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USERS' SURVEY FOR DEVELOPMENT OF PASSENGER DRONES

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Abstract

The prosperity of any megacities heavily depends on smooth transport systems. In India, however, most cities are failing to keep in step with the growing demands. With new technologies, such as passenger drones, an alternate mode of intra-city transportation seems within reach. For successful development of passenger drones in a diverse country like India, understanding users' needs are vital. This paper presents the results from a survey of potential users of passenger drones from across India. These are then used to derive concrete recommendations for passenger drones design parameters.

Keywords: passenger drones, user-centred design, design research, industrial design, urban air mobility

1. Introduction

The development of transportation can be traced to a prehistoric time when humans were hunters and gatherers, and they moved from one place to another (Nolan 2003). From a humble beginning, the modes of transportation have developed into vast arrays of devices with the help of technological advancement and growth of industries (Donaldson 2008). With the growth of science and technology and the affluence of the city dwellers, there is an exponential increase in the demand for personal, On Demand Mobility (ODM) (Greenblatt and Shaheen 2015). This research specifically focuses on India, where the land infrastructure cannot keep in pace with the growing population of megacities. In the 21st century, the prosperity of the city heavily depends on smooth and efficient transport systems (Alfarsi 2017). Cities in the 21st century have become the hubs of economy and growth of culture (Ogburn et al., 1946); it is predicted that in the coming century, cities will host more than 80% of the world population (Ramakrishnan 2001). At any given time, a large part of the population is in transit for various reasons, such as work, education, health and emergencies, leisure, shopping, etc. This growth has inevitably also led to exponential growth of private vehicles adding to the traffic problem (Singh 2006) thus, leading to a rise in traffic congestion. So people are continually looking for more efficient, flexible, faster and end to end transport solutions. And for the first time, we can consider passenger drones (a type of Personal Air Vehicle - PAV) with the potential to reduce the pressure on ground-based city traffic as it requires comparatively less infrastructure development and can run parallel to existing transport system (Thipphavong et al., 2018; Justin and Mavris 2019). Passenger drones, though in their nascent stage of development, promise to be one of mobility device that can create an alternative mode of personal transportation system for Indian cities in the near future. It is well known that users expect the same reliability of service that they are used to from the current standard of travelling with any new technology entering the market. A way to ensure meeting this goal

is co-develop passenger drones, explicitly taking into consideration the users' insights, to develop a product that is customer-centric from the start (Miaskiewicz and Kozar 2011; Ulrich 2016).

1.1. Passenger drones in urban mobility

Thipphavong et al. (2018), in their paper on urban air mobility, they have described the different working modes of passenger drones:

- Urban Aerial Mobility (UAM) fall under the category of ODM that deals with urban air traffic operations, and that can carry passengers or goods of equivalent weight within the city.
- Along with passenger drones, UAM also includes aircraft that work in emergency services like ambulance drones, search and rescue, fire-fighting, adventure sport etc. in metropolitan.

Antcliff et al. (2016) have explained the parameters necessary to adopt PAV with Vertical Take-Off and Landing (VTOL) operations in any given metropolitan city, such as low community noise (a reduction by 20+ dB), improved safety (more than six times safer to be equated with car), and better economy (as compared to road transport). They explained how the development of new helipad in the Silicon Valley for VTOL aircraft have not only reduced noise but also reduced the door-to-door travelling time by a factor of six as compared to current automobiles for frequent commuters. Duffy et al. (2017) have conducted a comparative study between the economy of motorised VTOL aircraft. They found electric winged vehicles to have significantly less operating expenditure (35% less cost per seat per mile) compared to conventional planes, owing to the lower cost of electrical energy. It also has lower maintenance cost as electric aircraft have fewer unique dynamic components as compared to traditional fuel-based helicopters.

