Project 3
Masters in Design, 2015-17

Design for Blind people accessing Public Buses

April, 2017

A project by
Faizan Zahid
156130010
M. Des. (Industrial Design)

Under the guidance of
Prof. G. G. Ray and **Prof. Sugandh Malhotra**
Industrial Design Centre,
Indian Institute of Technology, Bombay

1. Approval Sheet

This project titled "**Design for blind people accessing public buses**" is prepared and submitted by 'Faizan Zahid' under project 3 course for partial fulfilment of the requirement for the degree of 'Masters in Design' in Industrial Design. It has been examined and is recommended for approval and acceptance.

Prof. G. G. Ray
(Project Guide)

Prof. Sugandh Malhotra
(Project Guide)

External Examiner

Internal Examiner

Chair Person

2. Declaration

This is to declare that this report entitled **"Design for Blind people accessing Public buses"** is the record of bonafide work carried out for Project 3 course by the undersigned under the guidance of *Prof. G. G. Ray* and *Prof. Sugandh Malhotra* at Industrial Design Centre, Indian Institute of Technology, Bombay. Also to further declare that this report has not previously formed the basis for evaluation of any degree, diploma or any previous project at IDC, IIT Bombay or any other similar title of recognition at any other university.

Faizan Zahid
17th April, 2017

3. Acknowledgements

First of all, I am extremely delighted to give a special thanks to my project guides *Prof. G. G. Ray* and *Prof. Sugandh Malhotra* for their valuable inputs and guidance throughout the project. I would also like to show appreciation to other industrial design faculty members for their precious time and comments on the project. I am also thankful to my friends and colleagues, for their intermittent valuable inputs and help. I am also thankful to people from *National Association of Blinds, Mumbai* and *Xavier's Research Centre for Visually Challenged, Mumbai* for their timely help.

Lastly, this project would be incomplete without acknowledging Allah and my family members, who supported me throughout.

Faizan Zahid
April, 2017

4. Contents

05

5. Introduction

5.1 Birth of the project

Initially started as a part of Exchange program in collaboration of IDC, IIT Bombay, India with IAD, TU Darmstadt, Germany this particular project has been done in majorly two parts.

Part 1 (Dec. '16 - mid Feb. '17): The initial part was done in Germany, where students worked in groups of 4 (two from India and 2 from Germany) in an attempt to promote cross cultural problem solving among participating departments of institutes of India and Germany. The idea behind the project was to come up with a common platform where students and institutes could exchange their design thinking and explore potential as a team. In order to achieve this objective, a common issue was identified which could be studied and researched further. The proposed solution should work in both contexts. In the present case, the issues faced by visually challenged people in public transportation system were addressed. This first part was also further was split into two stages where two students from India visited Germany and worked with the other two students. After the end of the initial period of six weeks, all four came to India to get exposure to the second context and finish the initial group project.

Part 2 (Mid. Feb. '17 - April '17): The second part was individually worked on by the author. In this, the initially proposed area of work was further explored in Indian context in order to find areas of intervention. These areas of intervention were further understood in depth as a Design Project 3 for industrial design stream at IDC. Finally, a project brief was finalised and design exercise was carried out in the said context of Design for visually impaired people accessing public buses, and the project was taken purely as a problem solving exercise.

5.2 Abstract

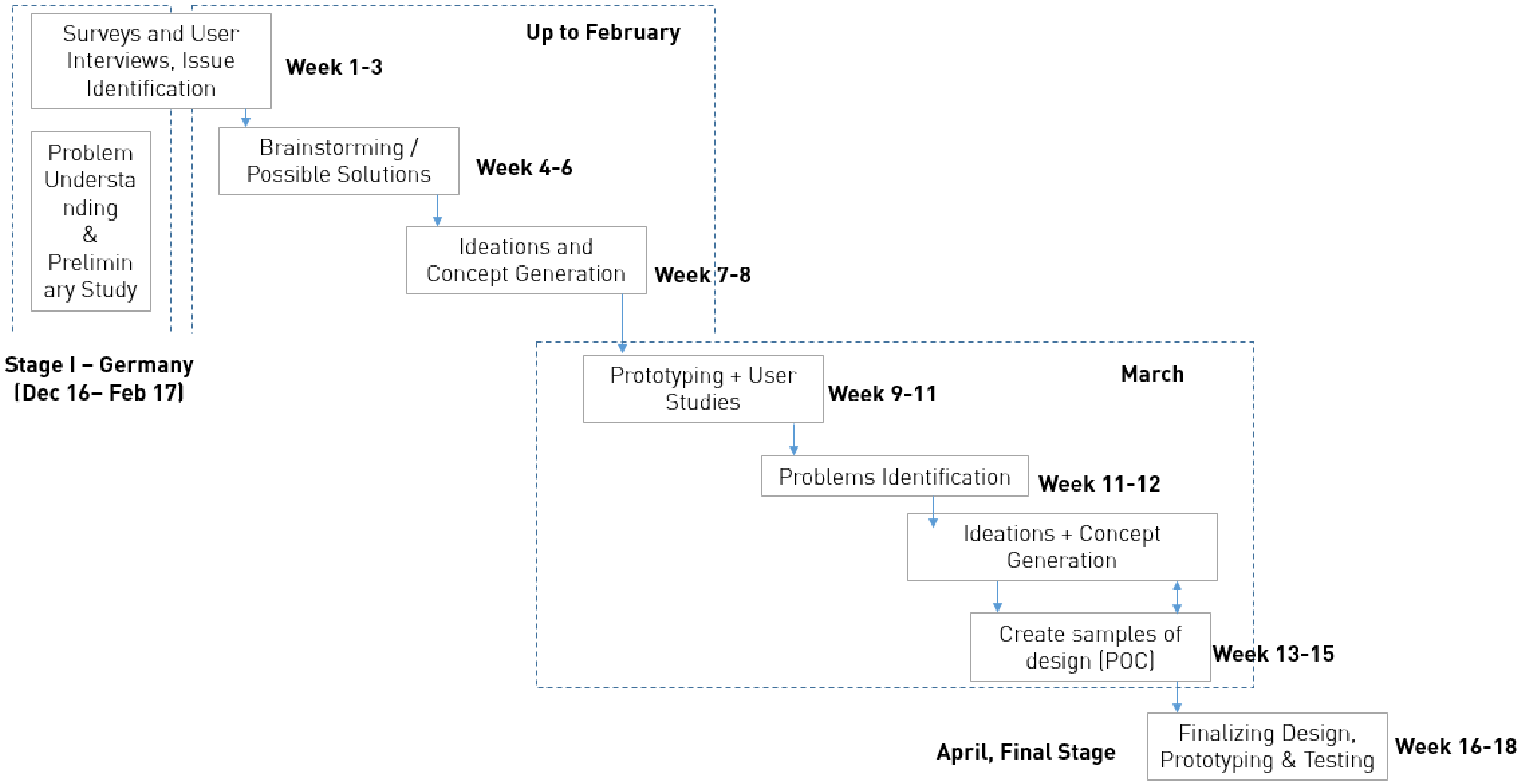
Public transportation is the basic amenity that any city is supposed to have for travelling within and outside the city. That being the case, this amenity must be available to the residents irrespective of their social status, gender, physical condition, etc. It is also a basic right for every citizen to be able to navigate comfortably to places of work and so forth in the city of their residence.

Buses and trains are used by a great number of people on a daily basis. “Bus and rail networks are the lifeblood of Indian society and prime movers of the local economies” says Jamie Osborne, a Transit Planner and Accessibility Specialist with the San Francisco Municipal Transportation Agency after a travel through India (Osborne, 2007). A lot of work keeps happening in the domain of transportation to give this comfortable commute to the citizens in a country like India with such a large population. Year after year more people move to cities for opportunities and the cities have to battle with infrastructural maintenance nonetheless but we still need to buckle up to make public transportation accessible.

India has the largest blind population in the world of nearly 20 million. Around 1.5% of the population is blind. But the impairment does not restrict them from studying, having ambitions and raising a family. Sadly, many portions of the world have still not been completely made accessible. Their basic requirement is affected when the navigation is curbed. Many people prefer staying indoors than to get out there and battle everyday with transportation and infrastructure.

This entire project is an attempt to help the visually impaired people access public transportation with less difficulty and navigate to places of their requirement more efficiently. As part of this project, I spent the initial part of the project’s tenure in Darmstadt, Germany. This was an attempt to understand the cultural differences, infrastructural advancements, understand the attempts to provide solution and design a guiding system which would act as an assistant to the person using it whether visually impaired. For the project, the chosen mode of transportation is public bus since after looking at some other transportation means it seemed the bus system is pretty much the same in both Germany and India. Both countries have visions to make the countries barrier free by 2020 (Johari, 2017). Though one is a developed country and one is developing pretty fast, the visually impaired citizens did have their concerns about not being able to travel like their counterparts.

5.3 Time line



Surveys and User Interviews, Issue Identification
Week 1-3
Up to February
Problem Understanding & Preliminary Study
Brainstorming / Possible Solutions
Week 4-6
Ideations and Concept Generation
Week 7-8
Stage I – Germany (Dec 16– Feb 17)
Prototyping + User Studies
Week 9-11
March
Problems Identification
Week 11-12
Ideations + Concept Generation
Create samples of design (POC)
Week 13-15
April, Final Stage
Finalizing Design, Prototyping & Testing
Week 16-18

5.3 Understanding Blindness

Visual impairment, also known as vision impairment or vision loss, is a decreased ability to see to a degree that causes problems not fixable by usual means, such as glasses. Some also include those who have a decreased ability to see because they do not have access to glasses or contact lenses. Visual impairment is often defined as a best corrected visual acuity of worse than either 20/40 or 20/60. The term blindness is used for complete or nearly complete vision loss. Visual impairment may cause people difficulties with normal daily activities such as driving, reading, socializing, and walking.

5.3.1 Classification of Blindness

The definition of visual impairment is reduced vision not corrected by glasses or contact lenses. The World Health Organization uses the following classifications of visual impairment. When the vision in the better eye with best possible glasses correction is:

- 20/30 to 20/60 : is considered mild vision loss, or near-normal vision
- 20/70 to 20/160 : is considered moderate visual impairment, or moderate low vision
- 20/200 to 20/400 : is considered severe visual impairment, or severe low vision
- 20/500 to 20/1,000 : is considered profound visual impairment, or profound low vision
- More than 20/1,000 : is considered near-total visual impairment, or near total blindness
- No light perception : is considered total visual impairment, or **total blindness**

Blindness is defined by the World Health Organization as vision in a person's best eye with best correction of less than 20/500 or a visual field of less than 10 degrees. This definition was set in 1972, and there is ongoing discussion as to whether it should be altered to officially include uncorrected refractive errors.

06

6. Part One: Exchange Program with TU Darmstadt, Germany

6.1 Kick start

People with visually disability are a very specific group which needs special care and attention while designing. Unlike all other, the designs especially which are directed towards public use must take care of this group. The kind of issues they face while living their daily life are very peculiar to them and it's necessary as a designer to pay attention to them while designing. However, this critical user group is most of the times not paid attention to and it makes difficult for them to survive through even the smallest of the daily tasks.

Looking at the current scenario of public transportation, especially in Mumbai, one can easily find that it hardly tries to help this user group or promote public transportation among them. Metro is one mode of transport which has considered visually impaired people as their user group and one can see that in the designs of metro stations and trains.

The initial phase of the study was to understand the issues in real life scenario and come up with areas of interventions. The following chapter will be about the initial study and design explorations. This includes the work done during exchange program in Germany.

6.1.1 Visit to Germany

The visit to IAD, TU Darmstadt, Germany was of a total duration of 8 weeks from December 10th 2016 to February 10th, 2017. The main objectives of the visit were:

- Understand the issues faced by blind people while accessing public transportation.
- Looking at the solutions available in Germany.
- Find areas of work common to both the context of India and Germany.

6.1.2 Current state in Germany

In Germany, the public transportation plays a major role in the context of transportation of passengers. Roughly ten billion passengers use the service every year. Providing mobility to the German population is a part of the governmental basic service. It is strictly coined by the German federal state organisation. This gives a short introduction to the most important transportation systems in Germany, the legal conditions and the circumstances in the city of Darmstadt.

In Germany commonly used transportation systems in public transportation are taxis, busses, trams, underground trains, local trains and intercity trains. Inside cities taxis, busses, trams, underground trains and local trains are in use. The busses are mostly low floor busses to provide barrier free access. When using public transportation in Germany the passenger must buy a ticket at a vending machine in advance to the ride. In busses the passenger can also get a ticket from the bus driver. Normally the ticket is valid from the access to the vehicle until the final destination and can be used for the different vehicles. This means one ticket is valid for a bus, tram and train ride. Bus, tram and train stops are visually signed, so that they are recognisable as a stop. Mostly they are also barrier free, which means they are built on a higher level to provide an easy access to the vehicle and have orientation systems for blind on the ground.

The public transport in Germany is governed by the law “Gesetz zur Regionalisierung des öffentlichen Personennahverkehrs-Regionalisierungsgesetz (RegG)” at the federal level and by county laws at the state level.

Public transport in Germany is mostly a loss business, which is subsidised by government (state, county or city). Therefore, to achieve the best efficiency district councils tender the service of public transport to semi private companies.

Within the city of Darmstadt, the "HEAG Mobilo GmbH" provides the local service with buses and trams. Countrywide regional trains or Inter-City trains are provided by "Deutsche Bahn AG" or other companies. The public transport in Darmstadt is part of the transport association "Rhein-Main-Verkerhsbund (RMV)" which is an association of all public transport companies in the region of Rhein-Main and "DADINA" a local association for Darmstadt and its suburbs.

In the following table statistics about the HEAG Mobilo GmbH are summarized.

Table 1: Germany Transportation Statistics

Annual passengers	**45,1 million**
Number of Employees	727
Number of busses	105
Length of the bus network	327 km
Number of trams	48
Length of tram network	42 km

6.1.3 Darmstadt

Most transportation systems in Germany are claimed to be barrier free. In the vehicle, specific seats close to the doors are reserved for disabled or elderly people. Also, busses normally have a ramp for wheelchair access. The bus, tram and train stations provide an easy access to the vehicle by being on the same level as the door of the vehicle. At the stop orientation systems for blind on the ground are implemented. Nevertheless, there are still many stops not prepared for barrier free access, since the preparation is costly.

Figure 1: A typical bus in Darmstadt, Germany (Source: Author)

For the usage of public transport for disabled persons in the city of Darmstadt a lot of things have been done already. There are orientation systems for blind on the ground, dynamic passenger information screens with voice output at several bus and tram stops and most busses and trams are low floor and therefore barrier free. Nevertheless, these circumstances don’t occur at all bus and tram stops. For the design and maintenance of bus stops the city of Darmstadt is responsible, whereas for the tram stops the HEAG Mobilo GmbH is responsible. There is no statistics about the existing and development of barrier free bus stops. The HEAG states that 56 of its 76 tram stops are barrier free.

6.1.4 Primary Research

During the tenure in Darmstadt we worked in a four member team. The team comprised of two German students from Industrial Engineering department from the TU Darmstadt and myself from Industrial Design and another student from Interaction design. We got help to conduct interviews in Germany and for understanding of documents revealing the critical issues within the system for visually impaired people.
A three-stage process, involving as much stakeholders as possible was undertaken.

First, in a brainstorming session the team itself approached and identified all relevant points of intervention and critical issues while using public transportation. Second, including transport providers, counties and blinds using a guided telephone interview to reveal the critical issues. Third, the confirmation of the critical issues in this context with interviews and an on-site field study.

5.1.4.1 An Ideal Bus Journey

After brainstorming, we came up with the ideal journey a passenger does by bus. In that journey that one takes from one destination to the other, there are a lot of steps involved as follows:

1. Plan the trip (origin/ destination)
2. **Locating origin bus stop**
3. **Locating the right bus**
4. **Access the bus**
5. Ticketing
6. Finding a place to stay (sit or stand safely on the bus)
7. Knowing the current location/ the route of the bus
8. Getting down the bus
9. Locating destination

Each of the earlier discussed steps has its own details and requisites in terms of visually impaired passengers. However, current infrastructure solves only a fraction of the issues and makes enough room for intervention at each level for making the service more accessible for the said population.

One of the major issue that we found is common to both the countries is the problem of identifying the correct bus and correct direction to bus door. There is no such affordable and user validated system which provides the right cues from the bus, helping them in identifying his/her bus of interest before the bus approaches the bus stop. Further the process of identifying the entry door of the bus is integral part of the system. (IIT Delhi) It was eventually decided further that this area of work (of guiding blind people to correct bus and bus door) could be worked upon, as a collaborative project in the exchange program.

5.1.4.2 Experiencing darkness (Blind Museum)

In order to empathise with the visually impaired users, the team went to Dialog Museum in Frankfurt. Guided by a blind instructor, we spent 1.5 hours in a dark room in a complete state of blindness. We had to undertake various tasks and navigate around the museum's made-up city.

The Experience gave us key insights such as

1. How important the vibrations from environment is
2. How the blind stick extends as a limb
3. How the sense of hearing takes over with time to compensate lack of vision
4. Sense of orientation for blind people
5. Need of reference points
6. Physical cues in the environment
7. How to communicate with the environment using the haptic feedback

Figure 2: Dialog Museum in Frankfurt. (Source: Google Images)

5.1.4.3 Interviews with the transport providers

The interview partners were Mr. Andreas Rathöfer from the council of Soest, Mr. Gerhard Renzel from DBSV (blind association), the leader of the department environment and traffic and Mr. Dirk Kornelius from HEAG mobilo, the coordinator of inDAgo project.

Based on their studies the basic problem in the process of using public transportation is the accessibility of buses, which includes finding the way to the bus stop, finding the right bus and finding the door to the bus. Especially, these problems occur when more than one bus is departing at the same time or the stop has more platforms. In these cases, existing solutions like announcements and guiding cobblestones are not reliable. Thus, the DBSV urges to improve the accessibility to busses in general, to integrate audio sounds of the vehicle/ doors to find bus/ door, a standardisation of all systems in different cities as well as the improvement of e-ticketing. Additionally, the issues looking up the connection, knowing where the bus departs and knowing where one is while being at the bus are mentioned as issues for blinds.

5.1.4.4 Blind Users interview, Darmstadt

Further interviews were conducted with 7 Blind people in order to understand the following:

1. Since when are you visually impaired?
2. Do you use a smartphone?
3. Do you use any gadgets to assist you in your daily life?
4. Are you comfortable doing everything including navigating on your own.
5. How do you navigate, can you briefly narrate a typical day
6. Have you tried navigating using voice feedback
7. Do you mind wearing a gadget that is visible to other people?
8. Are you concerned about the physical appearance of the gadget
9. **Try out shear, pressure and pattern (discuss how)**
10. Would you mind wearing two gadgets (one for touch and one for voice feedback)
11. **Will you be able to navigate if feedback is given on the neck or the temples of your forehead like this (try and see)**
12. Do you like to ask help from other while travelling alone?
13. Do you like wearing glasses while travelling?
14. What is the most annoying thing about public transportation?
15. How often do you use public transportation? Do you think it needs improvement?

6.1.5 Design Brief

"To design a system/product for helping blind people find their desired bus correctly and guide them to the bus door, when the user is already at a bus stop."

6.1.6 Limitations

The system for such a device doesn't exist and it's very necessary to test such a system after designing. Hence, the design would probably be tested using Wizard of Oz method with the help of simulations.

6.2 System Design

This further led to the focus mainly being on these specific areas which are as follows:

1. **Locating origin bus stop/ platform**
2. **Locating the right bus**
3. **Accessing the bus**

The above mentioned problems are prevalent in both the countries and many blind users of public transportation face issues which restrict their navigation in general.

6.2.1 System Overview

Based on the secondary and primary research, and the main problem areas further identified as existing in both the countries. It was clear that a system level intervention was required and for the same mainly 3 systems were identified in the overall journey as,

1. User System
2. Platform System
3. Bus System

All of these need to communicate with each other and the user needs to get input from these contextually in order for him or her to navigate.

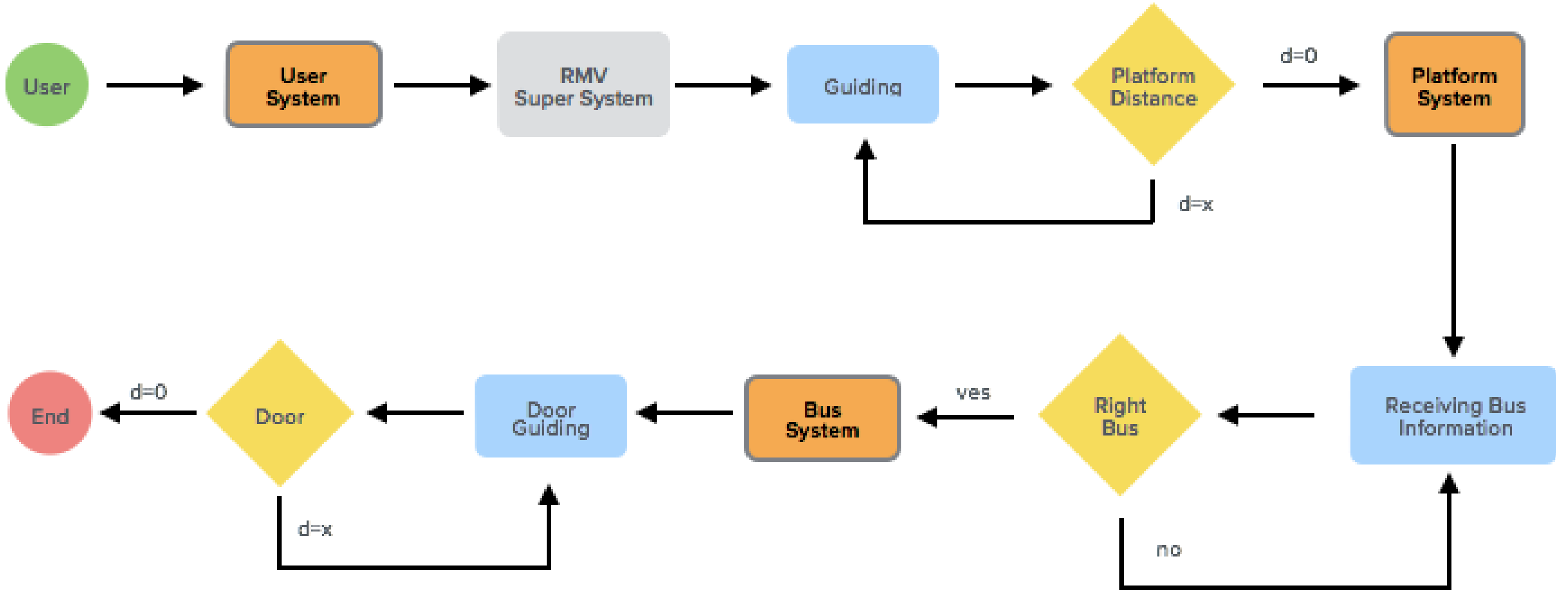


Figure 3: System overview of the proposal (Source: Author)

6.2.2 System overview with a Scenario

In order to explain the system overview, we made a persona.

Paul Kooper has these targets on a daily basis:

-Find the stop and the bus safely

-Convenient ride

-Fast orientation

-Be independent

User Characteristics:

-Paul Cooper

-Totally blind

-Usually uses public transportation on his own

-Orients with audio and tactile stimulus

-Uses smartphone and blind stick

Figure 4: Paul Kooper, the persona
(Source: Author)

6.2.2.1 Scenario

So, when Paul leaves from his home to work he goes to a bus stop. The bus stop is in a busy junction of the city. Many buses leave from the same bus stop every day. So it becomes difficult for him to locate his bus stop.

