ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

SAFETY AT PLATFORM-TRAIN INTERFACE (PTI) AND PEDESTRIAN-RAIL CROSSINGS OF THE ADDIS ABABA LIGHT RAIL TRANSIT(AALRT)

A Thesis in Railway Civil Engineering

By

Tamrayehu Kurema Ahmed

Advisor : Dr. Alemayehu Ambo

November, 2016

Addis Ababa

A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

The undersigned have examined the thesis entitled '**Safety at Platform-Train Interface (PTI) and Pedestrian-rail Crossings of the Addis Ababa Light Rail Transit (AALRT)**' presented by **Tamrayehu Kurema**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

Dr. ALEMAYEHU AMBO	______________________	______________
Advisor	Signature	Date
ATO RAEED ALI	______________________	______________
Internal Examiner	Signature	Date
ATO ATAKLTY GIDYELEW	______________________	______________
External Examiner	Signature	Date
______________________	______________________	______________
Chair person	Signature	Date

UNDERTAKING

I certify that the research work titled "**Safety at Platform-Train Interface (PTI) and Pedestrian-rail Crossings of the Addis Ababa Light Rail Transit (AALRT)**" is my own work. The work has not been presented elsewhere for assessment. Where materials have been used from other sources, they have been properly referred.

Tamrayehu Kurema

ABSTRACT

Train mass rapid transit becomes a necessary need for developing countries to solve traffic congestion. Addis Ababa is the first capital in the Sub-Saharan African countries that have operated this kind of urban transport mode, light rail transit (LRT). More research studies still need to be explored related to the operation of this mode in the context of developing countries. One of these is safety at station platforms and pedestrian-rail crossings. The main objective of this research is to determine the safety perception and safety awareness of the Addis Ababa LRT passengers on station platforms and to undertake safety assessment at pedestrian-rail crossings of the project, in order to identify and manage both the safety issues and their associated solutions. Two methodologies were used to achieve this objective of the study, a questionnaire survey and a checklist based observational study.

The questionnaire study was carried out with the main purpose of examining the safety perception and safety awareness of the Addis Ababa LRT passengers on the station platforms. A total of 50 passengers from the two corridors of the project were selected via simple random sampling method to participate in the questionnaire study. From the result, the study concludes that platform-train interface (PTI) accident is a safety issue for the Addis Ababa LRT stations and concerns of safety do exist on the station platforms.

Through the checklist based observational study, a number of pedestrian related safety issues and concerns were identified at pedestrian-rail crossings of the project. Among these safety issues and concerns; inadequate standing areas and safety zone, limited pedestrian warning devices and lighting devices, and collision risk due to second LRVs were the major ones. Finally, to avert the identified safety issues at station platforms and pedestrian-rail crossings of the project, recommendations have been forwarded in the last chapter. Lack of finance and incomplete responses to the questionnaire survey were the main constraints faced during the course of the study.

Key words: Safety perception, safety awareness, station platform, platform-train interface (PTI) accident, pedestrian-rail crossing, light rail transit (LRT).

ACKNOWLEDGMENTS

First of all I would like to express my sincere thanks to my advisor Dr. Alemayehu Ambo for his valuable contribution, suggestions and guidance at different stages from proposal development up to this stage. I would also like to express my gratitude and deep appreciation to Engineer Raeed Ali, for his valuable comment and advice during preparing this thesis. Next, I want to acknowledge the Ethiopian Railways Corporation (ERC) for giving me the chance to enroll in this MSc. program. Finally, I would like to express my gratitude to all of my families and friends who in one way or another support my studies at the Addis Ababa Institute of Technology, Addis Ababa University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACCRONOMY

AALRT:	Addis Ababa Light Rail Transit
AAU:	Addis Ababa University
BA:	Boarding or Alighting trains
CREC:	China Railways Engineering Company
ERC:	Ethiopian Railways Cooperation
FWI:	Fatalities and Weighted Injuries
LRT:	Light Rail Transit
LRV:	Light Rail Vehicle
PTI:	Platform-Train Interface
ROW:	Rights-of-Way
SCRRA:	Southern California Regional Rail Authority
TCRP:	Transit Cooperative Research Program
TRB:	Transport Research Board
UK:	United Kingdom
US:	United States

CHAPTER 1 INTRODUCTION

1.1 Introduction

In the United Kingdom, accident risks related to platform-train interface (PTI) accounts for 20% of total rail passenger risks as measured by fatalities and weighted injuries (FWI). In passenger fatality risk, PTI risk accounts for 38% of rail passenger fatality risk; of this, 9% occur during boarding or alighting while other PTI accidents, not due to boarding or alighting account for 29%which is this is the largest single contributor to rail passenger fatality risk (Rail Safety and Standards Board, 2011). Therefore, a greater understanding of the causal factors involved will provide the rail industry with the knowledge to help prevent some of these accidents, and to mitigate the consequences when they do occur. PTI accidents are distinguished from other slips, trips and falls around the station. To be a PTI-related injury, the incident must result in the passenger wholly or partially crossing the boundary between the platform and the track, or the platform and the train (if present). There are many factors which affect the occurrences of accidents at the PTI: - gender, intoxication, period of the day or week, weather, etc.

Collisions between light rail vehicles (LRVs) and pedestrians occur less often than collisions between LRVs and motor vehicles; however, they are usually more severe (Korve et al., 2001). Further, pedestrians are not completely alert to their surroundings at all times, and LRVs are nearly silent even at higher speeds. In addition, most pedestrians will attempt to take the shortest reasonable path between where they are and where they want to go. Thus, unless adequate controls are installed, pedestrians will often jaywalk, cross diagonally through an LRT crossing, and trespass along the LRT right-of-way if this path is the shortest and saves time. For these reasons, appropriate pedestrian controls are critical for LRT safety.

For the purpose of this study, the following definitions will be used:
Safety: The definition of – 'safety' as it was provided by the Oxford Advanced Learner's Dictionary (2005), namely, -the state of being safe and protected from danger and harm.

Safety perception: The safety perception of a passenger is an important element of this study; thus, the definition of 'perception' found in Oxford Advanced Learner's Dictionary (2005) will be used, namely, - an idea, a belief or an image you have as a result of how you see or understand something. Thus, the measure of safety perception in this study will be based on self-understanding.

Safety awareness: To eliminate confusion in this study, the definition of – 'awareness' as it was provided by the Oxford Advanced Learner's Dictionary (2005), namely, the - knowing that something exists and is important the information, understanding and skills that you gain through education or experience. Therefore, awareness in this study will be measured by the overall awareness measured by the survey.

1.2 Statement of the Problem

LRT is becoming an increasingly important mode of transportation for residents of major metropolitan regions of different countries. While road transportations have been in use in a number of cities for many decades, the concept and operation of the modern LRT is quite new. As more urban areas chooses to invest in LRT, it is increasingly important to understand the resulting safety challenges and the mitigation measures available to maintain and improve safety along LRT alignments.

Recently, Ethiopia inaugurated the first modern light rail line in the Sub-Saharan Africa countries. The project is a combination of exclusive and semi-exclusive alignment types running along the median of roadway. Although LRT operations in exclusive and semi-exclusive rights-of-way are mostly separated from potential conflicts by fencing or other substantial barriers, conflicts remain between LRVs and passengers, and pedestrians at platform–train interfaces and pedestrian-rail crossings.

As time increases, the AALRT station platforms are increasingly crowded with passengers during passengers' rush hours due to many reasons. For the rail owner, it is very important and has a vital value to prevent station platform incidents to prove passengers' safety and caution passengers while using the rail stations. High number of ridership is certainly a good revenue generation for the Ethiopian Railways Corporation (ERC). On the other hand, the increasing number of passengers leads to busy platform situation, especially during peak hour time. Thus, identifying the resulting passengers' and pedestrians' safety challenges on station platforms and pedestrian-rail crossings, and forwarding potential solutions towards a safe operation of the AALRT project will be the main focus of this research.

1.3 Research Objectives

1.3.1 General objective

The thesis intends to determine the safety perception and safety awareness of the Addis Ababa LRT passengers on station platforms and undertake safety assessment at pedestrian-rail crossings of the project in order to identify and manage both the safety issues and their associated solutions, ultimately saving lives.

1.3.2 Specific objectives

There are five specific objectives as stated below:

- To assess the safety of the station platforms in the Addis Ababa LRT from the passenger's perspective;
- To determine the safety awareness of the Addis Ababa LRT passengers on risks related with platform-train interface (PTI) accident;
- To examine the effect of travel frequency and travel purpose on passengers safety perception and safety awareness;
- To identify major safety concerns and issues at the pedestrian-rail crossings of the Addis Ababa LRT; and
- To forward recommendations for identified safety concerns and issues at the station platforms and pedestrian-rail crossings of the Addis Ababa LRT.

1.4 Scope and Limitation

The scope of the thesis is restricted to the LRT which is operating in the city of Addis Ababa. The study addresses the safety perception and safety awareness of the AALRT passengers on station platforms. This study would as well investigate relationship of some travel characteristics on the passengers' safety perception and safety awareness at the AALRT station platform. The travel characteristics involved are as follows:

- Travelling frequency, and
- Purpose of travelling.

Additionally, the study identifies the safety challenges at the AALRT pedestrian-rail crossings. As a result, the study tries to address the safety issues of the AALRT stations and pedestrian-rail crossings i.e., the risks related to LRVs collisions with passengers and pedestrians at stations and pedestrian-rail crossings of the AALRT are considered. Major limitation faced in the study was financial constraint and incomplete responses to the questionnaire survey which forced the research to be conducted in only few numbers of respondents. Limited scientific literatures to explain the research problem can be sited as another challenge in this study.

1.5 Expected Contributions

Generally, it can be said that this study should be able to identify the passengers' safety perception and safety awareness on station platforms. Findings of this study are new knowledge as there had been no study focusing on passengers' safety perception and safety awareness analysis of the AALRT before. Therefore, the outcome of this study will contribute and augment the knowledge regarding passengers' safety perception and safety awareness on station platforms. Moreover, information that was sought from the passengers could be utilized by ERC and AALRT project office in their implementation of safety measures and solutions in the project.

1.6 Thesis Organization

The study is organized in five chapters; the first chapter is a general introduction describing the background of the research, statement of the problem, and objectives of the study. A review of relevant literatures is presented in Chapter 2. Chapter 3 describes a methodology used for identifying the passengers' safety perception and safety awareness at the AALRT station platforms and the prevailing safety concerns and issues at pedestrian-rail crossings. Results from applications of the methodology are discussed in Chapter 4, with conclusions, recommendations and future study areas detailed in Chapter 5.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

There is some confusion about the definitions of different types of urban rail services. It is not vehicle that defines the transit mode, but the quality of rights-of-way (ROW). The Transportation Research Board (TRB) Light Rail Committee offers these definitions: (Victoria, 2015).

- Streetcar: A steel wheel on rail transit mode, operating on-street, sharing the pavement with other vehicles, with little or no priority signaling at intersections.
- Light Rail Transit: A streetcar system that has extensive priority signaling at intersections and at least 30% of its route operating on 'reserved rights-of-ways.' LRT may be grade separated but must retain the ability to operate in mixed traffic. Light rail which operates on grade separated ROWs are more commonly referred to as Light Metro's.
- Light or Heavy Metro: A transit mode that operates on a fully grade separated (separated from street level) 'rights-of-ways.' Unlike generic LRT, many metro's, including monorail, are proprietary transit systems and cannot share their ROW with other transit modes including other metros.

One of the chief characteristics of LRT is its versatility which leads to very significant differences in performance and capacity from system to system and even from line to line within a given system. The advantage of this versatility is the ability of LRT to present a viable solution to a very large range of transportation problems and to provide room for incremental growth in capacity (Robert R., 2009). It is considered an effective, sustainable urban mode of transportation that has a long product life cycle, reduces congestion in cities, particularly during peak hours, lowers carbon dioxide emissions, and increases development along transit lines.

2.2 LRT Alignment Classification

There are three general classes of right-of-ways: Exclusive, Semi-exclusive, and Non-exclusive. These classifications are used for operational safety studies because; the type of alignment and the resulting level of exposure to vehicles and/or pedestrians have significant safety implications. Descriptions of the three right-of-way types are as follow:

- **Exclusive (Type A)**: A right-of-way that is grade-separated (e.g., subway or aerial structure) or at ground level, but protected by a fence or substantial barrier (as appropriate to the location) without at-grade crossings.

Figure 2-1: Exclusive type right-of-way
(Source: Korve et al., 1996)

- **Semi-exclusive (Type B)**: Semi-exclusive alignments keep the LRT apart from road vehicles and pedestrians, except where road vehicles and pedestrians intersect at-grade crossing. Under this category the five sub-type alignment classifications are presented in Table 2-1. Figure 2-2 illustrates Semi-exclusive type right-of-way.

Figure 2-2: Semi-exclusive type right-of-way
(Source: Korve et al., 1996)

- **Non-exclusive (Type C)**: Non-exclusive alignments allow for mixed flow operation with motor vehicles or pedestrians, resulting in higher levels of operating conflicts and lower-speed operations. There are three sub-type categories under this alignment type which are presented in Table 2-1. Figure 2-3 below illustrates Non-exclusive type right-of-way.

