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AN EMPIRICAL STUDY ON VULNERABLE INDIVIDUAL PROTECTION SERVICES IN TAIPEI: THE CASE OF THE BLIND AND VISUALLY IMPAIRED

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Abstract: This paper provides a strategy planning to design a new portable LED-display system, named Travel Kit, based on an extensive survey and demand function analysis among visually impaired persons in Taipei, Taiwan. Accessibility to take a bus, ability to travel and Dilemma of daily affair are three measures to evaluate performance of Travel kit. Using two samples T-test to compare the number of successfully boarding the requested bus before and after employing Travel Kit, it shows that Travel Kit significantly improves not only in boarding a bus, but also increasing the ability of independence for individual visual impairment to take transit in Taipei.

Key Words: LED-Display System, Travel Kit, T-test

1. INTRODUCTION

The latest Intelligent Transportation Systems (ITS) development areas in Taiwan have been expanded to nine areas including Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Public Transit Systems (APTS), Commercial Vehicle Operations (CVO), Electronic Toll Collection & Payment Systems (EPS), Emergency Management Systems (EMS), Advanced Vehicle Control & Safety Systems (AVCSS), Vulnerable Individual Protection Services (VIPS) and Information Management Services (IMS) with twenty-seven corresponding user services are identified (see Table 1). These ITS user services are prioritized to be promoted and deployed in the short-term stage (ITS Master Plan in Taiwan, 2003).

Several deployment projects associated with pedestrian, cyclist and motorcyclist safety in VIPS are currently undertaken by central and local government in Taiwan. However, with the appeal for protecting mobility and accessibility of disable people, many transportation agencies are required to provide accessible services to persons with mobility, sensory or cognitive impairments. Categories of types of impairments provide a framework to identify subgroups that have similar transportation needs and problems. In general, sensory and cognitive impairments can be divided into three categories:

(1) Deafness and hearing impairments
(2) Blindness and visual impairments
(3) Cognitive impairments

Table 1. ITS Development Areas and User Services in Taiwan

Development Area	User Service
Advanced Traffic Management Systems (ATMS)	1.Traffic Control 2.Traffic Management/Signal Control 3.Incident Management 4.Automated Detection of Weather/Road Condition
Advanced Traveler Information Systems (ATIS)	5.Route Guidance 6.Traveler Services Information 7.En-route Driver Information 8.Pre-trip Travel Information 9.Parking Information
Advanced Public Transit Systems (APTS)	10.En-route Transit Information 11.Public Transportation Management
Commercial Vehicle Operations (CVO)	12.Hazarous Material Incident Response 13.Automated Roadside Safety Inspection
Electronic Toll Collection & Payment Systems (EPS)	14.Electronic Toll Collection & Payment
Emergency Management Systems (EMS)	15.Emergency Notification 16.Personal Mayday Support 17.Emergency Vehicle Management 18.Public Mayday Support
Advanced Vehicle Control & Safety Systems (AVCSS)	19.Safety Readiness 20.Pre-crash Restraint Deployment 21.Driving Safety Warning
Vulnerable Individual Protection Services (VIPS)	22.Pedestrian/ Cyclist Safety 23.Motorcyclist Safety
Information Management Services (IMS)	24.Data Collection and Analysis 25.Data Filing 26.File Management 27.File Applications

Source: ITS Master Plan in Taiwan (2003-2010), 2003

It was observed that the process of training the blind and visually impaired to use adaptive technologies was very focused on individuals, and so the resource use could be larger or smaller depending on the individual (Seccaspina et al., 2001). In addition to some specific problems faced by the blind and visually impaired people when confronted with printed information, such as schedules and vehicle identification, they also face several other problems, especially in new environments. Without vision, the ability to gain suitable and sufficient information about the environment and its spatial arrangements, to enable a person to independently understand and navigate unfamiliar areas, is restricted. This paper lists the difficulty in getting the following types of information when navigating without sight (Marston, 2002).

