Evaluate the Necessity of Using the Navigation System for Blind People in Urban Spaces (Based on Case-Study Research in Tehran)

Kamran Rahimov[1], Amir reza Nickkar[2], Hassan Khaksar[3]

1- PHD, Iran University of Science and Technology, Tehran, Iran
2- MS.c, Azad University of Tehran, South Tehran Branch, Tehran, Iran
3- PHD Candidate, Iran University of Science and Technology, Tehran, Iran

K.Rahimof@TSML.ir ,Amirreza.nickkar@yahoo.com, Khaksar@iust.ac.ir

Abstract

Public transportation reduces traffic congestion and develops equity in urban area. Barely this equity is seen for handicapped. Blinds or people with vision difficulties are a part of these people. Lack of infrastructure equipment for blinds in public transportation systems, not only made these systems useless for them, but also endangers their lives. Although considerable progress performed to develop public transportation systems for blinds in recent years, which urbanarea, sidewalks and public transportation stations development are some of them but there are still some deficiencies, especially for blinds approach to transportation systems. Major part of these deficiencies isrelated to blinds transportation infrastructure and lack of using modern technologies in blinds transportation. Several technologies are formed to serve blinds transportation in urban area which the modernist and the most compatible techniquesare navigation systems. This paper described the various stages of the process of navigation system for the blind people. Therefore, in addition to introducing the navigation system for blind people, its benefits were presented. After that, studying White Cane education center in tehran as a blind education center, blind traveling pattern was analyzed using questionnaire forms. Then feasibility of implementing navigation system for blind people in 6th district of Tehran was studied as a pilot. Based on investment returning analysis, the navigation system for blind people system implementation costs will return in less than 10 years. In this study the cost saved from reduction in incidents and accidents were considered

Keywords: Navigation, Orientation, Navigation, Personal Digital Assistant, questionnaire

1. Introduction

Since each people even blinds and people with vision difficulties have the right to approach public transportation, technology serves these people to ease and safe their approach to public transportation. Blinds needs facing public transportation system should be well recognized to design a workable assisting system helping blinds in public transportation system in which media and communication approach ability and amount of blindness, deafness, disturbance in environment perception, support necessity and mood should be considered. So it has to be a comprehensive and flexible system.

Surveying in a real space including challenges like path programming, surrounding environment survey, recognizing path, orientation and obstacle distinguishing is a complex set for a blind in fact [1]. Problem is defined in this paper initially and necessity of considering it is presented too. Concept explanation and navigation system general information were introduced in this section and RAMPE[1] project is introduced in next section. The system is evaluated then and advantages and disadvantages with necessity of utilizing it in Iran are presented. A case study is done to evaluate the system advantages and disadvantages for blinds in a blind special educational center (White Cane in Tehran). Finally results and conclusions are presented for future studies.

2. Problem Definition

Routing problem for blinds including navigation systems performance, blind routing measures and routing requirements is described in this section.

2.1. Navigation Systems Performance

Navigation is to find the route in a real or virtual environment which starts from an origin and ends at a destination. Therefore navigation as a basic human skill is an essential part of motion [1].

Adams [2] presented a man motion heuristic model which divides navigation from one point to another into 3 phases: Preliminary Planning, General Routing and Appropriate routing.

In the Preliminary Planning phase, Person decides where to go and investigates different routes to destination in the preliminary planning stage and finally chooses the best route according to factors such as distance, time, safety and other important factors.

Required measures for motion from one point to another point of the route are described in general routing stage. These measures are midterm strategies such as orientation, reaching one point of the route and surveying a long path of the route.

A short term strategy is determined in appropriate routing stage, for preventing dangers and obstacles existing in the route such as stairs, congested intersections and ground holes.

Blind faces these three stages from preliminary planning to appropriate routing, however not exclusively in this form always. For instance considering a situation in which blind person has selected a route and entered, finds out the route is blocked because of an operation hence must return to the preliminary planning stage and choose a new route [2].