The idea is that the bus stand will interact with the device that Paul is using and give him cues.

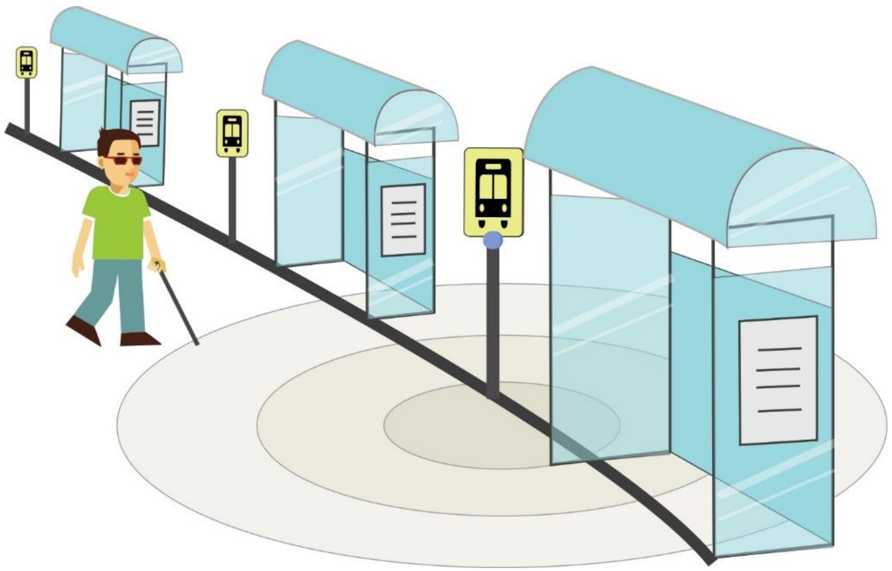


Figure 5: System Overview Illustration (Source: Author)

There is a beacon the bus stop and when Paul comes in its range, He gets signals from the bus stop and navigation feedback on the device on his hand which helps him orient himself in both known and unknown space easily since the signal is pretty accurate even for close proximity navigation. When close within a radius of one meter. Paul can just use his blind stick to confirm if he is standing at the right spot, which will be confirmed by the device, he is wearing.

When Paul reaches the right bus stop, he waits for the bus of his requirement to come. But when many buses come and leave the bus stop, it becomes difficult for Paul to determine his bus by himself.

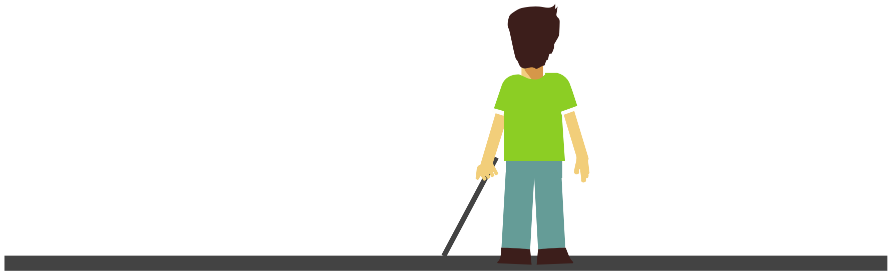


Figure 6: Persona waiting for the bus (Source: Author)

When people are there, he talks to them and inquire about the approaching bus and they also help him board it. But Paul likes to be independent. So the idea is to inform Paul about the arrival of his bus in advance and prepare him. The device on Paul's hands will give him feedback when the right bus arrives too, thus eliminating the error of choosing the wrong bus.

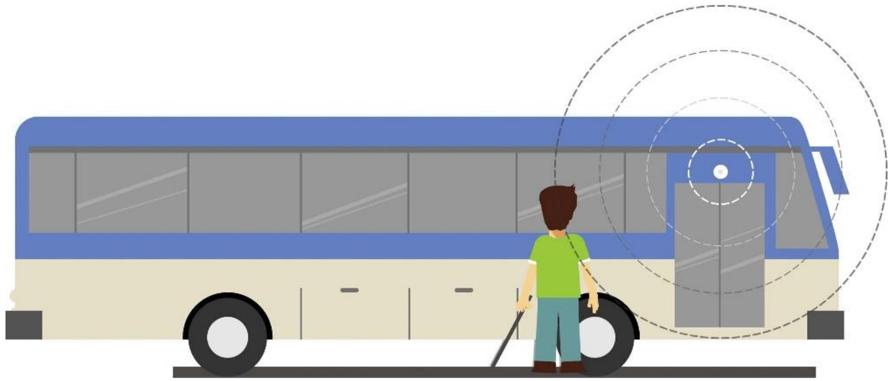


Figure 7: Illustration showing placement of beacon near bus door (Source: Author)

6.2.3 User Context

Based on the ideation and user interviews a table with user context was created as follows. This is a consolidation of the user and the stake holders along with the environment that could have possible impact on the user.

Table 2: User context, targets, work environment and equipment used by user

User and other stakeholder	blind or visually impaired person	-female and male person from the age of 7 (German regulation) -blind or visually impaired -unconfident in unknown territory -often recognizable as blind -commonly on their own -using public transport multiple times per day -collecting information in advance to the ride -sensitive for barriers -use smartphone mainly -orientation with audio and tactile stimulus	
		System	**Hardware**
Targets and work tasks	User targets	-find the stop and bus safely -convenient ride -fast orientation -bus identification -get on the bus safely -be independent	-useful -comfortable -keeping liberty of action -no disturbance of action -durable -inconspicuous -well designed
	System targets	-safe navigation of the user to the entrance -reliability -standardisation -integration and extension of existing systems	-allow user interaction -giving safety to the user -easy removable and put on

	Work tasks	-Interaction with the user -Bus stop and bus identification -distance calculation -guiding to platform, bus and door	-support system -calculate necessary processes
System environment	technical environment	-electricity on the bus (partly at the bus stop) -standard hardware on the bus is the ibis-wagon bus (VDV 300) and CANopen DIN EN 13149, slow transmission; GPS-, Bluetooth interface -BLIS Dresdner Verkehrsbetriebe AG -TRIAS new interface for standard real-time information VDV301, IP based -visual, auditory and haptic notification at the bus (partly at the bus stop) -Smartphone available for interaction over: radio-waves, Bluetooth, infrared, Wi-Fi, GPS -boarding aid (low floor busses etc.) -internet access -cell tower	-smartphone -other aid technology
	physical environment	-barriers/obstructions -different weather conditions (-20 to 40 degrees, rain etc.) -noises -vibration -illumination -passenger flow (crowd)	-clothes -blind stick -jewellery -(blind dog)
	social environment	-mostly on their own -hectic -availability of contact persons	

		-bus driver & conductor -passenger	
	cultural environment	-acceptance -language	
Equipment	User	-blind stick -blind sign -smartphone -blind dog	

6.2.4 Requirements

The following table is regarding the requirements for the development of the idea into a prototype. The requirement of the hardware, software, interactions, system and the legal norms are considered in this table.

Table 3: System requirement for prototype

Dimension	Nb.	Sub dimension	Type	Description	Source
system behaviour	1	independent, convenient and safe navigation	I	The user wants to travel independently and fast to find the bus stop and right bus	
	2	High location accuracy	I	Accuracy of the location should be designed for blinds (< 1m)	m4guide AP110
	3	Signal range	I	20m, because ranges >20m can be covered by GPS	example Luisenplatz

	4	Signal strength	W	resilient transmission and stability (e.g. other passengers vehicles)	
User hardware	5	Light, handy and portable	I	The user hardware is used and carried by the user in public. Therefore, is should be handy and light.	m4guide AP110
	6	Comfortable	W	The user will not use the system if it constrains the comfort in using public transportation	m4guide AP110
	7	Unobtrusive to wear	W	The user does not want to stand out as blind	m4guide AP110
	8	Easy to attach/ remove	W	The user hardware should be easily removable and attachable, but meet the requirement of steadiness	
	9	Affordability	W	The price of the hardware that is used by the blind passenger must be affordable for people from India and Germany.	
	10	Reliability	I	The hardware is used in traffic situation where an increased risk of incidents with other traffic participants exists. Therefore, the system and the battery lifetime must be reliable.	m4guide AP110
	11	Not hand wearable	W	The hardware should not be worn in the hands of the user due to theft and safety in case of slump	m4guide AP110
	12	One hardware	W	Due to comfort and price issues there should only be one hardware	m4guide AP110
	13	Resilient	I	Touchable for tactile feedback	
	14	Low risk of loss and theft	I	The product should have a low risk of loss and theft	

Interaction Requirements	15	Two-Sense-Principle	I	The barrier-free usage of public transportation requires that people with sensorial restrictions can receive information. Therefore, always two senses should be addressed simultaneously.	DIN 18040-3:2014-12
	16	Consistent design of guiding systems	W	The design of the system should be consistent to existing solutions that blind passengers know the meaning of the stimulus.	Interview DBSV, DIN 18040-3:2014-12
	17	Visual, Audio and Tactile feedback	I	Seeing, Hearing and Feeling is for a safe navigation inalienable.	DIN 18040-3:2014-12
	18	Visual Feedback	W	Good Contrast (K>0,8 - Luminance - DIN 39975), legible writing, bold letter	DIN 18040-3:2014-12; DIN 32975
	19	Audio Feedback	I	High relation between useful signal and disturbance noise	DIN 18040-3:2014-12
	20	Voice interaction	I	Voice entry and voice output, high volume	m4guide AP110
	21	Tactile Feedback	I	The signal must be recognisable. Sensation with fingers, hands, guiding stick, feet, minimum 2mm height	DIN 18040-3:2014-12
	22	Vibration	I	Vibration feedback is demanded by blind people	m4guide AP110
	23	Continuous feedback	W	Geiger counter for continuous feedback is the recommended solution	m4guide AP110
	24	Self-description	W	The user hardware is easy to understand and enables an easy and intuitive input of information.	DIN EN ISO 9241.10
	25	Expectation-compliant	W	System reacts as the user would expect.	DIN EN ISO 9241.10

	26	Individualisation	W	Changing between input and output signals and the user interface.	DIN EN ISO 9241.10, m4guide AP110
	27	Fault-tolerance	W	Autocorrect and avoidance of mistakes	DIN EN ISO 9241.10
	28	Controllability	W	Several function: Back, Repeat, Delete, enough break between commands	DIN EN ISO 9241.10
	29	Appropriate for tasks	W	Just provide the user with the necessary information (e.g. default values or often used functions)	DIN EN ISO 9241.10
	30	Facilitation of Learning	W	User improves usage speed while using the system	DIN EN ISO 9241.10
	31	Minimal disturbance of passengers or environment	W	The system shouldn't disturb other passengers or the other environment.	Interview m4guide
	32	Minimal interference on other senses and signals	W	The user shouldn't be disturbed in his important senses (e.g. no additional tactile feedback on the stick)	
	33	status feedback	W	The system should give feedback that it works and in case of an error it should give a warning.	
Offered Information	34	Location of the platform and the bus stop	I	Warning in advance and when the user finally arrives at the platform	DIN 18040-3:2014-12; VDV
	35	Bus number of the vehicles departing from the platform	I	Bus number of all approaching and departing vehicles from the platform	m4guide AP820
	36	Delay	W	Warning when the selected bus is delayed	m4guide AP820
	37	Information for change of busses	W	Getting necessary information about changes of busses	m4guide AP820

	38	Location of the bus door	I	Guiding the way from the platform to the bus door	Interview DBSV
	39	Information about the distance	I		m4guide AP110
System Architecture	40	Integrate ability into existing infrastructure	I	The system for the bus and platform must be integrate able in the vehicle or the platform, especially existing technology.	
	41	Compatibility with Interfaces	I	The system requires the compatibility with existing systems (like RMV, TRIAS) ,especially concerning the interfaces between them	
	42	Interaction with Stakeholders	W	The interaction between the user and the bus driver or conductor may improve the comfort of usage	m4guide
	43	Evaluation friendly system	W	The system and its impact should be evaluable.	
	44	Modularity	W	The system exist out of different modules. Functions can be activated or deactivated on demand	
Miscellaneous	45	Legal Conformity	I	The system and the usage must comply with relevant legal issues.	Personenbeförderungsgesetz BO-Kraft; Straßenverkehrsordnung; ISO 612-1978; TÜV
	46	Impairment on health	I	The user must not be impaired on health or lead in dangerous situations.	
	47	Data Security	I	The data and the privacy of the system user must be secure.	GG, Bundesdatenschutzgesetz
	48	Acceptance	W	Acceptance of the product by the society and the individual user, especially concerning the German and	

				Indian market as well as the target groups.	
	49	Cost Effectiveness	W	The system should be produced sustainable and market profitable.	

6.3 Product Proposal

6.3.1 Wearable

Based on the system overview, an initial idea was to create a wearable as the system that the user has on him or her. For the ideation many factors were considered and compared. The place to wear and the feedback that the device has to give to the person wearing are a few of the considerations made. The following sections have these considerations in tabular format for convenient comparison.

6.3.2 Categorisation for development of Idea

Table 4: Categories of various technologies, feedback mechanism, places to wear, sensor, Existing examples, wearables and possible solutions

Technology	**Feedback Mechanism**	**Sensor**	**Place to wear**	**Gadget/Existing Examples**	**Wearables**	**Possible solutions**
Bluetooth	Voice, Noise	Visual	Hand	Smartphone	Wrist band/Watch	Blind Stick with navigation
Wi-Fi	Visual	**Auditory**	Wrist	Smartwatch	Shoes/Vibrating Soles	Guiding Dog/Bot
GPS	Touch/Tactile	Vestibular	Head	Fitness bands	Glasses	Segway
Infrared	-Vibration	Gustatory	Arms and Hands	New Gadgets	Collar(neck)	Google glass sorts
Radio-waves	-Thermal	Olfactory	Neck	blind stick	Glove	Wearable dress
	-Shear motion	**Somatoviszeral (tactile)**	Leg/Feet		Clothes	
	-Texture/Pattern	Motoric (kinaesthetic)	Ears			
	-Puncture		Body (others)			

6.3.3 Pros and cons of various feedback mechanism

Table 5: Pros and cons of various feedback mechanism

Feedback	Pros	Cons
Voice, Noise	-demanded by DBSV -much information within short time -feeling of interaction with a person -blinds are used to it -sense enhances when blind (echolocation improves)	-problem of understand ability -disturbance of other important information (e.g. missing of car sounds) -cannot replace vision
Visual	-much information within short time -seeing of items -depth of focus	-some might not see at all
Touch/Tactile in general	-tactile spatial acuity enhances when becoming blind	-difficult interaction design (blind has to learn)
-Vibration	-demanded by DBSV -blinds are used to it	-disturbance of other important information (e.g. missing of feedback of blind stick)
-Thermal	-no disturbance of other feedback	-needs time to recognize, high contrasts needed -not much information can be transferred
-Shear motion	-clever for showing directions	-not approved yet (product has to be developed)
-Texture/Pattern	-commonly used by blind	-needs time to be read, realized
-Puncture	-independent of other feedback mechanism	-pain

6.3.4 Physiological Constraints

Comparison of places to wear

Table 6: Comparison of various places to wear

Wrist	>Comfortable >But when folded slightly, the feedback accuracy is lost >Easy to operate (even while moving) >For sighted it is comfortable to use the display at a distance that is convenient >Traditionally used to wrist watches so it is easy to adapt	>Sweat >for voice feedback need additional device	(Frank, 2015)[11]
Head	>Increases proximity to ear and eyes - helps to combine senses >Step by step navigation with confirmation		[11]
Ears (heads + ears like head mounted display)	>Very less disturbance as this body part is like a tunnel >Best for feedbacks that involve sound >Can also keep hands free >Can answer calls >can shake head to answer a call and just talk >For giving multiple feedback (auditory, vibration etc.) this reduces the number of wearables >The device remains hidden >Works for step by step navigation	>Invasive >Less comfortable to wear for a long time >The moisture from the ear canal spoils the electronics (needs great care while manufacturing for long run)	(Know, 2006) [12] [11]

Types of Receptors on Skin

- Meissner Corpuscle - Stroking, fluttering
- Pacinian Corpuscle - Vibration
- Merkel Disc - Pressure, texture
- Ruffini Ending - Skin stretch
- Hair tylotrich, Hair guard - Stroking, fluttering
- Hair-down - Light stroking

Pressure on skin

Pressure and skin stretch take longer to return to rest state, which means the impact is felt longer. They return to rest state as long as it does not cause any pain.

Pressure can be felt in 3 dimensions
>as a point of pressure (where force of a mass on the body is focused at one point, such as a digging corner of a solid form),
>as a line or band of pressure (a digging edge or belt),
>as a planar pressure (such as a circumferential compressive garment like a girdle, or as force spread over a contoured surface).

Pros and Cons of different places if wearable

Table 7: Pros and cons of wearable at different places

	Pros	**Cons**	**Types**
Head	The proximity to our eyes makes glasses the most natural device for tasks that require our sense of sight.		>Head up display (google glasses) >Display with sound (VR devices)
Ear	>discreet so remains unnoticed >continuous instructions	>The smaller the device the smaller is the battery and this reduces its lifetime	>BTE Hearing Aids; These devices are worn with the hearing aid on top of and behind the ear. All of the parts are in the case at the back of the ear and they are joined to the ear canal with a sound tube and a custom mould or tip. >ITE Hearing Aids: These are custom made devices, all of the electronics sit in a device that fits in your ear, they come in many sizes including CIC (completely in Canal) and IIC (Invisible in Canal). >RIC RITE Hearing Aids: These devices are similar in concept to BTE hearing aids, with the exception that the receiver (the speaker) has been removed from the case that sits at the back of the ear. It is fitted in your ear canal or ear and connected to the case of the hearing aid with a thin wire.
Wrist bands / watches	>Disappears in a while (forget that one is wearing it)	>certain material and weight can cause sweat rash or muscle fatigue	

For the placement of the device, a placement study was done. As identified in this research (Design for Wear ability; Francine Gemperle, et al. (1998)) by Carnegie Mellon University, we identified these places on the human body were a wearable is convenient when a person is in motion. Since the person needs to wear it while walking, all the body fluidity has to be considered and the areas identified are shown in figure 4.

Based on considerations of ease of device operation while in motion outdoors, the shortlisted areas where neck, hips and forearm. For the conclusion of the placement position, we asked them about their convenience in the interview conducted with 7 blind users.

Most people felt forearm as the most convenient with the feedback being vibration supported with audio feedback. Thus we proceeded forward with an arm band for the wearable with vibration and auditory feedback.

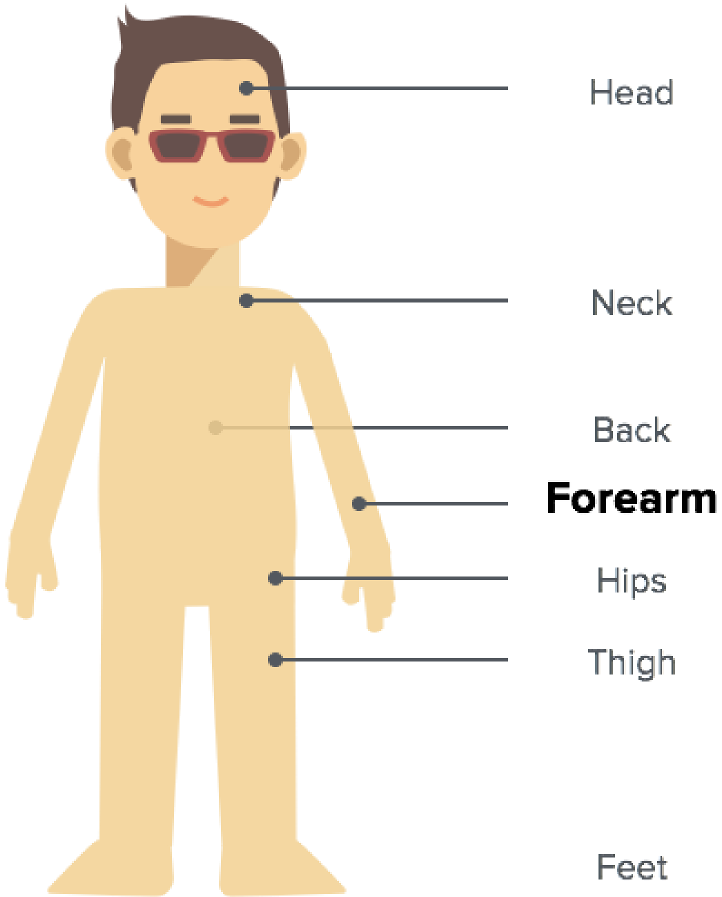


Figure 8: Illustration showing various places to wear

6.3.1 Prototype

After the required placement and feedback study, it was decided to generate ideations for placing the device on forearm and build prototype accordingly. The theoretical framework of the device is given in the following image. As noticeable, the entire system is driven by a smart phone which acts as a processor. The smart phone takes information of the door location of the bus from the beacon fitted on the door top, and transfers it to the device. The wearable device then converts the information into a more legible and understandable manner and gives it to the user in form of auditory and tactile feedback.

