MMME 4057
HUMAN-COMPUTER SYSTEMS

AUTONAV: AN IN-VEHICLE REAR SEAT INFOTAINMENT SYSTEM

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1. Executive Summary

For transport services aiming to elevate passenger experiences and gain a competitive edge, our AutoNav in-car rear seat infotainment system offers a personalised multimedia experience with intuitive controls, secure connectivity, integration to official application suites and real-time travel updates, ensuring seamless and enjoyable long-distance journeys.

This report introduces an in-car rear seat infotainment system for passengers aged 18 and above during long car journeys, addressing the lack of passenger-focused designs. The project followed a human-centred design (HCD) approach, ensuring that the design process revolved around the needs, preferences, and behaviours of the end users. The process started with interviews to gather requirements, exploring diverse participants' attitudes and experiences with in-car rear seat infotainment systems. Key themes such as travel frequency, media consumption preferences, and interaction preferences were identified through thematic analysis of interview data. To gain a deeper understanding of user needs, motivations, and contextual factors, tools including user personas, empathy maps, competitor analysis, and Context of Use Analysis (CoUA) were further utilised.

Insights from the requirement gathering informed the User Requirement Specification (USR) document, based on the Volere template. The USR identified 37 requirements, including 21 functional and 16 non-functional specifications, and prioritised them using the MoSCoW method.

Next, user requirements were translated into prototypes for the in-car rear seat infotainment system. The aim was to create low-fidelity prototypes grounded in user needs, ensuring both functionality and aesthetic appeal. The information architecture was designed to ensure intuitive navigation, with key functions strategically placed for ease of access. Sketching and digital tools such as Figma facilitated quick iteration and collaboration, reducing the time between feedback and design changes.

Following the design phase, the next step involved evaluating the prototype through user-based and non-user-based assessments. The heuristic evaluation based on Jakob Nielsen’s heuristics identified usability challenges, suggesting improvements for navigation, tutorials, and error clarity. Conversely, the Verbal Protocol and System Usability Scale questionnaire showed generally positive ratings, indicating satisfactory overall usability for participants.

Based on our observations and evaluations, we identified key areas of improvement for further design iterations. These included bringing consistency to the UI, improving navigation for usability, and including in-app tutorials and helpful error messages.

2. Introduction

In the transportation services industry, evolving passenger expectations have driven the development of advanced in-car experiences. As companies strive to enhance their offerings, integrating sophisticated infotainment systems into their fleets has become crucial. Our product AutoNav introduces a bespoke in-car rear seat infotainment system designed to transform ordinary journeys into luxurious experiences for passengers. This system is not only a source of entertainment; it is an integrated suite designed to meet the varied needs of modern travellers.

With the prevalent trend of infotainment systems being designed primarily to address driver needs (Meschtscherjakov *et al.*, 2011; McGill and Brewster, 2019), there is a clear imperative for designers to pivot towards systems that prioritize the comfort and convenience of passengers. According to prior research (Berger, Pfleging and Bernhaupt, 2021), passengers regard well-being, physical comfort, and safety as the key elements contributing to a satisfying in-car experience. The research further highlights the significance of accessing information, customizing user experiences, offering recommendations, and connecting passengers' external devices. Another research (Inbar and Tractinsky, 2011) previously suggested that trip-related information can significantly enhance the passenger experience on long journeys. Passengers crave information that surpasses basic updates like arrival times, speed levels, or traffic conditions and extend to searching for points of interest for a satisfying user experience (Berger, Bernhaupt and Pfleging, 2019; Berger, Pfleging and Bernhaupt, 2021).

Furthermore, research has shown that during longer journeys, the demand for engaging entertainment and interactive activities becomes crucial to enhancing passenger experience and managing boredom, especially for children (Wilfinger *et al.*, 2011). This aligns with findings by another research (Meschtscherjakov *et al.*, 2011, 2016) which emphasizes the importance of including video and gaming services in vehicle systems as essential components for enhancing the passenger experience. There has also been research to support that control over in-car systems is a fundamental need for passengers, not just drivers (Berger, Pfleging and Bernhaupt, 2021). This study reveals that 75% of participants view the ability to directly manipulate device settings and functions as essential for a convenient experience. According to the research, personalization also plays a significant role on passenger convenience, and it is not just limited to content recommendation but also extends to the choice of route and control over physical aspects like temperature. A study on intelligent in-car infotainment systems introduces significant advancements designed to reduce cognitive load through user-adaptive and context-aware features (Garzon, 2012). The study highlights the use of contextual personalized shortcuts and automation, which simplify system interactions by automatically adapting to the user's habits and current context.

Our project is dedicated to designing AutoNav a state-of-the-art infotainment system for transport businesses looking to provide a luxurious passenger experience. Our system will offer

a suite of features designed to keep passengers engaged, productive, and well-informed throughout their journey. Passengers will be able to enjoy personalized entertainment, seamlessly integrate their work commitments, and access timely, relevant information about their journey and local interests, significantly enhancing their satisfaction and comfort. Additionally, AutoNav integrates an AI-powered voice assistant for effortless system navigation and contextual personalized shortcuts and automation that adapt to user habits and the environment, simplifying interactions and enhancing user experience. This will ensure that every journey is not just comfortable but also customized to meet individual preferences and needs. For transport operators, AutoNav will aim to offer a competitive advantage by elevating the standard of passenger experience, thus not only attracting but also retaining a discerning clientele.

3. Requirements Gathering

The requirement gathering phase is a crucial step in the development of any product, ensuring that we meet the needs and preferences of our intended users. Understanding the requirements are essential for designing a successful product that effectively addresses user needs and expectations. We employed a range of techniques such as interviews, user personas, empathy maps, competitor analysis, and literature review to gain a deep understanding of user requirements and preferences which further allowed us to design the system effectively.

3.1 Semi-Structured Interviews

Semi-structured interviews were conducted to explore participants' attitudes and experiences with rear-seat infotainment systems. These interviews served as an initial discovery phase to uncover broad patterns and themes regarding users' experiences. Six participants, three females and three males aged 24 to 58, were recruited to ensure diverse perspectives while managing interview and analysis timeframes effectively. The participants were recruited through convenient sampling primarily from the friends and family of group members.

The interview schedule was designed for open-ended discussions while maintaining consistency. Questions followed a logical sequence: introduction, warm-up, main discussion, cool-off, and closing. Open-ended and follow-up questions were used to explore diverse perspectives without leading the participants' responses.

For data analysis, thematic analysis was conducted, following the six-stage process outlined by Braun and Clarke (2006). This involved breaking transcripts into meaningful excerpts, classifying them into codes and sub-themes, and organizing them into broader themes. These themes covered a range of factors, including user preferences, challenges, and expectations. The following prominent themes were identified:

Travel Frequency and Activities:

Participants reported engaging in long car journeys a few times a year, primarily for commuting or travelling. During these journeys, they enjoyed activities such as listening to music, podcasts, or audiobooks, reading books, engaging in phone calls, or having conversations. For example, one participant mentioned, "I take long trips a few times a year, usually office trips, which last for 1.5-2 hours. On call with clients to resolve issues most of the time."

Media Consumption Preferences:

Most participants preferred using their smartphones for media consumption, using apps like Spotify. Connectivity, particularly Bluetooth and Wi-Fi, was found to be important for streaming music and accessing online content without exhausting mobile data. One participant stated, "I prefer using my own devices because they give me access to my playlists and podcasts, and I can use headphones to not disturb others."

Purpose of Infotainment Usage:

Participants used infotainment systems during travel to pass the time, stay entertained, and occasionally stay informed about current events. Lack of connectivity or drained phone batteries negatively impacted their experience, making the journey feel longer and more boring. A participant mentioned, "Once my phone's battery ran out, the journey felt longer and boring."

Journey-Related Information and Navigation:

Real-time updates on traffic information, weather conditions, and navigation were highly valued by participants. They preferred clear and concise presentation of journey-related information, with simple visual displays or occasional voice updates being acceptable. For example, one participant stated, "I would prefer real-time updates, especially on traffic and weather conditions, as they directly impact my journey."

Interaction Preferences with Infotainment Systems:

Participants varied in their preferences for interaction with infotainment systems, with some preferring their own devices for control, while others preferred simplified touchscreen controls or physical buttons. Desired features included access to personalized content, Wi-Fi connectivity, good speaker systems, and automatic turn-off when not in use. A participant expressed, "No, I prefer to be in control of what I watch or listen to during the journey."

Challenges and Frustrations:

Participants identified challenges such as access and control issues, lack of entertainment during traffic, system complexity, slow response times, and ergonomics concerns. For example, one participant mentioned, "If it was overly complicated, I might opt for simpler alternatives like reading or enjoying the scenery."

3.2 User Personas and Empathy Map

Through thematic analysis of semi-structured interviews, user personas and empathy maps were created. Business travellers, tourists, commuters, and senior citizens emerged as the primary users, each presenting unique needs and perspectives.

For instance, Maya, a 27-year-old master's student, represents the casual traveller persona. She values simplicity and safety in her infotainment system, prioritising Wi-Fi connectivity for streaming and Google Maps integration for navigation. Maya's challenges include limited control over the infotainment system, dependency on connectivity, and safety concerns regarding voice assistants.

On the other hand, Derek, a 45-year-old senior manager at an ad firm prioritises comfort, accessibility, and simplicity in his infotainment system, facing pain points related to complexity, technical issues, and lack of integration with his preferred services.

Lastly, Sven, a 35-year-old tech entrepreneur, emphasises cutting-edge technology, connectivity, and productivity. He requires seamless device integration, access to a broad range of content, and personalised recommendations, with pain points including distractions, unresponsiveness, and lack of content. Each persona's motivations, core needs, and pain points inform the design considerations for the ideal in-car infotainment system.

