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Link to prototype: https://z28uox.axshare.com

Contents

Motivation and dedication

I would like to show some gratitude to the Al-mighty God for allowing me to think broad-mindedly and for giving me patience during the time where pressure was at its peak. I would also like thank my family and friends for motivating me to work when I gave up or was unable to achieve my goals at times. Lastly, I would like to thank my supervisor, whom played a big role in terms of guidance and support. I would like to express appreciation as she dedicated her time in helping me and pushing my ideas and thoughts into what it is now.

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I have read and understood the University regulations on plagiarism and I understand the meaning of the word *plagiarism*. I declare that this report is entirely my own work. Any other sources are duly acknowledged and referenced according to the requirements of the School of Computer Science and Mathematics. All verbatim citations are indicated by double quotation marks ("…"). Neither in part nor in its entirety have I made use of another student's work and pretended that it is my own. I have not asked anybody to contribute to this project in the form of code, text or drawings. I did not allow and will not allow anyone to copy my work with the intention of presenting it as their own work.

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Abstract

This project presents an in-car information system and dashboard design of a driverless car. This report will look at current technologies that are used by driverless vehicles such as Tesla. This report will give an insight of the security, data and technology aspects of driverless car. It will also give an insight of current information and entertain system that is used by big companies such as roll-Royce and Tesla. The following report defines the technologies that will be used in order to design the interactive prototype. Additionally, the report consists of several analysis techniques, which were used in order to gain a better understanding of the design elements and requirements of the prototype design. The techniques used in the report are requirement elicitation, use cases, comprehensive analysis tools, cost and benefit analysis and stakeholder analysis. Furthermore, the design of the project will be presented using a prototype, wireframes, flow charts, activity diagram, data structure, UML class diagram and personas. Finally, the report focuses on validation and critical review where the design prototype is evaluated through relevant testing methodologies.

Chapter 1: Background and Introduction

The definition of autonomous is to obtain power of self-government [1]. If one object has autonomous controls, it has the power and ability for self-governance in performing its functionalities [1]. Autonomous controllers contain collection of hardware and software that allows necessary control functions to be performed without the need of external involvement [1]. Along conventional functionality, autonomous objects should obtain ability to tolerate failures [1].

The idea of introducing a fully autonomous vehicle means a vehicle, as well as driving from point A to point B, should also be able to tolerate and encounter complicated situations. An intelligent autonomous control system use technique such as artificial intelligence in order to achieve autonomy [1]. Autonomous control system uses intelligent components where the development of such technology requires interdisciplinary research [1]. Autonomous vehicles and related technology have become one of the biggest research topics [2]. Intelligent vehicle development has motivated researchers to study new traffic and transportation system worldwide. Large number of papers [2] has already revealed local planning control theories.

1.2 Aims

Aspects like sensors, computation and algorithm needed to encounter complex situation, are important. However, this project focuses on the in-car information system and user interaction between users and the dashboard. Technology has advanced and the aim of this project is to offer as many features and elements in order to reduce or even eliminate the use of mobile phones or laptop once the driver/ passengers enter the autonomous vehicle. The aim of this project is to research and understand which elements a user is most likely to dedicate their time to, and potentially utilise the research by presenting those elements in a user-friendly way. Finally, the aim of this project is to produce a user-friendly and easy to use prototype, which achieves all the functionality.

1.3 Objectives

Aim	Objectives	Strategy
- Analyse current driverless vehicles in the industry	- Obtain an insight of current functionality of Tesla and Waymo - Compare the in-car information of Tesla and Roll Royce	- Obtain data through qualitative research
The aim above will help get a better insight of functionalities, elements and features that currently exist within driverless vehicles. This will make requirement elicitation easy, and help understand what types of people are likely to use driverless vehicle. Research is one of the fundamentals in building and progressing in a project. This will aid in distinguishing and highlighting the key features and areas that are used and interacted by users.		
- Create pain-points and requirement elicitation	- Think of at least 10 functional and non-functional requirements	- Observe driver's interaction with dashboard - Brainstorm ideas (ideation)
The research carried out through first comparison (aim 1) will help build a list of problems, which will potentially become requirements of the design which ultimately builds an efficient system. The system will be efficient because it should be able to cover the needs or the pain points that are created through the observation and research. The requirements will be prioritised so the fundaments of the system are achieved if not the advanced elements.		
- Create personas which expresses the characteristic and personality that the users may obtain	- To produce 5 personas	- To research more about driverless vehicle in order to gain a better insight of the type of users who will drive - To research on the type of functionalities these users are likely to use
By producing personas, the prototype design will be able to target audience who are likely to drive and interact with the design produce.		
- To design prototypes/ wireframe of the dashboard	- To design the prototypes using Axure or similar software - Prototype must be interactive - Design wireframes of the dashboard	- Research on the type of prototyping tool that can be used - Use YouTube tutorial or Lynda.com to gain better understanding on how to use the prototyping tool

Wireframes will be created before the prototype of the dashboard is created using Axure or similar software. It is important to have wireframe before focusing on the interactive prototype because many drafts, redesigning of the dashboard will be needed before finalising the final design of the dashboard.		
- To visualise how a user's journey may be like in form of video series	- To create at least 3 user journey - Choose three personas and produce video series of their user journey	- Research on the type of video editing tool that can be used - Use YouTube tutorial or Lynda.com to gain better understanding on how to use the video-editing tool
5 personas will be created in this project. Three personas will be chosen out of the 5 personas. The three chosen personas will be illustrated in video series, which will demonstrate what and how the user will interact with the dashboard.		

Table 1- List of all aims, objectives and strategy

Chapter 2: Literature Review

2.1 Wider aspects of system

Computation integrates and controls the whole system of an autonomous vehicle [3]. The computation platform is responsible for the video and image processing. Computation directs the inputs to the correct system [3].

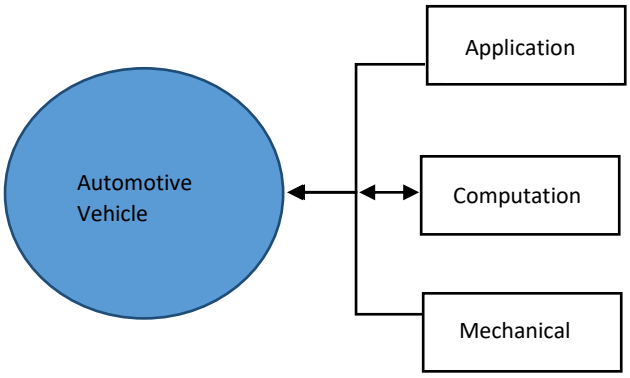


Diagram 1 – Illustrates automotive vehicle structure design

There are many applications stored within an autonomous system, which ensures the system is efficient and accurate. The sensory systems are used for collating data, which is used for further calculation for the movement of the vehicle in a safe manner [3]. By allowing autonomous vehicles to easily access and interact with devices such as cameras, monitoring sensors, actuators, displays and other vehicles around, internet of things(IoT) will allow the autonomous vehicles to use variety of data which is generated [4]. This can potentially increase the speed limit, with reduction of separation amongst the car and eventually increasing the rate at which the traffic flows [3].

In order to obtain a continuous feedback mechanical control uses pneumatic actuators. The feedback system is integrated with the main system; this allows feedback to be consistent and based on real-time [3]. In order to make this system work the mechanisms in conventional system is attached to the sensors and encoders [3].

2.2 Sensors

Sensors are complicated devices used for detecting and responding to the electrical or optical signals [3]. There has been a progress made in the industry of sensors by 'research and development' team [4]. Industry like automobile, electronics, healthcare and disaster prevention are now using these sensors [4]. Through the advancement and progress of sensors, they are also used during manufacturing, research and development, testing and experimentation. The importance of sensors is such that development of technology is only possible through sensors [4].

Fully autonomous vehicle will have to be functional in every situation and cannot be considered as a back-up system. This makes fully autonomous vehicle reliant on sensors and increases the need of sensors [5]. Automakers and tech companies are working hard in order to set up and release a fully automated vehicle in the next couple of years. In order for the fully autonomous vehicle to navigate through the streets safely, it needs sensors. Vision, radar and LIDAR are one of the most valuable sensors currently in the industry [5].

2.2.1 Vision

Obstacle detection is one of the issues an autonomous vehicle must be able to resolve. Vision sensors can be used for distinguishing an obstacle [6] and they are inexpensive compared to sensors like LIDAR or radar [6]. There are two approaches that a vision sensor can take monocular vision and Stereo vision [6].

2.2.1.1 Monocular Vision approaches

In this approach, the depth of the obstacle measurement is not as strong. This approach consists of extraction of many images where the obstacle is detected by the means of features in the image collection [6].

2.2.1.2 Stereo Vision approaches

This approach generates a depth map for obstacle detection, which is in 3D. A high accuracy of obstacles is guaranteed. In order to produce a 3D map, the complexity of the algorithm will also increase [6].

2.2.2 Radar

The primary purpose of radar sensors is the accurate detection of objects [8]. The future automobile has motivated Radar sensors to develop further, where it will provide object classifications when the vehicle is in different situations. This will be done in all weather and light conditions [8]. Driving on road increases the chance of unpredictability, which is why assessment and trajectory planning where motion prediction and fast situation update is becoming an important feature that a driverless car should have [8]. Circularly polarised signals can be used for more targeted information. A circularly polarised signal is when "light is composed of two plane waves of equal amplitude by differing in phase by 90 degrees" [9]. This allows radar to obtain images from different polarisation.

2.2.3 LIDAR

A spinning LIDAR sensor is mounted on top of the vehicle and most automakers'are reliant upon this single sensory solution [5]. This is because it provides a highly accurate point cloud of the environment [5]. It also provides higher-level functionality such as planning paths and detecting objects [5]. LIDAR moves in a spinning motion, which allows them to obtain 360 coverage. This enables them provide large amount of data [7].

2.3 How sensors are used

It is important to have an autonomous vehicle performing its functionality properly. Any incorrect behaviour can have a 'catastrophic outcomes' [12]. The system consists of multiple sub-modules, which interact with each other; this can cause incorrect behaviour if interactions do not occur properly [12].

Several classes are used when the lane change module is implemented for an autonomous vehicle. Planner is one of the classes for lane change module, which is responsible for controlling and deciding when the lane change should take place. There is a possibility of logical errors when complicated software system, especially of those which consist of multiple sub module interaction [12]. Planner class receives regularly updates of the status of the vehicle at high frequency; on receiving the lane change request, the planner class calculates a path and required signals to ensure the lane is changed in an efficient and safe way [12].

Waymo is a subsidiary of Google's parent company, Alphabet Inc. it is an autonomous vehicle development company [10]. Waymo have designed software and sensors, which are capable of detecting obstacle such as pedestrians, vehicle, cyclists and roadwork. These obstacles can be detected from up to three-football field, in 360 degrees [11].

Sensors and the software system of Waymo's vehicle can detect and predict the behaviour of the road users such as cyclist [11]. In order for Waymo's vehicle to navigate safely, it relies upon 4 million miles of world experience [11]. The vehicle uses the sensors to observe the actions of the cyclists. For example, the sensor detects the cyclist extending his or her left arm; the software will predict that the cyclist is moving towards the left hand side. The software system will slow down in order to make room for the cyclist to pass by [11].

2.5 Technologies and mapping in autonomous

There has been a development of many services and application, but every company are disposed to installing proprietary technologies [13], this limits connectivity due to the incompatible interaction between devices. This issue is solvable through the Wireless communication standard, which provides interaction between all the devices.

There are many technologies such as WAVE/IEEE 802.11p in the United States and ITS-G5 in Europe, which support vehicle- to-everything communication. Upon the development of technologies, many more options have now opened up, such as 3GPP and Long Term Evolution (LTE) [13]. Locating accurately is important for autonomous vehicles in order to ensure safety [14]; in order for autonomous vehicles to navigate safely the vehicles will be connected to other vehicles and become part of the cooperative intelligent transport systems (C-ITS) [13]. This will produce an interactive atmosphere for smart vehicles, which will allow the vehicles, pedestrians, road stations and traffic managers to build data and information, which will be used as co-ordination for actions [13]. Co-operative awareness service is one of the applications for public safety. In a vehicle-to-vehicle connection, small packets, beacons, are periodically broadcasted to the on board units (OBU) which are installed on vehicles. These packets contain information about vehicle's position, the speed, and other relevant data regarding the vehicle [13]. This information produces interactive information, which can improve road's safety [13]. The packets shared to each vehicle regarding other vehicles will help in accurate decision at right time and potentially improve the congestion and parking

2.6 Similar System

Driverless car was just a fantasy before the advancement of technology. The technology advancement has now opened the doors of producing driverless vehicle, and many companies such as Honda, Volvo, Tesla and Google have started their journey of manufacturing a self-driving vehicle and bringing it to the market [15]. In this section, Tesla and Goole's driverless vehicle design will be discussed, there way of approaching and manufacturing driverless car.

2.6.1 Tesla

Tesla is an American company, which focuses on electric company, energy storage and solar panel manufacturing [16]. Tesla has designed and manufactured several models:

- Model s
- Model x
- Model 3
- Roadster

[Source: 17]

This section will give an insight of Tesla's first Model; Model S. Tesla's 17-inch touch-screen is angled towards the driver [17]. The driver will be more involved with the interaction with the touch screen as the driver can easily access the touch screen. The night and day modes feature further enhances the visibility of buttons and information for the driver [17]. Using the 17-inch touch screen the driver has access to mobile connectivity, navigation, favourite songs and new restaurants [17]. Tesla has designed its Model S such that its 17-inch touch screen contains most of the control functionalities. From opening the roof to controlling the climate, all of these functionalities could be found within the touch screen.

The infotainment system within Tesla's touch-screen [17]:

Media

- AM/FM/DAB+ radio,
- online radio,
- on-demand Internet radio,
- Bluetooth®,
- USB audio devices

Controls

- Driving personalisation
- climate controls
- cabin controls

Camera

- High definition backup camera: optimised for visibility and safety

Calendar

- Calendar synchronisation for daily schedule and tap to navigate

Map

- Simple, intuitive Google Maps with real time traffic information

Navigation

- Smart routing that adjusts for real time traffic conditions

Energy

- Real time energy consumption
- range estimation

Phone

- Bluetooth-enabled, voice controlled hands free phone system

2.6.1.2 Tesla and its sensors

Tesla utilised eight surround cameras, which provides visibility of 360 degrees around the camera; the cameras provide visibility up to 250 meters of range [18]. The vision is further improved via the twelve updated ultrasonic sensors; this allows hard and soft objects to be detected at nearly twice the distance of the prior system [18]. A forward facing radar provides extra data via enhance processing; a redundant wavelength, which enables visibility through heavy rain, dust, fog and the vehicle ahead [18].

Figure 1 illustrates how Tesla utilised its sensors and their visibility range.

New capabilities are added to Tesla due to its enhanced Autopilot. The speed at which the vehicle moves will depend on the traffic conditions. The vehicle will keep within lane and change lane when required without any drivers input. The vehicle is parked on its own once the parking spot is found [18].

The autopilot software is designed to make the journey as efficient as possible. Autopilot will search for opportunities to move to a faster lane if the vehicle is stuck in a slow traffic [18]

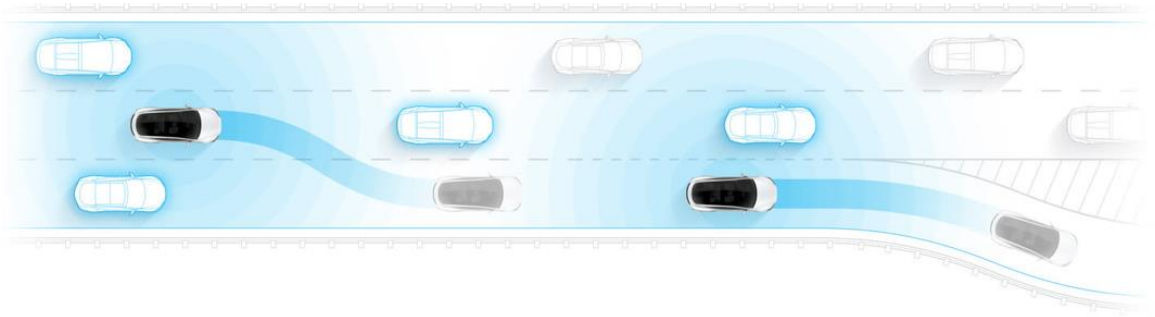


Figure 2 ensures autopilot takes the right exit on the freeway [18]

Sometimes road can have many turns, not all roads are straight:

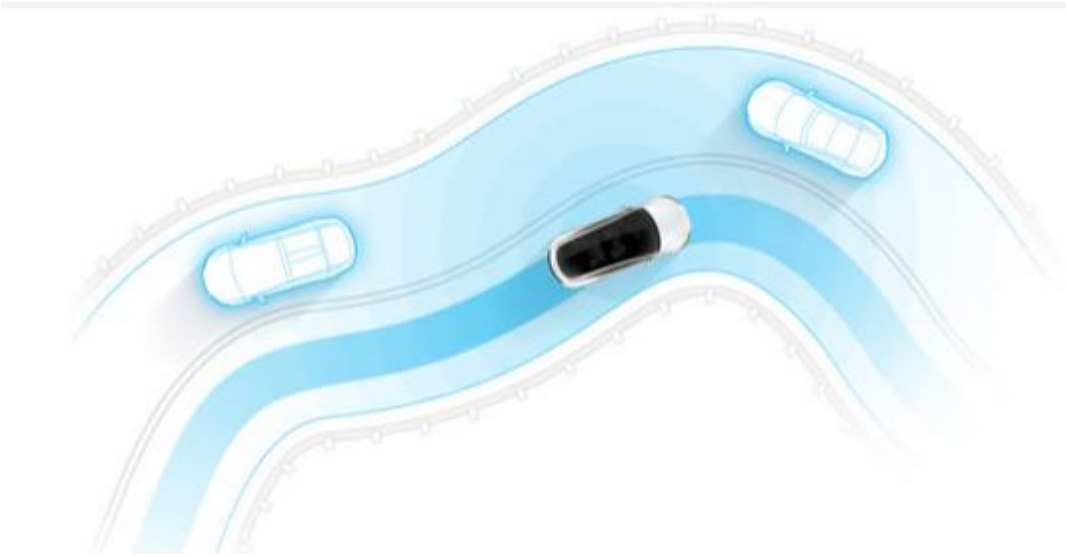


Figure 3 shows Tesla can auto steer even if the road is in strange shape [18]

The figure above demonstrates how the auto steer feature is utilising vision cameras, sensors and computation in order to encounter complex road structure [18]

Tesla and Technology

- Software updates available over-the-air for features and performance enhancement
- Real time traffic system for navigation and Maps
- Garage door opens and closes via the GPS enable home link feature

[SOURCE: 19]

Tesla and Safety

- Automatic emergency braking and collision avoidance system in case of an accident
- Heated Side mirrors with additional features such as power-folding, auto dimming
- Night-time's visibility enhanced through three-position Dynamic LED turning lights

[SOURCE: 19]

2.6.2 Waymo

The aim of Google's self-driving project is to make the roads safer, save time for drivers so they can utilise it in a more productive manner, and improve the overall mobility for everyone [10]. Google's self-driving project began in 2009; they set a challenge to drive autonomously for over ten, uninterrupted, 100 mile routes. This challenge was achieved months later in Toyota Prius vehicles. In 2012, Google accomplished a total of 300,000 miles of self-driven journeys [10]. Google managed to operate seven autonomous vehicles which managed to reach a total of 140000 mileages. The autonomous vehicle surprised the autonomous industry when the vehicles managed to drive through narrow turns of San Francisco, crossing the Golden Gate Bridge and Lake Tahoe without any human control [20]. Lexus RX450h was added to their list of vehicle which they used for self-driving experiments on freeways. Google eventually moved from freeways to complex city street, where they focused on environment that consists of pedestrians, cyclists, road works and vehicles [10]. In 2016, Google's self-driving project transformed into Waymo, Waymo is a self-driving technology company [10].

2.6.2.2 Waymo and Firefly

Firefly was one of experimental platform for Waymo which allowed them to get a better understanding of the driverless algorithm from the very beginning. Firefly is a fully autonomous vehicle which is developed and manufactured from scratch [21].

[source 22]

Firefly is a two seater vehicle, with no pedals or steering wheels. It has been travelled millions of miles for road test purposes [21]. Through such design, Waymo obtained a better insight of where to place the sensors, integration of computer and user's needs [21]. This innovation was a platform of experiment and understanding, rather than mass production [21].

There are three components to Google's autonomous vehicles. Sensors, software and Google's mapping database. One of the sensor Google used was a Velodyne high-density LIDAR light-detection [20]. This system is designed to map the surrounding of the car. This LIDAR rotates 10 times per second and captures 1.3 million points which is used for mapping. This allows the system to detect up to 165 feet of pavement and trees which is within 400 feet [20]. Any moving obstacle, bicyclists, pedestrians and traffic signals can all be detected by the high resolution camera inside the car. Furthermore, with the aid of GPS and its inertial motion sensor their positions can also be calculated [20].

Using Google's mapping database, the car can generate the map of local roads in a street level view. As the car uses the database, it keeps it up-to-date. The vehicle maps the route and the road condition before it drives [20].

2.6.2.3 Waymo and Technology

Waymo's vehicles use sensors and software to detect pedestrians, cyclists, vehicles and road works. The sensors and software can provide visibility of up to three football fields, in all 360 degrees [11]

Figure 4- Waymo vehicle and other road users using the same road

The following figure demonstrates how Waymo uses its sensors and software system to detect cyclists, pedestrians and other road users at a point of intersection. Waymo relies on 5 million miles of real world experience in order navigate safely through the traffic [11]. Sensors and software system is designed to detect and predict the behaviour of road users.

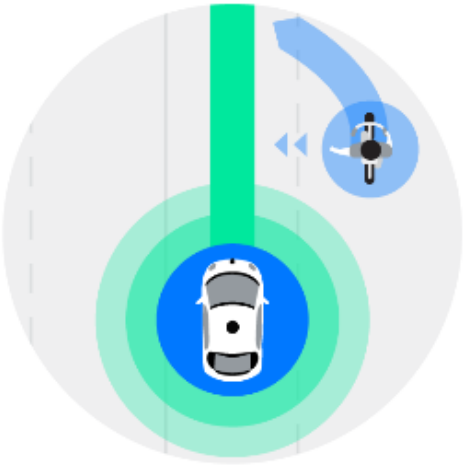


Figure 5- Waymo's vehicle acknowledges cyclist's signal

The figure above shows a cyclist who is giving hand signal, which is detected by the software. The software predicts that the cyclist will move to the left side of the lane; software system plans to slow down the vehicle in order to form distance between the vehicle and the cyclist, creating a safe and comfortable environment for the cyclist.

2.7 Security

Charlie Miller and Chris Valasek demonstrated a remotely hack of a Jeep, Cherokee, via its internet connection to paralyze it on a highway [23]. According to foreign policy, Dr. Charlie Miller is one of most technically proficient hackers on earth; he has received his PhD in mathematics from university of Notre Dame. Dr. Miller was a hacker for National Security Agency for five years, and has been working for security teams of twitter and Uber [24]. Chris Valasek, who has a B.S in computer science from university of Pittsburgh [25], is an automotive security researcher. He has worked for many companies such as Uber and IBM [26].

This hacking experiment proved how the hackers have the ability to disable the brakes, causing unintended acceleration and controlling the steering wheel.In order for the hackers to successfully obtain the control of the vehicle, they have to exploit vehicles' existing automated features [23][27]. In the hacking experiment, where the two hackers took control of the jeep, they demonstrated how Toyota Prius' collision avoidance system was used to apply brakes, and how the jeep's cruise control feature caused unintended acceleration [23].

Charlie Miller stated, "Cars are already insecure, and you're adding a bunch of sensors and computers that are controlling them...If a bad guy gets control of that, it's going to be even worse" [23]. This emphasises on how much control a hacker can obtain by hacking into a driverless vehicle such as a Tesla where majority of the car functionality can be controlled via the 17'' touch-screen.

System vulnerabilities are the key for the hackers to have access to the system. Trail of exploitable bugs can create a path through which a hacker can encounter the defence a company like Tesla has set out to protect its system [28].

Tesla's chief technical officer JB Straubel stated, "Cryptographic validation of firmware updates is something we've wanted to do for a while to make things even more robust"[28]. Tesla decided to improve their security system after a Chinese hacking team, Tencent, explained the bugs thatare within Tesla's system and how they can exploit their Model S and hack into it. Tesla decided to use cryptography to encrypt their internal network of computer, which controls functionalities such steering, wheel, brakes, and windscreen. This was secure as the only way to decrypt is via the cryptographic key, which only Tesla possesses. Tesla decided to digitally sign the internal network in order to make its system more confidential [28].

2.8 Big Data

The advancement of the autonomous vehicle is such that it can approximate its geographical position and its distance from walls, pedestrians and traffic light all in real time. All of these functionalities compute data allowing the manufacturers and designers to take the autonomous industry even further by allowing the vehicle to use the processed data and alerting the drivers when they are over the speed limit or when they are too close to car or wall.

Autonomous companies like Tesla for example, have used big data to enhance the experience a driver has whilst in the car. One system that Tesla used was “Driver’s profile” where a driver can make his own profile, which saves information such as the position of the seat. This automatically reduces the effort needed by the driver to make himself/herself comfortable as soon as they take a seat. These similar fashionable, powerful learning systems are embedded inside the cars such as Tesla, Mercedes and Ford [29], which utilises the data entered by the driver to enable the car to suggest actions which users are likely to take.

One of the biggest usages of big data in the world of transportation is the improvement of efficiency and safety [30] for the transportation system. All the connected devices, trains, planes or automobile brings together data, which could be used, for traffic tracking, delivery routes optimisation and payment processing which will be based on real-time data.

2.9 Dashboard design and elderly users

As you age, your vision, hearing and movement in general slows down in terms of performance. Thus, there is a reduction in the performance of elderly drivers [31, page 1]. As the age of the driver increases, he/she is likely to spend more time in travelling because of social activities and shopping [31, page 1]. Whilst travelling in their car, their primary task like every driver will be driving the car. The efficiency of their secondary tasks will not be as good as it used to be because of their hearing, vision and movement. Hence, performing secondary tasks such as looking at navigation display or instrument panel, smoking, talking to others can affect their driving [31, page 1, 3].

Some of the information, which is displayed, needs visual attention from the driver, which can cause a division in attention [31, page 3]. To drive safely drivers should reduce the amount of time their eyes are off road and how frequent their eyes are off road [31, page 3]. The frequency and the amount of time a driver is looking away from the road can be reduced by fixing the visual design of the Instrument panel [31, page 3]. For example, in navigation system, the amount of data shown or needs to be inserted can be restructured and redesigned in a more interactive manner; a driver can speak to the system so that he/she does not need to insert data whilst driving. The frequency can be reduced if the navigation display reduces the complexity of how the route is displayed [31, page 3].

An autonomous vehicle will be used by people of different ages, from teenagers to elders. Elderly drivers have a slow reaction and weak vision. The information displayed on the information panel can distract the driver from their primary task. By improvinghow data is displayed, it can help elderly drivers focus more on driving. One of the most common parts

of dashboard is the instrument panel (IP). IP can be restructured and redesigned in order to alert and attract attention of the driver. For example, one of the most common reasons why an elderly driver may look at the IP is to check the speed of their car. This problem could be fixed by giving speed alert, where the IP alerts drivers if the speed is over the speed limit.

An experiment was carried out by Human Computer Interaction Institute, where they produce six different design of a dashboard where different colours, contrast and cluttering were used. The experiment was to compare the reaction and performance of elderly drivers and young drivers; this will highlight the factors that are affecting their performance. Ultimately, the results will help improve the interface design of the dashboard [31, page 2]. The result illustrated how utilising different colours and cluttering when displaying the speedometer had reduced the reaction time of the elderly drivers.

Due to the weak vision of elderly drivers, the concept of pop-out effect will help them with task that require visual search. Pop-out effect is used to draw attention to an icon or information, which is distinctive. Colours, brightness and movement of the object, icon or information are used to produce pop-out effect [31, page 3]. When producing an in-car information system on dashboard, the icons and information displayed on each page could be emphasised using clutter, colour and contrast**.** The experiment and the research above illustrate the importance of the colour, font and brightness of the dashboard used to display the functionality and information.

2.10 Driverless car and parking

Parking is one of the biggest concerns for the UK's motorists, with restrictions such as double yellow and single yellow lines, finding a parking spot can take 20 minutes [32]. Parking spaces are limited in cities and are worth more than a house [32].

Driverless cars will have a huge impact on the current parking and refuelling system [32]. Where the car park will be the charging ports used for empowering electric cars. There will be thousands of charging ports available for the millions of electric vehicles predicted to be manufactured [32]. Parking on the street will be an historical event, and new and the norm in the era of fully autonomousindustry will be parking in the car park.

The car park will be determined by the software, which suggests car park depending on the price, duration of car park, local availability and number of allocation [32]. Car park will be designed for driverless electric vehicles which will be connected to environment embedded devices and internet [32].

2.11 Technology

2.11.1 Prototyping Tool

Wireframe.cc

Wireframe.cc is an idea-orientated prototype tool, which focuses on ideas and simplicity; this is achieved by their clutter-free environment, which has eliminated many unnecessary toolbars and icons. To keep the design, idea-oriented, only limited palette of options is available. This emphasises on the importance of the functionality of the idea, which is the focus of Wireframe.cc. Annotations can also be created as side notes to remind users on any changes or improvement that may be needed.

[Source 33]

Axure

Axure is a solution-designing tool created for prototyping and wire-framing projects. Axure is a powerful tool allowing the user to have a design, which consists of dynamic content, conditions and animation, adaptive, data driven and maths functions. The users will be able to visualise the project without the need of any implementations.

[Source 34]

Mockflow

Mockflow is a designing tool, which is designed to provide solutions that include wireframes, sitemap, UI spec system and design workflow.

Mockflow aims to improve user interface design by allowing the users to brainstorm their ideas, enabling them to digitalise their ideas, which they can work on in future too. Working as a team is a vital part of production. Mockflow encourages collaborations by allowing teammates to share their design allowing the team to sprinkle their creativity. Consistency is maintained through their UI documentation, this element of their package allows designers to follow document accessible to all team members, which keeps everyone on track and same page. Finally yet importantly, Mockflow provides the tools and animation banners, which allows the designers to demonstrate how the real product or service will behave and interact.

[Source 35]

Flinto

Flinto is a Mac app, which is used for interactive and animated prototypes. A designer can create animated transitions and enable the user to scroll. This gives the designer the flexibility to increase to complexity of their design. There is no need of coding or timelines, allowing designers to fulfil their ideas and demonstrate their requirement more efficiently. To enhance the visual effects further, there are micro-interactions within the screen, such as the zoom-in effect when the user hovers over a button. Not everyone prefer templates, Flinto encourages unique design through its drawing tool, which can create accurate and professional icons with animation effect.

[Source 36]

2.11.2 Video Editing Tool

Camtasia

Camtasia captures the action displayed on the computer screen and converts it into video file. Different ratio of screen can be recorded, from a full screen to a chosen region. Camtasia also allows face recording of the user as the screen is recorded via webcam.

Advantages

- Offers editing tools and features that make Camtasia better than similar applications
  For example, video recording of program such as Skype.
  Also records computer audio as well as audio from microphone

Disadvantage

- Cannot set-up an automatic recording

[Source 37]

Icecream Screen recorder

Icecream screen recorder records computer screen and is flexible enough to record specific part of the screen. Icecream screen recorder allows user to shoot webinars, record video and conference calls as well as game plays.

Advantages:

- Videos can be recorded in MP4, MKV and WebM format
- Webcam recording and screen recording can be done simultaneously
- Allows user to draw on screen whilst recording the screen
- Hotkey configuration provided to easily stop, record and pause recording
- Provides easy access to project history

Disadvantage

- Free users are entitled to screen recording which is limited to 10 minutes
- Limited functionality provided and editing features provided to free users

[Source 38]

Ezvid Video maker

Ezvid Video maker is a tool used for screen and desktop recording. Screen can be recorded which potentially allows users to produce a high-resolution videos with titles, description and keywords.

Advantages:

- Videos are auto-saved
- Allows users to create slideshows
- On-screen recording can have annotation
- Videos can be uploaded directly to YouTube
- Enables webcam recording

Disadvantages

- Does not support customisable screen region recording
- Videos are limited to 45 minutes

[Source 38]

Screenpresso

Screenpresso allows screenshot and HD video records of the desktop. This video editing tool is used for training documents; collaborative design work and producing IT bug reports. It also contains a built-in image editor, user guide generator and options for sharing

Advantages:

-
- Audio recording and webcam can both be utilised simultaneously
- Recording is in MP4 format which can be changed into WMV, WebM and OGG format later on
- Previous screenshots and recordings can be accessed easily through quick-access feature
- Editing, labelling and sorting can be kept in a custom folder
- Edits and project can be shared through email, Google drive, one drive, Facebook and twitter

Disadvantage

- Free edition does not support android
- Recording duration is limited to 3 minutes
- Limited featured for editing for free users
- Watermark on images and videos created, for free users

[Source 38]

2.11.3 Choice and justification

The chosen software for creating wireframes in this project is Wireframe.cc. This is because it is easy to use and provides all the features that are needed to design the in-car dashboard. The wireframes that are created are improved and were referred back to for the interactive Prototype. Axure is a good application that will help illustrate and visualise the functionalities and features that this in-car information system and design offers to the users. This will be different from the static wireframes because Axure will introduce the functionality, colour, and the user-friendly interface.

The interactivity and functionalities, which the designed in-car information system consists of, is illustrated through series of videos. The video editing tool chosen for this task is Camtasia as it provides the editing tools and features, which allow the audience to feel and visualise as the walk-through is shown. The videos will demonstrate user journeys of 3, it will illustrate how they interact with the system, and how efficient the system and the infotainment system is for the users as they interact with system to fulfil their daily task.

2.12 In-car Information System and design

Driverless vehicles consist of many elements, for example sensors, security and computation algorithm. This project aims to focus on the in-car information system and user experience design of the dashboard. The following is comparisons of the in-car information system of two well-known companies in the vehicle industry: Tesla and Roll Royce.

Model S in-car information system [19]:

- One touch power windows
- High definition backup camera
- Hands free talking with Bluetooth
- Voice activated controls
- AM/FM/DAB+ and Internet streaming radio
- Auto dimming mirrors
- Soft LED ambient interior lighting
- Lighted door handles
- Power folding, heated side mirrors with memory
- Two USB ports for media and power
- Twelve-way power adjustable, heated front seats with memory and driver profile

Roll Royce phantom in-car information system [39]:

- Air Conditioner
- Power Steering
- One Touch Operating Power Windows
- Foldable Rear Seat
- Navigation System
- CD Player CD Changer DVD Player FM/AM/Radio
- Audio System Remote Control & Rear Entertainment System
- Bluetooth Connectivity
- Automatic Climate Control
- Air Quality Control
- Memory Functions for Seat
- Voice Control
- Glove Box Cooling
- Bottle Holder
- Heated Wing Mirror
- USB Charger
- Central Console Armrest
- Rear Curtain
- Battery Saver
- Lane Change Indicator

Rolls Royce Rear Entertainment System

Rolls Royce is unique because of the spacious seating arrangement and its personalised in-car theatre setting. The front seats and the rear seats both have the same adjustment. Passengers have 6.5-inch monitors, which is attached to the back of the front seats. The central console contains the headphone sockets and there a six-disc changer which is fitted beneath the seat. To personalise the environment for the passenger, a second central controller allows the passenger to control the rear DVD, TV and sound system [40].