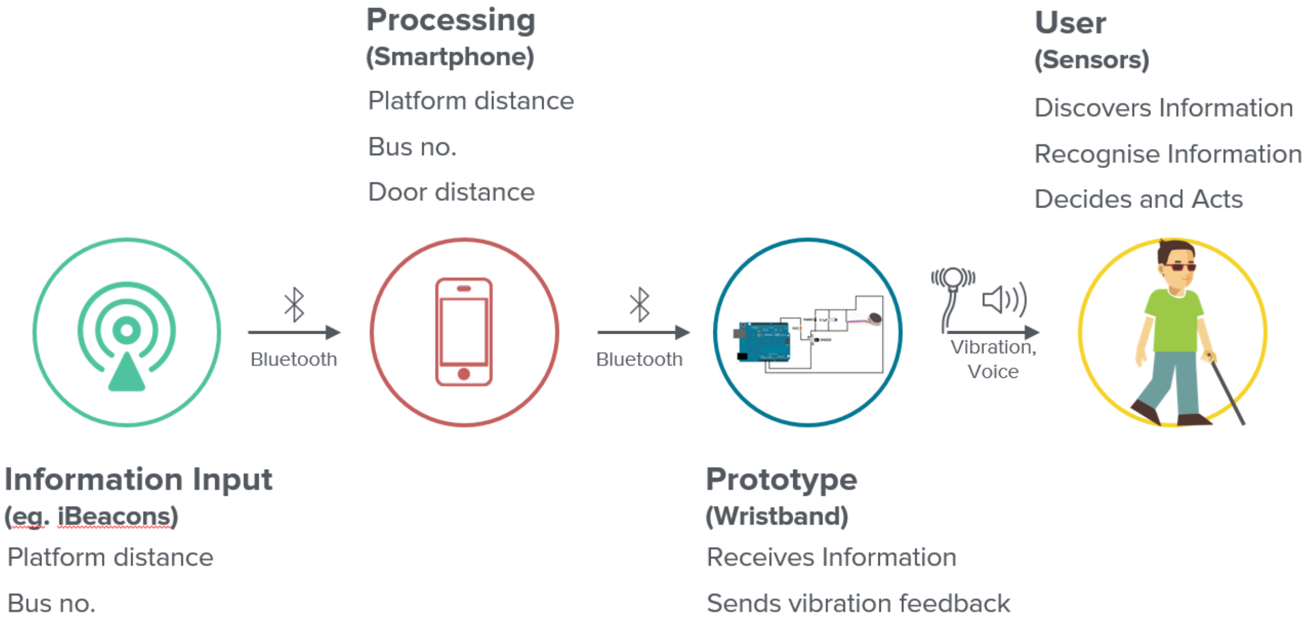


Figure 9: Theoretical framework of the device (Source: Author)

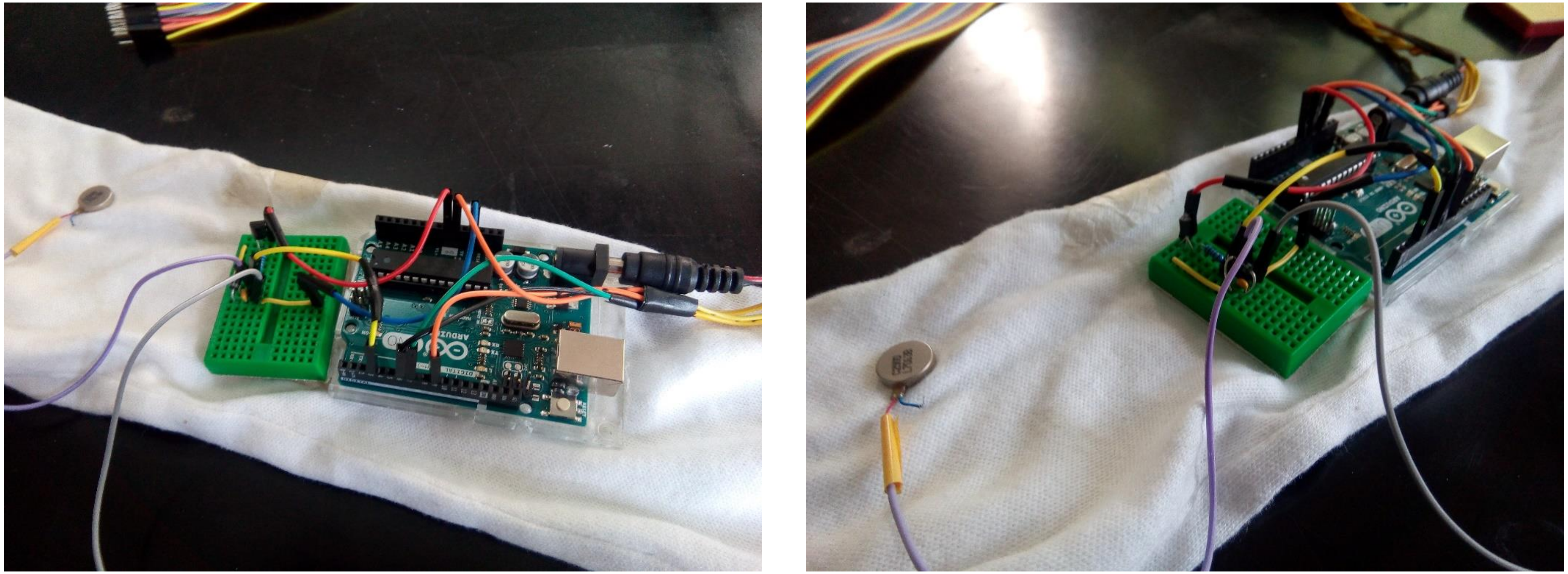


Figure 10: Arduino Prototype Glove Used for testing the concept (Source: Author)

The prototype was basically a simulation of the vibration patterns. The vibration patterns were generated with the help of Arduino board and a vibration motor. This prototype basically had four types of vibration pattern distinctive in the frequency of vibrations it generates. Thus, each vibration is basically a recognisable signal which user can recognise and act accordingly.

6.3.2 Ideations

The various ideations for the arm band or the vibratory feedback device were also generated, the following image shows a few of them. The ideations generated were majorly focussed on understanding the aesthetics, usability and wearability of the device, based on the current trends in wearable technology. The shown sketches below are only schematic and conjectural, however, the final outcome at the end of the design process might be completely different in aesthetics but conceptually similar to these.

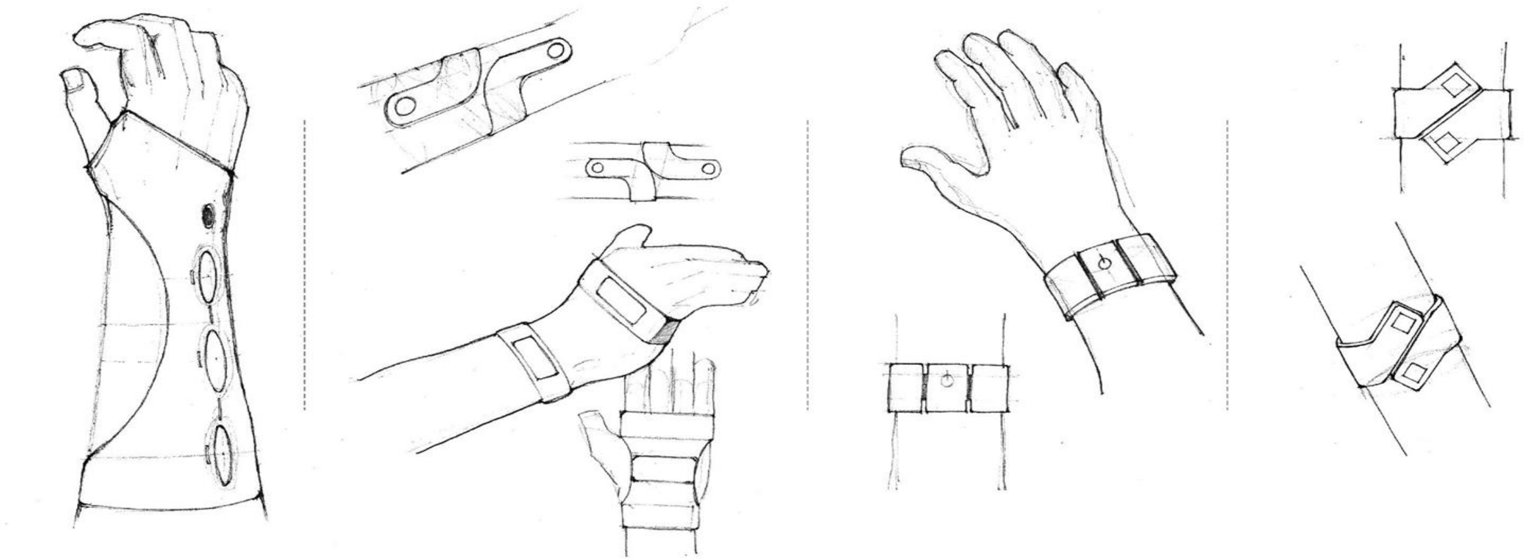


Figure 11: Ideation sketches for guiding glove (Source: Author)

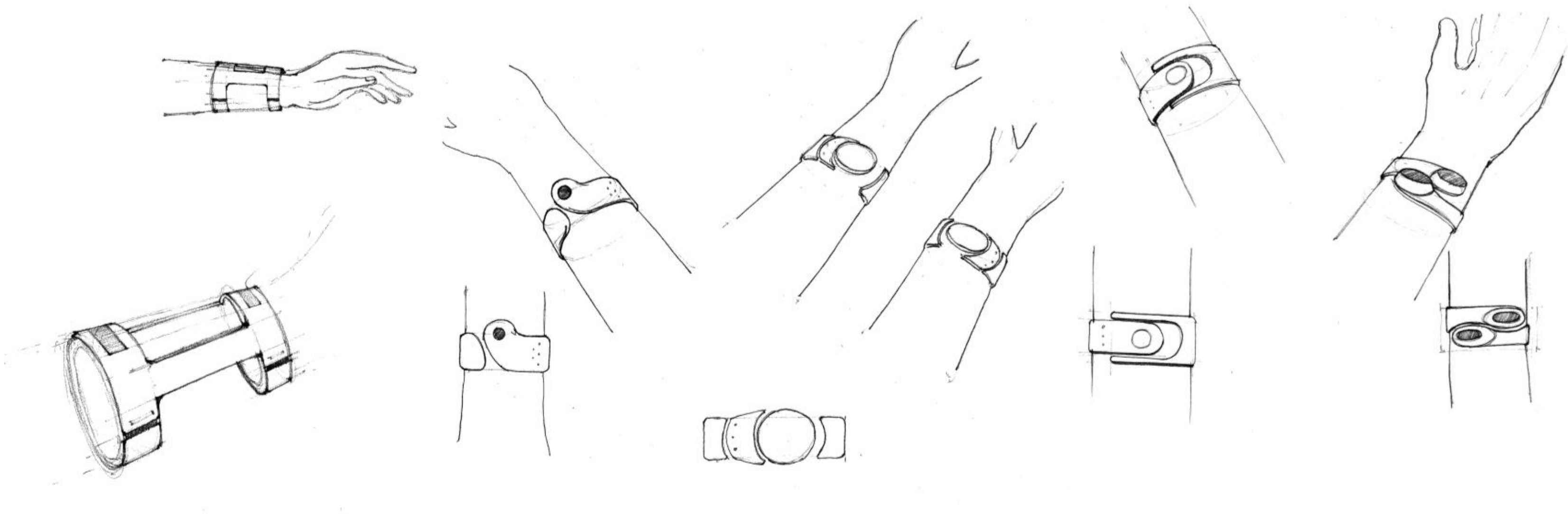


Figure 12: Ideation sketches for guiding glove (Source : Author)

6.4 Product Evaluation

The evaluation of the concept was done in Mumbai after all the students came back to IDC on 10th Feb. 2017. The users were chosen based on their age and were given a task to do with the help of the prototype.

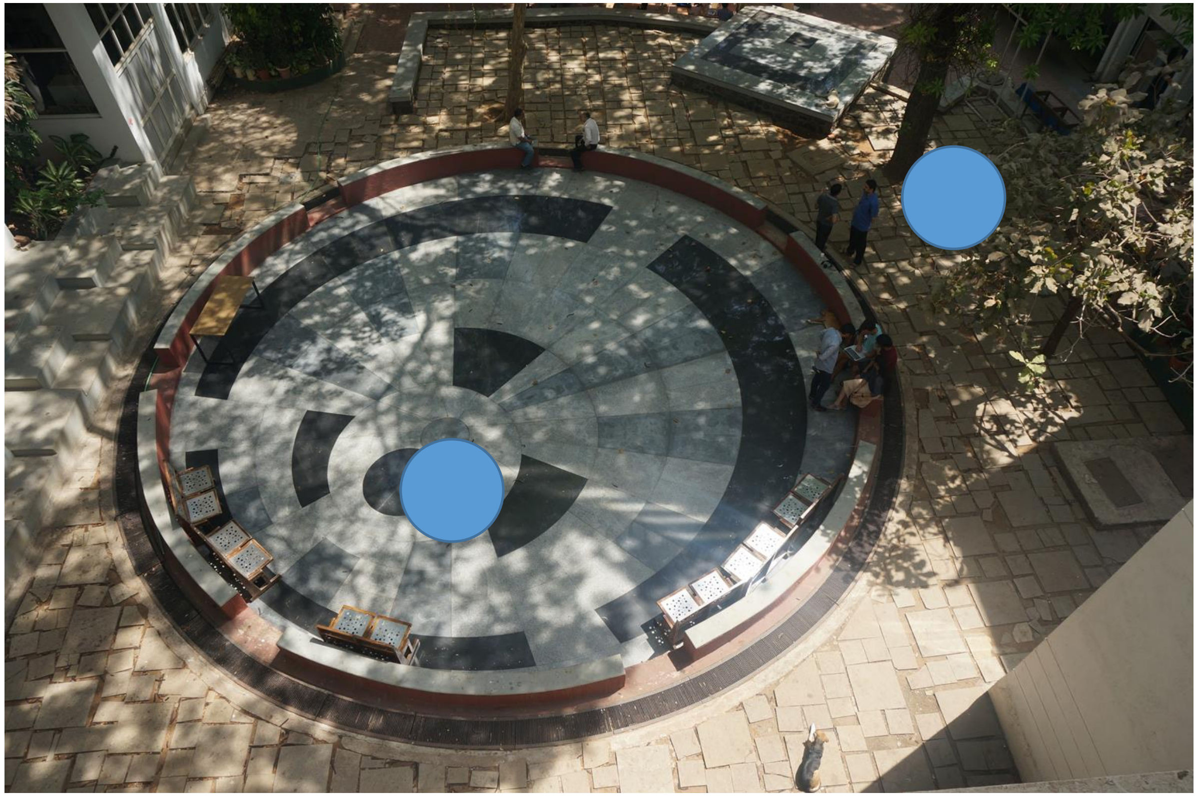


Figure 13: The testing being done at design circle. (Source: Author)

Figure 14: User testing in progress (Source: Author)

6.4.1 The Task

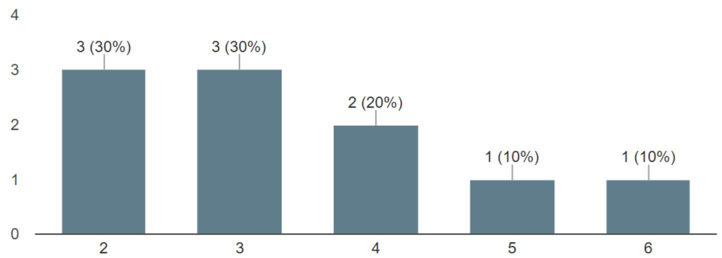
The device gives vibratory feedback as per the distance from the destination. For distance as far as 10m it vibrates with a lower frequency.

As close as the person moves towards the destination, the frequency increases and ultimately turns into continuous vibration once the destination is reached. If the user moves in a wrong direction, the vibration feedback stops and gives an auditory feedback to recalibrate or reset.

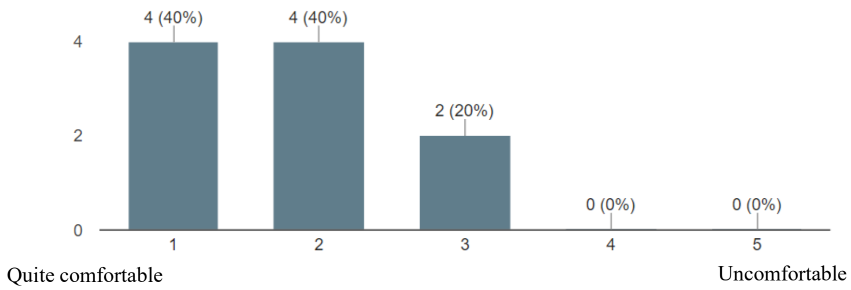
After re-calibration, the user is supposed to turn/rotate in any direction. Once the user is in right direction, the device starts giving feedback as per the distance at the point from the destination, in this case the bus door. For user testing, a particular point was demarcated as bus door, and the user was given the task to reach to that destination while recognizing the device patterns.

6.4.2 Evaluation Results

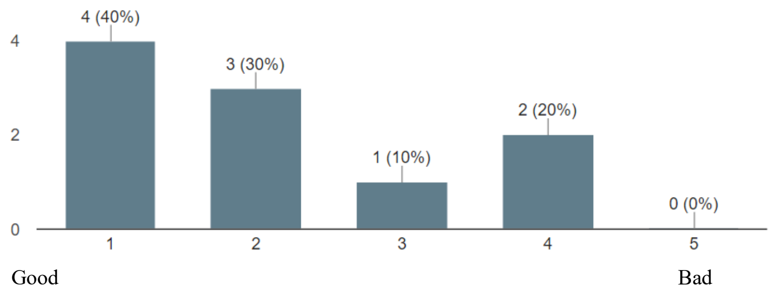
Number of recalibrations (10 responses)



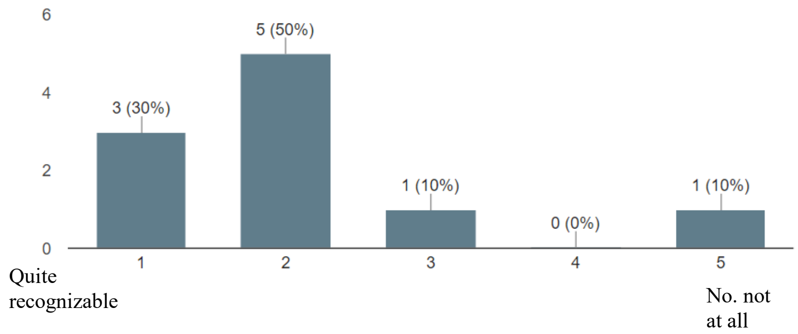
How is the comfort of wearing this device? (10 responses)

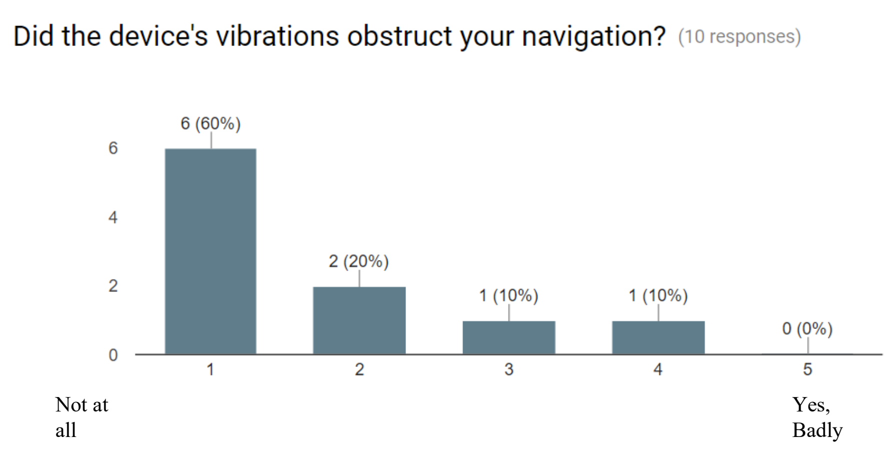


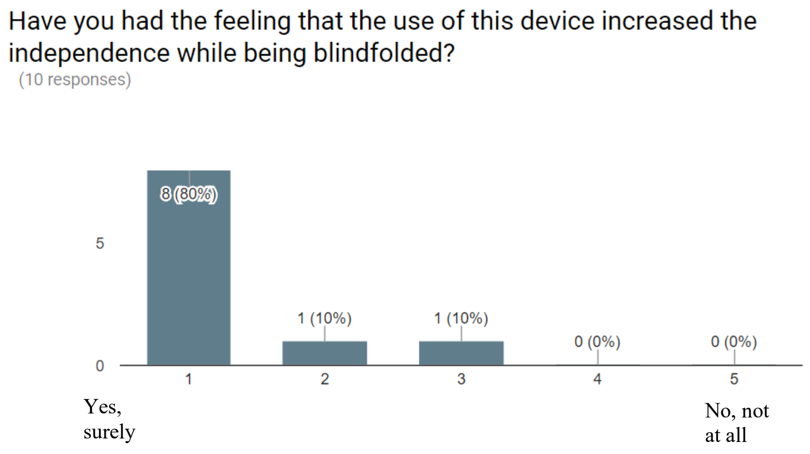
How do you like the placement of the motor? (10 responses)



Was the pattern generated recognizable? (10 responses)







5.3.2.1 Feedback about patterns

A little more contrast with audio would be needed.
More training is required before testing.
More patterns (number of changes) would help better in guiding.
Vibrations coming from different directions could also be explored.
Intensity difference can also be incorporated.
Alerts sounds can also be incorporated with the changing vibration pattern so that you won't miss the pattern change.

5.3.2.2 Feedback about Device

Voice feedback should be used more frequently
Calibration, vibration and the rest coincide. The first vibration need not be so intense.
Felt like a co passenger, but auditory signal was difficult to understand in crowded area.
There should be different vibration for right and left.

6.5 Conclusion of first part

Designing for visually impaired is one such field of design which has been a point of discussion for decades and still the solutions are debateable. This doesn't mean that the solutions are ineffective but that it's such a critical and special human condition that it's not easy to predict the success or acceptance of any product. And hence, this makes it more interesting to work on such projects. The unique finding during the project was that these two contrasting cultures of India and Germany still face difficulties in finding solutions for such population similarly which made the problem even more challenging. The common issues faced by visually impaired people both in India and Germany were well understood and brainstorming and detailed discussions were carried out in order to come up with something which would be suitable for both the contexts holistically and can adapt to both the systems.

Till this stage, conceptually the device has been designed and discussed with visually impaired people in Darmstadt. The response to the device has been quite positive and motivating. The device design and experience with the blind users were quite motivating and insightful. It shows how difficult is it to be not able to see and how such small things could be so difficult if one doesn't have sight. This background and benchmark knowledge was carried forward in later stages of the project, and then both the students from IDC took it forward differently and individually.

06

7. Part Two: Designing for Indian Context

7.1 BEST Bus system in Mumbai

The transport wing of Brihanmumbai Electric Supply and Transport Undertaking (BEST Undertaking) operates a large number of bus services in the Mumbai metropolitan area. These buses are called BEST or BEST bus. BEST bus serves the entire Mumbai City. It has operations outside city limits into neighbouring Navi Mumbai, Thane and Mira-Bhayandar. In addition to buses, it operates a ferry service in the northern reaches of the city.

The present BEST undertaking was started as an electric supply company which then branched out to provide bus and tram services.

7.1.1 Bus Routes

The routes operated by the BEST can be broadly classified in the following categories.

- Feeder Routes: These routes which feed the railway stations either from the residential complexes or business districts.
- East-west connectors: These are the routes, which run east/west, where railways have no role to play and connect the western suburb with the eastern suburb.
- Trunk routes: These routes run south-north through the city and are almost parallel to the railways.
- AC express routes: These route runs on western and eastern express highways, to provide faster services to the commuters.
- AC standard routes: These are air conditioned routes across the city.

7.1.2 Depot and Fleet

The BEST uses CNG and conventional diesel buses. As of January 2015, the BEST has a fleet 3600 buses. The fleet comprises single-decker diesel buses (602), CNG buses (2694), double-decker buses (122) and JCBL Cerita A/C buses (282). All are tagged with a route number and its corresponding destination. They are displayed in the front in Marathi and on the side in English.

7.2 Understanding the users in context of Mumbai

After the design and testing of the device for guiding blind user to the door of a public bus, the further research was carried out to form the basis of the further project. The aims of the study were as follows:

- Understand the current system of public transportation in Mumbai.
- Find out issues faced by blind users accessing public local buses.
- Find out the areas which need to be improved in the current infrastructure.
- Find out the areas which could be developed for future.
- Finalise the problem statement and design brief.
- Create design solutions and test with actual users.

In order to achieve aims discussed above, author interacted with the blind users, experts in the field and empathised the situation with the help of role playing exercise. The following parts of the report shows the inferences from the above.

7.2.1 Blind Users interview, Mumbai

An interview was conducted with residents of Mumbai and I did a cluster analysis of the information to understand cultural differences and contextual requirements. Findings of the interviews were:

- Blind people need help to find out bus numbers and gets help from people (mostly family)
- While on a bus route is new, asks conductor
- Gets familiar with the new route in 3 to 4 days
- Uses maps to identify bus stop himself (creates his own hacks to use the technology)
- When no one to identify bus number, misses the bus.
- Conductor or people who know the person help or if they know the person is blind then help is extended
- Crossing roads at intersections or while changing buses is difficult
- Any digging or construction signs are not accessible since information is not known
- While using talk back it is difficult to keep the phone near ears and the volume has to be low in public spaces
- Users don't have much options other than to travel by BEST buses to go from one place to the other in Mumbai.
- Daily users prefer to take bus from their fixed bus stop daily.
- Bus stops and buses are not designed keeping in mind this critical passenger group. This makes this non-inclusive for such passengers.
- The infrastructure is such that they have to depend on the fellow passengers for even the smallest information.
- The information about the buses and routes is always in print media. It's impossible for them to access this information.
- This information most of the times is not even available for sighted users.
- Sometimes this information is available but only through the help of smart phones.