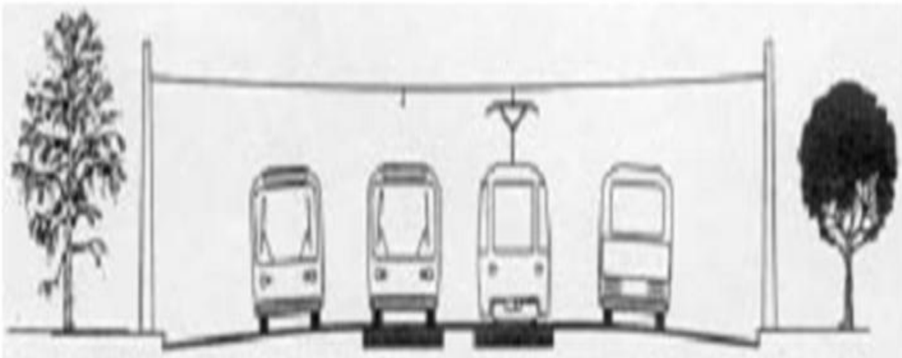

Figure 2-3: Non-exclusive type right-of-way

(Source: Korve et al., 1996)

Table 2-1: Alignment classification and descriptions of each subcategory

SN	Class	Category	Description of Access Control
1	Exclusive	Type A	Fully grade separated or at-grade without crossings.
2	Semi-Exclusive	Type B.1	Separate right-of-way
		Type B.2	Shared right-of-way, protected by barrier curbs and fences (or other substantial barriers)
		Type B.3	Shared right-of-way, protected by barrier curbs
		Type B.4	Shared right-of-way, protected by mountable curbs, striping and/or lane designation
		Type B.5	LRT/pedestrian mall adjacent to parallel roadway
3	Non-Exclusive	Type C.1	Mixed traffic operation
		Type C.2	Transit-only mall
		Type C.3	LRT/pedestrian mall

Source: (Korve et al., 2001.)

2.3 Station Platforms Safety

A railway platform is a segment of pathway beside rail tracks at a train station, from which passengers board or alight from carriages. The train station and its platform are the first point of contact the passengers have with the railway. The success of a rail transit system in attracting ridership is highly dependent upon the ability of passengers to safely and conveniently access stations. Therefore, the designs of stations are of great importance to the success of rail transit. Station platforms should be designed to minimize the possibility of accidents. Particular attention must be paid to the more accident-prone areas, such as the space between the platform edge and the yellow and the space between the platform edge and the train, where passenger-use characteristics may result in a greater possibility of injury.

Station platforms can be located either between or outside the tracks. The center platform has certain advantages especially in underground sections. Except for immediate downtown stations peak hour loadings are directional and therefore the platform area required for a center platform can be considerably less than twice the area of a side platform (Robert R., 2009).

2.3.1 Platform-Train Interface (PTI)

The PTI gives rise to a risk unique to rail transport. This risk forms a significant proportion of the total risk faced by rail passengers, especially fatality risk. (Rail Safety & Standards Board, 2011). PTI accidents are differentiated from other slips, trips and falls around the station. PTI-related accident must result in the passenger completely or partially crossing the boundary between the platform and the rail track, or the platform and the train. PTI accidents are categorized in two distinct ways: Accidents

- occurring while boarding or alighting trains; or
- occurring at the platform edge not during boarding or alighting.

Major PTI accident types not due to boarding and alighting which have high FWI (fatalities and weighted injuries), are: passenger fall from platform and struck by train, passenger struck by train while on platform and passenger fall off the platform onto the rail track (no train present). These severity accidents are the reason that can explain high fatality risk in PTI accidents not due to boarding or alighting. (Djoen et al, 2013)

Another railway serious mortality issue in some countries is suicide. Railway suicide is attempted or completed suicide by throwing oneself on to the electrified track or into path of an on-coming train. Most of railway suicide cases occur at platform area more than station area outside platform and level crossing. Both intentional and unintentional accidents are distinctive in their strong socio-economical and physiological impacts brought not only to the injury or fatality, but also to the railway company, the driver, the passenger and other witnesses who have seen the accident. Only one accident may affect a wider spread area although people who are not related to the accident and cause negative effect to public in many ways. To prevent and reduce PTI accidents, station platform design has a major role to reduce risk of accident.

There are many factors which affect the occurrence of accidents at the PTI. These factors overlap, making up a complex list of criteria that contribute to the accident rate. This means some of the effect of a particular factor may be hidden by the effects of other factors. The factors that can be shown to have an effect on the occurrence of accidents at the PTI include:

- intoxication of the passenger;
- time of day or week that the journey is taking place;
- weather at the time of the journey;
- station and train operator; and
- unit class and the type of door mechanism in use on each unit class.

2.3.2 Station Platform Safety Treatments

The Transit Cooperative Research Program TCRP Report No. 175 (Kay Fitzpatrick et al., 2015) has established standards for station area safety treatments.

2.3.2.1 Installation of Safety Barrier or Fences

At stations where installation of safety barrier or fences is provided, there will be two zones on the rail platform: safety zone and danger zone (Figure 2-4). Passengers are not supposed to be in or close to the danger zone. Therefore, the fence will be constructed as a dividing line between these two zones. The barrier did not disturb the flow of passengers so they could be used to reduce the number of incidents.

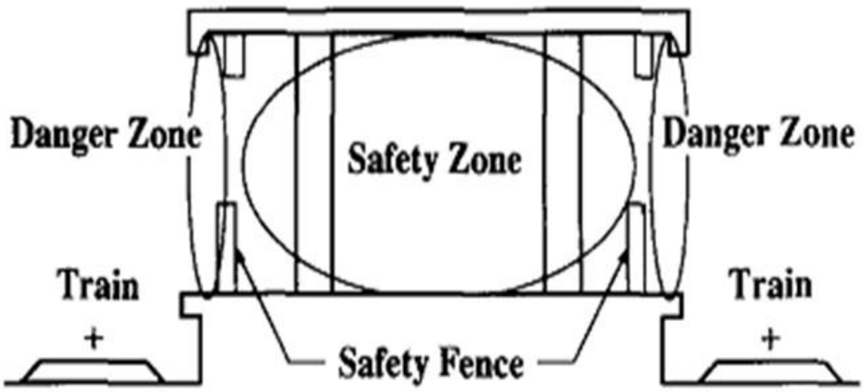

Figure 2-4: Zoning in railway platform

2.3.2.2 "Do Not Cross Track Way" Signage

At station platforms in tie and ballast track way, it may require the placement of a warning notice on the vertical edge of the platform opposite to customers who await oncoming trains. The warning notice shall read "Do Not Cross Track way." as illustrated in Figure 2-5 below. Easily readable, painted black lettering over a white background may be used.

Figure 2-5: Do not cross track way signage

2.3.2.3 Between-Car Barriers at Platform Edges

Between-car barriers are used at specific locations along LRT platform edges or between rail cars to prevent passengers who are visually impaired from mistaking the space between the ends of rail cars for the doors into the cars. Figure 2-6 and 2-7 illustrate between-car barriers flexible delineators and between-car barriers attached to rail cars respectively.

Figure 2-6: Between-car barriers flexible delineators

Figure 2-7: Between-car barriers attached to rail cars
(Source: Kittelson et al., 2012)

2.3.2.4 Platform edge warning ramp

A stationary ramp is positioned at the edge of the platform to provide stable access to the train. The system comprises an inclined supporting surface extending over a portion of a train platform edge to a predetermined distance from the platform edge. The first longitudinal edge of the device (Figure 2-8) can be raised or lowered by an adjustable bolt.

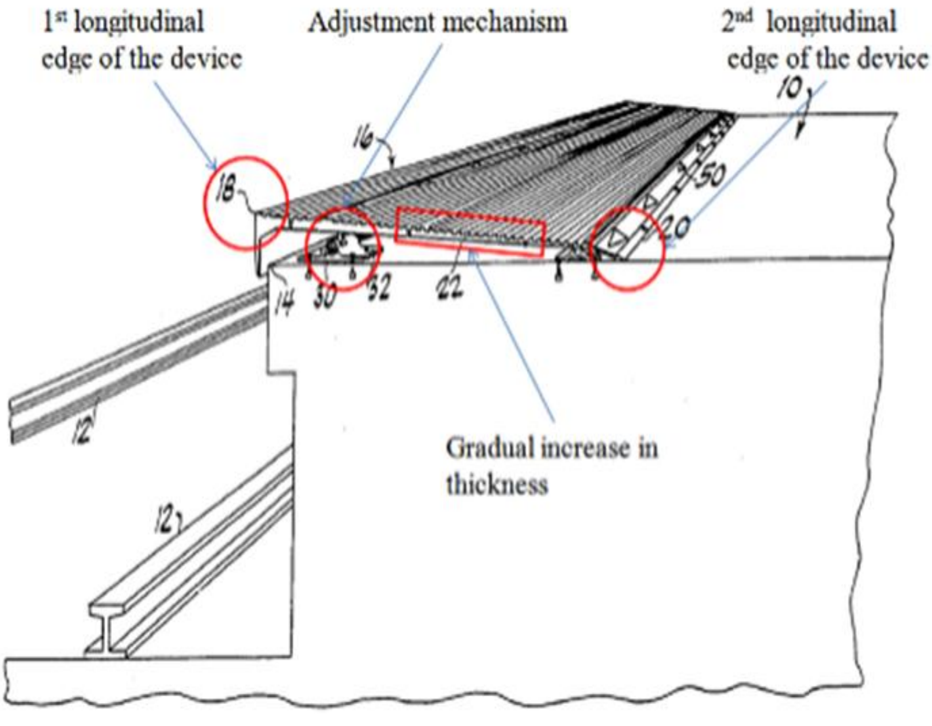

Figure 2-8: Platform edge warning ramp (Source: Rajkumar et al.,2012)

The adjustment reduces the horizontal and vertical gap to some extent. A platform edge warning ramp provides a stable raising platform with predetermined gap-closing distances. The change in adjustment requires manual operation that can be automated by an electric motor. The inherent warning principle will help increase passenger safety, in particular for passengers with vision impairment.

2.3.2.5 Station Entrance to a Platform

Passengers exiting a train platform that is located within an intersection need to be directed to turn right or left to cross the roadway. When passengers are trying to find and use the station, visually impaired or blind passengers need an indication of the location of the platform entry. Figure 2-9 below shows treatments used at the station entrance.

Figure 2-9: Treatments used at the station entrance

2.4 Pedestrian-rail Crossings Safety

TCRP Report 69 (Korve *et al*., 2001) notes that collisions between LRVs and pedestrians occur less often than collisions between LRVs and motor vehicles; however, they are usually more severe. Further, pedestrians are not completely alert to their surroundings at all times, and LRVs are nearly silent even at higher speeds. Also, most pedestrians will attempt to take the shortest reasonable path between where they are and where they want to go. Thus, unless adequate controls are installed, pedestrians will often jaywalk, cross diagonally through an LRT crossing, and trespass along the LRT right-of-way if this path is the shortest and saves time. For these reasons, appropriate pedestrian controls are critical for LRT safety.

2.4.1 Pedestrian-rail Crossing Types

The highway-railroad crossing design guide published by the Southern California Regional Rail Authority (SCRRA) (Metrolink, 2009) notes that pedestrian-railroad grade crossings can be characterized as one of four types and is explained as follows:

- **Pedestrian-rail grade crossings adjacent to a motor vehicle crossing**: These involve crossings that are parallel to a roadway crossing the tracks. These crossings include cases where the road and adjacent pedestrian route cross the train tracks. Another case is where the street and pedestrian crosswalk cross both the train tracks and vehicle lanes.

- **Pedestrian-rail grade crossings at stations adjacent to a motor vehicle crossing**: These are pedestrian-rail grade crossings at a station adjacent to a motor vehicle crossing. These crossings, along with pedestrian-rail grade crossings at stations (but not near a motor vehicle crossing), are used to provide access to rail transit station platforms for pedestrians from parking lots, intermodal transfers, or land uses adjacent to the rail transit line.

- **Pedestrian-rail grade/elevated crossings at stations**: These are pedestrian-rail grade crossings at a station.

- **Pedestrian-rail grade crossings not adjacent to motor vehicle crossing or in a station**: The fourth type of pedestrian-rail grade crossing is when the crossing is not adjacent to a motor vehicle crossing or in a station. Such crossings are typically used on multi-use (i.e., walk or bicycle) paths adjacent to rail transit lines or to maintain established pedestrian traffic paths that are interrupted by the construction of a new rail transit line.

2.4.2 Pedestrian-rail Crossing Standards

Particular attention should be paid to the safe design of pedestrian crossings. It is important to note that in many cases LRT has priority over the rest of the traffic when running on the streets. Hence, it is common to avoid marking the LRT channel with zebra crossings, which give priority to pedestrians. In any case, the designated zones for crossing are usually marked in any other way, to guaranty a clear identification of allowed zones for crossing. Special attention should be made to visually and mobility impaired people.

TriMet (Don Irwin, 2008) has established standards for use to mitigate or warn of track way crossing risks or hazards in various light rail environments. Standardized treatment is intended to promote the understanding of and compliance with the safety treatments by customers and the public at large.

2.4.2.1 Passive Safety Treatments

Passive treatments are not activated by approaching trains. Different types of passive treatments are listed below. A typical at-grade installation is depicted in Figure 2-10 below.

2.4.2.2 "Stop Here" Pavement Markings

The purpose of this marking is to identify for pedestrians and bicyclists a safe stopping location that is outside the light rail vehicle dynamic envelope. "Stop Here" markings should be considered where:

- LRV design speeds exceed 25 km/h in non-city environments, and
- Safe pedestrian stopping location is unclear.