(1) Specific information and positive identification at locations
(2) Spatial information accessed from a distance
(3) Directional cues to distant locations
(4) Self-orientation and location
(5) Integrated model of the space

The terms of “blind” and “visually impaired” recommended by Manual of Style for Depicting People with Disabilities (2004) are used. Blind refers to a total loss of vision. Visual impairment indicates partial vision, also referred to as partial sight.

Blind or visually impaired people can get "lost" or disoriented when they make a wrong choice at a decision point (go straight or turn). Each of these decision points is an independent event and the probability of success (or failure) for each event is multiplied as the number of decision points increases. If a very skilled blind traveler made only one mistake in every 100 attempts, there would be a cumulative probability (>50%) of making an incorrect choice after 69 decision choices. If a traveler made only five mistakes in every 100 attempts, there would be a cumulative probability of making an incorrect choice after 14 decision, and if a person made a wrong choice 10 times out of 100 choices, it is more likely than not that an incorrect decisions occurs after only 7 choices. In addition, without a way to "view" the world, it can be much more difficult for a person with severe vision loss to recover from these types of errors.

The most effective means of identifying transportation needs is through an individualized assessment of the mobility requirements of the environments into which he or she functions or is expected to function and matching those requirements to training, adaptation, or support options that are available. Therefore, a portable LED-display system named Travel Kit is developed to solve problems of bus transit access for passengers who are blind or visually impaired. The purpose of this paper is to discuss the effect of Travel Kit for bus transit passengers who are blind and visually impaired by conducting statistical analyses.

2. DEMAND ANALYSIS

The ability of accessing different environments increases the range of options that are attainable in the areas of work, socialization, and recreation and housing. Being mobile also enables those individuals to exercise control, allowing them to decide where and how they live, rather than relinquishing that control to service agencies, family members, or others (West et al., 1995).

2.1 Spatial information for visual impairments

For many disabilities, such as visual impairments, law strictly restricts driving. Ride sharing is almost the only choice and sometimes must be accompanied by either family members or close friends. To increase the individual accessibility for blind and visual impairments, environment factors, facility layout and adaptive equipments should be regarded as a whole system to help disability individual to accomplish his or her journey.

To identify the spatial interaction in an uncertain environment, disabilities with visual perceptual deficits need to have three types of information to reach their trip destinations, one of which is the point information, such as sound and vocal messages (see Figure 1). Employing this information, individual person is likely to get further knowledge about current geographical location.

Secondly, rugged brick is designed in public building to show the guide way. It often provides line information about the space. Furthermore, touch map gives the spatial interactions of space objects in details. Integrating these three types of information, visual impairments could have a first trial to take public transit individually.

