

An Interactive Universal Framework for the Blind

Enabling Awareness and Manoeuvring in Urban Built Environment

Abstract

Article 25 of the UN Convention on the Rights of Person with Disabilities emphasizes that persons with disabilities should not be ignored or left behind in their being able to enjoy the best of health, and obtain same quality healthcare as others without disability. [1] Sustainable Development Goals of the UN, and the World Health Organization recognize the inclusion of visual disabilities under the normative principles of the UN Charter to “leave no one behind” (LNOB.) [2] Towards this goal, advances in research on “human-computer-interface” has driven innovation in the development of assistive technologies, with new designs creating more accessible and user-friendly devices, especially for the blind, and people with visual impairment. However, these are assessed as more appropriate for high-income countries, are either not appropriate from an ethnographic aspect or context and lack mechanisms for repair or follow-up.[3] An attempt has been made in this paper to present an assessment of existing conventional travel assistive devices used by the blind within built environments. In the light of further research, invention of new devices and assessment of efficacy, this paper proposes a set of solutions for use within a new framework for urban built environments, that would help create a digitally-interactive universal ecosystem by retaining the use of conventional and hence intuitive means of assistive device depended upon currently, as the base to build on for expanding the awareness of blind people to the built environment and smoothen gaps in manoeuvring to accomplish incident-free mobility.

Keywords:

Digital, Ecosystem, Blind, Vision Impairment, Built Environment, Sustainable Development Goals, Cities, Urban areas, urban planning, inclusivity, LNOB, Assistive Devices, Travel Aids, Public Amenities, Public Utilities, Braille, Signboards, Traffic Signals, Roads, Road Traffic, Road Signs, Pedestrians, Pavements, Walkways, Footpaths, Road Intersection, accessibility applications, accessibility features, assistive technology, vision loss, blindness, low vision, functional low vision, legal blindness, vision rehabilitation, usability testing, usability evaluation, smart cane, white cane, folding cane, long cane, smart glasses, smart spectacles, camera, LIDAR, assistive laser devices.

Sustainable Development Goals:

2030 Agenda for Sustainable Development: SDG5-GenderEquality; SDG10-Reduced Inequalities; SDG11-Sustainable communities and cities.

1. Introduction

1.1 UN's Department of Economic and Social Affairs champion the cause of addressing the comprehensive rights of Persons with Disabilities under the broad vertical of Social Development Issues, formulating a Convention on the Rights of Persons with Disabilities (CRPD.) The convention was adopted on 13 December 2006, during the sixty-first session of the General Assembly and India ratified the convention on 1 Oct 2007 for development and implementation of legislation and policies in consonance with the convention, inter alia, to promote protect and ensure the full and equal enjoyment of all human rights and fundamental freedoms by all persons with disabilities, and for respecting their inherent dignity.[4]

1.2 LNOB (Leave No One Behind), one of the six Guiding Principles of Sustainable Development Cooperation Framework, is grounded in the UN's normative standards that are foundational principles of the Charter of the United Nations, international human rights law and national legal systems across the world. Seen through these lenses, persons with disabilities as addressed by the UN include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others. LNOB requires combating discrimination and rising inequalities within and amongst countries, and their root causes. A major cause of people being left behind is persistent forms of discrimination, including gender discrimination, which leaves individuals, families and whole communities marginalized, and excluded.

1.3 The charter suggests that disabled people face many barriers to accessing services, resources and equal opportunities, not simply as accidents of fate or a lack of availability of resources, but rather as the result of discriminatory laws, policies and social practices that leave particular groups of people further and further behind. LNOB compels us to focus on discrimination and inequalities (often multiple and intersecting) that undermine the agency of people as holders of rights. A rights-based approach helps locate disability as the interaction between a person's capabilities (limitation in functioning) and environmental barriers (physical, social, cultural or legislative) that may limit their participation in society. Assistive technology can step-in to help blind people and to live in dignity, and optimize their productivity as active members of their communities, to reach their full potential in society [5]