7.2.2 Understanding the existing infrastructure

The existing system of Buses and Bus stops are non-inclusive for the Blind users. They are in no way designed keeping in mind these users, and because of this these users face difficulties in using public BEST buses and it discourages them to use it or compel them to be dependent on fellow passengers.

Figure 15: A typical Bus stop in Mumbai (Source: Google Images)

7.2.3 Bus Stop Issues: IIT Market Gate

Figure 16: IIT Market Gate Bus Stop (Source: Author)

Missing Identity: Lacks sense of place, unable to help people use the system without prior knowledge.

Figure 17: IIT Market Gate Bus Stop (Source: Author)

Necessary Information: Information regarding bus and bus route is not available either for sighted or blind people.

Information board: Very crudely designed bus board. No way to get the routes of buses.

Figure 18: IIT Market Gate Bus Stop (Source: Author)

No Tactile Paving. The bus stop provides no additional support to blind users

Obsolete Seating. Buses stop away from bus stop, hence in order to get a seat, people prefer to stand out over sitting in shed.

Inadequate Space. Not enough space for people to stand in case of harsh sun or rain.

Advertisements. More emphasize on advertisements than necessary information.

Figure 19: IIT Market Gate Bus Stop (Source: Author)

7.2.4 Bus Stop design standards

Following are some bus stop design standards as suggested by CPWD, Delhi and Ministry of Urban Affairs & Employment:

- Two rows of guiding blocks for persons with impaired vision should be provided 300 mm. away from the bus stop pole on the sidewalk.
- The bus stop pole should be clearly visible after dark.
- The bus stop area should be equipped with a roof and bench.
- Information on the names of all stops along a bus route should be indicated inside the bus by displaying text in a suitable position. Preferably, this information should also be announced verbally.
- Information on a route and its final destination should be displayed outside the bus in large text, especially on its front and side.

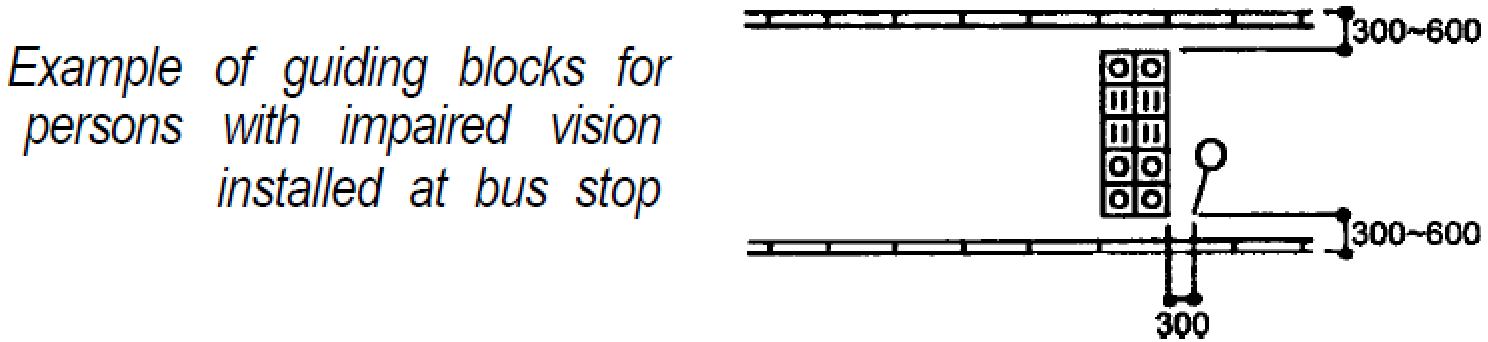


Figure 20: Guiding Blocks at Bus Stop (Source: CPWD Guidelines)

7.3. Issue Identification

Though among so many other issues, one of the major issue found out was the unavailability of information of the buses at the bus stop. Furthermore, this information is also unavailable to any user let alone blind people. Hence, this issue of no information available will be taken ahead and understood, and the design proposals will be given for the same.

To sum up, following are the issues faced by blind users while accessing information at a Bus stop.

- There is no way to know which bus is about to come to the Bus stop
- The information boards don't provide information for the upcoming buses
- The information for bus routes is also not present.
- There is no way a blind user can get information about the buses without taking help from any fellow passenger.

7.4. Scope of the project

The project is primarily designed while keeping blind users as primary users. The design issues are primarily understood in perspective of the blind users. The need for information to be accessible to these users is very critical. However, the design would also consider sighted and users with low vision as well, as being the nature of the project.

7.5 Limitations

This timeline of the project restricts it to be ended in stipulated time period. As the nature of the project is inter disciplinary, working prototypes might not be ready in the stipulated time period. Simulations through soft prototyping and 'Wizard of Oz' would be a primary method of testing the system.

7.6 Final Design Brief

“To design an information system to be deployed at bus stops of Mumbai for passengers (primarily blind) to aid users to choose appropriate bus to reach his/her desired destination”

The major aims/deliverables of the information system would be:

- To inform user about the current upcoming bus.
- To suggest user which bus to take for his/her desired destination.
- To inform the user about scheduled arrival & ETA of the desired bus.

Along with that, the system needs to be

- Designed for general public too (i.e. sighted people)
- Requiring less maintenance
- Easy to deploy
- Unobtrusive

7.7 Research

After finalising the design brief, a research was needed for understanding such systems which are used for disseminating information at bus stops and what are the various constraints which would govern the design of this system.

7.7.1 Existing Examples

7.7.1.1 Electronic Boards

Generally, such kind of information systems which provide information about upcoming buses could be easily seen throughout the world. However, the information is still inaccessible for people with visual impairment.

Figure 21: A typical information board at bus stop (Source: Author)

Above image is a typical example of an information board at bus stops. One can find such information boards all across the world. These boards are not only insufficient but also inaccessible for blind people.

Figure 22: Information Board at a Bus Stop in Oregon, USA (Source: Google Images)

The design of such boards are mostly done while keeping in mind the larger population which is sighted and can understand visual information. This is critical issue because makes blind people dependent on fellow passengers and sometimes there is no one to help them when they need help.

7.7.1.2 Printed Route Maps

Another kind of way to information system available on the stops are the printed maps. In this medium, the amount of information is generally so much that it's difficult for people even with sight to even grasp all that. Every major city of the world has such maps which are designed for knowing the transportation routes but it's so complex to read them even for a sighted person that it is almost impossible to design the same for a blind user.

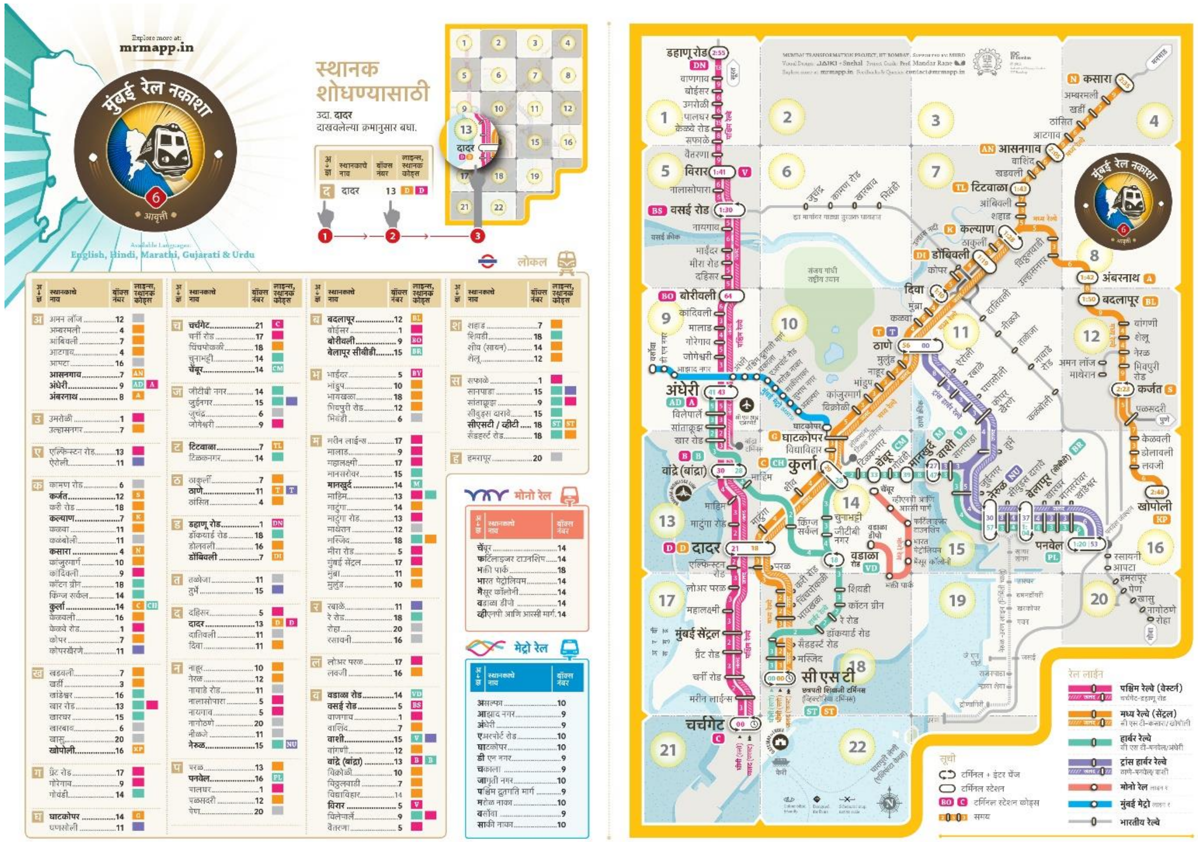


Figure 23: MRM Map by Prof. Mandar Rane (Source: MRM)

Figure 24: Bus Route map in London (Source: Google Images)

6.8.1.3 Interactive Kiosks

Another medium of information one can find on a bus stops in some countries are the interactive information kiosks. These are quite helpful in providing information mostly with the help of touch based interface, and user can find out various routes easily. But, it's very unlikely that these are designed keeping in mind the blind population.

Figure 25: Information Board at Busan, South Korea (Source: Author)

A Bus Information System (or BIS) collects real-time data of buses' locations, and then displays estimated arrival times on the BITs (Bus Information Terminals). As part of their trial operation, 160 BITs were installed and operated around Busan. They were quite successful in providing necessary information about the routes but again non inclusive for blind users.

7.7.2 Ergonomic Study

There are basically two parts of understanding ergonomics in this particular project.

1. Understanding ergonomics for physical interaction of the device with the users.
2. Understanding visual ergonomics for the display of information

Physical ergonomics

Whilst functionality and aesthetics are crucial in any kiosk solution, an equally important consideration is user comfort.

Considerations include immediate ease of use, which is affected by factors such as the height and angle of the screen and the size of the on-screen keys or buttons. These are factors that can subconsciously affect a person’s decision to interact with the kiosk or not. However, kiosk design must also account for the ongoing comfort of the user, avoiding any feature that may lead to a type of repetitive strain injury.

Designing for Multiple Anthropometric Dimensions. There are several body measurements that could be relevant for reaching a touch screen, but a practical one would be Forward Grip Reach distance - roughly the distance from the shoulder axis to the palm of the hand. With those two metrics in mind - eye height and forward grip reach - you could picture any user as the function of two perpendicular lines - a vertical line, representing the individual's eye height, and a horizontal line representing arm reach. This is illustrated in the accompanying figure for three different representative users - note that the wheelchair user has a sitting eye height compared with the two standing users.

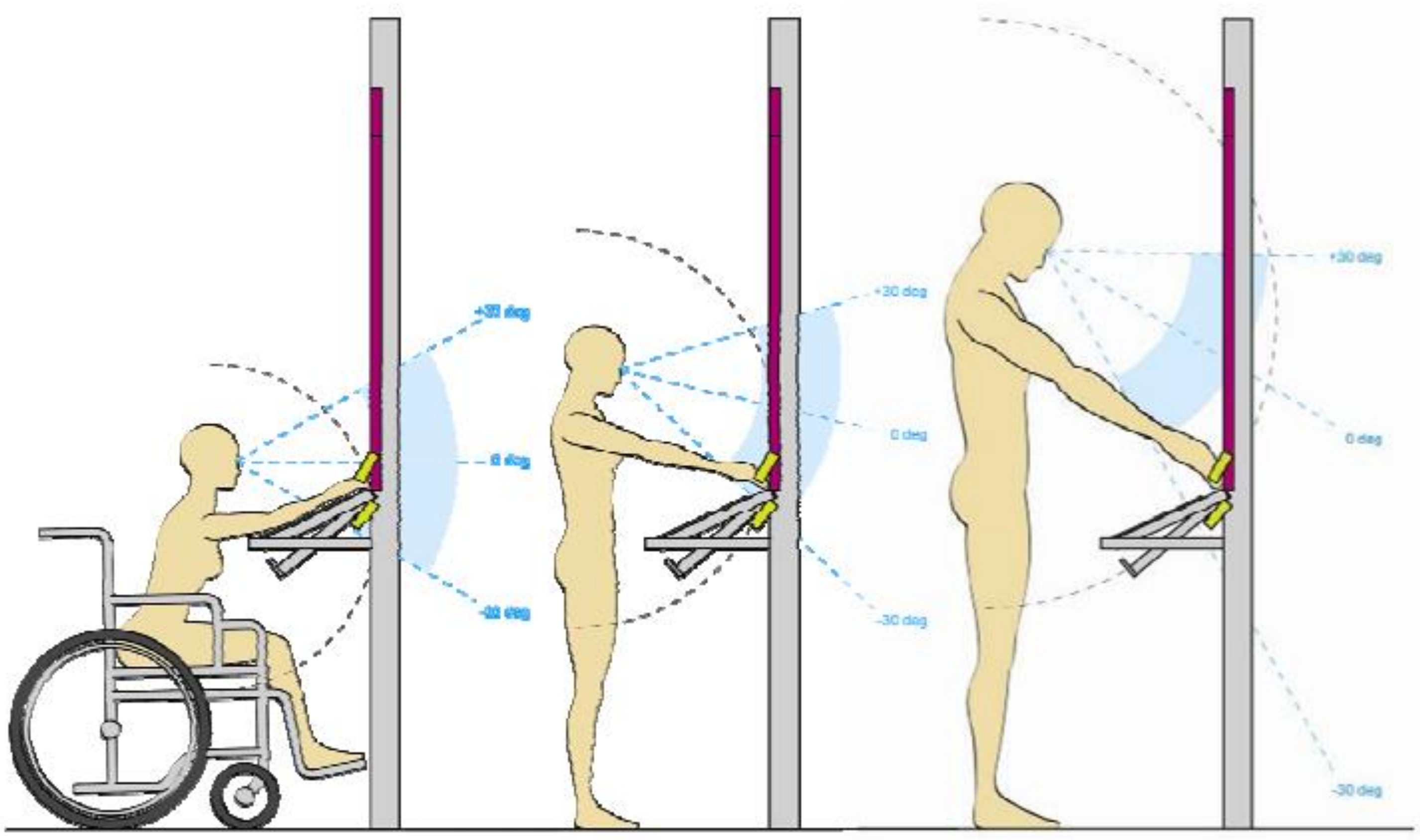
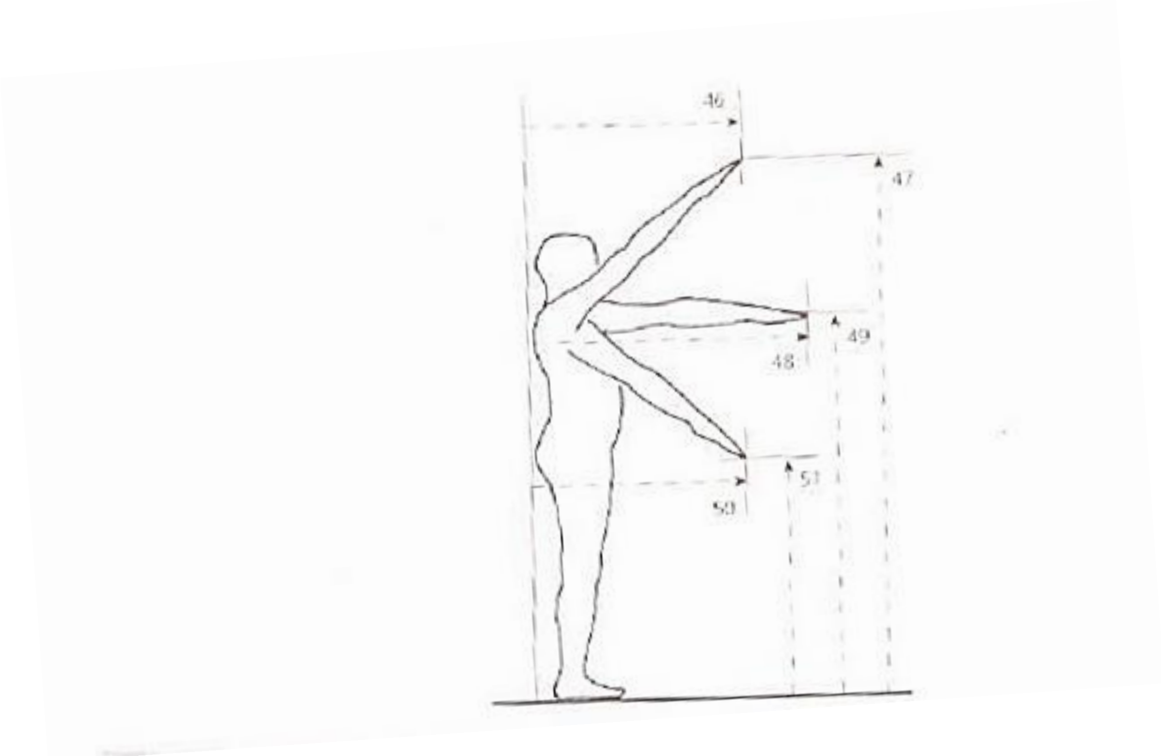


Figure 26: Kiosk Ergonomics (Source: Ergonomics for Interaction Designers, IDSA, Bresseler group)

Various dimensions to be considered are taken from Indian Anthropometric Data by Debkumar Chakrabarti.



			5th	25th	50th	75th	95th
Upper Position Height	Male	1575	1659	1799	1869	1949	2064
	Female	1290	1519	1659	1753	1849	1949
	Combined	1290	1624	1769	1849	1929	2059
Mid Position Height	Male	1090	1229	1309	1369	1409	1509
	Female	1070	1139	1209	1279	1329	1439
	Combined	1070	1179	1279	1349	1399	1489
Lower Position Height	Male	510	659	729	779	839	939
	Female	560	619	719	769	819	889
	Combined	510	649	719	779	839	939

Visual Ergonomics

Points to consider include the text size, colour and glare from the screen, suitability of the interface design and even the feedback that the interface offers a user. These are particularly vital considerations for interactive solutions that are likely to be used regularly by the same people.

Contrast between the foreground and background is one of the most important factors for the ease of reading. If coloured text is used on a bright background the contrast will be weak, for optimal contrast results is white text against dark coloured backgrounds. In signage & wayfinding design colour is the combining factor to harmonize the sign with the environment. Colour programs will distinguish signs from each other and can offer an indication of the message without having to be able to understand the language of the sign.

The Letter Size

Information boards above the ground need this additional size to attract a motorist's attention. The following chart is a standard guideline used by most sign professionals:

Letter Height (in Inches)	Maximum Readable Distance	Distamce for Maximum Impact
2"	50'	20'
3"	100'	30'
4"	150'	40'
6"	200'	60'
8"	350'	80'
9"	400'	90'
10"	450'	100'

Another way of finding the text size for good visual comfort is using this formula from the book "Fitting the task to the human",

Text Height (in mm) = Viewing distance (in mm.) / 200

Contrast of Display

1 Black on Yellow
2 Black on White
3 Yellow on Black
4 White on Black
5 Blue on White
6 White on Blue
7 Green on White
8 White on Green
9 Red on White
10 White on Red

All the above combinations produce an effective and readable sign contrast, even #10 on the list. The customer may have certain colour preferences or leave the decision up to you. Colours not listed above or custom colours that are in the user's design scheme may be used if maximum impact is not required.

Type styles

Not only is the contrast important also the chosen typeface will make the difference in a good or bad sign. When using too bold weighted typefaces the text will look like its expanding of the sign, when using too light weighted typefaces the text will fall back into its background. Medium or Regular weights are usually the best options to choose for a good and readable information.

7.8 Designing the Information System

7.8.1 Information required

After talking to Blind people and people using public transportation, the information required at the bus stop was majorly following:

- The information of the upcoming bus (route and ETA).
- The information about the routes of various buses coming at the stop.
- The information for a particular bus as per one's destination.
- Various buses available for a desired destination.

The above information is supposed to be critical and the further explorations would be done based on that.

7.8.2 Ideation Level 1

Initially, it was understood that design of route map was more important, because there's no way in which they can know what buses pass their stop unless they have a smart phone. Hence, the initial ideations are based on the routes of various buses at the stop. This ideation below shows just a printed route board in text and braille which could be read by users at the stop. Each cell represents a bus stop.

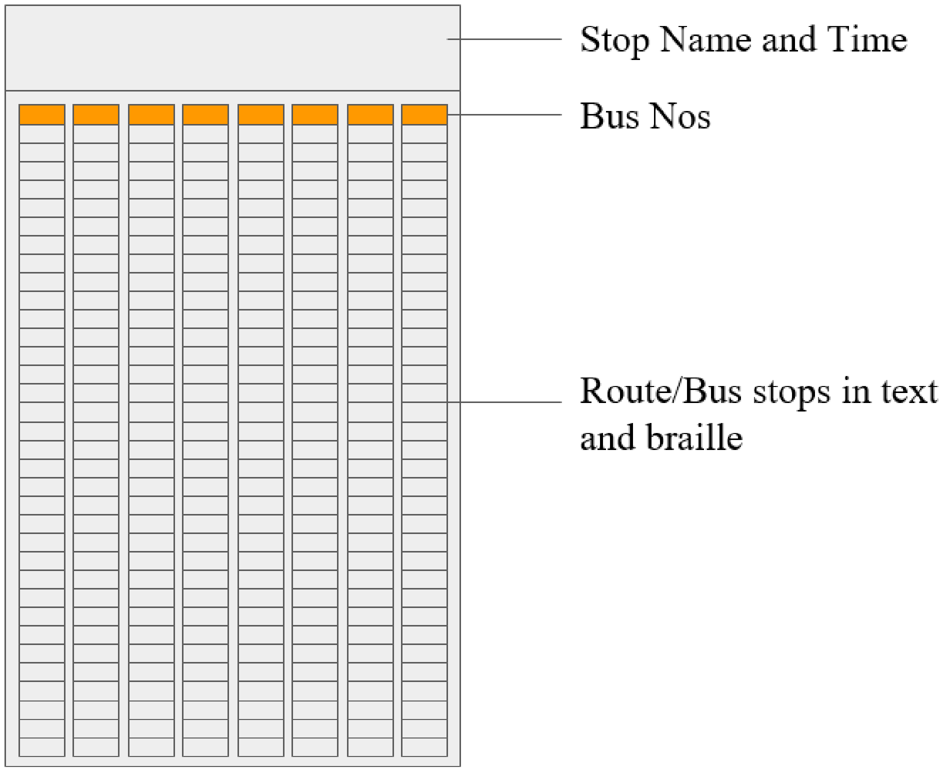


Figure 27: Ideation 1 (Source: Author)

7.8.3 Ideation Level 2

In the later ideations, it was understood that blind people would be able to explore the map more efficiently if they know the position of the current bus stop. Hence, all the cells with current bus stops were kept at the centre and are demarcated with a extruding rail. This helps user find the position of the bus stop on the route of each bus. The cells above show the bus stops the buses have already passed and the cells below show the upcoming stops.