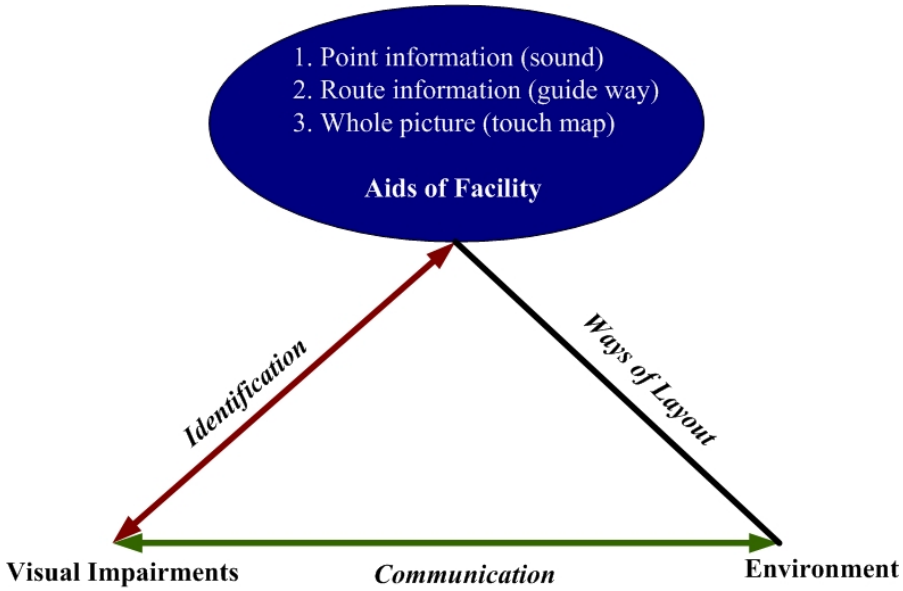

Figure 1. Visual Impairments Getting Familiar with Environments

The current aids include electronic guide cane, laser cane, pathsounder, Mowat sensor, sonicguide and electronic eyes. Advanced tools, such as Radix Tactile equipment, Talking Sighs, Striders and Atlas Speaks, either helps visual disable persons to cross over a signal intersection or provides them spatial information. Those helpful kits actually only improve handicap with more degree of walking ability in space. To catch a bus, however, remains a big problem for the blind and visual impairments.

2.2 Latent demands for potential users

An extensive survey was conducted before operations of rapid transit several years ago regarding the blind and visual impairments taking public transit. According to these 177 interviewees, working and school trips are the major trips with 61.1%. It highlights that the blind and visual impairments usually share ride with other members and take either private vehicle or the Para-transit (i.e. Taxi) if afforderable.

To identify the potential needs of these blind and visual impairments taking bus transit in Taipei metropolitan area, this paper randomly selects thirty interviewees, including blind and visually impaired after an intensive home interviews. Some of findings shown in Table 2 are similar with the results of previous studies. Over fifty percent interviewees are willing to try a new aid if it really enhances their accessibility or mobility. It is found that most of interviewees are very interested in knowing how to catch their busses with this new aid.

Given a satisfaction scale with 5 points, the larger number stands for fitting the interviewee's needs. The further questions to the necessary functions of aids give clear and solid information regarding a new design to increase probability of catching a bus (see Table 3).

Table 2. Characteristics of Interviewees

		Blind (%)	Visually Impaired (%)
Gender	Male	33.3	30.0
	Female	23.3	13.4
Trip purpose	Working	46.7	43.3
	Shopping	6.7	0.0
	Others	3.3	0.0
Spatial information	Signal unrecognized	30.0	16.7
	No barrier information	33.3	26.7
	Easily get lost	23.3	10.0
	Fear to cross road	26.7	20.0
	Others	6.7	10.0
Mode choice	Bus	26.7	30.0
	Walking	3.3	3.3
	Demand Responsive Transit (DRT)	6.7	0.0
	Taxi	13.3	6.7
	Mass Rapid Transit	6.7	3.3
Willing to use aids	Yes	26.7	30.0
	No	30.0	13.3

Table 3. Function Identification

Demand Function	Blind (points)	Visually Impaired (points)
Safety improvement	4.2	3.7
Traffic information	4.3	3.6
Lower Nervous	4.4	3.7
Accessibility of taking bus	4.4	4.6
Extension of activity perimeter	4.3	4.2
Less waiting time	4.2	4.4

Most of the blind and visually impaired interviewees complain that they are frustrated to catch a bus, because bus driver may stop at the far end of bus platform since the implementation of

exclusive bus lane in Taipei. It makes them catch a bus with much more efforts. If in rush hour with too many passengers at the bus stop, neighbors may actively help them boarding a bus. Unfortunately, they often miss their expected bus in the off-peak time because there are few passengers standing by them, so as to significantly increase their waiting time. Therefore, one of the important measures of increasing probability of catching a bus is to provide both the information of coming bus and dynamic boarding location shown in Table 4.

Table 4. Bus Information

Required Information	Blind (points)	Visually Impaired (points)
Arrival notice	4.5	4.5
Route information	4.3	4.3
Running bus nearest location	4.6	4.1
Boarding location	4.6	4.6

Boarding a bus successfully seems a challenge to these interviewees. This dilemma emphasizes on the information of running bus location, boarding location, reconfirmation of bus route information and destination to get off (see Table 5). New designed equipment with these functions may greatly improve bus accessibility for the blind and visually impaired passengers.