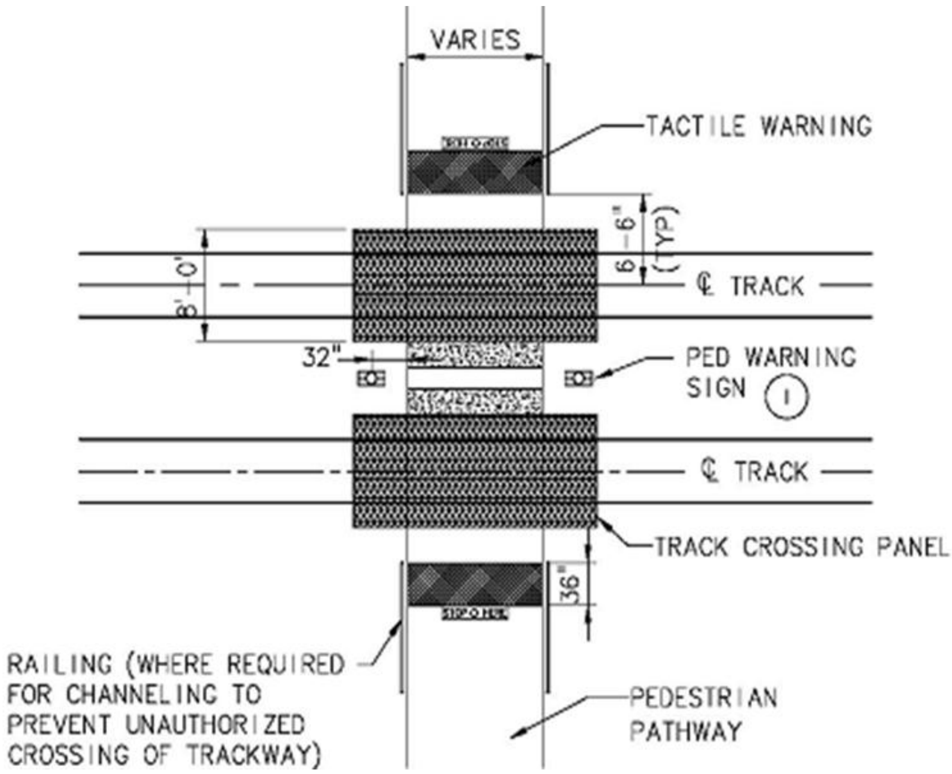

Figure 2-10: Typical at-grade pedestrian crossing installation

(Source: Don Irwin, 2008)

2.4.2.3 Tactile Warning

The purpose of the tactile warning is to identify for pedestrians a safe stopping location and safe refuge area that is outside the LRV dynamic envelope. This standard should be applied:

- In conjunction with “Stop Here” markings, or
- Where detectable warning is required at light rail station platforms and adjacent track way crossings.

The use of a tactile warning strip at pedestrian crossings at stations is required to delineate the platform edge and crossing location. A tactile warning provides a visual queue for pedestrians of the safe stopping location outside of the LRV dynamic envelope. The LRV's dynamic envelope shall be delineated in semi-exclusive and nonexclusive corridors at pedestrian crossings. Contrasting pavement texture should be used to identify an LRV's dynamic envelope. Figure 2-11 below illustrates pedestrian tactile warning.

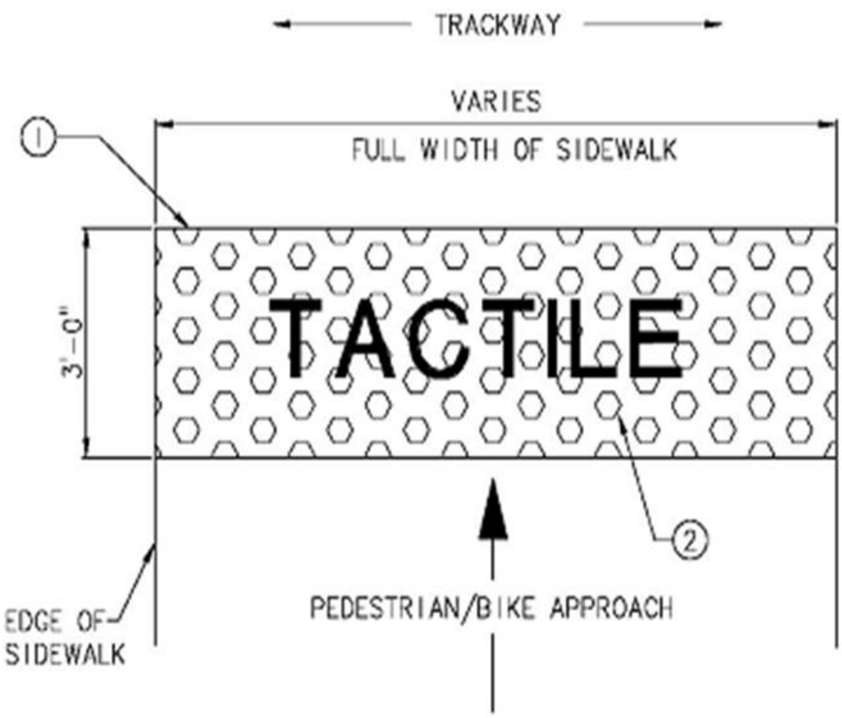

Figure 2-11: Pedestrian tactile warning

(Source: Don Irwin, 2008)

2.4.2.4 Channeling

The purpose of the channeling is to create a physical barrier that prevents or discourages persons from taking shortcuts or from crossing the track way in a risky or unauthorized manner. Channeling should be considered where:

- A high likelihood exists that persons may cross the track way in an unauthorized manner, particularly if in a hurry, and

- Other elements at the location will be effective in deterring unauthorized crossings.

2.4.2.5 "Look Both Ways" Signage

The purpose of the signage (Figure 2-12) is to remind pedestrians and bicyclists as they approach the track way to look for approaching trains in both directions. LRT crossing sign may be installed in advance of LRT non-gated, signalized crossings of semi-exclusive right-of-way on streets approaching the crossing. The primary warning sign for signalized pedestrian crossings of LRT tracks shall be the Light Rail Transit Crossing sign. The signage should be installed at

- Non-city track way crossing locations where LRV design speeds exceed 25 km/h,
- Light rail platforms in ballasted track way, or
- Mid-block pedestrian crossings.

Figure 2-12: Light rail transit crossing signs

Pedestrian-only signs should be installed so that pedestrians walking on the intended path will not strike them. A better solution is to mount near the ground where, pedestrians tend to look while they are walking, right at the track crossing or installing at a height of 1.2 m. Figure 2-13 below shows pedestrian sign mounting examples**.**

Figure 2-14: Pedestrian sign mounting examples

(Source: Korve et al., 2001)

2.4.2.6 Swing Gates

The purpose of swing gates is to slow persons who hurriedly approach the track way. Gate operation is not electrically interconnected into approaching train or vehicular traffic signal systems. Swing gates may be appropriate where:

- Pedestrian to train sight lines are restricted;
- A high likelihood exists that persons will hurriedly cross the track way;
- Channeling or other barriers reasonably prevent persons from bypassing the swing gates; and
- Acceptable provisions for opening the gates by disabled persons can be provided.

Figure 2-15: Manual swing gate (Source; Korve et al., 2007)

Where there is a defined pedestrian pathway, swing gates should be used to alert pedestrians to the LRT tracks by forcing them to pause before crossing, thereby deterring them from walking or running freely across the tracks without unduly restricting their exit from the track area.

2.4.2.7 Pedestrian Barriers

Similar to swing gates, these barriers are intended to slow persons who are hurriedly approaching the track way. A major advantage of barriers is that there are no operating parts or systems to maintain. Pedestrian barriers may be appropriate where:

- Pedestrian to train sight lines are restricted;
- A high likelihood exists that persons will hurriedly cross the track way;
- Channeling or other barriers reasonably prevent persons from bypassing the barriers;
- Adequate space is available to accommodate their installation.

2.4.2.8 Crossing Channelization

Z-crossings (Figure 2-15) are designed to turn pedestrians toward an approaching LRV before they cross each track, forcing them to look in the direction of oncoming LRVs. Z-crossings may be used at isolated pedestrian crossings located away from highway-LRT crossings or at standard highway-LRT crossings.

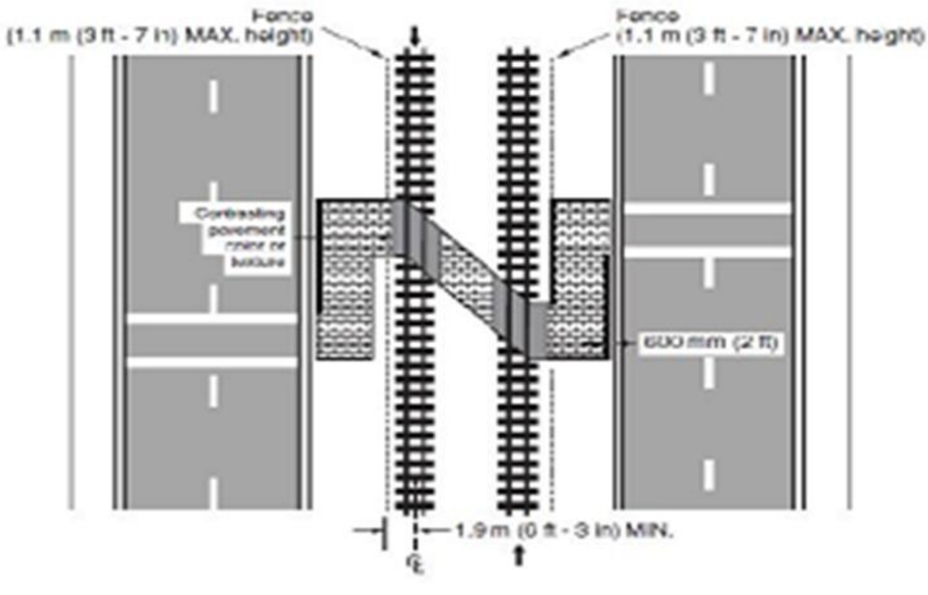

Figure 2-16: Pedestrian Z-crossing Channelization

2.4.2.9 Active Safety Treatments

An approaching train automatically activates these devices. These systems may consist of automatic gates, flashing light signals, traffic control signals, warning signs, audible signals, and other active warning devices.

2.4.2.10 Led Flashing Train Warning Signs

Flashing train signs are an effective warning device for both pedestrians and motorists. Figure 2-16 illustrates such a device in a pedestrian application. At pedestrian crossings and at intersections equipped with traffic control signals, pedestrians cross the light rail tracks in response to standard “Walk” and “Don’t Walk” signal indications. Generally, a pedestrian LED flashing sign and audible warning device is not required in the traffic signal controlled environment.

- The device may be appropriate where:
- LRV design speed at the location exceeds 25 km/h,
- The LRV operates in the median of city streets,
- Motor vehicle traffic is discouraged within the track way and does not normally share the use of the light rail track way, and
- The pedestrian crossing is an un-signalized mid-block crossing or is at a traffic signal controlled intersection adjacent to a platform.

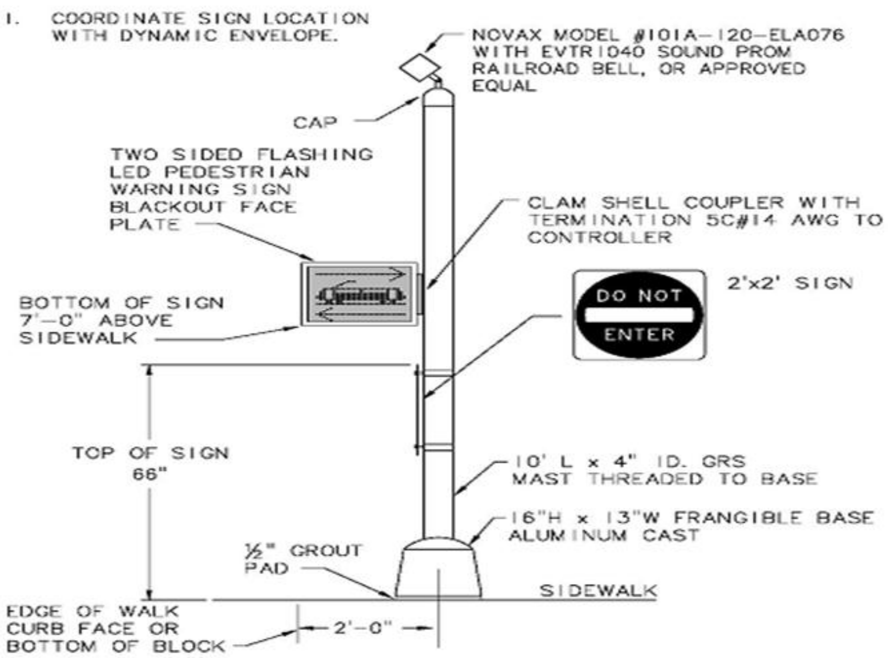

Figure 2-17: Audible or visual warning signal controlled crossing

To warn motorists of an approaching train at traffic signal controlled intersections, consideration should be given to incorporation of LED flashing train signs on traffic signal mast arms or poles in the following situations:

- Left turns by motorists are permitted across the track way,
- Cross traffic motorist volumes are high,
- Line of sight obstructions limit motorist ability to see oncoming trains, or
- There is a high volume of slow moving or turning truck traffic across tracks.

2.4.2.11 Pedestrian Flashing Lights and Audible Warning Device

The pedestrian flashing lights and audible warning device operate when a LRV is approaching at a train signal controlled environment. The purpose of this device is to warn pedestrians against crossing the track way as trains approach. This device is used where automatic crossing gates, lights, and bells are provided to warn of an approaching train. This standard should be considered where:

- LRV design speed at the location exceeds 35 km/h;
- The LRV operates in a semi-exclusive right-of-way; and
- Sight distance considerations or heavy pedestrian or bicycle activity warrant its use.

At LRT crossings some form of audible wayside warning should also be provided for the visually impaired persons. As an alternative to crossing bells, small audio devices could be installed in the crossing hardware to warn pedestrians of an approaching LRV. These small audio devices could be softer than a clanging bell and also focused on the sidewalk itself.

2.4.2.12 Automatic Pedestrian Gates

The purpose of this device is to prevent or discourage a pedestrian or bicyclist from crossing the track way when a train is approaching. These gates are electrically interconnected into and activated by the train signal system. Automatic pedestrian gates should be used only when severe safety hazards or risks, that cannot otherwise be eliminated, exist in the train control signal environment. Figure 2-17 illustrates pedestrian automatic gate.

Figure 2-18: Pedestrian automatic gate

(Source: Korve et al., 2007)

The circumstances for application of this standard include the following:

- Train speeds exceed 55 km/h;
- LRVs are operating in a semi-exclusive right of way;
- Pedestrian-to-train sight distance or visibility is severely limited; and
- A safe refuge area between the gates and LRV dynamic envelope can be provided.