2.2. Blind Routing Measures

Based on blind pedestrians traffic situation analysis, a set of measures has been identified which are required for moving from one point to another. These measures are done in six steps [1]:

Step1. Route finding

Step2. Identifying the current position

Step3. Reminding and selecting right orient in intersections

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[1] Referentiel d'assistance aux personnes Aveugle pour luer Mobilite dans les transports publics et les Poles d'Echange)

Step4. Determine the distance to the next intersection

Step5. Considering that part of the route orient

Step 6. Avoiding dangers and obstacles

Preliminary planning stage can be done by a blind person or by other person help. Steps 2-5 are a part of general routing measures: Blind must identify his location for managing other general routing measures (step2). 3rd step is to remind the direction to be selected. This selection is the difference between preliminary planning and general routing stages. Blinds need to determine next intersection distance to be prepared for reaching that. Distance detection (step4) is based on prior knowledge of the preliminary planning stage and indications provided by the tactility surfaces and blinds auditory perception. Considering path direction (step5) is largely done with tactility guide assistance. Appropriate routing is the last step (step 6) which is done with white cane and blind audition assistance.
A routing system helps blind to have a greater independence and mobility in transport which is favorable to them. The preliminary planning stages are done by blind people nowadays often. Moreover, routes with tactility surfaces and different kinds of PDA[2] help them in this stage. Some general routing devices are made but not widely used.

Some of these devices are not able to overcome some specific restrictions a reason that blinds reject them. When a blind uses a routing system, the system should not be restricting his freedom of action, hence it should be light and portable and not district using German shepherd dog and white cane, using it must not require both hands application. A navigation system should not cause a disturbance in blind perception of the environment or restrict him at a low level, since blind needs to gather all his senses in a traffic environment.

Since auditory is the only sense of a blind let him understand surrounding environment, this sense has enormous importance in navigation system. Therefore, headphones (to cover both ears) must not be used in this system and Sound level should be maintained at low levels. Auxiliary interfaces must be understandable and sensible, especially when user is walking, since in such circumstance his attention to the routing system assistant is very low [1].

2.3. The General Routing Requirements

User must know when he will reach next intersection in addition to know which intersection is there in order to identify this step. These data enables him making an integrated model for surrounding environment in his mind. Therefore, the user can identify and update his location in his mental model. Identifying the location and structure of surrounding environment let the user adjust his movement according to prior knowledge. In order to enable the user identifying his location, data must be given as he wants.

Direction selection in intersections (step 3). User wants to follow a route after reaching an intersection, so he selects his direction considering next path. He must know the direction of that part of the route now, so a personal statement such as "Please turn to the left" should be given to him for guidance into the right direction. Detailed information about exact direction, enables him

[2] Personal Digital Assistant

to act more carefully. This information should be given to the user based on actual (current) orientation, not the four original orients.

Distance to the next intersection (step 4). The user must know his distance from next intersection in order to be prepared to reach that. This information is more important when he is getting closer to the intersection. Therefore information should be presented not continuous but periodically.

Considering streets directions (step 5). After leaving the intersection, user needs to continue the route to the next intersection. So he walks along the path until reaches the end. To do this, he must keep his direction according to route direction. Therefore should be informed about how to change his direction if he wants doing that.

Existing blind navigation systems can be divided into two groups based on information presentation style: first group is based on information presentation by speech while other group is based on giving information as outputs connecting the blind physical sensors. Such as a system transferring simple awareness and orders by making vibration in sensitive point of body (i.e. arm) however this system can't transfer information such as direction or distance. These systems function are among general navigation stage measures [1].

3. Existing Methods Evaluation

Considering RAMPE project isn't introduced in Iran yet, this system will be introduced in this part. System performance stages and system performance is presented and evaluated then.

3.1. RAMPE Project Introduction

Few systems are available now to assist and inform blind in open urban area. These systems are based on Infrared (IR) or Radio Frequency (RF). Some of them announce traffic signs and some can state speech signals using infrared audio signals from a long distance. There are also audio systems like EO-guidage which are activated by remote control as radio frequencies. Both of these systems (IR and RF) are evaluated in PREDIT study at France [4].

RAMPE is dialog information and audio assist system for blinds which is used for their movement and independent them in public transportation designed by ESIEE engineering co cooperating with LUMIPLAN and Winsys University of Paris. It can be installed on all stations of public transportation network [3].

This technology requires a PDA which RAMPE software is installed in it. Process is described as follow: Blind closes to a station equipped with RAMPE network sending and receiving signal terminal with his PDA. Information is sent by this terminal continuously which is received by PDA. PDA sends a chime sending order to bus stop after receiving information to guide user recognizing station position and leading user there.