1.4 Lived space or the built-up environment can be accessed through different types of intentional (i.e. mental) acts. Two broad categories of intentional acts can be distinguished, presentational and representational acts. Perception belongs to the first category. Perception provides a somewhat direct access to space: one directly sees how objects are arranged or one directly hears where sounds come from. In more technical terms, perception is a presentational mode of awareness: being perceptually aware of something implies that there is something currently present that one is aware of. Space is also something we access through various representational modes of awareness, such as memory and imagination. An example of supermarket shelves would highlight the concept of representation in our memory. While the supermarket is not immediately proximate, the shelves can be imagined and related to from memory even though not presently available to look at. [6]Declerck 2017

1.5 Perceptual presentation makes the object actually there 'in person', while representational modes of awareness intend their object without making it physically present. Therefore, any awareness of a place implies some belief about, or acquaintance with, the spatial characteristics of that place, how it is organized, what you can find in that place and where, or where that place is with respect to some other places, how one can reach it. In our ordinary understanding of space, any place communicates with all the others, in the sense that any place is accessible from any other.[6] Declerck 2017

1.6 Wherever one is, it is possible to access any other place, by passing through the intermediate places. A visually able is always aware of where one is, knows what other places can be found nearby, and the place where one finds oneself has been assigned a position in the general network of places one is acquainted with. We would like to refer to this reticular interconnected lived built-up space the visually able operate within as an interactive framework. One's body not only shapes lived space as an organ of action, it also shapes it by making one irrevocably visible to other embodied subjects. When seeing others, we see if they look at us and we see if they can see us. Vision enables what could be described as an externalized awareness of the possibilities made available by the environment, the spatial layout and the objects. The visual space itself works as an external memory. However, to deal efficiently with the environment the blind must constantly make use of memory to keep track of what is there and where things are in the absence of a visual framework of the built environment. Blind people must replicate 'inside' the spatial arrangement of the 'outside', constantly needing a mental map. **[6]Declerck 2017**

1.6 There are an estimated 4.95 million blind individuals and 70 million people with visual impairment In India, with a substantial proportion being children **[7]Sunny Rishy [8]National Survey by AIIMS** The government, through initiatives like the Accessible India Campaign (Sugamya Bharat Abhiyan), has been working towards creating accessible infrastructure to support people with disabilities, particularly for the visually impaired. In the past, those who were blind or visually impaired used a wooden cane to go around, but over time, aluminium canes have overshadowed wooden canes. As technology advances, the conventional walking stick may no longer be adequate to grant visually impaired people their desired freedom.**[9] OKOLO and [10]PISSALOUX**. However, despite these efforts, navigating the world remains a daunting task for the blind due to various barriers, from the inadequacy of assistive devices to the complexity of urban environments. An important need in promoting access for people with disabilities is training of architects, engineers and planners in principles of universal design and accessibility.**[11] World Bank Report**. Empathizing and helping create an enabling environment is key to emancipation, aligned with the LNOB and CRPD.

1.7 In the light of the foregoing, the central focus of this paper is to minutely examine the conventional methods used by the blind during their movement outdoors and indoors, study the unaddressed gaps faced by the blind versus a visually-able person, and to postulate mechanisms for technological intervention to expand their awareness of and facilitate smoother manoeuvring in the built environments for achieving incident-free mobility and accessing public amenities.

2. Review of Mobility assistive devices

2.1 Mobility assistive devices. The most common solution to assistive device for the blind is to use a basic walking aid that has sensors to gather data about the surroundings.**[12]** Over time, several technological tools have been developed and large numbers of papers published on assistive devices that provide visual aural haptic and tactile inputs**[10] Edwige Pissaloux Ramiro Velázquez**. These include those based on a Smartphone based assistive technology, to aid mobility of the blind in urban agglomerations.**[13] Senjam** Hence, it would be infructuous to go through use cases for all of them again, and suffice to assess that most come with the baggage of weight, bulk, inconvenience, or possibly good in theory poor aesthetics but not intuitive enough for the blind to adopt enthusiastically and universally leading to abandonment of new assistive devices and technology **[14] Kuriakose**,and aesthetics **[15]DOS SANTOS**.