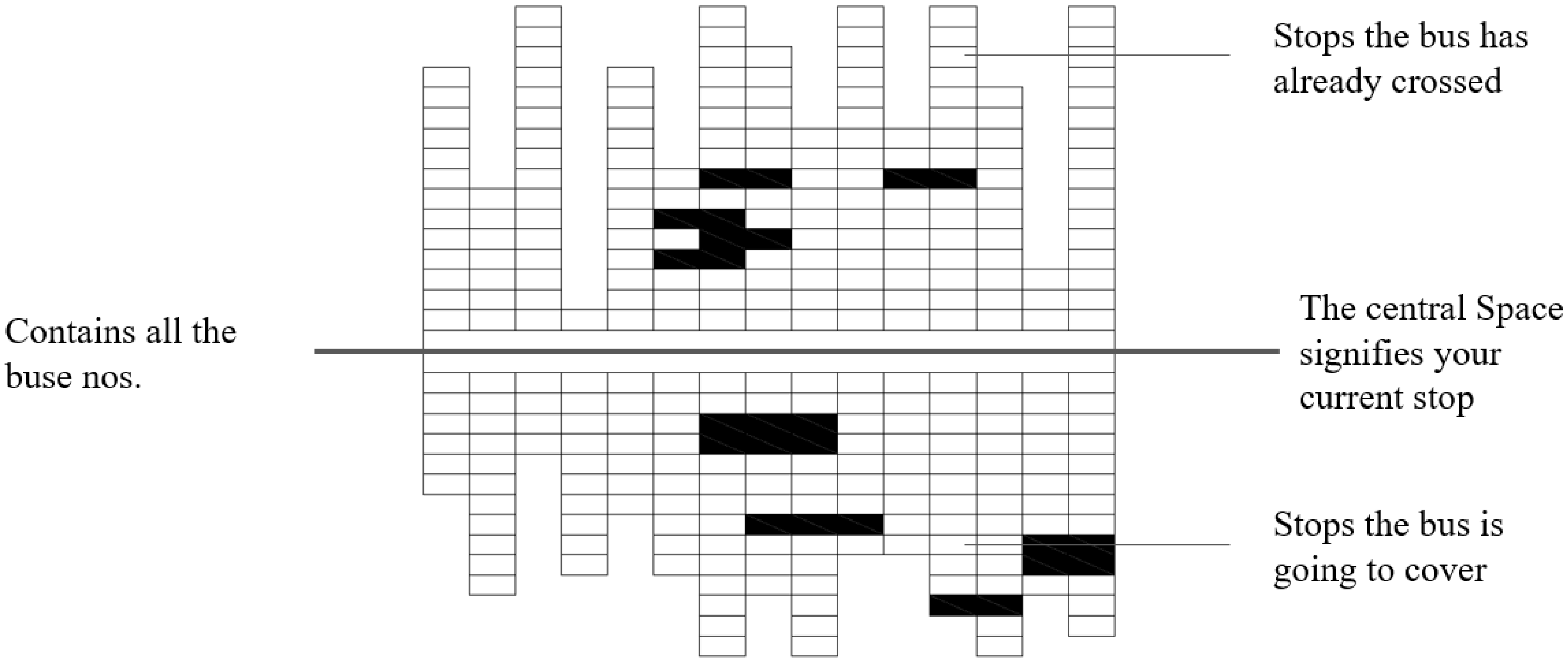
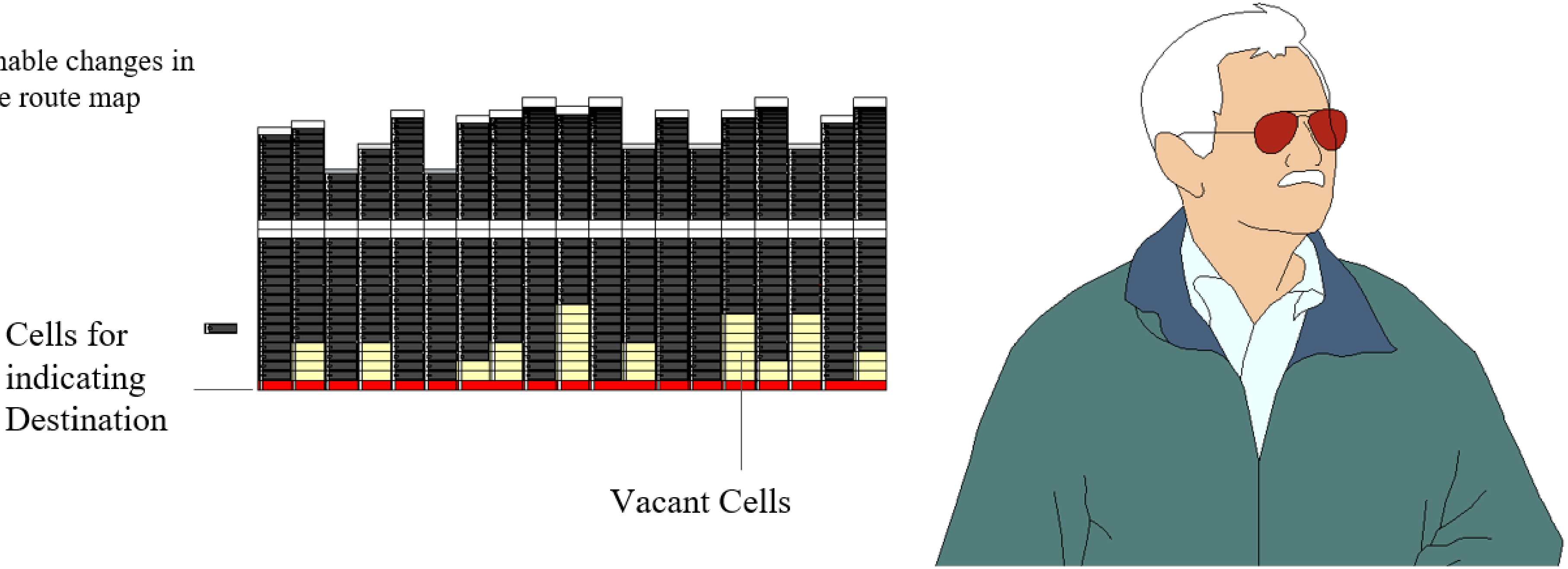


Figure 28: Ideation Level 2 Structure (Source: Author)

Modular Design
Could be customized as per the bus stop.

Cells can be mass manufactured.

Enable changes in the route map



Rough Dimension = 1050 x 290mm

Figure 29: Ideation Level 2 (Source: Author)

The system is also designed to be modular, where each cell is a module representing a bus stop. These modules can be changed and customised as per each bus stop. The upper side of the map is also given a curve, so that it's easy for blind people to locate the current bus stop on the route map.

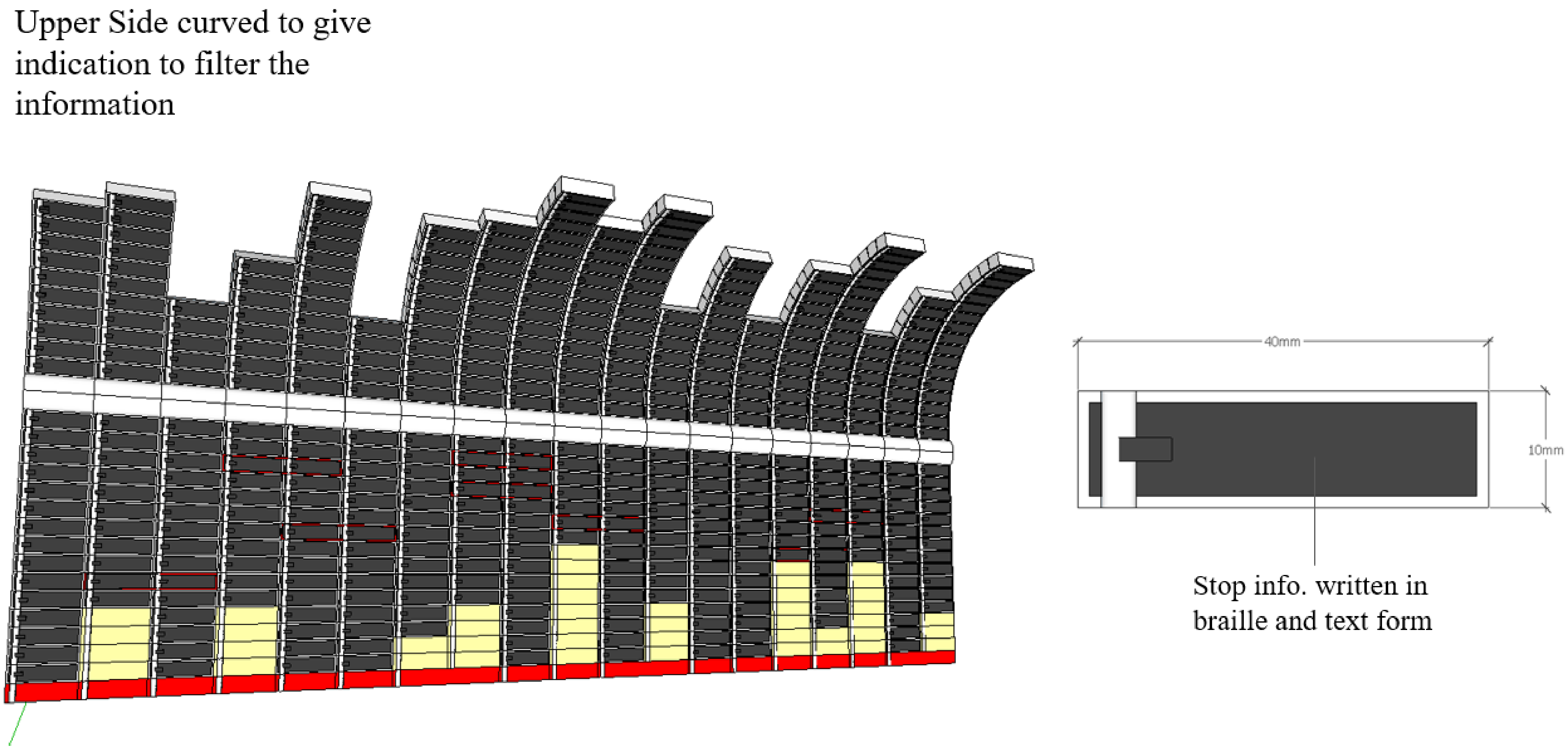


Figure 30: Ideation Level 2 (Source: Author)

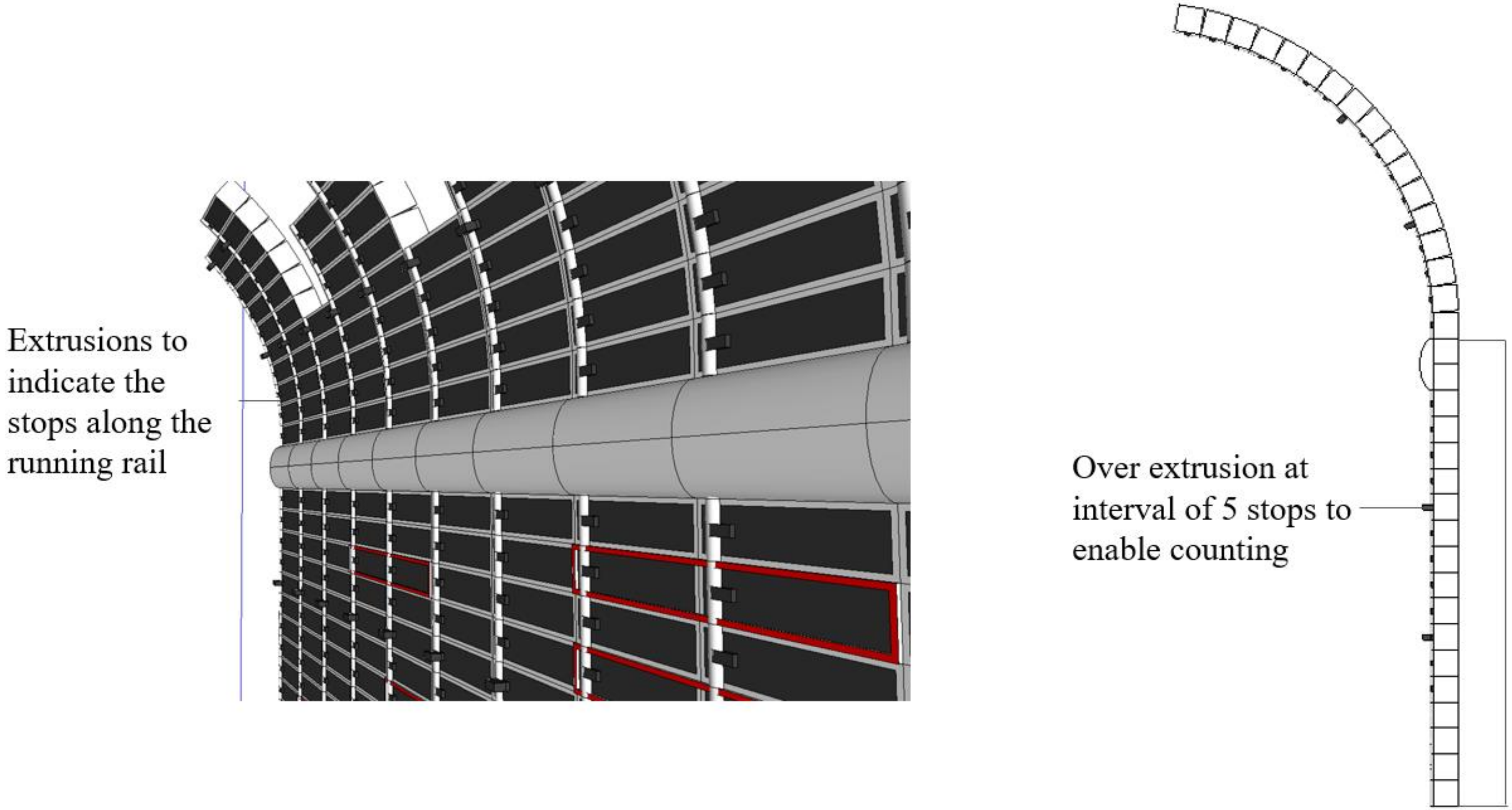


Figure 31: Ideation Level 2 Details (Source: Author)

7.8.4 Ideation Level 3

This ideation is just a refinement of the previous ideation. Here, the designs were looked as the deployable kiosks which could be placed at a designated spot near the bus stops. Again the methodology of disseminating information is same with modular cells combined to depict the route of each bus at the bus stop.

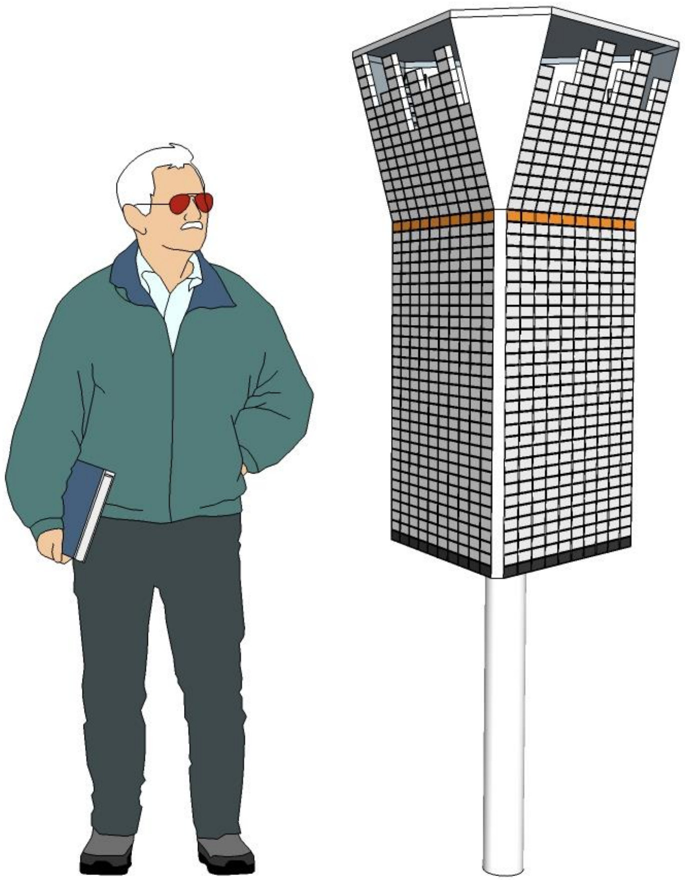


Figure 32: Ideation Level 3, refinement of Ideation 2 (Source: Author)

Option 2: Ideation Level 3

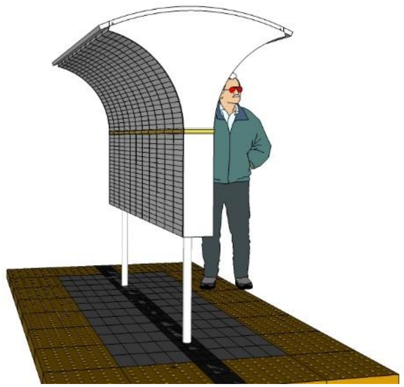


Figure 33: Ideation Level 3 (Source: Author)

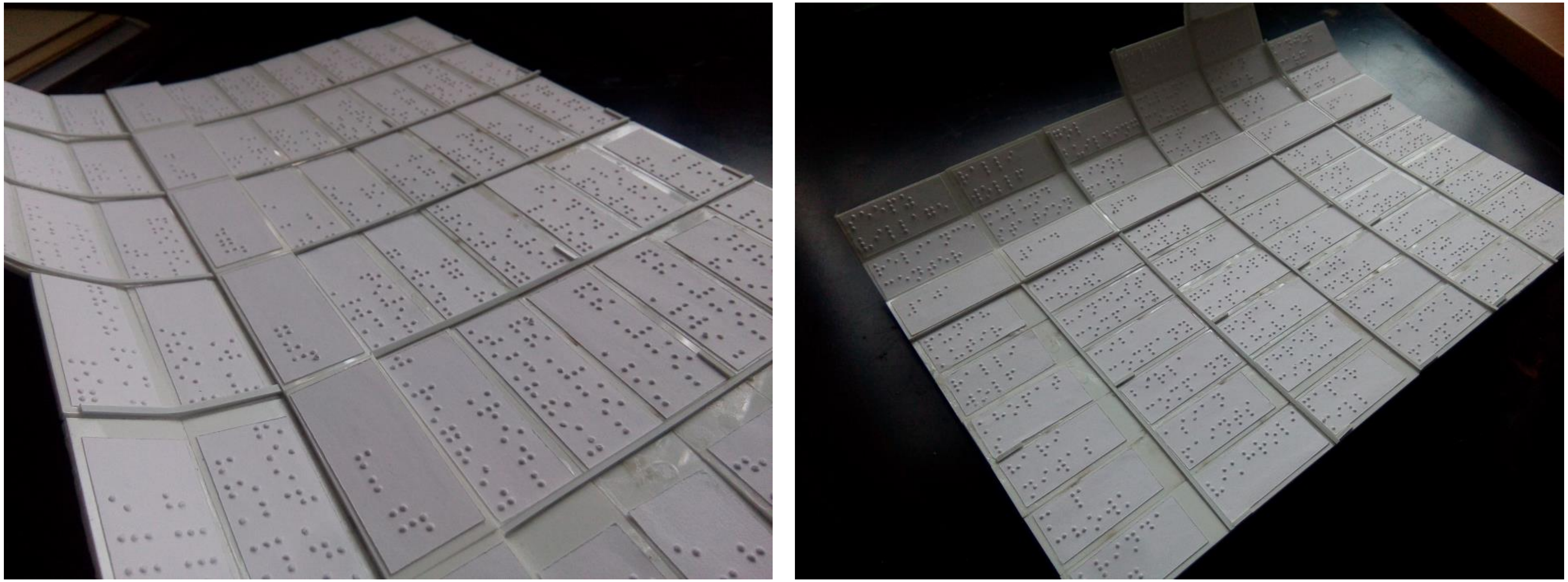


Figure 34: A mock prototype for validating the ideation (Source: Author)

Mock Up Testing:

A mock prototype for the ideation was made and tested with the actual blind users at NAB. The feedback was positive and users were able to read and find out the bus stops on various routes on the map. Users were able to easily able to identify the central rail where the bus no. is written and were easily able to learn the design.

7.8.5 Issues with design approach: Relooking the design method

There were various issues with the approach adopted till now in ideations e.g.

- The design only emphasised on the routes of the buses at the stop
- More than imparting information, it served the purpose of the static map
- It was cumbersome to extract specific information
- The designs were extremely space taking and hence non-deployable in real scenario
- Braille was the main feedback mechanism to the users
- Maintenance issues
- The user activity analysis was not done in order to understand the situation properly
- The current day technology was completely neglected in approach

Hence, it was decide instead of providing static information about the routes, it's more important to give relevant real-time information to the user standing at a bus stop, so it is necessary to know the actual needs of a blind person at a bus stop. The further concepts were developed accordingly.

7.8.6 Scenarios

After understanding the users at a bus stop, the scenarios for various were created for accessing the buses at a bus stop, in order to understand the information and information flow required for the system. The scenarios are:

Scenario 1
A blind is at the stop, he knows his bus number because he travels often with the same bus. He wants to know the estimated arrival time of his bus. In this case, even the fellow passengers can't help him as such information is not available.

Scenario 2
A blind person is standing at a bus stop, he knows where he has to go but doesn't know the bus number he has to take. He has to ask the fellow passengers for the bus number.

Scenario 3
A blind person is standing at a bus stop, he wants to know which bus has come every time a bus comes.

Scenario 4
A blind person is at the bus stop, he wants to know whether a particular bus passes through the stop or not.

Scenario 5
User wants to know the route of the bus.

7.8.7 Implementable Technology

With the advent of technology, it would be unfair if one doesn't consider the existing technology while designing for such critical user group. It would not only save time for these users while accessing information but also last longer in future. Along with that a no. of solutions also exist which could be incorporated with each other to create a more robust system for this complex issue. A few technologies which could be easily incorporated in the system are:

Refreshable Braille Displays

A **refreshable braille display** or **braille terminal** is an electro-mechanical device for displaying braille characters, usually by means of round-tipped pins raised through holes in a flat surface. Blind computer users who cannot use a computer monitor can use it to read text output. Speech synthesizers are also commonly used for the same task, and a blind user may switch between the two systems or use both at the same time depending on circumstances.

The mechanism which raises the dots uses the piezo effect of some crystals, whereby they expand when a voltage is applied to them. Such a crystal is connected to a lever, which in turn raises the dot. There has to be a crystal for each dot of the display, i.e. eight per character. Because of the complexity of producing a reliable display that will cope with daily wear and tear, these displays are expensive. Usually, only 40 or 80 braille cells are displayed. Models with between 18 and 40 cells exist in some note taker devices.

Figure 35: A typical refreshable braille device (Source: Google Images)

GPS/Vehicle Tracking System

A **vehicle tracking system** combines the use of automatic vehicle location in individual vehicles with software that collects these fleet data for a comprehensive picture of vehicle locations. Modern vehicle tracking systems commonly use GPS or GLONASS technology for locating the vehicle, but other types of automatic vehicle location technology can also be used. Vehicle information can be viewed on electronic maps via the Internet or specialized software. Urban public transit authorities are an increasingly common user of vehicle tracking systems, particularly in large cities.