This research paper aims to address the lack of supportive research concerning the users' needs, aspiration and concerns in the field of passenger drones. The data generated from these studies can help conceptualise new and viable designs for passenger drones from the get-go. Thereby significantly reducing the time required in the development stage. Section 2 defines the background development in the field of transportation and automobile research. Section 3 discusses the importance of user studies around design parameters and the methodology, with a descriptive representation of survey data. The results from users' survey and the key findings are shown in Section 4. Section 5 discusses the findings and their potential translation into design parameters for effective development of passenger drones. Conclusions from the research are drawn in Section 6, which include a discussion on the research and future scope for the same.

2. Background

2.1. The relevance of users' study

During the last couple of decades, products, in general, have changed the way of our living and how we interact with them. A large body of literature on experiential products stresses that products are not just for delivering functions, but to provide experiences (Kapkın and Joines 2018; Lee and Chang 2010). Schmitt quoted in his article that *"customer wants products that dazzle their senses touch their hearts and stimulate their minds"* (Schmitt 1999, p. 57). Klapwijk and Doorn (2015) stated that in last couple decades the importance of human-centred design has grown for the professional designers and series of techniques have been developed to understand and have empathy with varied needs of the users. Jung and Chung (2014) in their research paper, highlights that consumers are finding that the emotions and aesthetic sense based on their physical and emotional sensation of the product as one of the primary factors influencing their purchase. Documenting and analysing a users' requirements is a substantial plan to lunch successful products into consumer-led markets. Understanding users' insights are vital for the successful development of passenger drones in a culturally rich and diverse country like India.

2.2. Users' research in the automobile sector

For a closer comparison and to have a better understanding of the role of users' study in the transportation sector, a literature study was done on the automobile sector, especially cars. Gkouskos et al. (2014) in their research paper compared how today's vehicles have more functions and provide

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more information; as a result, the vehicle interfaces face similar users experience issues as computers and mobile phones. However, to design a better users experience, it is crucial to be aware of the driver's salient needs and wants from the vehicle. While doing literature reviews on users' research in the automobile sector, it was found that most of the research has been done on two predominant categories. The first category deals with the process of **designing the automobile and designer interpretation of design** (Jonson 2005; Karjalainen 2007). The second category deals with the **users' appreciation of designs or elements of design** (Mugge and Schoormans 2012; Ranscombe et al., 2012). Apart from this, there is also another large body of literature on automotive designs that deals with engineering aspects like mechanical design, different loads, structure, safety, etc. that does not deal with users' research.

So when it comes to the interior of vehicles, be it automobile or passenger drones, there is minimal research on users's needs and concerns that we could take or adapt to passenger drones. Most of the research on passenger drones like automobiles are on developing technologies. Hence there is a need to do our users study. Thus, we must devote time and resources for users' survey during the design and conceptualisation stage for better development of passenger drones. And this research paper is an attempt to bring forth the needs, wants, and concerns of users and how to develop design parameters from these insights.

3. Methodology

3.1. Survey design

Designers and researchers have used different methods and techniques to develop new products and collecting users' data is one of the essential ways to create more user-centric and commercially successful results. In this paper, we have used an online survey to understand and gain insights from prospective users of passenger drones in India. And with the change in the transportation media, the whole experience of urban transport is being redefined. So, this development of new UAM system is not only about the development of the latest technologies but also designing for the unique experience of the users. This survey is generative research, where users' needs, wants and concerns inform the design team in the early phase of the design process.

While piloting this survey with a limited users group, we understood that this study is not like any other product survey, as users have not used the specific product in question, i.e. the passenger drones, yet. However, we can infer a lot from their expectations, needs and concerns from their feedbacks and the data can be interpolated to give new insights. The questionnaire was circulated through emails and social media to attract a significant number of users. The focus was on metro cities, and tier two cities where traffic has become a considerable problem and people are looking for an alternative transportation solution. The survey was exploratory, so there were no limitations as to who can participate in the study. We were especially interested in getting a broad perspective of users' insights. The questionnaire was divided into three parts, as shown in (Figure 1). Each segment gave unique ideas into a better understanding of the users' aspirations.