Table 5. Improvements for Bus Related Functions

Count	Blind (%)	Visually Impaired (%)
Unexpected bus acceleration while boarding	41.2	5.9
Unknown current bus location	35.3	29.4
Unknown the arrival of destination point	52.9	47.1
Unknown the destination on the bus route	58.8	41.2
Unknown the bus route	41.2	23.5
Unknown the bus boarding location	64.7	35.3
Unfamiliar with the payment system	17.6	29.4
Dilemma for facing more than two buses	52.9	41.2
Bus moves with door not closed yet	11.8	5.9
Not enough time to call the coming bus	58.8	35.2
Waiting time too long	11.8	17.6
Unclear post information	0.0	41.2
Other	29.4	35.3

2.3. Design of Travel Kit

It was the first time in Taiwan that Taipei City Government funded a pilot project to study bus accessibility of the blind and visually impaired people (Tao and Chiang, 2003). To make the interface friendlier, the aid is designed to have functions including easy push buttons and presentation languages for input, and output messages with types of choices (sound, touch or vibration). To meet the special needs of catching bus successfully for the blind and visual impairments, a portable and active LED display panel embedded in a handbag or a backpack is developed named "Travel Kit" shown in Figure 2.

Figure 2. Travel Kit Displaying the Destinations to PanCiao Railway Station

The LED panel can display the bus route number or the name of destination, which also can be downloaded via RS232 communication interface by vocal instructions. Four option buttons consist of all simple operations. Blind or visually impaired passengers can bring Travel Kit either backload or side load as they wish. It is found that Travel Kit shines during the dark night with promising outcome; however, its performance is down slightly during the daytime.

3. METHODOLGY AND ANALYSIS

3.1 Evaluation process

An evaluation was conducted to assess how Travel Kit could be used for the blind and visually impaired passengers. The whole process splits into three aspects upon the accessibility, the willingness, and independence of daily life. The major issues in each group are listed as below:

(1) Accessibility to take a bus

a. bus driver actively stop the bus

b. passenger of neighborhood actively helps to stop the bus

c. less waiting time

d. other passengers take visual impairments to the right waiting area

(2) Ability to travel

a. degree of willingness to take a bus

b. degree of making an individual trip

c. degree of making a transfer trip

(3) Dilemma of daily affair

a. worry of no notice of coming bus

b. worry of wrong waiting location

c. no willingness to deal with personal affair outside

d. worry of personal safety to cross intersection or walking on the street

e. embarrass to bother strangers

(4) Cost impact

a. current employment status

b. willingness to pay on conditions (e.g. government subsidies, having a job)

c. acceptable cost

3.2 Method and results

This empirical case study randomly selects 17 volunteers. Recording the five-level of scale in satisfaction, a before and after study thus yields the results of our primary hypothesis. The two sample t-test is adopted here to test the significance of major effects.

$$s_{pool}^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

$$H_0 : \mu_1 = \mu_2$$

$$t = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{s_{pool}^2 (\frac{1}{n_1} + \frac{1}{n_2})}}$$

Results were analyzed using SPSS (version 10). If we inspect each item in Table 6 and Table 7, the t-value from each question is almost statistical significance with a 0.05 value for type I error α for both blind and visually impaired groups.

The paired t-tests reveal that the visually impaired group has no significant differences only in worry of no notice of coming bus and no willingness to deal with personal affair outside. Rest of the hypothetical questions for these two groups is positive response after using Travel Kit. This means that Travel Kit may have significant effects not only in boarding a bus, but also increasing the ability of independence for individual visual impairment. It can be deductive to have a better quality of life for the blind and visually impaired passengers after taking Travel Kit based on the third groups of questions.