PDA can recognize all available station and buses names (codes) for users by connection with RAMPE network. Information is announced to them by PDA and can be repeated unlimitedly. PDA mentions all bus stops in the route after choosing the bus and user can choose the destination station based on that. After software programming, PDA inform user about coming or late buses. When containing blind person bus reaches to the destination station, PDA sends a speech signal for the user to inform bus driver stopping in the station [5].

Buses and other public transportation systems should be equipped with this system and users should transport a belt or small bracelet to connect equipments in stations using WIFI to utilize this system. PDA functional program presents voice messages, adopts itself to information system which is applicable in station [3]. This set responses to station information. Man-Machine-Interface (MMI) is designed to manage priorities with high precision (figure 1).

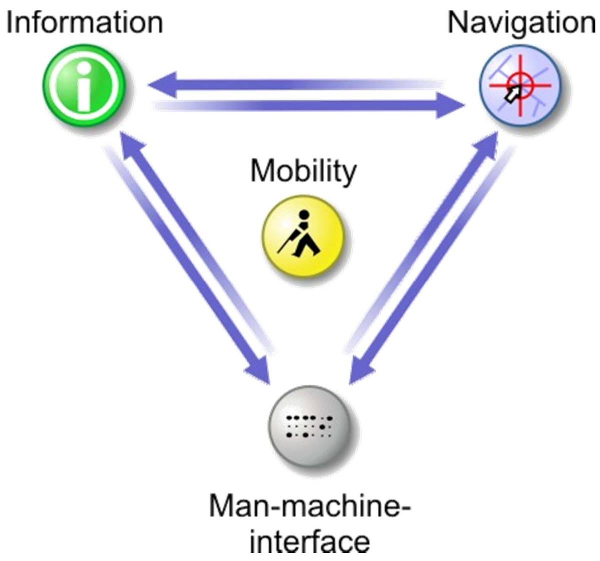

Figure 1 : Relationship between navigation system elements in RAMPE project [6]

3.2. The RAMPE System Survey

RAMPE system function is described in this section. As mentioned before, RAMPE is a network which is able to exchange information between users PDA and bus stations. RAMPE system (Figure 1) is based on [7]:

- A small bracelet or a belt carried by user. This device carries a PDA which has RAMPE function software and works by wireless connection
- A terminal installed at the station to receive and transmit signals including wireless access post and speakers which can be activated remotely by the user. Schematic design of the system is shown in Figure 2 [8].

Figure2. The overall index of how to use the RAMPE system [8]

3.3. RAMPE Function Phases

RAMPE function includes four phases which is described here. Figure 3 illustrates this process.

Phase 0: Blind walks in the street and looks for a bus stop. The receiving and transmitting signals terminal sends information to RAMPE network periodically and PDA detects the terminal to record the station.

Phase 1: Bus stop selection; User communicates with the selected receiving and transmitting signals terminal.

Phase 2: Bus stop entrance guide; established connection with terminal, PDA sends information to receiving and transmitting signals terminal. Terminal receives information and broadcasts audio signal from speaker for guiding the blind to enter there. Blind is able to hear the sound and understand the bus stop location, so can move toward it.

Phase 3: Routing interface; when blind reaches next to the receiving and transmitting signals terminal, broadcasting audio signal is stopped and blind receives terminal data. Figure 4 shows system functional phase communication [5].