Figure 6- Image of the interior of Rolls Royce and its rear entertainment system [44]

Tesla's Model S is an autonomous vehicle, which means it will have a different in-car system to Rolls Royce's phantom. Model S is designed in way where majority of the control is within the 17'' touch screen, controls such as climate, doors and roof can all be accessed from the touch screen. However, there are other information systems within Tesla Model S, which are unique, such as driverless profile, Power folding, heated side mirrors with memory, and voice-activated control.

Wi-Fi and Internet connectivity: Many of Tesla's features such as Software updates, navigation, music and web-browsing rely on internet connectivity [41][42]. Internet connectivity is also used to obtain information about car safety and its performance for remote monitoring [42].

Mobile app remote control: Tesla introduced its own mobile application that allows its customers to:

- Lock and unlock their car
- Horn and flash lights
- View the current status of their vehicle, for example if there is open doors, or open roof it will alert them
- Set climate to their own desirable temperature before they even sit in the car
- Locate the location of their vehicle

With this functionality, it increases the flexibility the drivers already have. It reduces the burden of remembering whether they locked the vehicle and where their vehicle is currently parked [43].

Driver's profile

This is a unique feature designed by Tesla, which allows the drivers to adjust and position themselves to comfort. This feature saves time and effort as position setting will be saved under the driver's profile. On selecting the driver's profile, the side mirror, steering wheel, and seating position will automatically adjust to the selected position.

There are many other features, which can be altered to the driver's personal preference, such as the instrumental panel layout, lights and locks, format and unit of time, temperature, charge [45].

Chapter 3: Analysis

3.1 Work breakdown structure

Fri	13/10/2017	Document	Deliverable	Status
Fri	13/10/2017	research	Dashboard design for driverless cars	Unchanged
Fri	16/10/2017	Document	Sprints/ Sprint back log	Changed
Fri	20/10/2017	Methodology	SWOT	Unchanged
Fri	20/10/2017	Implement	Install axure	Unchanged
Fri	22/10/2017	Methodology	Blue print service	Changed
Fri	25/10/2017	Document	Requirements Chapter	Unchanged
Fri	25/10/2017	Implement	Observations/ Making pain points	Unchanged
Fri	25/10/2017	Implement	Quantitative survey	Changed
Fri	27/10/2017	Methodology	persona	Unchanged
Fri	27/10/2017	Methodology	Value proposition	Changed
Fri	03/11/2017	Methodology	Brainstorming/ ideation	Unchanged
Fri	03/11/2017	Methodology	List of Requirements / MoSCoW	Unchanged
Fri	03/11/2017	Research	How the navigation system works currently	Unchanged
Fri	5/11/2017	Methodology	Task Analysis	Changed
Fri	5/11/2017	Document	Draft Requirements Chapter	Unchanged
Fri	12/01/2018	Research	List of key reference material	Unchanged
Fri	7/11/2017	Document	Design Chapter	Unchanged
Fri	7/11/2017	Methodology	Moodboard	Changed
Fri	12/11/2017	Methodology	**Storyboards**	Changed
Fri	17/11/2017	Methodology	User flow	Unchanged
Fri	22/11/2017	Methodology	Taxonomy	
Fri	22/11/2017	Document	Requirements Chapter	Unchanged
Fri	27/11/2017	Implement	Scenarios	Unchanged
Fri	4/12/2017	Implement	sketching	Unchanged
Fri	8/12/2017	Methodology	Plan for prototype demonstration	Unchanged
Fri	8/12/2017	Implement	Wire-framing	Unchanged
Fri	**15/12/2017**	Presentation	**Early Prototype demonstration**	Unchanged
Fri	12/01/2018	Document	Draft Design Chapter	Unchanged
Fri	12/01/2018	Document	List of key reference material	Unchanged

Fri	01/01/2018	Implement	Prototyping on axure	Unchanged
Fri	15/01/2018	Document	Design Chapter	Unchanged
Fri	15/01/2018	Implement	Video editing software research	Unchanged
Fri	20/01/2018	Implement	Test axure prototype	Unchanged
Fri	20/01/2018	Document	Review Chapter	Unchanged
Fri	26/01/2018	Implement	First draft of prototype demo using video	Unchanged
Fri	26/01/2018	Document	Draft Review Chapter	Unchanged
Fri	02/02/2018	Implement	First draft testing	Unchanged
Fri	09/02/2018	Document	TOC testing Chapter	Unchanged
Fri	09/02/2018	Document	Review Chapter	Unchanged
Fri	16/02/2018	Implement	Second draft of prototype demo using video	Unchanged
Fri	16/02/2018	Document	Technologies and Architecture Section	Unchanged
Fri	23/02/2018	Research	Identify viva story	Unchanged
Fri	02/03/2018	Document	Draft Implement Chapter	Unchanged
Fri	09/03/2018	Document	Testing Chapter	Unchanged
Fri	16/03/2018	Methodology	**Heuristic Analysis**	
Fri	16/03/2018	Methodology	**Metrics Analysis**	
Fri	16/03/2018	Document	Implement Chapter	
Fri	23/03/2018	Document	Introduction and Conclusion	
Fri	30/03/2018	Document	Appendices and references	
Fri	06/04/2018	Document	Complete draft report	
Fri	13/04/2018	Implement	Last functionality implemented	
Mon	**23/04/2018**	Document	**Report Submission**	

Table2 – shows the changes that were made in the project since the initial project proposal

The elements that have been altered since the initial proposed plan are:

- Sprint/ Sprint back-log
- Blueprint service
- Quantitative survey
- Value proposition
- Task analysis
- Mood board
- Story-board

The following design / research tool were not used in the project. This was necessary in order to save time. There was an under-estimation in time that was needed in research and understanding the design of an in-car information and dashboard design of a driverless car. The research/ design tool used instead gave a better insight of the data and information that is needed for the final prototype design. The following are the design/ research tool used to gather requirement and insight for this project:

- Requirement elicitation
- UML Class diagram
- Activity Diagram
- Sequence Diagram
- Data structure

3.2 Comprehensive use of analysis tools

In order to analyse the feasibility of the driverless car and its advantages and disadvantages, analysis tools such as PEST and SWOT will be used.

3.2.1 SWOT analysis

Albert S. Humphrey originated this strategic / analytical tool in 1960. This is used by businesses and organisation in order to audit opportunities that they can exploit. It also allows them to highlight the weaknesses of their business/organisation, and in this case project. This tool also points out the threats, which a business or an organisation is likely to face in future. This can eventually allow a business to compare itself to other competitor and build strategies

[Source 46]

Strengths	Weaknesses
▪ The self-driving car will move via computerised algorithms and real-time map data, this will be more efficient and accurate ▪ Less accidents are likely to take place because of the accurate driving ▪ Driver can monitor driving through features like energy consumption and warning alerts such 'low petrol' ▪ Drivers can save their seating position, climate setting, mirror positioning under their driver's profile ▪ Easy to pay for parking tickets through their in-car parking feature ▪ Driver can keep track of their vehicle from anywhere via an App that is linked to the car ▪ Driver can manage the car via an App, driver can open doors, close doors, turn the in-car system on so that the car is in a comfortable position before the driver enters	▪ Due to intense security system, only driver can unlock the car ▪ Creating driver's profile contains series of steps, this can be complicating for drivers who are not good with technology ▪ Some drivers like to drive, because this is a fully driverless car those drivers may not feel content ▪ Dashboard with a poor user-interface can cause misinterpretations which can prevent some features from reaching its potential ▪ This is a fully electric driverless car, there are only few spots for electric cars to charge
Opportunities	**Threats**
▪ Government is planning to increase number of charging spots for electric car, electric cars can be charged in various location ▪ Reduction in traffic congestion, journey will be more predictable as everything will be computerised ▪ Not much effort and time needed for the drivers to settle themselves up because of features like driver's profile, more time can be spent on projects and other useful activities	▪ Security/Data preaches - Produce complex algorithm and hiring ethical hackers to test whether the algorithm is complex enough. Regular updates to make sure software system is up to date with the technology ▪ Data confidentiality - This could be prevented by encrypting data and producing a strong security system needed to access the data.

	For example, a combination of both handprint and voice recognition in order to turn the car on

Table 3: SWOT Analysis

3.2.2 PEST Analysis

PEST is a business/ marketing tool used for analysing 'Political', 'Economical', 'Social' and 'Technological' changes made in the business environment. This business tool was created by Francis Aguilar. The aim of this technique is to allow the business to see its projects from an environmental perspective.

PEST analysis can highlight opportunities and point out threats, making the business aware of the obstacle they are likely to face. It can help businesses think of more strategies or improve their current strategies as PEST analysis will illustrate the Political, Economic, social and technological standpoint of the current business environment the business is in or is interested in. Businesses can make a suitable decision based on firm analytical data instead of unreliable assumption when starting new projects, as they will have a better understanding of the current stance of the market.

[Source 47]

Political	Economic
▪ Government is likely to support an idea which can prevent "ten thousands of " lives [48] ▪ It can be ambiguous as to whether this whole idea is trustable. Once the era of driverless car begins, who could be blamed, the manufacturer or the software programmer or none? [49] ▪ Policy makers finding it hard to introduce this technology onto the roads of UK due to 34% of drivers against this proposed idea [49]	▪ Increase in productivity as less time spent in traffic and more work can be done in the car ▪ Some of the workers will lose their job such as traffic court administrator ▪ Roads and cities will be more spacious as driverless industry takes place ▪ Insurance companies will need to change their route as there will be no driver liability
Social	**Technological**
▪ Drivers will be able to interact with their friends and family ▪ Drivers can have a business conference calls/ meeting whilst in the car ▪ Increase in the overall level of productivity for the driver	▪ Drivers can control the entire vehicle through the functionality displayed on the touch-screen on dashboard ▪ A real-time system which updates the in-car system whilst the driver navigates from one place to another

Table 4: PEST Analysis

3.3 Cost/benefits to client

Cost-Benefit analysis is carried out in order to highlight benefits and costs of a new project or proposals that will bring changes to the system. The data and information obtained from the analysis will state the feasibility of the project. Cost-benefit analysis can also help in evaluating capital purchase and the necessity of recruitment.

The aim of cost-benefit analysis for this project is:

- To determine the feasibility of the project
- To give an insight on the development stage of the project
- To give an insight of the team and tools that may be needed

Category	Details	Cost in First Year
Researchers	In order to keep up to date with designs, technology and algorithm	3X £65,000
UX designers	User experience designers to make the touch-screen, and any other interface that may be used in future, user-friendly	4X £65,789
Development tool	Axure	£854.33
	Photoshop	£888.00
Programmer	Several programmers may be needed (at-least 5)	5X £68,040
Cyber-security	Cyber security to keep system secure as possible	4X £51,919
Data analysis	Analysing and collecting data, utilising the data processed in the vehicle and proposing efficient algorithm	4X £57,462
System Engineers	Testing and developing system	3X £64,918
Total		**£1,432,376.33**

Table 5: Cost Analysis

[50][51]

Benefits

- System created will be up to date with the technology
- Complex algorithm created, providing efficient and robust system
- System and data will be secure
- User experience will be user friendly, users will find it easy

3.5 Risk and contingencies

The table below shows potential risks that can occur during the development of the project. It also states the impact, likelihood and mitigation methodology

Risk	**Impact**	**How Likely is it?**	**Mitigation**
The requirements of the system may not be up to date with the technology as technology is developing fast	High	Low	Keep up to date with technology and have regular requirement reviews and if possible make changes or add requirements in order to keep the software system and in-car technologies and information system up to date with the market
Activities or requirements may take longer than expected	High	high	Daily reviews and set of targets for each team. Hiring enough developers, researchers, designers in order to keep the implementation of the system up to date and avoiding any requirements from going above the time-scale
There may be unnecessary slippage or delays in tasks such as developers taking days off	High	high	Stayingup to date with schedules each developers have. Keeping the developers up-to-date with all the deadlines. Rearranging the targets if anyone takes a day off
Project cost can increase above expectation due to inaccurate estimates	High	Low	Hire professional accountants who are up to date with the project cost and informs the project manager if there is a risk of the cost of the project to increase.
The rules and regulation may change	High	high	Keeping up to date with the rules and regulation regarding driverless cars, as they maychange. Keeping the requirements of the project up to date with rules and regulation in order to avoid any illegal offence.
External hazards which human have no control over such as earthquakes and floods	High	Low	Data such as developed or in-progress algorithms should be stored in several different locations as backup.
Computer/ laptop may obtain viruses which can destroy the work produced	High	Medium	Data such as developed or in-progress algorithms should be stored in several different locations as backup.
Rival company or someone within the team may try to hack or steal data	High	Low	Data should be encrypted and not everyone within the organisation should have access to this data

Table 6: Risk analysis [52][53]

3.6 Use case Diagram

The diagram below is a Use case diagram. Use care diagram presents an overview of requirement usage within a system. Use case diagram are useful for identifying project stakeholders.

Use case diagrams depict:

- A use case describes an action of series of actions that brings value for an actor.
- Actors can be people, organisations or an external system that interacts with the system.
- Associations are represented as a solid line between actors and use cases.
- System boundary is represented as a rectangle, which is around all the use cases.

[Source 54]

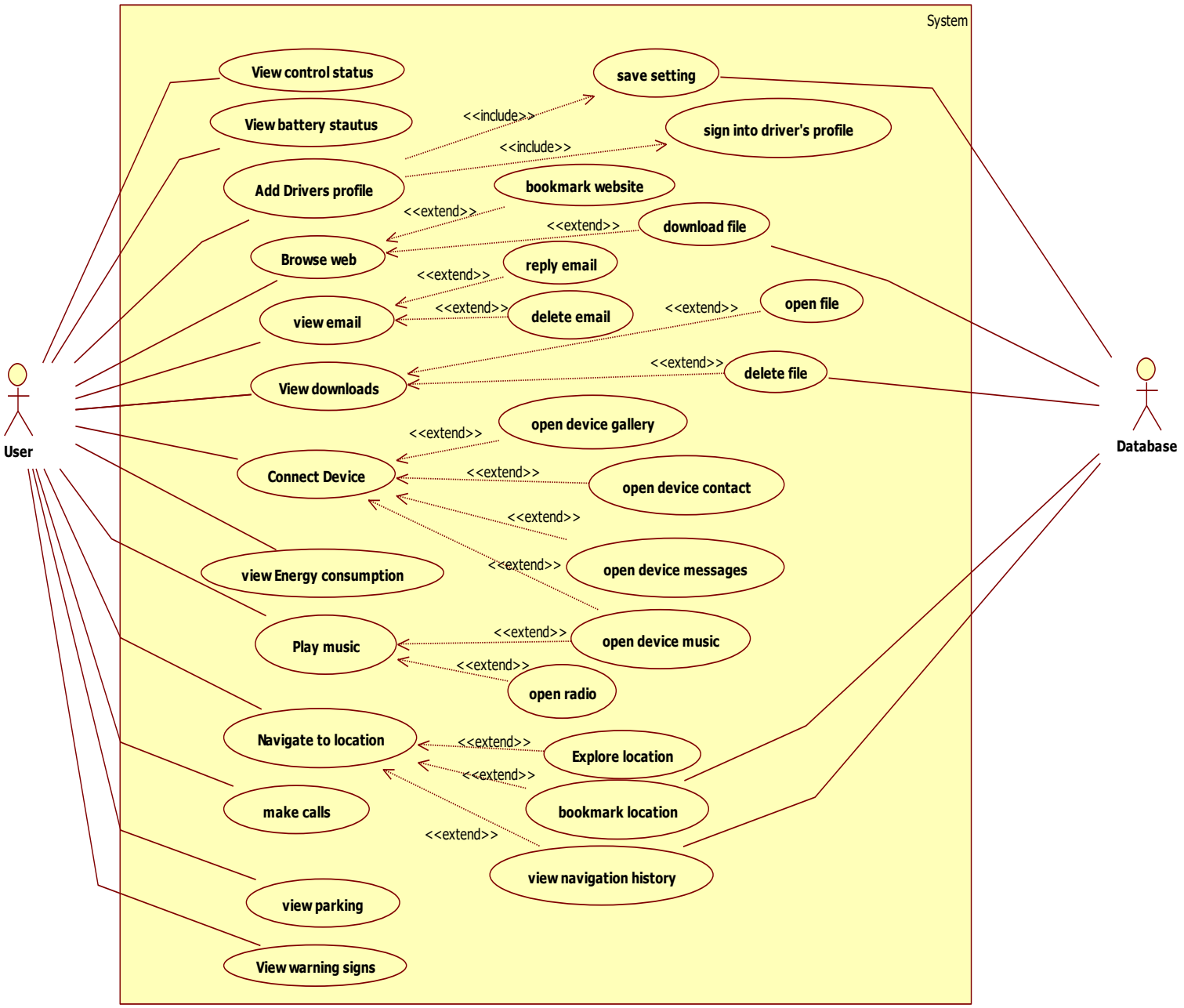


Diagram 2- Use case diagram

3.7 Requirements analysis

"Requirement elicitation is a process aiming to identify the needs of clients for the software to be developed" [55].

In order to design a system that meets a client's need or the market's trend, it is important to have a list of requirements. There are two types of requirements, functional requirement and non-functional requirements. Functional requirements are "Statements of services that the system should provide, how the system should react to particular inputs and how the system should behave in particular situations"[56]. Most of the requirements were gathered through research of different driverless cars such as Tesla. Some of the requirements were other latest technology, which are not yet added to the in-car information system. Non-functional requirements are "Constraints on the services or functions offered by the system such as timing constraints, constraints on the development process, standards, etc."[56].

MoSCoW

The collection of both functional and non-functional requirements will be prioritised using MoSCoW. Moscow is a technique, which prioritises requirements [57]. In order to set the priorities on each requirement, the following letters are used:

- M for Must have
- S for Should have
- C for Could have
- W for Would have

Requirements that are compulsory during delivery date, or are fundamental to the projects are 'Must have' requirements. Requirements that are needed for safety issue or legal issues are also 'Must have' requirements. Requirements that are important but the project is still viable, they are considered as a 'should' have requirement. Requirements that are not as important and will have less impact if not achieved compared to a' would have' category are considered a 'could have' requirement. 'Would have' requirements are not important but can be used to enhance for example the visualisation of the system.

Requirement of the control system

Functional Requirement	***Priority***
View status of the doors	***M***
Lock/unlock doors	***M***
Open/close charging port	M
View in-car temperature	M
Change in-car temperature	M
Turn on headlight / turn off headlight	M
Turn on fog light / turn off fog light	M
Turn on dome light / turn off dome light	M
Turn on hazard light / turn off hazard light	M
Open sunroof / close sunroof	S
Turn on AC/ turn of AC	M

Requirement for safety/alerts

Functional Requirement	***Priority***
View warning signs	M
View time/date	M
View speed	M
View energy consumed	M
view speed limit (navigation)	M
Display rules and regulation for driverless cars	S

Table 7 – functional requirements

Requirement for the overall system

Functional Requirement	***Priority***
View driver's profile	S
Create new driver's profile	S
Connect to Bluetooth	M
Connect to device	M
Access connected device's directory	M
Web	
Browse internet	S
Sign in to your email	S
View email	S
Delete emails	S
View downloaded files	S
Download files	S
Delete downloaded files	S
Music	
Listen to radio	M
Favourite a radio channel	S
Search radio channel	S
Select music from device	S
Select playlist from device	S
Navigation	
Search Destination	M
Navigate to destination	M
Search location	M
Select region	S
Save history/ delete history	M
Bookmark location	M
Select language	M
Select satellite view	M
Select terrain	M
Turn traffic on	M
Explore location	M
Search petrol station near by	M
Search hospital near by	M
Search cafe near by	M
Search supermarket near by	M

Search restaurants near by	M
Search recommended location	C
Non-Functional Requirement	***Priority***
Must have an internet connection	***m***
Must have have strong, reliable internet connection	***M***
Data must be process within 3 seconds	M
Map detail must be accurate and real time	M
User interface must be easy to use	M

Table 8 – functional requirements

3.8 Stakeholder analysis

Stakeholder analysis is important because it gives an insight of the organisations and people that will be affected by the project. Below is a stakeholder analysis of this project.

Government –the era of driverless cars will be a concern for the government as the rules and regulation of today's vehicle industry will change as the automotive industry begins to take over. Government needs to consider issues such as insurance, infrastructure, safety, security and rules and regulation in order to decide whether the automotive vehicle can safely drive on the roads. Government has also been investing in order to carry out as much research as they could [58]. This system like many other autonomous systems will benefit the government in many ways. One of the main benefits is the reduction of accident because of human error. This will allow the government to focus on bigger issues such as poverty.

Car insurance– The era of driverless cars in general will have an impact on the insurance company where fewer accidents will lead to lower premiums. There is a reduction in the number of accidents because of technologies such as AEB; a fully autonomous vehicle will bring further improvements to the road safety. Malcolm Tarling from association of British insurers stated that the development of the technology could have a 'significant impact' and reduce 'risk', which will make vehicle safer. He also stated that 'premium always reflects risk'. Although this may not be good news for motor insurance companies, this can bring forth more paths and opportunities for them. [59]

Driver and passengers– the in-car information system and the dashboard design of a driverless vehicle will benefit the drivers and the passengers in many ways for example, they will be able to save time by continuing with their own day to day activities, they will be able browse web, email and download files and view it on the bigger screen. These features will cooperate with different type of individuals such as businessman, parents, teenagers; Parents can carry on their family activities, whilst the individuals with projects and presentation can have that extra thirty minute of preparation.

Hackers–the in-car information system and the dashboard will contain data. This system will have access to internet and internet brings vulnerability to the system. Hackers try their best to exploit the system in order to have access to the system and its data.

Chapter 4: Design

4.1 Data structure

Data structure diagram is a modelling tool, which is used to visualise the structure or hierarchy of a system. It can be used to illustrate different structures within a system such as database or an application. The interaction and connection of the entities, component or modules within the system is shown through the hierarchical structure used to demonstrate the overview or a specific part of the system. Ultimately, structure diagram demonstrates how the system works [60].

Below, is a data structure diagram of the in-car information system, which gives a visual overview of the system structure of the two in-car screens that are embedded in the driverless car's dashboard. The data structure model highlights the functionality ofboth the screens. Screen 1 consists of the infotainment elements of the in-car information system, as shown in the diagram below. Screen 2 consist of phone, Bluetooth connectivity and user profile. It also consists of control-oriented elements such climate control and keyboard; users will be using this screen as keyboard throughout their journey.

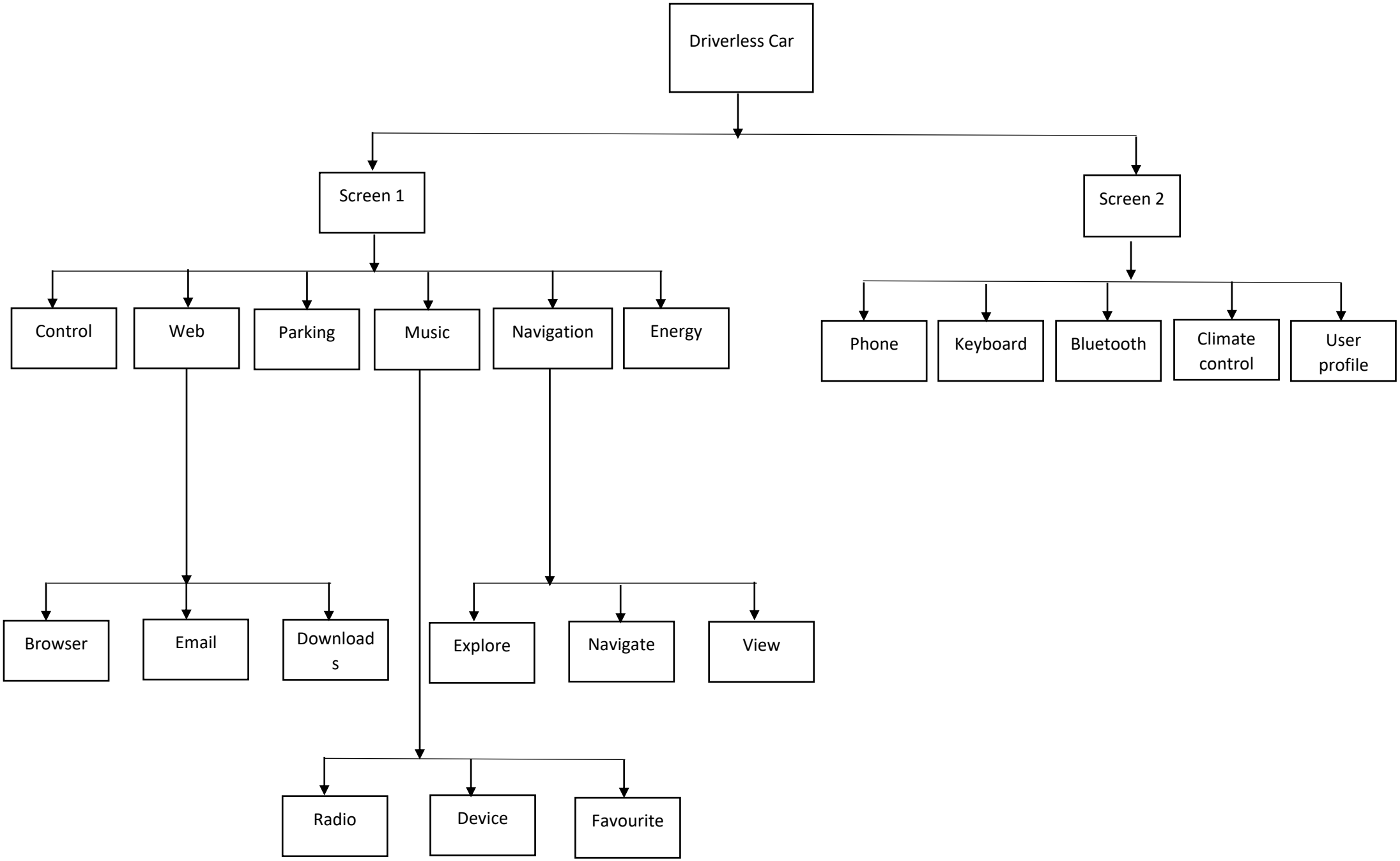


Diagram 3- Data structure diagram

Screen 1

Control

Controls in Screen 1 allow a user to interact with physical components of the car, for example, controlling the state of the doors; a user can lock and unlock doors, either individually or all together. Users can control the rooftop to their desire levels. Levels provided to them are 25 percent, 50 percent, 75 percent and 100 percent. Further controls provided to the users are the ability to turn the headlights and fog lights on, although this could be set to automatic mode where the vehicle will enable them during evening and nighttime of the journey.

Web

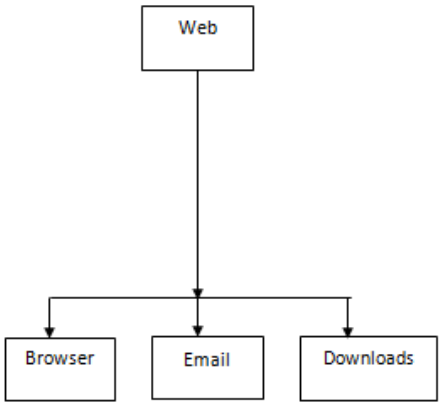


Figure 6- Web-system structure

Web browser in screen one is designed to allow users to access browser, email and current downloads. A user may use the browser for research purposes, for example, searching for queries on Google, yahoo or any other search engine, potentially leading to downloading documents, saving documents to their USB sticks or emailing documents to further work on their research in future. A user can also use a browser for entertainment purposes, for example, a user may watch YouTube videos on the large Screen (screen 1).

A user can use the email application, where he can be logged onto multiple accounts, for example, a user may have an email account, which he uses for work purposes, and an email account he uses for his personal use. Email application will keep the user up to date through alerts and notification.

A user can download documents and presentation which he can edit and utilise it for example his research. The documents, which can be edited, can be downloaded documents, email and from USB stick.

Music

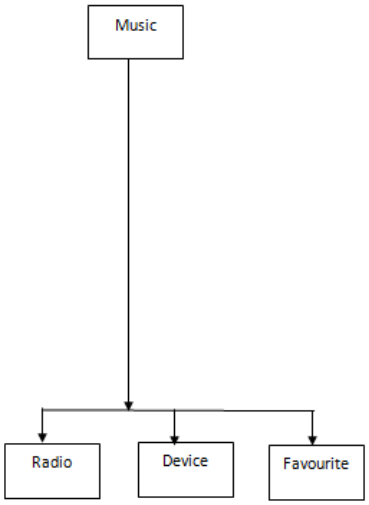


Figure 7- Music system structure

Three key elements are within the music system in order to ensure an efficient flow and utilisation of the system: radio, device and favourite. Radio containsthe entire internet and classic radio station a user may consider listening. User can also connect his device to the music entertainment system. This will allow the system to access all the audio, from single songs to albums to playlists, which a user can choose. Furthermore, users can favourite radio channels, which will be displayed under the favourite option. This will reduce the effort needed for the user to search for the radio channel in future. The same principle is applied to the songs and playlist in the user's device, however, the selected songs and playlist will only be displayed if the device is connected.

Navigation and Parking

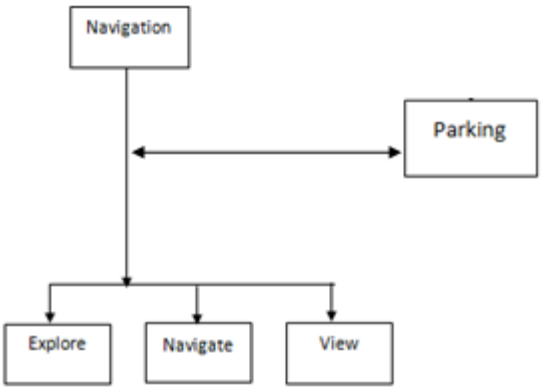


Figure 8- Navigation and parking interactivity

Navigation and parking is one system. Navigation system allows a user to explore, navigate and select different views for a map. A user will follow the classical methodology of searching in a navigation system, where the user will input the destination. Number of routes will be generated which will depend on real time traffic and data. Routes can vary depending on road works and congestion. The quickest and efficient route will be displayed at the top. Once the user selects a route, the user can view the directions, which the vehicle will be taking, from the start of the journey

to the point where the vehicle is parked. User can use the explore option to add stops to the journey, for example, the user may want to go to a local market which comes on the way.

User can use the explore feature in many ways. A user may want to explore its local area, where all the nearby shopping malls, hospital, charging ports and restaurants can be discovered. User can also explore using the recommendation feature where most popular places to visit is presented to the user, for those who may enjoy long road trips with family. Different views can be selected, from real-time traffic to satellite view.

Parking is a pop-up feature that is activated 30 minutes before the user reaches their destination. The user can however, choose the parking option anytime of the journey. This feature allows user to ensure vehicle is parked at a convenient spot. Parking system will provide local parking places, from on-road parking to near-byparking lots; it will also inform how much the parking space is worth.

Energy

Screen 1 displays Energy consumption, which allows the user to analyse how well the vehicle is performing from which they may change their methodology of maintaining the vehicle.

Screen 2

User-Profile

User can create a user-profile, which allows the user to save multiple environmental elements under their account for example, a comfortable seating position, adjustment of the side mirrors and climate adjustment. The purpose of user profile is to eliminate the need of making same changes. The user will potentially utilise the time instead on elements like navigation system. The users have the flexibility to make amendments to the user-profile, for example, changing climate setting as season changes. Multiple users can create their own personal user-profile.

Climate control

User can adjust the in-car climate provided on the second screen. User can view the outside temperature and adjust the in-car temperature. Several options are provided, for example, allowing user to turn on the rear fan or turning on the air condition. These setting can be manually changed or automatically adjusted once the user enters his/ her user profile

Bluetooth

Users can connect their device via Bluetooth. This is one of the essential elements for users because it improves the interactivity a user will have with in-car information system. Once the device/ devices is connected to the in-car information system, the Bluetooth system is designed in a way where the user can have access to all the media files, music, contacts and messages within their device.

Phone

Phone allows user to make calls using the 4G network provided. User can access phone directory once their device is connected via Bluetooth.

Keyboard

Keyboard is only presented if the user needs to input data. Keyboard is only presented on the second screen; this allows the entire infotainment system to be centralised.

4.2 Activity sequence diagram

Activity Diagram is a visual illustration of series of actions or flow of control in a system. Activity diagram are often used in a business process modelling [61].

Elements used in the activity diagrams in this project are:

Initial state (start point)

Figure 9- initial state symbol

Represents the starting point of the activity diagram [61]

Action state

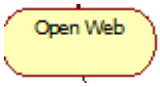


Figure 10- action state symbol

Action state represents the non-interruptible action of objects [61]

Action flow

Figure 11- Action flow symbol

Also called edges and paths, demonstrates transition from action state to another [61]

Decision and Branching

Figure 12- decision symbol
Represents a decision with alternate path [61]

Swimlanes

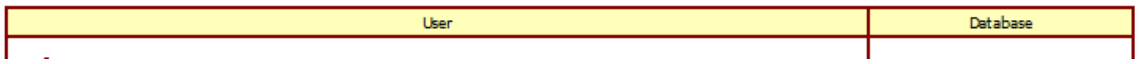


Figure 13- swimlanes symbol

Groups related activities [61]

Final State

Figure 14- final state symbol
Ending point of the activity diagram

Web and navigation are one of the important sub-systems with the infotainment system. Below are activity diagrams that represents series of activity with Web and Navigation system.

Activity diagram for WEB

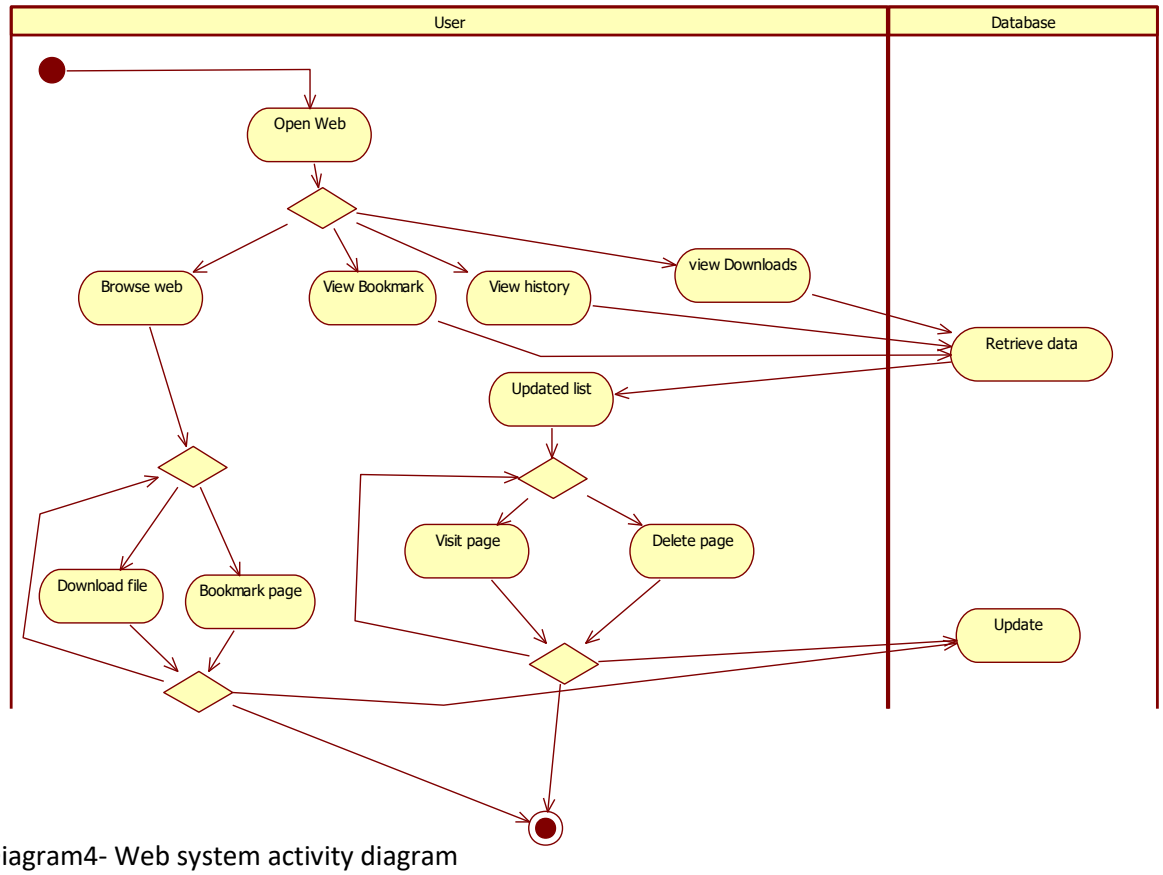


Diagram4- Web system activity diagram

The diagram above demonstrates that users can carry out four different types of actions when using web. They can browse web, view bookmarks, view history or view downloads. Once they browse the web, apart from visiting different web pages, they can download files or bookmark a page; this updates the database of the web-browser for future reference. If the user wants to view bookmark, history or downloads, the first step in the series of steps are to update the list with accurate history, bookmarks and downloads. The user can either visit those pages or delete the saved pages, which will than update the database for future reference as the activity ends.