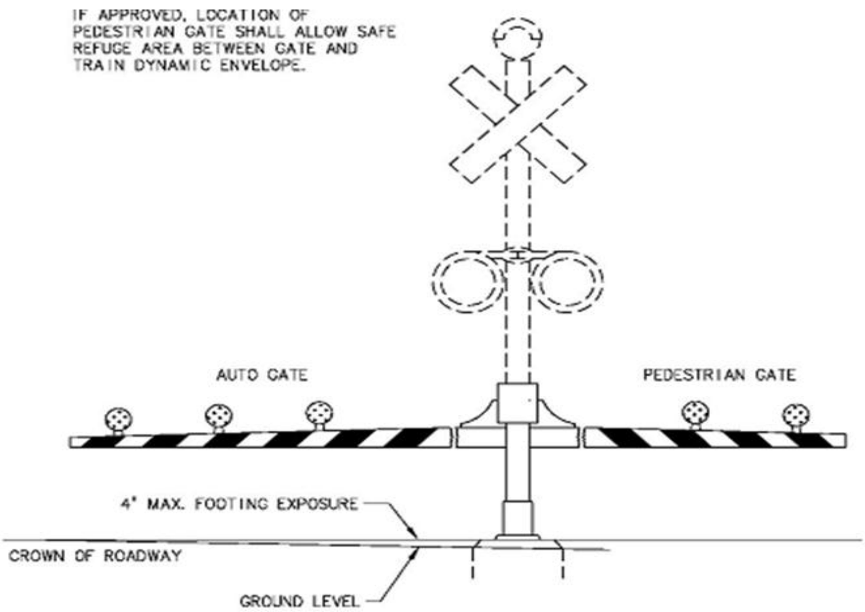

Figure 2-19: Automatic automobile or pedestrian gates

In general, pedestrian automatic gates should be installed at all pedestrian crossings with limited sight distance for LRV operators and pedestrians to see each other. Pedestrian crossing located near a hump, which can result in pedestrians not being able to see approaching LRVs. Possible solutions: decrease in speed limit for LRVs so that pedestrians have more time to see the vehicle coming and reciprocally; installation of an active signaling system like lights flashing when the LRT is coming; and, the obvious one, to change the pedestrian crossing location if that is possible. Figure 2-18 depicts an automatic pedestrian gate installation.

2.5 Public Education Programs

Public education programs techniques vary widely from one LRT agency to another. Although most agencies have comprehensive public education programs, activities are highly variable. There is little or no evaluation of the effectiveness of public education from the perspective of specific elements or of the arena as a whole.

Although agencies are not required to present safety instructions in exactly the same way, experience suggests that safety information is best received when it is delivered clearly, deliberately, and simply; this is most important when agencies are attempting to reach children and adolescents. Some LRT systems have adapted techniques used in the commercial world to reach out to children, such as using cartoonlike mascots or rap songs to convey safety messages.

Although these delivery mechanisms are not inherently problematic, it is important that LRT agencies use these techniques judiciously so they do not mask the intent of their safety messages. In the case of LRT safety, the messages are infinitely more important than the medium. Conversely, materials do not have to be dull and monotonous to deliver a serious message (Korve *et al*., 2001). Several critical elements are common to all good safety training programs regardless of the actual message delivered, the training medium, the training locale, and the age of the audience. These are as follows:

- Clarity and simplicity of the central message;
- Honesty and integrity in the delivery of the central message;
- Statement and restatement of the central message; and
- Program evaluation.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

Methodology is defined as the activity of choosing, reflecting upon, evaluating, and justifying the methods being used (Wellington, 2000). Research methodology refers to process in applying the most effective methods to obtain valuable data and achieve research aims with minimum cost. Failure in using effective method to collect data will give inaccurate and bias information, thus increase data load (Neuman, 2003).

This chapter describes the methodological approach used to carry out the research and it explains how the study was performed. The chapter is divided into the following sections: introduction, project description, data collection (passengers' questionnaire survey and checklist based observation) and data analysis.

3.2 Project Description

3.2.1 AALRT Stations

There are 22 stations along the east-west (E-W) route of the project, five of which are shared with north-south (N-S) route. Average interval between two adjacent stations is 815 meters. The longest interval is 1,210 meters and the shortest interval is 525 meters. There are 22 stations along the N-S route of the project, five of which are shared with E-W route. Average interval between two adjacent stations is 793 meters. The longest interval is 1,370 meters and the shortest interval is 510 meters (CREC, 2012).

3.2.2 AALRT Pedestrian-rail Crossings

Among different characteristics/types of pedestrian-rail crossings, the AALRT pedestrian-rail crossings share the followings:

- **Pedestrian-rail grade crossings adjacent to a motor vehicle crossing**: These include pedestrian pathways at grade vehicle crossings; and
- **Pedestrian-rail crossings at stations**: These include all the AALRT pedestrian-rail crossings other than mentioned above.

3.3 Data Collection

This sub-section describes the source and procedure of data collection from different sources.

3.3.1 Secondary data collection

Every research project should begin with a search of secondary data. It involves all existing and available data on current research survey. In this research, date was gathered and compiled from various written and published sources such as:

- Books;
- Journals;
- Periodicals;
- Government documents and regulations; and
- Electronic resources (e-journals, websites, online materials).

The analysis of secondary data was based only in descriptive manner.

3.3.2 Primary data collection

3.3.2.1 Passengers' Questionnaire Survey

The questionnaire study was used to address the first three specific objectives of the thesis; to determining the passengers' safety perception and safety awareness on the AALRT station platforms. (See Section 1.3). A five (5) point Likert items are used to measure passengers' perception and awareness of safety on the AALRT station platforms through the 21 safety indicating statements in the questionnaire.

The rating scales of passengers' safety perception and safety awareness assessing questionnaire were:

1 = "Strongly disagree";

2 = "Disagree";

3 = "Somewhat agree";

4 = "Agree" and

5 = "Strongly agree".

A high score on the scale indicated the high perception towards station platform safety. On the other hand, a low score on the scale designated the low perception towards station platform safety.

3.3.2.1.1 Population

The target population of this study is the AALRT passengers. A passenger is any individual who is travelling in a vehicle, plane, boat etc., but is not driving it or working on it (Oxford dictionary).

According to CREC (2012), the capacity of the AALRT is approximately 200,000 passengers per day.

3.3.2.1.2 Sampled population

For populations that are large, Cohen (1988) developed the following formula to yield a representative sample for proportions:

$$n_o = \frac{Z^2 P(1-P)}{e^2}$$

Where:

$n_{o:}$ sample size;

Z^2: abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, e.g., 95%);

e: is the desired level of precision;

P: estimated proportion of an attribute that is present in the population; and

q: is 1-p.

The value for Z is found in statistical tables which contain the area under the normal curve.

Since this study assume that p is equal 0.5 (maximum variability) and to determine the actual sample size at 95 percent confidence level with a 0.1 margin of error (± 10% precision) , the infinite sample size n_0 can be obtained using the following procedures:

$$n_o = \frac{Z^2 P(1 - P)}{e^2}$$

$$n_o = \frac{1.96^2 * 0.5(1 - 0.5)}{0.1^2} = 96.04 = 96$$

Next, applying the n_0, into the following formula, we are able to determine the number of samples n to be included in the study:

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}}$$

$$n = \frac{96}{1 + \frac{(96-1)}{200000}} = 95.95 = 100$$

Therefore, approximately 100 respondents should be included in the actual survey to obtain the required level of confidence in the results. However, according to Cohen a sample size of at least forty-five participants is necessary if the intent is to achieve an eighty percent (80%) chance of obtaining a statistically significant correlation at the 0.05 level. (Cohen, 1988).Therefore, the current survey resulted in only 50 responses.

3.3.2.1.3 Sampling method

The survey was administered by the researcher, starting with introducing self as a student from AAU, whereas this questionnaire is merely for the sake of a research in finishing the study to obtain the master degree. The highlighting of being student is mentioned to help in gaining the passengers confidence about the confidentiality of the survey result. Moreover the researcher announced to the respondents that the survey was voluntary and they could stop anytime they choose to stop. The subjects then are asked to respond to the questionnaires sincerely. At an average respondents spent 8 minutes to complete the questionnaire sheet.

The survey was conducted in Amharic language over a period of three days (May 28-31, 2016) through direct contact and filling up of the questionnaire by on-board passengers and by passengers at the stations of the AALRT. The stations identified for the survey were mainly on the common section of the two lines: namely: Stadium, Leghar, Mexico, and Tegbared. Simple random sampling was utilized in this current research. The reason of utilizing the simple random sampling method is based on the assumption that the sample taken represents the population of this current study (A group of passengers, taken as sample, would represent other passengers in term of giving response to the questionnaires). Figure 3-1 shows questionnaire filling at one of the AALRT station.

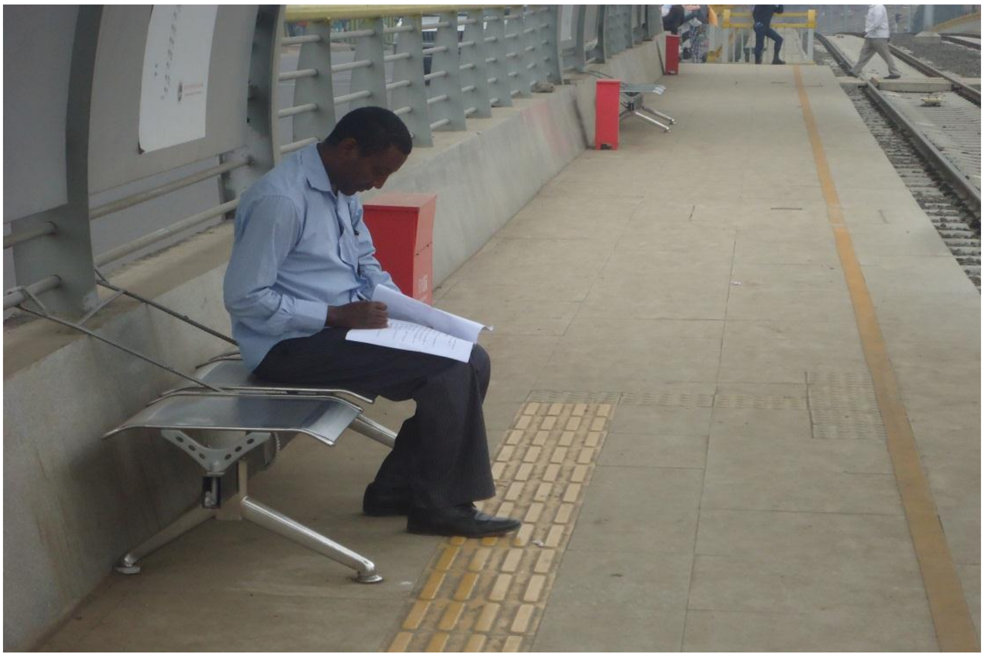

Figure 3-1: Survey participant filling the questionnaire at one of the AALRT station.

3.3.2.1.4 The instrument

A 21-item of station platform safety assessment questionnaire developed by Djoen S.S. et al. (2013) was used. There were two parts of this survey questionnaire as follows: socio-demographic factors of respondents (checklist) and measuring passengers' safety perception (closed ended) in five dimensions including:

- Design of station;
- Service provisions of the rail operator;
- Passengers' activities;
- Attitude of passengers; and
- Future safety enhancement works.

The English and Amharic version of the questionnaire used for this study is presented in the Appendix A and B.

3.3.2.1.5 Variables

In general, the questionnaire consisted of two kinds of variables, namely independent and dependent variables. The independent variables include gender, age, educational level, income, travel frequency and trip purpose.

The dependent variables are those variables which are used to measure passengers' safety perceptions on AALRT station platforms. These variables can be categorized into three groups due to their nature and purpose in the questionnaire survey. They can be listed as follows:

A. Seven (7) statements (variables) were used to measure passengers' perception of safety on station platforms and they are as follows:

- Station platform design is safe enough;
- Space from platform edge to yellow line is enough;
- Space between platform edge and train do not expose to accident;
- During peak hour, the number of station conductors is not enough;
- Although you stay behind the yellow line, when train approaching, you still feel unsafe;
- In crowded platform, passenger has more chance to fall into the track; and
- You prefer to wait for the train close to yellow line to get on the train faster.

B. Eight (8) statements (variables) were used to measure passengers' awareness of safety on PTI accident risks and they are as follows:

- Passenger with heavy luggages should not stand close to yellow line;
- Wearing high heels and standing close to yellow line increase accident risk;
- Teasing and playing around on the platform should be prohibited;
- Reading, listening to music, talking on mobile phone while standing close to yellow line increase accident risk;
- In crowded platform, passenger has more chance to fall into the track;
- One prefers to wait for the train close to yellow line to get on the train faster;
- One need to be more careful on the platform when raining and windy; and

- One need to be more careful when being the first passenger waiting for train behind the yellow line.

C. Eight (8) statements (variables) were used to measure passengers' opinion on safety enhancement works and they are as follows:

- ERC should provide information about safety tips on platform;
- ERC should not let drunken passengers to use the service;
- Warning sound signal when train approaches make more careful;
- Warning from station conductor makes more careful;
- Fence or barrier between tracks and platform makes passengers feel safer;
- More station conductors can replace installation of fence or barrier;
- It is not necessary to install fence or barrier for stations with few passengers; and
- If installation of fence or barrier involves costs to ERC, increase in fare by about 0.50 cents, is acceptable by passengers.

3.3.2.2 Checklist Based Observation

Checklist/observation was used to address the fourth specific objective of the study; identify the major safety concerns and issues at pedestrian-rail crossings of the AALRT (See section 1.3). A printed copy of the checklist is presented in the Appendix-C.

3.4 Data Analysis

3.4.1 Quantitative analysis

The statistical software SPSS, Statistical Package for Social Science, (SPSS Version 22.0 for Windows) was employed as an analytical tool to process data acquired through the questionnaire. Mean, standard deviation, and independent t-test were used to analyze the data. The fact that the number of respondents is few didn't allow the use of extensive descriptive statistics.

Data collected from respondents would be analyzed to fulfill the objectives of the study. As shown below, few statistical methods were used to analyze the data in this study. Once the respondents completed the surveys, the researcher immediately collected them to evaluate the data by coding the surveys into the Statistical Program for Social Sciences as well as Microsoft Excel. In entering data to SPSS, the five point Likert scales which were used to measure passengers' level of perception of safety were coded as follows.