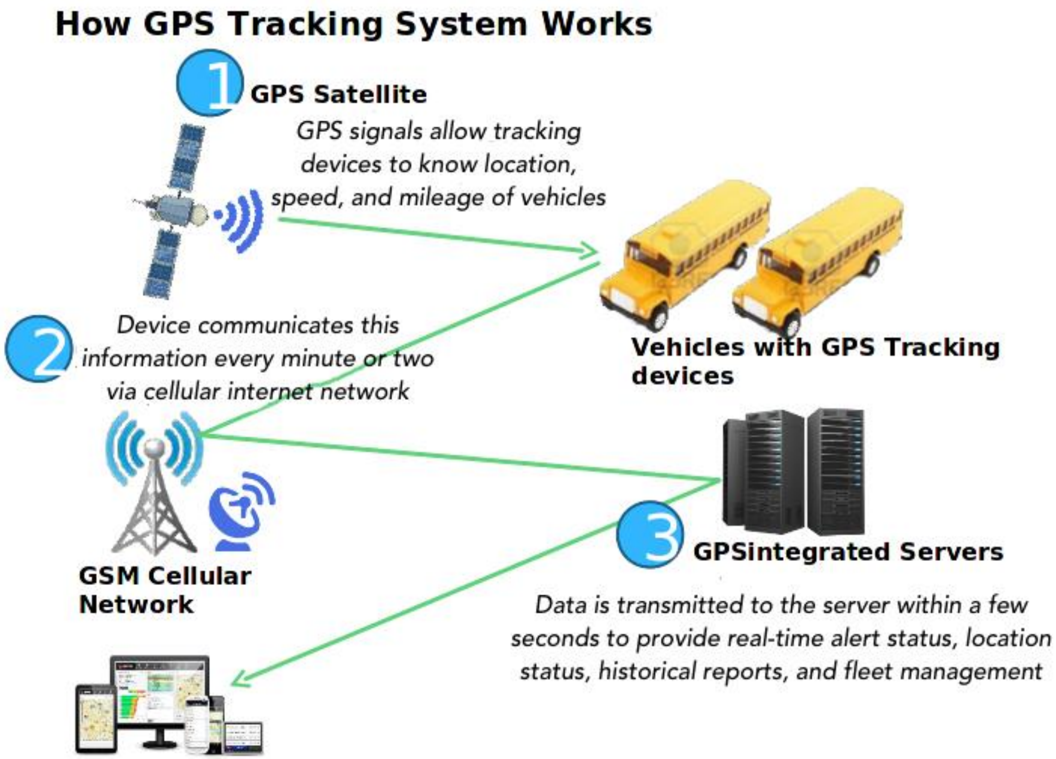


Figure 36: GPS Working Structure (Source: Google Images)

Online Database

At present there are many mobile applications which maintain and provide the data of various bus routes in almost every metro city. M-Indicator in Mumbai is one such application. It stores all the routes of the Mumbai local buses and is easily used on a smart phone. This database could be used in order to connect to the kiosk and provide accurate information to the user.

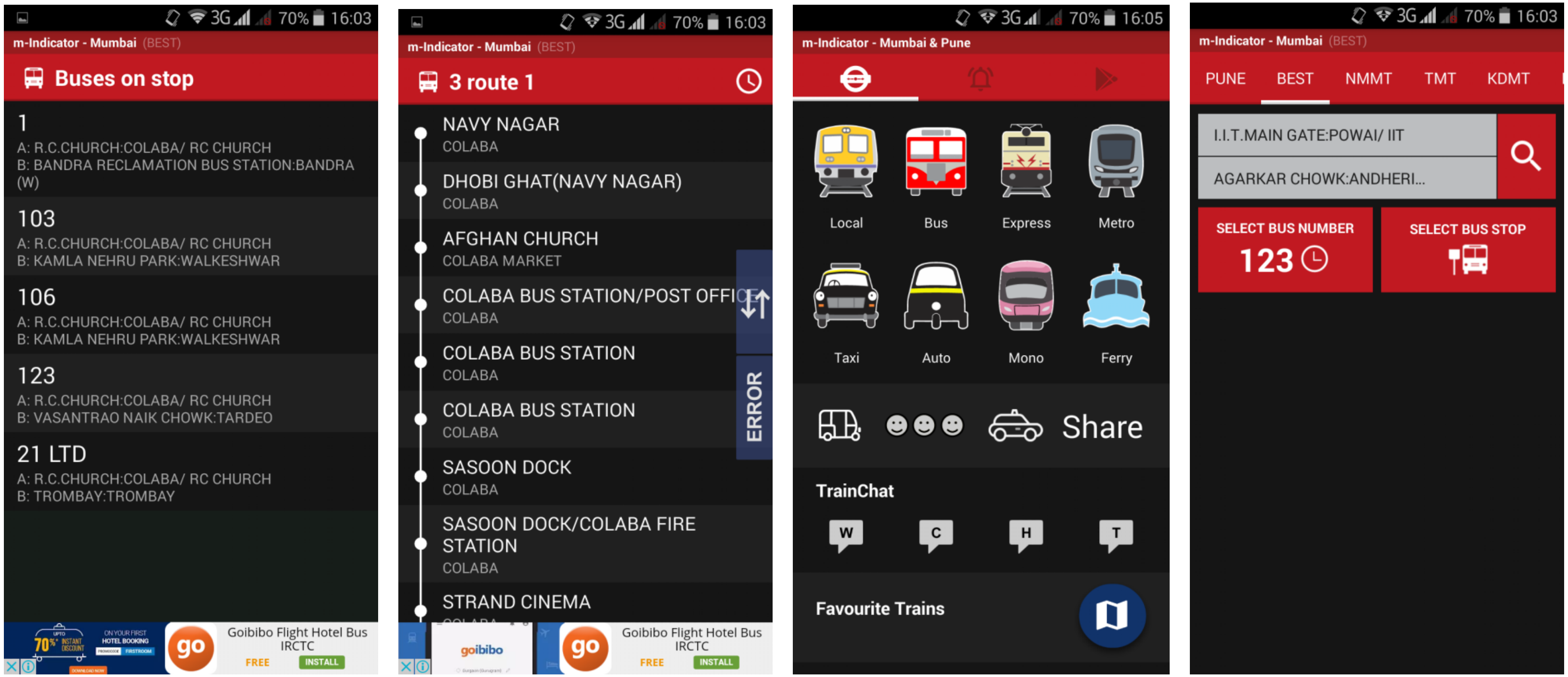


Figure 37: M-indicator App (Source: Author)

OK Google

This mobile application works on voice command and allow people to ask anything they want to search online via google. If one asks about the route of buses in Mumbai or bus to a particular destination, it is able to give the appropriate result in real time via voice feedback. Such kind of technology is useful and is implementable for a project like this one.

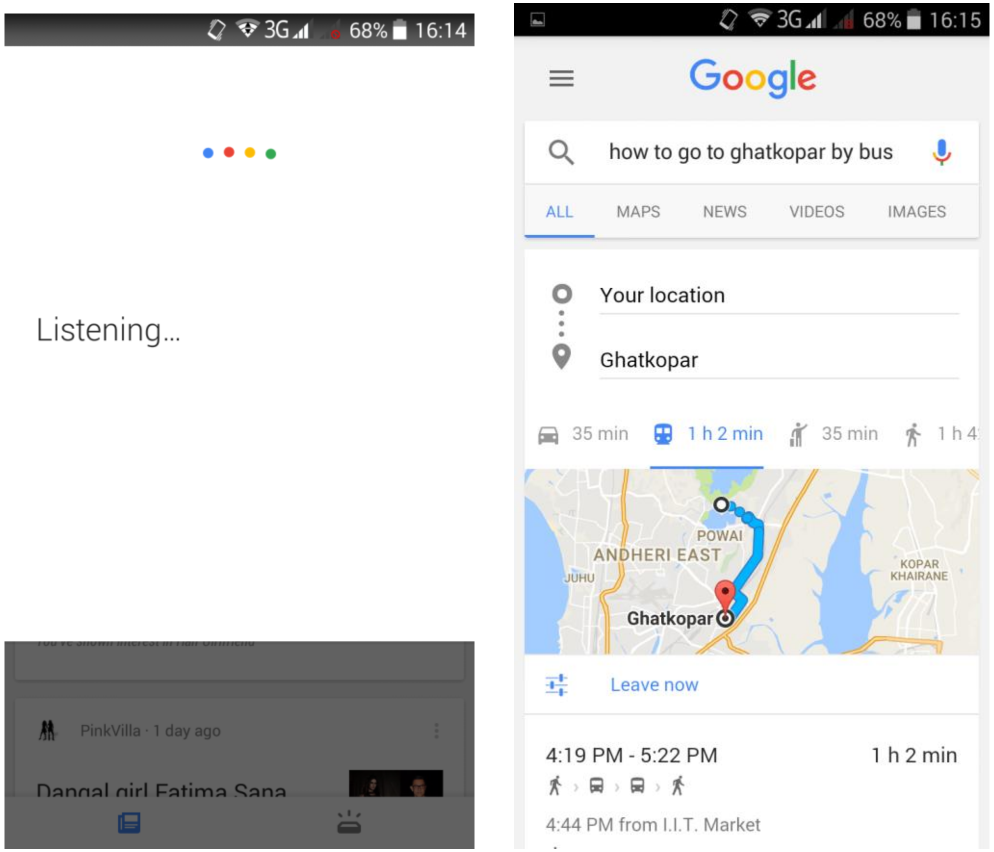


Figure 38: Google app (Source: Author)

7.8.8 System Proposal

After having studied the available technology, a system had to be developed for the working of this information module. The overall working of the information module would be like below:

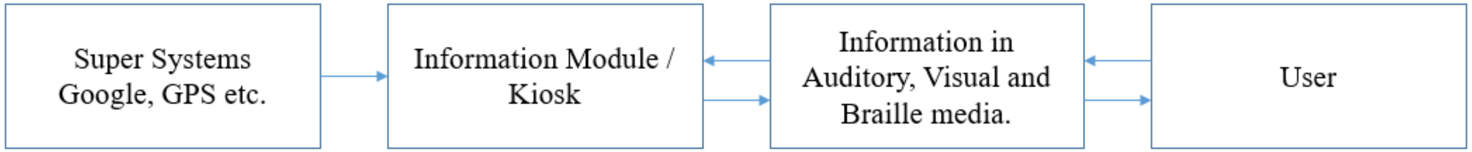


Figure 39: System Overview (Source: Author)

The main interaction would be between user and the kiosk which would be connecting with the Super systems like Google, GPS via internet and can give real-time information to the user.

7.8.9 System Task Description

As per the scenarios discussed earlier, following flowcharts explain the working of the system in various scenarios.

Scenario 1:

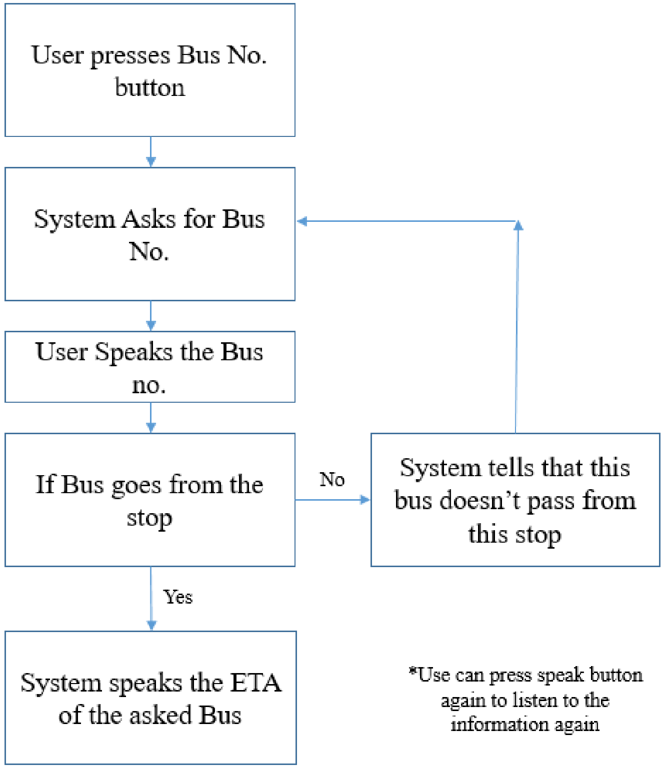


Figure 40: Scenario 1 (Source: Author)

Scenario 2:

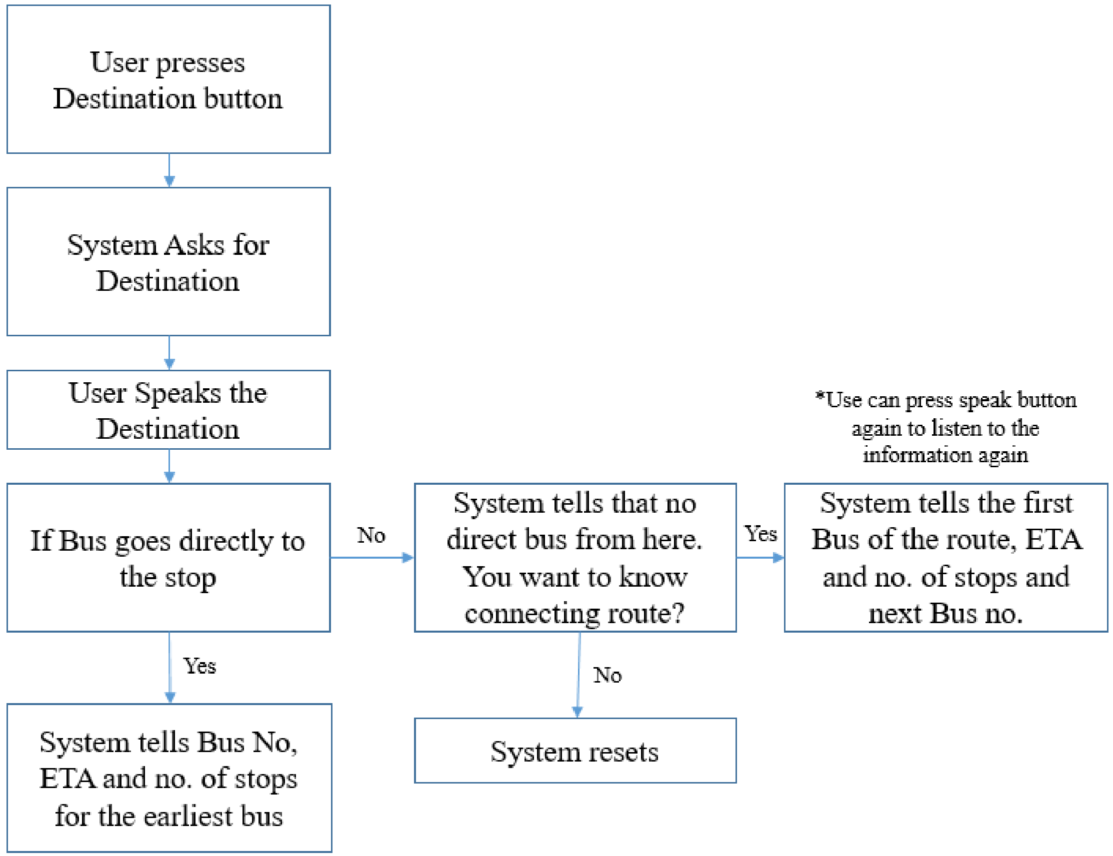


Figure 41: Scenario 2 (Source: Author)

Scenario 3:

In this case, the user either can press the speak button every time he hears a bus coming. Or can read in braille directly from the module each time a bus comes.

Scenario 4:

This will be similar to the first scenario.

Scenario 5:

In this case user can press the speak button for destination to know the route of the bus one by one, till the destination.

7.8.10 Concepts

Concept 1: Interface

This concept is an evolution of the initial ideations. The usability is as per the Task description and Scenarios discussed earlier. Dimension of interface is 260x580 mm.

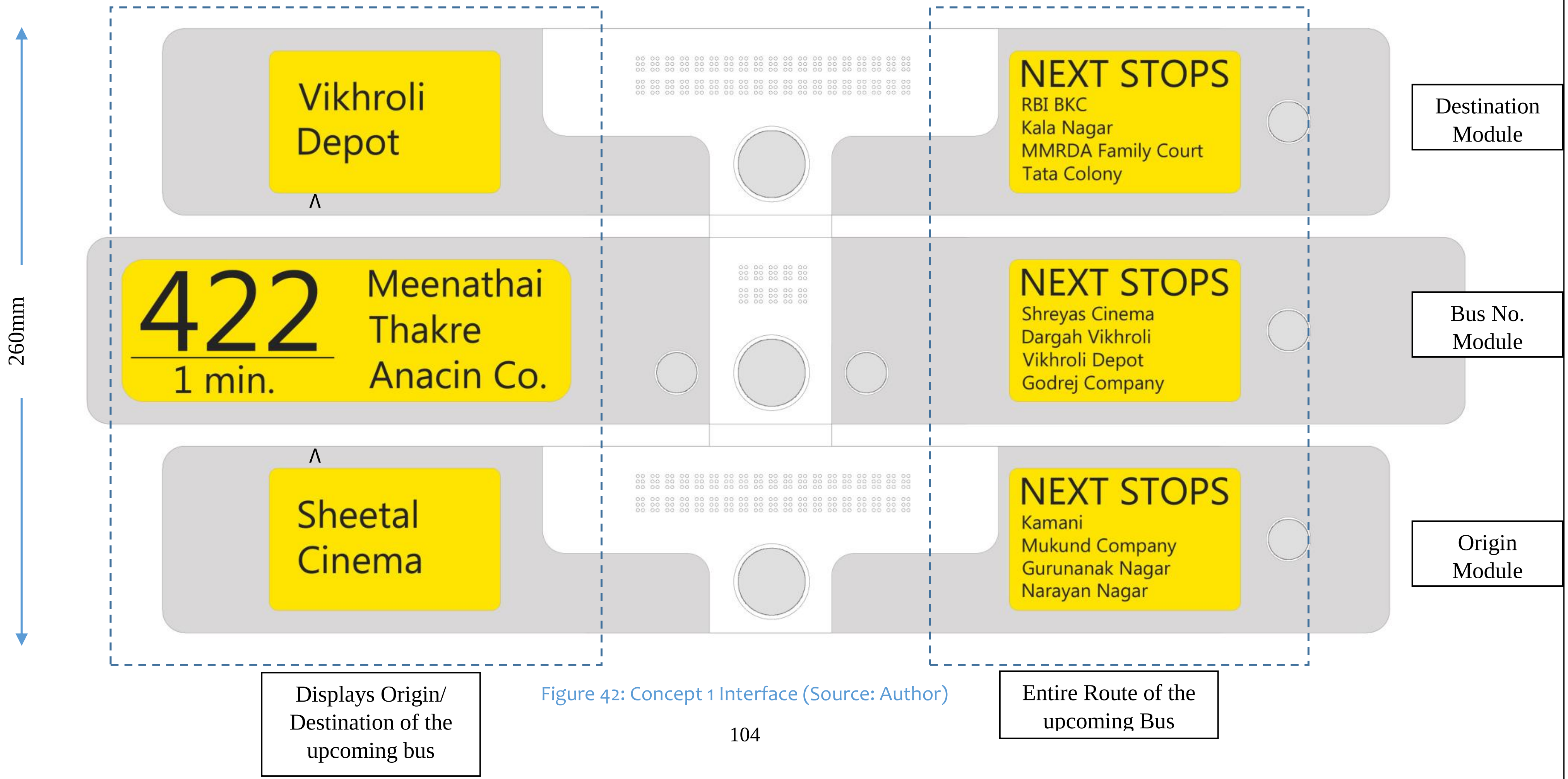


Figure 42: Concept 1 Interface (Source: Author)