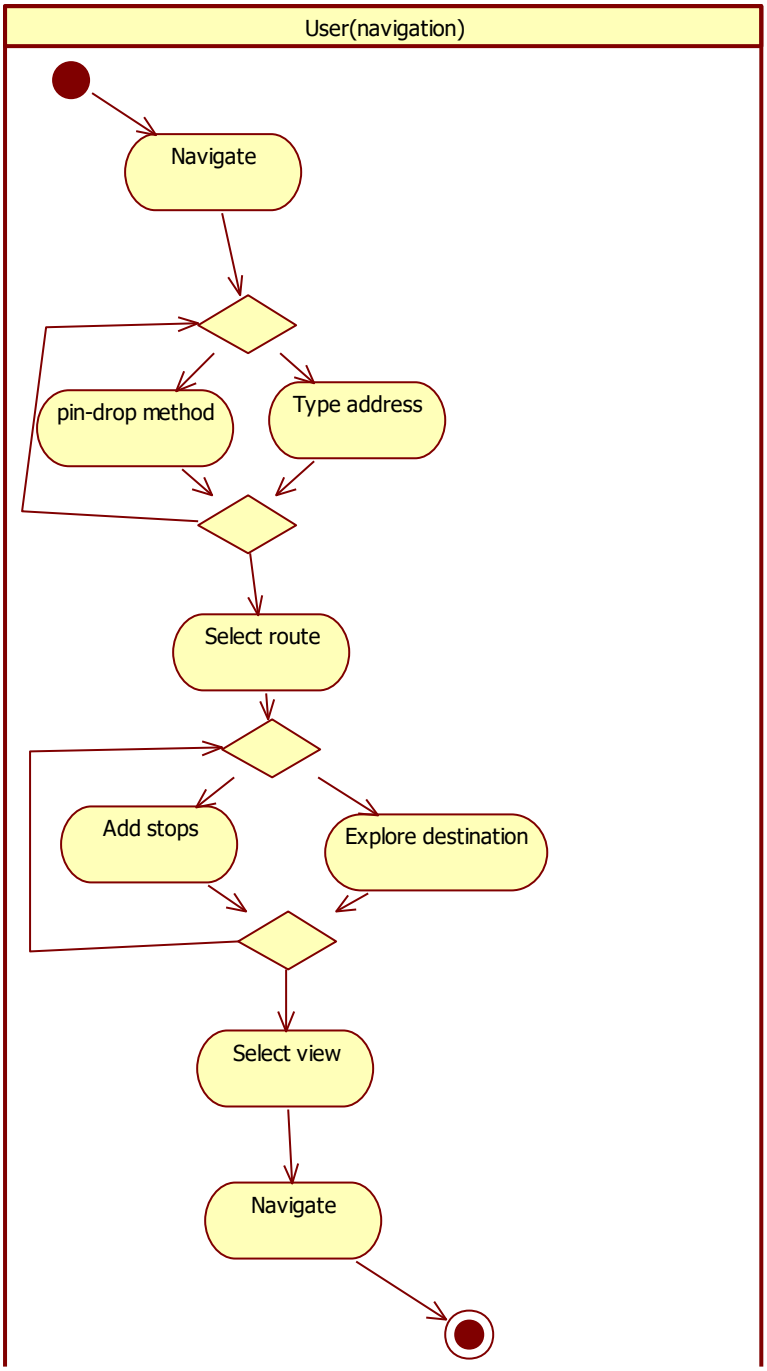


Diagram 5- navigation system activity diagram

The activity diagram above illustrates series of actions within the navigation system. A user can navigate using two different methodologies. The user can either manually type the address or use a pin-drop method where the user can drag a little pin onto the map and drop it anywhere on the map. Pin drop method is mainly used for local navigation. On selecting the route, a use can add stops, for example a café or a supermarket that a user may want to go before reaching the final destination. User can also explore location, for example checking out malls, hospital and places to eat near the destination. User can select view, for example satellite or terrain, with live traffic. Finally, the user can navigate to the selected destination as the activity ends.

4.3 Data model

Data modelling is a design tool, which illustrates the flow of data within a system. This design tool is used for constructing new software or redesigning an application. It ensures that the requirement of the system is understood. It shows the relationship between data and interactivity of data within the system [62]

In this project, data-modelling tool is used for demonstrating how the data and the entities within the system interact with each other. It is a visual illustration of the in-car information system. The data-modelling diagram below shows how the navigation system will interact with the database in order to retrieve real-time data. How the user will interact with the system, from signing in to the driver's profile, to accessing control of the vehicle and device connectivity. This model also describes the infotainment of the in-car information system and they interact with each other.

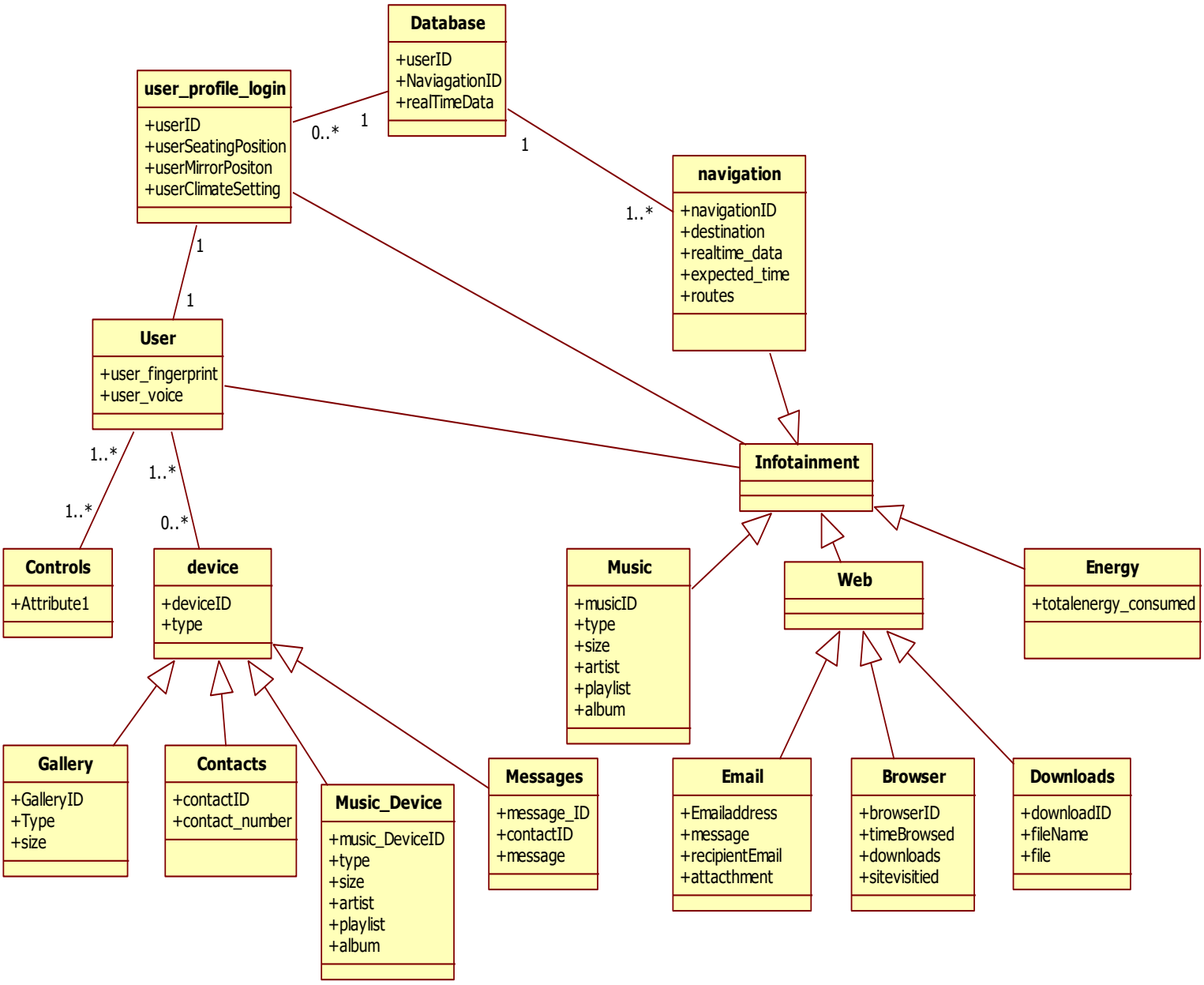


Diagram 6- UML Diagram for the in-car

4.4 Wireframes

(See appendix – Wireframes)

4.5 Persona

Below are 5 personas which describes 5 different type of people with different characteristic and personality. Each individual represents 5 different type of people who are likely to use this system. The design is built based on the requirements of these individual. This is a good technique because it gives the design a vision and goals, which the system should achieve. The personas are based on research carried out.

Tom Austin

- David Austin is 42-year-old senior product designer at Google
- Has tight schedules and projects with overlapping deadlines
- great passion for bodybuilding and spending time in gym is a great stress reliever for him

Pain points

- Phone's battery died, could not check emails
- Cannot drive and work on my laptop at the same time

Goals:

- to minimise the continuous illuminations of signs like seat belts and petrol; instead the system reminds me verbally
- to have a monitor embedded into dashboard so I can prepare my presentations/view emails
- to have a charging port

User story

As a senior product manager, David wants to utilise most of his time planning and designing his product. He needs facilities such as a socket to charge his laptop or to connect his laptop to the dashboard so he can work on his projects.

David Austin

- 21 years old, just passed his driving
- loves sports and cars
- has started college recently, and drives to University everyday

Pain Point

- Because I am a new driver, I forget about the speed and petrol and go over the limit
- I am always engaging with the media system and sometime it can be my biggest distraction

Goals

- To have voice recognition system to avoid constant interaction with dashboard; want to minimise the need of constantly moving from my seat
- A reminder message for when the petrol is low/ when the driver is going over the Speed limit

User story

As a new driver, David Austin wants to keep track of his speed limit and petrol usage. He wants a voice recognition system to interact with the radio system.

Linda Mark

- Originally from Switzerland and speaks German
- In her early 30s, and has 3 children
- A single mother, responsible for picking and dropping her children and other in-car duties like shopping
- Addicted to reading books
- A pharmacist, graduated in 2006

Pain points

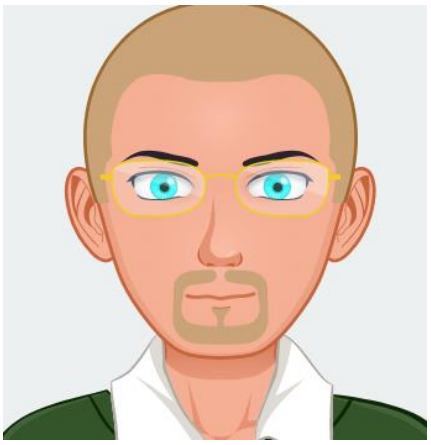
- "lately, I have been so busy with my day-to-day routine, I am unable to read any books, I can't read while I am driving, and I've either been working or behind that steering wheel"
- "I am working more than usual; I can't spend enough time with my family"

Goals

- An entertainment system which will keep the whole family busy

User story

As a busy single mother, Linda Mark wants to stay committed to her hobbies and stay close to her children as much as possible.



Wynne Stewart

- Lives in London, United Kingdom
- 26 years, has a leg injury due to an accident in a football match
- Was a pro-footballer, but now is a coach at Leyton Orient football club
- Cannot drive for too long due to his foot injury
- His coach career has been going great, he has been offered for coach training at West Ham united club

Pain points

- "I have to travel long distances lately for presentations and I need time for planning training for my team"
- "I need regular breaks from driving because of my injury, I'll say every 40 minutes"
- "I live in London, it's so congested, I can't find any parking because most of the roads have 'permit only' signs now"

Goals

- Navigation system which can easily find a parking space
- Use the dashboard to view and edit presentations

User Story

As a football coach, Wynne Stewart wants to utilise his time as much as possible in planning his team's training strategy and minimise his time in finding parking for his car.

Monna Idony

- British citizen, new to the rapping industry
- Travels to different and far locations for concerts
- Recently graduated from university, studied Music, Media and theatre

Pain points

- "I travel very far, for that I have to use navigation. I try my best to rehearse for my performance whilst travelling but that navigation reminder keeps interrupting the beat"
- "I am always in a rush, so I forget my USB or AUX cable; I cannot cope with the music on radio. I have a different taste"

Goals

- Give user an option to enable or disable the voice guidance for navigation system
- Allow user to save music so that they don't have to carry USB or AUX cable all the time
    - Or allow user to connect to the dashboard wirelessly

User Story

As a rapper, Monna Idony would like to rehearse for her performances during her journey.

Chapter 5: Proof of Concept

5.1 Appropriate technologies

In order to create the prototype and the video series, which demonstrates the functionality through user-journey of three personas, the technology listed below played a huge role in achieving the outcome

- Internet: Internet played a huge part in gathering requirements and in comparison of similar system.

- Lynda.com and Youtube: these website was the guideline in understanding on how to use tools like Camtasia and auxre

- Star UML: UML tool was used for creating use cases, UML data modelling class diagrams and activity diagram. These diagrams, as well as online research using internet helped in obtaining a design vision of the driverless vehicle in this project

- Axure: axure is a prototyping tool which was used to create an interactive prototype of the in-car information system and dashboard design

- Camtasia: this video editing tool was used for editing and capturing screen, it also allow voice over for narration. The features and facilities gained from this software helped in producing a useful tutorial on how the system works

- Powtoon.com: this website was used to help narrate the user's persona. Powtoon is used for animated presentations.

- Wireframe.cc: this is a wireframe tool, this was used for the first draft and for a rough idea of how the system will look and work. This was a great help in designing the final system.

5.2 Video series

Open following URL: https://kingston.box.com/s/g5ngrkesps3w5i98urtzn12wb3yu77qk

5.3 Prototype

Figure 15: Main dashboard of the car

The figure above shows the main dashboard of the vehicle with two embedded screen; the big screen will be referred as screen 1 and the small screen is referred as screen 2. The dashboard also has a wireless charging port which is in-place of the gear shift. The dashboard is designed in such way that the two tables can open so that users can use it for food and laptop, see figure below:

Figure 16: Dashboard with opened tables

Screen 1

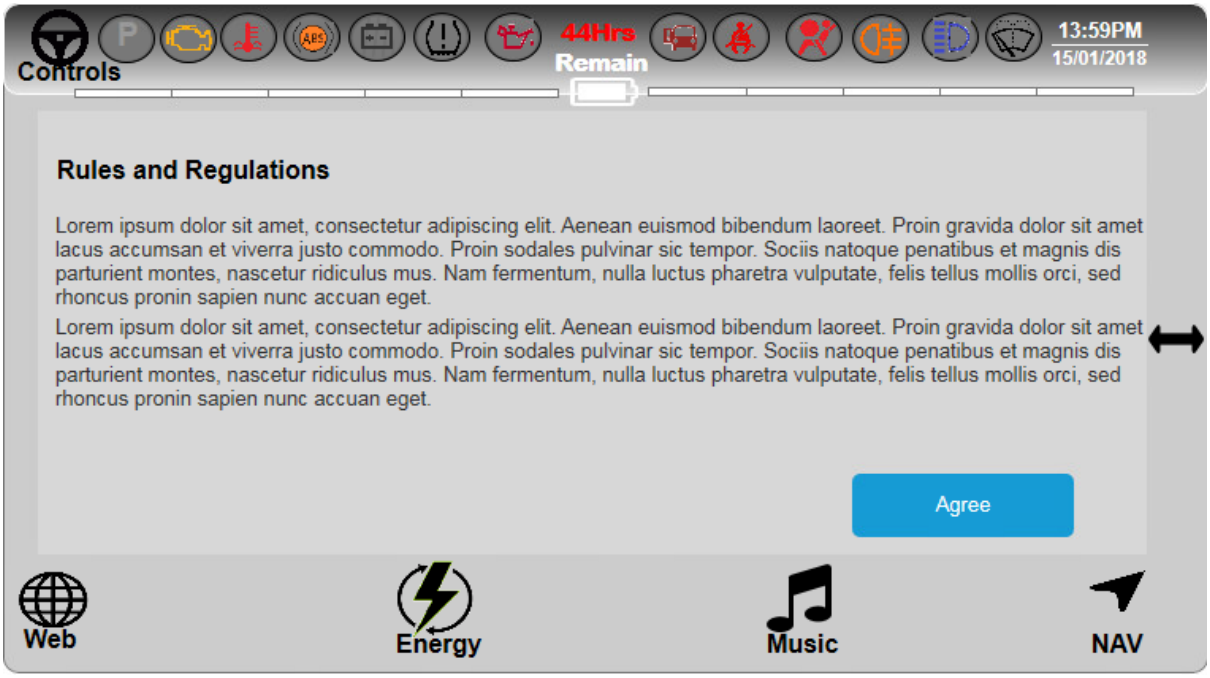


Figure 17: Landing page of screen 1

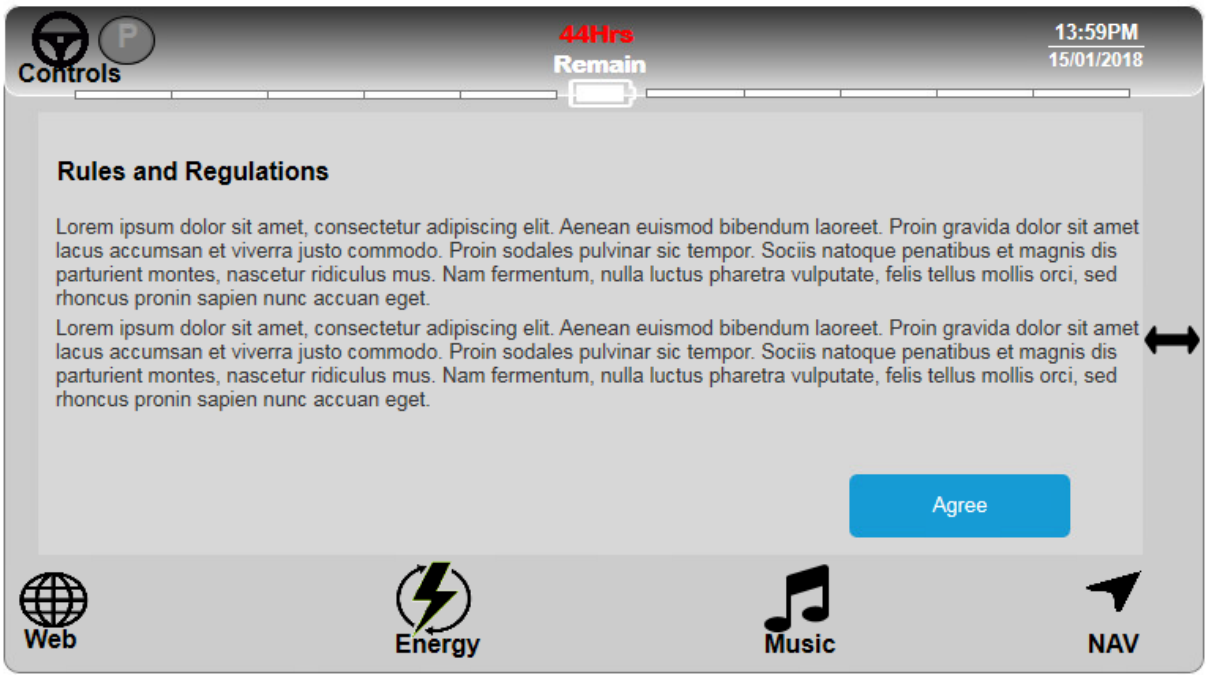


Figure 18: Landing page of screen 1

The two figures above illustrate how the dashboard will warn the users against any hazards, where figure 17 displays the illuminated warning lights and figure 18 illustrates how the screen should look like with no hazards

Controls

Controls is a system that allows the dashboard to control physical components of the car such as, doors, headlights, charging port for the vehicle and the sunroof.

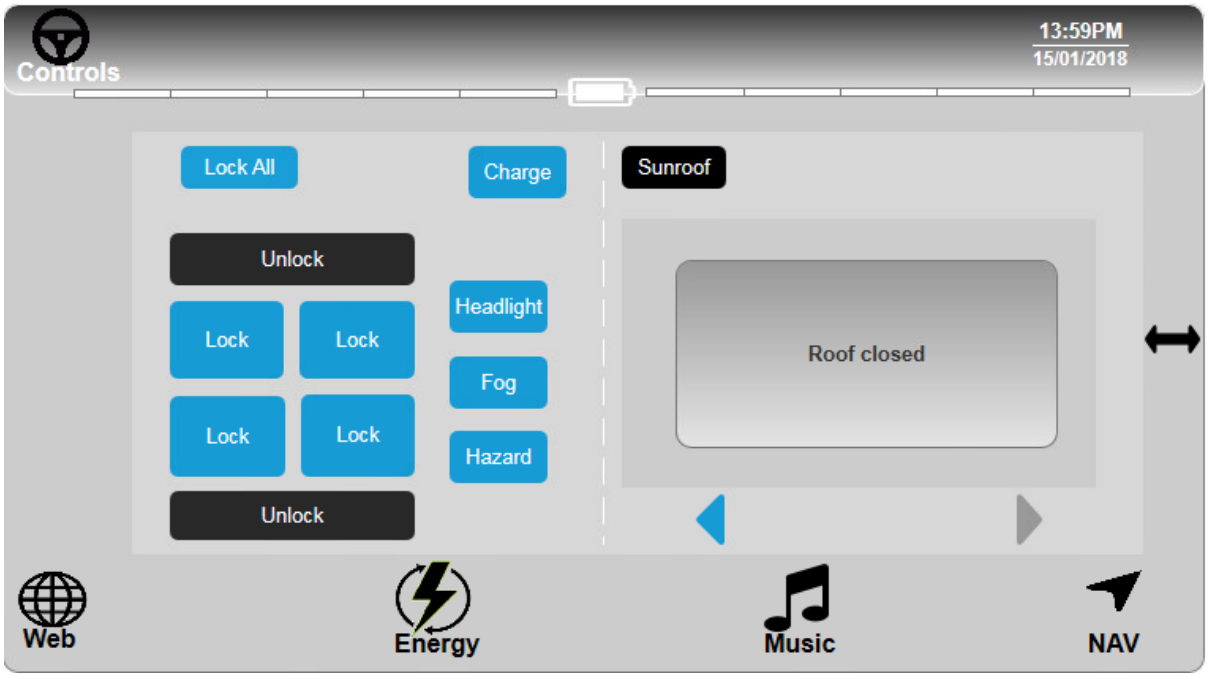


Figure 19: Controls system

Web

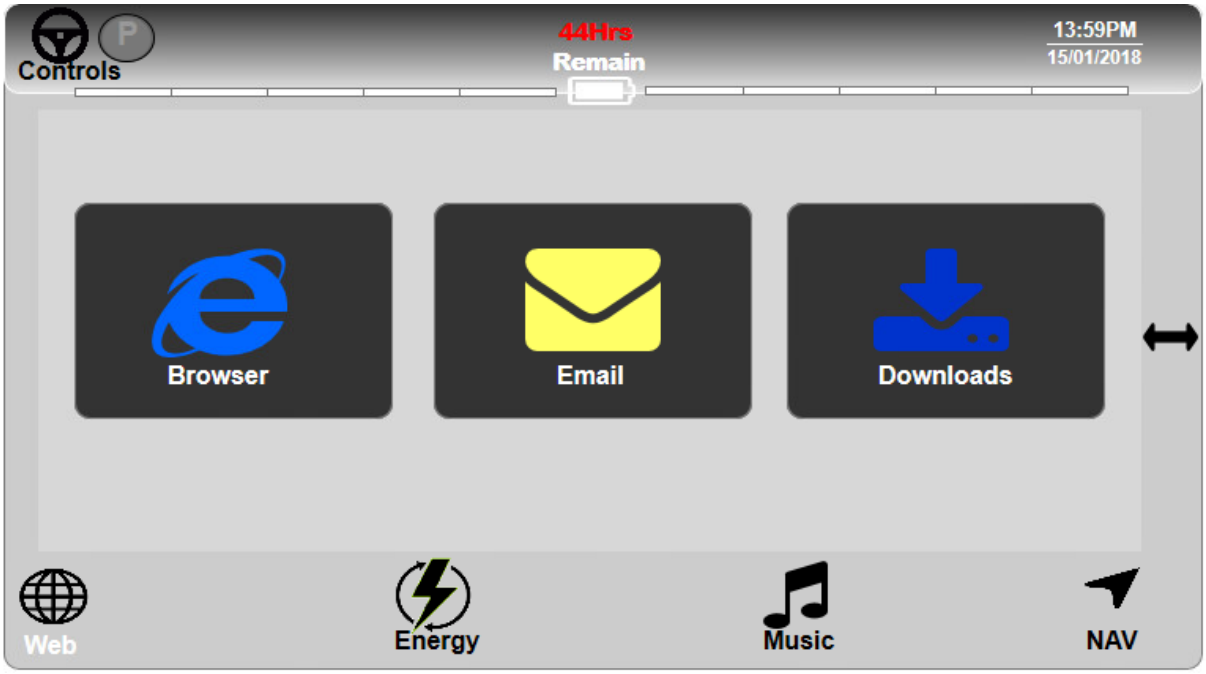


Figure 20: Web system

The figure above illustrates web system where users can browse web, view email and view downloaded documents and PowerPoint

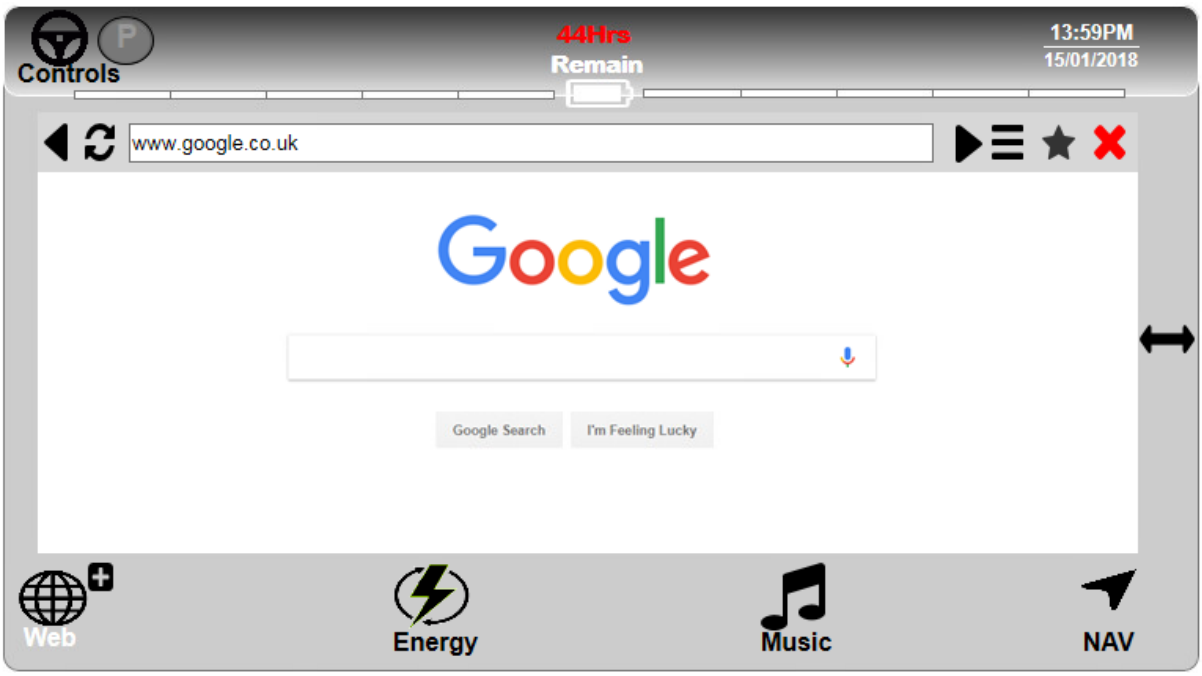


Figure 21: Web browser

The figure above shows the default page for web-browser which is google. Uses can view setting, favourite a web-page and open new tabs, see figure below

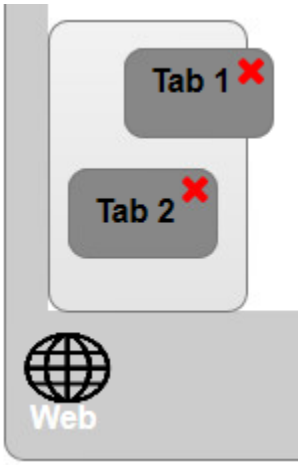


Figure 22: New tab option

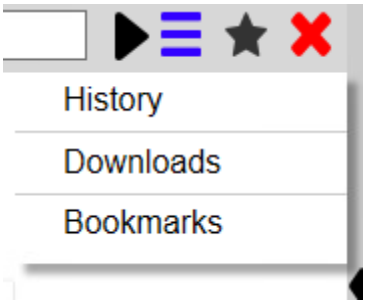


Figure 23: Settings in web-browser

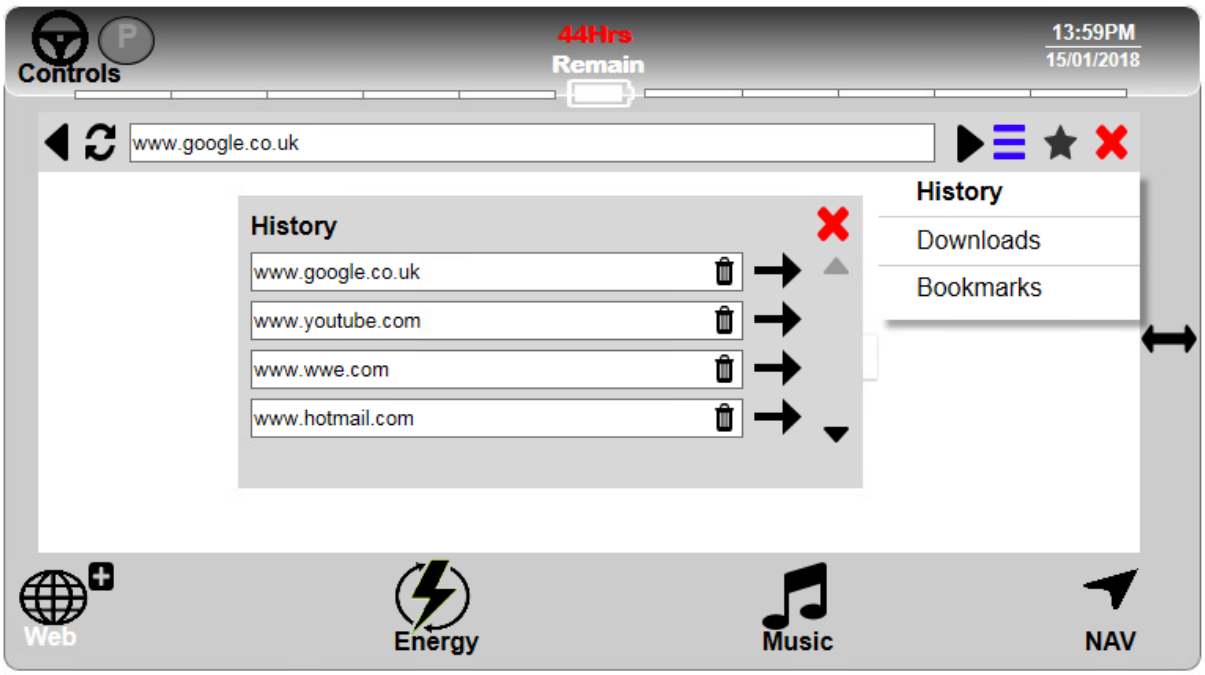


Figure 24: Web-browsing history

The figure above shows that users can visit the pages (arrow) and delete the pages. The same pattern and design is used for downloads and bookmarks, see figures below:

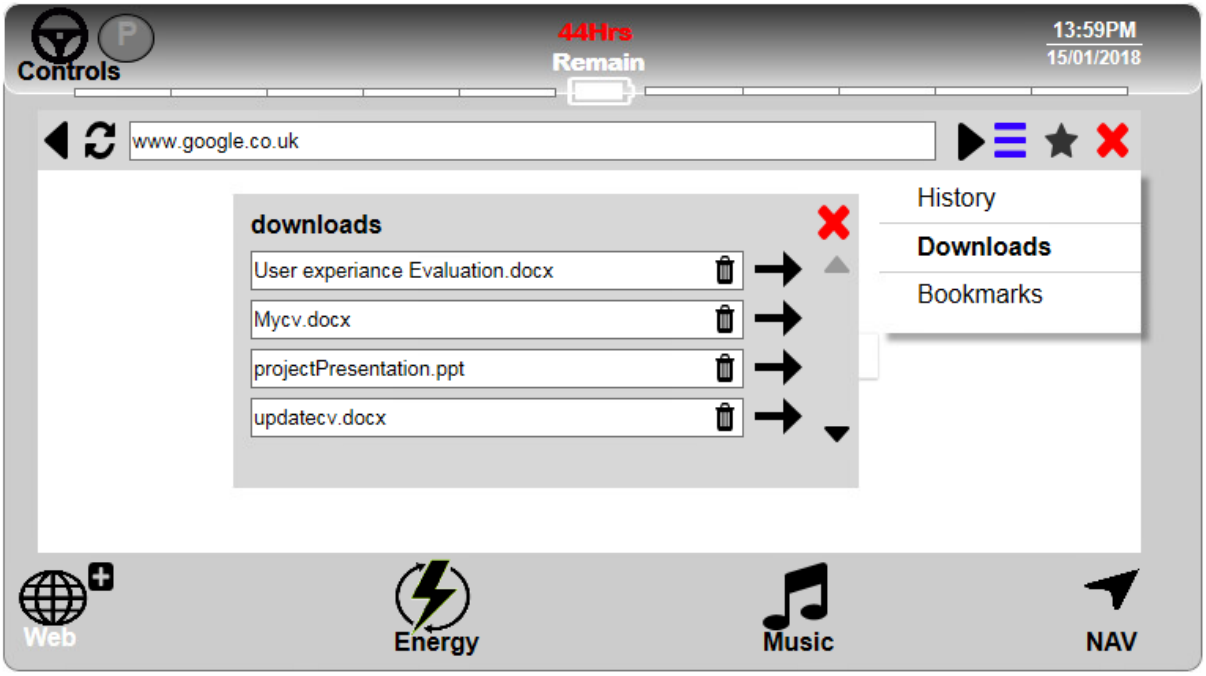


Figure 25: Documents downloaded using web browser

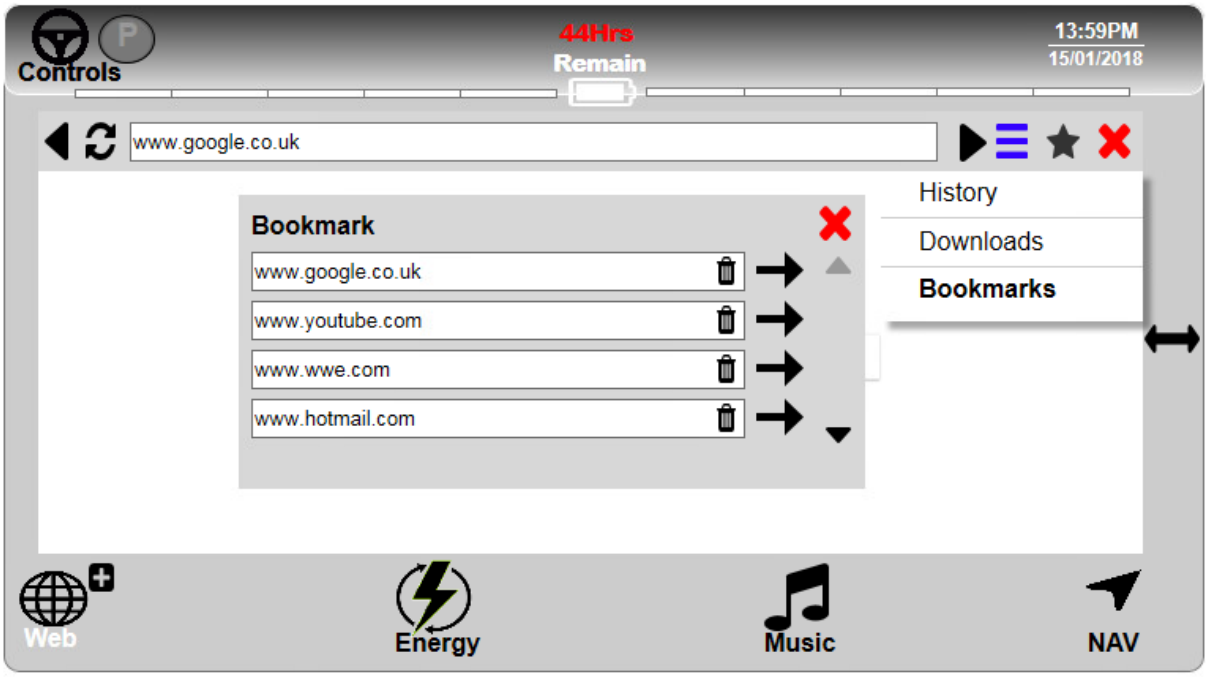


Figure 26: Bookmarked pages on web-browser

Downloads

The aim of Downloads is to avoid users from opening web-browser if their primary purpose it to open downloaded documents. Download allows users to access the downloaded files easily, additionally providing extra features such as emailing the documents, saving the document in a USB stick and editing the document.