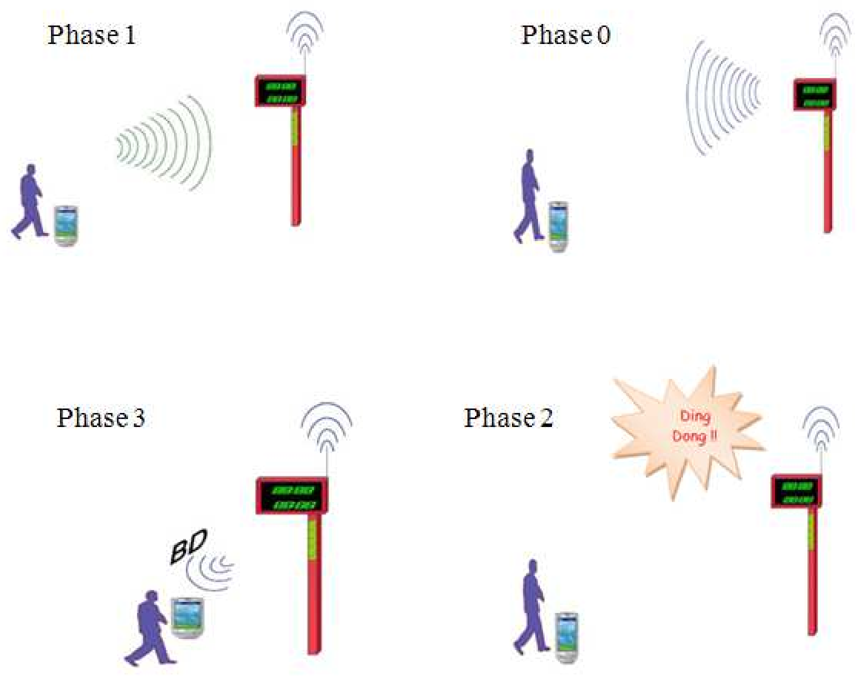

Figure 3. RAMPE function phases [5]

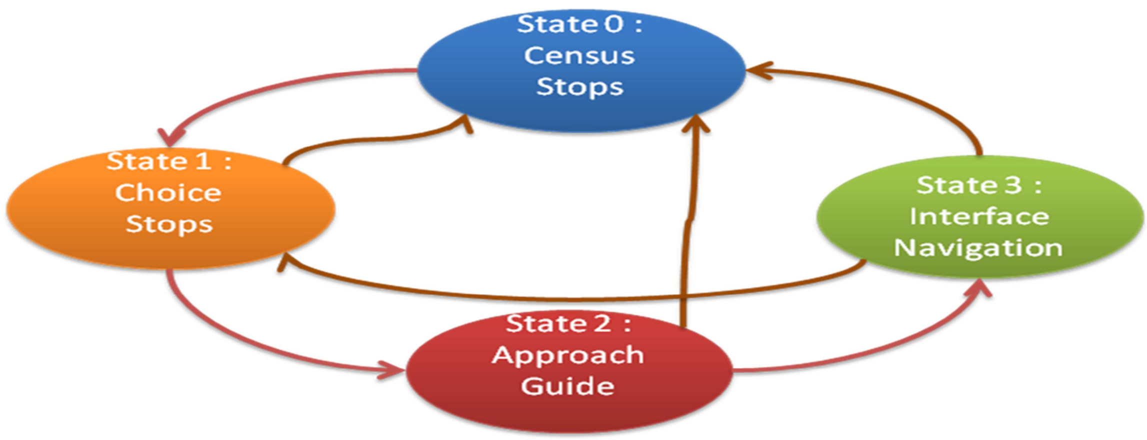

Figure 4. RAMPE functional phase communication [5]

3.4. RAMPE System Function in Different Situations

Blind behaviors can be divided into three categories based on importance of them [3]:

1. **Safety** (preventing falling and collision risks)

2. **Location** (not only location in one part of travel , intersections and bus stop names but also equipments location, entrance and exit of bus stop or subway station, vehicle entrance and exit in station and bus stop, door position in bus or subway and …)
3. **Reliability**: difference between real and mental position of blind in travel.

Using bus is harder than other public transportation systems for blind usually because of reasons such as bus stop existence and location, more vulnerability than other systems such as subway, probability of traffic congestion [9].

Since blind needs getting appropriate information in different time and locations, there must be a convenience communication between areas which blind may be there and information level which is appropriate to the location. Therefore, these areas are divided into four categories [3]:

1. Urban area (Position information is required, such as the existence and location of stations)
2. Transfer area (Requires guidance information)
3. Access area (Requires real information such as bus arriving time to the station)
4. In-vehicle (Requires information about the surrounding environment changes)

Access and transfer areas have been merged for public transportation systems like buses.

All accessing information by the receiving and transmitting signals terminal is transferred to RAMPE functional program which is embedded in PDA. These are three different levels for information [3]:

- **Structural:** first level is associated with data structure including lane number information, station name, theoretical scheduling and sidelight (evidence dependent)
- **Short time:** this information can be in constant exceptions form such as interrupting service or credit for a few days or weeks.
- **Immediate (real time):** last level is immediate information such as sudden interruption of service due to crisis or accident, vehicle entrance and service messages.