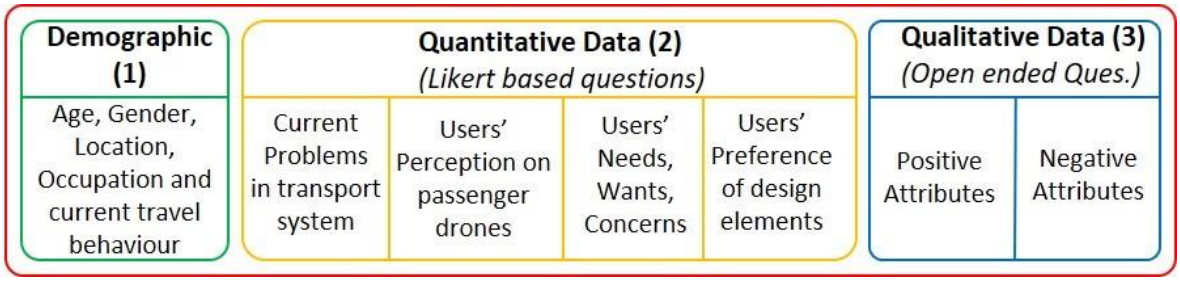

Figure 1. Questionnaire design

The first segment (*Demographic–1*) of the questionnaire asked about the demographic data like age group, gender and location of users. This section also included questions about the travel behaviour like ownership of vehicle, travelling time and distance, travelling preference, flight duration and sensitivity to ecology. The second segment (*Quantitative data–2*) analysed the relative importance of

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current problems in the transport system, users' perception on passenger drones, users' needs, wants and concerns and finally on users' preference of design elements. This section was based on 5-points Likert scale questions to measure the perception of the users on different design aspects of the transportation in general. Finally, the third segment (*Qualitative data-3*) explores what users associated with passenger drones on positive and negative sides, which will help us in understanding what aspects of this transportation system are important to people, and what concerns they have. This section had open-ended questions where users could express their perception freely without any constraints.

3.2. Converting users' insights into design parameters

Zhang et al. (2011), in their research paper, explained that for any successful product development, starts with acquisition, definition, and decomposition of customer requirements (CRs). For adequate segregation of the CRs, they are categorised into three separate different requirements: Functional Customer Requirements (FCRs), Performance Customer Requirements (PCRs) and Environmental Customer Requirements (ECRs). The CRs acquired from the users' survey are undefined, varied and sometimes fuzzy. Therefore, raw CRs are not helpful to the designer for the product development process. These CRs needs to be processed and transformed into design parameters.

- **Semantic decomposition:** The users' inputs in the form of CRs are not adequate and even contradictory. Thus, these vague CRs must be deduced to form Requirement Units (RUs) for further analysis.
- **Semantic transformation:** The RUs generated from CRs still mirrors users' preliminary requirements, and are difficult for product designers to accept. Thus, the RUs are further processed through standardisation so that they become more useful for the designer.
- **Semantic mergence and supplement:** Once the standardised RUs are developed, we may find overlap between the RUs and to maintain the uniqueness they are merged. At the same times, designers need to add information of RUs based on the context of the users and their experiences to avoid loss of semantic contents.
- **Consistency scrutiny:** The contradiction among RUs are analysed, and to improve the usability of RUs they are synchronised.

These users' insights help to develop products best suited to the customers' needs, wants and concerns and cultural context where the product is intended to be launched. This is an essential step in users' survey, through which the qualitative data gathered in the study are segregated, analysed and inferred to make a holistic list of requirements for product development.