- Strongly disagree (SD) = 1
- Disagree (D) = 2
- Somewhat agree (SWA) = 3
- Agree (A)= 4
- Strongly agree (SA) =5
- Missing data =99

3.4.1.1 Mean Score

The mean (or average) is the most popular and well known measure of central tendency. A measure of central tendency is a single value that attempts to describe a set of data by identifying the central position within that set of data. As such, measures of central tendency are sometimes called measures of central location. They are also classed as summary statistics. It can be used with both discrete and continuous data, although its use is most often with continuous data. For a data set, the mean is the sum of the observations divided by the number of observations. It identifies the central location of the data, sometimes referred to in English as the average. The mean was calculated using the following formula.

$$M = \frac{\sum(X)}{N}$$

Where: Σ = Sum of;

X = Individual data points; and

N = Sample size (number of data points).

3.4.1.2 Standard Deviation

The standard deviation is the most common measure of variability, measuring the spread of the data set and the relationship of the mean to the rest of the data. If the data points are close to the mean, indicating that the responses are fairly uniform, then the standard deviation will be small. Conversely, if many data points are far from the mean, indicating that there is a wide variance in the responses, then the standard deviation will be large. If all the data values are equal, then the standard deviation will be zero. The standard deviation is calculated using the following formula.

$$S^2 = \frac{\sum(X - M)^2}{N - 1}$$

Where: Σ = Sum of;

X = Individual score;

M = Mean of all scores; and

N = Sample size (number of scores).

3.4.1.3 Independent Samples t-Test

Independent samples t-test is used to compare two groups whose means are not dependent on one another. In other words, when the participants in each group are independent from each other and actually comprise two separate groups of individuals, who do not have any linkages to particular members of the other group.

3.4.2 Qualitative analysis

Finally, for the primary data collected through the checklist based observation, a qualitative analysis was carried out.

CHAPTER 4 ANALYSIS AND DISCUSSIONS

4.1 Introduction

This chapter focuses on the findings of the research. It will describe the results of the questionnaire study by explaining the coded responses of the sample in SPSS in order to determine the safety perception and safety awareness of the surveyed passengers. The responses were also analyzed and described in detail in order to find out whether or not travel frequency and travel purpose influence AALRT passengers' safety perception and safety awareness. In addition to this, the chapter also presents the result of the observational study.

4.2 Passengers' Questionnaire Survey Results

As it was defined in chapter one, the first three specific objectives of the thesis deal with the determination of passengers' safety perception and safety awareness on the station platforms of the AALRT (See section 1.3). Therefore, in the following sections, the result of the questionnaire study is presented with regard to these specific objectives.

4.2.1 Characteristics of Respondents

This subsection provides the social-demographic and general information of respondents interviewed in the questionnaire. Such background information is essential to interpreting the findings and understanding of the results presented later in this study. General information collected includes gender, age, level of education, income, frequency of travel and trip purpose.

The majority of the respondents (80%) were male. More than three-quarters of the respondents were in the productive age of 26-60 years old, which is reasonable considering that the current routes are serving mostly business and shopping related locations. Only less than 25% of the respondents have education below college and university level. More than 65% of respondents have monthly salary or allowance below 5,000 Birr (US$ 250). This seems reasonable as high earning citizens of Addis Ababa prefer to use private cars to public transportation. The characteristics of the respondents are presented in Figure 4-1 below.

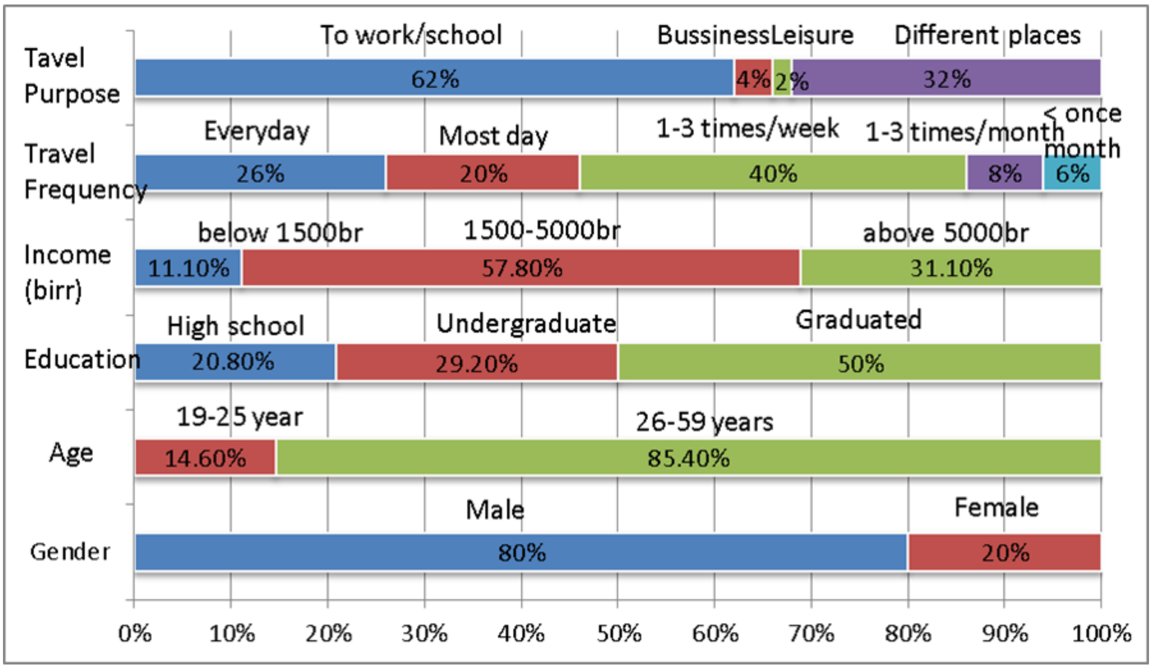

Figure 4-1: General characteristics of respondents

4.2.1.1 Frequency of Trips by Rail

In the questionnaire, the AALRT passengers were interviewed regarding frequency of using rail transportation. A large percentage of the respondents (40%) said they travel by train once to three times per week. Figure 4-2 illustrates frequency of travel by train..

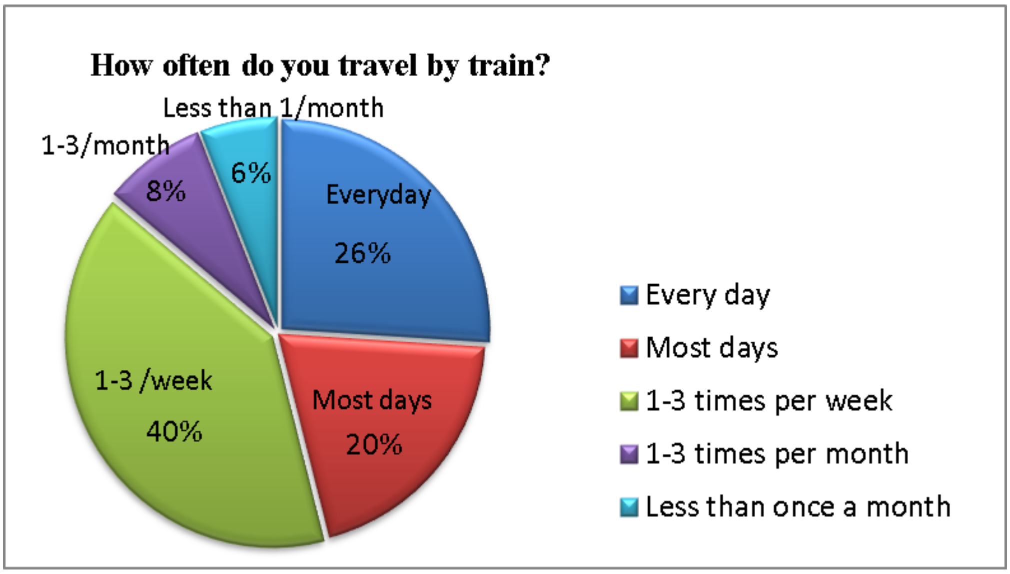

Figure 4-2: Frequency of travel by train

The minority of the respondents use AALRT once to three times per month (8%) or less than once a month (6%). The most frequent use of the AALRT among respondents is distributed between everyday use (26%) and many days use (20%).

4.2.1.2 Purpose of Journeys by Rail

A majority (62%) of respondents mainly took the train to go to their work, school or university (i.e. commuted). In other words, about 6 in 10 rail passengers of the AALRT mainly took the train to work, school or university. Roughly, thirty-four percent (34%) of the rail passengers mainly travel to different places like to medical centers, visiting relatives etc. A smaller proportion (4%) of the AALRT passengers travel for business purposes. Finally, 2% of the respondents travel for purposes other than the ones mentioned above like for leisure purposes. Figure 4.3 shows frequency of purposes of travel.

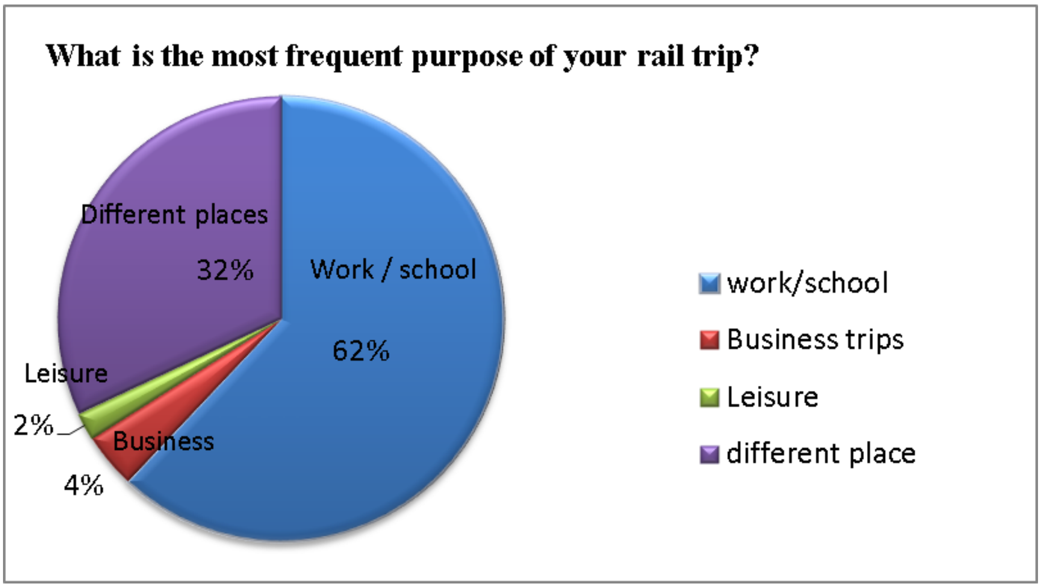

Figure 4-3: Purposes of travel by AALRT passengers

4.2.2 Passengers' Safety Perception

Passengers' safety perception analysis was conducted to assess the safety level of the AALRT station platforms from the passengers perspective (the first specific objective) and this was done by evaluating the safety perception of the AALRT passengers with various features of the station platform facilities, including the design of the station platforms and safety measurements provided by the operator like provision of station conductors. As safety issues on the station platform also depend on the behavior and cultural factors of the passengers, statements related with passengers' activities and attitudes were considered in this analysis. In total, seven safety indicating statements were selected from the questionnaire to measure the safety perception the AALRT passengers on station platform (See 3.3.2.1.5). Table 4 1 depicts mean and standard deviation values of safety indicators.

Table 4-1: Mean and standard deviation values of safety indicators

Category	No.	Safety Indicating Statements	SD %	D %	SWA %	A %	SA %	Mean Score	S.D
Design	1	Station platform design is safe enough.	12	8	48	24	8	3.08	1.07
	2	Space from platform edge to yellow line is enough.[a]	12	8	22	32	24	3.49	1.29
	3	Space between platform edge and train do not expose to accident.[a]	12	8	22	26	30	3.55	1.34
Service	4*	At the stations of high passengers flow, the number of station conductors is not enough.	4	0	18	26	52	4.22 (1.78)	1.02
Passengers activity & attitude	5*	You prefer to wait for the train close to yellow line to get on the train faster.[a]	28.6	28.6	18.3	12.2	12.2	2.51 (3.49)	1.36
	6*	Although you stay behind the yellow line, when train approaching, you still feel unsafe.	14	22	28	16	20	3.06 (2.94)	1.33
	7*	In crowded platform, passenger has more chance to fall into the track.	2	2	10	28	58	4.38 (1.62)	0.90

SD: Strongly Disagree; D: Disagree; SWA: Somewhat Agree; A: Agree; SA: Strongly Agree

Notes: * = 'negative' values in the bracket are transformed score for 'negative' question.

[a] = one missing data

Source: Questionnaire survey analytical results

Under the design of the station platforms category (Nos. 1-3) (Table 4.1 above), passengers were asked about the station platform design of the AALRT project. More precisely, they were asked about the space from the yellow line to the platform edge, and space between the platform edge and train at station. In the service provisions category (No. 4), they were asked on the available number of station conductors at stations to help passengers with safety information. Table 4.1 above demonstrates the safety perception descriptive analysis based on mean and standard deviation. In the passengers' activities and attitudes category (Nos. 5-7), they were asked about the risk characters of passengers like standing in the danger zone of the platform by disregarding the yellow line, on their feelings when train approaching the stations and passenger chance of exposure to risks in crowded platform situation.

For all statements in the form of 'positive' question (Nos. 1-3), the higher the mean score implies the less safety concern. The remaining statements (Nos. 4-7) are in the form of 'negative' question, which suggests the conclusion is the opposite way: the higher the score means the more concern in platform safety. These statements could not follow the question format of the former statements because the current is a better form to test practicality of the seriousness of safety concern of the respondents. Transform score of this indicator is provided in bracket so that the value can be easily compared with others. Figure 4-4 shows the space between the train and the platform edge at AALRT.

Figure 4-4: Space between the train and the platform edge at AALRT

Among all types of categories examined, the highest level of safety perception were measured for the design of station platforms (Mean = 3.37, S.D = 1.232) (average of the first three statements) which means, in the AALRT the design of the station platform in general seems not to be a safety issue but not to the level satisfaction. The available space between the platform edge and the train was ordinarily perceived by surveyed passengers (Mean = 3.55, S.D = 1.339). Moreover, the available space between the platform edge and the yellow line may make people standing and waiting close to the yellow line feel uneasy with only an average response (Mean = 3.49, S.D = 1.293).