Figure 1: User Persona 1

Figure 2 User Persona 2

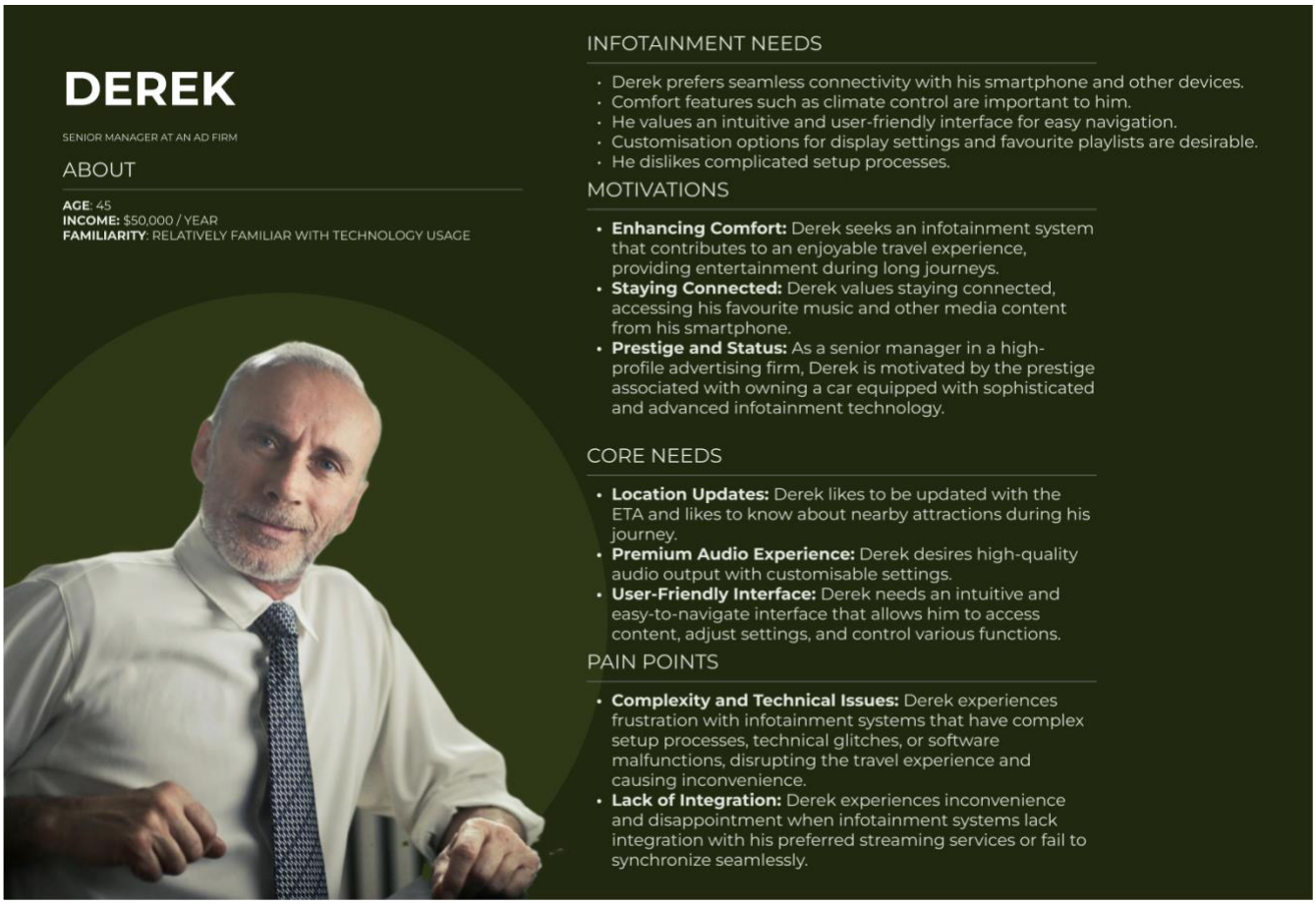


Figure 3 User Persona 3

Figure 4 Empathy Map

The empathy mapping process provided crucial insights, revealing significant aspects of user experiences and expectations. These findings have informed and shaped the user requirements and design strategy for our infotainment system. Below is a summary of the empathy map derived from the analysis:

- **They Do:** Users engage with the infotainment system to manage climate control, seating adjustments, and system settings. They use features for navigation assistance, making calls, and enjoying a variety of entertainment options like music and podcasts, while utilizing safety features to minimize distractions.
- **They Say:** Participants expressed appreciation for real-time updates and the integration with personal devices which enhance their journey. They favor interfaces that allow the use of personal headphones and prefer physical controls over touchscreens due to responsiveness.
- **They Think**: There is a strong preference for intuitive, user-friendly interfaces that facilitate seamless connectivity with personal devices. Users value safety and comfort, emphasizing the need for systems that allow easy control over content and settings without causing distraction.

- **They Feel:** The design and functionality of the system evoke happiness when user-friendly, anxiety with complex navigation, delight with multiple connectivity options, and fear of potential distractions affecting driving safety.
- **Their Pains:** Frustrations arise from limited interaction with personal devices, concerns over the usability of touchscreens versus physical controls, and the occasional lack of Wi-Fi or Bluetooth connectivity.
- **The Gains:** Their desires from the system include voice control functionality, high-quality visual displays, extensive entertainment options, real-time update on travel information and seamless connectivity with personal devices, all of which enhance the in-car experience.

3.3 Competitor Analysis

A competitor analysis was also conducted to examine different aspects of rear seat infotainment systems, such as user experience, screen size, entertainment choices, connectivity, audio quality, compatibility, and exterior design. Each system from competitors was carefully assessed using a standardised scoring key. This evaluation identified strengths and weaknesses in each competitor's product, informing improvements for an ideal rear seat infotainment system.

Competitor Analysis

Competitors	User Experience	Screen Size	Entertainment Options	Connectivity	Audio Quality	Compatibility	Exterior Design
Tesla Model X	Intuitive user interface, advanced graphics	17-inch touchscreen	Advanced graphics, streaming movies, playing games	Bluetooth, music streaming	High-fidelity sound with immersive surround sound	Compatible with external devices	Spacious and luxurious
Audi Q7	Seamless media playback, interactive controls	Two 10.1-inch screens	DVD playback, gaming consoles, simultaneous media playback	Wireless headphones, USB, HDMI input	Premium sound reproduction with crystal-clear clarity	Multiple media formats supported	High-end
BMW X7	Integrated entertainment apps, personalized settings	Two 10.2-inch touch screens	DVD playback, streaming from tablet	USB, Bluetooth, HDMI connectivity	20-speaker surround sound system	Android-based tablet compatibility	Full-size
Mercedes-Benz V-Class	Intuitive navigation system, voice-activated controls	Two 10.2-inch screens	DVD playback, streaming, USB, HDMI, Bluetooth	USB ports, HDMI, Bluetooth, Wi-Fi hotspot	High-quality audio output with enhanced clarity	Various media devices supported	Luxury minivan
Kia Sorento	Easy-to-use interface, customizable settings	Two 8-inch screens	DVD playback, USB, HDMI ports	USB, HDMI, wireless headphones	12-speaker surround sound system	USB and HDMI compatibility	Mid-size SUV

Scoring Key		
Poor	1	Fails to meet value proposition. Lacks key features and functionality and/or lacks affordances to reach desired outcome within reasonable number of attempts.
Fair	2	Falls short of value proposition. Lacks some features or functionality. Reaching the desired outcome requires expert knowledge or training.
Neutral	3	Meets value proposition. Offers the right features and functionality. Requires many clicks or complex series of steps to reach desired outcome.
Good	4	Above value proposition. Desired outcome can be reached with a moderate amount of steps. Interface is intuitive to use for people new to the tool.
Very Good	5	Exceeds value proposition. Anticipates questions, uses intuitive terminology and provides necessary guidance and affordances. Desired outcome can be easily reached with minimal amount of steps and within one or very few attempts.

Figure 5 Competitor Analysis

3.4 Context of Use Analysis (CoUA)

The Context-of-Use Analysis (CoUA) method is required to analyse the context in which the product will be used. It stems from the combination of interviews, empathy maps, usability tests. The data collected from these research methods can be used to shape the user

requirements and help answer certain key questions related to any product. The factors affecting the context includes User Factors, Task Factors, Physical Environment, Organisational and Social Factors. It improves the designers' perception of the final product in the presence of these factors (Chamorro-Koc et al. 2004). The CoUA table was iteratively changed and gradually defined during the design process.

Unlike other methods, the context of use analysis is used throughout the development cycle which required multiple iterations of analysis and review

From this analysis, we identified 6 new requirements, namely:

- Headphone Support: To ensure that audio from the infotainment system does not distract the driver or other passengers preferring silence
- Enable voice control supported by AI
- Provide high-contrast display options
- Provide text-to-speech option for visually impaired passengers
- Haptic feedback for tactile interaction cues
- Gesture shortcuts for easy navigation

Furthermore, we identified 12 other requirements that were impacted. These requirements were improved to accommodate the relevant design considerations.

- Intuitive and Easy to Use: Given the diversity of users, the system should have an intuitive interface that can be easily used by people of all age groups and tech-savviness
- Multilingual Support: To cater to international travellers, the system should support multiple languages
- Responsive Touchscreen Display: High-quality, responsive screens
- Ergonomics: Comfortable distance between passenger and screen
- Local Interest and Tourism Information: Information about the destination, including maps, points of interest, events, and cultural insights to help passengers plan their stay
- Wi-Fi & Bluetooth Connectivity: To allow passengers to use their own devices to access the internet, social media, emails, etc
- Recommendation Engine: Suggest content based on previous selections and popular choices among similar users
- Identify when the passenger has onboarded and have personalised welcome message
- GPS Integration: For real-time journey tracking and updates on estimated arrival times
- Include Ambient Intelligence display and lighting in the environment
- Offer live cinematic view of surroundings during the journey
- Multi-screen support

4. User Requirements

There are certain essential specifications that are expected by a user to be present in a system to assist in solving their problems whilst performing a task. The User Requirement Specification

(USR) document profiles the various requirements such as functional and non-functional requirements, performance requirements, accessibility requirements, operability requirements, compatibility requirements and User Interface (UI) requirements.