4. Survey and Evaluate Applying RAMPE System in Iran Necessity

The necessity of using navigation system for blinds in urban public transport network in Iran will be evaluated in this section. This requires investigating initial components for successful feasibility of similar project in Iran. According to necessity of providing social equity in all levels and accessibility for all segments of society, it’s clear that developing this system is necessary. Following steps should be taken for these purposes:

- **Step1.** Data and statistics collection; collecting physical data and blinds تردد volume in the zone covered by this system is one of the main study phases of these projects, so obtained results influence the feasibility of this system directly. For instance statistics on blinds public transportation systems utilization and blind passenger volume in a fine weather weekday in considered zone must be obtained. Zone physical characteristics like passage length, zone topography and … must be extracted by field inspections too.

- **Step2.** Technical – economical evaluation; this project must be technically and economically evaluated and be justified from traffic and economic point of view like any other new project. Main concentration of this research is on the same side of the RAMPE project. In following sections, this issue has been fully investigated.
- **Step3.** Physical feasibility; physical indices used for RAMPE system feasibility include bus stop position in passage from accessibility point of view and existence of adequate space to install equipments. Therefore, bus stops as-built plans and their surrounding areas must be studied. Also strategies for interacting between applying RAMPE system in a bus stop and its construction standards should be presented and assessed, i.e. equipment installation for charging blind PDA battery. Considering lack of this detailed information, this part of feasibility has been ignored in this paper.
- **Step4.** Feasibility with traffic measures; traffic measures considered for the feasibility of creating a RAMPE system include: safety and travel time. Since blinds are vulnerable in traffic areas especially congested passages, safety is the most important factor for creating a navigation system for blinds. Another traffic measure is blind travel time which would be reduced since this system gives great autonomy to the blind in routing and using public transportation system. Obviously, safety is more important for the blind.

4.1. Technical Evaluation

The system must be technically evaluated to study whether the project is succeeded in achieving the objectives. Factors are introduced as technical index for this purpose [10]. These indices are introduced considering objectives which are followed by implementing this system (table1).

Table1. Objectives and performance indices to evaluate RAMPE system

index	objective
Number of public stations or intersection	Evaluating RAMPE system effect on passing safety
Blind travel time	Evaluating RAMPE system effect on flow quality
Blind Reliability on Public transportation system	Evaluating RAMPE system effect on public transportation service and encouraging blind to use public transport system
Blind comfort in travel	Evaluating RAMPE system effect on service quality

4.2. Economic Evaluation

Economic evaluation includes two general parts: Project benefits calculation, project costs calculation. Benefit-Cost analysis is used to evaluate project. Benefits of RAMPE system consists of two parts: safety benefits and travel time reducing benefits. Obviously, the value of life is incomputable. Indices to evaluate the efficiency of the system are defined as follows: benefits index, initial costs index and financial system performance index [10].

4.2.1. benefits index

According to Table 2, using the RAMPE system can be considered from three point of view: National benefits, Corporate benefits, User benefits.

Table2. RAMPE system using benefits indices

✓ Financial value of time saving ✓ Reducing social costs	National benefits	RAMPE system using benefits
✓ Salary making due to offering this system for users ✓ Increasing monitoring and control on blind commuting treatment	Corporate benefits	
✓ Increasing public transportation system safety ✓ Increasing public transportation system reliability ✓ Decreasing travel costs for users	User benefits	

4.2.2. The initial cost estimate

Implementation costs of the project can be divided into four categories: initial costs, repair costs, maintenance costs and system upgrade costs.

Initial costs include the following:

- Project initial costs such as: inspection and checking existing status, contracts and documents and …
- RAMPE system central network software design
- Purchase, construction and installation of hardware equipments.
- Bus stops optimization for blind access

Utilization costs are related directly to extent and coverage of this system in the public transport network. Repair and maintenance costs include major or local repair costs and maintenance costs which are dependent on system indigenous hardware and software equipments in addition to system development. System requires to be upgraded and this process leads to system upgrading costs, considering system information must be updated at any time.

4.2.3. System Financial Performance Indices

System financial performance indices express system operating costs, public transportation system incomes and system efficiency [10]. The overall form of the considered index is as follows [10]:

$$\frac{\text{RAMPE system utilization costs}}{\text{Blind passenger volume}}$$

$$\frac{\text{RAMPE system income}}{\text{RAMPE system utilization costs}}$$

5. Case study

Observation, field inspection and questionnaire forms have been used for surveying and evaluating the necessity of applying RAMPE system in Iran. Therefore, questionnaire forms were prepared for blinds which 50 samples of them were filled in White Cane educational center which all clients are blind or have vision difficulties. The center is located in the 6th district of Tehran Municipality.