Services related to safety information and precautions received the lowest mean score (Mean = 1.78, S.D = 1.016), indicating that passengers are not satisfied with the safety service provisions of the rail operator specifically with available number of station conductors. From passengers' attitude measurement, it can be conclude that passengers feeling unsafe at station platforms of the AALRT may be due to the safety reason of no barrier between the platform and the track. (Mean = 2.94, S.D = 1.331). Furthermore, respondents testify that passengers are exposed to PTI accident risks in crowded station platforms situation of the AALRT during peak hours. (Mean = 1.62, S.D = 0.901)

According to the safety perception of the surveyed AALRT passengers', the following station platform safety concerns and issues were identified and listed. The value in the bracket shows the proportion of respondents who placed the highest, second highest and third highest levels of safety perception ("Strongly Agree" or "Agree" or "Somewhat Agree") at each issue ("rating") and ranking from 1 to 5 based on the ratings ("ranking"). This means that a ranking of "1" indicates that for the surveyed passengers, that particular attribute is the reason for their safety concern on station platforms of the AALRT. Station platform safety concerns and issues are as follows:

- Crowded platform during peak hours (96%);
- Inadequate number of station conductors (96%);
- Unsafe when staying behind the yellow line (64%);
- Prefer to wait for the train close to yellow line (43 %); and
- Station platform design is not safe enough (20%).

During rush hours at most of the major stations of the AALRT, there is no enough space for passenger to move or queue. With this problem, there is always the danger of someone accidentally falling, or being pushed onto the tracks. Until now, because of the relatively low speed at which the LRVs enter the station area together with the very efficient braking system with which they are fitted make the likelihood of someone being run over from this cause quite remote, so far.

Another observed safety issue at the AALRT station platforms is that there was no between-car barrier that protects visually impaired passengers, from falling into the gap between the ends of light rail cars by mistakenly missing the space for the doors to get into the cars. Passengers are exposed to PTI risks as safety implementations concerning this specific risk were absent at station platforms or on trains. Figure 4-5 below shows the space between double cars at AALRT.

Figure 4-5: The space between double cars at AALRT

4.2.3 Passengers' Safety Awareness

4.2.3.1 Safety Awareness from Passengers' Activities

Under the passengers' activities category of the questionnaire, the respondents were asked about the risk characters of passengers like standing very close to the yellow line with many luggage and wearing high heels, teasing friends and playing around the station platform, and reading, listening to music, talking on mobile phones while standing close to the yellow line. The respondents' answers for these questions are presented in Table 4-2 below. In Table 4-2 the "Rating" column shows the proportion of respondents who placed the highest, second highest and third highest levels of agreement ("Strongly Agree" or "Agree" or "Somewhat Agree") on each issue measuring the safety awareness of the passengers and ranking from 1 to 4 based on the ratings. This means that a ranking of "1" indicates that surveyed passengers are most aware with that particular attribute.

Table 4-2: Safety awareness rating and ranking measured from passengers' activities

No	Question on the Survey	SD %	D %	SWA%	A %	SA %	Safety Awareness	
							Rating %	Ranking
1	Passenger with many luggage should not stand close to yellow line.	4	0	6	28	62	96	2
2	Wearing high heels and standing close to yellow line increase accident risk.	6	2	16	30	46	92	4
3	Teasing and playing around the platform should be prohibited.	2	4	2	20	72	94	3
4	Reading, listening to music, talking on mobile phone while standing close to yellow line increase accident risk.	0	2	10	22	66	98	1

SD: Strongly Disagree; D: Disagree; SWA: Somewhat Agree; A: Agree; SA: Strongly Agree

Source: Questionnaire survey analytical results

In evaluating the safety awareness of the surveyed passengers, 98 % knew reading, listening to music, talking on mobile phone while standing close to yellow line increase accident risk. Likewise, most people who responded to the survey (96%) are at least somewhat aware with the risks related to carrying heavy luggage and standing close to the edge of the platform. Moreover, ninety four (94%) of the interviewees said that teasing and playing around the station platforms should be prohibited. Finally, 92 % of the respondents are aware of the risks related with wearing high heels and standing close to yellow line.

According to passengers' safety awareness rating, the following risky activities were ranked as most aware activities in descending order by AALRT passengers. The value in the bracket shows the proportion of respondents who placed the highest, second highest and third highest levels of safety awareness ("Strongly Agree" or "Agree" or "Somewhat Agree") on each issue ("rating") and ranking from 1 to 4 based on the ratings ("ranking"). This means that a ranking of "1" indicates that for the surveyed passengers, that particular attribute is the most awareness issue as they use the station platforms of the AALRT.

- Risk related with reading, listening to music, talking on mobile phone while standing close to yellow line (98 %);
- Risk related with standing close to the yellow line with many luggage (96%)
- Risk related with teasing and playing around the platform (94%); and
- Risk related with wearing high heels and standing close to yellow (92 %).

The activities of carrying many luggage, especially big and heavy luggage are not common at stations; although the route is connected to bus station in the case of N-S line. One of the reasons is that the elevator is not open for passengers, so it is not convenient to carry big and heavy stuff by stair. However, in the future, when the AALRT services become more popular and the elevator is open for passengers, luggage carrying passengers may cause high safety concerns. The activities such as bringing many luggage and wearing high heels are not recommended due to safety reasons of no barrier between platform and track.

4.2.3.2 Safety Awareness from Passengers' Attitude

The respondents were asked on their attitudes under passengers' attitude section of the questionnaire. The respondents' answers on these questions are presented in Table 4-3. In Table 4-3, the "Rating" column shows the proportion of respondents who placed the highest, second highest and third highest levels of agreement ("Strongly Agree" or "Agree" or "Somewhat Agree") on each issue measuring the safety awareness of the passengers and ranking from 1 to 4 based on the ratings. This means that a ranking of "1" indicates that surveyed passengers are most aware with that particular attribute.

Ninety six percent (96 %) of the respondents agreed with the rises of risk of falling into the track at the time of crowded station platform situation. Likewise, the majority of the surveyed passengers (94%) are aware of the risk at PTI related with bad weather condition, for they take special care when there is rainy and windy weather as they wait for the train. However, smaller share which account for 6 % said they do not take any attention when raining.

Table 4-3: Safety awareness rating and ranking measured from passengers' attitudes

No	Question on the Survey	SD %	D %	SWA%	A %	SA %	Safety Awareness	
							Rating %	Ranking
1	In crowded platform, passenger has more chance to fall into the track	2	2	4	34	58	96	1
2	You prefer to wait for the train close to yellow line to get on the train faster.*	28.6	28.6	0	30.6	12.2	57.2 (42.8)	4
3	You are more careful on the platform when raining and windy.	2	4	0	38	56	94	2
4	You are more careful when you are the first passenger waiting for train behind the yellow line.	6	4	0	36	54	90	3

SD: Strongly Disagree; D: Disagree; SWA: Somewhat Agree; A: Agree; SA: Strongly Agree

Notes: * = 'negative' value in the bracket is transformed score for 'negative' question.

Source: Questionnaire survey analytical results

Similarly, the majority of surveyed passengers (90 %) take special care as being the first passenger waiting for the train behind the yellow line. However, a small share which accounts for 10% said they do not take any attention while waiting for the train behind the yellow line (See Table 4-3). Among the statements under attitude of passengers' category, the risk due to waiting for the train very close to the yellow line (by disregarding the yellow line) to get on the train faster received the highest proportions of disagreement responses (57.2 %).

At the AALRT stations, the accumulation of passengers in the limited space of the platform during rush hours, with some of them trying to pass one another in the unsafe zone of the platform has created a high safety concerns at station platforms. Figure 4-6 below shows passengers standing very close to the edge of a platform at the stadium station.

Figure 4-6: Passengers stand very close to the edge of platform (Stadium)

According to PTI accident risk awareness rating, users ranked the following risks related with passengers' attitude as most aware.

- Risk of falling into the track in crowded platform (96 %);
- Risk due to rainy and windy weather (94%);
- Risk as being the first passenger behind the yellow line (90%); and
- Risk due to waiting for the train close to yellow line to get on the train faster (42.8 %).

4.2.4 Safety Perception Comparison

In analyzing the data, respondents were grouped by their characteristics. Two groups were considered for comparison whether there is any significant difference in the perception of safety within the group, i.e. frequency group (seldom vs. often); and trip purpose (commuters vs. non-commuters). To compare the mean differences of these variables independent sample t-test analysis were used to compare the difference levels of observed perception of safety on station platforms.

4.2.4.1 Safety Perception and Travel Frequency

This sub-section describes the test of significant difference in term of relationship between travel frequency and perception of safety. The safety perception differences between seldom and often use AALRT passengers were tested by utilizing independent sample t-test. Table 4-4 shows the result of the analysis.

Table 4-4: Relationship between perception of safety and travel frequency.

	Frequency Group	N	Mean	S.D	Independent sample t-test
Perception of Safety Comparison	Seldom	27	2.82	1.079	P-value=0.420 confidence level = 95%
	Often	23	2.84	1.314	

Source: Questionnaire survey and analytical results

As shown in the Table 4-4 above, frequent AALRT use respondents are more satisfied on the safety of station platforms (Mean = 2.84) compared to the seldom AALRT use respondents (Mean = 2.82). The mean of frequent AALRT use respondents is 2.84, which mean that they are slightly more into “somewhat agree” than the seldom use respondents which have mean value 2.82. However, the difference between seldom and frequent AALRT user respondents in terms of perception of safety on station platforms was found to be insignificant, where the p-value is close to 0.42. At confidence level of 95%, the alpha is 0.05; therefore there are no significant differences between seldom and frequent AALRT passengers in term of perception of safety on station platforms, due to the p-value being greater than the alpha. It shows that out of those passengers using the AALRT; frequently user passengers are not significantly more satisfied on the safety of station platforms as compared to passengers who use the AALRT infrequently.

4.2.4.2 Perception of Safety and Travel Purpose

This sub-section describes the test of significant difference in term of relationship between travel purpose and safety perception. The safety perception difference between commuters and non- commuters of the AALRT were tested by utilizing independent sample t-test. Table 4-5 shows the results of the analysis.

Table 4-5: Relationship between perception of safety and travel purpose

Perception of Safety Comparison	Purpose Group	N	Mean	S.D	Independent sample t-test
	Commuters	31	2.84	1.279	P-value =0.312 confidence level = 95%
	Non-commuters	19	2.81	1.039	

Source: Questionnaire survey analytical results

As shown in the Table 4-5, commuters of the AALRT are more satisfied on the safety of station platforms (Mean = 2.84) compared to the non-commuters (Mean = 2.81). The mean of the commuters response are 2.84, which mean that they are slightly more into 'somewhat agree' than 'disagree', than the non-commuters which have mean value 2.81. However, the difference between commuters and non-commuters in term of perception of safety on the station platforms was found to be insignificant, where the p-value is close to 0.31. Due to the significant level achieved for the variables used to assess the perception of safety of passengers which was greater than 0.05, it is concluded that: there is no significant difference between commuters and non- commuters of the AALRT in term of safety perception at station platforms.

4.2.5 Safety Awareness Comparison

In analyzing the data, respondents were grouped by their characteristics. Two groups were considered to analyze whether there is any significant difference in the awareness of safety within the group, i.e. frequency group (seldom vs. frequent); and trip purpose (commuters vs. non-commuters). To compare the mean differences of these variables, independent sample t-test analysis was used at levels of perceived awareness of safety.

4.2.5.1 Awareness of Safety and Travel Frequency

This sub-section describes the test of significant difference in term of awareness of safety. The awareness of safety difference between seldom and frequent AALRT users were tested by utilizing independent sample t-test. Table 4-6 shows the result of the analysis.

Table 4-6: Relationship between awareness of safety and travel frequency

	Frequency Group	N	Mean	S.D	Independent sample t-test
Awareness of Safety Comparison	Seldom	27	4.19	0.977	P-value = 0.320 confidence level = 95%
	Often	23	4.29	0.964	

Source: Questionnaire survey analytical results

As shown in Table 4-6, frequent AALRT user respondents are more aware of the risky activities related to PTI accidents (Mean = 4.29) compared to the seldom AALRT use respondents (Mean = 4.19). The mean of frequent AALRT user respondents is 4.29, which mean that they are slightly more into "strongly agree" than the seldom AALRT user respondents which have a mean value of 4.19. The difference between seldom and frequent AALRT user respondents in term of awareness of safety was found to be insignificant, where the p-value is close to 0.32. Since alpha is 0.05 at confidence level of 95%, there is no significant differences between seldom and frequent AALRT users in terms of awareness of safety on station platforms, due to the p-value is greater than the alpha. It shows that out of those passengers using the AALRT, often AALRT use passengers are not significantly more aware of the risks related with PTI accident to passengers who use the service infrequently.

4.2.5.2 Awareness of Safety and Travel Purpose

This sub-section describes the test of significant difference in term of the passengers' awareness of safety with differences between seldom and frequent AALRT users. The awareness of safety difference between commuters and non- commuters of the AALRT were tested by utilizing independent sample t-test. Table 4-7 shows the result of the analysis.

Table 4-7: Relationship between awareness of safety and travel purpose

	Purpose Group	N	Mean	S.D	Independent sample t-test
Awareness of Safety Comparison	Commuters	31	4.28	0.188	P-value = 0.312 confidence level = 95%
	Non- commuters	19	4.17	0.207	

Source: Questionnaire survey analytical results

As shown in the Table 4-7, commuters are more aware of the risky activities related to PTI accidents on station platforms (Mean = 4.28) compared to the non-commuters (Mean = 4.17). The mean of the commuters response is 4.28, which means that they are slightly more towards 'strongly agree' than 'agree', while the non-commuters response were more towards 'agree'. The difference between commuters and non-commuters in terms of risk awareness related to PTI accidents on station platforms was found to be insignificant, where the p-value is close to 0.31. Due to the significant level achieved for the variables used to assess the awareness of safety of passengers with greater than 0.05, it is concluded that there is no significant difference between commuters and non-commuters in terms of safety awareness.