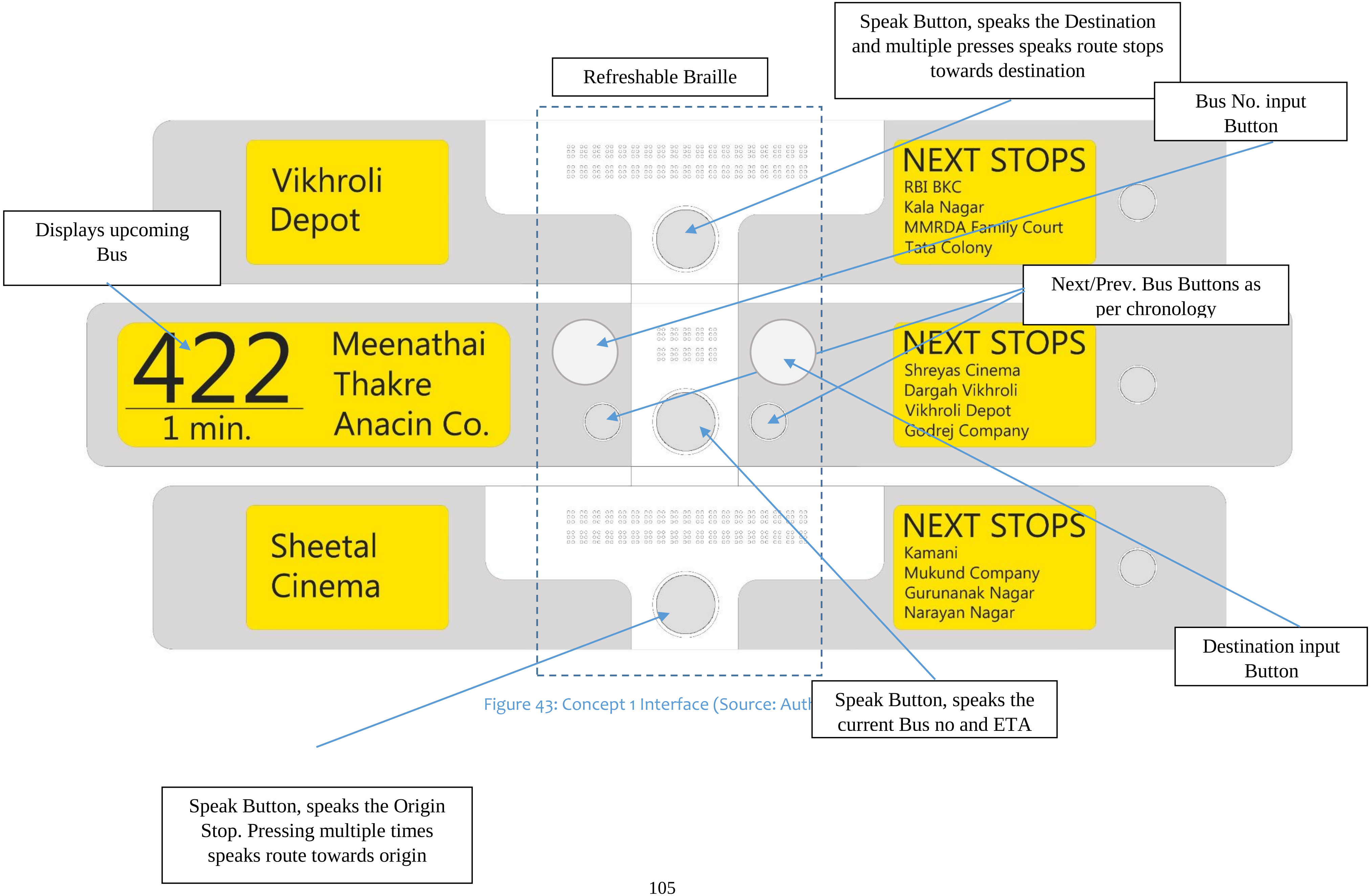


Figure 43: Concept 1 Interface (Source: Auth

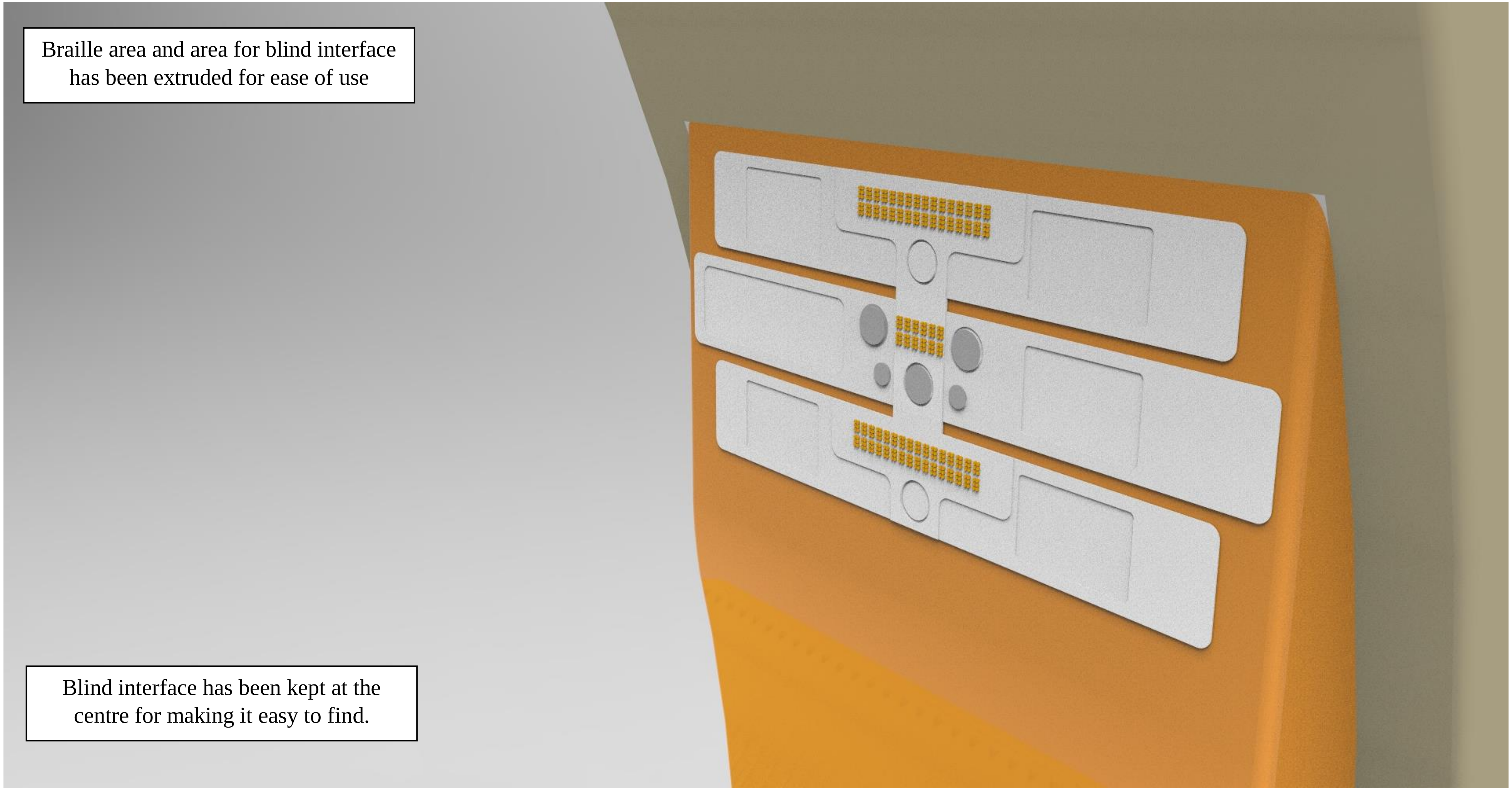


Figure 44: Concept 1 Interface Module (Source: Author)

Concept 2: Interface

Approximate dimension of the main interface (central module) is 300x600mm. In this concepts, these 3 modules can be kept at different position

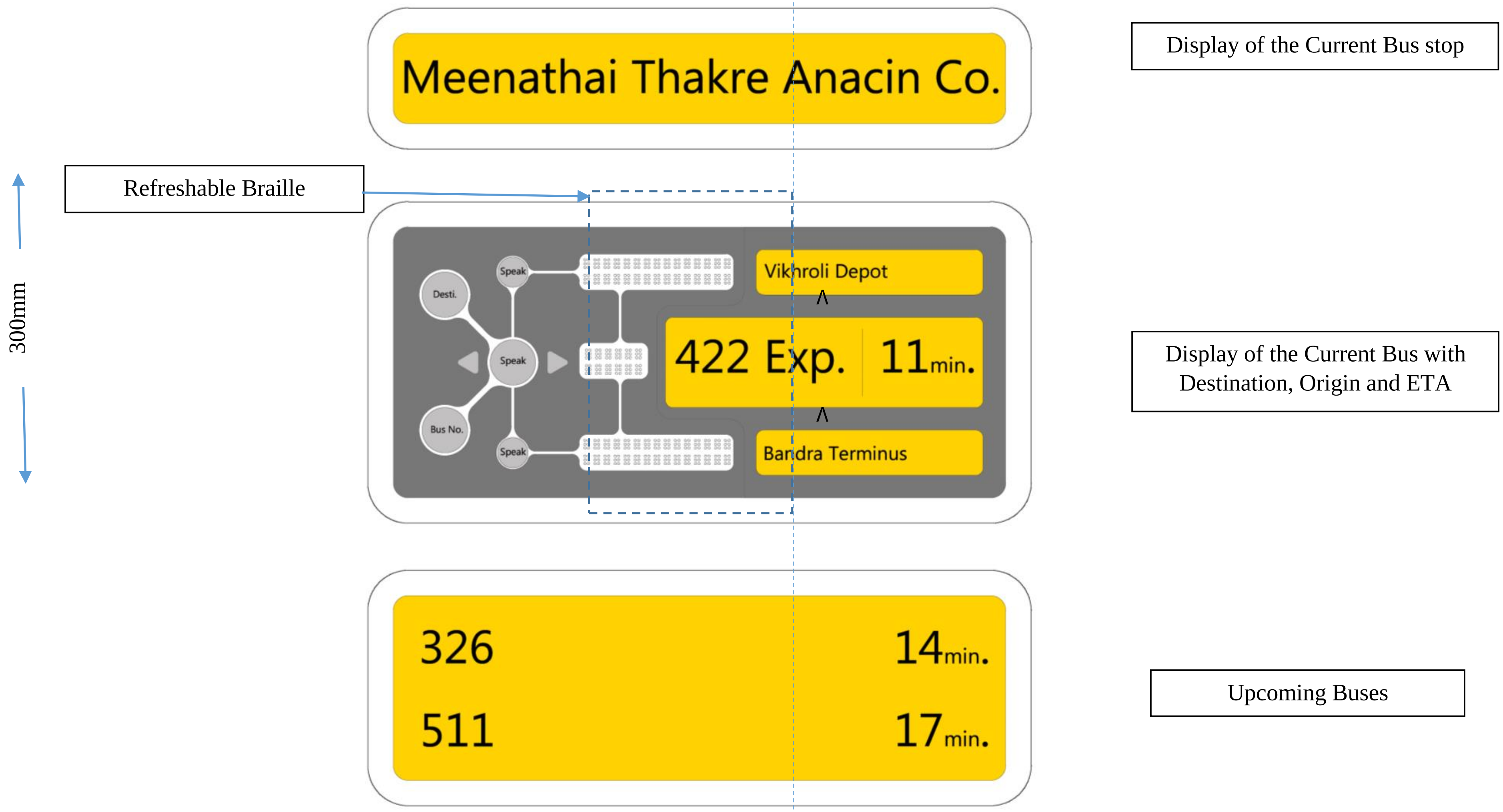


Figure 45: Concept 2 Interface Module (Source: Author)

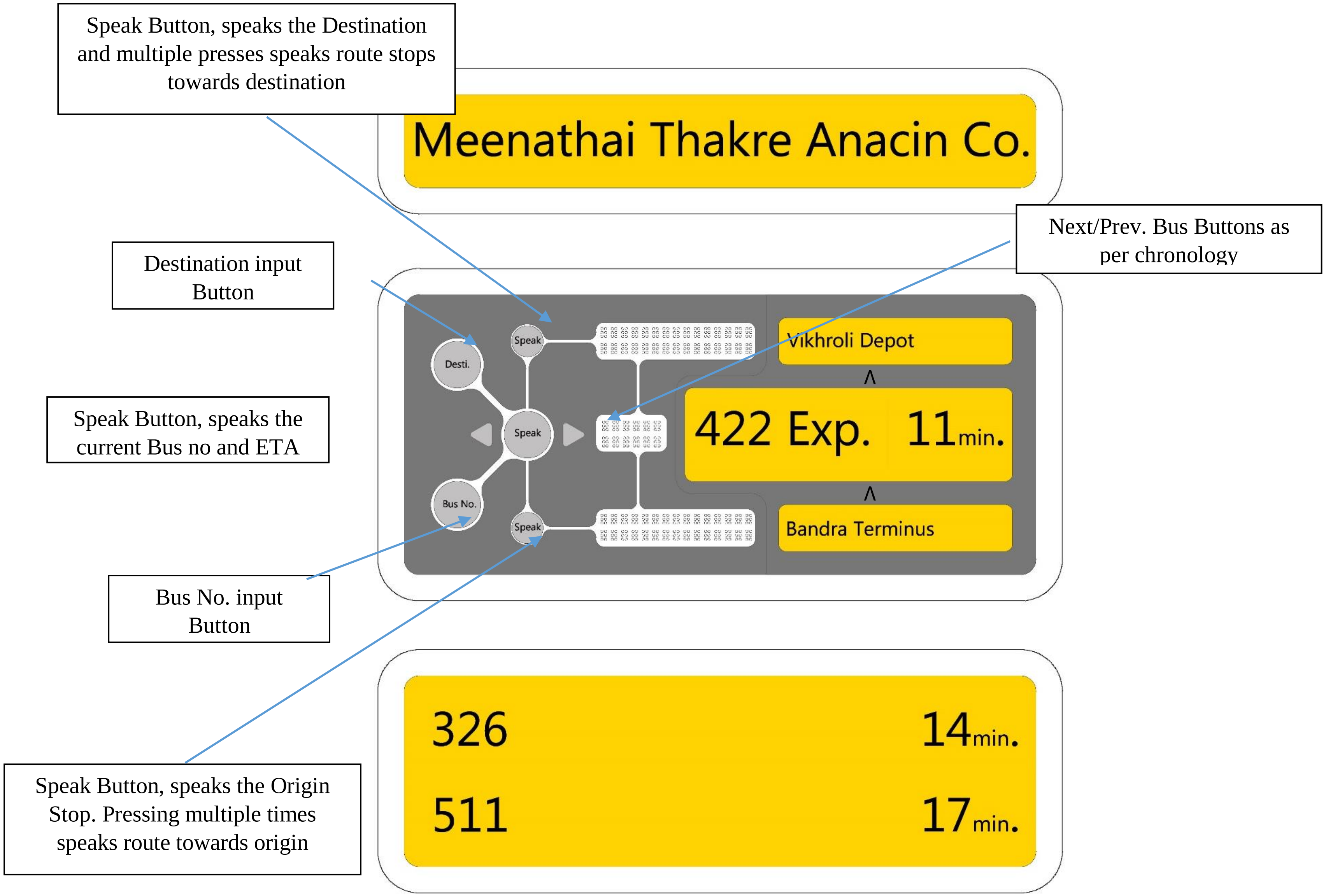


Figure 46: Concept 2 Interface (Source: Author)

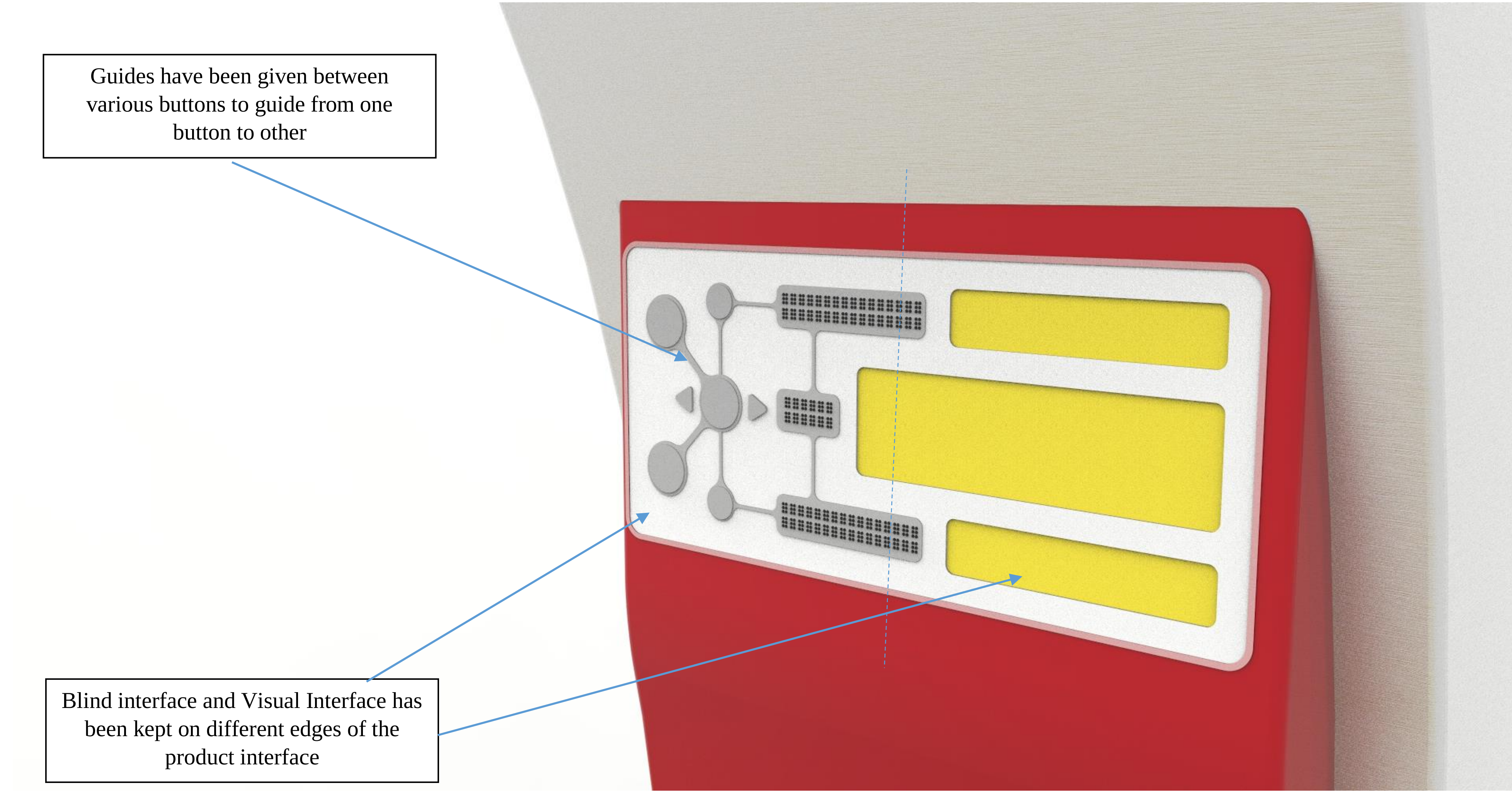


Figure 47: Concept 2 Interface Module (Source: Author)

Kiosk Concepts

Information Kiosks have been designed in order to match with the existing designs of the bus stops. They will be placed near each bus stop and hence should be responding to its design. Stainless steel has been used as primary outer casing material in order cater to the harsh weather of Mumbai and also to respond to the bus stop design.

After ideation, 3 concepts were developed among which one will be finalised later and prototype will be made.

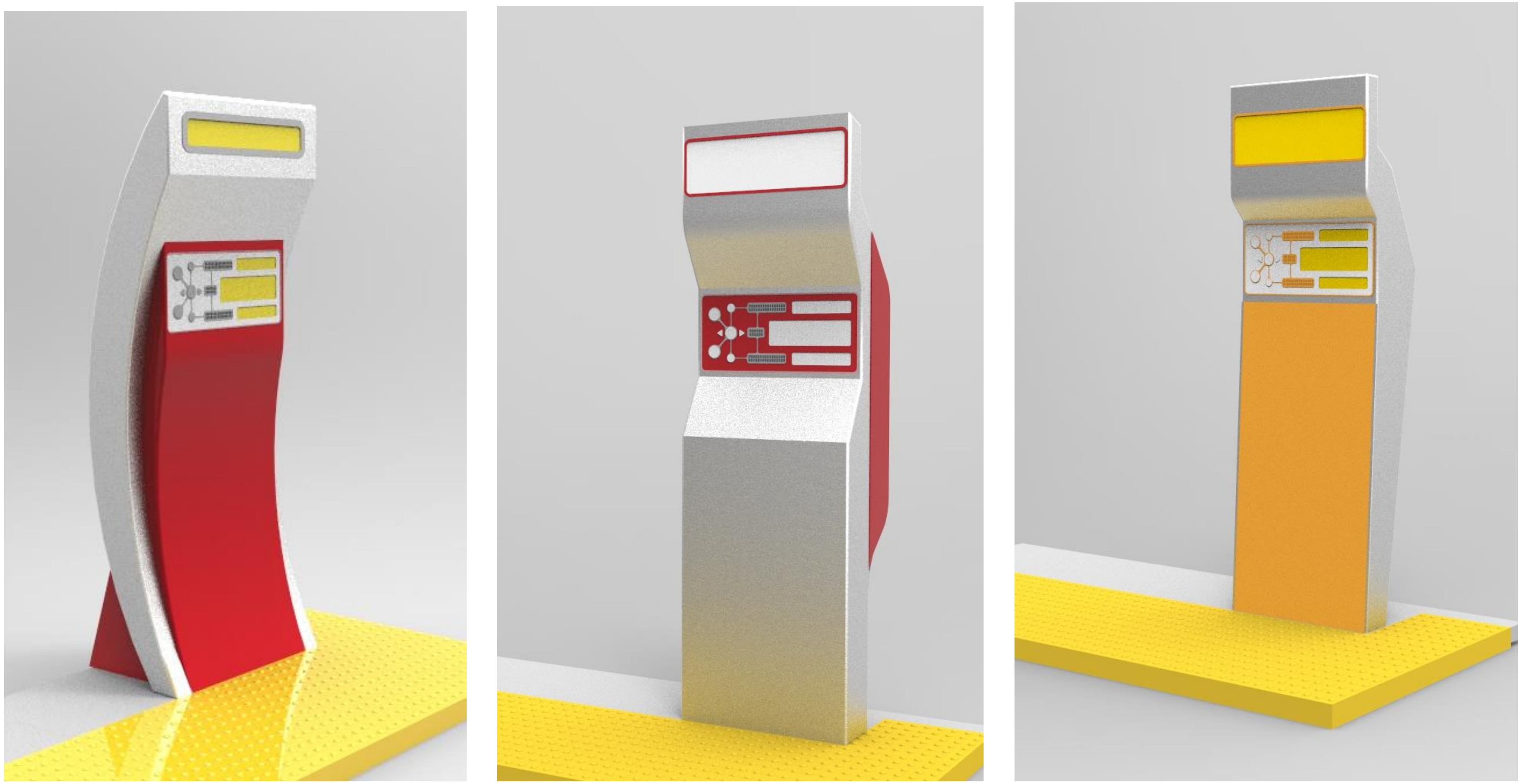


Figure 48: Kiosk Concepts (Source: Author)

Kiosk Concept 1:

This concept involves the curvilinear form inspired from the BEST bus stop design. Another powder coated panel is given red colour again to respond to the BEST bus's colour.

The rear of the kiosks could be used for advertising and hence kept bare.

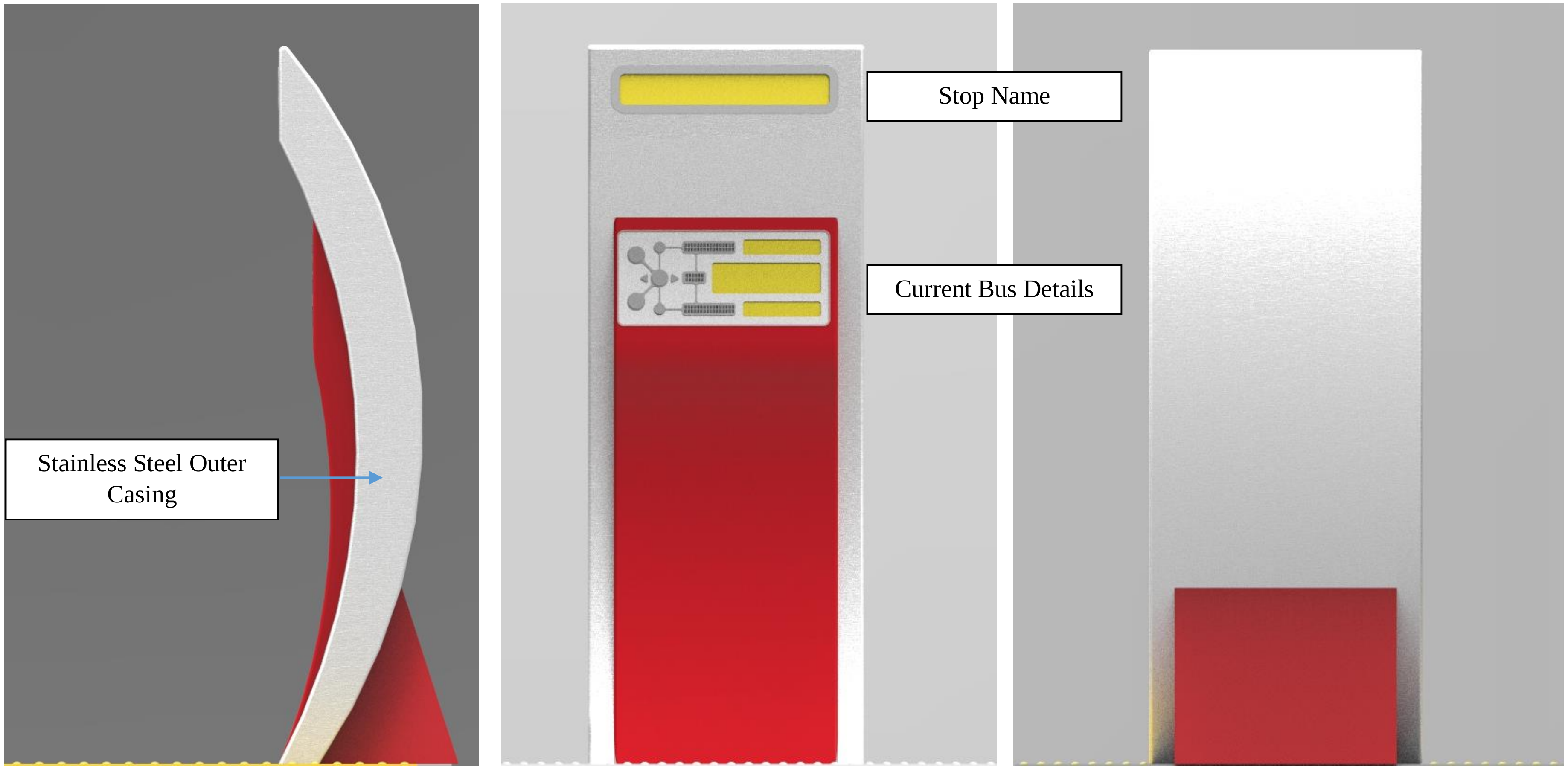


Figure 49: Kiosk Concept 1 (Source: Author)

Kiosk Concept 2:

This concept is more of a minimalistic approach to kiosk design. The intrusion has been given for helping blind people guide through the form which leads to the tactile interface of the module. The rear side again would be used for advertising.