The USR document provides a clear understanding of the functions and characteristics the final system is going to entail and what the end user is going to experience. This is a crucial step in the design cycle to understand and breakdown user requirements. Creating a USR organises and makes the process of designing the system smoother by producing viable goals, providing time frames and eventually a clearer vision of the expected product.

The design approach that we took was human-centred. The Human-Centred Design (HCD) cycle is a type of product development method where the end-user is prioritised. It is seen as an effective long-term solution to push user-engagement (Wong et al., 2018).

User Requirements is a vital part of the HCD cycle, is always done from the perspective of the user providing several key advantages:

- It entails the active participation and collaboration of users throughout the design cycle. Using methods like user interviews, user personas, empathy maps and other requirement gathering processes designers can gain valuable insight and feedback on their product pushing designers to make appropriate changes to their design reflecting the user's feedback.
- Understanding and analysing user requirements can also act as a foundation for highlighting real world problems faced by the user. We can proactively tackle these issues in the design process rather than dealing with issue later.
- When a proactive approach is taken, several risks in designing the product are mitigated and reduces the changes of the product failing.
- User requirements also aid in understanding the range of users (different backgrounds, disabilities) that exist. Naturally, usability and accessibility of the product is improved.

4.1 Prioritisation using Moscow method

One of the most prevalent user requirement prioritisation methods used in software development and product design project management teams is the Must Have, Should Have, Could Have, Won't Have (MoSCoW) method. This method is classified into four different categories each having different levels of priority. After gathering user requirements, they are then designated one of the four categories. This acts as a guide to filter out requirements. The following is what each group represents:

- **Must Have (M):** This group includes user requirements that are compulsory and are a non-negotiable and are essentially the core functionalities of the final product. These requirements make or break the product. This category is ranked the highest in priority. An example of a Must Have requirement from our product is R03 which defines responsive touchscreen display.

- **Should Have (S):** This group includes user requirements that are fairly important but will not lead to the failure of the system if not implemented. They will contribute to the betterment and improvement of the product but are only implemented if resources permit. This category ranks second in priority. An example of a Should Have requirement is R05 which defines the ergonomics of the system – the distance between the user and the screen.
- **Could Have (S):** This group includes user requirements that could possibility improve the user experience and performance of the system, but these functionalities might be implemented towards the end of the design cycle if they do not involve too much effort or cost (Ahmad et al., 2017). This category ranks third in priority. An example of a Could Have requirement is R13 which contains AI controlled voice assistant in the infotainment system.
- **Won't Have (W):** This group includes user requirements that are completely out of scope of the project and will not be included product at all. It is ranked the lowest in priority and does not contribute to the success of the product. An example of a Won't Have requirement is R17 which is related to the tracking of user data

Figure 6 MoSCoW Matrix

4.2 User requirements specification

After prioritisation activities, we created a list of our final requirements. We curated 37 requirements in total, with 20 functional and 17 non-functional requirements. These were collated using the Volere template and have been listed in detail below.

ID No	R01	Type	Non Functional
Description	**Intuitive and Easy to Use:** Given the diversity of users, the system should have an intuitive interface that can be easily used by people of all age groups and tech-savviness		
Rationale	User diversity necessitates an intuitive interface for easy adoption, enhancing satisfaction and ensuring accessibility for all passengers.		
Source	Group Discussions		
Importance	Must Have		
Requirement Met	Yes		

ID No	R02	Type	Functional
Description	**Multilingual Support:** To cater to international travellers, the system should support multiple languages		
Rationale	Accommodates diverse language preferences, ensuring inclusivity and ease of use for international travellers, thereby enhancing their overall experience and satisfaction with the system.		
Source	Brainstorming		
Importance	Could Have		
Requirement Met	No		

ID No	R03	Type	Non Functional
Description	**Responsive Touchscreen Display:** High-quality, responsive screens		
Rationale	Delivers smooth interaction and navigation, enhancing user satisfaction by providing a seamless and intuitive interface for accessing various features and content.		
Source	User Interviews		
Importance	Must Have		
Requirement Met	Yes		

ID No	R04	Type	Non Functional
Description	**Recent Apps:** Conveniently switch between recently accessed applications.		
Rationale	Streamlines user interaction by allowing quick transitions between recently used applications, optimising efficiency and enhancing overall usability during travel.		
Source	Brainstorming		
Importance	Wouldn't Have		
Requirement Met	Yes		

ID No	R05	Type	Non Functional
Description	**Ergonomics**: Comfortable distance between passenger and screen		
Rationale	Prioritises passenger comfort and safety by adjusting screen positioning relative to the user and car movement, ensuring optimal viewing angles and minimising distractions.		
Source	User Interviews		
Importance	Should Have		
Requirement Met	No		

ID No	R06	Type	Functional
Description	**Adaptive brightness:** Adjust screen light levels according to the environment		
Rationale	Enhances visibility and reduces eye strain by automatically adjusting screen brightness based on ambient light conditions, providing optimal viewing comfort for passengers during journeys.		
Source	Group Discussions		
Importance	Must Have		
Requirement Met	Yes		

ID No	R07	Type	Functional
Description	**Entertainment**: A wide range of options including movies, TV shows, music, and games to cater to different tastes and age groups		

Rationale	Offers a diverse range of entertainment options, including movies, TV shows, music, and games, catering to various tastes and age groups, thus maximising passenger enjoyment and engagement.
Source	User Interviews
Importance	Should Have
Requirement Met	Yes

ID No	R08	**Type**	Functional
Description	**Local Interest and Tourism Information:** Information about the destination, including maps, points of interest, events, and cultural insights to help passengers plan their stay		
Rationale	Enriches the travel experience by providing destination insights, maps, and event details, empowering passengers to explore and plan their itinerary, enhancing overall journey satisfaction.		
Source	Brainstorming		
Importance	Must Have		
Requirement Met	Yes		

ID No	R09	**Type**	Functional
Description	**Live TV and Streaming Services:** Access to live TV channels and streaming services for passengers who want to catch up on their favourite shows or watch live events		
Rationale	Enables access to live TV channels and streaming services, allowing passengers to stay updated with their favourite shows and events, enhancing entertainment options during travel.		
Source	Brainstorming		
Importance	Should Have		
Requirement Met	Yes		

ID No	R10	**Type**	Functional
Description	**Wi-Fi & Bluetooth Connectivity:** To allow passengers to use their own devices to access the internet, social media, emails, etc		
Rationale	Facilitates seamless integration with personal devices via Wi-Fi and Bluetooth, enabling passengers to access the internet, social media, and emails, thereby enhancing convenience and connectivity during the journey.		
Source	Group Discussions		
Importance	Should Have		
Requirement Met	Yes		

ID No	R11	Type	Functional
Description	**USB Charging Ports:** For passengers to charge their devices during the journey		
Rationale	Provides USB charging ports for passengers to keep their devices powered throughout the journey, ensuring uninterrupted usage and enhancing passenger convenience.		
Source	Brainstorming		
Importance	Could Have		
Requirement Met	No		

ID No	R12	Type	Functional
Description	**Headphone Support:** To ensure that audio from the infotainment system does not distract the driver or other passengers preferring silence		
Rationale	Offers flexibility in audio output through 3.5mm jack and Bluetooth connectivity, ensuring compatibility with various devices and enhancing passenger convenience.		
Source	Context of Use Analysis		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R13	Type	Functional
Description	**Enable voice control supported by AI:** To enable intuitive and easy navigation of the system with natural language processing, eliminating the need to learn pre-determined voice commands.		
Rationale	Enhances user convenience by enabling hands-free operation of the system, allowing passengers to interact with the infotainment centre effortlessly, thus improving overall usability and accessibility.		
Source	Context of Use Analysis		
Importance	Could Have		
Requirement Met	Yes		

ID No	R14	Type	Non Functional
Description	**High-contrast Display:** Provide high-contrast display options		

Rationale	Offers customisable display options such as high contrast settings, catering to individual preferences and enhancing readability, thereby improving user satisfaction and inclusivity
Source	Context of Use Analysis
Importance	Could Have
Requirement Met	No

ID No	R15	**Type**	Functional
Description	**Text-to-Speech:** Provide text-to-speech option for visually impaired passengers		
Rationale	Supports text-to-speech functionality for visually impaired passengers, ensuring inclusivity and accessibility, and enhancing the overall usability of the system.		
Source	Context of Use Analysis		
Importance	Could Have		
Requirement Met	Yes		

ID No	R16	**Type**	Non Functional
Description	**Remote Content Management:** Ability for the company to update and manage content remotely, ensuring that the entertainment options are current and diverse		
Rationale	Allows the company to update and manage content remotely, ensuring a fresh and diverse entertainment experience for passengers, thereby enhancing overall satisfaction and engagement with the system.		
Source	Group Discussions		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R17	**Type**	Non Functional
Description	**Usage Tracking and Analytics:** To monitor system usage and gather data on passenger preferences, helping to refine and improve the content offering		
Rationale	Provides valuable insights into passenger preferences and behaviour, enabling continuous improvement of the content offering to better meet passenger needs and preferences.		
Source	Group Discussions		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R18	Type	Functional
Description	**User Profiles:** Allow passengers to create profiles to save their preferences for future journeys		
Rationale	Enables passengers to save their preferences for future journeys, enhancing personalisation and convenience, thereby improving overall user satisfaction and loyalty.		
Source	Group Discussions		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R19	Type	Non Functional
Description	**Recommendation Engine:** Suggest content based on previous selections and popular choices among similar users		
Rationale	Enhances content discovery by suggesting relevant options based on user preferences, increasing engagement and satisfaction with the system.		
Source	Group Discussions		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R20	Type	Non Functional
Description	**Welcome message:** Identify when the passenger has onboarded and have personalised welcome message.		
Rationale	Creates a welcoming atmosphere for passengers, fostering a positive user experience from the outset, and enhancing overall satisfaction with the system.		
Source	Group Discussions		
Importance	Must Have		
Requirement Met	0		