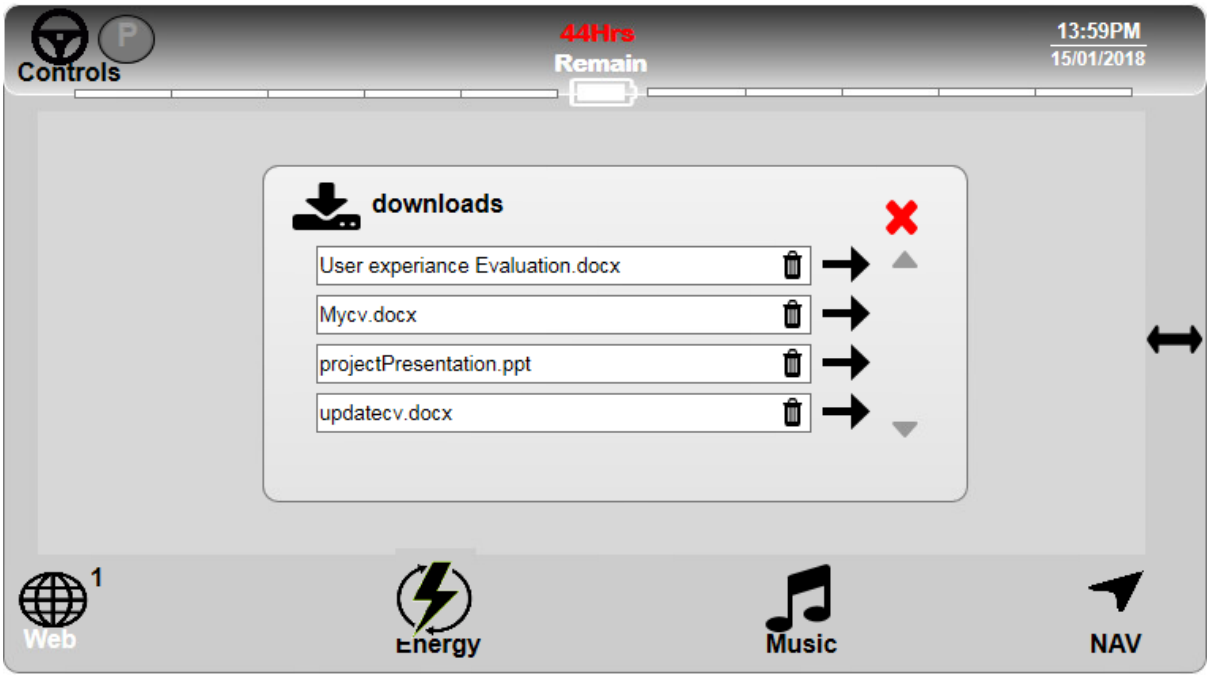


Figure 27: List of downloaded files, from web-browsers and email

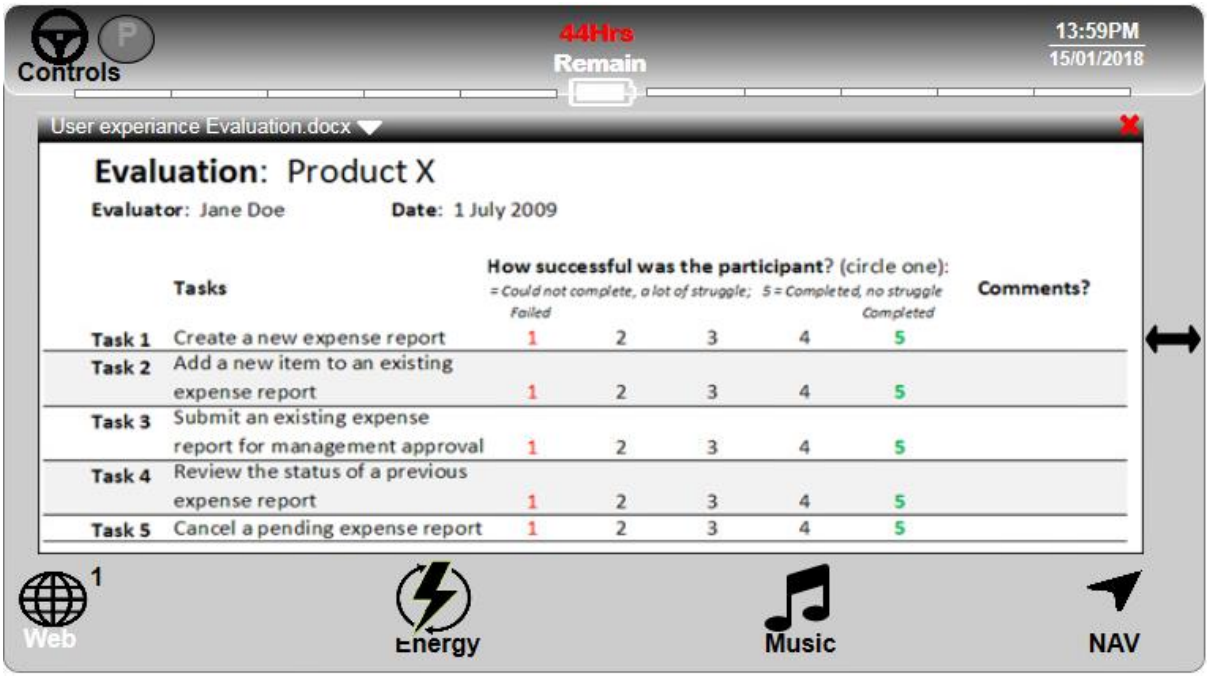


Figure 28: opened document

Figure 29: additional options

Figure above shows extra options that users have, which is to email, save the document in an usb stick and edit file, see figure below:

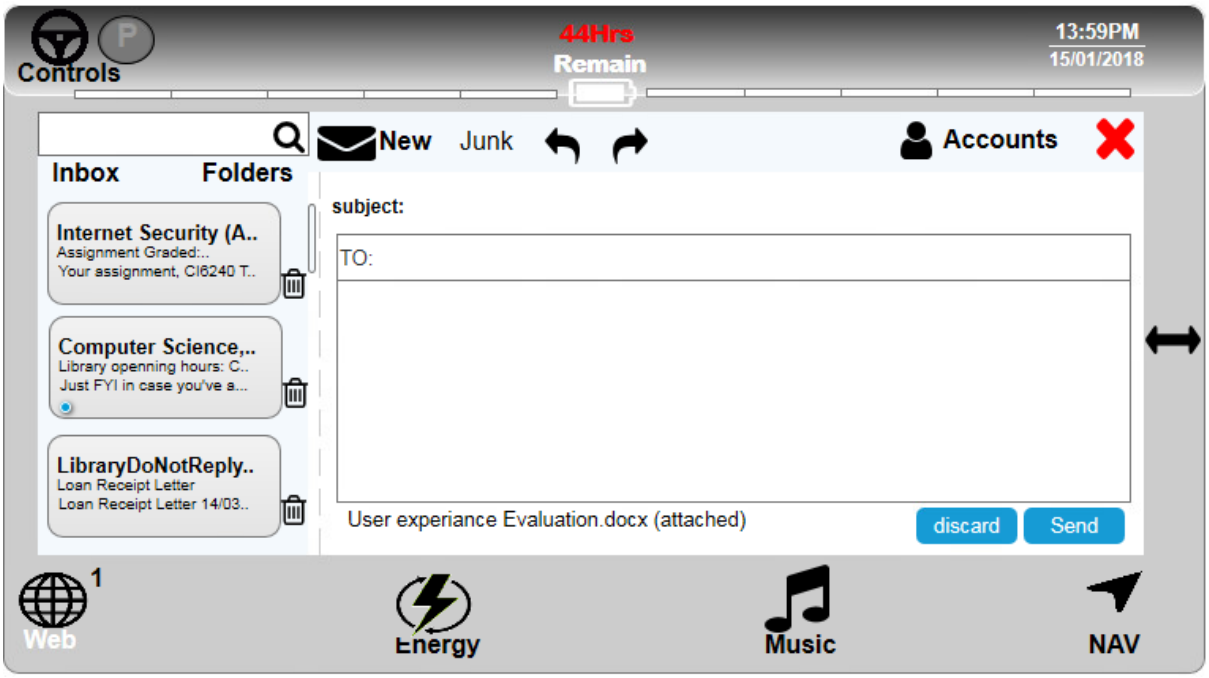


Figure 30: Emailing a downloaded documents

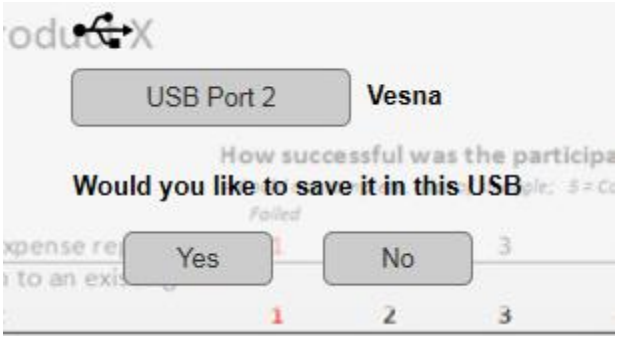


Figure 31: Saving a downloaded document in a USB stick

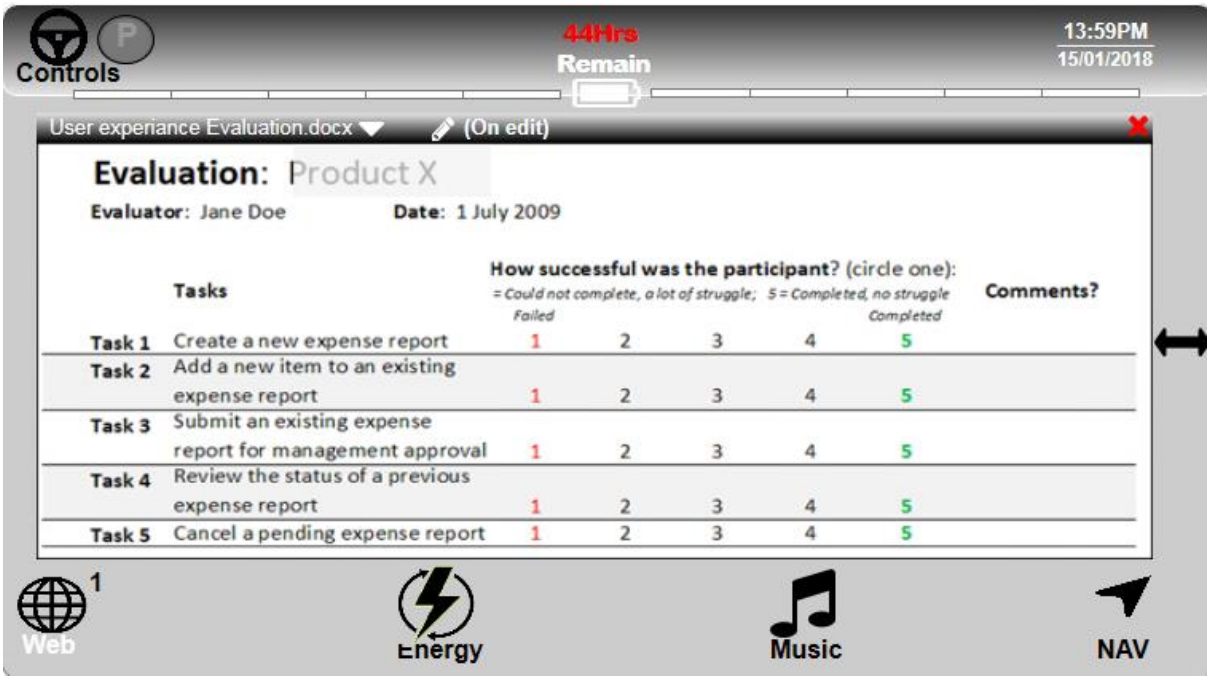


Figure 32: Editing a downloaded document

Email

Email is a sub-system which allows users to login using any type of account: yahoo, icloud, exchange, Google, Aol and outlook. Users can login with multiple account and manage emails of multiple accounts, see figures below:

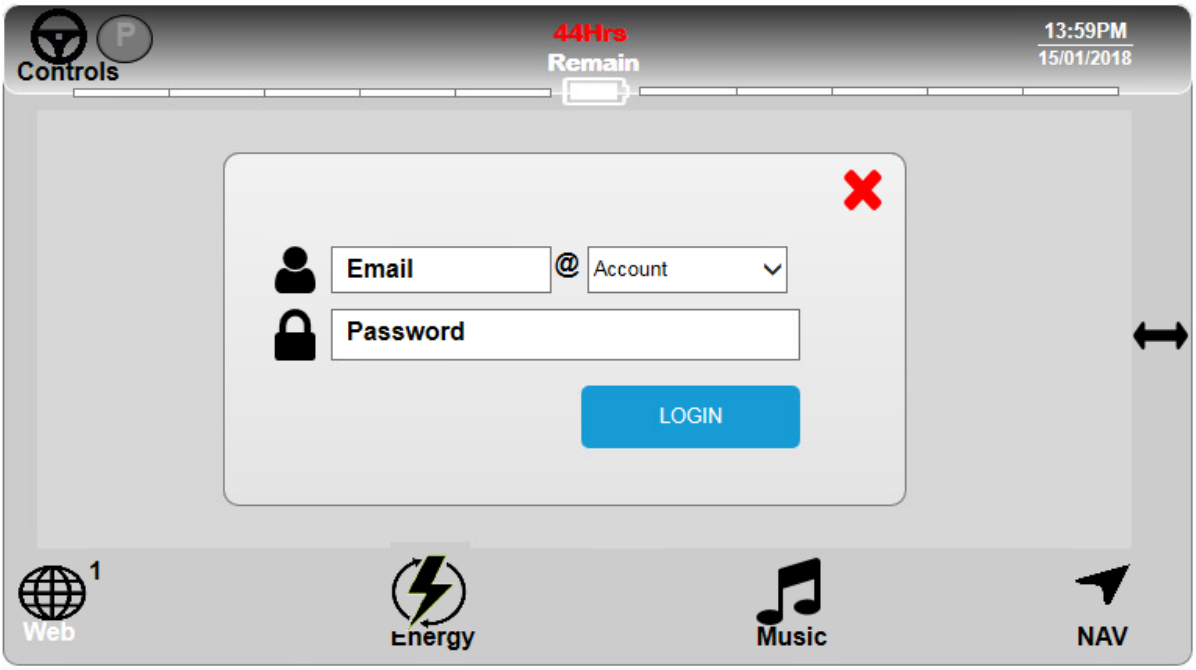


Figure 33: Login screen for Email

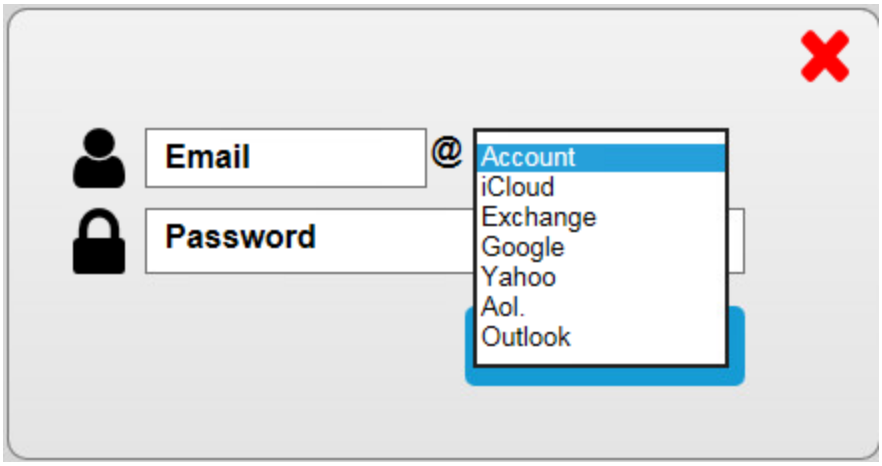


Figure 34: Login screen for email

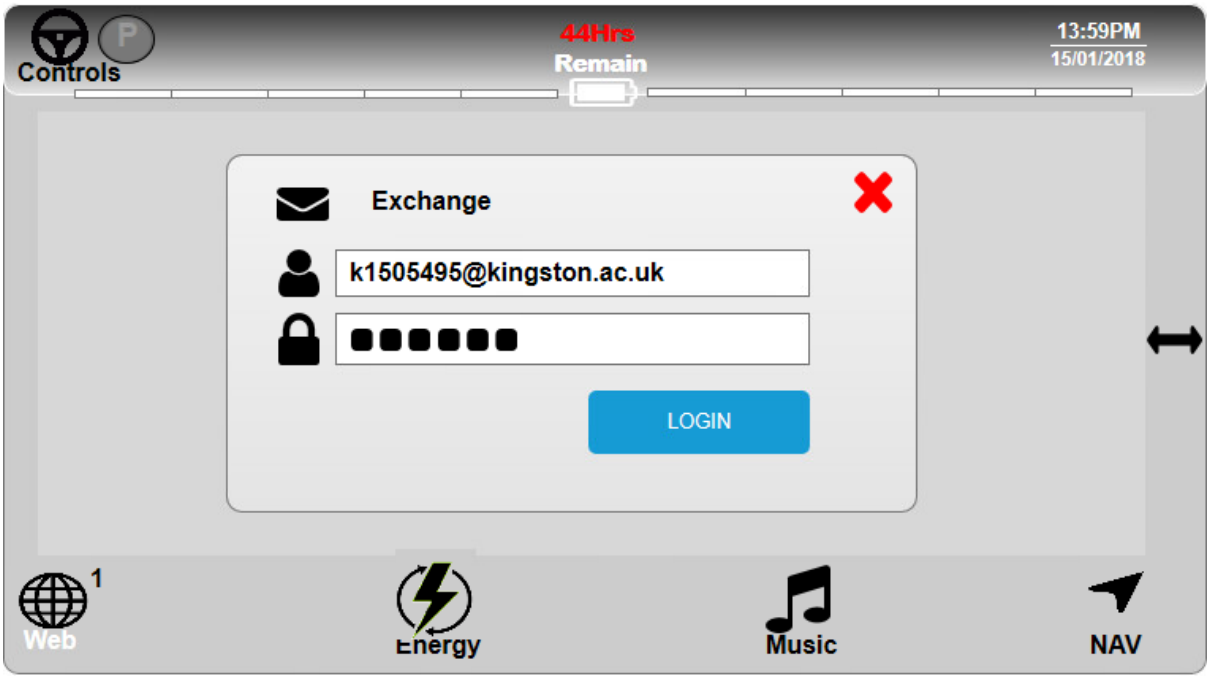


Figure 35: Login Screen for email

Figure 36: Layout of email page

The figure above illustrates the layout of email once users logs into their account

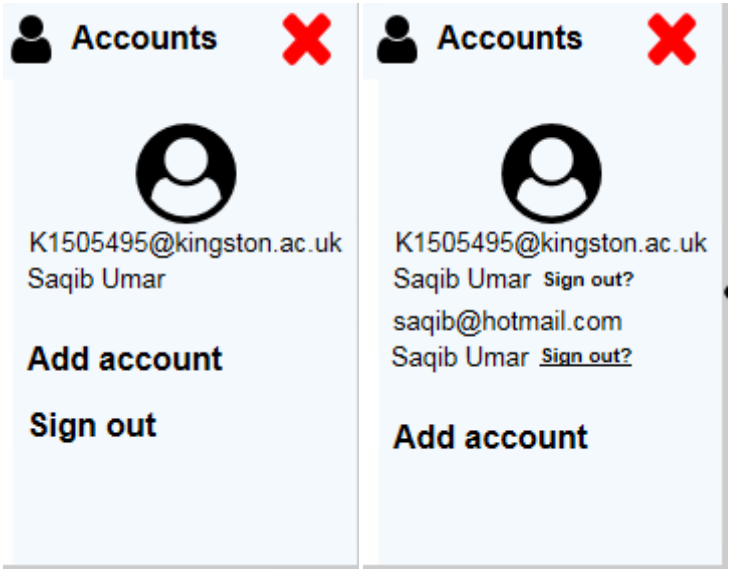


Figure 37: Multiple account log-in

The figure above demonstrates multiple account functionality of the email system

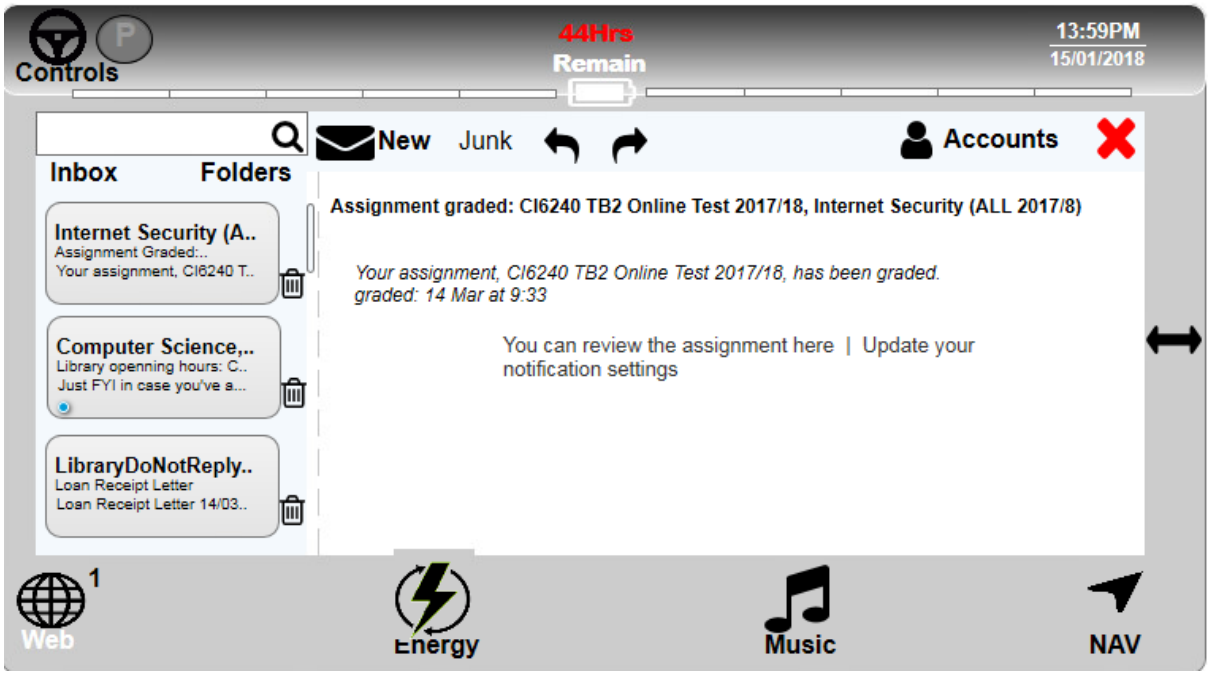


Figure 38: viewing email

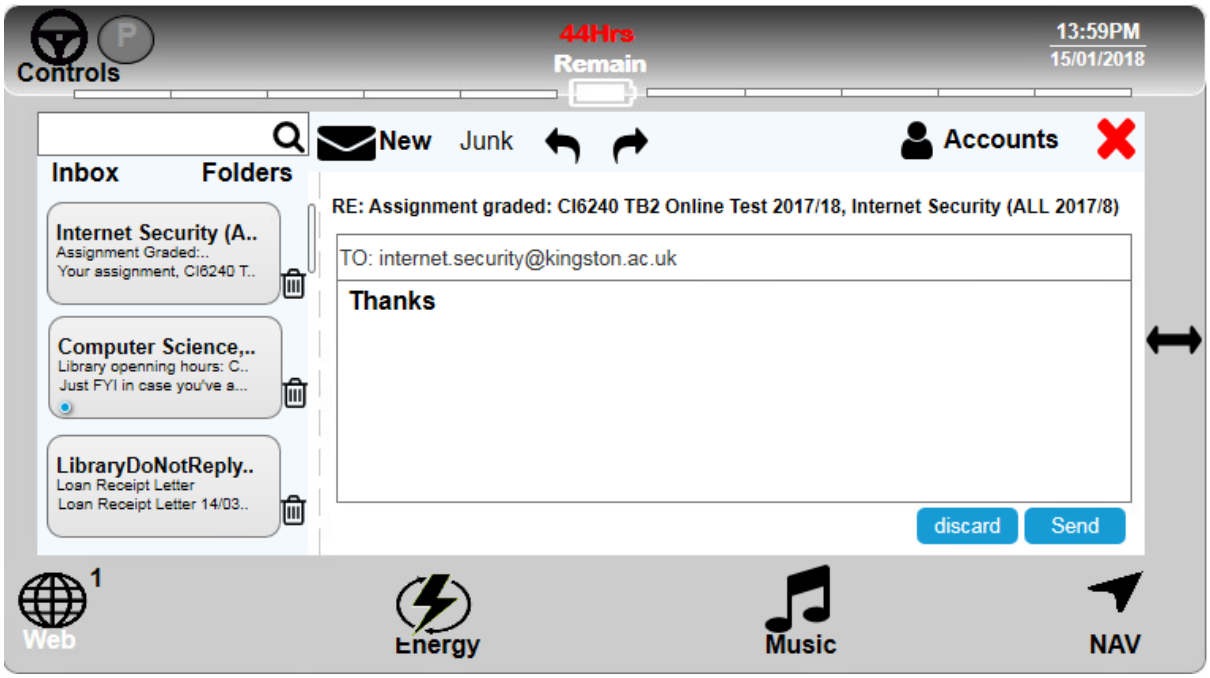


Figure 39: replying to emails

Energy

Energy consumption allows users to view the vehicle performance

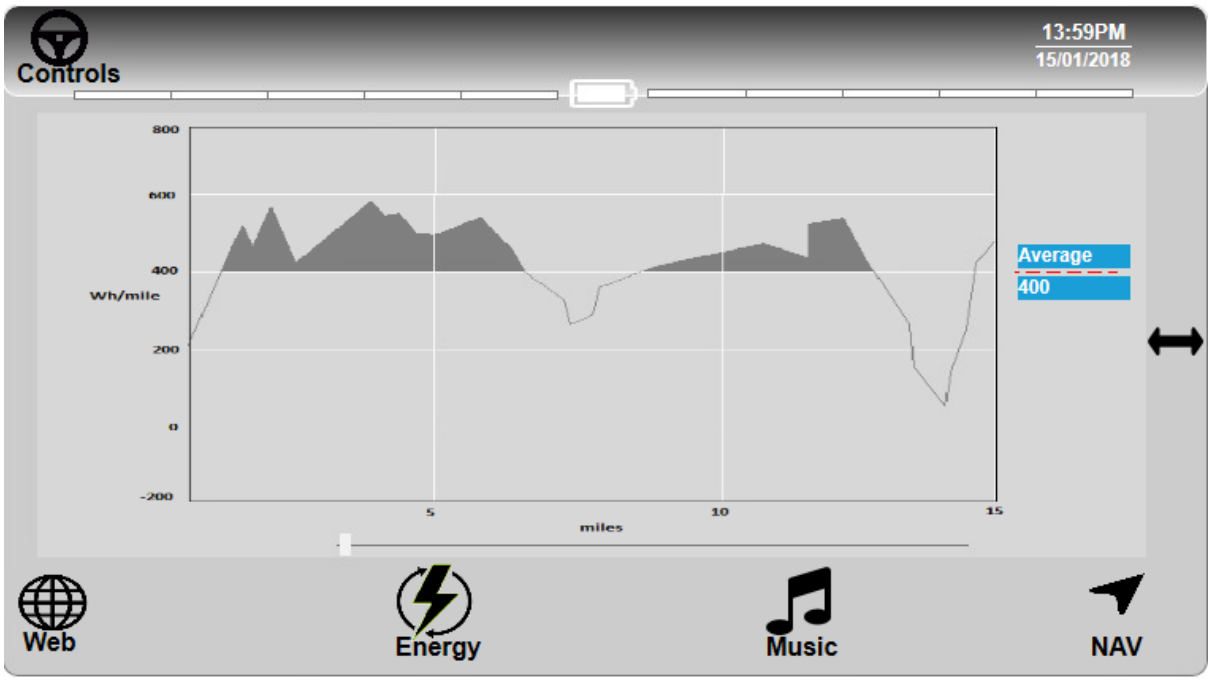


Figure 40: energy consumption between 0-15 miles

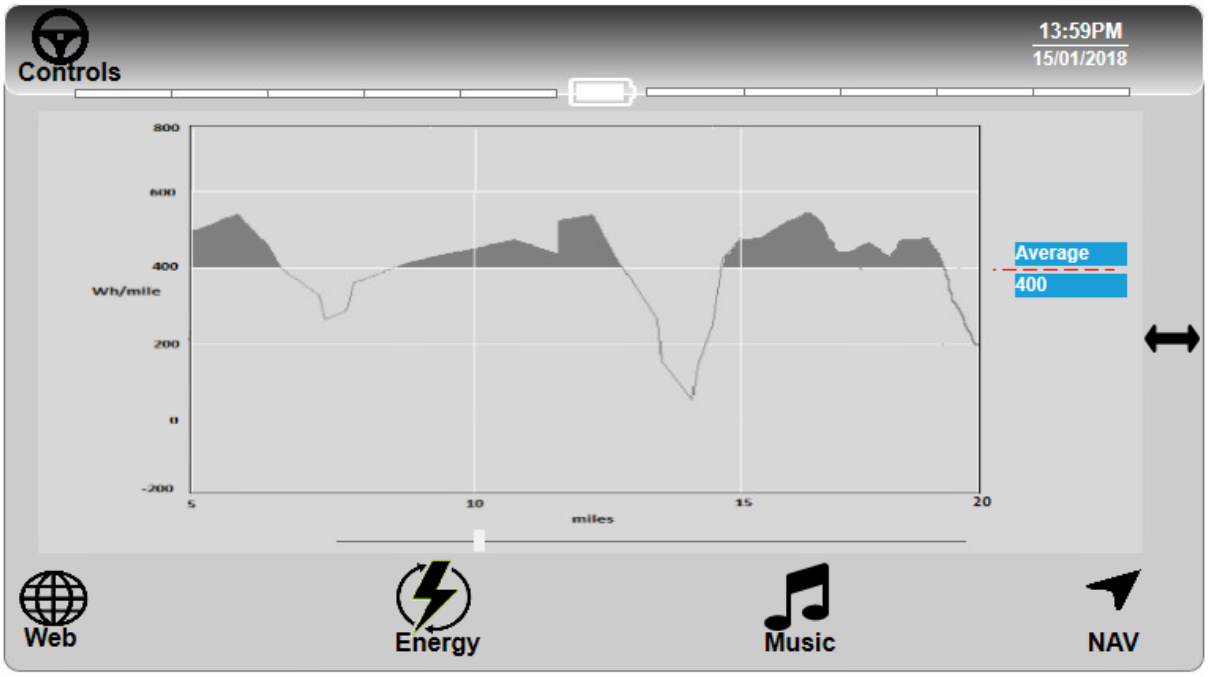


Figure 41: energy consumption between 5-20 miles

Music

Music system allows users to listen to the classic FM,AM radio stations, favourite a radio-station, search for a specific channel or listen to music on their device via Bluetooth, see figures below:

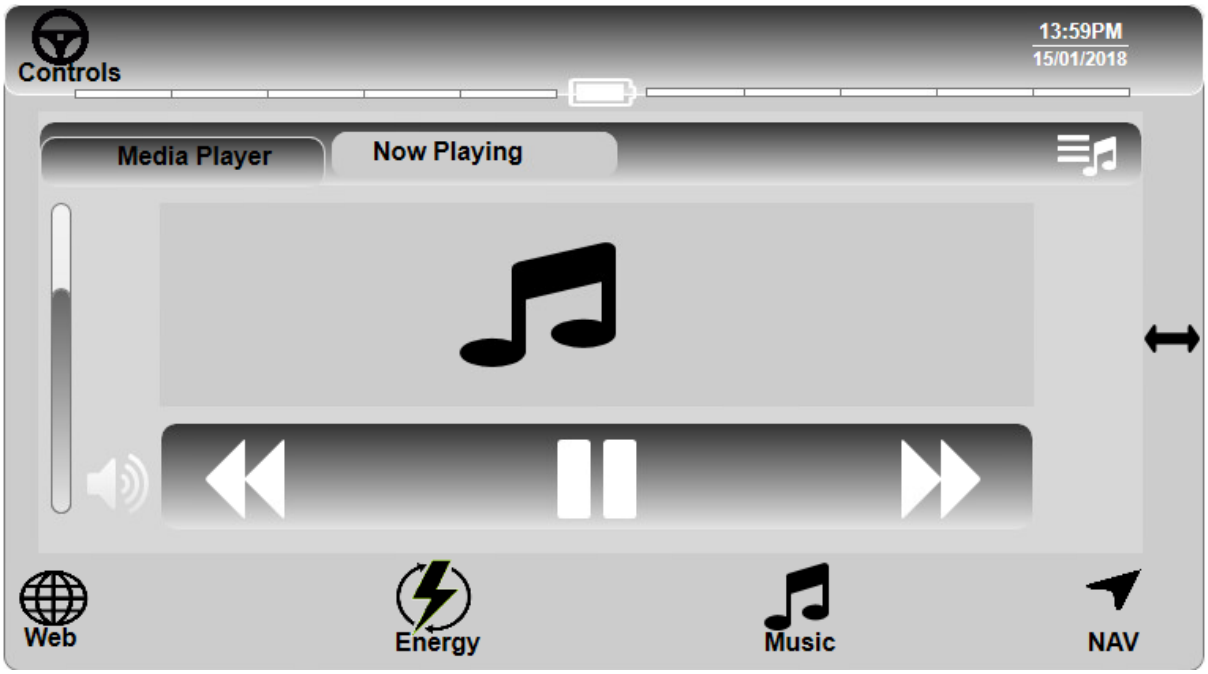


Figure 42: Default music page with no music or radio station active

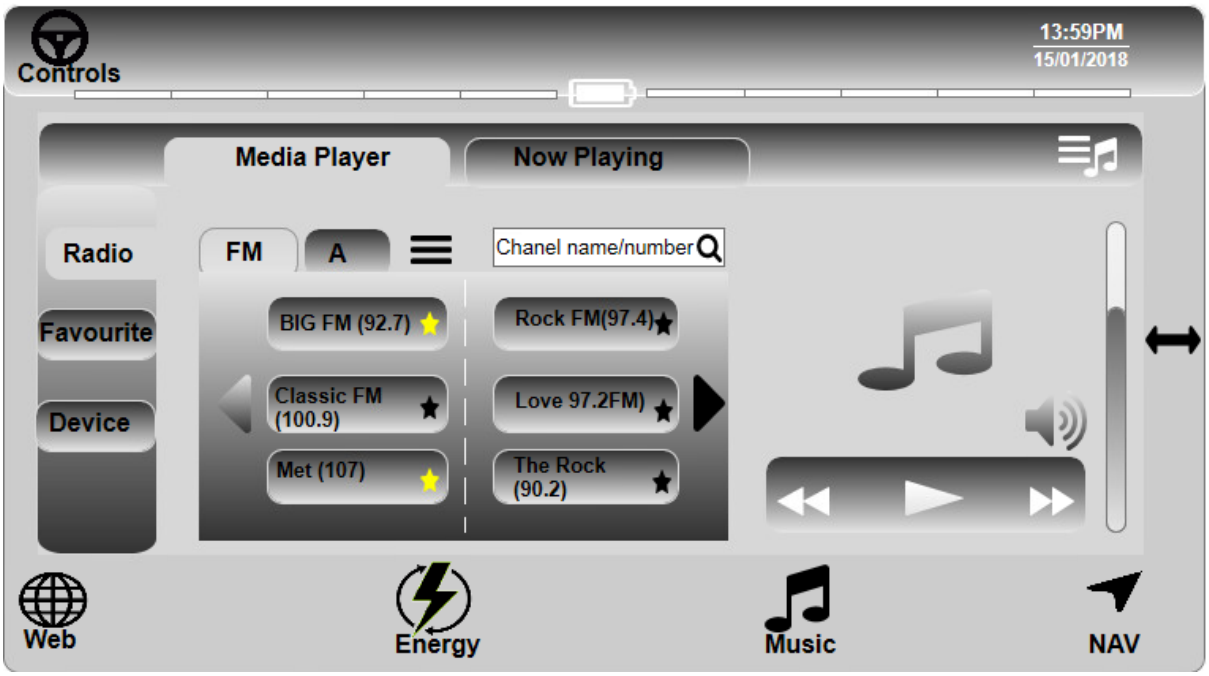


Figure 43: Radio channels in the music system

The figure above shows a search bar which allows users to search channels, FM and AM radio option and a category option, see figure below

Figure 44: Category for radio

The figure above shows categorised radio channels to organise radio station with its genre

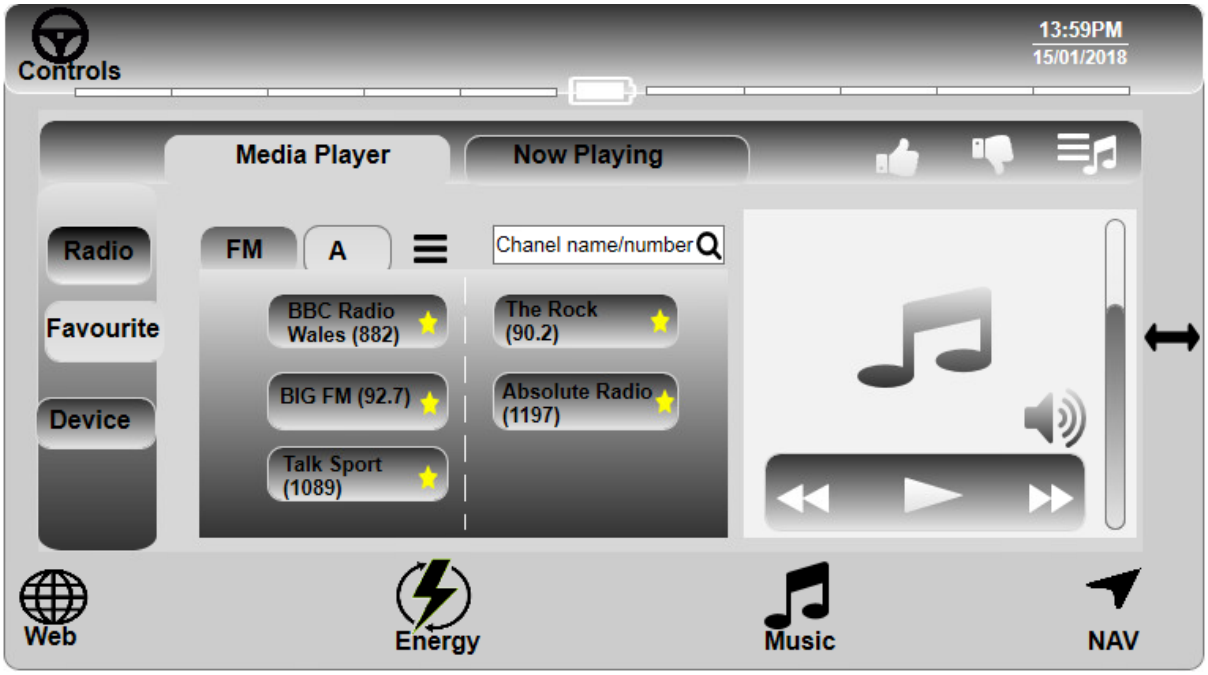


Figure 45 :List of favourite radio channels

Figure 46: Listening to music via device

See figure 62 for music and mobile phone interaction within the system

Navigation

Navigation system allows users to explore local and different areas, view map in a different way and for navigation, see figures below.

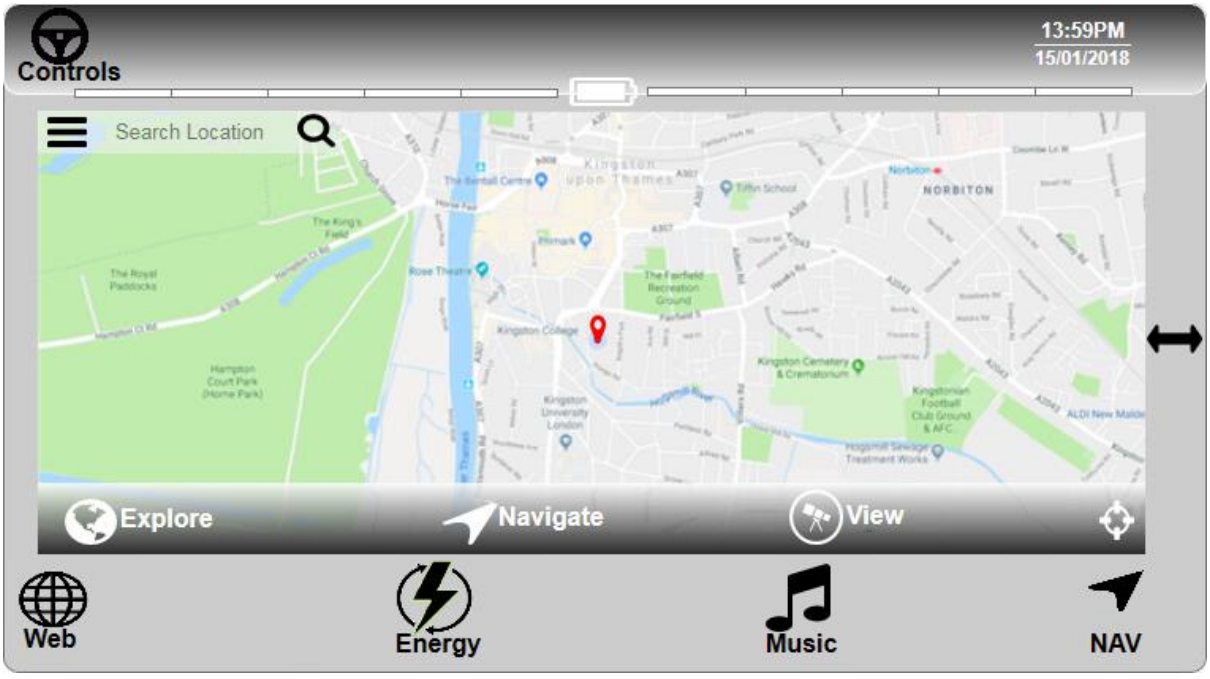


Figure 47: main screen for navigation

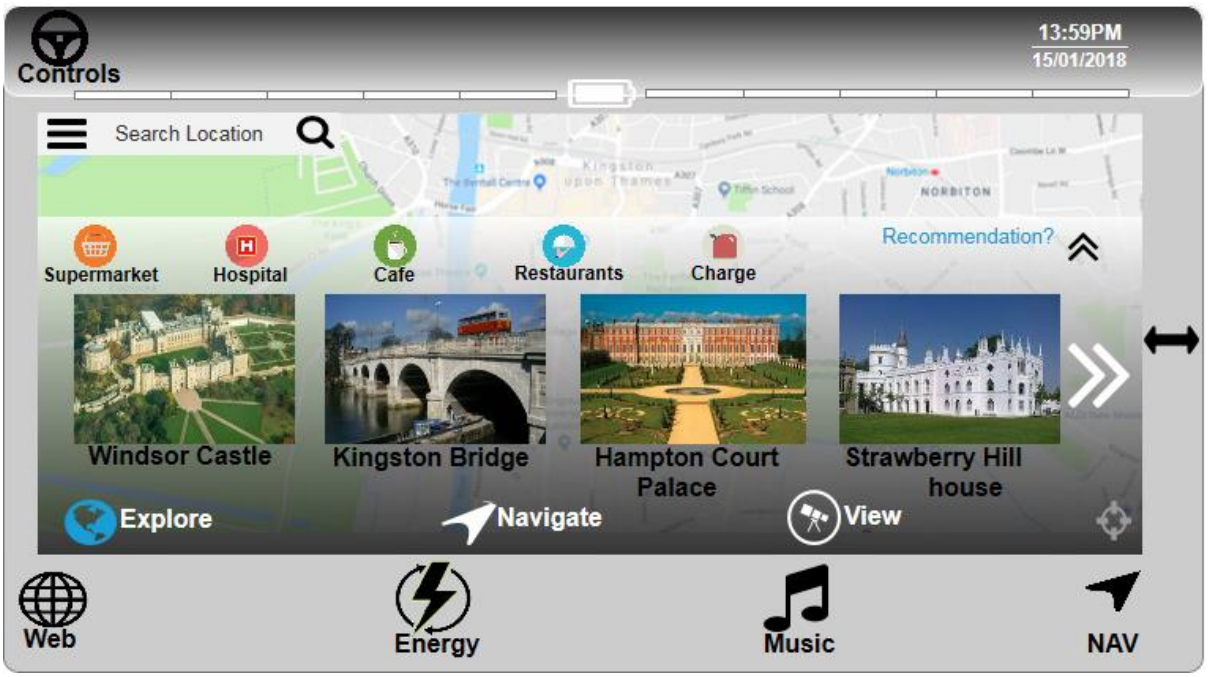


Figure 48: Exploring location

The figure above illustrates the options a user has which they can use to explore location

Figure 49: View options

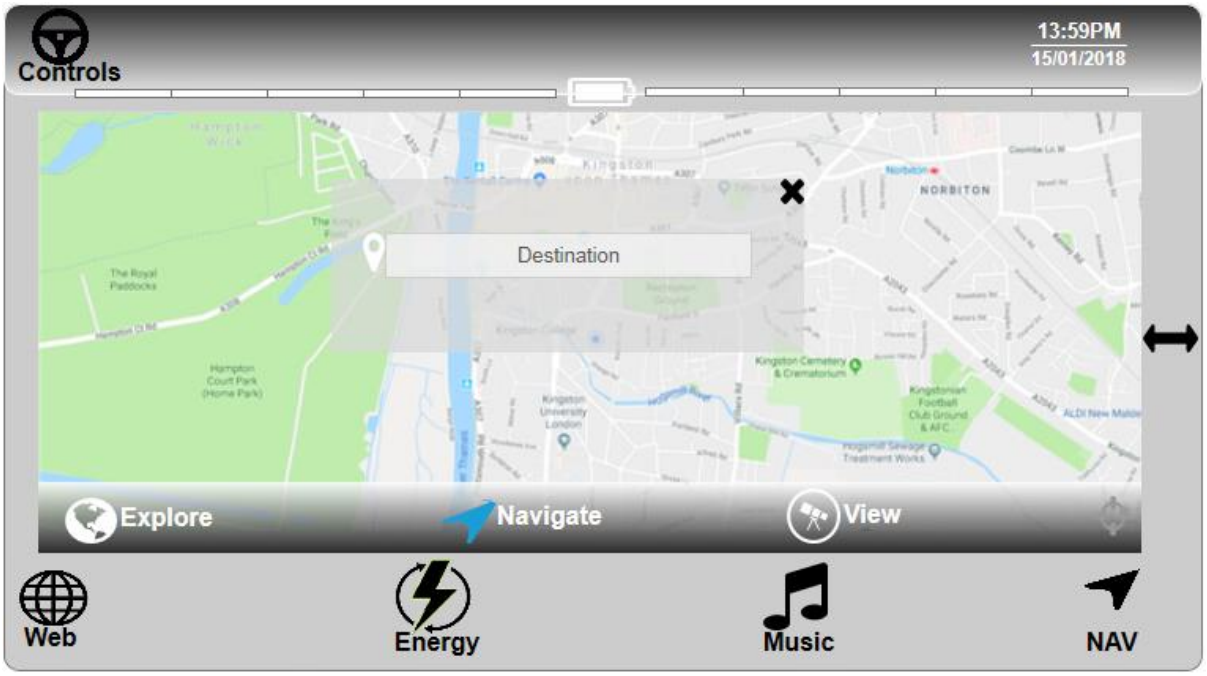


Figure 50: Navigating to destination

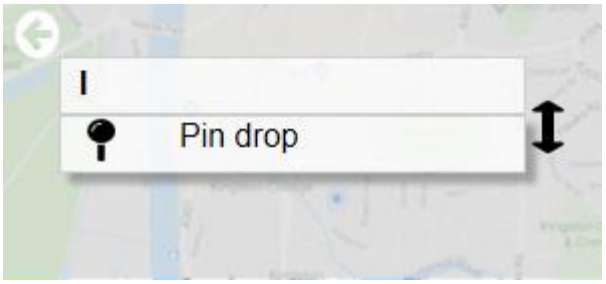


Figure 51: Navigating to a destination

The figure above illustrates two methodology of navigating, one of the method is a pin-drop method:

Figure 52: pin-drop navigation

This method allows user to drag and drop the pin anywhere on the map, this is intended for local navigation, which a users can simply drag and drop, confirm and start their journey.

Figure 53: Normal navigation search method

The figure above shows the second method which a user may use for navigation search, which requires a user to type the address manually

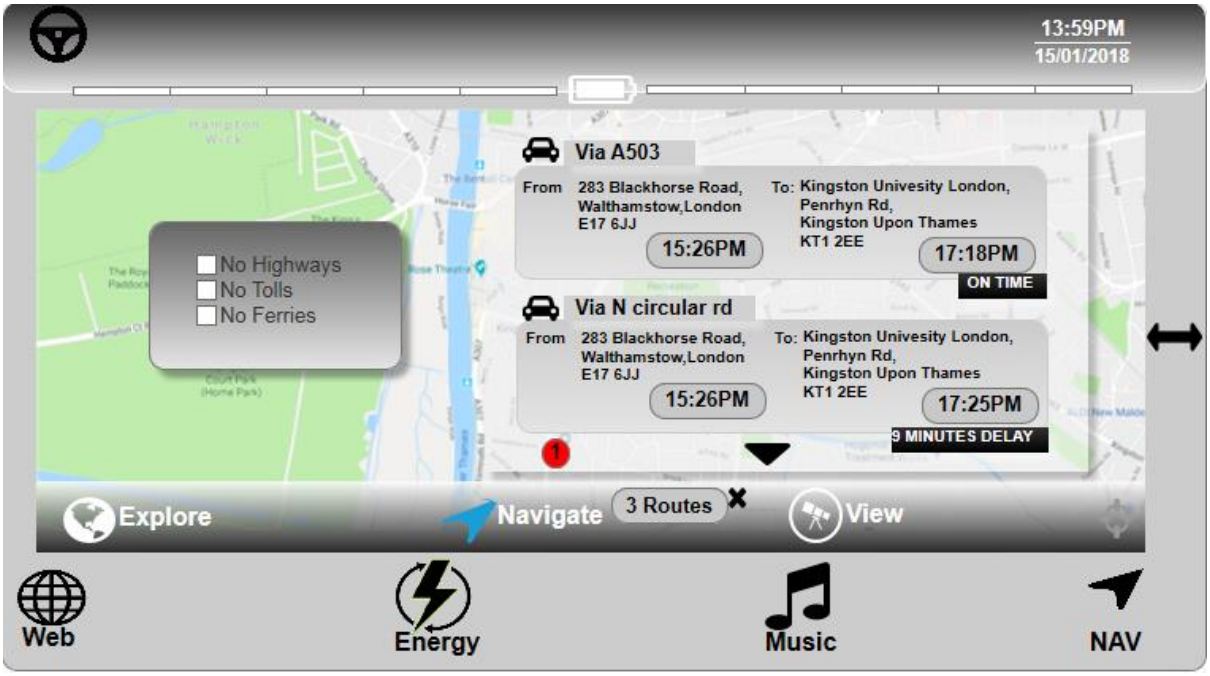


Figure 54: List of routes

The figure above illustrates list of routes which is obtained from real time traffic data

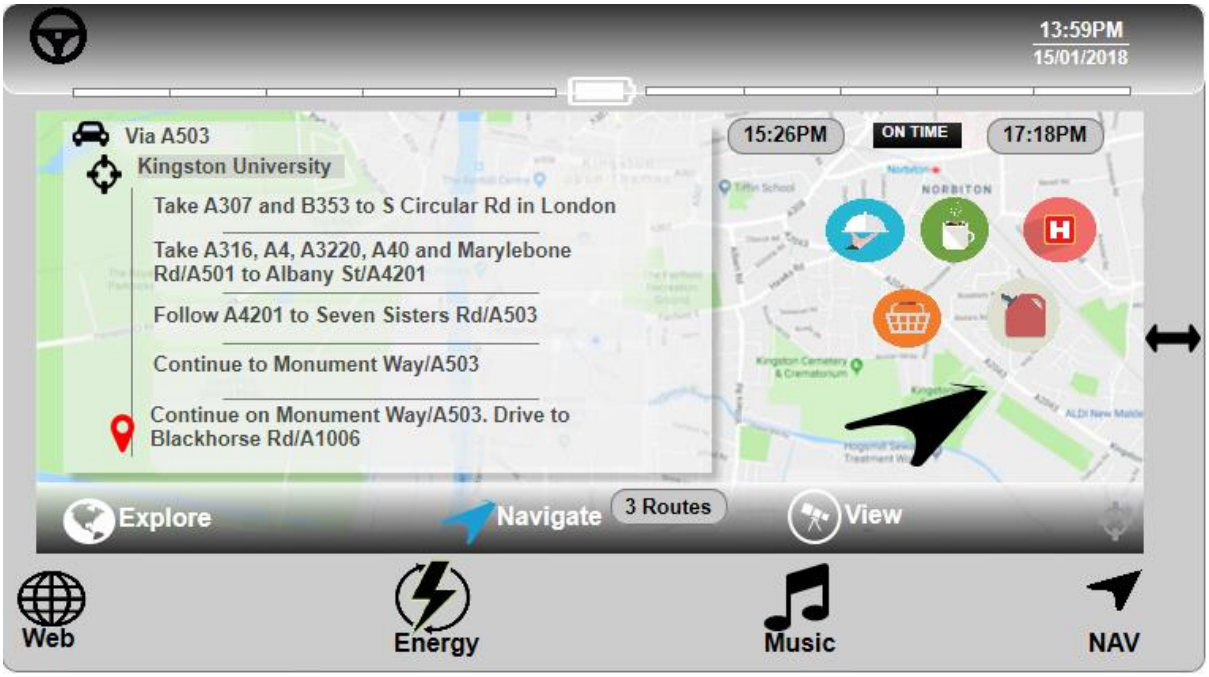


Figure 55: Navigation instruction

The figure above shows the navigation instruction for the journey which can be accessed any time of the journey. Beside the written instructions are additional options such as cafe and supermarket. These options can be added to the journey as a stop:

Figure 56: list of restaurants

The figure above shows list of restaurant which a user can choose from. The list will only show restaurants which will come on the way.

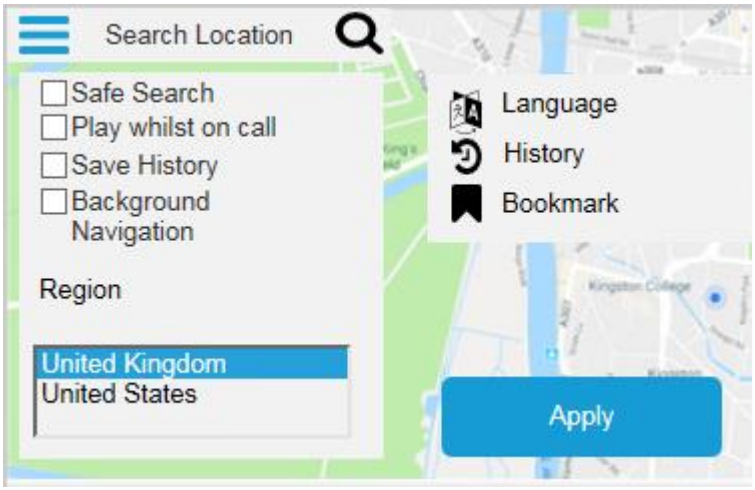


Figure 57: Navigation Setting

The figure above shows additional setting for users to make the journey more comfortable

Screen 2

Screen 2 contains drivers profile, Bluetooth, phone, and climate setting, see figures below:

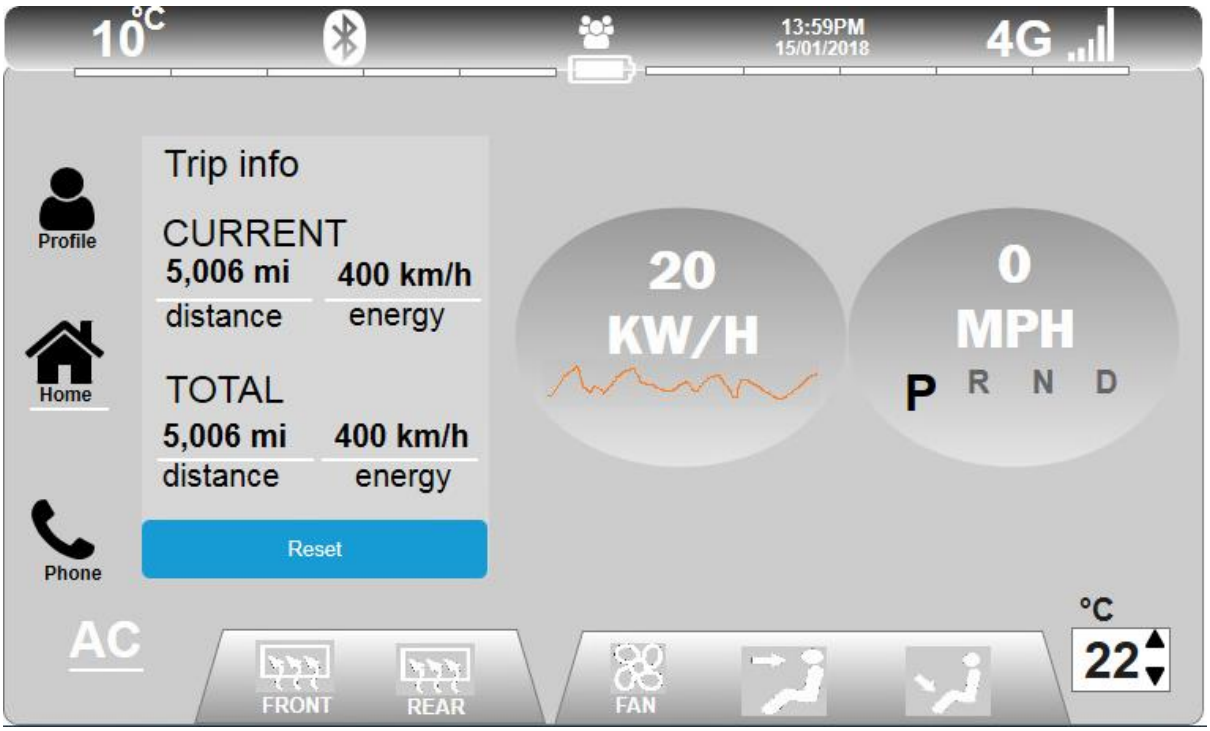


Figure 58: Screen 2 home page

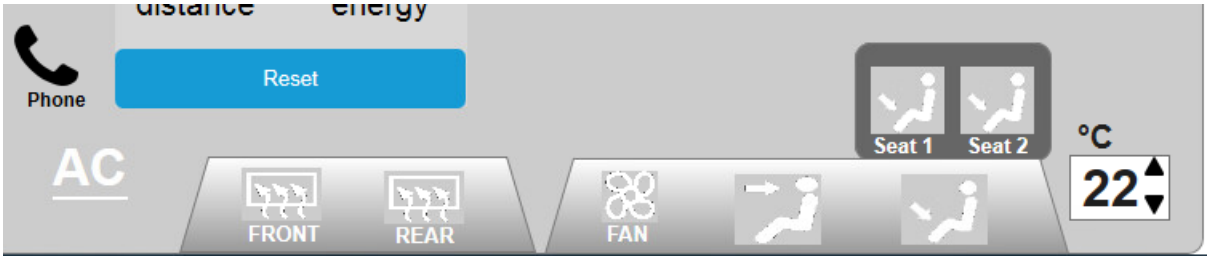


Figure 59: climate setting

The figure above shows climate panel which the user can use to make the journey more comfortable

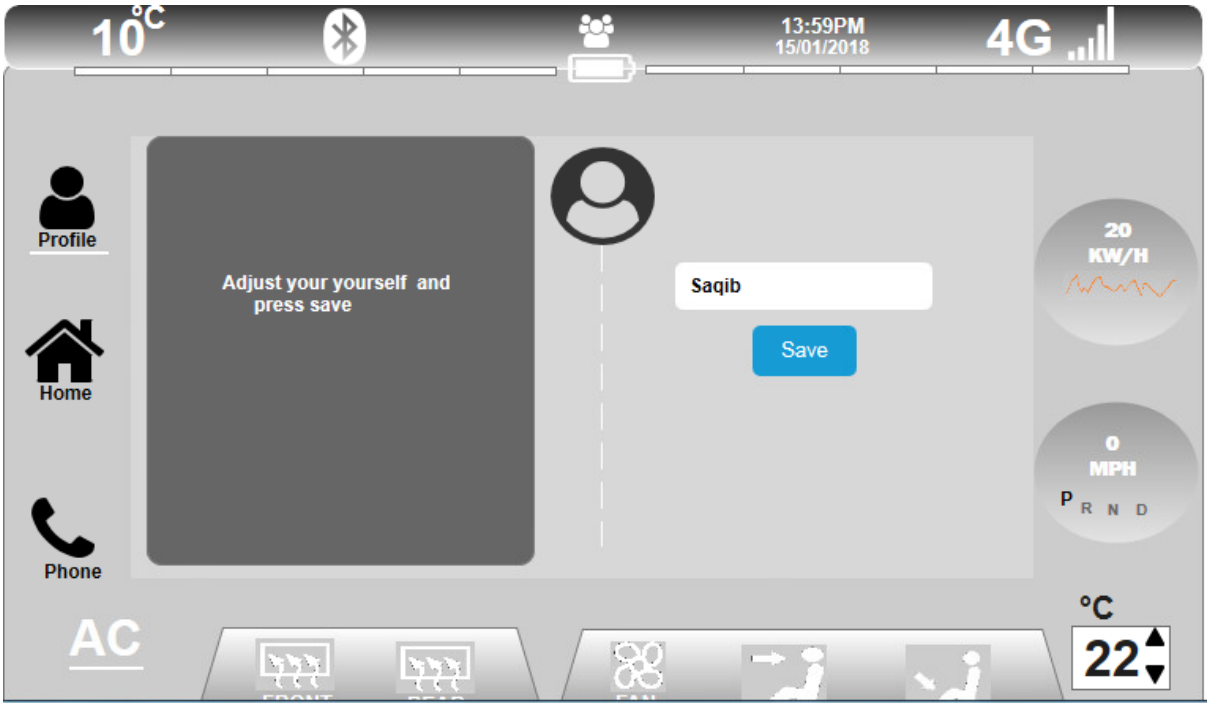


Figure 60: Driver's profile

The figure above shows how a drivers profile is created, this page is access via the 'profile' button on the left side of the screen. The grey box indicates that all the setting is being saved.

Figure 61: Bluetooth connectivity

The figure above shows a connected device (saqib). The contacts, Gallery, messages and music within the device can all be accessed

Figure 62: Music accessed from device (saqib)

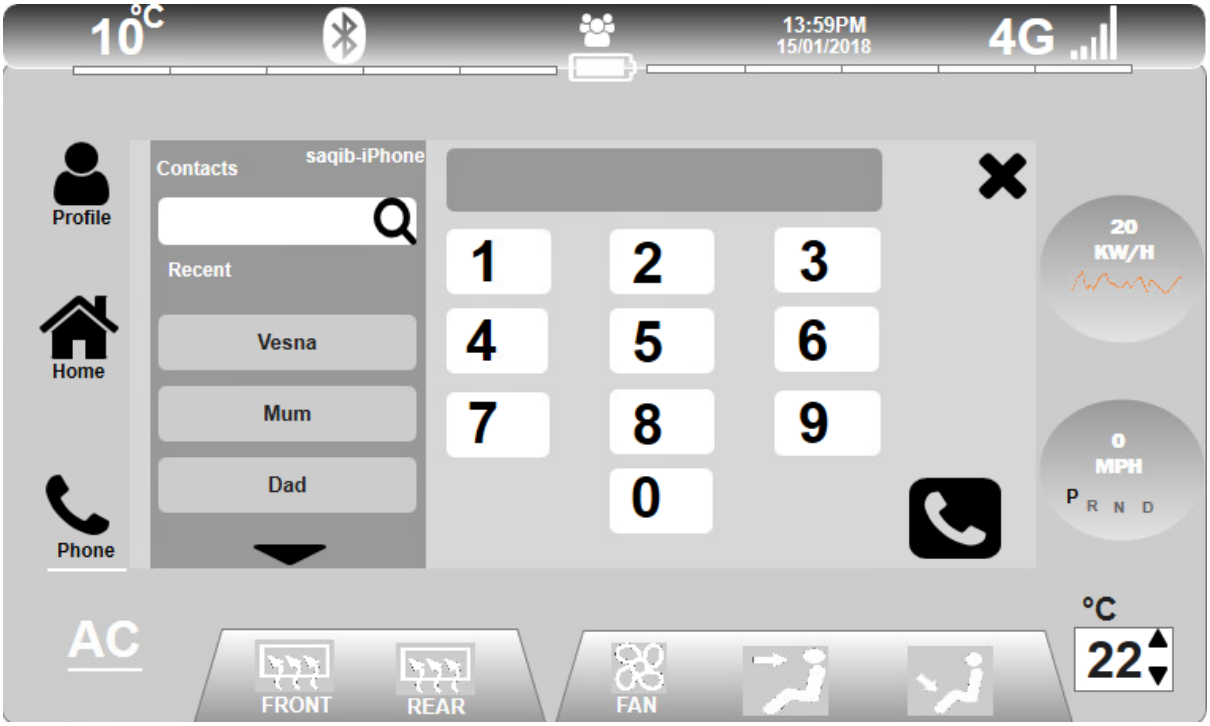


Figure 63: Phone directory

The figure above shows how the phone system uses contacts from ‘saqib’s iphone’, as all the contacts are accessible.

Chapter 6: Test and Results

This design project allows audience to visualise how the interactive prototype will behave as they interact with the system. Usability testing allows the product or service to be evaluated.

Process

In the usability testing, target audience chosen will vary, for example, it will consist of different age groups. In order to obtain fair results from usability testing, it is important to have a mixture of both males and females testing the prototype design. This usability testing will test specific elements of the system, for example the Bluetooth connectivity, navigation system, music system and Web.

TestID	Occupation	Age	Gender
1	Student	11	Male
2	retail	52	Male
3	Student	23	Male
4	Retail work	40	Female
5	Pharmacist	24	Female

Table 9- Participant information

The participants, upon request, accepted and participated in completing usability test. An online post-survey was carried out to gain quantitative data.