Although no direct benefit-cost estimates could be made, the volunteers' views concerned about Travel Kit cost impacts (roughly about $400 to $500) were also sought. Some preliminary findings shown in Table 8 indicate:

Table 6. Evaluation of Travel Kit for the Blind

	Item	**Before** Mean(std.)	**After** Mean(std.)	Paired t-test
Accessibility to bus		**8.33 (0.82)**	**14.83 (2.71)**	**5.40***
	Bus driver actively stop the bus	2.00 (0.63)	3.83 (0.75)	5.97*
	Passenger of neighborhood actively helps to stop the bus	1.83 (0.41)	3.33 (0.82)	3.50*
	Less waiting time	2.33 (0.52)	3.50 (0.84)	2.91*
	Other passengers take visual impairments to the right waiting area	1.83 (0.41)	3.67 (0.52)	5.97*
Ability to travel		**6.83 (1.17)**	**10.00 (2.45)**	**4.00***
	Degree of willingness to take a bus	2.83 (0.41)	4.00 (0.89)	3.80*
	Degree of making an individual trip	2.33 (0.82)	3.00 (0.89)	3.16*
	Degree of making a transfer trip	1.66 (0.52)	2.67 (1.03)	3.87*
Dilemma of daily affair		**21.67 (1.63)**	**16.00 (2.83)**	**-6.17***
	Worry of no notice of coming bus	4.66 (0.52)	3.17 (0.41)	-6.71
	Worry of the wrong waiting spot	4.83 (0.41)	3.33 (0.82)	-4.39*
	No willingness to deal with personal affair outside	4.00 (0.63)	3.00 (0.63)	-2.74
	Worry of the safety to cross intersection or walking on the street	4.50 (0.55)	3.50 (0.55)	-3.87*
	Embarrass to bother stranger	3.67 (0.52)	2.37 (0.82)	-3.87*

***P<0.05**

Table 7. Evaluation of Travel Kit for Visual Impairments

	Item	**Before** Mean (std.)	**After** Mean(std.)	paired T-test
Accessibility to bus		**7.00 (1.83)**	**12.25 (2.22)**	**7.00***
	Bus driver actively stop the bus	1.75 (0.50)	3.00 (0.82)	5.00*
	Passenger of neighborhood actively helps to stop the bus	1.75 (0.96)	3.25 (0.96)	5.20*
	Less waiting time	2.25 (0.50)	3.50 (0.58)	5.00*
	Other passengers take visual impairments to the right waiting area	1.25 (0.50)	2.50 (1.00)	5.00*
Ability to travel		**7.00 (1.41)**	**10.75 (1.71)**	**4.40***
	Degree of willingness to take a bus	2.75 (0.50)	4.25 (0.50)	5.20*
	Degree of making an individual trip	2.25 (0.50)	4.25 (0.50)	5.00*
	Degree of making a transfer trip	1.75 (0.50)	3.00 (0.82)	5.00*
Dilemma of daily affair		**19.70 (2.95)**	**14.80 (2.78)**	**-7.65***
	Worry of no notice of coming bus	3.00 (0.82)	2.50 (0.58)	-1.732
	Worry of the wrong waiting location	4.00 (0.82)	2.50 (0.58)	-5.00*
	No willingness to deal with personal affair outside	3.25 (0.96)	2.50 (0.58)	-3.00
	Worry of the safety to cross intersection or walking on the street	3.75 (0.50)	2.50 (0.58)	-5.00*
	Embarrass to bother stranger	3.75 (0.50)	2.25 (0.50)	-5.20*

***P<0.05**

(1) Only 24% of Travel Kit volunteers (n=17) report that having a job for which they received pay. The majority of non-working volunteers report that their disability makes it impossible for them to work.

(2) One of the more interesting findings is that all volunteers are not willing to pay for Travel Kit even some of them are working. One reason is that they all regard it as a social

welfare policy and should be subsidized by the government; the other is that they feel the cost of Travel Kit is too high.

(3) Only 18% of volunteers are willing to pay a median cost of $30 for each Travel Kit when they are offered jobs to receive pay.

(4) Even the cost of a Travel Kit is partly subsidized (50%) by the government, 30% volunteers are willing to pay a median cost of $50 for each Travel Kit.

(5) All volunteers are pleased to see that the government will fully subsidize them to purchase a Travel Kit and it should be promoted national wide.

