



Research Diary

World of PAVs

Practice-based research on Personal Aerial Vehicles

Priyabrata Rautray (L)

Joint PhD Scholar IIT Hyderabad and Swinburne University

Supervisor: Prof Deepak John Mathew (R), Department of Design

KID: 20220209

Exploring the forms in Personal Aerial Vehicle designs suitable for mobility in India's growing cities:

In the 21st century, where hamlets and towns are replaced with megacities, the load on the existing road infrastructure is very high, leading to a demand for smooth and efficient transport systems. As a result, there is an opportunity to design and develop alternative modes of a personal transportation system that does not rely on the land infrastructure or add to the existing traffic. Thus, aerial transportation can be faster and less expensive than developing new physical infrastructure.

The technologies involved in Personal Aerial Vehicles (PAVs) have been increasing rapidly over the last decade. We need to understand that PAVs are an entirely new transportation system. With the change in the medium, unique user experiences and challenges will need to be addressed. Thus, this research project aims to understand the users' form perception of PAVs, their needs, wants and concerns, and how to convert them into design parameters for future development. The research will have tangible and intangible outputs that will empower designers to create new PAVs.

This research project is a part of a funded project by the Government of India on the holistic development of PAVs for Indian cities. The group consist of research from various departments like Computer Science, Mechanical and Aerospace Engineering, Electrical and Electronics, Chemical Engineering, Department of Design, etc. As part of the project, these engineering departments will develop the required technologies for PAVs. Besides the essential technical and engineering details, the design parameters are critical for the PAV's overall physical form. Public acceptance and market success depends on how well the design accommodates users' needs, wants, and concerns and can make a crucial difference in their success. This research also tries to reduce or forgo the time taken for an automobile to develop from an engineering device to become more user-friendly and an object of desire. Thus, this research is focused on users' needs, wants and concerns, which can be translated into design parameters to explore the forms for these new PAVs. Even though the development of PAVs is in its nascent stage, it promises to be one mobile device that can create an alternative mode of the personal air transportation system for Indian cities in the near future.

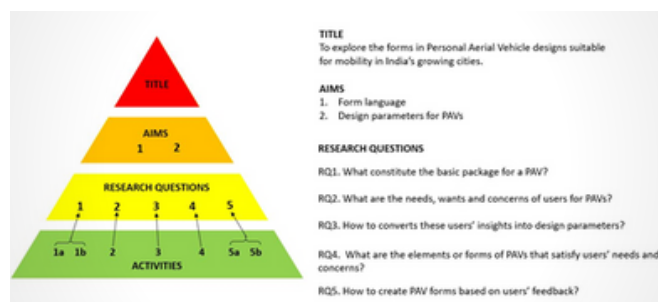


Figure 27: Research Design

The research project was designed so that the research activities formed the base of the pyramid and helped answer the research questions. These research activities include product reviews, storyboarding, Pugh Multi-criteria analysis of VTOL technologies, user surveys, and form surveys, as shown in Figure 27, Figure 28 & Figure 29.

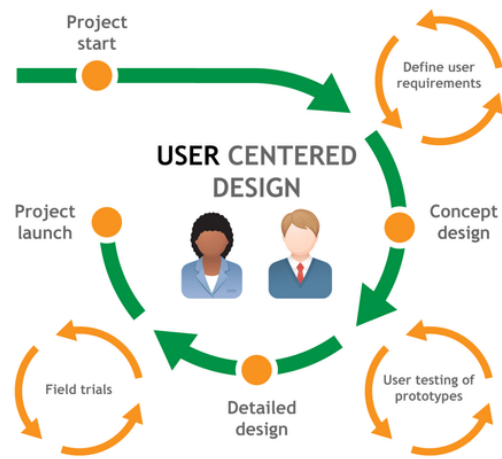


Figure 28: Usercentered design process

Product reviews are valuable information, and better help designers understand their products. Comparing current PAVs highlights various product criteria such as size, VTOL technology, number of passenger carrying capacity, flying distance or endurance, power source, control and form factors. The shape and outlook of PAVs vastly depend on the VTOL technologies and working scenarios used to design PAVs. Thus, the storyboarding method was used to highlight the different working scenarios and understand the requirements of modern cities for PAV operation.



Figure 29: Storybording as research method

Research Diary

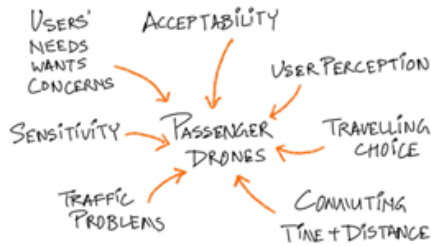


Figure 30: Key areas for users' survey

Designers and researchers have used different methods and techniques to develop new products. Collecting users' data is one of the essential ways to create more user-centric and commercially successful results. Traditionally, a user survey involves evaluative research where users generally evaluate existing prototypes or concepts. In generative research, users' insights are informed to the designers before production. The first online study presents users' needs, wants, and concerns about the PAVs and studies different aspects of the PAVs system and its relation to the user, as shown in **Figure 30**.