5.1. Analysis and Evaluation of Questionnaire Results

Women contributed *46%* of these clients while men contributed the rest. The sample population age pyramid is given in figure 5. According to interpretations made, half of this center clients are in the range of 20-30 years old which represent that population referring this center are young. This fact increases probability of accepting and learning new and intelligent systems usage among clients.

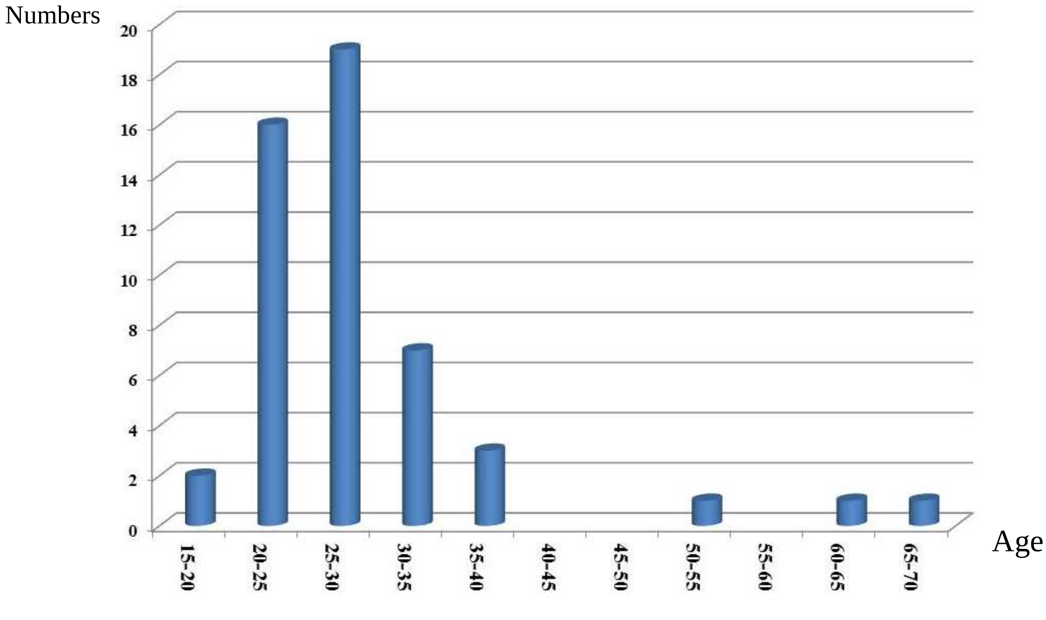

Figure 5. White Cane blind statistical population age pyramid

According to the interpretations made, most of students use taxi or bus for their daily trips. *64%* of blinds use these two modes to approach White Cane center, which is a significant contribution. Taxi agency and metro are two other major transportation modes for accessing this center. Figure 6 illustrates each mode portion in accessing this center. Only 6% of White Cane center clients use their family car to access this center, which reflects the importance of public transportation modes in accessing to the center. Therefore, implementation of the RAMPE system for accessing public transport system will have significant effects.