4. Data representation

4.1. Demographic data and travel behaviour

A pan India online survey was conducted, and a total of 224 valid responses were received and analysed. The demographic data shows that around 70% of the respondents were male, and 29% of them were female, and 1% did not answer. 72% of participants were below 35 years which suits the profile of the target users' group as it may take at least 5 to 10 years before passenger drones may become a reality. More 70% of them travel between 6 km to 50 km for work and spend around 1 to 2 hours in daily travel. The bar graph also shows that about 20% of the participants travel more than 2 hours out of which 5% spend more than 3 hours to commute as shown in (Figure 2). Thus, a considerable amount of time is spent in commuting and is a significant source of stress for urbanites in India.

In term of occupation, more than 60% are service holders where daily commuting is a part of their life. Thus their feedbacks give a more precise needs of the daily commuters. There is a high dependency on the private and ODM (which is around 67%) when it comes to intra-city transportation, and about 57% of participants would prefer to travel with co-passenger than alone in a passenger drones. Most participants (41%) were comfortable to fly for 16 to 30 minutes, where 20% were okay to fly for 31 to 60 minutes, and a similar percentage of participants wanted their flight to be less than 15 minutes. Now coming to the sensitivity of the participants towards ecology and environment, more than 40%

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would choose eco-friendly transport option even if the cost of travel is higher than fuel-based transport, while 29% preferred stayed with fuel-based transport.

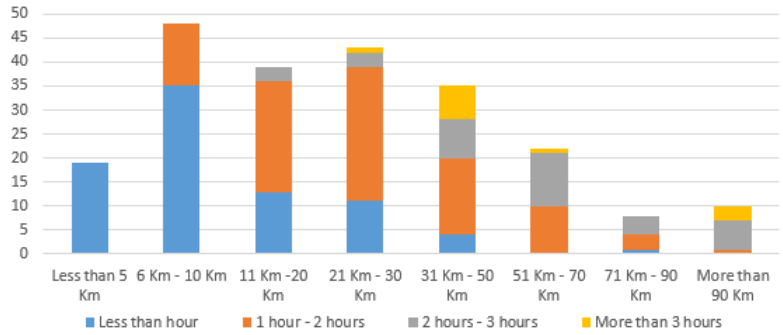

Figure 2. Commute time and distance travelled

4.2. The relative importance of design attributes

The first set (Set 1) of questions were based on 5-point Likert scales and was intended to capture the prospective participants' perception on the cause of the current transportation problems in their daily commute (see Table 1). They were asked to rate their concern for intra-city road transport relatively to given options. The result will help us in developing a UAM system that is not affected by these current problems or can help to mitigate these issues.

Table 1. Current problems in intra-city travel

Set 1		Poor infrastructure	Poor maintenance	Large no. of vehicles	Traffic offence	Mixed traffic	Unregulated crossing	Stray animals	Waterlogging
N	Valid	216	216	220	218	216	217	216	218
	Missing	8	8	4	6	8	7	8	6
Mean		3.73	3.92	4.28	3.96	4.00	4.02	3.64	3.80
Std. Deviation		1.16	0.93	0.93	0.99	0.93	1.02	1.13	1.06
Variance		1.34	0.87	0.87	0.98	0.87	1.04	1.28	1.12

The second set of questions (Set 2), which started with a demonstration video *(1.05 mins long)* showcasing the concept and working of passenger drones - Ehang 184 *(passenger drone developed by Ehang company)*. Through Likert based questions, we tried to explore users' understanding of passenger drones system (refer to Table 2). They were asked to rate their awareness of On-Demand Mobility (ODM), autonomous driving, helicopter service, and passenger drones. The results from this set will help in developing designs, and advertising campaigns to build a favourable public perception of the new mode of transportation.

Table 2. Users' perception of on-demand-mobility, autonomous diving and passenger drones

Set 2		On-demand mobility	Self-driven car	Helicopter service	On-demand air transport	Private passenger drones
N	Valid	216	208	195	208	206
	Missing	8	16	29	16	18
Mean		3.19	3.14	3.16	3.37	3.00
Std. Deviation		1.27	1.21	1.19	1.19	1.29
Variance		1.61	1.46	1.42	1.41	1.66

Finally, Table 3 shows the responses to the third set of questions, which tried to gauge users' needs, basic amenities and concerns for passenger drones as new mode of transportation and their impact on the interior cabin space. Here we tried to gauge the relative importance of different design attributes. These findings will guide designers to come up with designs which are better suited to the users' needs.