This second survey mainly focuses on the visual aesthetic aspect of the current PAVs' product form. To develop a conceptual design, one needs to understand the global trends in designing PAVs and users' perceptions of PAV. In this segment, three methodologies, as shown **Figure 31**, **Figure 32** & **Figure 33**, were used to analyse the product form of PAVs:

Design Format Analysis (DFA) - the study of visual elements, form language, identity, design elements, etc., and their relationships and organisation to form a coherent product.

Form Survey - A second survey was conducted to understand the users' perception of forms of PAVs.

Deconstruction - breaking the product form into constituent elements and studying the relation in shape, size, proportion, and location.

The form survey's objective was to analyse the visual aesthetic aspect of the product form of the existing PAVs and understand the users' perception of PAVs (Chiu & Lin, 2018; Dahlgard Jens et al., 2008; Nagamachi, 2016). The survey was based on the Kansei engineering method, where the user had to select a set of emotive words from a given list to describe the PAVs. Then using the process of deconstruction, the users were shown the outline of the current PAVs form and were asked to select the associated Kansei words. The user data were analysed using four methods: correlation, frequency, DFA and deconstruction, and analysis of answers to open-ended questions. The second survey's findings helped formulate the form parameters and four groups of PAVs based on the form attributes.

The practice-based research method was used to implement the findings of the research activities. This process includes the iterative design process through which seven different concept designs were created for each group. This step is followed by developing form models (scaled model 1:15) out of Polyurethane (PU) foam. A detailed 3D modelling and rendering were done to study the form. Out of twenty-eight designs, one design per group was selected for further form development. These selected models were shown through 3D animation for better perception of form and scale. The artefacts created in this activity were displayed as an exhibition to acquire user feedback on the PAV forms.

Exterior form and Elements				
Passenger Drone	Ehang 184	Airbus Popup	Aston Martin Volante	Augusta Westland Project Zero
Images				
Features/Elements				
No. of passenger	2	2	3	2
Rotor	8 Co-axial rotors	Detachable Rotor	2 Tilt-able Rotors, 1 Fixed rotor	2 Tilt-able Rotors
Wing type	NA	NA	Fixed wing body	Fixed wing body
Landing gear	Fixed landing gear	Detachable drive base	Fixed landing gear	Wheel base
Shape	Pear shape	Boxy with flats edge	Linear	Aero dynamic
Day light opening	Traditional front windshield, side opening on door	Traditional front windshield, side glass door	Complete glass Windshield	Complete glass Windshield
Door Type	Butterfly door	NA	Butterfly one side hinged	NA
Colour	White and Black	Silver Grey	Slate metallic grey	White, Red & Black
Surface type	Rounded and merging	Angled and fluted	Edge and sharp	Rounded and narrow
Edge type	Curvy	Straight with rounding	Mix of straight and curves	Gradual curves

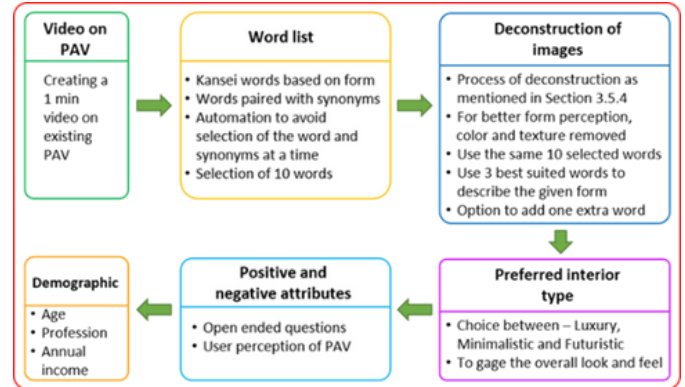


Figure 31 : Design Format Analysis & Form survey



Figure 32: Key areas for users' survey

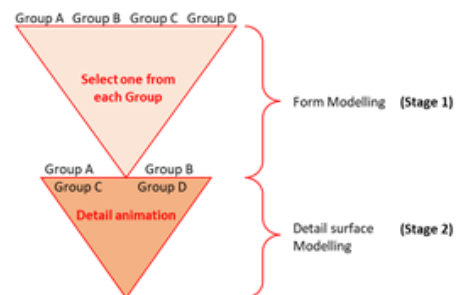


Figure 33: Process of creating artefacts

These twenty-eight scaled-form models were created based on these parameters and following practice-based research methodology. To conclude, here are a few images of the model-making process.

Research Diary

These twenty-eight models were displayed in an exhibition inaugurated by our honourable director Prof B S Murty, on Jun 24, 2022. The show was open for four days and was visited by students of IITH, faculties, designers from Hyundai, school kids from DAV Public school IITH campus and many more.

