Urban Mobility: Airtaxi Cabin from a Passengers Point of View

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ABSTRACT

Within German Aerospace Center (DLR), a project called HorizonUAM was launched in July 2020. Its main goal is to develop and design an aerial vehicle which would support the infrastructure of the ever-growing cities and strengthening the connection between as well the big cities as cities with their suburban areas. The vehicle will be designed for the four different scenarios: airport shuttle, intracity transport, intercity transport and suburban connection. This paper shows the research concerning the potential users of the vehicle including their requirements and shows a possible design solution for an airtaxi cabin. The process has followed the Design Thinking Method, ensuring a central role for the users. To determine whether there are potential passengers willing to use such a vehicle, in-depth research has been done. Data found in previously done research has been compared with results of the in-house research, consisting of a number of workshops with representatives of German population as well as results form questionnaires sent out to a different group of German population. During the workshops, the subjects were asked not only to indicate their opinion on the airtaxis, but also to create their own version of it. This was done following the so-called Disney method, creating the solution in three stages: dreamer, realist and critic. Based on this data, different fictive personas are created, to aid in understanding of the user's needs. In addition, trend analysis on how the urban mobility is developing, has also been executed. The state-of-the-art solutions available are analyzed and their strengths and weaknesses determined. The entire research has resulted in an extensive list of requirements for the design of the cabin. To address such a complex design challenge, a morphological chart has been created, systematically deconstructing the main function into subfunctions. This has been done by multiple workshops with a constant team.

Introduction

The human population is ever-growing. At the moment this paper is being written, this planet is a home to over 7,8 billion people (1). More people means more homes, and inadvertently, more/bigger settlements. Whereas new (mega)cities are built in Asia and Africa (2), Europe for example does not have that possibility. This has as a consequence that it is rather complicated and complex to built a new city to satisfy the needs of growing population, such as more efficient means of transportation. However, the existing cities still retain their attractive power and therefore grow in size (3). This leads to densification of urban areas, which in its turn, increases the demand for (public) transport possibilities. To answer that demand does not come easy for an already established city; the roads are often already as wide as they could be and can therefore process only a certain number of vehicles on a given moment. Public on-road transport is mostly dependant on the capacity of those same roads and can therefore be easily affected by the congested traffic. Subways and trams have their own network and therefore are not dependable on the traffic congestion. Unfortunately, they are not available in every city, have also a limited capacity and

often connect only the bigger traffic knots. In addition, suburban and rural areas are often times weakly connected to the larger urban areas, which makes them unattractive to live in, considering prolongated commute time. Another key component of reliable urban transport is reaching the connecting trips on time. Especially when connecting the city with and airport, a major improvement can be gained.
End of 2019, the world has been struck by a pandemic of a fast spreading virus with severe consequences. As the pandemic is slowly ebbing away, the urge to keep distance, high hygiene standards and private space remains. The consequences of the pandemic will not fully determine the results of the project, their influence however cannot and must not be ignored.

Within the scope of the project "HorizonUAM –Urban Air Mobility Research at the German Aerospace Center (DLR)", focus lies on one of the possible solutions to the future demands on urban mobility, namely the air transport within populated areas. As stated in the Raison d'Être of the project plan, efficiency, safety, feasibility, sustainability and affordability are the key characteristics of future urban mobility (4). HorizonUAM combines the research about UAM vehicles, the corresponding infrastructure, the operation of UAM services, as well as the public acceptance of future urban air transportation, including market scenarios up until 2050. The aforementioned issues have led to creation of four different scenarios for which the vehicle needs to provide a solution. The cabin design team is tasked with creating a travelling environment for a passenger of the future, fulfilling not only their demands, but also demands of other stakeholders as well.

This paper will demonstrate the level of acceptance among alleged passengers and their vision on how a cabin of such a vehicle should look like and what it should focus on, by following the user centred design. In addition, it will show how the different scenarios influence the cabin design and will establish whether it is possible to serve multiple scenarios with a single cabin, from a passenger's point of view. Furthermore, it will display how the results of previously committed research are translated into first ideas, sketched as well as 2D as 3D. As a wrap up, an insight in the next steps in the project will be given.