2.2 The central government had announced an Accessible India Campaign or Sugamya Bharat Abhiyan, on 03 Dec 2015, on the International Day of Persons with Disabilities, promoted by the United Nations since 1992. It aimed at retro-fitment of buildings, transport, modification of public building codes and government websites, to enable and empower people with disabilities. However, since then, almost all Metro (Subway) and Railway Station construction have adopted tactile tiles to be used outside and on platforms. Some universities of India and the NCR region of Delhi have also adopted tactile tiles on pavements, to aid the visually impaired. **[16] Govt of India, DEPD [17] World Bank Report 2009**

2.3 Concurrent Think Aloud and Retrospective Think Aloud assessments

2.3.1 The concept of Usability Testing (UT) was deployed on the mobility assistive device as well as the environment, using Think-Aloud Protocol, as used in Assistive device assessments, with both Concurrent Think Aloud (CTA) - the blind person verbalising thoughts while performing tasks with an assistive device- and Retrospective Think Aloud (RTA) - the blind person asked to provide their inputs after they completed mobility tasks. **[18] Van Den Haak** This helped pinpoint usability problems and separated the problems into those due to individual's specific disability and due to flaws in the interface of the device **[19]KIM HAN PARK PARK**

3. Observations & Assessments

3.1 Experiential observations. While walking around blindfolded, white cane in hand, and immediately that the first painful contact was made with the corner of a piece of furniture, the world that previously existed as a reticular organized space in memory, comprising of a kaleidoscope in 4k colour enriched with surround-sound, created for intuitive mobility of the visually enabled, instantly transforms to a dark unfamiliar moonscape in monochrome, shrouded in pitch darkness, full of unforgiving potholes pitfalls and body-piercing obstacles. Even ordinary sounds tend to amplify into overwhelming indiscernible noise, exhausting senses and intimidating the mind to give up the charade. A realistic feel for this phenomenon can effectively be recreated at what is called House of Horrors, a paid entertainment setup alongside mechanical rides, available at the local Circuses, some Malls, or even in a rural Mela, played out in dark rooms and passages, accessed through a tunnel-like entrance. The entrance leads to unfamiliar dark rooms along uneven ground surfaces, with prerecorded startling sounds and dimly lit sights of dismembered life-like corpses that would otherwise be stripped of their menace in broad daylight with plenty of visual references, to the extent of seeming silly and childish.

3.1.2 Every stumble creates imaginative fear of having walked into a trap, at the entrance of a chasm or grotto. Without visual cues accompanying natural habitation sounds that can be deconstructed individually with normal vision, allowing subconscious identification of individual sounds arriving uniquely from a specific place in a 360-degree field of view, the blind individual, is bereft of visual cues to locate themselves on a reference frame nor have an awareness of sight-sound combinations.

3.1.3 They are hence greatly challenged physically and mentally to identify label and point to its source or identify an origin; nor are they able to correctly assign threat level triggers, as a threshold to control panic and prevent or modulate initiation of the deeply embedded 'flight or fight' animal instinct. **[6] DeClerck**

3.2 Awareness of the environment

3.2.1 There are certain restrictions associated with the traditional use of white canes by people who are visually impaired for mobility assistance. Despite being inexpensive, the white cane's ability to identify impediments is restricted because it only provides tactile feedback. As a result, there might be a smaller window of time for the person to react to the demands made by the scenario, which could be detrimental to their well-being. [9]OKOLO. There are a number of technology permutations included in development of smart stick devices for the blind.[20] Choong and Reddy, 2019. These functions are intended to support autonomous movement and improve users' comfort. Mobility aids have historically been used by people with vision impairments but the modern iterations loaded with technological innovation to overcome flaws in the basic conventional device have a number of drawbacks. [14]KURIAKOSE.

3.2.2 Some of the gaps that were physically observed and others obtained from Usability Testing sessions with the blind[13], [18], are as follows:

- i) The tip end of the white or long cane used by the Blind has a small surface area. It is used to feel around the intended path that would be taken by the blind person, by waving the cane in front as they walk, as well as by tapping the tip on the ground in front to get haptic feedback from any obstruction in the path, caused by the cane impacting the obstruction. However, as compared to the much larger surface area of the track to be covered by their feet, 1.33SFT on average as they slowly move forward, the area that can be scanned by the cane tip is relatively small and as the scan of the ground in front is done irregularly and manually, there is always the chance of missing a brick or a missing pavement tile.
- ii) A cane is incapable of detecting all surface irregularities - dislodged or missing paving tiles, disjointed surfaces and stray debris on pavements and roads – and, these irregular surfaces can cause a stumble. Imperfect unfinished pavement surfaces and tilted paving tiles can cause the blind to stumble, slowing down progress on rough surfaces, even on detection of infrequent minor irregularity.
- iii) Stumbling changes the orientation and intended course of a blind individual with respect to the imaginary line they would have progressed along had the stumble not been caused, and this can lead them into oncoming or approaching traffic without warning, because of a lack of external visual references to keep oriented to the built environment.
- iv) The cane frequently cannot identify raised or low-suspended obstacles, located off the ground at a height, like a truck's open and horizontal tailgate deployed for loading or unloading, bollards or parked large vehicles, fire hydrants, leaning trees or low signboards or low branches.
- v) Curving roads and pavements cannot be detected using a Cane. A roundabout, with its circular shape, as well as the starting points of pedestrian walkways cutting across roads, are not identifiable to the blind.
- vi) Braille can be read only when both hands are resting on the surface. Braille used in signs in public spaces for assisting the blind is useful only when someone with sight leads and points them to the exact spot where the Braille writing is used, such as on seat number plates. Braille writing is not relevant to the blind when used on notice boards, designator sign boards, vehicle destination boards and registration number plates, railway coach designator, bus number boards, or platform numbering boards.

vii) Rain water puddles on a paved surface can disorient the blind as the pavement surface hidden under water is has no reference, with sloshing water overriding cane inputs.

viii) The colour white for the cane was introduced in 1921 in the UK and is meant to warn others around of the individuals' restricted mobility. However, it occupies too small a visual space of passers-by to be able to capture attention of pedestrians, especially in crowded areas such as concourses and passageways, or by micromobility and bicycle riders, or by distracted motorists executing turns.

ix) Use of smartphone-based Apps in public spaces can potentially invite the wresting away of the device by thieves. Besides, fumbling around for a smartphone, white/long cane and luggage being carried by the blind in an urban environment might not be conducive to a peaceful state of mind.

x) Rural population identified to have maximum blindness cases do not have the luxury of pervasive internet access, as do urban citizens. Even in urban areas, a sighted person has to move around monitoring the network signal strength indicator, to improve reception; This a blind person cannot do.

4. Proposed solutions framework

4.1 Problem statement. A folklore has it that an urban dweller visiting rural environs would face significant difficulties in moving around as distance time and numbers are different, and at times typically ephemeral rural concepts based upon practical lifestyle adapted to nature. We could generate a problem statement by critically observing urban built environments around us and by relating it as a parallel set of differences as between the Urban-Rural setting, with an assessment that the built environment was created by the visually able for use of the visually able. This observation helps us to realize difficulties faced by the blind as opposed to the visually able. The visually able obtain cues differently from the built environment, subconsciously visually mapping various standardized features fixtures and furniture against a reference framework centred around themselves, allowing them to move around effortlessly within it. The blind, on the contrary build a reference framework for mapping their reality for manoeuvring based only on tactile and audible inputs. New assistive devices providing technology intervention to make the blind more mobile in urban built environments pose significant hurdles in acceptability and adoption, due to various practical reasons listed above and importantly that they are attempt superimposition of a vision-based framework when the blind have grown up from childhood to depend on tactile inputs. A vision free framework that creates a tactile and audible perception of the built environment therefore, would immediately allow all other new technology-based devices to operate successfully within it. As the hurdles are complex, the solutions are proposed to be divided in two parts – the environmental framework; and personal devices operating in coordination, within it.

4.2 Proposed environmental framework (E1 E2 E3)

We propose that a reference environmental framework in three parts, termed E1 E2 and E3, when created for the blind as a part of the built environment for the blind to glean cues from, would enable them to use tactile and aural inputs from an interactive environment now mimicking a visual framework, as currently obtained subconsciously by the visually-able manoeuvring within built environments.