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Table 3. User's insights for the passenger drones

Set 3		Seat cushioning	Adjustable seat	Head-room and leg space	Air-conditioning	Low vehicle noise	Low vehicle vibration	Entertainment system	Connectivity
N	Valid	216	219	220	219	217	215	209	215
	Missing	8	5	4	5	7	9	15	9
Mean		4.0926	4.1461	4.3091	4.1187	4.3456	4.4372	3.2679	4.2326
Std. Deviation		.86843	.81647	.90403	.87502	.81388	.77611	1.12017	.92820
Variance		.754	.667	.817	.766	.662	.602	1.255	.862

Set 3		Exterior looks	Interior	Storage space	Safety	Performance	Ease of handling	Work on both land and air
N	Valid	216	216	214	216	217	217	210
	Missing	8	8	10	8	7	7	14
Mean		3.40	3.79	4.00	4.88	4.69	4.67	4.26
Std. Deviation		1.06	0.94	0.88	0.39	0.59	0.586	0.98
Variance		1.12	0.89	0.77	0.15	0.35	0.34	0.96

4.3. Mapping positive and negative attributes of passenger drones

The feedback from the open-ended questions were separated into groups and mapped into Figure 3 and Figure 4. These figures represent the relative importance and frequency of participants that expressed similar insights or attributes as compared to others. The numbers on the graph highlight the frequency.