Design Approach

At the Institute of System Architectures in Aeronautics at German Aerospace Center (DLR), a cabin design team has been established beginning of 2016. Over the past couple of years, the team has developed a characteristic way of working, based on the Design Thinking Method. The choice to base the design approach on this particular method was due to the ultimate goal of the design team, to ensure the needs of the users (in this case, passengers) are met. This way, progress in the field of aircraft cabin design can be enabled. Being a user- centric design approach, Design Thinking Method provides the team with the possibility of including the end user into the design process in its earliest stages (5).

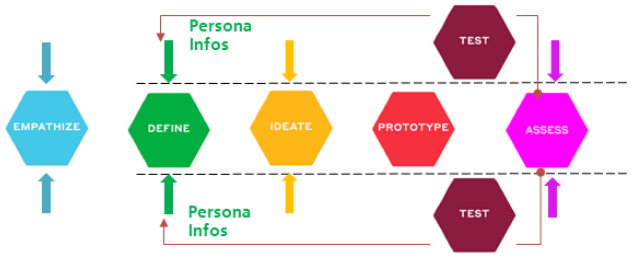

Figure 1: Graphic representation of Design Thinking Method, source: Fabian, DLRK2020

This method has proven to be of great value in the previous projects, which can be seen in the design study cases of (6), (7) and (8). Figure 1 shows the main phases of the design process according to the Design Thinking Method. In the course of the project HorizonUAM, all five phases of the design process will be completed. The Prototyping and Testing phase will be done by means of a Virtual Reality model which will be lifelike and high in detail. As the project has started in July 2020, only the first two phases, namely Empathise and Define have been completed, while the third phase, Ideate, is in its early stages. Accordingly, this paper will demonstrate the progress achieved so far, showing the results made in the aforementioned phases.

To fly or not to fly: Empathise phase

To design cabin concepts for UAM vehicles, awareness of the current state of technology and research is vital. Thorough background research has been done to gain an overview concerning new and conceptual urban mobility (air) vehicle interior concepts. Numerous factors have been considered during the research: user spectrum, storage options, distances, layout, number of seats, type of seat, interior in general, storage options, light, security systems, comfort aspects, aesthetics. The acceptance of the passengers has a major influence on the feasibility of new types of air taxis. Accordingly, different cabin concepts that are already being used successfully are examined in more detail. When looking at the automotive sector and the innovation within this particular market, there are several notable observations to be made. For example, strong colour contrasts are very present in the most innovative models (dark brown/grey tones for a noble look; white/cream tones for cleanliness and high quality). In addition, green tones and wood optics attempt to represent durability and environmental awareness. By means of bionic forms in the storage compartments or the ceiling columns, the design of the vehicle tries to mimic the nature and confirm the connection to sustainable design. The connection to the nature is also sought through large windows which allow the passenger to have a clear view of the surroundings. One of the important goals in automotive innovation being the first impression, the door concepts are very different from todays common vehicles. Designed in a unique way, a door is used to wow the potential customers. Vehicle designs are an extremely important indicator of feasible innovations in the UAM area. People are familiar with automobile design, so distinctive features from this sector certainly need to be factored in to be able to create recognition value and herewith form sense of familiarity and security.

Figure 2: representative current UAM Vehicles, concept design. Focus on the panorama view can be seen here as well.

Research on the existing UAM vehicles shows that this branch has learned from the innovation in the automotive sector. A lot of the companies developing a UAM vehicle is still in the early stages of the design process and has not revealed the cabin concepts yet. Those who have, show large overlap with creations of most modern cars (figure 2). The interiors are based on strong colour contrasts and minimalistic design, conveying a sense of connection to the automotive sector. Clarity in the design is here as well achieved through bionic window shapes and large windows, meant to enhance the flight experience. Seats are most often arranged according the automotive standard, creating recognition value.

According to the results of the state-of-the-art research, UAM vehicles are supposed to be modern, spacious, safe means of transportations for the near future. However, it is very difficult to say whether the broad public shares this view. Considering the fact that at the time of the writing of this paper no vehicles have been used by intended passengers on a regular basis, it is rather safe to say