4.2.1 Environmental Framework (E1) The proposal includes the creation of a continuous longitudinal line, of the first part, using thermosetting plastic paint as used for road markings, with iron powder mixed into the paint while it is being heated. The longitudinal line could be of suitable width (4 inches could be optimum outdoors, and two inches, when laid indoors), along corridors passageways concourses walkways pavements platforms sidewalks pedestrian paths and internal roads (commonly referred to as walkways, hereafter), for both outdoors and indoors use. The line could be differentiated from road marking lines by mixing in a dye of a suitable colour, say red. [21]IRC35-2015 code section 803 and [22]IS:164. At every point of break of the longitudinal line, and if the line runs through areas where entry/exit is possible from other points along its length, into walkways having the longitudinal line laid, it is proposed to add lateral lines at the start and end of the longitudinal line, at obtuse angles to form funnels, laid end to end across the width of the walkways, and connecting the main longitudinal line suitably without a break. These funnel lines created from the same paint composition, would facilitate detection by devices (using **Personal Device P1** described below) to guide the blind home-on to the main longitudinal line E1. Stencilling letters on the longitudinal main and lateral funnel lines E1 with words FOR THE BLIND could reduce scuffing and abrasion from others riding the lines. These lines would also facilitate evacuation of the blind during emergencies and natural disasters from indoor locations, by allowing their following the line independently, which capability does not exist currently. [23] FAA AC 25.812-1A. The above proposed lines E1 would act as a spatial environmental framework similar to breadcrumb navigation enabling computer users to instantaneously know at all times where they are within the digital environment effortlessly[24] **Barbara Bonnie**.

4.2.2 Environmental Framework (E2) STEP SIGN E2 are as illustrated in Figure 1, painted appropriately on walkways, intersecting longitudinal line E1, using the same material as for E1. The STEP SIGN E2 is proposed to be a total size of a tile of 15x15 inches (381x381 mm) The lines used to create the finalized STEP SIGN E2 could be 2.6 inches (66mm) wide, permitting the manipulation of **Personal Device P1** to trace the lines of the STEP SIGN E2 to derive meaningful actionable alerts. A directional STEP SIGN E2 comprising of a broken line composed of Dots and Dashes, forewarning the presence of a STEP SIGN E2 ahead, within three steps, could be used on the upwind side of each of the STEP SIGN E2. These STEP SIGN E2 can be read using the **Personal Device P1** by the blind and could serve the function of warning them of turns, rough surfaces, detours, danger, and etc. The STEP SIGN E2 are envisaged to alert the blind to the conditions they are approaching toward as they walk, riding the environmental framework E1 lines. These alerts could be on approaching points of interest or, to be wary of an approaching turn used by vehicles, such as turns gates ramps traffic signals and intersections. The STEP SIGN E2 mimic standardized Road Signages in their use. [25] IRC 67-2012 Some of the proposed STEP SIGN E2 are illustrated below and more can be added in consultation with Blind Associations on a similar line.

4.2.3 Environmental Framework (E3) Digital Maps have the drawback of showing an approximate location of the place of interest at a 5m resolution in urban areas of the country, from imagery provided by SPOT Satellites, provided the location name was captured previously. This resolution is too low to pinpoint gates doors and such granular details, of public utilities such as entrances to railway stations bus stations public utilities and government buildings. E3 is a mechanism for recognizing points of interest such as location of gates entrances doors and exits, as well as platform numbers, bus numbers, railway coach numbers et al. This recognition could be achieved by using UHF RFID Tags, written with prearranged standardized Hexadecimal code in the user field that can be deciphered with an onboard dictionary carrying generic translation for public facilities and utilities.

4.2.3.1 As an example, **Impinj Monza R6 UHF RFID Gen2 Tag** has 96 positions in the EPC Field and none in the User Field, and even this minimally provides a decimal equivalent of 24310 combinations with repetition of numerals, for encoding a pre-recorded library of word-translations. Other Tags have a separate User written field that can considerably enhance this number, allowing greater flexibility. [26] **ISO 18000-6C**, [27] **Plikynas Zvironas**. We propose that these pre-written Passive UHF Tags be enclosed and sealed in aluminium boxes, with one vertical outward-facing side (two outward facing sides, if mounted on a Pole) open and closed-off with a Polycarbonate window. The boxes could be fixed at eye level, whenever used. Aluminium foil is known to act as a shield to prevent eavesdropping by malicious actors [28] **NIST 800-98** Passive UHF Tags are sensitive to presence of metal, unless cushioned by a piece of foam at least 1/8 inches thick, and liquids can short their transmission out. The one (two) facing side(s) of the boxes with the polycarbonate window could receive and transmit, without hinderance. This achieves weather proofed sealing of the Tag and provides directivity as required, preventing interference with other nearby tags that may be operating in the wild and used in logistics identification and tracking.