Testing

TestID	description	Results expected	Instruction	Result
1	Bluetooth device Search (Screen 2)	System searches for Bluetooth devices	Click on the Bluetooth icon, and click on the screen (device should appear)	Pass
2	Bluetooth connectivity (Screen 2)	Devices connected via Bluetooth, device's gallery, contacts, messages and music can be accessed	Click on Connect, Gallery, Music, Contact and messages should appear	Pass
3	Create User-profile (Screen 2)	User creates a user profile	Click on Profile, Click on Add, User can add their name, adjust their seat and climate setting and save	Pass
4	Multiple user-profiles (Screen 2)	User create more than one user profile	Add another User profile, using the same steps as before	Pass

5	User-profile swapping (Screen 2)	User can choose which user-profile to pick	On the top of the screen, click on the profile icon, User should be able to choose which profile to pick	Pass
6	Navigate using the pin-drop method (Screen 1)	User drags pin and drops it to the map to navigate	Click on navigation, Click on Navigate Click on destination Click on pin-drop (drag and drop pin to Norbiton station in this case)	Pass
7	Navigate using the keyboard (Screen 1)	User can manually type the address	Click on navigation, Click on Navigate Click on destination Click on the search bar	Pass
8	Explore a location (Screen 1)	User can explore different location: nearby hospitals, supermarket	Click on navigation, Click on the explore button (choose supermarket)	Pass
9	Choose a fast route to destination (Screen 1)	List of routes are displayed. Fast route at the top	Follow testid 7 Click on the search button List of routes will appear (choose first route)	Pass
10	Add a stop to the route (Screen 1)	User can add a supermarket to the route	Follow testid 9: Click on the restaurant icon	Pass
11	Browse web (Screen 1)	User can browse web, view history, bookmarks	Click on Web Browse Web	Pass
12	Open another tab and search Kingston university (Screen 1)	User can open another tab	Click on Web Browse Web Add tab 2 (Click on the google page to search)	Pass
13	Open email and log-in	User can login their email	Click on Web Click on email	Pass

	(Screen 1)	account	(Choose exchange for account type) Login	
14	Email someone (Screen 1)	User can email someone	Follow TestID 13: Click on “internet security “email Click on reply icon	Pass
15	View downloads (Screen 1)	User can view list of downloads	Click on Web Click on downloads	Pass
16	Open and edit download document (Screen 1)	User can open and edit documents, can add and delete words and save	Click on Web Click on downloads Click on the arrow next to “Usability experience evaluation.docx”	Pass

Table 10- usability testing

Results

An online survey was created using monkey survey.

1. What is your age?
2. What is your gender?
3. From 1 to 5, how attractive was the colour scheme of the dashboard design (5 being very attractive)
4. Do you think the colours were dull? Yes or no
5. From 1 to 5, how attractive was the layout of the screens (5 being very attractive)
6. From 1 to 5, were the icons used, meaningful?(5 being very meaningful)
7. From 1 to 5, how easily could you navigate through the system (5 being very easy)
8. From 1 to 5, how pleased were you with the amount of feedback received for each functionality(5 being very pleased)
9. From 1 to 5, how useful was the information display (5 being very Attractive)
10. Would you purchase a driverless vehicle with this infotainment system? Yes or No

See Appendix for results (“Feedback”)

Chapter 7: Critical Review & Conclusion

Unsolved problems

Axure is a prototyping tool, which allows a designer to produce high fidelity prototype, which consists of static wireframes where most of buttons are clickable. The content, colours and layout allows users to visualise how the final system will look like. Axure gives an insight on the functionalities this system consist of, where for example, if the user creates a driver's profile they are taken to another page, which allows them to add user. There are still limitations in regards to allowing the user to experience a fully functional system, where when they add the user they should be able to type their own name, and make real changes to the climate setting and seating position.

Users could visualise the final design, because of the structure, layout, colour and content used in the system. However, this project would be more effective if there are real algorithms and coding used to illustrate what the system really offers. For example, obtaining real live traffic information when a user is using the navigation system is better than a static map.

Proposed Solution and attempt

The prototype created can only offer limited functionality for the user. However, in this project, attempt to illustrate the functionality of the system has been made using series of videos. The aim of the series of videos is to illustrate how user will use the system and how the functionality of the system will benefit the user. The attempt is effective as the video illustrates, for example, if David decided to create a user profile, he will save the user profile with his name. In the original prototype, when a user profile is created, it can only create a user profile with the name "saqib". The video illustrates the dynamic and flexibility of the system.

Furthermore, in order to make this system more functional, the prototype have to be more dynamic, this can be achieved by creating more scenario however, this solution is still not effective because prototype design does not consist of backhand development.

Achievement

I was first exposed to prototyping and wire framing in my first year of university. At that time, I was given a group project where we had to design a prototype for an airport application. We used Microsoft PowerPoint presentation to design the prototype. One of my achievements for this project is the improvement in researching and designing. In this project, I learnt how to compare similar system, according to trend and fashion choose, and pick layout, colour and information for such system.

I also created a Lynda account (Lynda.com). Lynda is an online education platform, which offers video courses taught by industry experts [63]. I revisited topic such as ideation,

wireframming and tutorials on how to use different prototype tools such as Photoshop, Axure, and Invision. During this period, my knowledge in this field has expanded, I have a portfolio of work within the field and I have gained confidence in designing and prototyping.

As I chose a design project, which required prototyping and video editing, I chose ‘user experience' as one of my module. Due the lectures and coursework from user experience module, I have realised that utilisation of models can even make projects with high complexity easy. I have gained confidence, and with a year or more experience in prototyping and designing, I can now advance in this field by producing prototypes that require advance features such as animation. I can use tools such as Flinto and principle to improve my domain of knowledge and tools.

Comparison

In this comparison section, the design of Tesla will be compared to the design of the driverless car of this project. The dashboard design chosen for this project is unique:

Figure 64: Dashboard design of Tesla

Figure 65: Dashboard design for this project

The design chosen for this project, see the figure above, illustrates a complete elimination of the steering wheel. There is no steering wheel used because it is a fully autonomous vehicle. However, Tesla have a steering wheel as the driver has the option to drive and option to turn on the autopilot functionality. The chosen design for this project was motivated by devices such as computers and

laptops. The idea that the use can only enter the input from keyboard is inherited as the same principle is applied; user can only enter input from the small screen:

Figure 66: Screen 2

This methodology of input is different from how Tesla chose it, where Tesla inherit the new modernised method of entering input, which is from the same screen the information is displayed. The reason why this methodology of entering input was chosen for this design was because it is close to the passengers, which means less movement and effort is needed.

Two screen are used in this designed to keep all the features organised, the design focuses on the idea that each screen has its own purpose. Screen two is designed for the in-car information system which contains all the trip information, device information, phone, driver's profile, climate setting and. Whereas the other screen consist of features that focuses on the entertainment features such as Web and music.

The biggest change that can be seen between the two designs is the layout of the screen. The chosen layout for this project is centralised. This design decision was made to eliminate the idea of driver and passenger, and it encourages everyone in the vehicle to utilise the system. However, for Tesla, the concept of driver and passengers is still there, and this will give the driver the dominance position in the car, discourage the passengers from using the features and technologies that Tesla is offering.

Future work

If this project is taken further, there should be more focus on user-system interaction. One way of improving such interaction is by implementing technologies such as 'Google home' or 'Alexa' from Amazon; such implementation can cause the system to be more interactive as user will be communicating with the system more often.

Another functionality that should be added is the connectivity of devices such as laptop to the dashboard screen, where the user can utilise the screen in front for their work. The aim of such implementation is to interact with the dashboard rather than devices such as mobile phone and laptop.

Adding features such as embedded web-cam onto the dashboard screen would also be an idea considered; this will be useful for businessman who can do conference meeting as they travel from point A to point B. This will also be good for those who like to talk to their family abroad. The dashboard does not contain application such as Whatsapp, Skype or Facebook. One way of improving the in-car information system in future could be by adding such applications.

Conclusion

In the procedure of designing, modelling, and documenting, I understood the importance of modelling and how modelling could improve ideas and give an insight of what the design should consist of. The designed prototype, allows users to browse Web as they view their email, download, and edit downloaded documents. Users can also navigate to their destination while explore the nearby hospital, restaurants and supermarket. Users can connect their device via Bluetooth while having access to all their media file, music, contacts and message with having to go on their phone.

This project has taught me how to research properly, considering how big and new the topic is to the vehicle industry. I have gained experience and wealth of knowledge, and a project to put in my portfolio of work and it can be a career path, which I may consider.

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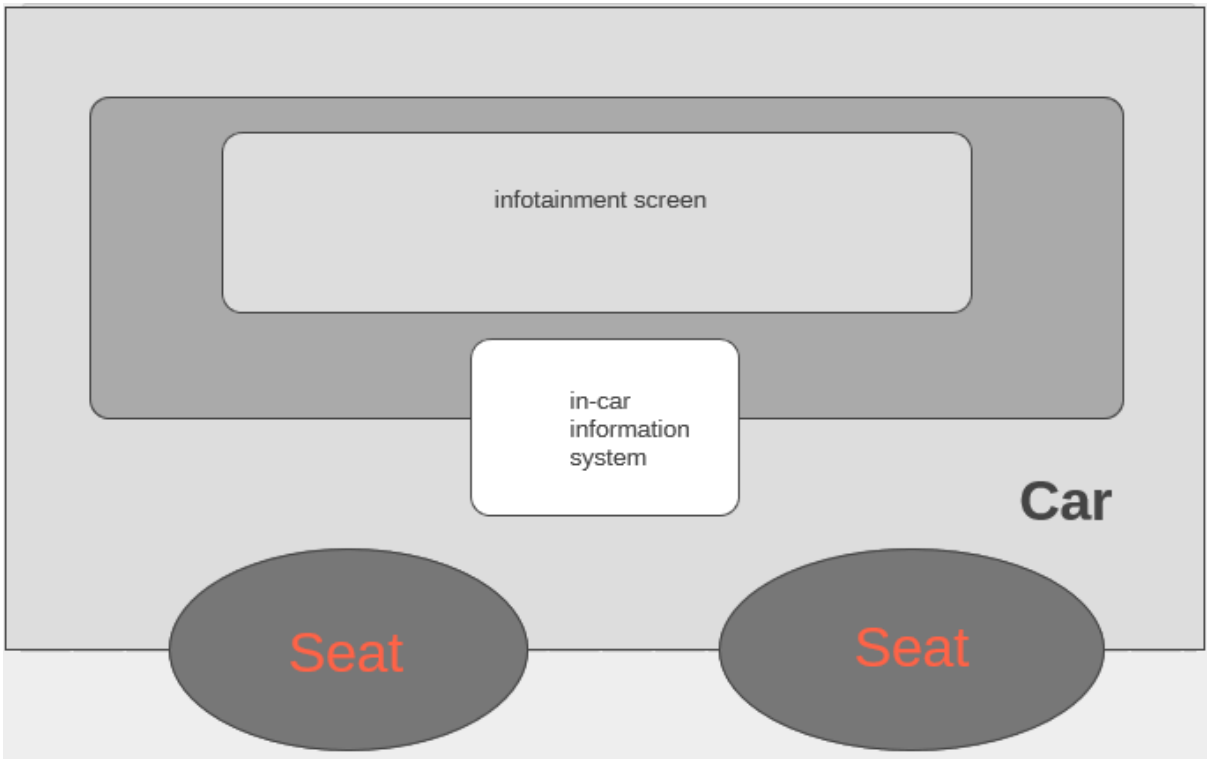
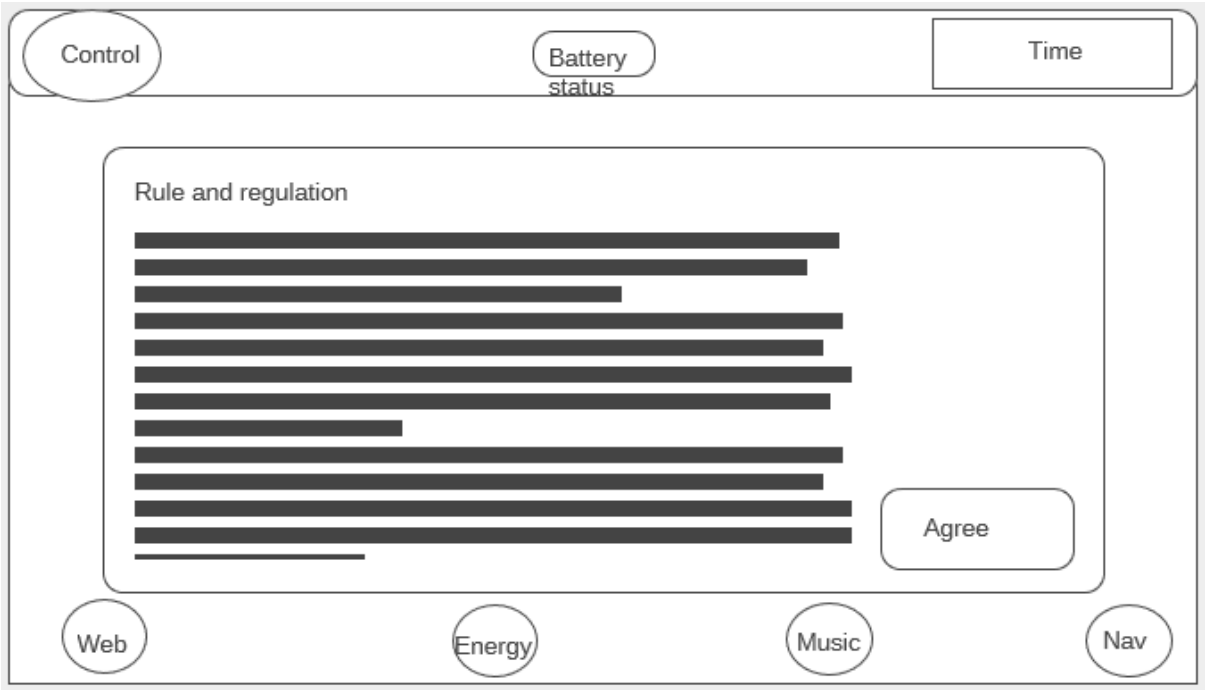
Appendix

Wireframes

Dashboard overview

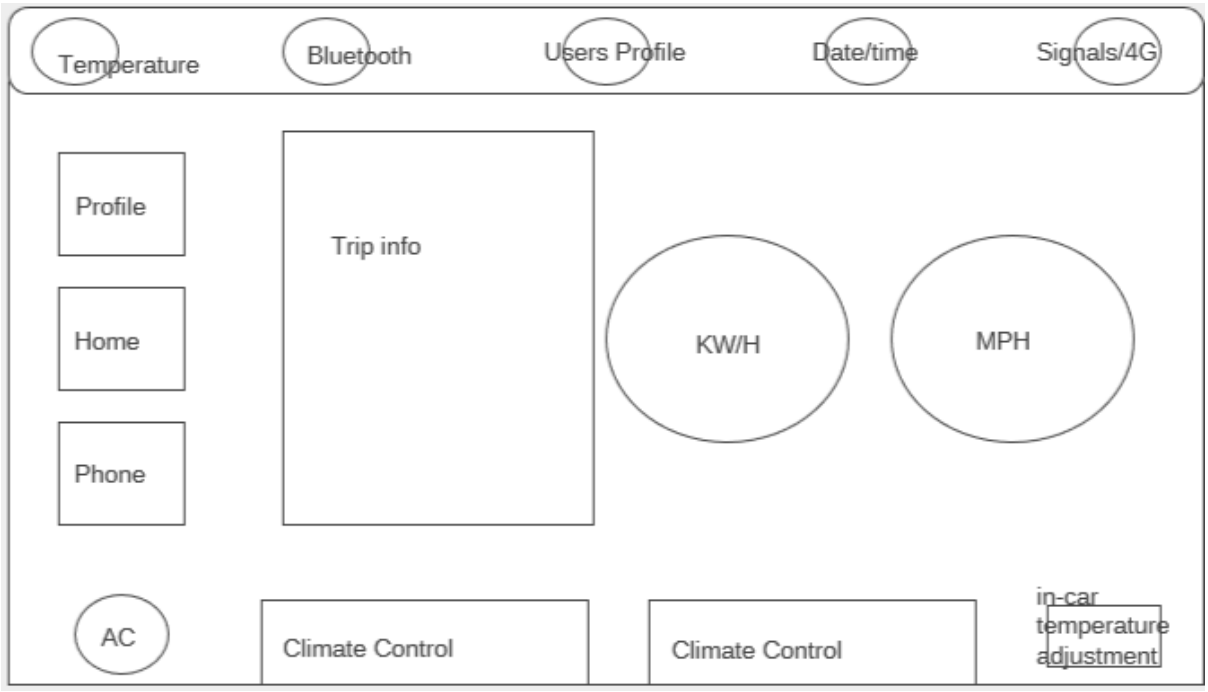


Screen one (infotainment system)

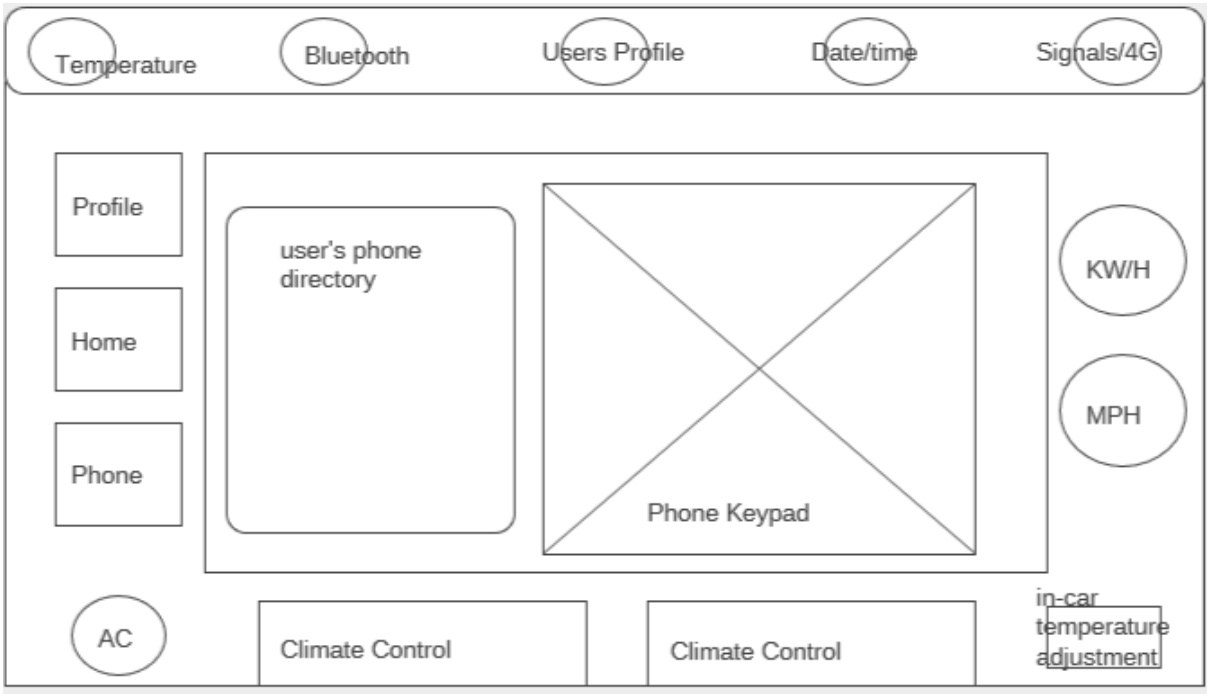


landing page of screen one (infotainment system)

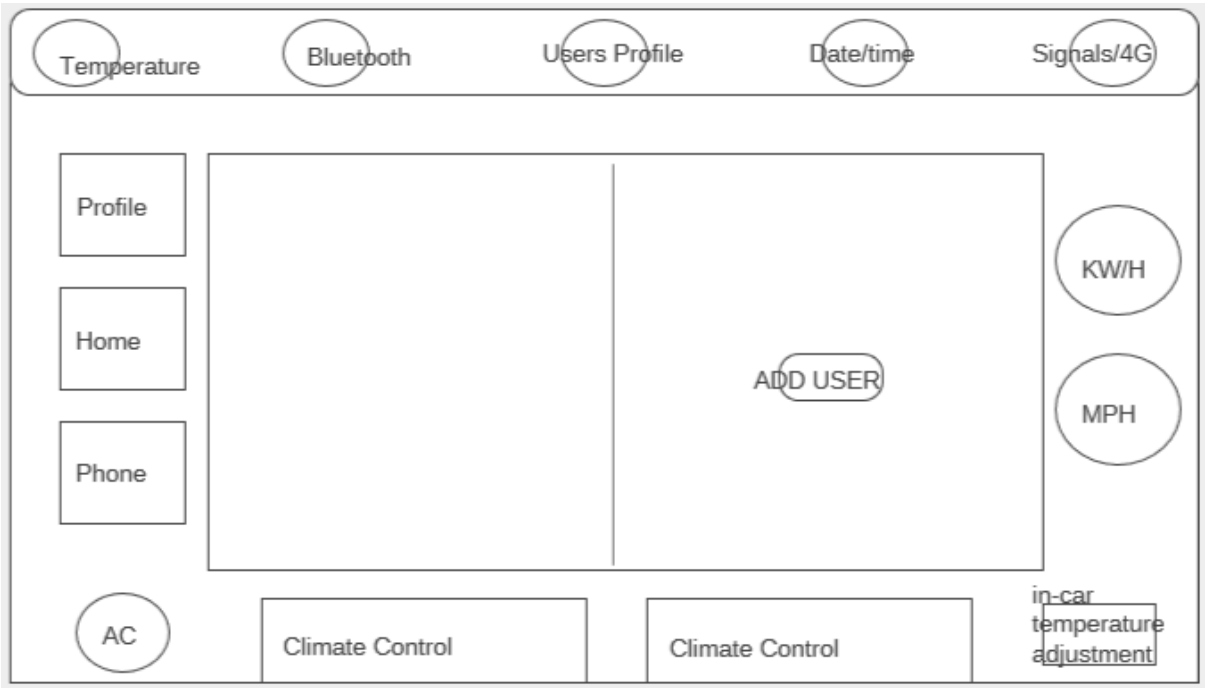
Screen two(in-car information system)

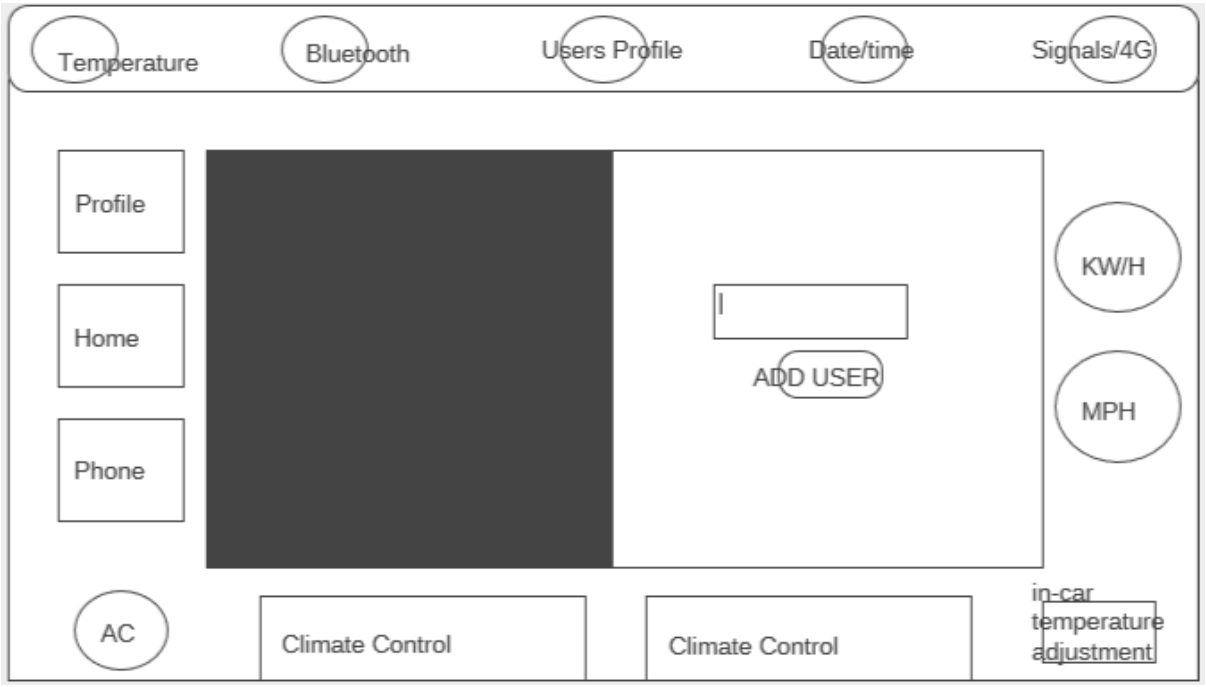


Screen 2- Phone



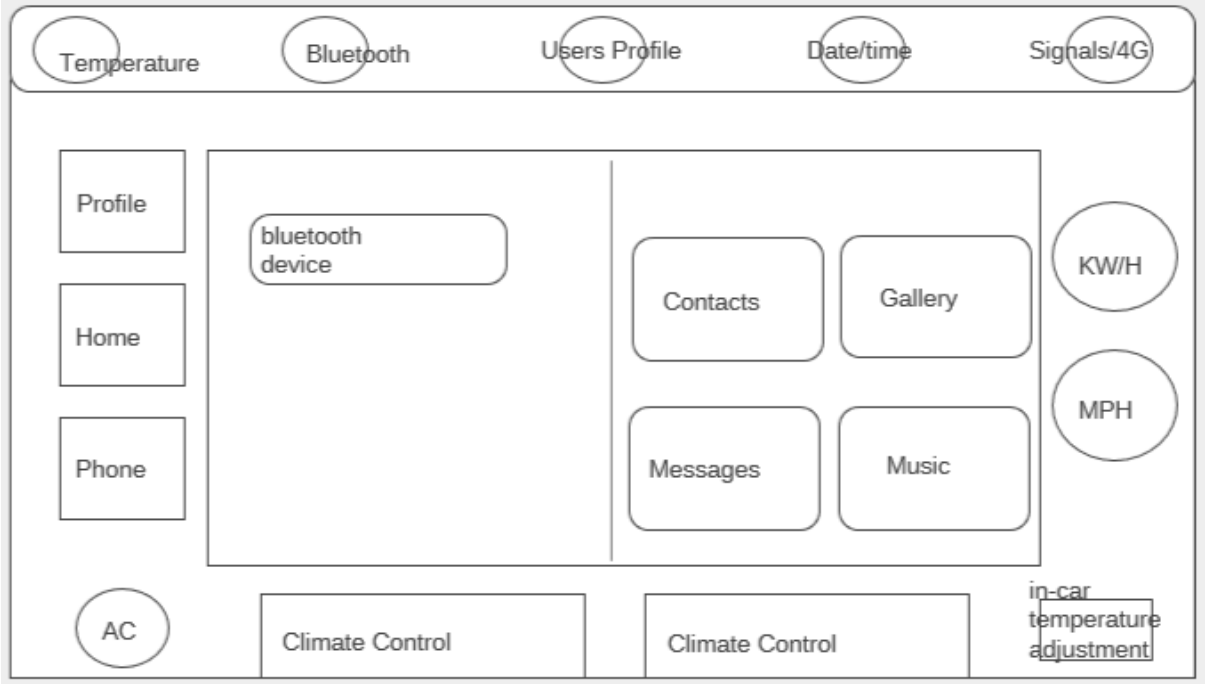
Screen 2: User Profile



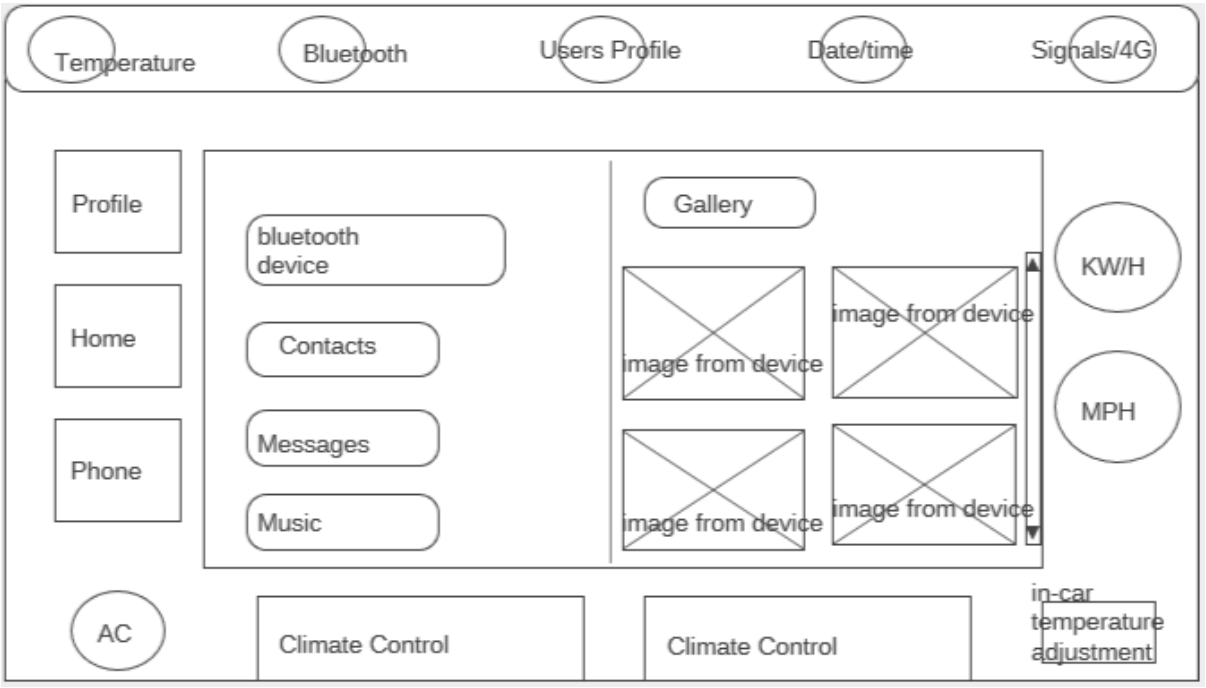


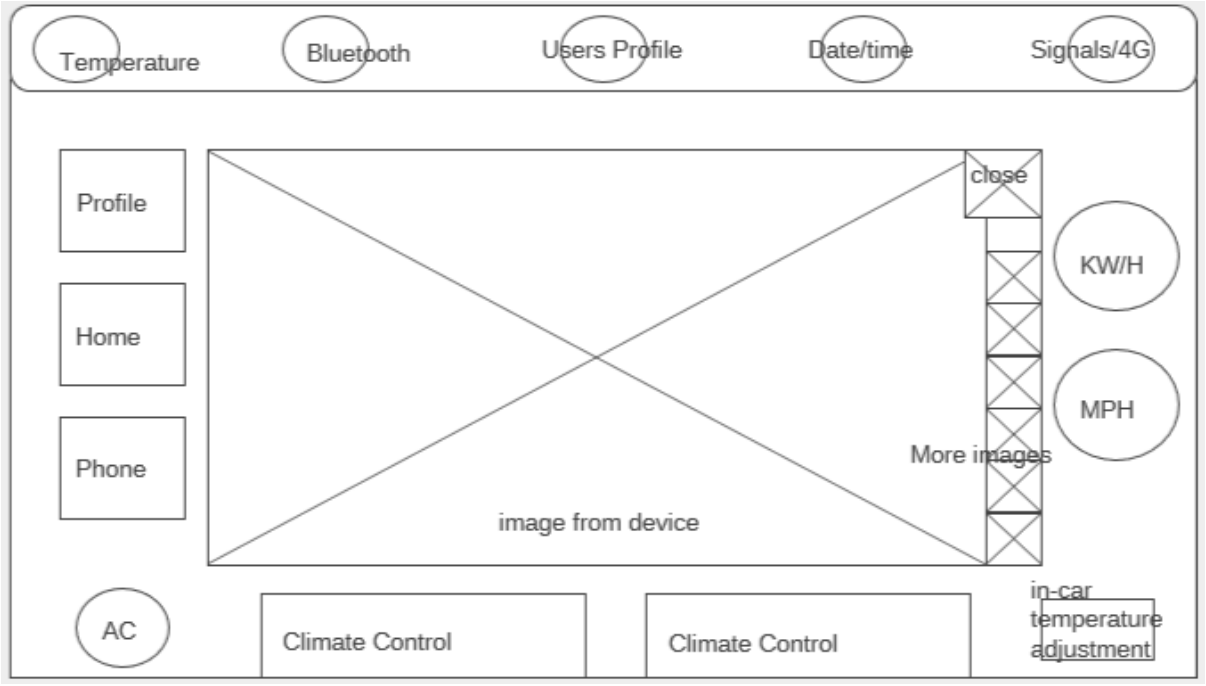
Black screen indicates that the system is recording all the changes