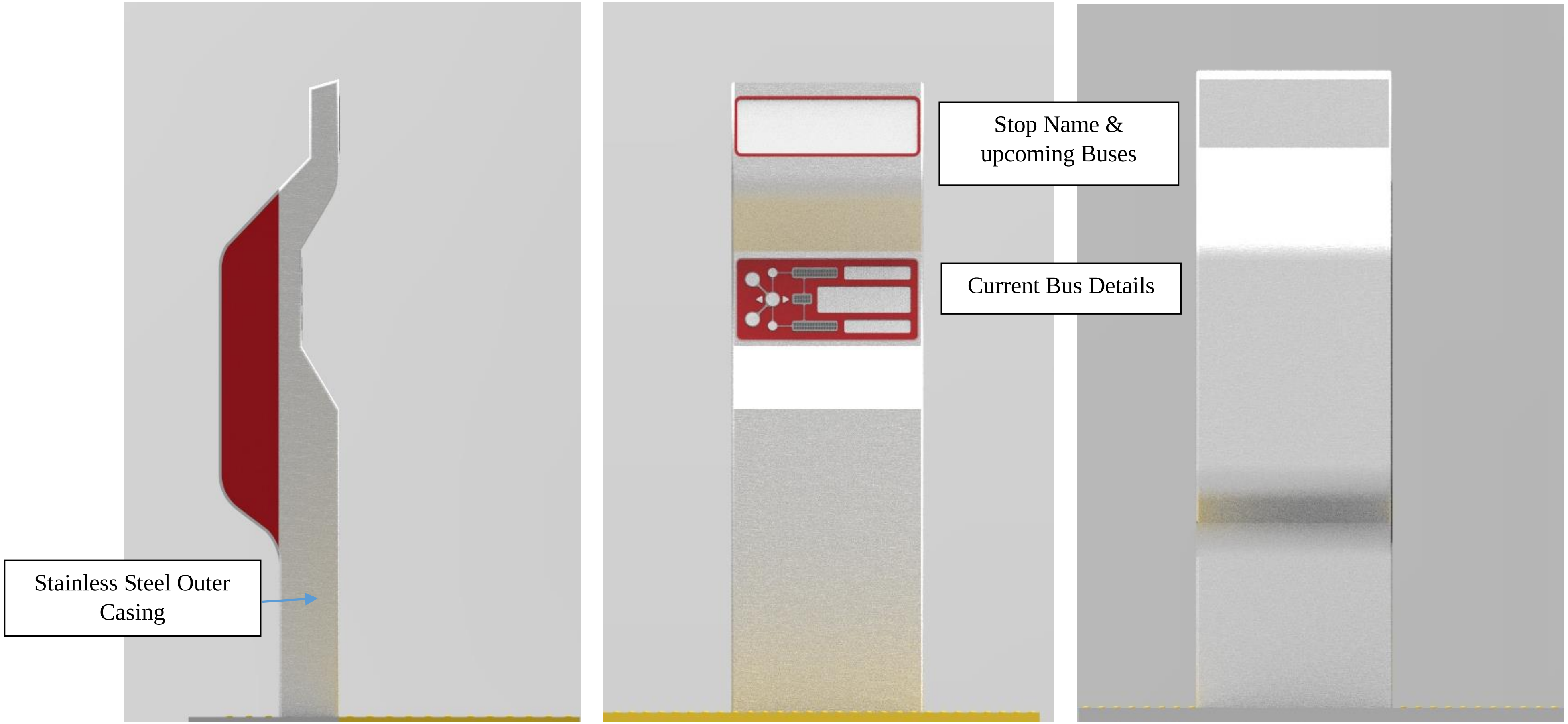


Figure 50: Kiosk Concept 2 (Source: Author)

Kiosk Concept 3:

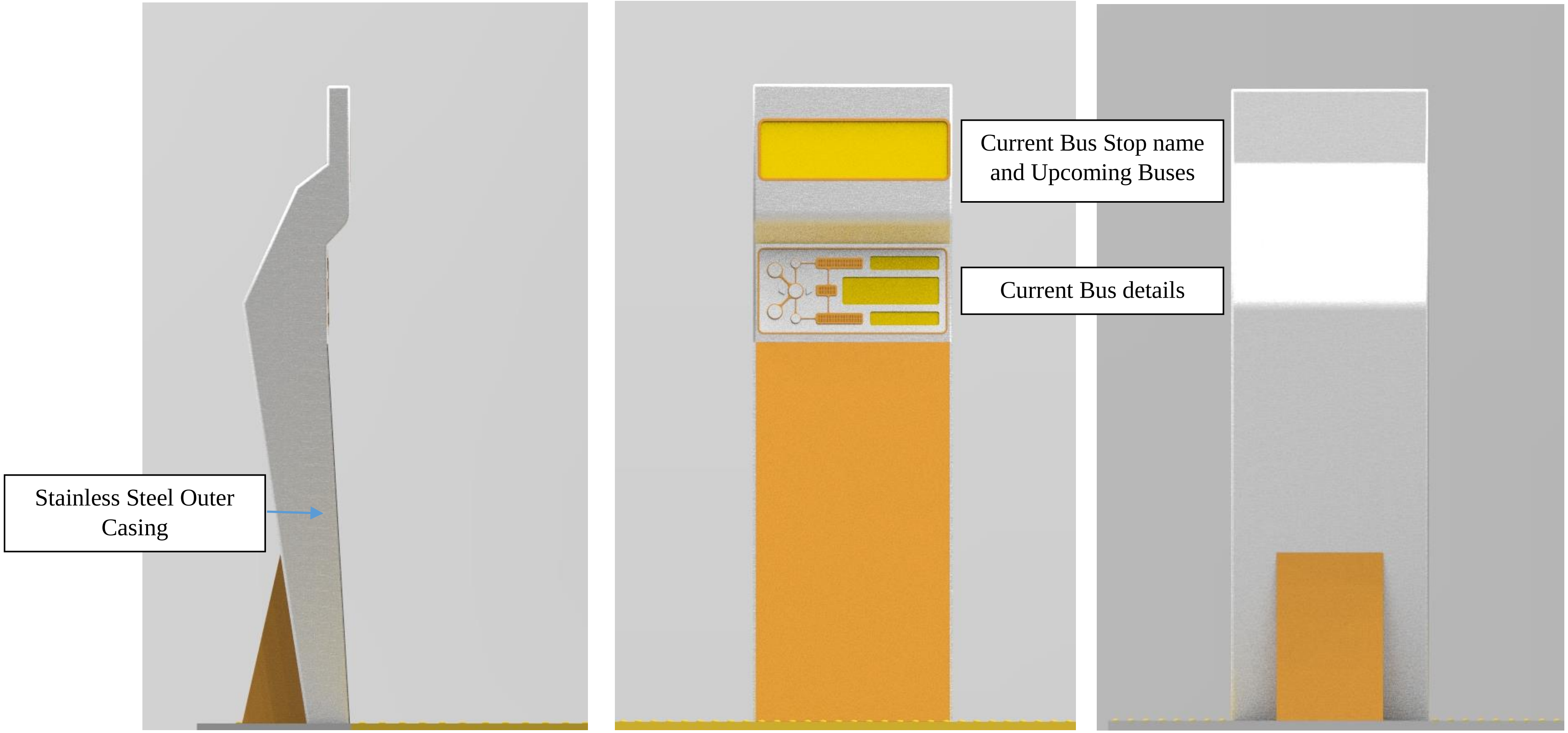


Figure 51: Kiosk Concept 3 (Source: Author)

Proportions and Human Relations

The kiosks dimensions has been kept considering the various percentiles of people. The display panel is kept at a position where it's easy to access for all sizes of people and also visible to others as well on the bus stop.

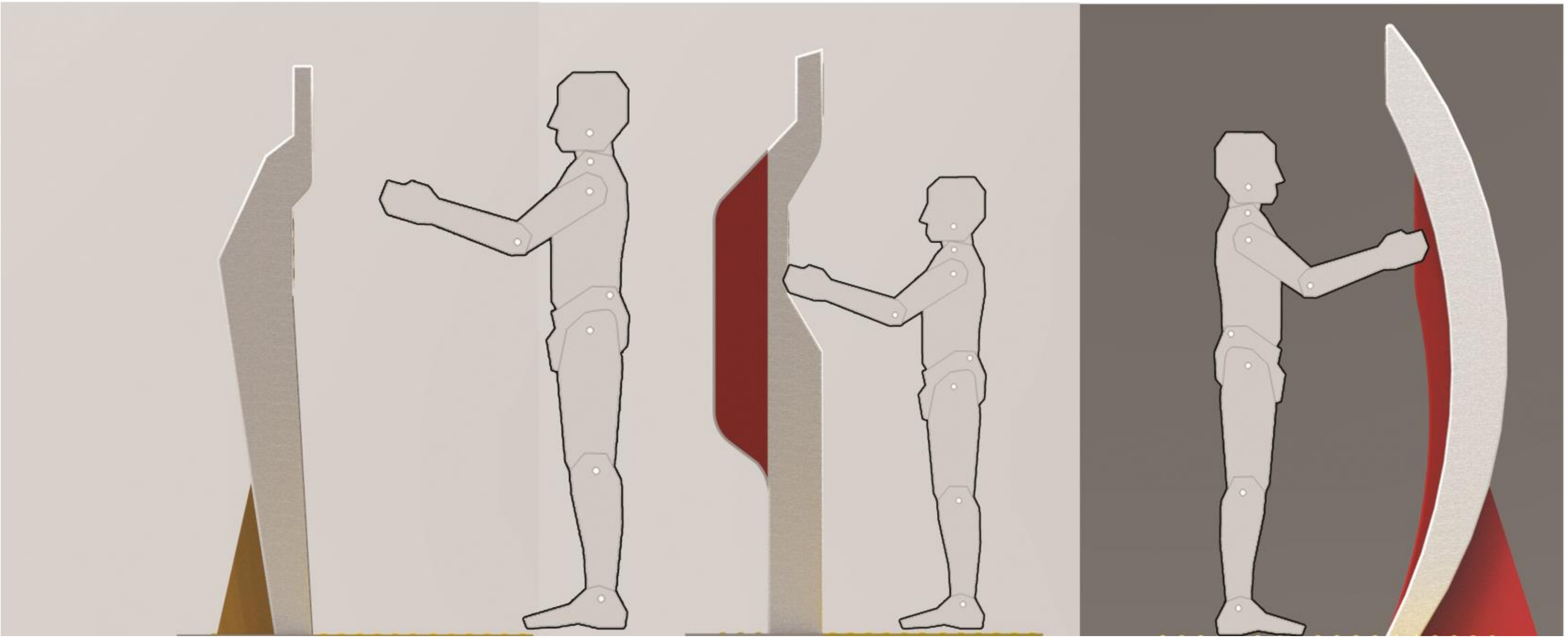


Figure 52: Kiosks and Body Proportion (Source: Author)

7.8.11 Product Positioning

Another important task other than designing such information system is to designate a place for such kiosk which could be universal and would be known to the frequent blind users. Hence, as suggested by the CPWD guidelines, there is a need to incorporate tactile tiles for mobility at any bus stop for guiding blind users to towards the bus, following is a proposal for the positioning the kiosk at every bus stop.

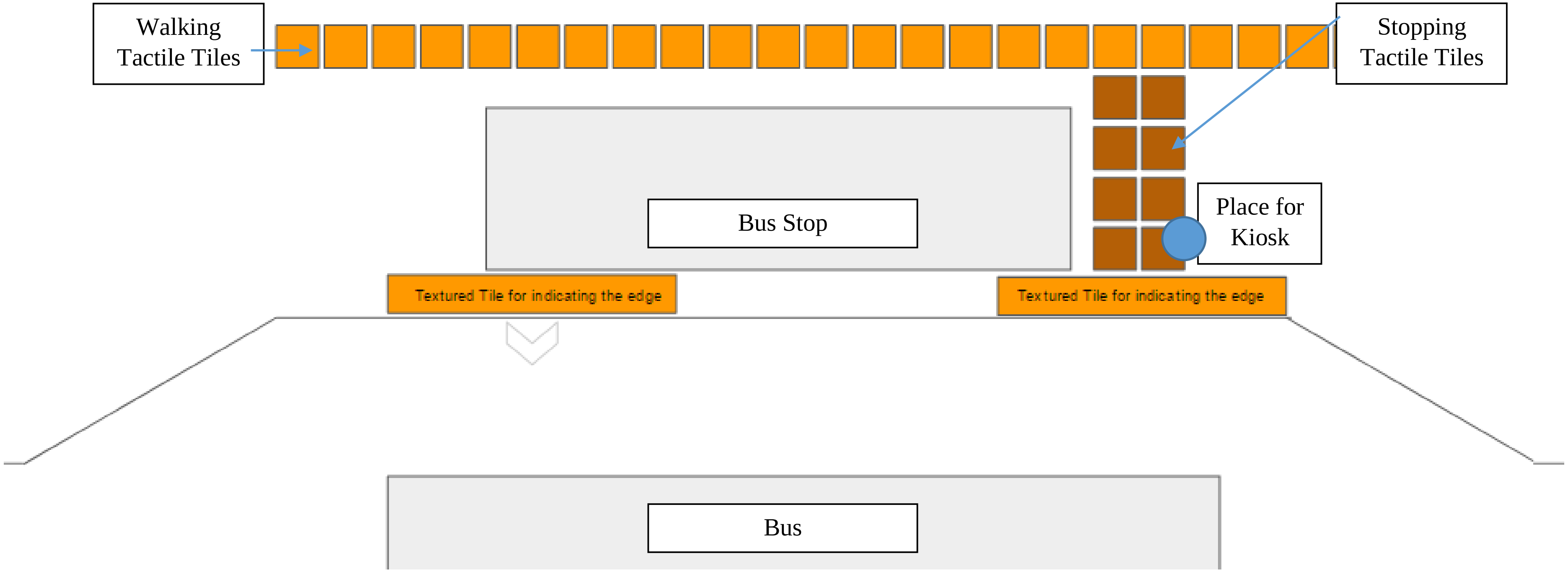


Figure 53: Positioning of the Kiosk and proposed Stop Layout (Source: Author)

As generally, the space behind the bus stops is generally unused and left blank. This place should be provided with tactile mobility tiles as per standards. These tile will guide them towards the entry of the bus stop and that's where the information kiosk would also come, as shown in the Illustration above.

7.8.12 Axure Prototyping:

An Axure RP prototype was made in order to simulate the device and was tested with the user. The layout was used in the prototype and buttons were provided with audio feedback so that this could be used to test the usability of the device or interface.

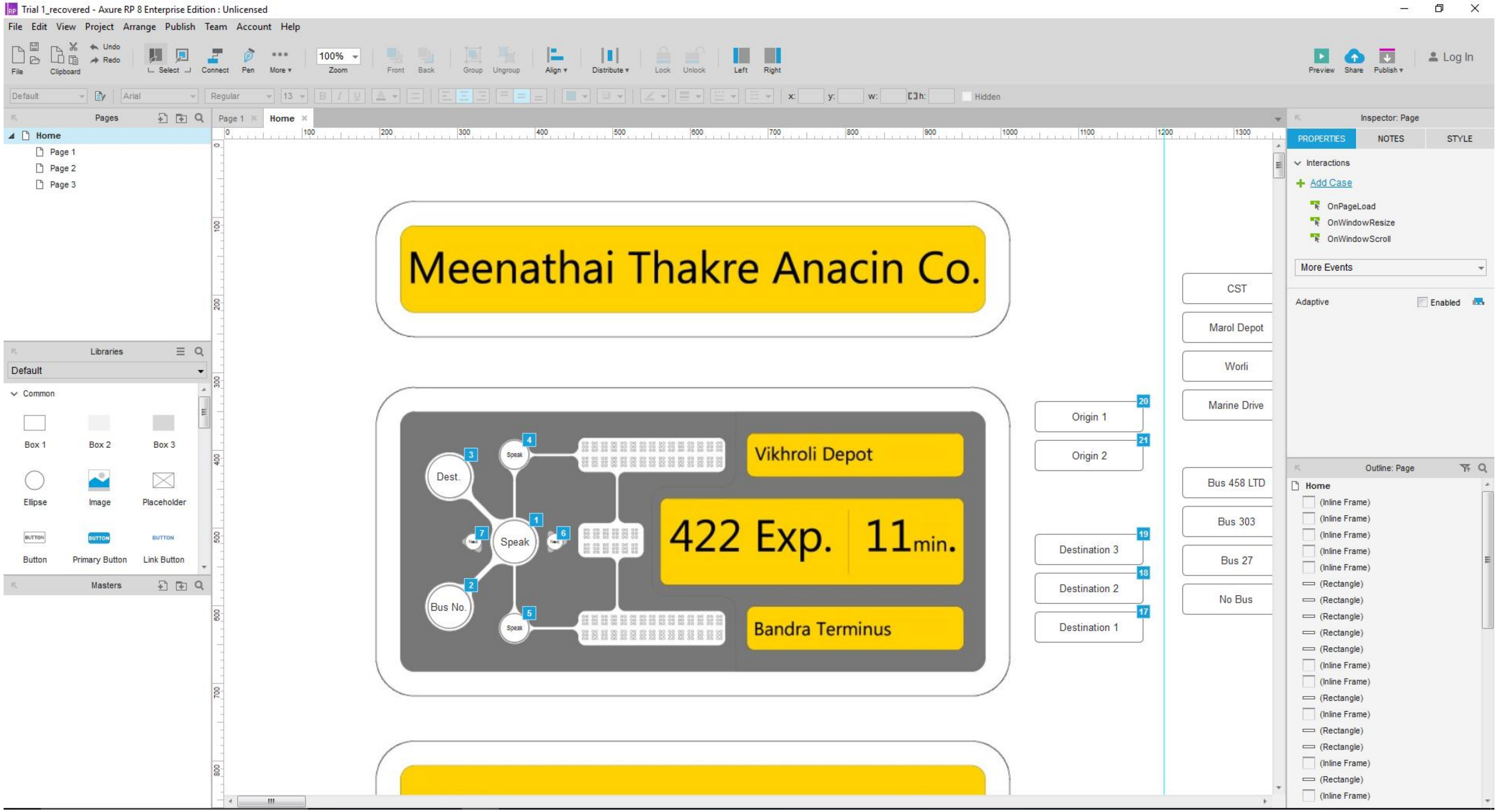


Figure 54: Axure (Digital) prototype for user testing

7.8.13 User Testing

User testing was done with the tangible and digital prototype in order to simulate the device working. The users were made to use the prototype while they were given some tasks to perform. The tasks were like:

- Find the next bus coming to this stop.
- Find the ETA of Bus no 422
- Find the ETA to next bus to Marine Drive

The user testing was done at NAB, Mumbai and users included 3 males and 2 females. Out of these 5 users 4 were completely blind while 1 was a low vision user.

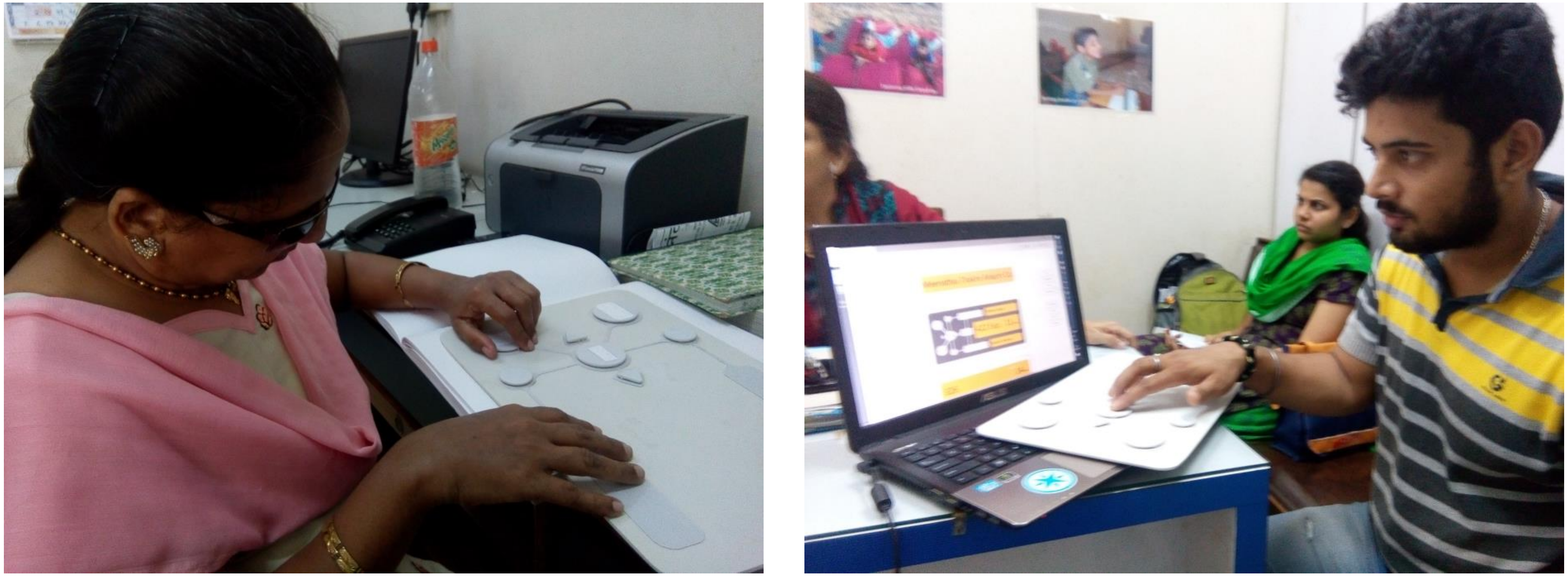


Figure 55: User Testing being done at NAB

8. Table of Figures

9. Bibliography

[1] Osborne, J. (2007, May 1). The key to accessible transport is a complete accessible trip chain. (D. Sharma, Interviewer)

[2] Johari, A. (2017, march 9). As Modi launches Accessible India, Mumbai activists put focus on safety of women with disabilities. *Scroll.in* , p. 2.

[3] Hessisches Landesamt für Statistik (State of Hessen): Bevölkerung der hessischen Gemeinden [1] Retrieved 14 October 2014

[4] India, G. o. (2007, feb 2). *censusindia*. Retrieved March 9, 2017 from Office of the Registrar General & Census Commissioner: http://www.censusindia.gov.in/

[5] group, T. w. (2016, march 9). *Transport in South Asia*. Retrieved March 9, 2017 from The world bank: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSARREGTOPTRANSPORT/0,,contentMDK:20703625~menuPK:868822~pagePK:34004173~piPK:34003707~theSitePK:579598,00.html

[6] Anindita Ghosh, K. K. (2016). Institutional and financial strengthening of intermediate public transport services in Indian cities. *Science Direct*

[7] John Puchera, *. N. (2005). Urban transport crisis in India. *Transport Policy*

[8] 1, S. K. ((2012)). Urban Transport in India: Issues, Challenges, and the Way Forward. *European Transport*

[9] Soans, I. (2014). *All you need to know about Mumbai's newly launched metro.* Mumbai: Firstpost.

[10] Christian Gold, D. D. (2013). “Take over!” How long does it take to get the driver back into the loop? *Sage Journals*

[11] Frank, M. (2015). *Your Head Is Better for Sensors than Your Wrist.*

[12] Know, H. A. (2006, march 9). *Hearing Aid Types*. Retrieved march 9, 2017 from Hearing Aid Know : https://www.hearingaidknow.com/hearing-aid-types