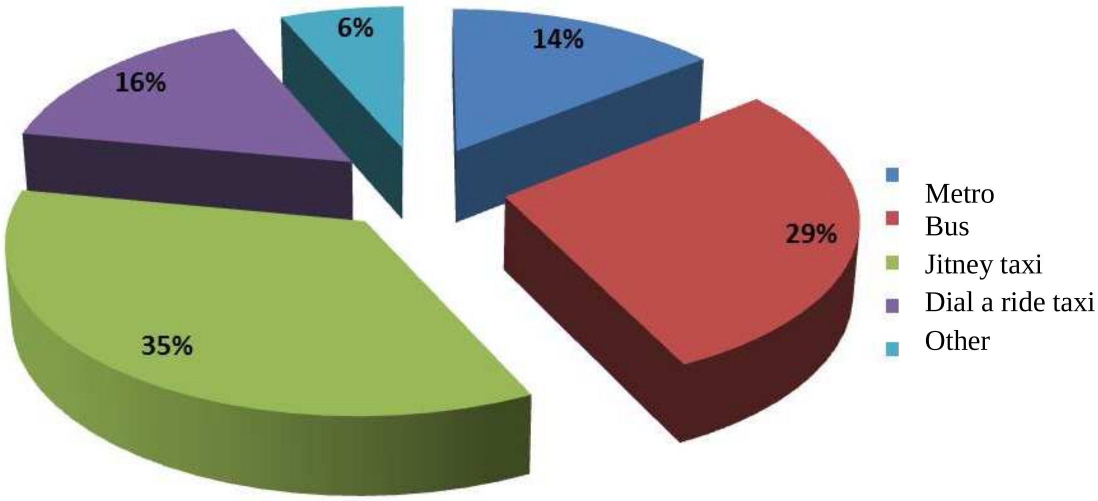

Figure 6. Accessing modes for White Cane blind client

Figure 7 shows White Cane clients travel time alignment chart. As shown, most of these clients travel time is in the range of 45-105 minutes. Note that access time of *84%* of clients was among this period.

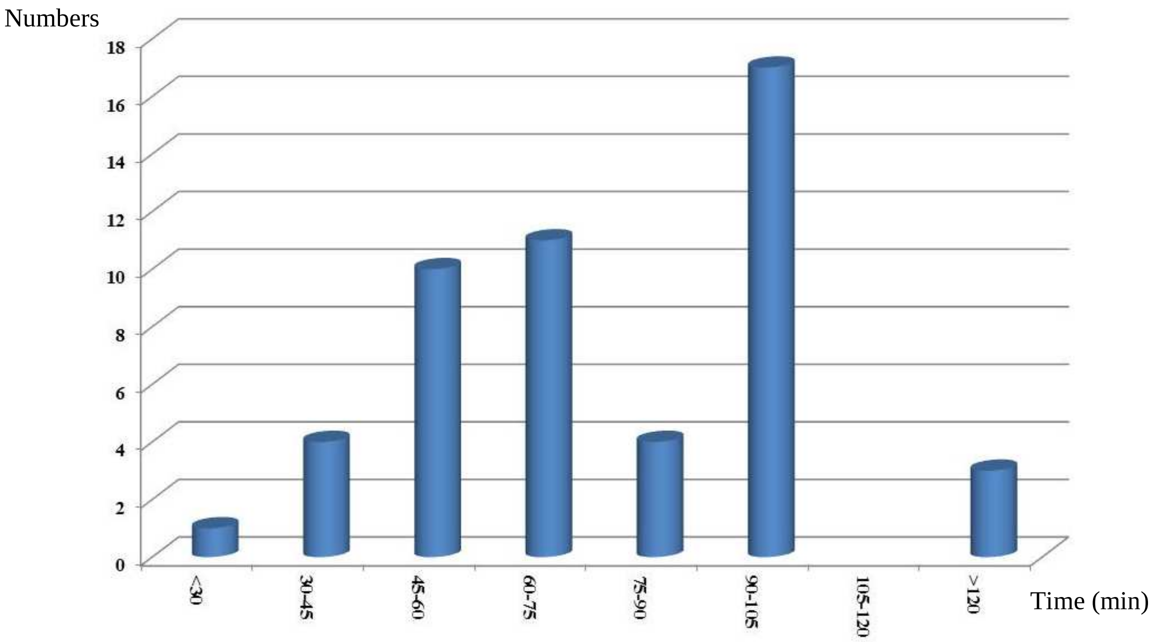

Figure 7. White Cane blind client travel time

5.2. Economic Evaluation of Employing the RAMPE System

Basis of technical evaluation of the RAMPE system was studied in section 4. Economic evaluation of employing the RAMPE system for Iran and white cane education center is considered in this section. Implementing this system has significant benefits. But given that a precise determination of national and corporate benefits of this system is not possible, this paper just focuses on user benefits of this system. User benefits include increasing safety and reliability and reducing travel time. Calculation and quantification of system reliability is not considered in this paper. Regarding reducing travel time is negligible against safety benefits for blinds, this part of benefits is ignored in this paper. Exposure concept is used for calculating safety benefits. By definition, exposure consists of: cases in which road user (the pedestrian or the car) are at risk of accident [12]. White Cane education center is located in the 6^{th} district of Tehran Municipality. The 6^{th} district of Tehran municipality has 221 bus stops and per but stop equipping with RAMPE system cost is equivalent to 12000000 Rs [13]. Therefore the cost to equip all of 6^{th} district bus stops with RAMPE system will be equivalent to 2652000000 Rs. According to statistics, 29% of blind people use bus to access the white cane center. Considering the total of 100 people – trip per day occurring to / from this center, each day 29 trips generate from 6^{th} district bus stops. Considering 275 workday for each year, 7975 blind trips would be generated from 6^{th} district bus stops during a year.

