ALL STAKEHOLDERS INVOLVED

The strategic plan involves several stakeholders that benefit from the roadmap solution. Embraer is the main stakeholder. The bus manufacturer is a core element in the strategy and starts collaborating with Embraer during the first horizon. The government supports Embraer in creating a hydrogen airplane for society in 2035. The Faculty of Industrial Design is further involved in the concept embodiment during the next year. All core values for each stakeholder can be found in the following text. Furthermore, the core values are pointed out beside the text.

Embraer
Hydrogen is the most abundant element in the universe (Campen, Mondal, & Wiltowski, 2008) and is the only fuel capable of enabling zero emission long haul flights in the future. The strategy reveals a pathway about looking into hydrogen that keeps risks low, while using it at the same time to explore the growing market of mobility-as-a-service and providing a better connected passenger experience.

Gaining strong stakeholder network
Avoiding major threats
Sustainable low risk strategy
Preparing for the future
Strengthening disruptive innovation department

Bus Manufacturer
While Embraer learns from the bus manufacturer about hydrogen, Embraer gives value to the bus manufacturer through its knowledge about aerodynamics and leightweightness. Through improvement of aerodynamics of the bus fuel operational costs can be saved.
Furthermore, Embraer adds value through improving

Improving bus aerodynamics
Saving operational costs
Improving the desirability of the bus experience
Making the passenger journey more seamless

the passenger experience of the bus.

Government
The government is enabled through Embraer to act against major risks like climate change by substituting polluting mobility forms with zero emission mobility. Also, acting against the risk of scarcity of resources is supported by Embraer through acting against vehicle ownership and substituting it with a mobility service system.

Society
Embraer provides zero emission mobility and enables society to move around in a sustainable way. Having zero emissions instead of greenhouse gas emitting mobility does not threat health and does not further risk climate change, which has an impact on the life quality of society.

TU Delft
The faculty of Industrial Design Engineering will further make an embodiment of the concept during the next year. The vision and the hydrogen airplane can be used for a further embodiment design. Furthermore, awareness about what sustainable mobility includes gets promoted through the concept.

ANSWERING THE RESEARCH QUESTION

Reflecting on the introduction of this thesis the following research question was phrased in chapter 1.2: How can Embraer embrace sustainable mobility in an innovative and strategic way in the coming 15 years?

The thesis included several strategic and innovation tools that supported coming up with the final roadmap solution. From a strategy point of view analysis tools such as company, competitor (or stakeholder), context, and consumer analysis were considered as well as sustainability implications were created through a literature review. The roadmapping approach provided strategic value through the technology scouting, vision creation, creative trend research, the different horizons leading to the vision, and the time pacing strategy. Figure 57 makes clear how the strategic analysis tools relate to the final strategic plan.

Through creating a step by step approach over time that leads to the future vision and an ideal scenario the approach roadmapping was useful.

In terms of innovation tools generative research (Sanders & Stappers, 2012), creative brainstorming techniques (Tassoul, 2012), and co-creation has been used to research and create a strategy. The different backgrounds of participants during the idea generation helped in including various points of views in the brainstorming process, which lead to a variety of ideas. Furthermore, the roadmapping approach is an innovation method. Also, visualizations like for example the context map supported communicating with stakeholders in an innovative way.

Figure 57: Reasons for selecting hydrogen as a fuel, and MaaS and the USA as a market.

Company analysis

- Embraer is strong in commercial aviation, the US market, certification procedures, and stakeholder management.
- A unique element of Embraer is that its CEO Francisco Gomes Neto used to be chief executive of a bus manufacturer.
- There is a need to stand out from competitors and strengthening the innovation department EmbraerX.

Competitor analysis

- Barely prototypes are created of hydrogen airplanes by competitors. Embraer can stand out from competitors with the prototype.
- No aircraft manufacturer has a collaboration with a bus manufacturer, which makes Embraer more unique.
- It needs to be pointed out in public marketing that the connection to the bus manufacturer stands for how much Embraer is connected to everyday people. Affordable sustainable transport through busses is also affordable for everyday people. Addressing 'everyday people' is part of Embraers brand DNA.

Airbus and Boeing, the strongest competitors (or in case of Boeing even ally), in comparison provide mobility solutions that are more expensive and for better paying clients.
- The vision of the thesis should be visualized to stand out even more from competitors. While visualizing the vision not the timeframe of 2035 should be considered, but something more futuristic should be visualized as can be read in the next subchapter 'limitations and recommendations'.