ID No	R21	Type	Functional
Description	**GPS Integration:** For real-time journey tracking and updates on estimated arrival times		

Rationale	Provides real-time journey tracking and updates on estimated arrival times, enhancing passenger awareness and satisfaction with the travel experience.
Source	Brainstorming
Importance	Should Have
Requirement Met	Yes

ID No	R22	**Type**	Non Functional
Description	**Ambient Intelligence:** Include Ambient Intelligence in the display borders and lighting in the environment.		
Rationale	Creates immersive experiences through adaptive display and lighting based on the environment, time-of-day, and other factors - enhancing passenger comfort and enjoyment during the journey.		
Source	Competitor Analysis		
Importance	Could Have		
Requirement Met	No		

ID No	R23	**Type**	Functional
Description	**Surround View**: Offer live cinematic view of surroundings during the journey.		
Rationale	Provides real-time visuals of the surroundings, offering passengers a unique and engaging perspective during travel.		
Source	Brainstorming		
Importance	Could Have		
Requirement Met	No		

ID No	R24	**Type**	Functional
Description	**Screencast**: Ability to screencast from their mobile device to the infotainment screen		
Rationale	Facilitates seamless sharing of content from mobile devices to the infotainment system, expanding entertainment options for passengers.		
Source	Group Discussions		
Importance	Must Have		
Requirement Met	Yes		

ID No	R25	Type	Functional
Description	**International Radio:** Provide International Radio to offer diverse radio options		
Rationale	Offers access to diverse radio stations catering to varied cultural preferences, enhancing the entertainment experience for passengers.		
Source	Group Discussions		
Importance	Could Have		
Requirement Met	No		

ID No	R26	Type	Functional
Description	**Interactive Games:** Provide interactive games during the journey		
Rationale	Provides additional entertainment options, promoting passenger engagement and enjoyment during journeys.		
Source	Group Discussions		
Importance	Could Have		
Requirement Met	No		

ID No	R27	Type	Functional
Description	**Temperature control:** Ability to control temperature from the infotainment centre		
Rationale	Allows passengers to adjust climate settings directly from their device, enhancing comfort and convenience during the journey without the need to interact with physical controls.		
Source	Competitor Analysis		
Importance	Could Have		
Requirement Met	Yes		

ID No	R28	Type	Functional
Description	**Emergency SOS:** Provide emergency options		

Rationale	Provides quick access to emergency services via an SOS button, ensuring passenger safety and peace of mind during the journey.
Source	Competitor Analysis
Importance	Must Have
Requirement Met	Yes

ID No	R29	**Type**	Functional
Description	**Passenger Feedback:** Enable passenger to provide feedback at end of the ride		
Rationale	Improves service based on user input and enhances customer satisfaction.		
Source	Group Discussions		
Importance	Should Have		
Requirement Met	No		

ID No	R30	**Type**	Functional
Description	**Billing and Tipping:** View billing at end of journey with option for tipping		
Rationale	Facilitates seamless transactions and builds trust between users and service providers.		
Source	Group Discussions		
Importance	Must Have		
Requirement Met	Yes		

ID No	R31	**Type**	Non Functional
Description	**Notification system:** Alert the user near end of journey		
Rationale	Helps users prepare for the conclusion of their ride, reducing missed stops.		
Source	Competitor Analysis		
Importance	Should Have		
Requirement Met	Yes		

ID No	R32	Type	Functional
Description	**Live sports:** Provide live sports updates		
Rationale	Provides entertainment and information for sports enthusiasts during the journey.		
Source	Group Discussions		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R33	Type	Non Functional
Description	**Multi-screen support:** Allows user to share items across screens in the same car, enabling connectivity among passengers.		
Rationale	Enhances accessibility and flexibility across various devices and screen sizes.		
Source	Competitor Analysis		
Importance	Wouldn't Have		
Requirement Met	No		

ID No	R34	Type	Non Functional
Description	**Social media integration:** Allows users to connect to their social media profiles like Facebook, Instagram etc		
Rationale	Enables users to share experiences and interact with others, boosting engagement.		
Source	Competitor Analysis		
Importance	0		
Requirement Met	No		

ID No	R35	Type	Non Functional
Description	**Haptic Feedback:** Haptic feedback for tactile interaction cues		

Rationale	Enhances interaction and usability through tactile cues and responses when actions are carried out in the touch screen interface.
Source	Context of Use Analysis
Importance	Should Have
Requirement Met	No

ID No	R36	**Type**	Non Functional
Description	**Gesture shortcuts:** Gesture shortcuts for easy navigation		
Rationale	Streamlines navigation and improves efficiency with intuitive gestures.		
Source	Context of Use Analysis		
Importance	Could Have		
Requirement Met	No		

ID No	R37	**Type**	Non Functional
Description	Rear-seat audio volume limits to prevent driver distraction		
Rationale	Reduces driver distraction and prioritises safety for all occupants.		
Source	Group Discussions		
Importance	Should Have		
Requirement Met	No		

ID No	R38	**Type**	Functional
Description	**Microsoft 365 Integration:** Supports suite of Microsoft 365 applications, such as, Word, Excel Powerpoint and allows passengers to connect their account.		
Rationale	Allows passengers to connect their MS365 accounts to remain updated on their work and review materials on the journey.		
Source	Group Discussions		
Importance	Should Have		
Requirement Met	No		

5. Design Phase

The design phase was a crucial time when ideas for our in-car rear seat infotainment system became concrete prototypes. The goal at this point in the project was to produce low-fidelity prototypes that were firmly grounded in the user requirements that were developed earlier on in addition to being aesthetically pleasing.

We were able to quickly visualise and refine interface concepts by using low-fidelity prototyping, which gave us an agile way to respond to the insights we obtained from our analysis of user requirements. Every aspect of the prototype was meticulously designed to cater to certain user requirements, such as the necessity for multilingual support (R02), responsive touchscreens (R03), or intuitive use (R01). They purposefully maintained low fidelity to give priority to iterative flexibility and functional clarity. Every design aspect was examined and modified over time to ensure that it complied with user feedback and heuristic evaluations.

To sum up, our low-fidelity prototypes were the result of a design process that was closely connected to and influenced by user needs, providing a strong basis for the user testing and interface development stages that followed.

5.1 Design Methodology

For our design, we adopted a low-fidelity (lo-fi) prototyping approach, focusing heavily on HCI principles such as simplicity, consistency, and user feedback. This approach allowed us to quickly sketch out ideas, enabling early visualisation of concepts and facilitating iterative feedback without a significant investment of time or resources (Virzi, 1989).

Lo-fi prototypes were crucial for incorporating user requirements into the design. For instance, the need for an intuitive interface (R01) informed our decision to adopt a minimalist design, reducing cognitive load and enhancing usability. The requirement for a responsive touchscreen display (R03) led us to prioritize clear, touch-friendly elements in the layout. Multilingual support (R02), adaptive brightness (R06) and AI Assistant (R13) were also directly reflected in our prototype features.

Throughout the process, we adhered to the HCI standards of user-centred design, ensuring that our prototypes were crafted with the end user's needs and preferences at the forefront. This methodology not only streamlined the design process but also ensured that the resulting interface was aligned with user expectations and best practices in HCI.

5.2 Storyboarding

Building on our foundational design principles and HCI standards, the implementation of the infotainment system was exemplified through a practical scenario involving a persona, Sven—a tech entrepreneur. This narrative was visualized through a detailed storyboard that illustrated

how the system aligns with both his professional needs and personal preferences during a typical journey from the airport to a conference centre.

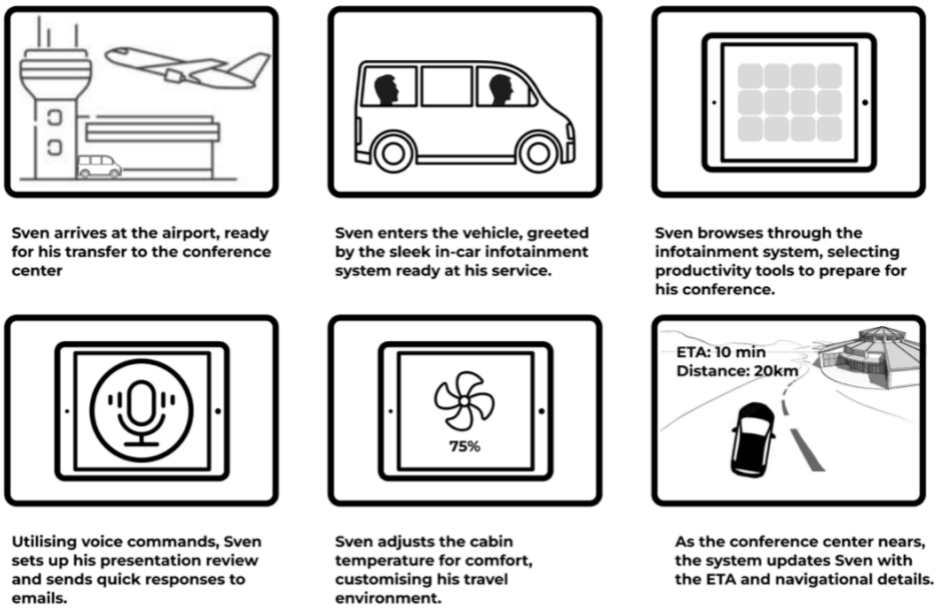


Figure 7 Storyboard for persona Sven

Sven's interaction with the infotainment system was a direct testament to our commitment to user-centred design. As demonstrated in the storyboard, upon entering the vehicle, Sven was greeted by the system which immediately recognized his profile. This personalised greeting showcased the system's capability to provide a seamless, intuitive experience (R01), critical for engaging tech-savvy users like Sven who value efficiency and customization.