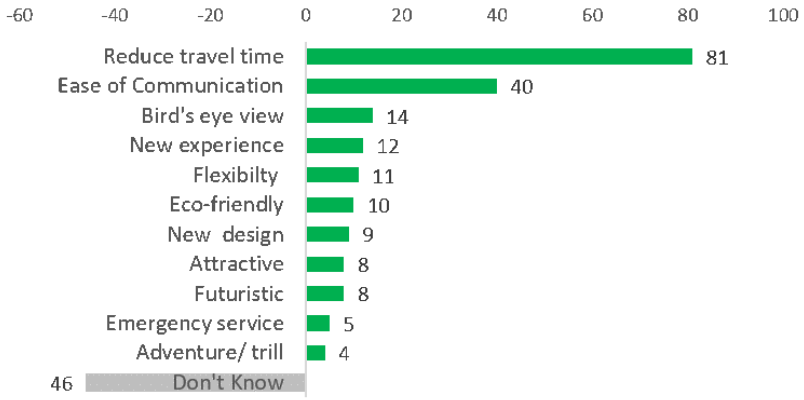

Figure 3. Positive attributes

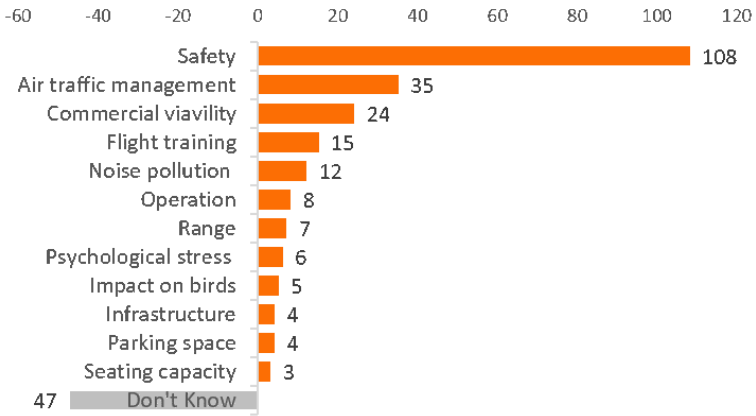

Figure 4. Major concerns

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In describing positives points of passenger drones, a large part of the participants (81 responses) believed that passenger drones could reduce the travelling time, it also included responses like speed, faster connectivity, etc. Following quotes from the participants' highlights this attribute: *"we can save our time lost due to road traffics", "Avoiding the traffic and commute time and reaching destination in time".* Apart from this people were excited to have a birds-eye view of the city and this was evident from quotes like: *"You can have the entire view", "To see the entire view of the city & to escape from traffic jams".*
On the negative side, safety was a primary concern (108 responses). Participants were worried about the safety of the passenger drones as they were apprehensive about the new technologies involved in the system; it included notions like an unexpected failure, mid-air collision, technical glitch, etc. And is highlighted by the following statements: *"I am concerned on safety and during catastrophic situation how the drone will be safe", "Technical glitches. Safety. Purely automated or is there a possibility for manoeuvring by passenger if required?".* Second priority from the users' data was about concerns regarding the management and regulation of such flying vehicles in the sky and their impact on the society. This line of reasoning was extracted from the following quotes: *"Lack of infrastructure. No regulation to monitor development. Development and building infrastructure are completely ad hoc", "Air space management and the decision of optimal height".*

5. Data analysis and design parameters

The data from the first segment *(Demographic and Travel Behaviour)* were analysed by taking the highest frequency to different multiple-choice questions. Design attributes suitable to the average working-age or travel behaviour were investigated and prescribed in terms of design parameters. For the second set (*Quantitative data*) responses with higher mean were considered to form the design parameters. Finally, for the third set *(Qualitative data)* the analysis is done as per the process mentioned in Section 3.2. From the raw statements of participants, keywords were derived, then these keywords were compared, and similar terms were merged into one. Once all the data were converted into selected unique keywords, the frequency of the keywords were calculated. The keywords with higher frequencies highlight the importance of the respective attribute to the users. From this, these attributes were converted into design parameters by transforming or supplementing them into distinct themes that build the basis for design specifications.
From the demographic data, we found that a large part of young working Indians must regularly travel in congested traffic and are looking for an alternate mode of intra-city transportation. In addition to the frustration of sitting in slow-moving traffic, this also entails a considerable amount of time lost in commuting every day, which could otherwise be used working towards personal prosperity and even contribute to the economic growth of the country when used to raise the productivity. Figure 5 illustrates the requirements guiding the development of passenger drones generated from the age group of the demographic data and related travel behaviour.

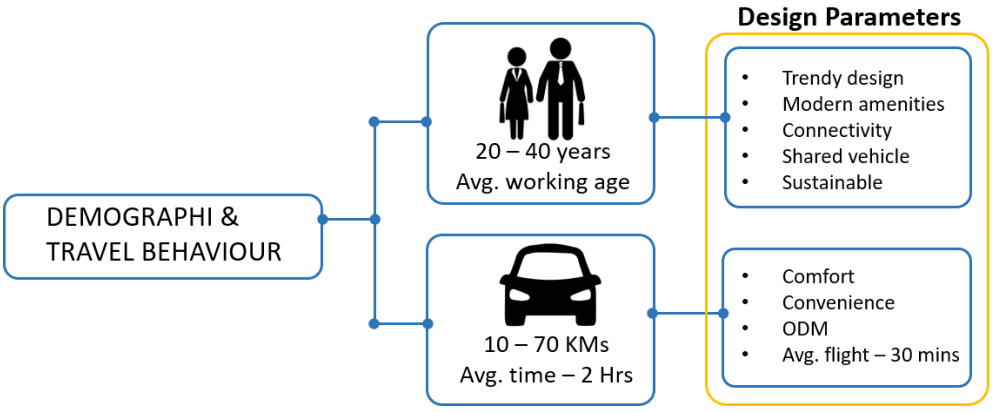

Figure 5. Inference from demographic and travel behaviour data

On analysis of the data from the Likert based questions where users' have rated the design elements on their relative importance, following inferences can be drawn, as shown in Figure 6. The responses

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with higher mean were considered, and methods or activities that can resolve these issues were listed as design parameters as a suggestive guideline.