Screen 2- Bluetooth

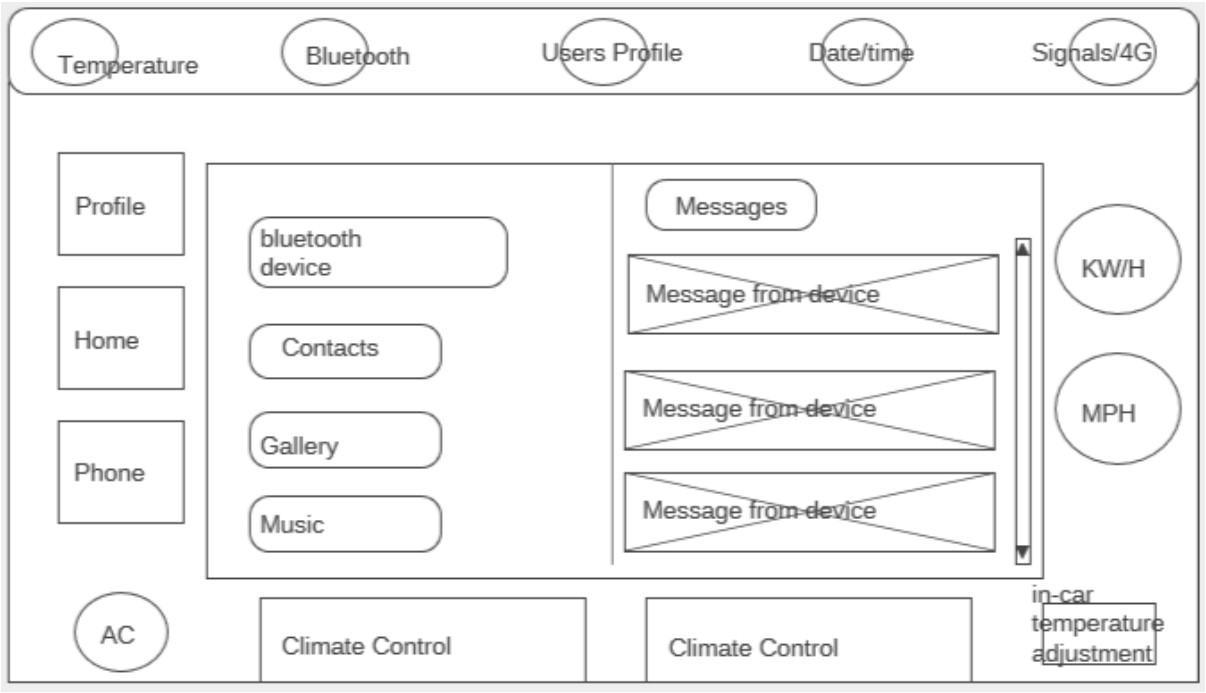


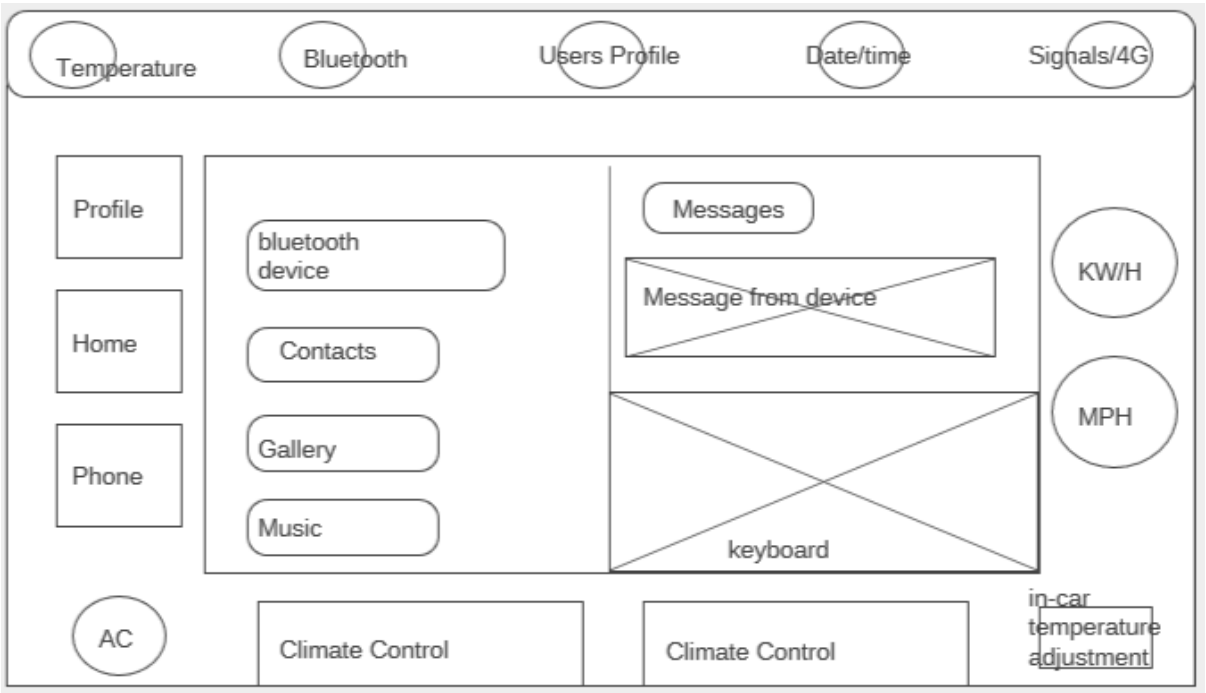
Screen 2: Bluetooth: Gallery



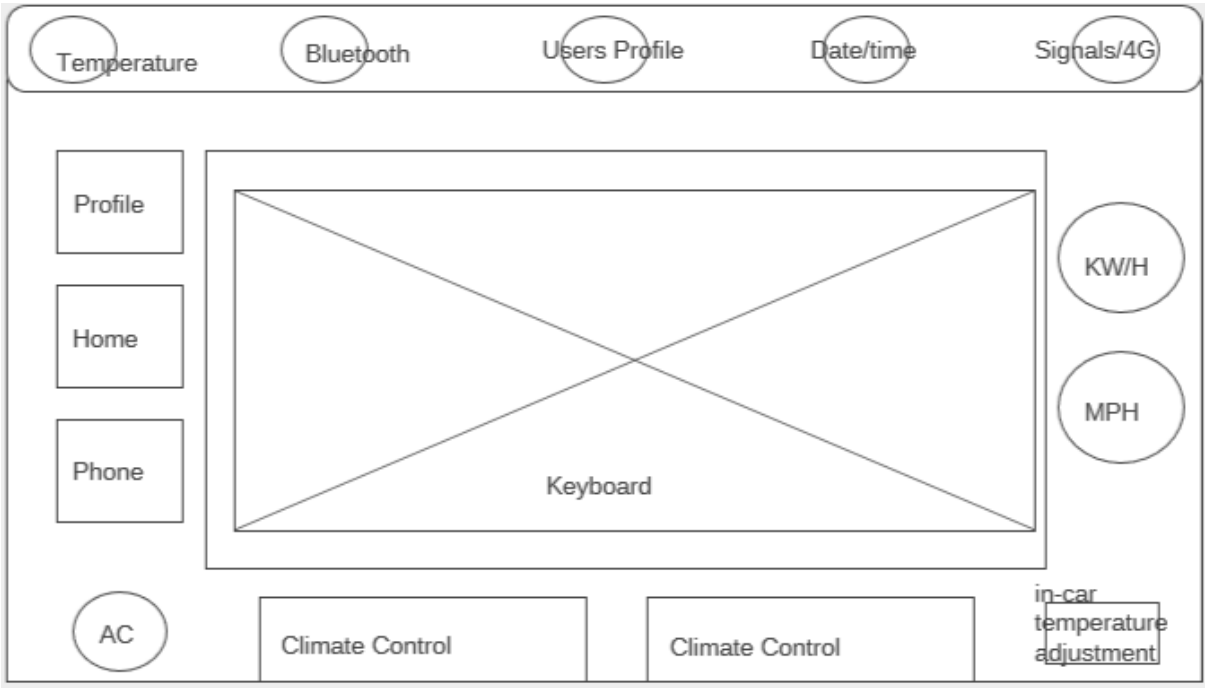


Screen 2: Bluetooth: Messages


Temperature
Bluetooth
Users Profile
Date/time
Signals/4G
Profile
Home
Phone
bluetooth device
Contacts
Gallery
Music
Messages
Message from device
Message from device
Message from device
KW/H
MPH
AC
Climate Control
Climate Control
in-car temperature adjustment

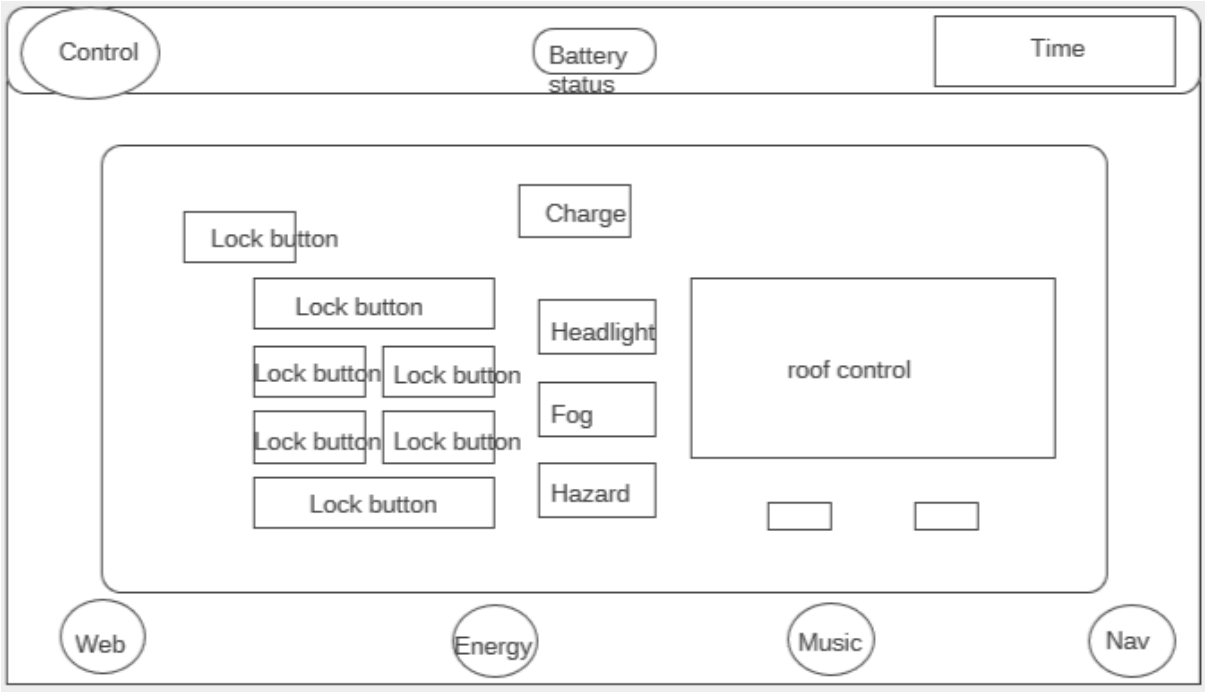

Temperature
Bluetooth
Users Profile
Date/time
Signals/4G
Profile
Home
Phone
bluetooth device
Contacts
Gallery
Music
Messages
Message from device
keyboard
KW/H
MPH
AC
Climate Control
Climate Control
in-car temperature adjustment