The storyboard further highlighted the functionality of the voice commands (R13), allowing Sven to multitask effectively by setting up his conference presentation and responding to emails hands-free. This feature reflects our dedication to reducing cognitive load and enhancing usability, emphasizing the responsiveness (R03) of the touchscreen display that facilitates ease of navigation through voice activation.

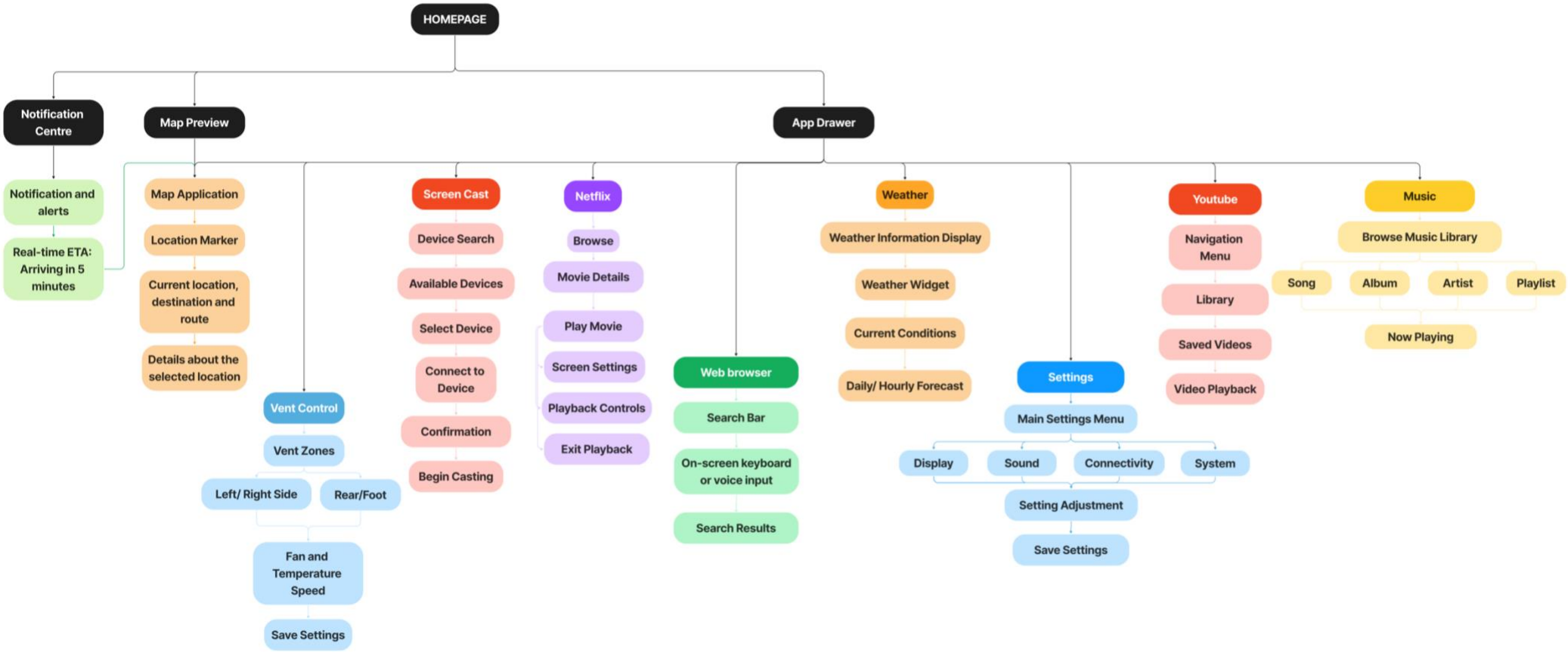
Additionally, the storyboard depicted Sven adjusting environmental settings, such as cabin temperature, using a simple, intuitive interface. This scenario underscored the importance of ergonomic design (R05) and adaptive system brightness (R06), ensuring comfort without distraction, thereby enhancing the overall user experience.

As Sven approached his destination, the system provided timely updates on ETA and navigational details through the integrated GPS (R21), confirming the system's utility in keeping the user informed and prepared. This interaction not only demonstrated the system's high functionality but also its alignment with Sven's need for a connected lifestyle, integrating seamlessly with his digital world.

5.4 Information Architecture

Information architecture plays a crucial role in shaping how information is presented and accessed by users as they navigate through the website (Tankala, 2023). During the initial stages of our design process, the information architecture was designed to ensure intuitive navigation. The home page served as the central hub, offering quick access to essential functions such as notifications, maps, weather updates, vent control, and an app drawer. Each component was strategically positioned to ensure ease of use and intuitive access for users.

Figure 8 Information Architecture



5.4 Low-Fidelity Prototyping

For our project, we leaned on sketching and Figma for our lo-fi prototypes. Sketching was our starting point—quick, freeform, and without the need for digital tools. In this primary stage of design thinking, there was rapid iteration and brainstorming. We soon developed a tangible way to explore different layouts and interaction flows without committing too many resources.

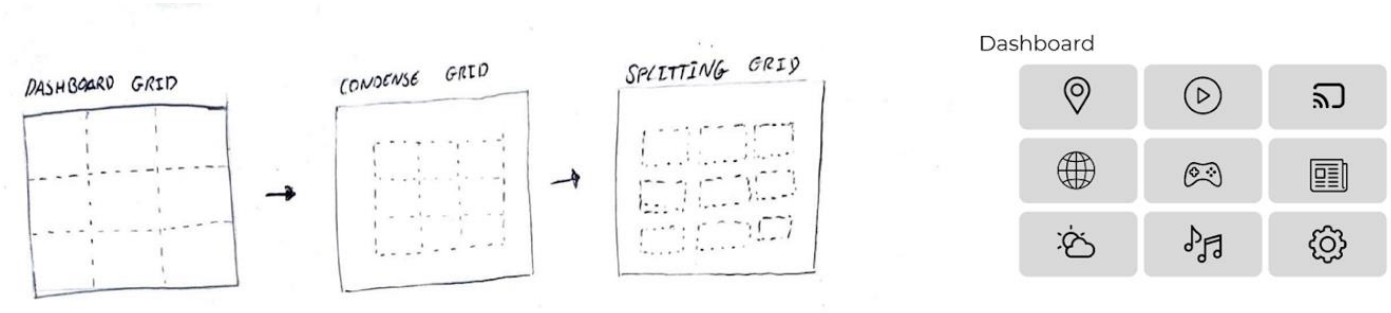


Figure 9 Example of sketching process

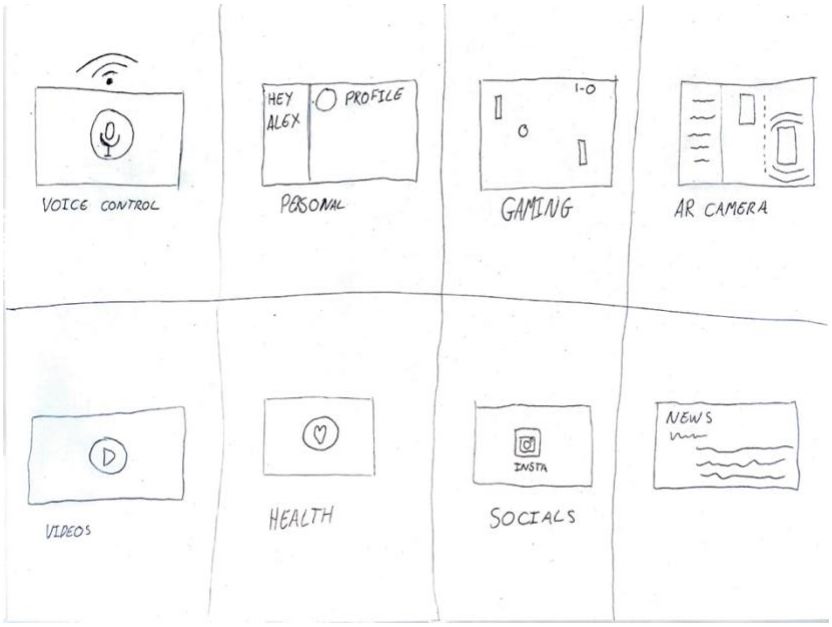


Figure 10 Example of crazy 8 method

Figma came into play in the next phase of design as we moved our sketches into a digital format. It allowed for the creation of design components, more precise layout planning and the ability to share prototypes easily with team members and stakeholders for feedback. Figma allowed for collection of inputs and making real-time adjustments. Our goal was to reduce the lag between feedback and design iterations which was successfully achieved in subsequent design phases.

5.5 Iterative Design Process

Our iterative design process was a cycle of design, feedback, and refinement to align our design closely with user needs. Starting with lo-fi prototypes, we proceeded with one iteration of design in our project (Kelley, 1984).

Significance of iteration

The iterative approach allows for the early discovery of design flaws, reducing the cost and time involved in making changes later in the development process. By continually refining the design based on user feedback, we ensure the final product meets and exceeds the user expectations.

Iterations allow for progressive incorporation of user requirements. With our single iteration we were able to improve the intuitiveness of the interface (R01) and ensure the system was accessible for individuals with lower technical backgrounds. This process underscored the dynamic nature of design, where each iteration brought us closer to a solution that was both practical and delightful for the user.