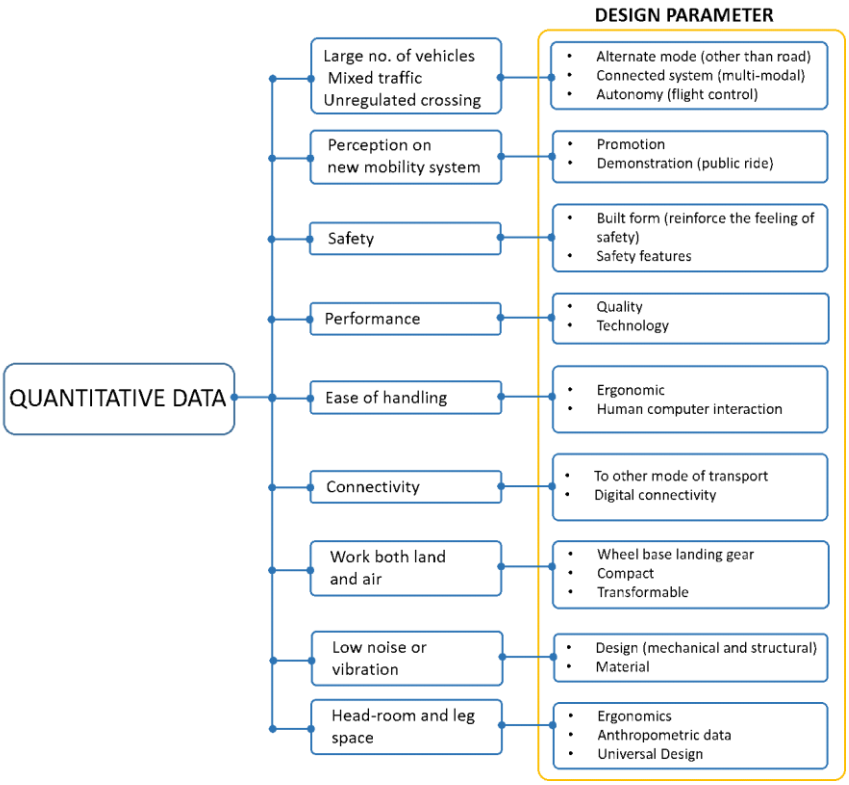

Figure 6. Inference from quantitative data

The qualitative data (refer Figure 3 and 4) gave a few unique insights about the users' perception of passenger drones, as illustrated by Figure 7. A similar process was followed, as mentioned above, to suggests the design parameters for the qualitative data.