Screen 2: Keyboard

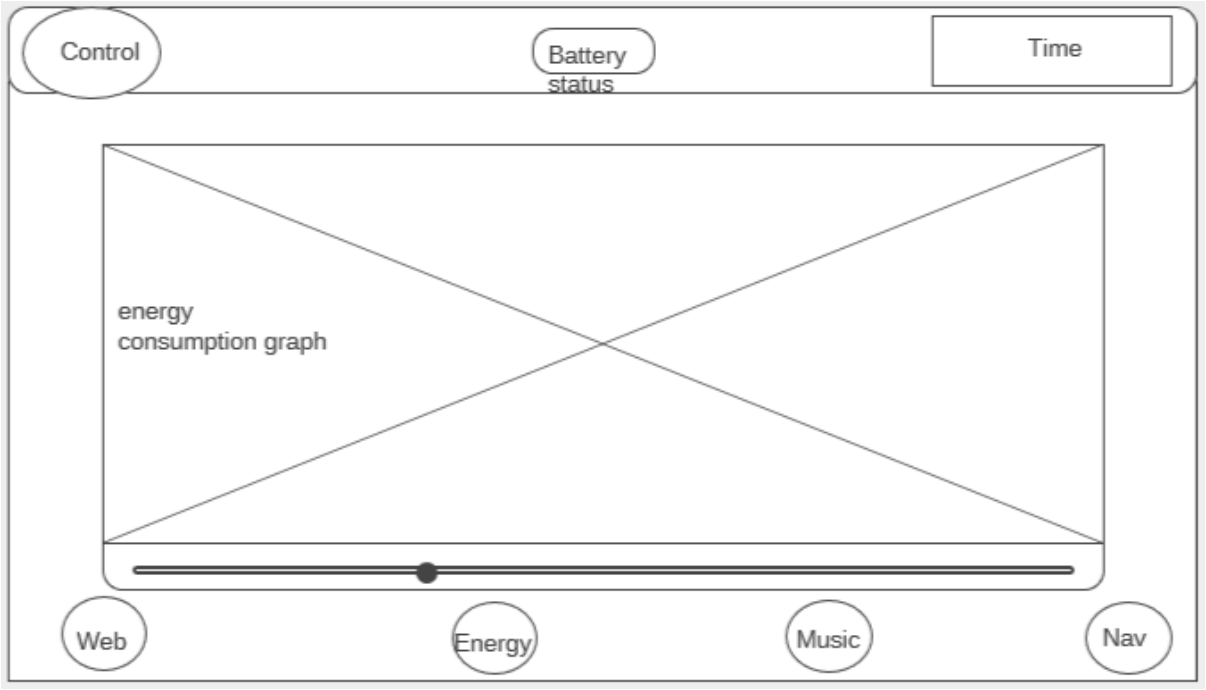


This screen will only show when there is an input needed

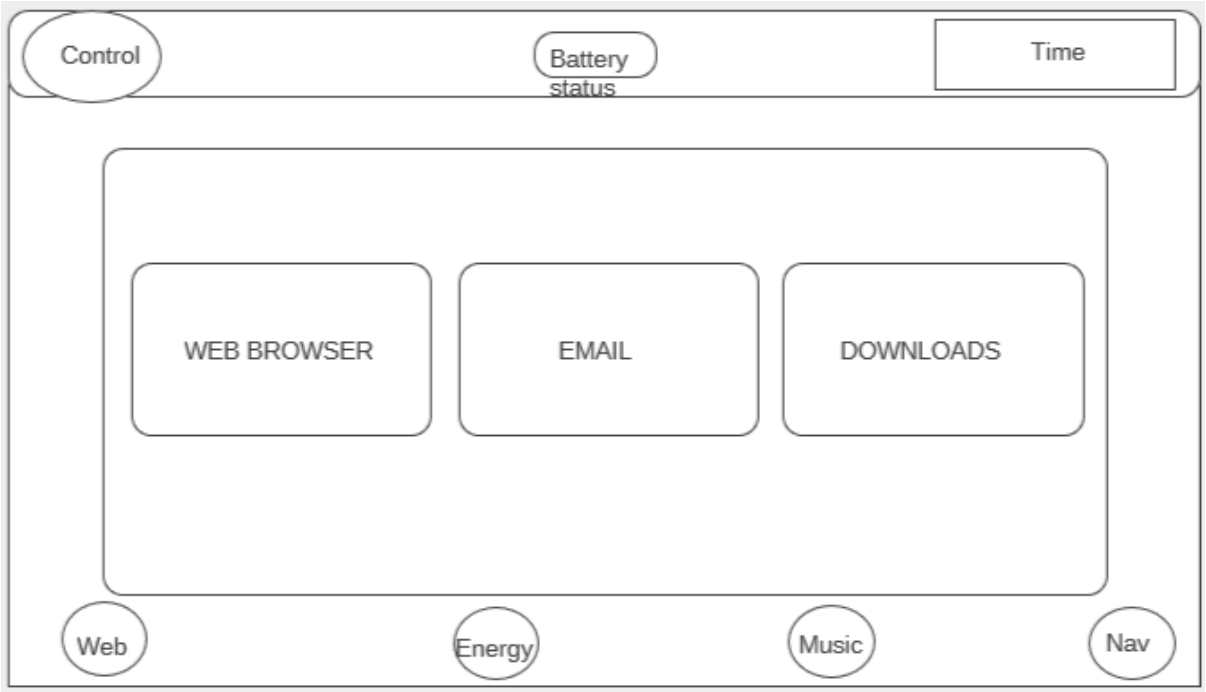
Screen 1: Controls



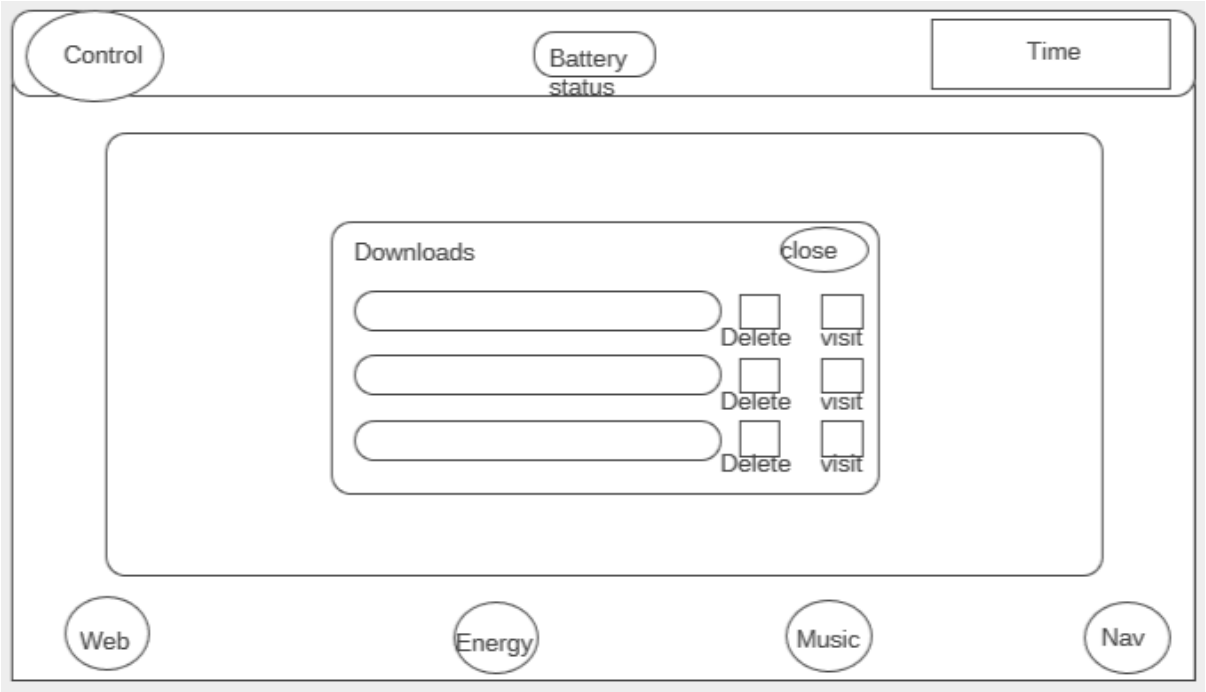
Screen 2: Energy consumption



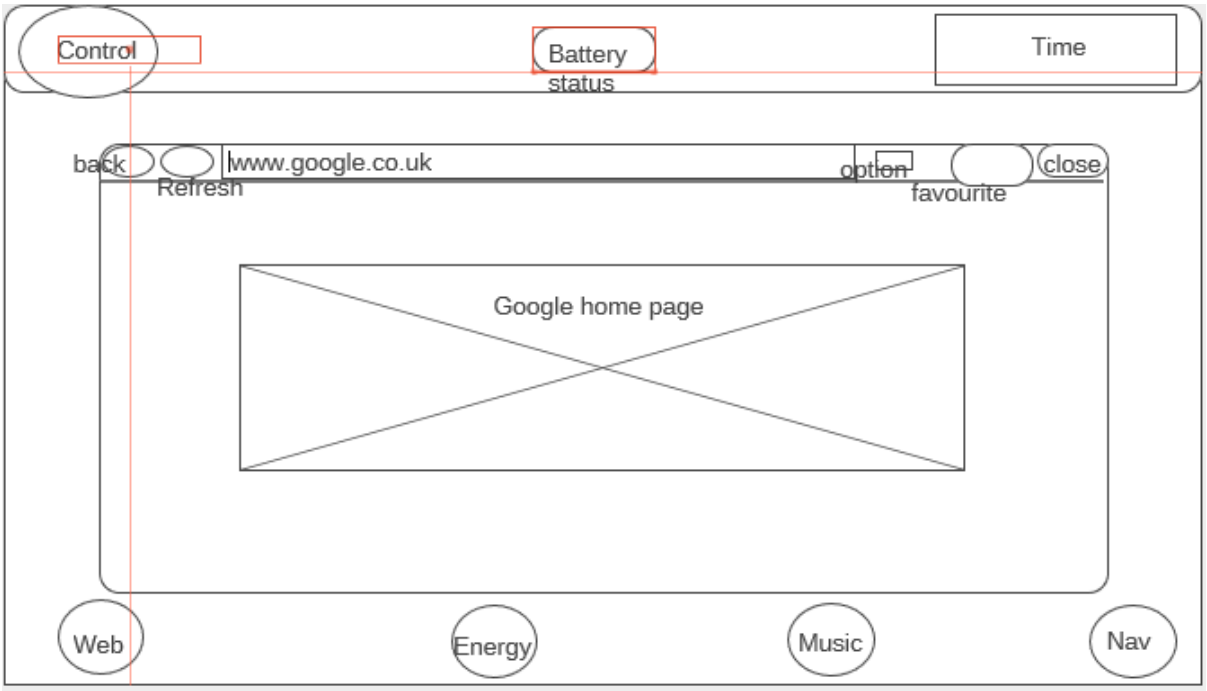
Screen 1: Web



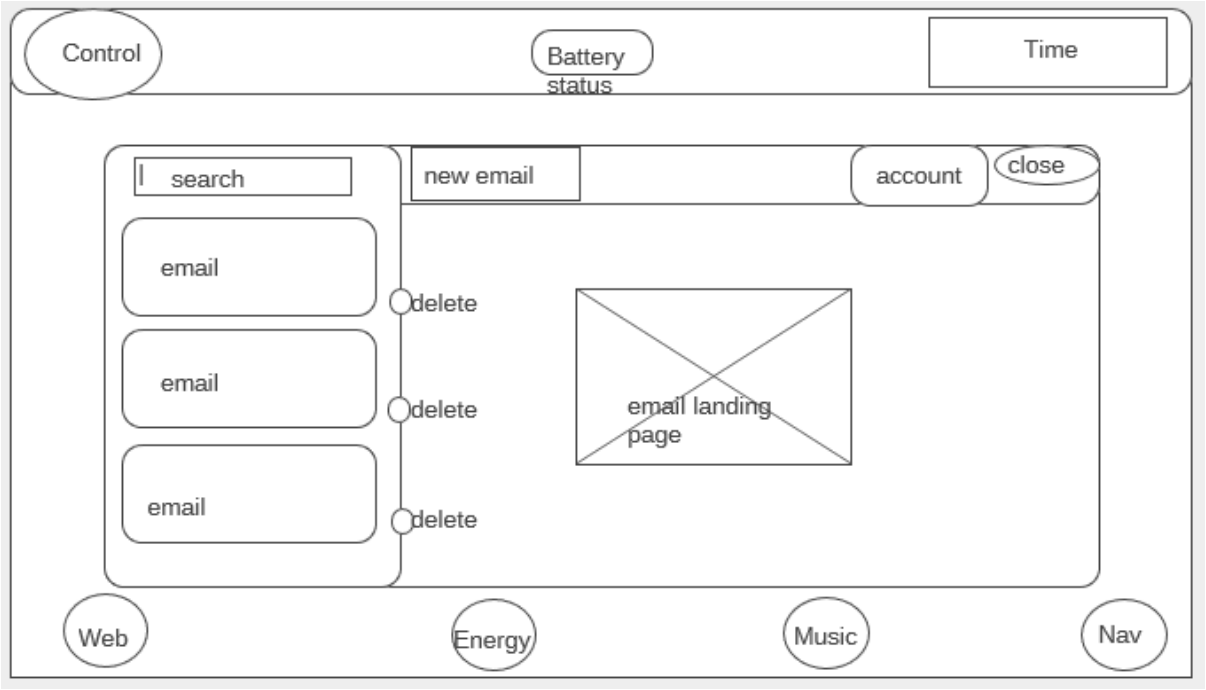
Screen 1: Web: Downloads



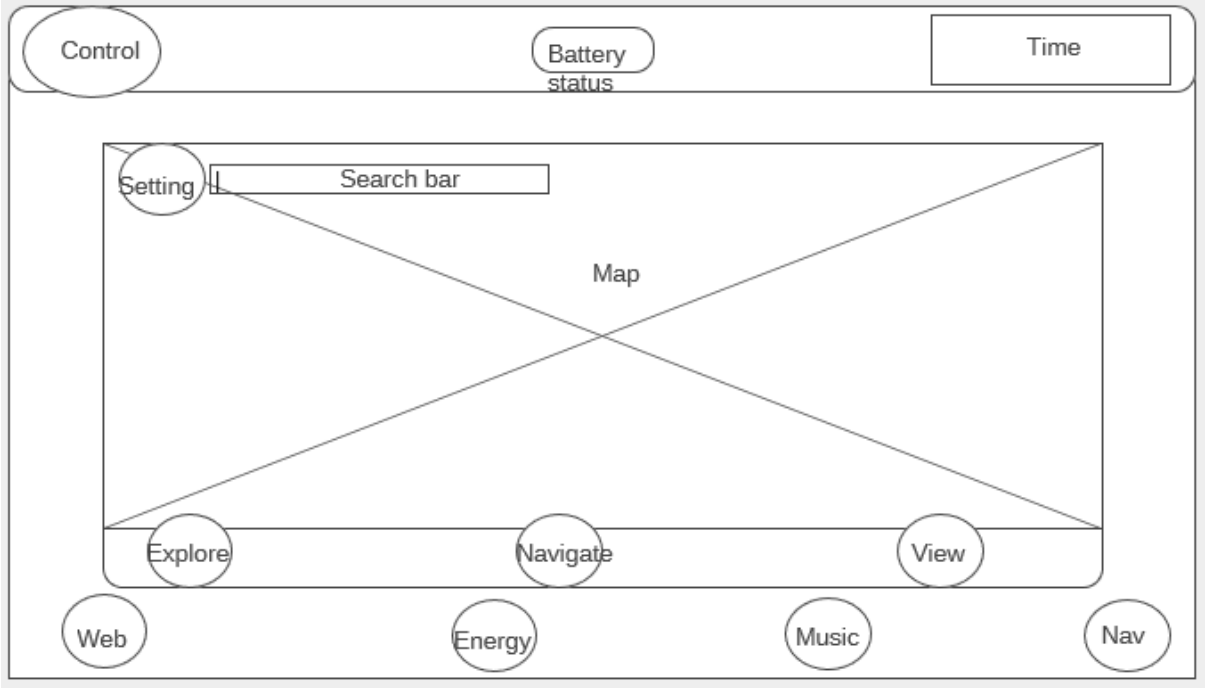
Screen 1: Web: Browser



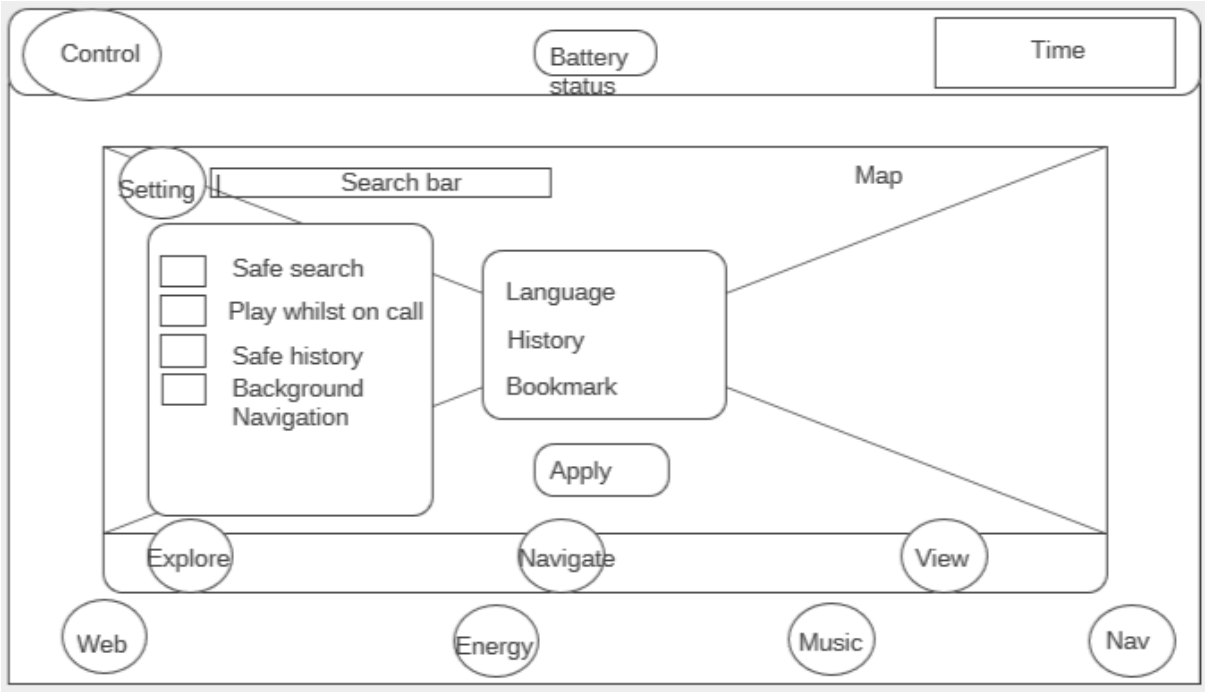
Screen 1: Web: Email



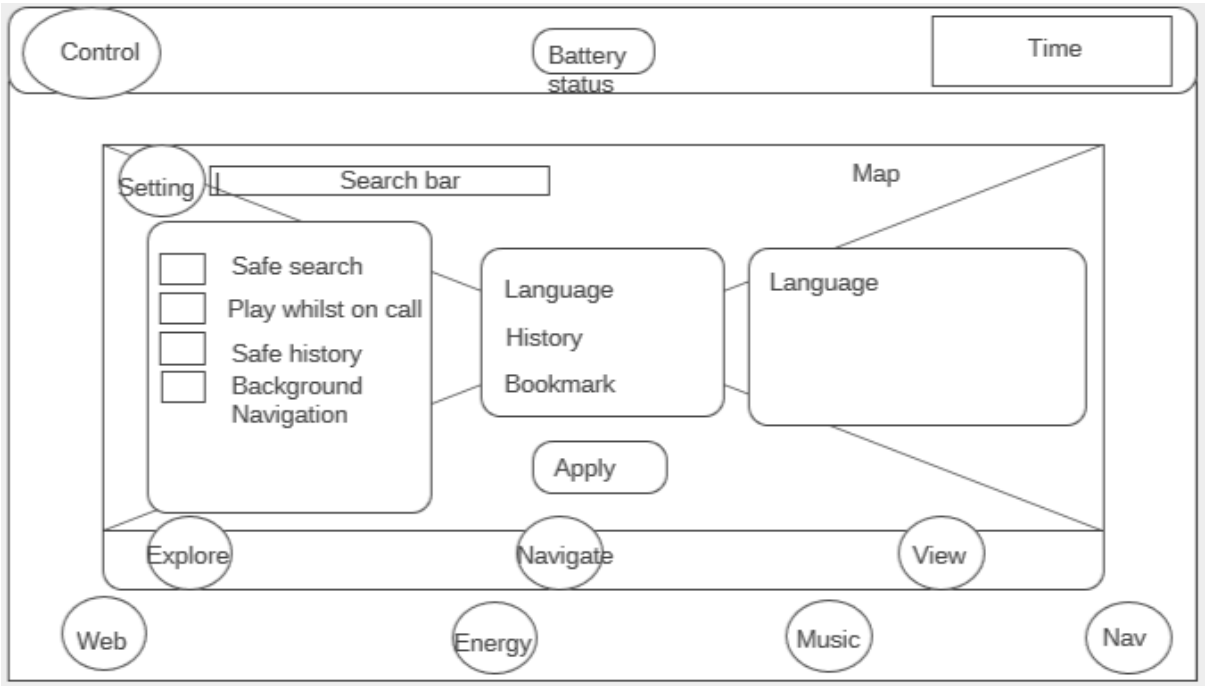
Screen 1: Navigation



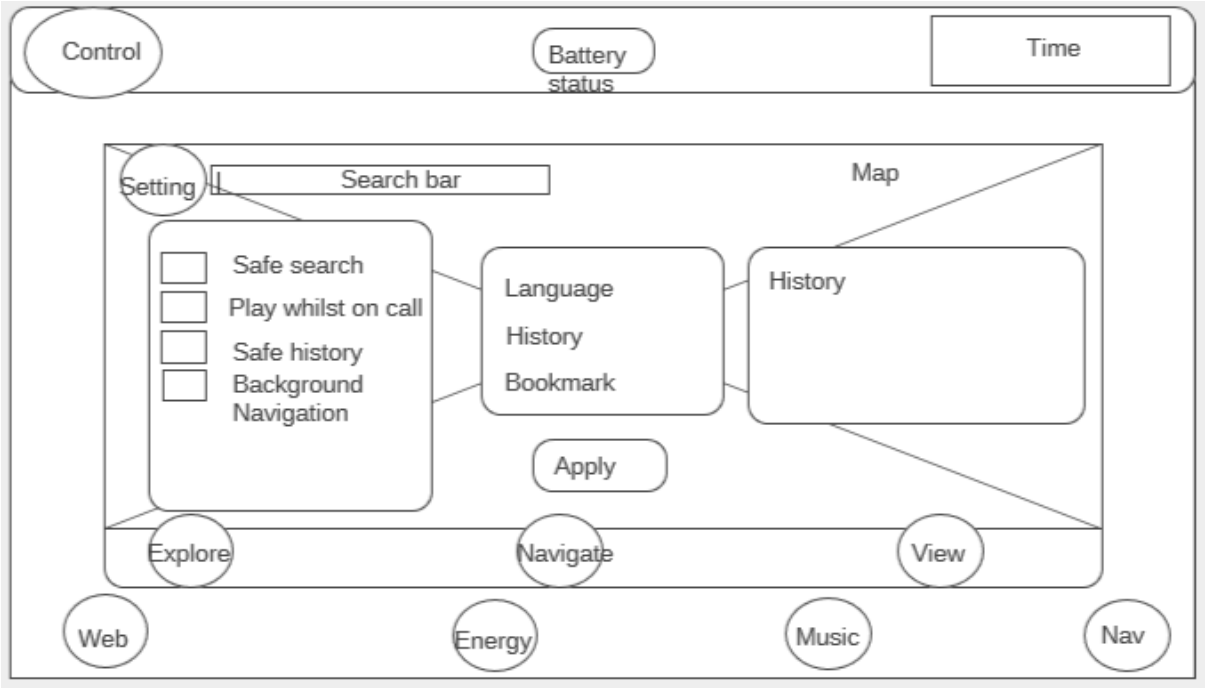
Screen 1: Navigation: Setting



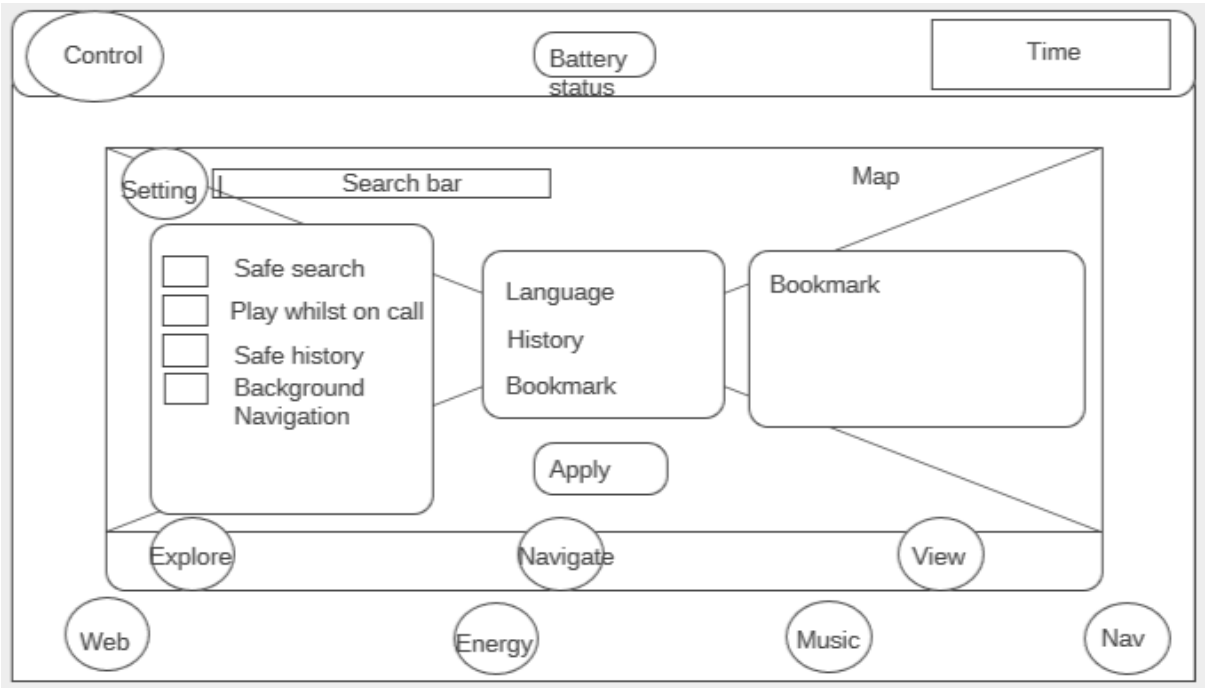
Screen 1: Navigation: Setting: Language



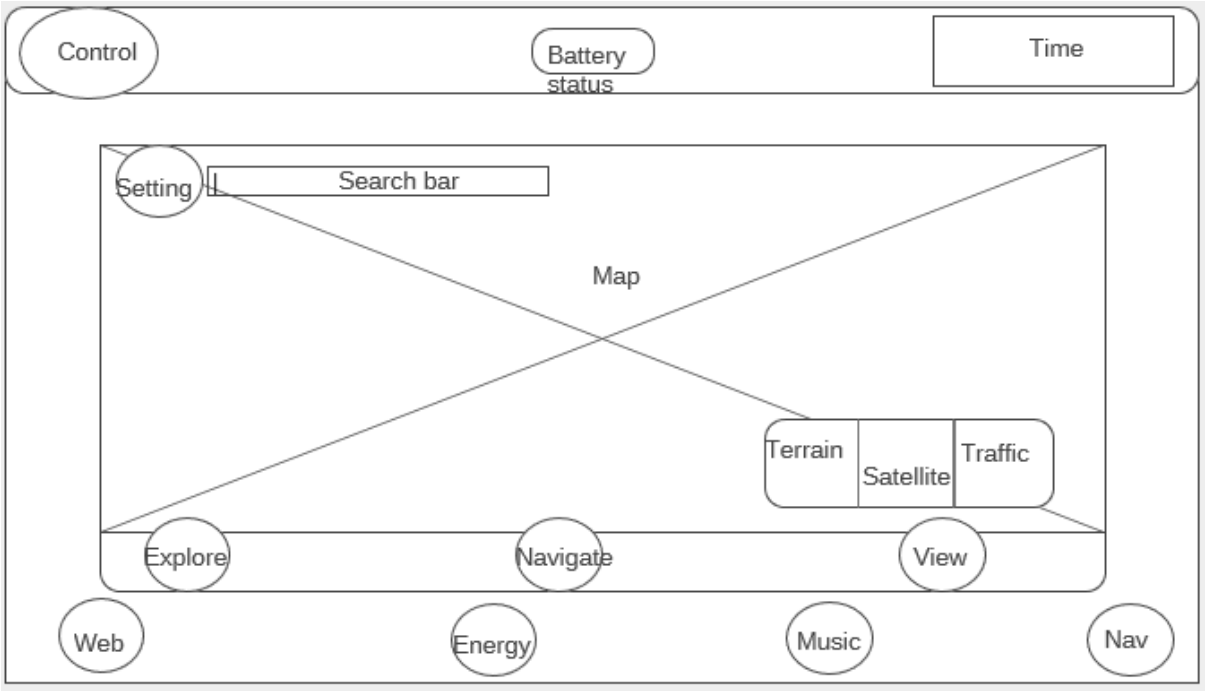
Screen 1: Navigation: Setting: History



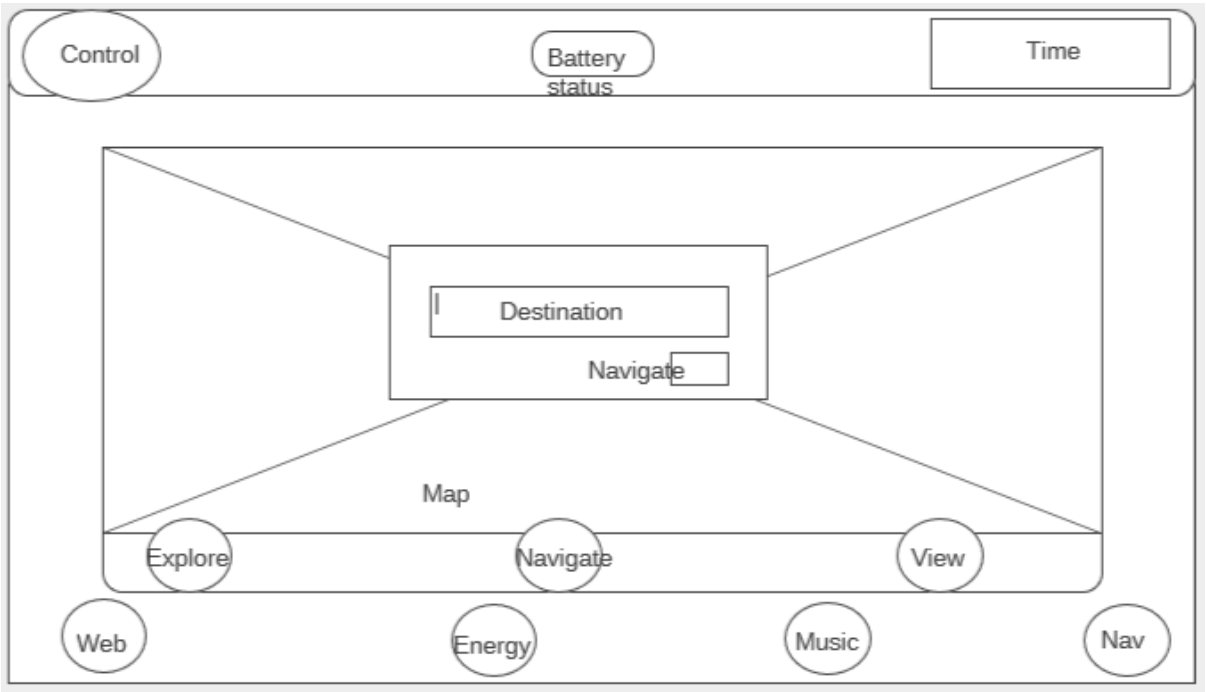
Screen 1: Navigation: Setting: Bookmark



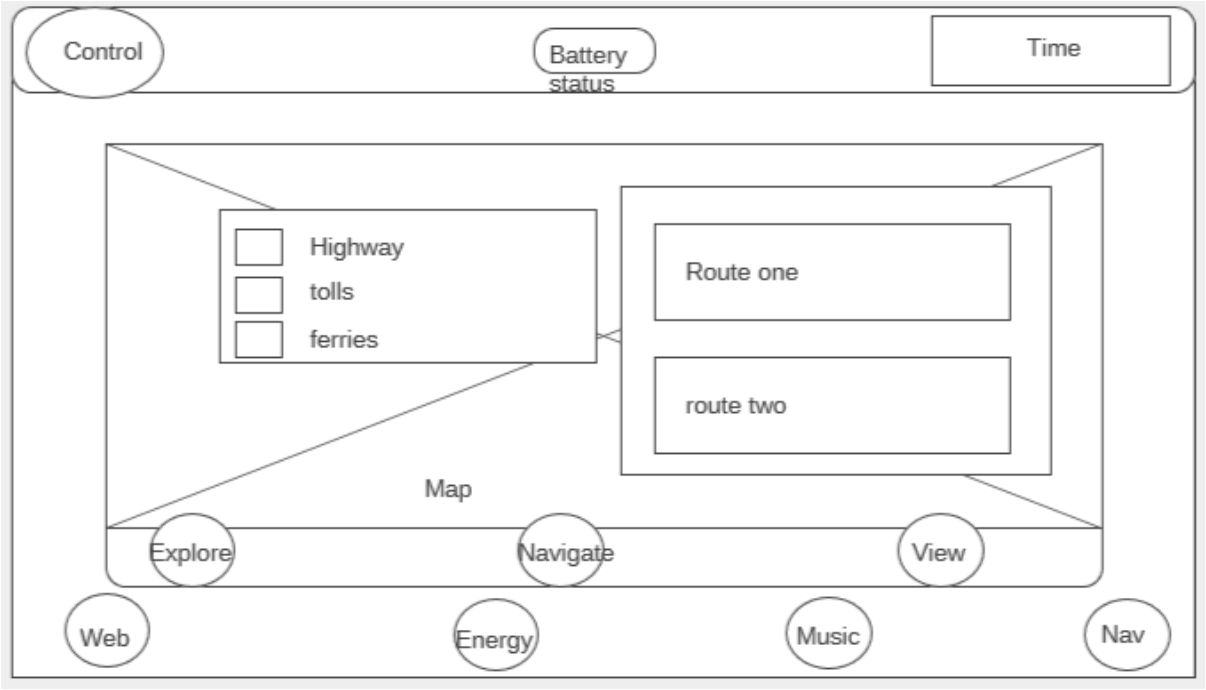
Screen 1: Navigation: View



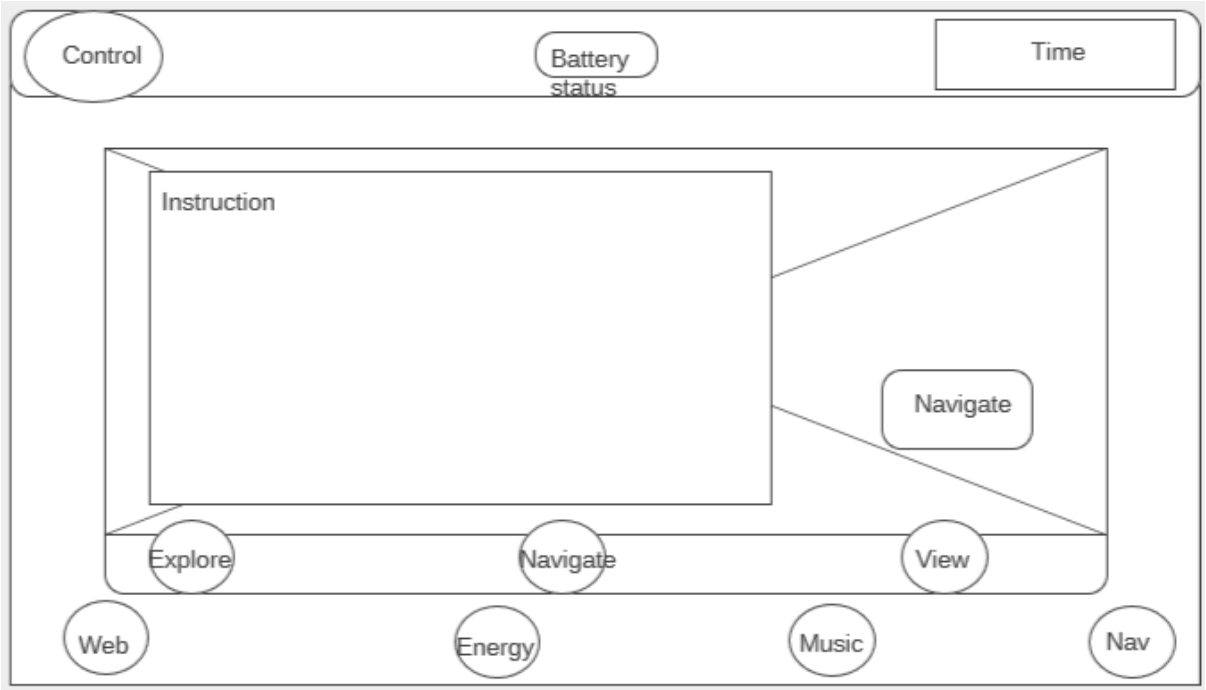
Screen 1: Navigation: Navigate



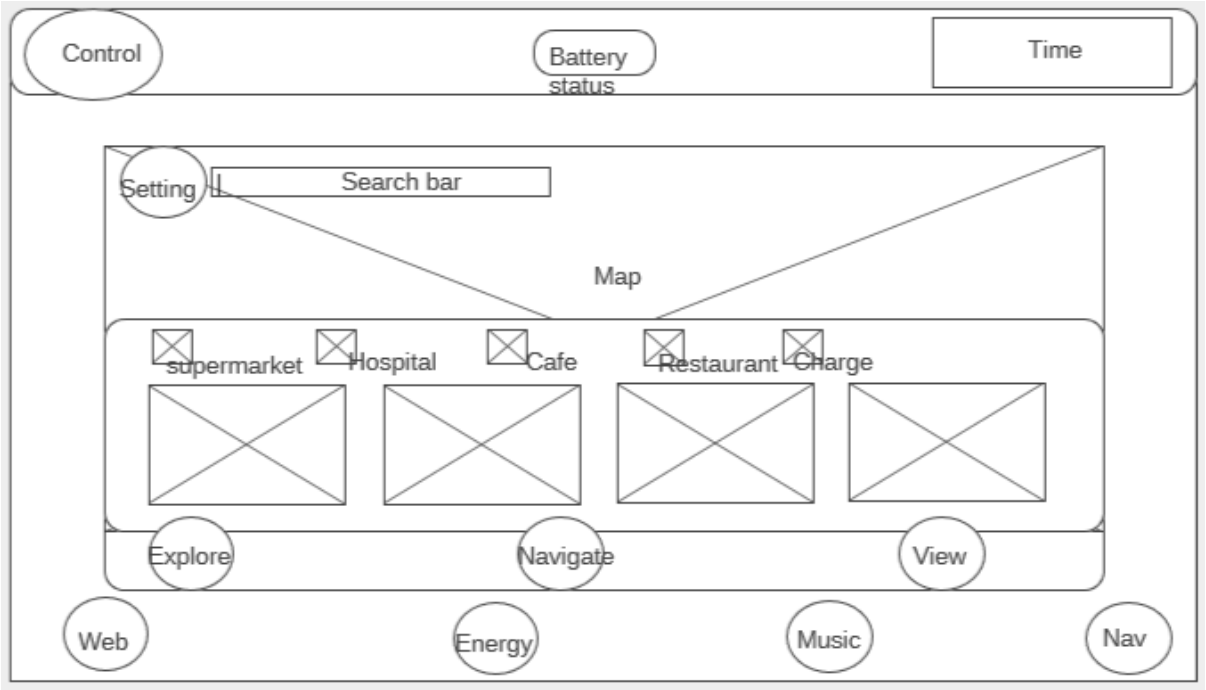
Screen 1: Navigation: Navigate: route



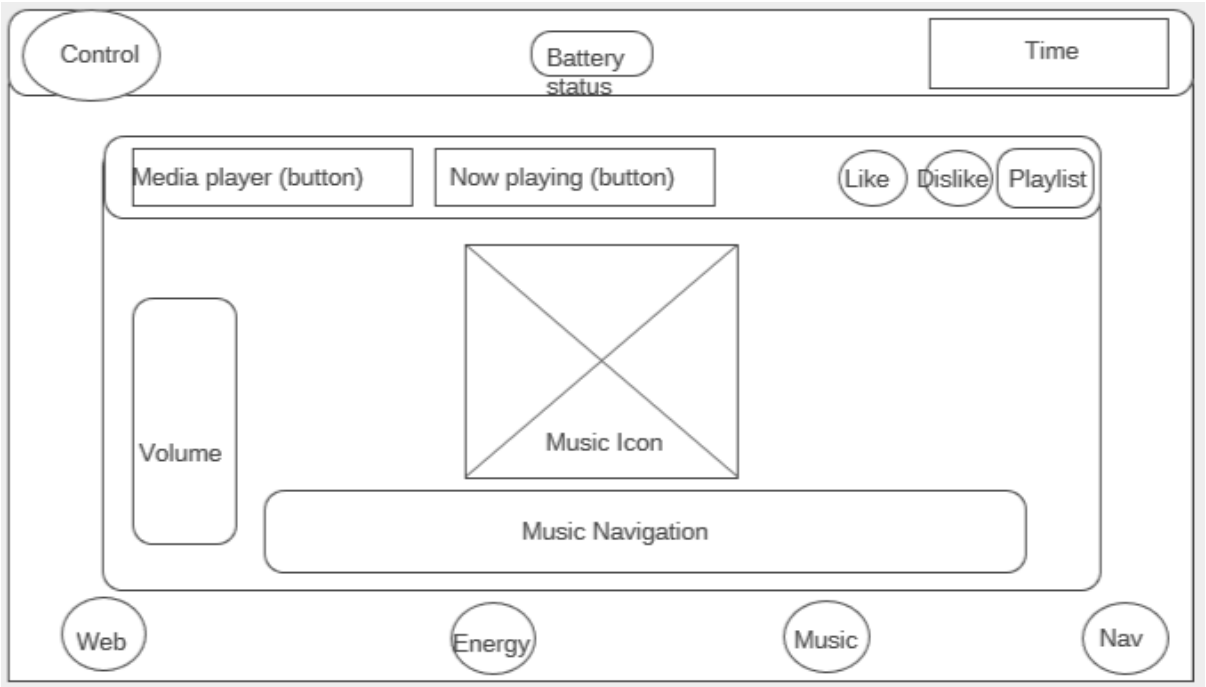
Screen 1: Navigation: Navigate: route



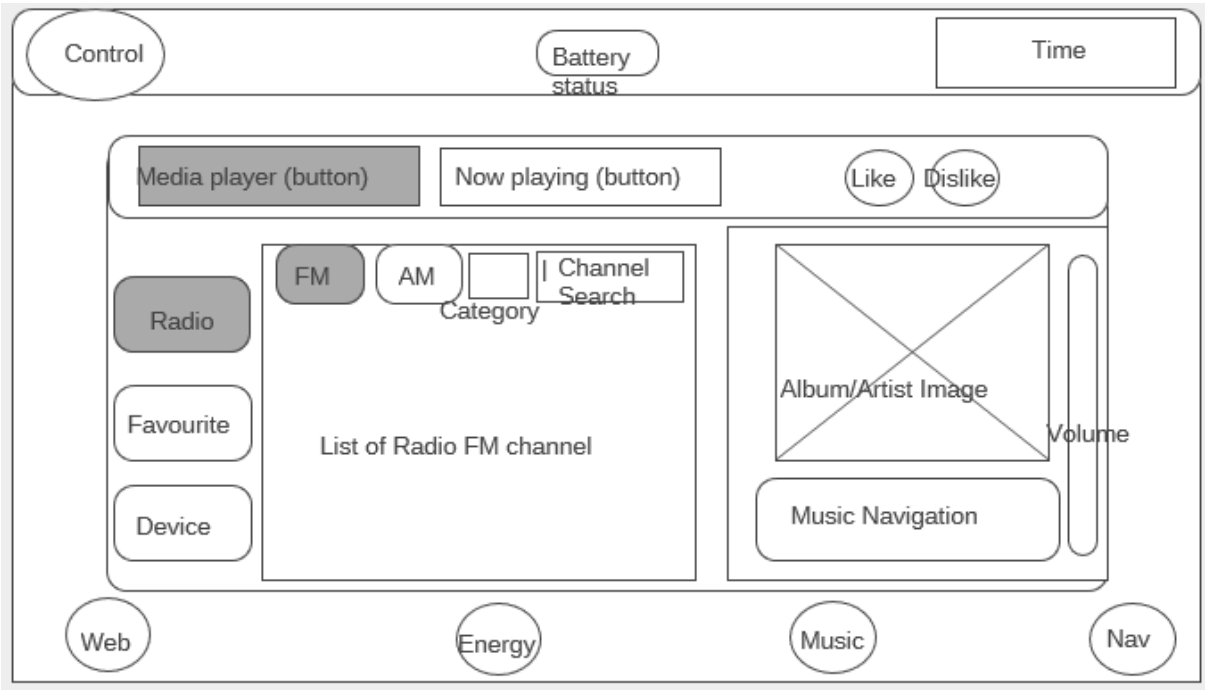
Screen 1: Navigate: Explore



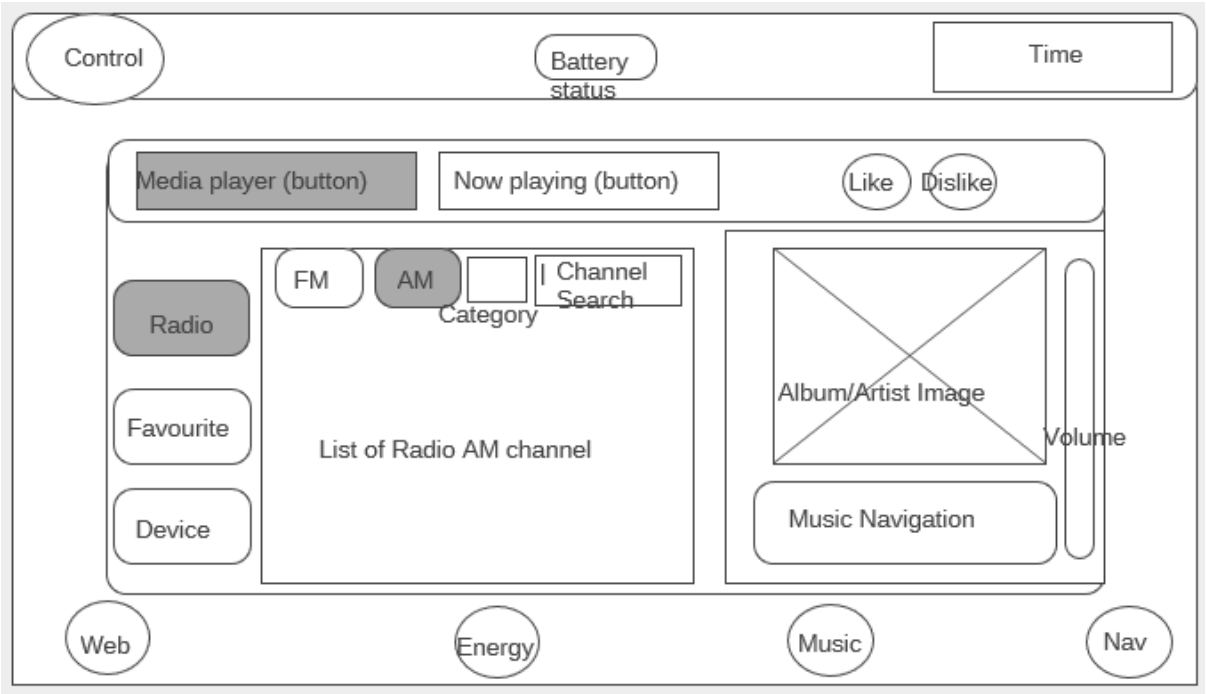
Screen 1: Music



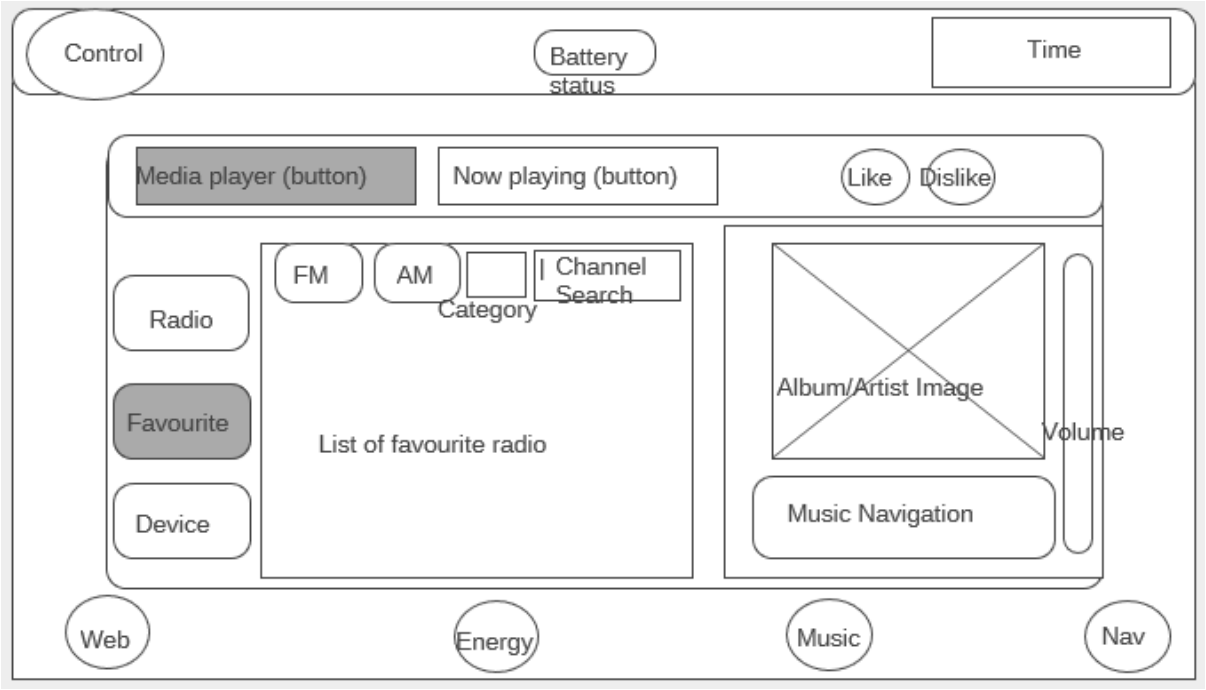
Screen 1: Music: Radio



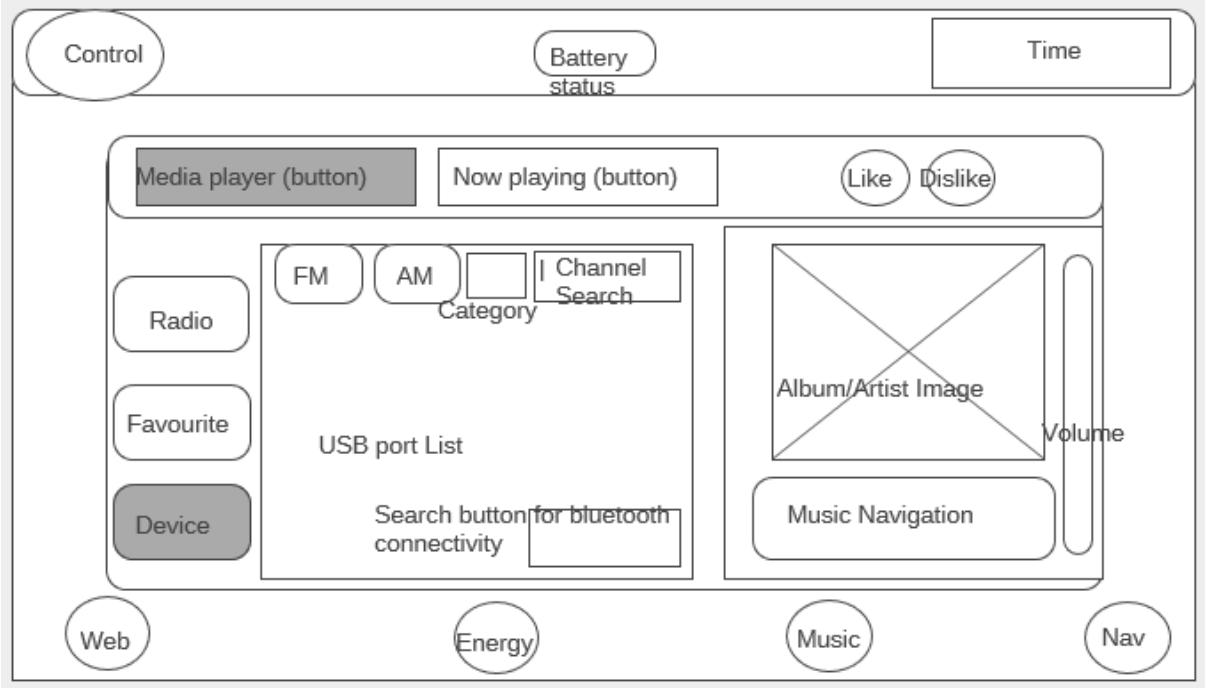
Screen 1: Music: Radio



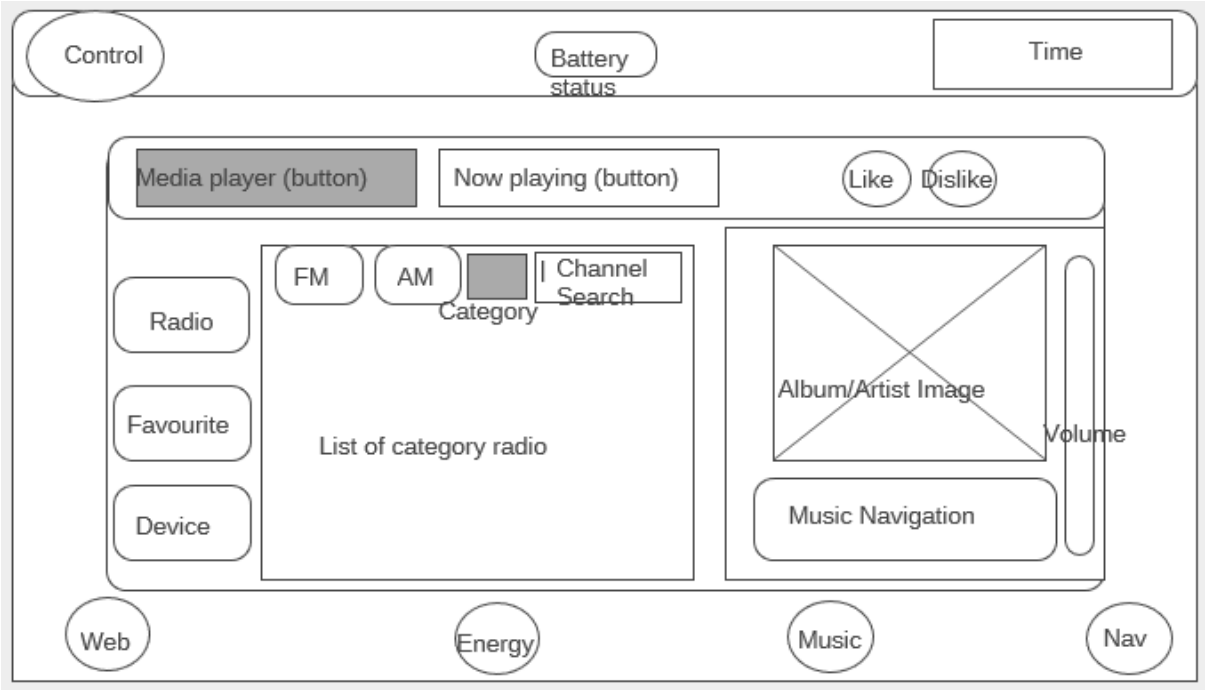
Screen 1: Music: Favourite



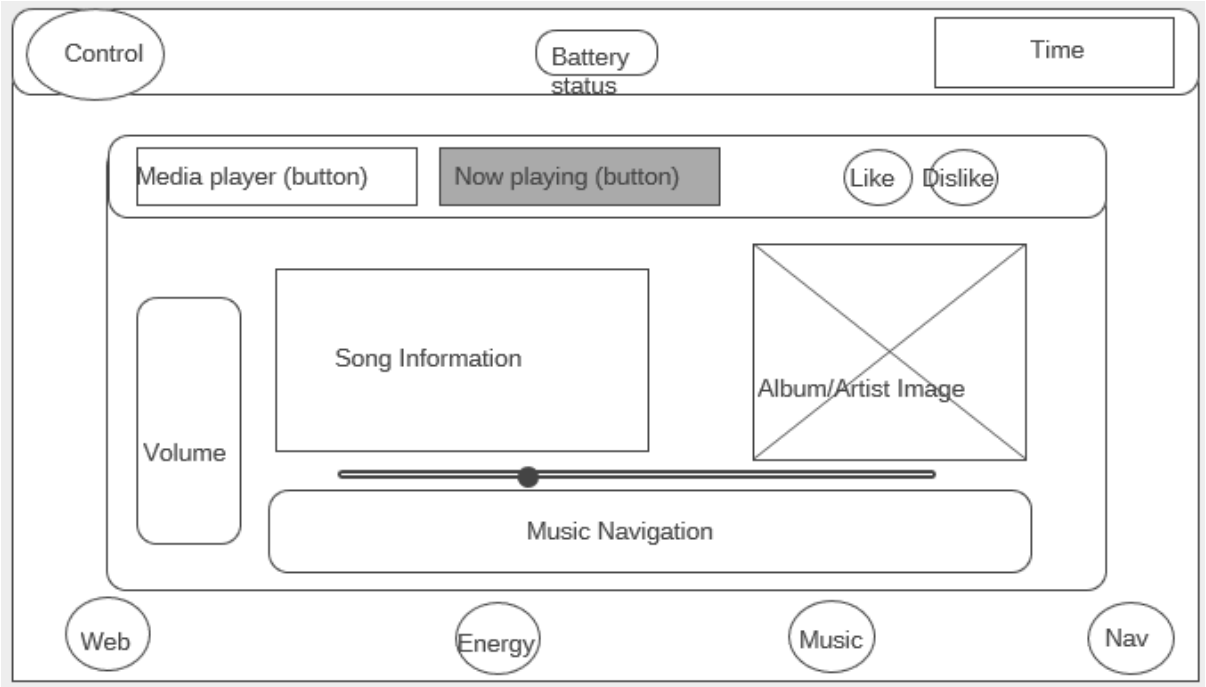
Screen 1: Music: Device



Screen 1: Music: Category



Screen 1: Music: Now playing



Feedback

From 1 to 5, how attractive was the colour scheme of the dashboard design (5 being very attractive)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	20.00% 1	40.00% 2	40.00% 2	0.00% 0	5	3.20

Figure ... shows participant feedback for colour scheme of the dashboard design

One participant rated 2 stars
Two participants rated 3 stars
Two participants rated 4 stars

Do you think the colours were dull?

ANSWER CHOICES	RESPONSES	
Yes	60.00%	3
No	40.00%	2
TOTAL		5

Figure ... shows participant feedback for colours used in the design

Two participants said “No”
Three participants said “Yes”

From 1 to 5, how attractive was the layout of the screens (5 being very attractive)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	0.00% 0	20.00% 1	80.00% 4	0.00% 0	5	3.80

Figure ... shows participant feedback for the layout of the design

One participant rated 3 stars
Four participants rated 4 stars

From 1 to 5, were the icons used, meaningful? (5 being very meaningful)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	20.00% 1	60.00% 3	20.00% 1	0.00% 0	5	3.00

Figure ... shows participant feedback for the icons used

One participant rated 2 stars
Three participants rated 3 stars
One Participant rated 4 stars

From 1 to 5, how easily could you navigate through the system (5 being very easy)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	20.00% 1	20.00% 1	60.00% 3	0.00% 0	5	3.40

Figure ... shows participant feedback for the navigation of the entire system

One participant rated 2 stars
One participant rated 3 stars
Three participants rated 4 stars

From 1 to 5, how pleased were you with the amount of feedback (5 being very pleased)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	40.00% 2	60.00% 3	0.00% 0	0.00% 0	5	2.60

Figure ... shows participant feedback for the feedback of the system

Two participants rated 2 stars
Three participants rated 3 stars

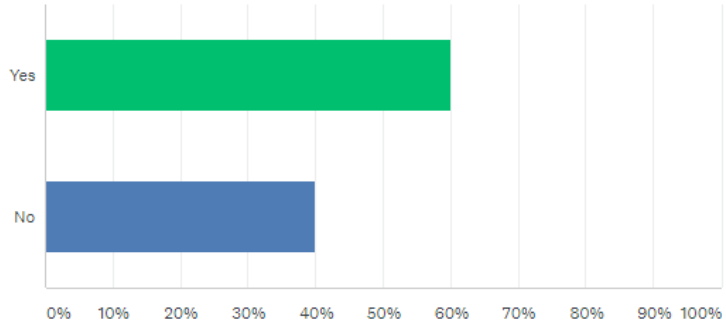
From 1 to 5, how useful was the information display (5 being very Attractive)

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	0.00% 0	100.00% 5	0.00% 0	0.00% 0	5	3.00

Figure ... shows participant feedback for the information displayed

Five participants rated 3 stars

Would you purchase a driverless vehicle with this infotainment system?



ANSWER CHOICES	RESPONSES	
Yes	60.00%	3
No	40.00%	2
TOTAL		5