4.2.3.2 UHF Passive tags, carrying standardized prerecorded code stored in these sealed aluminium boxes, should be installed with their polycarbonate transparent side facing the STEP SIGN E2 sign, allowing the blind to retrieve granular data using their **Personal Device P2** from Information available in the Tag, by turning their head (to have their spectacles and hence the RFID Reader antenna) positioned in the direction of arrow of the relevant STEP SIGN E2.

5. Proposed personal devices (P1 P2 P3 P4)

5.1 Personal Device P1. We propose that a Pulse Voltage-based metal detection coil mounted inside a conventional white/long cane at its lowest end, wired to a Lithium-polymer battery shaped to fit within the handle of the cane. An unpowered wheel of about 2 inches diameter, fitted to the end of the stick, shielded by a smaller dummy wheel cover, carrying the loop of the detection coil as close as possible to the moving wheel's contact point with the ground. Detection of the embedded iron powder within the Environmental Framework lines E1 would activate a haptic output, fed to the handle of the white /long cane, confirming to the blind operating the Cane that the Personal Device P1 has positively identified and is tracking the lines E1, thereby allowing navigation by using the cane, without requiring separate devices such as a smartphone to detect BLE Beacons [29] **Chen Dongyau**. The same method could possibly be used for the STEP SIGN E2, using the Personal Device P1 to recognize and read the alert encoded therein. [30] **Garrett, Texas-manufactured concealed metal and non-ferrous material detection hand-held wand.**

5.2 Personal device P2. We recommend that an antenna and associated electronics of an UHF RFID passive reader be embedded in a dummy spectacle, shaped to resemble the conventional ones used by the blind, operated by a rechargeable Button cell. This UHF Reader as Personal Device P2, with an onboard translation library that could decode and play a standardized output, in the form of an audio file, with the onboard dictionary containing generic names of public facilities. The output of the RFID Reader could be played through a speaker located near the ear by depressing a concealed button on the frame of the spectacle, and facing the direction in which the tag is located, with the direction to face the tag indicated by the applicable STEP SIGN E2. The Reader antenna needs to be Circularly Polarized to prevent inability to detect and read Passive UHF Tags with incorrect orientation. In addition, as Reader antennae are available from 21 mm they require to be matched with custom designed extra-large passive tags, catering to Friis transmission formula. Eg: Model **S4 Reader (Type A-115226-C)**[31]

5.3 Personal device P3. To identify proximity of obstacles in the nearby volume of space, especially vertical obstacles like tree branches, leaning poles, a parked truck, seated bovines or stray dogs, its relative movement with respect to the blind and to identify other stationery or moving living things, a ToF(Time of Flight) camera using Analog Front End (AFD) OptoElectronics used in conjunction with a pulsed non-collimated Laser, range-gated to acquire information of targets within its active cone-shaped beam(s), as Personal device P3, integrated into the buckle of a custom belt. With BlueTooth radio connectivity, it could provide audible output to a speaker located on the spectacles, indicating the presence, distance and whether receding or approaching (probably calibrated in steps of 18 inches and called out audibly in step count.) An onboard offline closed-loop embedded algorithm contained in the spectacles could provide inputs by depressing a toggle switch. Depressing the switch would disable the Personal Device P3 and activate Personal Device P2 to provide audible information from the RFID; and vice versa. The speaker output could be made directional with a pinnae-like cover around it, to overcome environmental noise and protection from rain. Such a combination should be able to assess the inputs and provide a reasonably effective actionable audible output, without causing an overload of information, unlike with a purely camera-based approach, normally available using AI-driven or manual back-end object identification system designs [14] Kuriakose.

5.4 Personal device P4. Personal device P4 could be a two-colour flashing strip of LED (white and red bands), in two parts. One could be affixed to or merged, below the handle area of the blind cane, of approximately 8 inches length (4 inches each) powered from the battery carried inside the handle. The second could be integrated to the belt facing the rear, to enhance all weather visibility of the blind in the environment when they manoeuvre outdoors. Pedestrian fatalities are high in the country [32]ADB Study, though the proportion of blind in the statistics is not explicit. The white cane was created for addressing that purpose, but with increasing traffic, pavement spaces inaccessible due to appropriation for other purposes [33] Last Mile Report, and virtually soundless Battery-powered vehicles using roads, capable of rapid acceleration without the familiar audible output conventionally associated with combustive tractive effort, the blind are particularly vulnerable to avoidable incidents, when unable to attract the attention of distracted vehicle drivers and riders, now faced with LCD Display based integrated ICT Controls and Navigation.