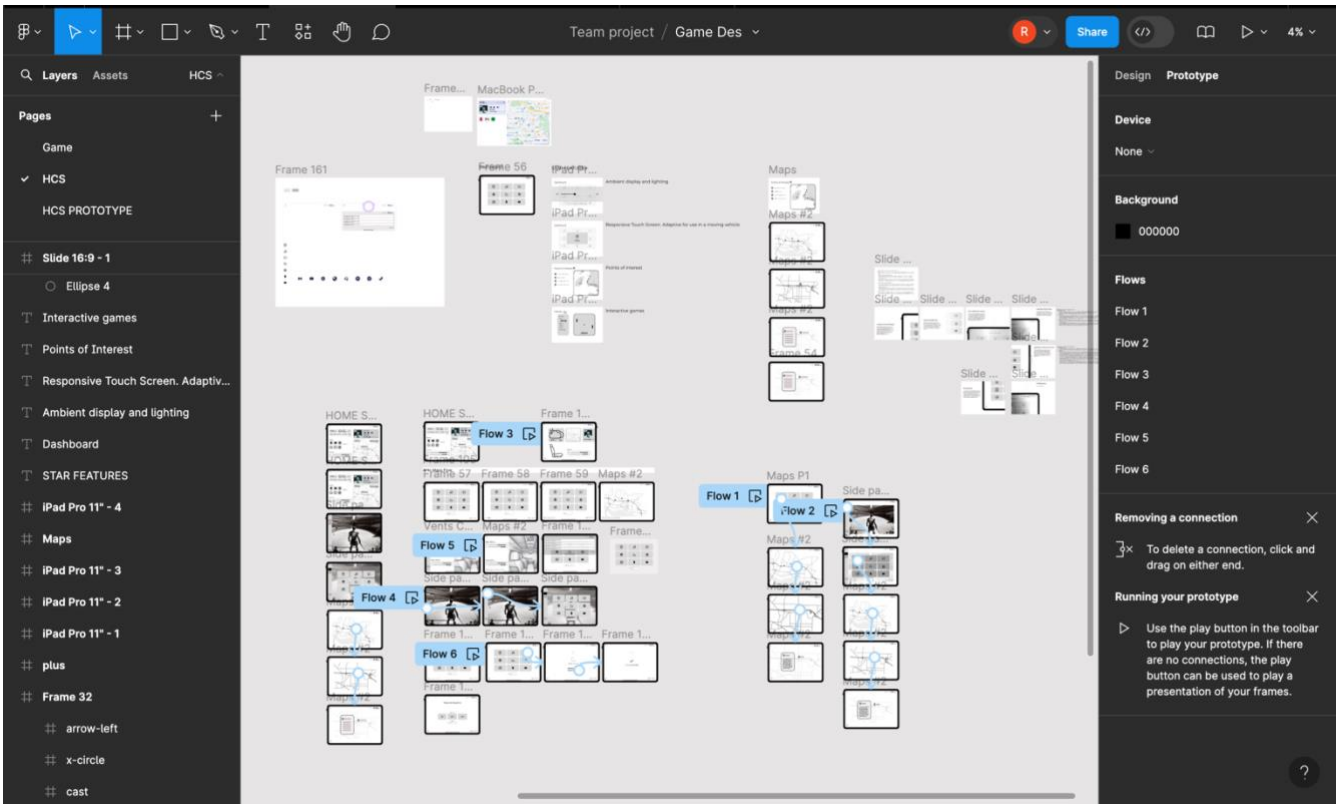


Figure 11 Overview of our design file

5.6 Design Rationalisation

Our design hinges on a direct linkage between each prototype feature and the user requirements outlined in our specification document. Each decision is grounded in user data, data from literature reviews, and established HCI standards.

- **Intuitive Interface (R01):** We prioritized an intuitive interface to cater to a diverse user base. This decision was backed by studies that suggested the importance of usability across different age groups and tech-savviness levels (Holzinger et al., 2011). In HCI, simplicity and ease of navigation are fundamental principles that enhance user satisfaction and adoption/conversion rates.
- **Adaptive Brightness (R06):** We implemented adaptive brightness after receiving feedback in the user interview sessions regarding the challenge of screen visibility under various lighting conditions. This feature enhances the ergonomic standard of the product, enhances viewing comfort, thus improving the overall user experience.
- **Multilingual Support (R02):** The decision to incorporate multilingual support was taken to ensure the system is accessible to international travellers. Few studies highlight the positive impact of language support on user satisfaction and system usability (Association for Information Systems (AIS) eLibrary, n.d.).
- **AI Voice Assistant (R13):** Since a lot of our users wanted the interaction with the system to be easy and considering the learning curve of getting familiar with a new interface on your journey, we decided to make it easier for our users to navigate the UI or perform tasks with an AI assistant. The AI assistant is always present on the corner of the screen as shown in our designs and can be invoked by pressing on the icon or clicking the knob on the side of the screen. This reduces the number of interactions needed to perform a certain task on the device and allows the users to focus on more important tasks, thus boosting productivity.

Figure 12 Using AI assistant to set up a route on maps

- **Wi-Fi & Bluetooth and USB Connectivity (R10):** Connectivity options are crucial in modern devices. There is a high demand for continuous internet access and device integration during travel from our users. Multiple layers of connectivity reduce the friction of usage and makes the experience more seamless. The USB connectivity allows older phone models to connect with our device and addresses an issue with having lower

battery percentages. Having the phone battery run out is common during long distance travel, as found from our user feedback.

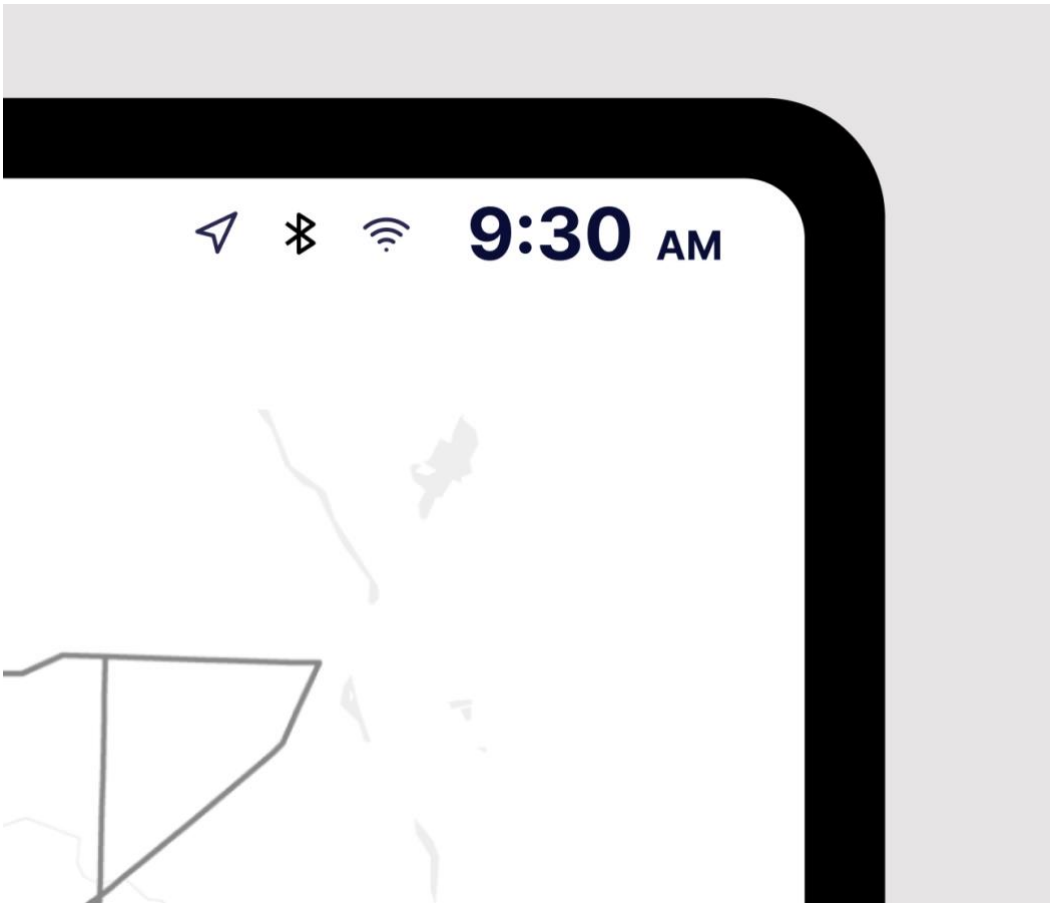


Figure 13 Notification bar showing multiple connectivity features

- **GPS Integration (R21):** Integrating GPS functionality is a key feature to enhance the utility of the product. As the product is part of a car in journey, GPS is an essential integration to maintain the utility of the system.
- **Personalization (R18):** Users can set up the infotainment according to their preferences. Users have an option to log in with their Spotify and Netflix accounts to view their personalized content on the infotainment system. This allows passengers to tune it to their media content instead of being limited to built-in entertainment.