that the reaction of the public to this particular product is yet barely known. In order to counter this effect, an acceptance study was organized within the scope of this project. Goal of this study was to find out what the general public thinks of this vehicle and its utilization. The study focused solely on the acceptance of such a means of transportation and has taken the factors such as pricing not into consideration. It consisted of a number of focus group with representatives of German population as well as results from questionnaires sent out to a different group of German population. During the gatherings, the subjects were asked not only to indicate their opinion on the air taxis, but also to create their own version of it. This was done following the so-called Disney method, creating the solution in three stages: dreamer, realist and critic (9). In her paper "A User-Centered Cabin Design Approach to Investigate Peoples Preferences on the Interior Design of Future Air Taxis", Maria Stolz goes into detail on the size, depth and significance of this study (10). The results of the study are encouraging. Most of the people have indicated readiness to use such a means of transportation at least every once in a while, thereby considering the factors like hygiene, safety, comfort, accessibility. When conducting the focus groups, participants were divided into different groups, once according to their age range and once according to the nature of their residence. The results showed clear differences in the requirements they set on a passenger's cabin of such a vehicle. When looking at the participants divided according the age range, all of them expressed a desire for certain technological features, such as augmented reality technologies. However, the participants from the younger group put a much lower focus on the on the aspects of comfort, privacy and accessibility than participants in the older group. Within the participants divided according the nature of their residence there also were quite distinguished differences. Where the inhabitants of a city were inclined to individualizing the cabin (modularity, adaptable seating), the residents of rural areas are more focussed on including the minority groups, such as families and physically impaired passengers. However, for both these groups comfort and privacy were of vital importance.
The research conducted in the Empathize phase has laid the foundations needed to understand not only the potential user of the final design but also the context in which the design will be used. All these findings are used as a direct input in the forming of the next phase in the design process, namely the Design phase.

Who is flying where and why: Define phase

The results gained in the previous phase have directly led to forming of the personas. Building a fictive personality, aka persona, helps the designer to understand the potential users better, which in its turn, ensures the development of a product that truly suits the user's needs (11).

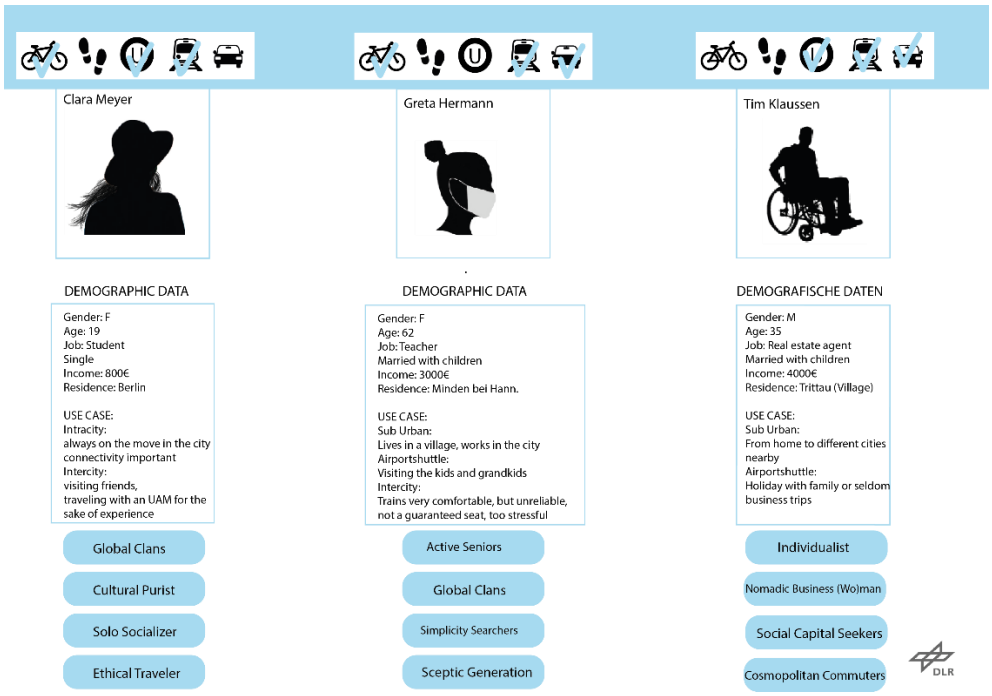

Figure 3: Persona overview

As it can be seen from figure 3, the discussions resulted in three different personas. Each of these personae have provided a set of requirements on the factors important to the particular user group the respective persona is representing.

When compiling the project plan, the decision was made that there were four different use cases that needed to be researched. An airport shuttle is supposed to pick up the passengers through out the city and bring them to the airport for their outbound flight. The Intracity vehicle should circumvent the traffic and bring the people from A to B as a taxi would. Where the Sub-Urban Commuter connects the rural areas with the bigger cities close by, the Inter-City should connect the cities themselves. Each of the use cases brings a different set of requirements to the design table.