4.2.6 Passengers' Opinion towards Safety Enhancement Works

4.2.6.1 Installation of Barriers or Fences

The topic of the final section in the first part of the questionnaire was about future safety enhancement works. Statements in the future plan category are questions related to the installation of barriers or fences between the track and platform, and increasing the number of station conductors for improvement of safety at station platforms. Regarding this, the respondents' answers are presented in Table 4-8.

In Table 4-8, the importance rating column shows the proportion of respondents who placed the highest, second highest and third highest levels of agreement ("Strongly Agree" or "Agree" or "Somewhat Agree") on each issue measuring passengers' opinion of future safety enhancement works.

As a result, 70 % of the respondents who answered to the questionnaire placed their agreement on the importance of constructing a barrier or fence between the track and platform edge. Installation of barriers or fences was also perceived positively by respondents even for stations with small number of passenger flow (52%). However, if the installation of barriers or fences meant the increment of fare by 0.5 cents, it did not receive positive reply from the respondents (only 40% agree and 60% disagree). Assigning more station conductors instead of installing barriers or fences may be an alternative as the idea was strongly supported (78%).

Table 4-8: Safety enhancement works importance rating and ranking

No	Safety Indicator	SD %	D %	SW A %	A %	SA %	Importance rating %
18	If ERC install fence or barrier between track and platform, you feel safer.	14	16	_	28	42	70
19	More station conductors can replace installation of fence or barrier.	14	8	_	40	38	78
20	It is not necessary to install fence or barrier for stations with small numbers of passengers.*	22	30	_	24	24	48 (52)
21	If installation of fence or barrier increases fare by 0.50 cents, you are willing to pay.	48	12	_	18	22	40

SD: Strongly disagree; D: Disagree; SWA: Somewhat agree; A: Agree; SA: Strongly agree

Notes: * = 'negative' value in the bracket is the transformed score for 'negative' question.

Source: Questionnaire survey analytical results

4.2.6.2 Safety related Service Provisions

The respondents were asked regarding safety related service provisions on the AALRT under service provision category of the questionnaire. Service provision of the rail operator can for example include safety tips on how passengers should behave at stations while waiting for the train, rules concerning intoxication (drunken passengers), train warning sound signals and safety information provided by the station conductors. Concerning these issues the respondents’ answers are presented in Table 4-9.

In Table 4-9, the “importance” column shows the proportion of respondents who placed the highest, second highest and third highest levels of importance (“Strongly agree” or “Agree” or “Somewhat Agree”) on each issue (rating) and ranking from 1 to 4 based on the ratings. Services related to safety information and precautions were considered important to inform and remind passengers of possible dangers and prevent any possible accidents and incidents to happen.

Table 4-9: Safety related service provisions importance rating and ranking

No	Question on the Survey	Category	Importance	
			Rating %	Ranking
1	ERC should provide information about safety tips on platform.	Service provisions	94	1
2	AALRT should not allow drunken passenger to use the service.	Service provisions	90	3
3	Warning sound signal when train approaches make you more careful	Service provisions	90	4
4	Warning from station conductor makes you more careful.	Service provisions	92	2

SD: Strongly Disagree; D: Disagree; SWA: Somewhat Agree; A: Agree; SA: Strongly Agree

Source: Questionnaire survey analytical results

Adherence to safety should be well informed to passengers so that risks on the platform can be avoided such as playing around or reading, listening to music and talking on mobile phone, while standing close to yellow lines. Table 4-9 shows safety-related service provisions importance ratings and rankings. Figure 4-7 shows the station conductor at work (Station station).

Figure 4-7: Station conductor at work (Stadium)

Based on safety provisions importance rating, the need for 'safety tips' received the highest importance rating (94%), followed by warning from 'station conductor' (92 %).The third most important attributes indicated by passengers under the service provisions category had to do with the forbidding of drunken passengers from using the AALRT services followed by the need for warning sound signal from station approaching train (90%). In conclusion, this indicates passengers believe that safety provisions from the rail operator are very important during making a transit trip to reduce the occurrence of platform-train interface (PTI) accidents and incidents.

Out of the four service provision attributes, passengers ranked provision of safety tips the most in terms of importance as follows:

- ERC should provide information about safety tips on platform (94%);
- Warning from station conductor makes passengers more careful (92%);
- AALRT should not allow drunken passenger to use the service (90%); and
- Warning sound signal when train approaches makes passengers more careful (90%).

4.3 Checklist Based Observation Results

A checklist based observational study is used to address the fourth specific objective of the study; identify the major safety concerns and issues at pedestrian-rail crossings of the AALRT and the results are described as follows.

4.3.1.1 Poor Geometry of Pedestrian-rail Crossings

All pedestrian-rail crossings along the AALRT corridor are designed and constructed perpendicular to the track alignments which means; crossing pedestrians are not forced to face the oncoming LRV direction as they walk along the crossing paths. Figure 4-8 below shows a typical pedestrian-rail crossing at one of the AALRT area. In addition, clearly designed safe locations for pedestrians are lacking. In many of the AALRT pedestrian-rail crossings, pedestrians do not have adequate and safe queuing areas. There is also lack of refuge space between the LRT and vehicular right-of-ways for crossing pedestrians which is a serious safety issue. Figure 4-9 below shows pedestrians queuing in the vehicular right-of-way at saris station.

Figure 4-8: Typical pedestrian-rail crossing at one of the AALRT

At many of the AALRT pedestrian-rail crossings, pedestrians stand on the LRT track and in the streets after they have alighted from the LRV and are waiting to cross the street. Such actions put them at risk when LRVs approach or depart the station, or as motor vehicles approach in the traffic lanes where the pedestrians are queuing.

Figure 4-9: Pedestrians queue on vehicular right-of-way at Saris stations

4.3.1.2 Limited Pedestrian Warning Devices and Lighting Devices

Along the AALRT pedestrian-rail crossings, there are no enough pedestrian warning devices installed. Another observed problem at these crossings is that there are no lighting systems installed for pedestrians during dark time. Figure 4-10 shows a pedestrians crossing at one of the AALRT tracks without enough lighting systems.

Figure 4-10: Pedestrians crossing the AALRT track in dim light

4.3.1.3 Collision Risk due to Second LRVs

Most of the time, passengers alighted from one LRV attempt to cross the LRT track behind the stopped LRV but in front of another LRV that is approaching or departing the station from the other direction. This problem has potential for collision between LRVs and pedestrians since the operator of the second LRV has limited ability to see pedestrians since visibility of pedestrians may be blocked by the first LRV. Likewise, the first LRV may block the pedestrians' visibility for the second approaching LRV.

CHAPTER 5 CONCLUSIONS AND RECCOMENDATIONS

5.1 Conclusions

The study was conducted using data acquired through the questionnaire. The results of the study shows that station platform safety concerns do exist in the AALRT services, even if nothing serious has happen so far. In this regard, the study concludes that platform-train interface (PTI) accident is a safety issue for the AALRT operation by studying a wide variety of stations in regards to safety concerns and issues. Among these safety issues the following have been identified: crowded station platforms at peak hours, insufficient number of station conductors, no barrier between platform and track, lack of safety tips on stations, passengers standing in the danger zone of the platforms (disregarding the yellow line), and no between-car barrier for the gap between double light rail vehicles.

The analysis of independent t-test showed no significant differences between travel frequency and travel purpose groups in evaluating the safety level of the AALRT station platforms. This means that travel frequency and travel purpose did not affect the perception on safety satisfaction of the AALRT passengers. The study also found that travel frequency and travel purpose has no significant influence on the passengers' safety awareness of PTI risks in the AALRT. However, passengers who frequently used the AALRT service and commuters were more aware of the risks related to PTI accidents than passengers who seldom travelled by the AALRT and non-commuters. This means that they gradually observed the environment and recognized some safety measures provided at the stations or on the trains when travelling to their destinations.

The study also identified a number of pedestrian related safety issues and concerns at the pedestrian-rail crossings along the AALRT corridor. Among these pedestrian related safety issues and concerns, inadequate standing areas and safety zones, limited pedestrian warning devices, accessibility for disabled pedestrians and collision risk due to second LRVs were the major ones. In order to avert these identified issues concerning pedestrian-rail crossings facilities, recommendations have been forwarded in the following section.

5.2 Recommendations

5.2.1 Station Platforms Safety

For the identified safety concerns and issues at the station platforms of the AALRT, the following possible solutions are forwarded as recommendations.

- **Install safety barriers or fences at stations:** one way to reduce platform-train interface (PTI) accidents and incidents is to construct barriers or fences between tracks and platforms in a way not to disturb the movement of passengers on platforms.
- **Educating the public:** Educating and informing passengers about safety awareness and precaution on the station platform is also a necessary way to prevent any platform accidents and incidents. This will include providing safety information and station conductors.
- **Use "Do Not Cross Here" signage:** At stations in the common section of the E-W and S-N lines, where station crossing pathways are not provided (Leghar, Mexico and Tegbared) use "Do Not Cross Here" signage to warn and control unauthorized crossing pedestrians.
- **Provide crossing pathways:** At stations in the elevated section of E-W and S-N lines where crossing pathways are not provided (Leghar, Mexico, Tegbared, Awtobus-tera) there should be direct pedestrian links to connect the platforms. These techniques will increase passengers' safety by reducing the longer travel distance and travel times.
- **Training operators for second LRV collision avoidance:** Where possible, LRV operators should be trained to minimize the occurrence of accidents resulting from pedestrians crossings behind one LRV and into the path of a second, opposite direction of LRV. One strategy to minimize the second LRV conflict is to have the first LRV operator slow or stop to physically block pedestrians' path until the second, the opposite direction LRV enters the crossings. In this manner, pedestrians cannot enter the crossing before the second LRV arrives.

5.2.2 Pedestrian-rail Crossings Safety

In order to avert the issues identified concerning pedestrian crossings facilities in the AALRT project, the following counter measures are recommended:

- **Install pedestrian manual gates:** Installation of manual swing gate is also important to control the hurried crossing user's movement by slowing the person at entrance of the crossing. This crossing device is of great value especially at pedestrian crossings of limited sigh distance problem. For detail of the device refer to section 2.4.2.6.
- **Install pedestrian automatic gates:** the installation of pedestrians' automatic gates at high pedestrian flow crossings is recommended to control the inattentive

and dangerous movement of pedestrians flow from the crowded streets. A detail use and installation criteria's are described in chapter two of this thesis. (See section 2.4.2.12).

- **Provide adequate queuing and storage area:** Pedestrian refuge area between the LRT tracks and roadway should be provided at pedestrian-rail crossings to protect pedestrians from parallel traffic. These provisions are relatively inexpensive methods of improving crossing facilities for pedestrians.

- **Install Z-crossing channelizing:** Pedestrian pathways should be z-crossing channelization type so that pedestrian faces in the direction of approaching train while crossing. The installation of this crossing system is not costly compared to other safety enhancement techniques.

- **Provide a separate way for pedestrians:** One solution to protect pedestrian safety during crossing is to design and build safe and simple pedestrian steel truss bridge which will eliminate traffic congestion and delay, as well as eliminate conflicts between pedestrians, trains and motor vehicles.

CHAPTER 6 PROPOSALS FOR FUTURE STUDIES

The need for continued research regarding LRT safety will provide the necessary tools for LRT agencies to increase the level of safety of their systems. Furthermore, as the country is planning to implement more railway transportation projects in the coming years, the need for more researches on the subject is critical and timely. Accordingly, this study lists possible future research areas that should be conducted to improve the safety of LRT stations and pedestrians-rail crossings for passengers and pedestrians. The proposed topics are the following:

- Evaluating traffic engineering treatments at highway and pedestrians crossings;
- Determining the impact of new “quieter” LRVs on pedestrian safety; and
- Evaluating the effect of low-floor vehicle station platforms on pedestrian behavior at stations.

REFERENCES

AMIR TURTUGULOV (2009). Passengers' Awareness and Perceptions on Safety and Security Measures and Procedures in Airport Terminal Building. MSc. Thesis in Transport Planning. University of Technology Malaysia

CHAIYASET PROMSRI (2015) Passengers' Perception Towards Physical Security Measures of Suvarnabhumi Airport Rail Link Service. Mediterranean Journal of Social Sciences, Vol. 6 No 1 , PP.309-312, MCSER Publishing, Rome-Italy

CHINA RAILWAY GROUP LIMITED (CREC). (2012) Addis Ababa E-W & N-S (Phase I) Light Rail Transit Project Schematic Design. Addis Ababa: Ethiopian Railway Corporation.

COHEN, J. (1988). Statistical Power Analysis for the Behavioral Sciences. Hillsdale, New Jersey: Lawrence Earlbaum Associates.

DJOEN SAN SANTOSO *et al*. (2013). How Safe is the Rail Platform? A Study of Bangkok Mass Transit System (BTS). Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9. Bangkok.

DON IRWIN. (2008). Safety Criteria for Light Rail Pedestrian Crossings, Tri-County Metropolitan Transportation District of Oregon. pp266-288.

GALLUP ORGANIZATION. (2001) Survey on passengers' satisfaction with rail services. Analytical report Flash Eurobarometer No 326, Hungary.

HIROYUKI ISEKI *et al*. (2007). Evaluating Transit Stops and Stations from the Perspective of Transit Users, Institute of Transportation Studies University of California, Los Angeles.

KALPANA DUBE (2012). Passenger Satisfaction Survey Report and Benchmarking of Performance Standards. Indian Railways Institute of Transport Management Lucknow ,Government of India – Ministry of Railways.

KARL FRIDOLF AND DANIEL NILSSON (2012). A questionnaire study about fire safety in underground rail transportation systems. Department of Fire Safety Engineering and Systems Safety Lund University, Sweden.

KAY FITZPATRICK *et al*. (2015). Guidebook on Pedestrian Crossings of Public Transit Rail Services. TCRP Report 175. Washington D.C.: National Academy Press.

KITTELSON. *et al*. (2012). Guidelines for Providing Access to Public Transportation Stations. TCRP Report 153. National Academy Press. Washington D.C.