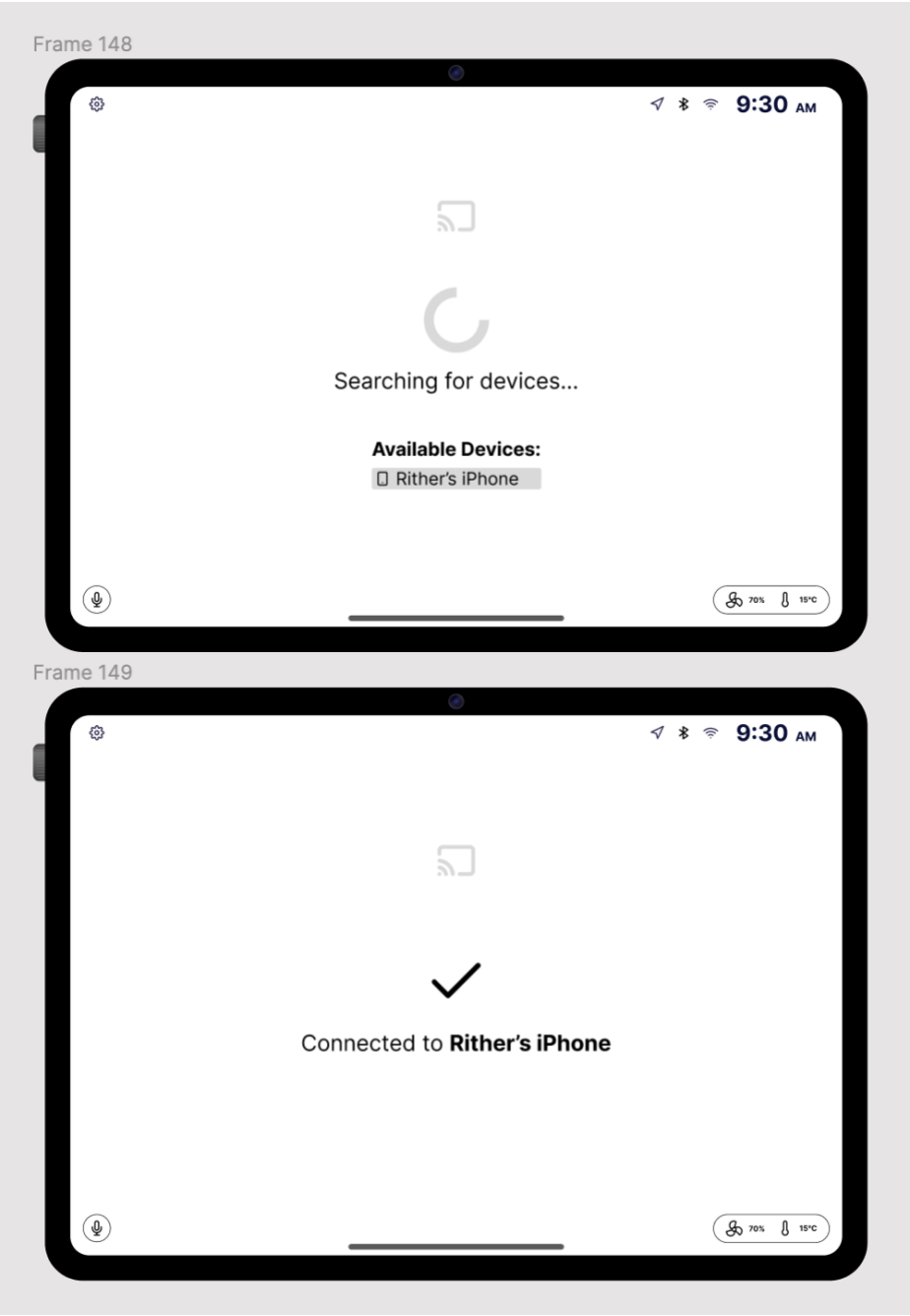


Figure 14 Screen cast design

- **Ergonomics (R05):** The UI elements are positioned within comfortable reach for users. The size and placement are designed to accommodate motion disturbances in a car. The screen is also tiltable to accommodate user viewing angles for passengers of different heights.
- **Control Temperature from the Infotainment Centre (R27):** The ability to control the car climate from the infotainment display is an important functional requirement. This control is available to the user from the dashboard/home screen for easy access. The control

adjusts only the passenger's side A/C controls. This opens more real estate inside the car and transforms the infotainment system into a well-integrated car portal.

Figure 15 Home screen design

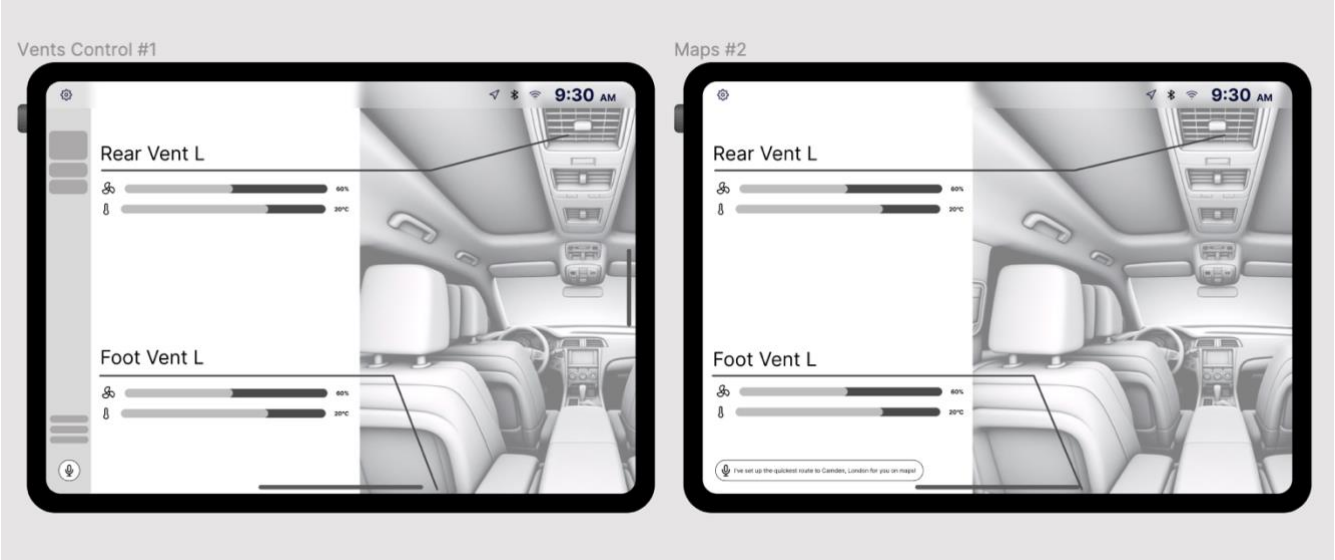


Figure 16 Vent control UI design

5.7 Design Challenges and Resolutions

Design Challenges

Conflicting Requirements: One significant challenge was balancing the demand for a rich set of features (like entertainment options R07 and multilingual support R02) with the need for an

intuitive and simple interface (R01). Including too many features risked overwhelming the user, while oversimplifying could detract from the system's utility.

Technical Limitations: Implementing adaptive brightness (R06) and responsive touchscreen display (R03) required hardware capable of supporting these features. Constraints related to screen technology and sensor accuracy impacted our ability to deliver these functionalities seamlessly.

Resolutions and Trade-offs

Prioritising Core Functionalities: To resolve the conflict between feature richness and usability, we prioritized features based on user feedback and the Moscow method. This meant some 'Could Have' features (like R02) were initially simplified or deferred in favour of 'Must Have' functionalities (such as R03 and R06) that directly impacted user satisfaction and system usability.

Technical Workarounds: Faced with hardware limitations, we explored software solutions to enhance user experience. For adaptive brightness (R06), we implemented a manual adjustment option as a temporary workaround, planning to upgrade hardware in future iterations to fully automate this feature.

Impact on the Final Design

These trade-offs led to a streamlined infotainment system focused on delivering a core set of features exceptionally well, rather than a bloated system with compromised usability. While some advanced features were deferred, this approach ensured the system remained user-friendly and met the primary needs of its audience. It also left room for future enhancements.

6. Evaluation

In order to test the validity of our design, it was imperative that we evaluate the prototype. For our approach to evaluation, we decided to use a combination of user based and non-user-based evaluations to gather perspectives. For user-based quantitative evaluations, we chose to conduct Verbal Protocol (Think Aloud) Method supplemented by a questionnaire to provide qualitative evaluation. Furthermore, we also used heuristic evaluation within our team for non-user-based evaluations. Apart from validating whether the design meets the specified requirements, the findings and insights from these tests helped us identify problems in the design, areas of improvement and further understand the behaviours and preferences of the target user group. (Moran, 2019)

6.1 Non user based evaluation

Non-user based evaluation for a product involves assessing our prototype's quality, functionality, and appeal through methods that do not rely on target user feedback but instead is evaluated by experts. Such evaluations are crucial as they provide an objective perspective on the product's performance and suitability. By assessing factors like Jakob Nielsen's 10 usability heuristics, non-user based evaluation helps ensure that a product meets industry standards and fulfils its purpose effectively. Additionally, it offers insights into areas for improvement and innovation, guiding further development efforts. Conducting non-user based evaluations first helps minimise trivial bugs and make user based evaluations more effective. These evaluations serve as a checkpoint in the development process, promoting an informed decision-making and enhancing overall product quality. In the context of this project, we have recruited our team members as the experts to conduct evaluations.

6.1.1 Heuristic Evaluation

For non-user-based evaluation, a heuristic evaluation was conducted. This method was chosen for its efficacy in providing valuable insights into system usability against predefined criteria (Harvey et al., 2011). Its cost-effectiveness and early identification of usability issues made it a practical choice for the project.

Jakob Nielsen's 10 usability heuristics were employed, in which aspects of a system or device are judged by experts according to a checklist of principles or 'heuristics'. Evidence suggests that 75% of total usability problems can be revealed by five evaluators (Nielsen, 1994). All six group members participated in the evaluation on Figma. Prior to the evaluation, each member familiarised themselves with the heuristics and interacted with a prototype of the in-car rear seat infotainment system, assessing its usability by engaging with its features and functionalities.

Each heuristic was assigned a severity rating on a scale ranging from 1 to 5, with 1 indicating a cosmetic issue and 5 indicating a critical issue. After determining the average severity rating for each heuristic, the issues were prioritised based on their impact on usability. Subsequently, recommendations were proposed for addressing these issues. The findings are presented in the table below:

Table 1 Heuristic Analysis

Heuristic	Severity	Concern	Recommendations
User Control and Freedom	4.5/5	Lack of fixed navigation menu	Fixed navigation for consistency.
		Missing exit/cancel button	Clear exit options throughout the interface.
	4.5/5	Absence of in-app tutorial	In-app tutorial with tooltips.