Not only different users can be expected in the different use cases, but those utilizations bring along versatile boundary conditions. For a longer flight, more entertainment is expected; an airport shuttle has to provide ample luggage space. Sub-Urban-Commuter can expect more families (often meaning small children, their strollers and a vast amount of accompanying luggage for a day trip) and elderly people visiting the big city. These passengers are slower in their movements, need more space and an easily accessible and understandable cabin. Intra-City vehicle will probably serve passengers for a quick commute, business people going from one appointment to another. Combining the results from the state-of-the-art research with the requirements forth flowing from the personae and the use cases set by the project plan, list of requirements is compiled (available upon request at the main author). This list serves as a direct input in the next phase of the design process, where the solutions are created for the established problems.

How to fly: Ideation phase

At the time of writing this paper, the HorizonUAM project is still in its first out of three years. Based on the list of requirements compiled in the previous phase of the design process, first ideas have been created that might prove to be a partial solution to the established problems. Figure 4 shows a grasp out of the wide spectrum of different design solutions.

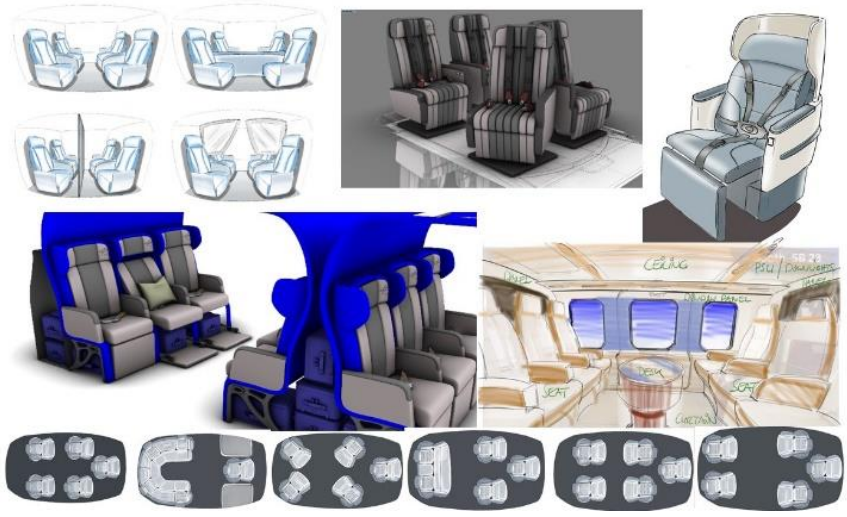

Figure 4: first ideas, rough sketches in 2D and 3D

To be able to solve the issues like privacy, a design study has been done on the installation of (retractable/collapsible) partition walls, which can be seen in the top left sketch. The 3D sketch in the upper middle shows an idea of pivoting seat, what can ease boarding and deboarding of physically challenged passengers (PRM, pregnant women, elderly people). Lower left 3D sketch demonstrates a possible luggage stowage in an airport shuttle or an Inter-City vehicle. Sketch on the lower right is an artist impression of a possible cabin, used as an inspiration. Last row of grey sketches is a top view of the cabin, each representing a different seating arrangement. These arrangements will be presented to the public in a new series of workshops in order to find out what the preferences of potential users are. The results of those workshops will be incorporated in the next design iteration.

What's next: Discussion

The direct and immediate feedback from the alleged user has proven to be of a great value in this case. Bringing an innovative and game changing product like this one on the market carries a high risk. Acceptance is a major factor, defining the success of the vehicle. In order to ensure the acceptance, a continuous dialogue with the potential passengers is vital.

The next steps in the concept design will include the aspects such as colour scheme study, ergonomics study, inclusion of the new hygiene standards as well as providing a feeling of safe distance to the other travellers. In case of the colour scheme study, a suitable combination between emphasizing the design details and providing psychological comfort to the passengers needs to be found. Here, different perceptions coming from different age and gender groups have to be considered. Ergonomics study is necessary to make sure most of the people are provided access to the vehicle. With to high entry/exit, lack of handle bars or any other assistance, people with restricted mobility are directly excluded. Two out of four use cases require vast amount of space for different kinds of luggage. This poses an extra challenge when trying to make sure that one vehicle can be deployed in most if not all use cases.

Considering the time gap between delivering the final version of this paper and presenting it at the conference, an updated version of the paper including new results from the ongoing design studies and following concept designs will be presented at the conference.

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