Stakeholder analysis

Airlines: There is a need to connect the different mobility experiences.
Government: Governments support sustainable forms of transport, in particular public transport, and limit polluting forms of mobility.

Context/ trend analysis

Market opportunities and growing markets such as mobility-as-a-service, sustainable fuels (in particular hydrogen), autonomous vehicles, passenger experience, and sustainable public transport have been considered.
Potential threats and uncertainties were taken into account in the strategy, some of the threats and uncertainties are mentioned here:Climate change demands a zero emission strategy, also environmental regulations might become more when facing more natural disasters due to climate change. Strengthening electric sustainable transportation powered through batteries is challenging due to the scarcity of material of the batteries. Therefore, a strategy going into hydrogen is more suitable. Furthermore, a MaaS system going away from vehicle ownership is preferable in terms of resource usage, energy consumption, and considering a growing population that demands high consumption.

Consumer analysis

Especially, generation z has a need for moving sustainably. They are globally connected, but still have the value of being sustainable.
MaaS enables a low cost mobility system that is suiting to the low cost mentality of consumers. Limitations of the consumer analysis can be found in the next subchapter 'limitations and recommendations'.

Sustainability implications

- Hydrogen is the most abundant element in the universe and is therefore preferable in terms of scarcity of resources. The element is leightweighted, can be stored easily inside an aircraft and therefore allows also long haul flights in the future, which are currently problematic in terms of air pollution. Besides, it can be recharged very quickly in comparison to electric batteries, which take more time to recharge.
- More sustainability implications can be found in chapter 8.2.

9.2

Limitations & **Recommendations**

RECOMMENDATIONS & STEPS TO TAKE

How can the vision be useful for marketing purposes? Why suggesting a MaaS solution to a B2B company such as Embraer? Were all sustainability aspects covered in the strategy? Is the selected target market the right one, and how to proceed with the strategy? These information can be found here.

There are a few limitations of the thesis, which are explained in this subchapter. Recommendations are implied in the mentioned limitations.

VISION

The vision of having a seamless one-mode transport system was derived from the idea that an airplane transforms into a train on the ground. Meanwhile, the train on the ground can transform itself into various cabins that drive you seamlessly to your home. This way, the passenger doesn't need to change the mode of transport and can enjoy the passenger experience even more. However, this vision is not feasible in 2035, but rather in 50 to 100 years from now. In 2035, a feasible way to connect the different modes of transport towards a one-mode transport system is MaaS.
Although the vision is not feasible at the given time frame Embraer can visualize the vision to stand out even more from competitors and strengthen the innovation perception of the company towards the public. There is no other company that connects to public transport as much as Embraer does in this concept and the connection to 'everyday people' can be pointed out even more.

SUGGESTING THE B2C SOLUTION MAAS TO A B2B COMPANY SUCH AS EMBRAER?

MaaS is a huge market opportunity and a way of a sustainable business model transforming product ownership into a service. By going into the market actively Embraer is not dependable on further service providers. However, a service provider offering the mobility service should be included, either as an additional department within Embraer or as an external party. Uber might not have high sustainability values and therefore collaborating with a startup as a service provider is recommendable. The MaaS system and strategy shows a concrete case of how the passenger experience needs to be created by a manufacturer to provide a suiting service. Furthermore, as an aircraft manufacturer Embraer can enable creating a better infrastructure, which is urgently needed for a transition towards a sustainable system, e.g. an infrastructure of sustainable fuels.

SUSTAINABILITY IMPLICATIONS

This thesis focussed in particular on improving the impact during the use phase of vehicles, because the use phase is currently the most unsustainable phase of the product life cycle of mobility, and especially airplanes. However, more sustainability implications e.g. in terms of materials or production methods can be made. Considering the whole lifecycle the EcoDesign Strategy Wheel by Brezet and van Hemel (1997) and the method cradle-to-cradle should be taken into account. The sustainability of the product can be measured through a LCA (Life Cycle Assessment), although doing a LCA for a vehicle might be a time consuming task. For the reason that the thesis did not go into depth of sustainable materials the recommendation to get in touch with the companies VerdraaidGoed and AELS was made.