Figure 1. Environmental framework E2

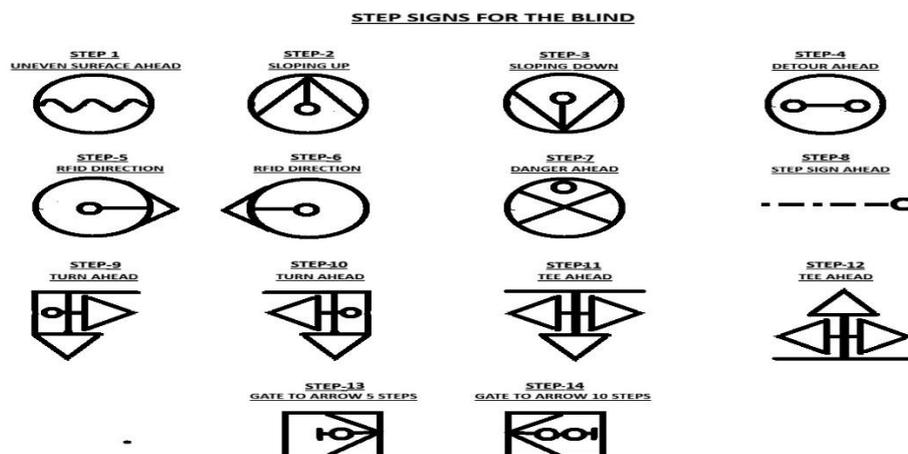


Figure 1.
Environmental Framework E2

Figure 2. Personal Devices (P1, P2, P3)