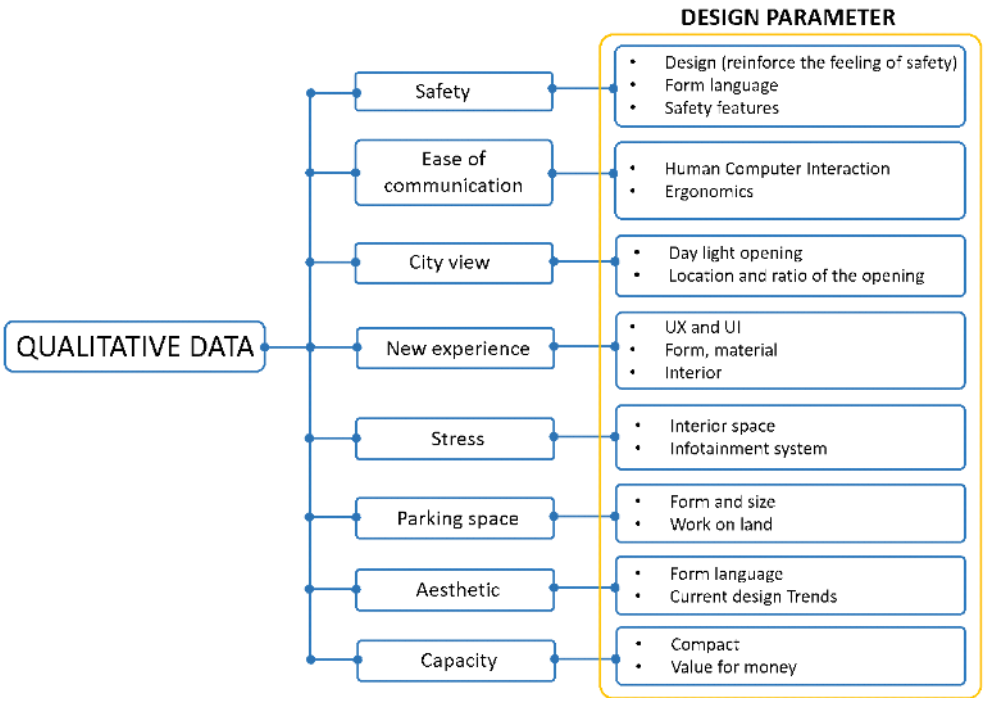

Figure 7. Inference from qualitative data

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Following are few of the essential design considerations derived from the users' survey:

- Growth of passenger drones should not cause air traffic congestion.
- Participants wished for a vehicle that can work both on land and air for secure parking.
- Proper ergonomics and universal design for better passenger comfort.
- The amount of daylight opening should be designed in such a way that it promotes 360^0 views.
- The cabin space should be able to reduce the feeling of vertigo and claustrophobia.
- Interaction with the vehicle should be natural with intuitive controls.
- Every aspect of the product should be able to encapsulate the notion of speed and should be the basis of the design.
- Safety was one of the major concerns from the study, and as designers, one must be able to reinforce the feeling of security in all the aspect of design which includes the built form, material used, the cabin space, etc.
- The flight system should be such that, there is less dependency on the users for the control of the flight, and the autonomous system should be able to handle the majority of the operation without disruption.
- On a system design level, one must evolve a concept which is not only cost-effective but also commercially viable to make passenger drones more affordable to the common people.

6. Discussion and conclusion

The conducted pan-India survey on users' needs, wants and concerns for passenger drones supports the researcher assumption that such users' survey can give new and unique insights that will help in designing the new mode of transportation. It was also first of its kind of online study on the development of passenger drones in India. At the same time, there were few limitations to the survey conducted, such as the number of participants was limited to 224 which is a small sample size to gauge the users' perception for a vast country like India. Secondly, the spread of participants was not equal and was limited to a few states only. Thus, the result cannot be generalised. And finally, the survey was conducted on prospective users as passenger drones are yet to be launched commercially. So, the result of the study should be used as suggestive measures rather than prescriptive design parameters.

With the development of technologies, drones have come a long way from being developed as a weapon, to be a means of recreations and finally emerged as a mode of transportation. With users willing to travel in this new mode of transportation, passenger drones will face new obstacles and challenges. Understanding these problems and needs of users before designing will drastically improve the efficiency and working of the system. During the analysis of the responses from the participants, it was evident that many of them were not aware of the development of passenger drones and chose not to answer. With companies like Uber Air planning to launch passenger drone as early as 2023 in USA and Australia, with plan to launch in India by 2025 (Agarwal 2019) such users' survey must be conducted to understand the needs, wants and concerns of users.

In the future, to explore and better understand the users' perception, personal interviews or group workshops/focus groups will be conducted. Through Virtual Reality (VR) simulation, participants will experience flying in a passenger drones before it becomes available in the market. It can be used effectively to simulate and monitor the users' behaviour and reaction to the new medium of transportation. Future studies may able to capture the first generation of users flying in these new PAV devices and with their responses may able to develop better intra-city passenger drones. Thus, the knowledge gained from such users' survey can inform designers and product manufacturers about the new strategies in term of form language, aesthetic, etc. that can significantly help in designing a passenger drones apt for intra-city commuting in India.

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