Help and Documentation		Lack of user manual	In-app user manual accessible from menu.
Help Users Recognize, Diagnose, and Recover from Errors	4.17/5	Insufficient error message visuals	Clear error visuals for better clarity.
		Lack of troubleshooting tips	Contextual troubleshooting tips.
Visibility of System Status	4/5	Missing notification indicators	Notification indicators for system status.
		Unclear temperature controls	Clear temperature control labels.
Match Between System	4/5	Lack of icon labels	Icon labels for clarity.
		Absence of temperature level indicators	Temperature levels for reference.
Consistency and Standards	3.5/5	Inconsistent labelling	Consistent labelling across the interface.
Error Prevention	3.3/5	Unclear error messages	Clear error messages.
		Small dismissal options	Enlarge dismissal options to prevent mistakes.
Recognition Rather Than Recall	2.5/5	Lack of visual indicators for settings	Visual indicators for settings.
		Unclear playback status indicators	Clear playback status cues.
Aesthetic and Minimalistic Design	2.5/5	Absence of dedicated notification screen	Dedicated notification screen.
Flexibility and Efficiency of Use	1.6/5	Difficulty accessing recent apps	Quick-access buttons for recent apps.
		Inability to customise app drawer	Customization of the app drawer layout.

It is important to note that while the heuristic evaluation method offers a structured approach for quick usability assessment, its efficacy relies on guideline quality and interpreter understanding, potentially overlooking specific usage contexts. Our findings highlight valuable insights alongside limitations, stressing the importance of interpreter understanding.

6.2 User based evaluation

We recruited non-expert participants to assess the usability of the design. Using the prototype we developed, we asked participants to complete a list of tasks and talk through their thoughts while interacting with the prototype. Based on this experience, we also asked participants to complete a questionnaire based on System Usability Scale.

After careful deliberation, we decided to use 2 methods for user-based evaluations. While the Verbal Protocol method helps us understand the user's thought process in the moment while interacting with the system, the questionnaire helps evaluate the user's overall experience based on reflection. We believed this would give us a better understanding of the user's behaviours and preferences, both aspects being equally important to help us evaluate our design.

We recruited 5 participants for this session. All transcripts and results are anonymised.

6.2.1 Verbal Protocol

In Verbal Protocol (or Think Aloud analysis), the participants are asked to continuously think aloud while interacting with the system. The users are given a set of tasks to complete and are prompted to verbalise their thoughts as they go through the tasks.

Through this method, we are not only able to infer the user's genuine thoughts about the product, but we can also identify misconceptions about the design. These insights can form important findings for future design iterations. Furthermore, this is an easy yet powerful method for facilitators and participants alike. (Nielsen, 2012)

Before the session, we identified key themes that we would like to assess based on our requirements (listed in Table 1)

We recruited 5 participants for this exercise. Initially they were asked what features they infer from the homepage. We then provided them the list of tasks to perform as outlined in Table 1

To obtain the most from these sessions, facilitators provided minimal guidance and instead prompted users to verbally dictate how they achieved these goals.

Table 2: Themes, tasks for Verbal Protocol along with quotes from participants

Theme	Task	Quotes from participants
Find Local Points of Interest, **Estimated Time of Arrival**	Find local areas of interest on your route.	"*The icons should tell me what kind of point of interest each pin is - like cafes and hotels should have a distinct icon - everybody's used to Google maps. If I'm looking for something particular, icons can help guide my eyes to find them faster*" (P2)
Adjust Climate Controls	Increase the airflow of foot vent. Decrease the overhead temperature.	"*Is airflow that fan? Okay I would slide the fan thing and the temperature slider to change it.*" (P1) "*There's no way to understand in the home screen that there is an overhead and foot vent*" (P2) "*You have that bar, so we should be able to click on the bar and move it forward or backward.*" (P5)

Access Entertainment Features	Play a movie on Netflix.	"*It doesn't have an icon, it would help to have an icon - I clicked on it because I couldn't find anything else. "* (P1) "*I am guessing the 3 lines are menu because it looks like a hamburger menu."* (P3)
Screen Cast for Personal Content	Go back to main page and screencast your phone. Connect to your device and screen cast it.	*"Okay I am not sure how to navigate to other apps. That was a bit confusing."* (P4)
Check Notifications	Check notification to get travel updates	"*I'm expecting that I can drag the notification drawer from the top and see the notifications*" (P2) *"Only thing is notifications, you normally have a bell icon, which makes it, you know, like it's a standard way of showing that it's a notification. Yeah. So I was looking for something of that sort."* (P3)
System Features and Design	Describe what you see in this screen (home screen)	*"This looks like the homepage. I see a map with locations, some entertainment icons, weather, weather forecast, time, AC control I think, music playing, a map with my current location, where I am going and the ETA."* (P4) *"I think this screen is the best one because it gives you an idea about everything that's there."* (P3) "*Oh an there's a microphone at the bottom - is that like Siri? That's cool*" (P1)

Observations

From these evaluation sessions, we find some common concerns and feedback from users. Users were able to interpret the home screen UI accurately with ease. They were able to identify main functionalities - temperature control, music, apps, location, etc. - available in the application simply by observing the home screen. This stems from our design using layouts and icons that users would be familiar using in other applications; in line with Jakob's Law of UX. (Nielsen, 2000)

Similar behaviour can be observed when users were given the climate control task which they were able to perform correctly. We did observe users struggling to navigate when they had to go 'back' to the home screen to play a Netflix movie. The menu icon was not apparent to users for navigation. They could be seen trying different navigation methods that they use in other digital devices like swiping.

We observed the similar behaviour when users were asked to screencast from the Netflix menu.

Again, users found it confusing to locate the right navigation option. However, the did not seem to find an issue while using the screencast option itself. The UI was in line with their expectations for this task.
When asked to find locations of interest, most users were able to open the UI and click through the “pin-drop” icons to identify locations. We noticed some confusion with the users here. One of the participants expected to search for a place. Another participant expected a zoom-in response on click instead of opening the pin. We also received insightful suggestions for improvements to this page which included showing current location and having name of the locations on first view.
The final task was to check notifications. We see that some users naturally chose to drag the notification pane from the top drawer. However, some participants expected an icon (like a commonly seen ‘bell’ icon) to find notifications. We also observe from one participant it did not align with their expectation for the interaction to be similar to when asked to navigate from the Netflix page.

Overall, we see that our design’s strength lies in the familiarity of design with the user’s own devices and that had a positive impact on their usability. We can also derive that there is a scope of improvement with navigation throughout the system.

6.2.2 Questionnaire

After the participant had completed all the tasks, we asked them to answer a questionnaire based on the System Usability Scale(SUS). SUS questionnaire consists of ten statements to gauge the user’s perceived system usability. It is a reliable and valid method that measures both learnability and usability. (Brooke J., 2013) (Soegaard, 2024)

The statements included in the SUS questionnaire are: (Brooke, J., 1995)

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Reponses were collected from all 5 participants using a Google Form. The form contained the predefined questions from System Usability Scale (Brooke J., 1995). After collating the responses, the usability score was calculated for each participant as described by Brooke. While

scores of individual questions are not significant, the overall score can help understand the usability of the system.

Table 3 SUS Scoring and Interpretation

Participant	Score	Interpretation
P1	67.5	Below average
P2	90	Good
P3	55	Below average
P4	85	Good
P5	80	Good

Observations

Based on research by Sauro and Lewis, the benchmarks are 68 (average) and 80(above average). (Lewis J. R., Sauro J., 2018). We found that 3 scores were above average and 2 were below average. Based on Sauro's suggestion that scores about 82 (+-5) are considered 'promoters', we can conclude that these participants are promoters for the design. (Brooke J., 2013)
From this evaluation, we can infer that the design has an overall positive usability score for the areas we tested.

However, there are a few limitations to this method. While it provides a quantitative score for usability, it cannot provide diagnostic insight as to what issues are present in the product. Additionally, the scores are self-reported data and is prone to user's subjectivity.

6.3 Design Implications

Based on our observations, evaluations, and suggestions from this phase of development, we have observed some areas of improvements that we can undertake. It was clear that improvements need to be made to navigation, consistency and providing tutorials. Apart from building on our other requirements, the next design iteration would include the following enhancements to the system:

- Make navigation more prominent from all pages, such as, including a hamburger menu to indicate the menu bar
- Make navigation consistent on all pages
- Add more information to map page like location names, icons based on location types such as hotels, cafes etc and include search option in map.
- Include in-app tutorial with tooltip and modals for selective features that might be difficult to navigate for users.
- Bring consistency on labelling
- Provide useful and easy to understand hints and error messages
- Provide users the option to cancel or undo actions such as disconnecting the phone from bluetooth or stop screencasting

7. Conclusion

The aim of this project was to build an in-car infotainment for transport businesses who want to offer a luxurious passenger experience to their customers with a system that keeps their passengers engaged through personalised entertainment, ability to work while travelling and contextual information about the journey and local interests.

The project followed a human-centred design approach in every stage. Requirements were gathered through interviews, personas, and context analysis. These requirements were prioritised and refined to build a detailed User Requirement Specification with 37 requirements. These requirements informed the iterative design process, focusing on functionality and intuitive navigation. We built a prototype with select features that was then assessed. Evaluation methods, including heuristic evaluation and user testing, identified usability challenges and strengths. From this we discovered improvement areas for the next iteration of the product.

Moving forward, it's crucial to address the usability issues identified during evaluation to enhance the overall user experience. This involves implementing clearer navigation cues, intuitive interface design, and informative error messages. Additionally, integrating emerging technologies like augmented reality (AR) and virtual reality (VR) into the infotainment system will be important for enhancing the entertainment and immersive experience for passengers.

To ensure an inclusive and safe user experience, it's important to focus on accessibility for users with disabilities and follow safety measures. This would include implementing features like voice commands, automatic screen dimming, emergency assistance buttons and hands-free operation that minimise distractions for drivers. Prioritising safety while enhancing the passenger experience will remain essential for future iterations.

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Appendix

Word Count

7179/8000

Excluding headers, titles, tables, references, appendix

List of documents used:

- Interview Consent Form
- Usability Test Consent Form
- SUS Responses and Calculation
- Heuristic Evaluations
- Context of Use Analysis
- Verbal Protocol Transcripts and Analysis
- User Requirements
- Workshop Discussion - Miro Board
- Figma Prototype