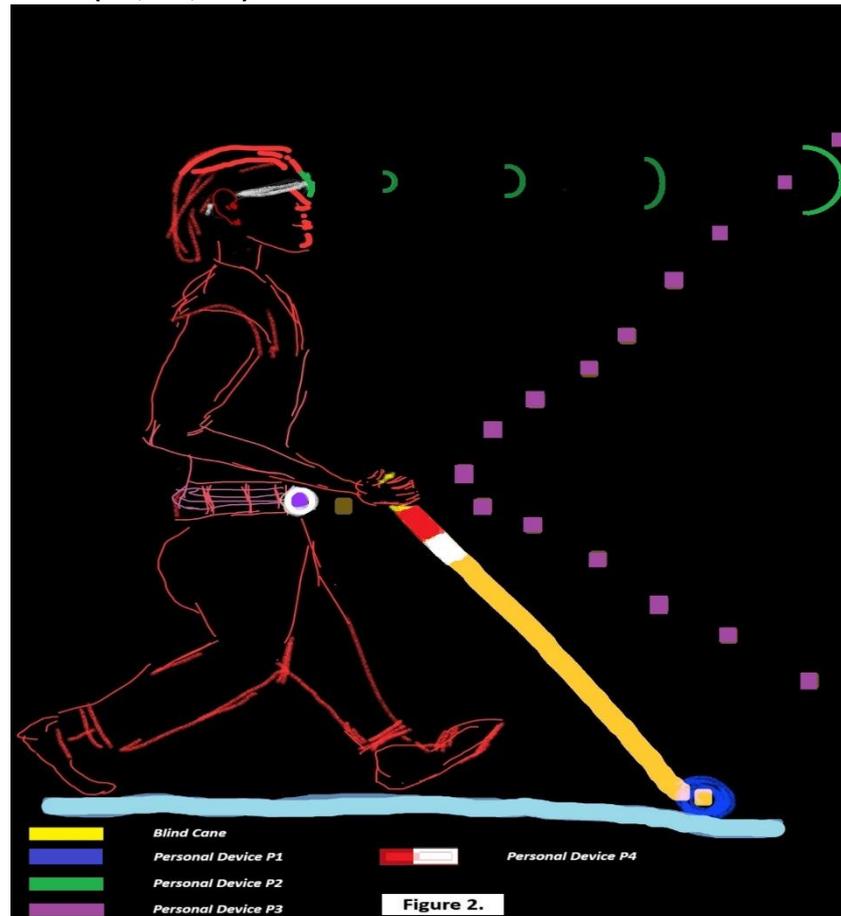


Figure 2.
Personal Devices P1 ~ P4

6. Macro analysis of proposals

The Department of Economic and Social Affairs of the UN notes that persons with disabilities are being left behind, in its Disability and Development Report of 2024, with progress for 14 per cent of SDGs, with targets having been missed or progress stalled or gone in reverse. We believe that the proposals in the preceding paragraphs will accelerate development for the populations of blind among the disabled – the most crippled in helping themselves within built environment — through a pre-cast man-made reference framework. Aside from the blind being able to manoeuvre safely within the environmental framework E1 E2 E3 proposed in this paper, a salutary positive social pressure can be expected on municipal engineering (pavements/footpaths/Sidewalks) and traffic management departments to ensure that the Environmental Framework E1, Step Sign E2 and RFID Tag Boxes in E3 are marked and placed such as to create pre-vetted and safe ecosystem, as the blind will lower their guard with the greater ease of mobility made possible with these. **Dos Santos[15] UN Report [34], European Best Practices [35]** . Throwing open the field to private enterprise and prodding PSUs to take up manufacture of Personal Devices would enable market forces to reduce prices, initiate R&D and improve Town Planning schema to align with safety of the blind along similar lines as standardized Traffic Signals, Road Signages and Markings developed as public services and utilities, after 1908 when automobiles mass marketing commenced.

7. Recommendations

The National Institute for the Empowerment of the Persons with Visual Disabilities (NIEPVD), a department under the Ministry of Social Justice and eEmpowerment of the Government of India and the designated nodal agency for all aspects of development and upliftment of the blind in the country together with National Blind Associations, representing the blind and their pain points, could jointly study and assess the above proposals from a user perspective. The nodal agency is ideally placed to liaise with other Government Ministries and Departments for the standardization of Paint and iron-powder mix, RFID translation vocabulary, standardized Tag antenna design and EMI/EMC aspects of Aluminium shielding, for use with personal device P1, P2, P3 and P4 to be created by private parties.

8. Conclusion

8.1 We had set out on a journey of discovery, after being invited to visit a blind school in Chennai, in 2018, and subsequently experienced the hurdles that our built environment throws up at unsuspecting Blind pedestrians. The learning was difficult, certainly an eyeopener, and we continued down the road with Helen Keller's chiding quote echoing in our ears "the only thing worse than being blind is having sight but no vision." Our aims were to:

1. Increase awareness about the limitations of current mobility aids, such as the cane's inability to detect obstacles all the time, or to decode curved paths.
2. Addressing challenges of blind individuals in urban settings, where technological intervention, infrastructure design of built environment and inclusivity measures are not matched.
3. Advocating for more inclusive designs and greater meaningful use of assistive technology, to improve quality of life for blind people.
4. Finalizing conceptual solutions rather than a device that would circumvent or resolve most of the challenges at the most economical price for the greatest penetration of the final beta devices.

Declaration of generative AI and AI-assisted technologies in the writing process

No use was made of automated algorithmic editing tools, other than built-in spell checker in MS Word, neither was any form of AI made use of to improve the appeal of the language used or any suggestion to present the research or the recommendations in this paper.

Disclosure

No potential conflict of interest is reported by the author. As this paper was generated with altruistic purposes, experimental engineering on obtainable ranges, trade-offs in using the inverse relationship between antenna sizes at the Reader and the Passive Tag, quantum of iron powder required in thermosetting paint, changes in permeability and detection by the proposed device when its detection coil is in proximity to it, and etc, were not scientifically ascertained.

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Author

Thomas, Alex, PG, Avionics, NavalAirTechSchool, Kochi; PGDBM-GIM, Ribandar; BTech-NSS-Palakkad; Air Accidents Investigator, QAS(Aero),Flight Safety Inspector, FSI &CTI, IAF [Founder-Partner, TDCO.Design,Bangalore; (Formerly) Director-Ops, KSEDCL (KELTRON), Kerala; GM-OEM/PLT Batteries, HBL Power Systems, Hyd; OpsMan, Amazon.Com, Hyd; Project Head DIGITAP '03-Concept Pilot of Sea Harrier Air Publications Digitization & Access]

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