If conflict and accident probability for each blind be considered as 1 death and 2 sever injury per 20000 exposures, the probability of their death and injury accidents in a year would be equivalent to 0.4 killed and 0.8 injured. By using RAMPE system, this cost will be zero (this cost reducing is considered as system benefit). Considering each person wergild equivalent to 600000000Rs and average injury cost equivalent to 50000000 Rs, Blind accidents cost each year for the sixth district would be equivalent to 280000000 Rs. So if 2010 be assumed as this plan initial year, investment return curve would be as figure 8. So in less than 10 years the costs of implementing RAMPE system will return.

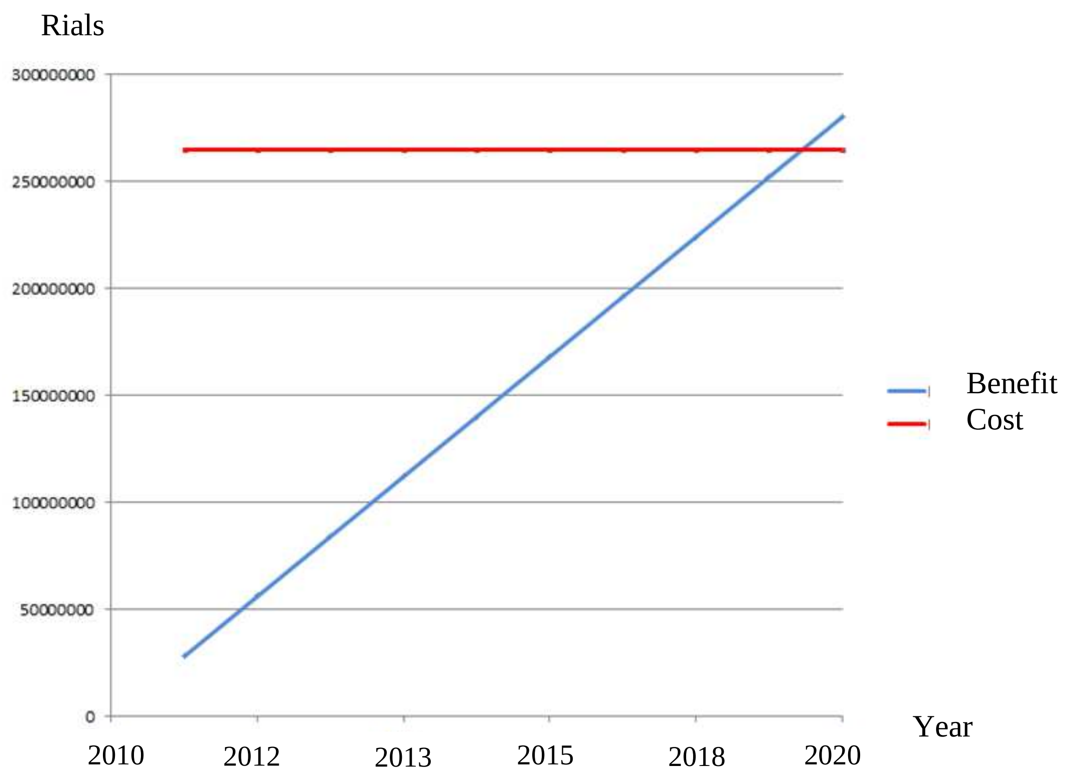

Figure 8. Investment return curve for RAMPE project

6. Conclusions

This paper described the various stages of the process of navigation for the blind and mentioned the RAMPE system in this connection. Today, blind navigation systems have significant growth simultaneous with technologies development in developed countries and bright future can be imagined for them. Therefore, in addition to introducing the RAMPE system, its benefits were presented. After that, studying White Cane education center as a blind education center, blind traveling pattern was analyzed using questionnaire forms. Then feasibility of implementing RAMPE system in 6^{th} district of Tehran was studied as a pilot. Based on investment returning analysis, the RAMPE system implementation costs will return in less than 10 years. In this study the cost saved from reduction in incidents and accidents were considered and the cost saved from reduced travel time is ignored.

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