TARGET MARKET

As a target market the USA was selected due to various criteria and the promising development of hydrogen fuel cells in the country.
However, it needs to be considered that support from political institutions is a relevant aspect of the strategy. For this reason, it is recommendable that Embraer gets in touch with various political institutions in several countries to find out how much support the company can get from those institutions. The biggest subsidies for aviation are expected in Norway and the UK. Norway aims that all domestic flights have zero emissions by 2040 and subsidizes green aviation (Avinor, 2019). Currently, the Norwegian government financially supports electric cars (Jordans, 2018).
377 million Euro of subsidies for green aviation are granted in the UK (Department for Transport et al., 2018). Electric cars are supported in the Netherlands (Randall, 2018). Therefore, also subsidies in the Netherlands might be possible.
In terms of the hydrogen fuel cell busses, these buses can be found in various countries. The biggest markets of sustainable busses are however in the UK, Germany, and the Netherlands (Gray, 2018).
Based on the subsidies and the expected revenue that Embraer can make in the country, the company should select the target country. Depending on the target country the target group might need to get refined. Entertainment and reward programmes as mentioned in the final solution are expected to work in various countries.
Also, the modes of transport that the passengers like to connect to might vary from country to country.

GET CONNECTED

Apart from getting connected to a governmental institution, Embraer should soon get in touch with the Hydrogen Council and the startup, which develops the hydrogen airplane prototype for the second horizon. Apart from that the plan as described in the roadmap solution should get followed up.

RECOMMENDATIONS FOR STUDENTS WORKING ON THE PROJECT

Students, who will continue working on the project and embody the design have the option to either embody the hydrogen airplane or the vision. Regarding the hydrogen airplane propellers at the wings need to be considered. Blended wings help in the design to reduce the noise of the airplane. Also, the passenger experience should be considered in the design, meaning the connection of the different modes of transport, as well as the entertainment and reward programme.
Designing the vision can lead to a higher marketing resonance and also should be considered. However, it should be taken into account that the vision can be really futuristic and doesn't necessarily suit to the year 2035.

9.3

Personal **Reflection**

OF A 5 MONTH JOURNEY

As found out in the thesis many are aware that airplanes have a high carbon footprint, and trigger climate change. Also, I was aware about this issue and was wondering if there are solutions that can prevent the high amount of emissions. On my journey of this master thesis, but also before even starting I have talked with many people about the topic of sustainable mobility. With people, who are convinced that politicians are the main stakeholders that can enable sustainable mobility. I agree that politicians do have the capability to have an impact on sustainable mobility, but in my opinion more stakeholders are involved in the transition towards sustainable mobility. Consumers need to be willing to pay more for sustainable products and services and be willing to consume less. Companies need to rethink and restructure themselves to be more sustainable, and are in need of sustainable business models. Companies can enable politicians and society with their know-how to be sustainable. In the end, the issue of unsustainable mobility depends on multiple stakeholders. This is why, a sustainable solution in the aviation industry should trigger a dialogue between the different parties. An issue depending on multiple stakeholders is solved best including those stakeholders in developing a solution together.

A sustainable solution in the aviation industry should trigger a dialogue between the different parties. An issue depending on multiple stakeholders is solved best including those stakeholders and developing a solution together.

Another interesting point of view that people told me throughout my journey was when talking about sustainable mobility the bike is the preferable mode of transport. This comment made me think of the pyramids of needs, which I explained in chapter 6.2, figure 30. It surprised me that I couldn't find in literature that other people had thought about this pyramid in relation to sustainability. If someone is about to die and needs to be brought to the next hospital, no one would suggest "Take the bike.". If a car is available, and even if the car pollutes the environment, people would agree to get a seriously injured person with the car and not with the bike to the hospital. That's why it was important for me to include into the vision the phrase 'move you to the place, where you need to be'. Also, I see the value of a globalized world and its intercultural and educational exchange, which is enabled through airplanes, that move you internationally. Prohibiting this exchange would be a value loss in my opinion, and therefore airplanes do have their value of transporting people internationally. However, mobility should consider the limitations of nature and be more sustainable and ideally have zero emissions.

While I was curious in the beginning what is possible and achievable in terms of sustainability in the aviation industry, after talking a lot too experts with different kinds of educational backgrounds, I now have the feeling that I can answer my questions that I had when I started the thesis. Reducing or even having zero emissions in the aviation industry is possible. However, the different types of fuels do have their limitations, advantages, and disadvantages. I understand better now why sustainable fuels are not applied as much as they could and what kind of role different stakeholders play in the development of a sustainable mobility future.

The takeaways of the thesis make me more aware about the possibilities of sustainable products and services, and aid me in creating sustainable design and innovation strategies as it was my learning objective at the beginning of this thesis.

10

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OVERVIEW

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