Table 8 Cost Impacts of Travel Kit on the Blind and Visual Impairments

		Blind	Visually Impaired
Current employment status	Working	5.9%	17.6%
	Not working	35.3%	41.2%
Willingness to pay without any condition	Yes	0%	0%
Willingness to pay if a job will be offered	Yes	5.9%	11.8%
	median of acceptable cost	$30	$30
Willingness to pay if government subsidies are provided	Yes (partly subsidized)	11.8%	17.6%
	median of acceptable cost	$50	$50
	Yes (fully subsidized)	100%	100%

To obtain a more detailed understanding of bus drivers' responses to the Travel Kit project, a small survey of the views of bus drivers is also conducted. The participating drivers are interviewed to complete a questionnaire about general attitudes and view. Only 17 responses are received to the questionnaire. This small sample size does not permit reliable statistical analysis, nor inferences to be drawn as to the general views of bus drivers, nevertheless, there are some strongly suggestive patterns that arise in the responses (see Table 9).

(1) Fourteen of 17 respondents fully realize the accomplishment of the Travel Kit project is meaningful.
(2) Most of bus drivers agree that the number of the blind and visually impaired passengers getting on the bus has increased and these passengers appear less stressed on the bus.
(3) The Travel Kit project seems to have no problematic effects to the amount of dwell time at bus stops, the amount of fatigue and stress that bus drivers experience.
(4) There is a distinct impression that bus drivers are pleased to see the Travel Kit project can carry on.

In summary, significant results are listed as follows:
(1) Travel Kit to enhance accessibility of catching a bus is the major concern for blind and visually impaired people in Taipei.
(2) The blind group is influenced by Travel Kit more significantly than the visually impaired group.

(3) The accessibility measures should include information of running bus location, boarding location, reconfirmation of bus route and destination to get off.
(4) Travel Kit would distinguish the disability to get much more attention and helps from outside, both from bus driver or passenger of neighborhood.
(5) Travel Kit has significant effects not only in catching a bus, but also increasing the ability of independence for individual visual impairment.
(6) All the blind and visually impaired volunteers hope that government should fully subsidize them to own a Travel Kit, for they usually don't have a job to receive pay.
(7) Most of bus drivers are very positive towards the Travel Kit project and its goals. They are also pleased to see the project can carry on in the future.

Table 9 Bus Drivers' Responses to Travel Kit using by the Blind and Visual Impairments

Question	Positive	Same	Negative	I don't know/ no answer
I have a sense of accomplishment in the Travel Kit project	14	2	1	0
The number of the blind and visually impaired passengers getting on the bus has increased	13	3	0	1
The blind and visually impaired passengers appear less stressed on my bus	12	3	1	1
The amount of dwell time at bus stops has increased	5	7	2	3
The amount of fatigue that I experience has increased	3	10	2	2
I feel more stressful than before when I approach the bus stop	3	9	2	3
I support to carry on with the Travel Kit project	12	2	2	1

4. CONCLUSION AND FUTURE WORK

Based on an extensive survey and demand function analysis among the blind and visually impaired people in Taipei, this paper provides a strategy planning to design a new portable LED-display system named Travel Kit. It was designed to solve problems faced by the blind and visually impaired passengers in accessing public transportation. An evaluation, which was conducted to test the significance of using Travel Kit for each group, considers three major issues: accessibility to take a bus, ability to travel and dilemma of daily affair. It has been found that the visually impaired group has no significant differences only in worry of no notice of coming bus and no willingness to deal with personal affair outside. However, rest of the hypothetical questions for these two groups is positive response after using Travel Kit. Therefore, we may draw the conclusion that Travel Kit can really help the blind and visually impaired passengers have higher bus accessibility and a better quality of life.

Improving accessibility of blind and visually impaired people is a sustainable goal. To catch a bus easily may only meet one requirement of their daily life. The next stage development will be to integrate Travel Kit into a system by which real-time navigation information can be provided automatically by GPS, GIS and mobile communication technologies. Moreover, we will conduct case studies on the new system with the blind and visually impaired people.

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