KORVE, H. *et al*. (1996). Integration of Light Rail Transit into City Streets. TCRP Report 17. National Academy Press. Washington D.C.

KORVE, H. *et al*. (2001). Light Rail Service: Pedestrian and Vehicular Safety. TCRP Report 69. National Academy Press. Washington D.C.

KORVE, H. *et al*. (2007). Railroad-Highway Grade Crossing Handbook. U.S Department of Transportation: Federal Highway Administration. Washington D.C.

LAETITIA FONTAINE AND GIUSEPPE INTURRI. (2014). Operation and safety of tramways in interaction with public spaces COST Action TU1103, Transport Research Arena (TRA), Paris.

METROLINK (2009). SCRRA Highway-Rail Grade Crossings: Recommended Design Practices and Standards Manual. Los Angeles, California.

NEUMAN,L.W. (1994). Social Research Methods (2nd edition). Boston, Mass:Allyn and Bacon.

OXFORD ADVANCED LEARNER‘S DICTIONARY 7th Edition. (2007). Oxford University Press.

RAIL SAFETY AND STANDARDS BOARD (RSSB) (2011). Passenger Risk at the Platform-Train Interface (PTI). London.

RAJKUMAR, SHAN AND DHAMODHARAN (2012). Platform–train interface for rail passengers – technology review. Project no: R3.115, CRC for Rail Innovation, Central Queensland University.

ROBERT R. (2009). General Guidelines for the Design of Light Rail Transit Facilities in Edmonton.

TRANS CONSULTING INC. *et al*. (2009). Improving Pedestrian and Motorist Safety along Light Rail Alignments. TCRP Report 137. Washington D.C.: National Academy Press.

VICTORIA TRANSPORT POLICY INSTITUTE (2015). Light Rail Transit TDM Encyclopedia.

WELLINGTON, J. (2000). Contemporary Issues and Practical Approaches. Biddles LTD, King‘s Lynn Norfolk.

APPENDIX A

SURVEY QUESTIONNARE (ENGLISH)

Dear Sir/Madam, This questionnaire has designed to solicit information for purely academic purposes. This is to enable the student researcher Tamrayehu Kurema who is a final year student at Addis Ababa University School of Graduate Studies department of Civil Engineering, conducting a thesis on the title; Safety at Platform-Train Interface (PTI) and Pedestrians-rail Crossings of the Addis Ababa Light Rail Transit (AALRT), for the partial fulfillment of the degree Master of Railway Engineering. I would request you to kindly spare some time to fill up this questionnaire.

N.B:

- You don't need to write your name.
- All information given would be treated with utmost confidentiality.
- ERC stands for Ethiopian Railways Cooperation.

PART ONE: For the next 21 questions, please choose a number from 1-5 and write it next to each statement to indicate how much you agree with that statement.

Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5

A. Design of Station

1. _______ Station platform design is safe enough.
2. _______ Space from platform edge to yellow line is enough.
3. _______ Space between the train and platform edge do not expose to accident

B. Service Provisions of Rail Operator

4. _______ ERC should provide information about safety tips on platform.
5. _______ ERC should not let intoxication/drunk passenger to use the service.
6. _______ Warning sound signal when train approaches make you more careful.
7. _______ Warning from station conductor makes you more careful.
8. _______ During peak hour, the number of station conductors is not enough.

C. Passengers' Activity

9. _______ Passenger with many luggage should not stand close to yellow line.
10._______ Wearing high heels and standing close to yellow line increase accident risk.
11. _______ Teasing and playing around on the platform should be prohibited.
12.._______ Reading, listening to music, talking on mobile phone while standing close to yellow line increase accident risk.

D. Attitude of Passenger

13. _______Although you stay behind yellow line, when train approaching, you still feel unsafe.
14. _______In crowded platform, passenger has more chance to fall into the track.
15. _______You prefer to wait for the train close to yellow line to get on the train faster.
16. _______You are more careful on the platform when raining and windy.
17. _______You are more careful when you are the first passenger waiting for train behind the yellow line.

E. Future Plan

18. _______If ERC install fence or barrier between track and platform, you feel safer.
19. _______More station conductors can replace installation of fence or barrier.
20. _______It is not necessary to install fence or barrier for stations with small numbers of passengers.
21. ________If installation of fence or barrier increases fare by 0.50 cents, you are willing to pay.

PART TWO: For the next 6 questions, please choose a number from the lists below the each question and write it next to each statement to indicate the most appropriate answer concerning you.

1. What is your gender? ________

- Male ………………………………….....1
- Female ……………………………….....2

2. How old are you? __________

- Below 18 ……………………………....1
- 18 -25 ….……………………………....2
- 26 -60 ………………………………..3
- More than 60 ………………………… 4

3. What is your educational level? _______

- High school……..……………………1
- Undergraduate …………………………2
- Graduated ……………………………3

4. How much is your total monthly income? _______

- Less than 1500 birr …………………...1
- 1500-5000 birr ……………………....2
- 5000 birr or more ……………………. 3

5. How often do you travel by train? ________

- Every day………………………………1
- Most days 2
- 1-3 times per week................................3
- 1-3 times per month...............................4
- Less than once a month………………..5

6. What is the most frequent purpose of your rail trip? ________

- Travelling to work/school/university......1
- Business trips..2
- Leisure..3
- Other……………………………………4

APPENDIX B

SURVEY QUESTIONNARE (AMHARIC)

የአዲስ አበባ ከተማ የቀላል ባቡር ተጠቃሚ መንገደኖች በባቡር መሳፈሪያና መዉረጃ ቦታዎች ስለደህንነት ያላቸዉን እይታ የሚገመግም መጠይቅ

ክፍል አንድ: መመሪያ :ቀጥሎ ለቀረቡት 21 ጥያቄዎች ከዚህ በታች ካለዉ ሠንጠረዥ ዉስጥ ከተጠቀሱት ምርጫዎች በመጠቀም በእያንዳንዱ ዐረፍተ ነገሮች ማለቂያ ላይ ባለዉ ክፍት ቦታዎች ከ 1 (በጣም አልስማማም) እስከ 5 (በጣም እስማማለሁ) ያሉትን ቁጥሮች በመጠቀም የእርሶን አመለካከት በይበልጥ ሊገልጥ የሚችለዉን ሀሳብ ያመልክቱ፡፡

በጣም አልስማማም	አልስማማም	በከፊል እስማማለሁ	እስማማለሁ	በጣም እስማማለሁ
1	2	3	4	5

ሀ)የባቡር መዉረጀና መሳፈሪያዉን ንድፍ (ዲዛይን) በተመለከተ

1. የባቡር መዉረጀና መሳፈሪያ ቦታዎች ንድፍ(ዲዛይን) በበቂ ሁኔታ ከአደጋ የሚከላከል ነዉ፡፡------

2. ከባቡር መሳፈሪያና መዉረጃ ጠርዝ እስከ ቢጫ መስመር ድረስ ያለዉ ስፍራ በቂ ነዉ፡፡-----------

3. በባቡር መሳፈሪያና መዉረጃ ጠርዝ እና በባቡሩ መካከለ ያለዉ ክፍተት ለአደጋ አያጋልጥም፡፡---------

ለ) የትራንስፖርት አገልግሎቱን ደረጃ በተመለከተ

4. የኢትዮጲያ ምድር ባቡር ኮርፖሬሽን በባቡር መሳፈሪያና መዉረጃ አካባቢ ለአደጋ መከላከል የሚረዱ መረጃዎችን (ማስጠንቀቂያዎችን) ለተሳፋሪዎች ማስተማር አለበት፡፡-------------

5. የኢትዮጲያ ምድር ባቡር ኮርፖሬሽን የአልኮል መጠጥ የጠጡ ተሳፋሪዎች የትራንስፖርት አገልግሎቱን እንዳይጠቀሙ መከልከል አለበት፡፡------------

6. በባቡር መጠበቂያ ፌርማታዎች ባቡሮች ወደ ፌርማታዉ በሚቀርቡበት ጊዜ የሚያሰሙት የጥሩንባ ድምጽ ከአደጋ ይበልጥ እንድጠነቀቅ ያደርገኛል፡፡------------

7. በባቡር ፌርማታዎች በተቆጣጣሪዎች የሚሰጡት የማስጠንቀቂያ መልዕክቶች የበለጠ ራሴን ከአደጋ እንድጠብቅ ይረዳኛል፡፡-----------

8. ተሳፋሪዎች በሚበዙባቸዉ አንዳንድ የባቡር ፊርማታዎች የተቆጣጣሪዎች ቁጥር በቂ አይደለም፡፡--------

ሐ) ተሳፋሪዎች በባቡር መሳፈሪያና መዉረጃ አካባቢ የሚያደርጉትን እንቅስቃሴዎች በተመለከተ

9. በባቡር መሳፈሪያና መዉረጃ አካባቢ ብዙ እቃ የያዙ ተሳፋሪዎች ለቢጫዉ መስመር በጣም ቀርበዉ መቆም የለባቸዉም፡፡----------

10. በባቡር መሳፈሪያና መዉረጃ አካባቢ ላረማመድ የማይመቹ ጫማዎችን አድርጎ ከቢጫዉ መስመር በመቅረብ መቆም ለአደጋ ያጋልጣል፡፡----------

11. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ለአደጋ ሊያጋልጡ የሚችሉ እንቅስቃሴዎችና ጨዋታዎች (መታገልን፣መጉዋተትን) የመሣሠሉ ሊከለከሉ ይገባል፡፡------------

12. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ለቢጫዉ መስመር ቀርቦ በመቆም መጻህፍትን ማንበብ፣ሙዚቃ ማዳመጥ፣ስልክ ማነጋገር የመሳሰሉ እንቅስቃሴዎች የአደጋን መፈጠር እድልን ይጨምራሉ፡፡----------

መ) የመንገደኞችን አስተሳሰብ በተመለከተ

13. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ባቡሩ በሚመጣበት ጊዜ ምንም እንኳ ቢጫዉን መስመር ሳላልፍ ብቆምም ከአደጋ ነፃ መሆኔ ግን ያጠራጥረኛል፡፡-------------

14. በባቡር መሳፈሪያና መዉረጃ ቦታዎች መንገደኞች በሚበዙባቸዉ ሰዓታት በሚኖረዉ መጨናነቅና ግፊያ ምክንያት አንዳንድ ተሳፋሪዎች በሀዲዱ ላይ የመዉደቅ አደጋ ሊደርስባቸዉ ይችላል፡፡-------------

15. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ባቡሩን በምጠብቅበት ጊዜ ወደ ባቡሩ ቀድሞ ለመግባት ቢጫው መስመር በጣም በመጠጋት መቆም እመርጣለሁ፡፡------------

16. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ዝናብና ነፋስ በሚኖርበት ጊዜያት ለደህንነቴ ይበልጥ እጠነቀቃለዉ፡፡-----------

17. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ከሌሎች ተሳፋሪዎች ይልቅ ለባቡሩ የቀረብኩ በምሆንበት ጊዜ ለደህንነቴ ይበልጥ እጠነቀቃለዉ፡፡---------

ሠ) የወደፊት የማሻሻያ ሥራዎችን በተመለከተ

18. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ተሳፋሪዎች በሚሰለፉበትና ባቡሩ በሚቆምበት መካከል ከአደጋ የሚከላከል አጥር/ግንብ/ ቢሠራ ይበልጥ ደህንነት ይሠማኛል፡፡-----------

19. በባቡር መሳፈሪያና መዉረጃ ቦታዎች ተሳፋሪዎች በሚሰለፉበትና ባቡሩ በሚቆምበት መካከል ከሚሠራ አጥር/ግንብ/ ይልቅ ተቆጣጣሪዎች በበቂ ቁጥር ቢኖሩ እመርጣለሁ፡፡----------

20. ተሳፋሪዎች በማይበዙባቸዉ ጣቢያዎች አደጋን የሚከላከሉ አጥሮች መገንባት አስፈላጊ አይደለም፡፡------

21. በሁሉም የአዲስ አበባ ከተማ የቀላል ባቡር ፌርማታዎች ተሳፋሪዎችን ከአደጋ የሚከላከሉ አጥሮች ተገንብተዉ የጉዞ ታሪፉ 0.50 ሣንቲም ቢጨምር እስማማለሁ፡፡-------------

ክፍል ሁለት: *መመሪያ*: ቀጥሎ ለቀረቡት ራሶን ለሚመለከቱ ጥያቄዎች ትክክለኛዉን መልስ ለማመልከት በሳጥኖቹ ዉስጥ ምልክት ያድርጉ፡፡

1. **ጾታ**?
   - ☐ ወንድ
   - ☐ ሴት

2. **ዕድሜ**?
   - ☐ ከ18 ዓመት በታች
   - ☐ 19-25 ዓመት
   - ☐ 26-59 ዓመት
   - ☐ ከ60 ዓመት በላይ

3. **የትምህርት ደረጃዎ**?
   - ☐ እስከ 8ተኛ ክፍል አጠናቅቄአለዉ
   - ☐ እስከ12ተኛ ክፍል አጠናቅቄአለዉ
   - ☐ የዩንቨርስቲ/ኮሌጅ ተማሪ ነኝ
   - ☐ ዲግሪ አለኝ
   - ☐ ሁለት እና ከዚያ በላይ ዲግሪ አለኝ

4. **የወር ገቢዎ ምን ያህል ነዉ** ?
   - ☐ ከ1,500 ብር በታች
   - ☐ 1,500 ብር– 5,000 ብር
   - ☐ ከ 5,000 ብር በላይ

5. **ምን ያህል ጊዜ በባቡር ይጓዛሉ** ?
   - ☐ እለት እለት

- ☐ አብዛኛዉን ጊዜ
- ☐ በሳምንት 1-3 ጊዜ
- ☐ በወር 1-3 ጊዜ
- ☐ በወር ከአንድ ጊዜ በታች
- ☐ አልፎ አልፎ

6. **ባብዛኛዉ ባቡሩን ተጠቅመዉ የሚሄዱባቸዉ ስፍራዎች ?**

- ☐ ወደ ስራ ቦታ ፣ ወደ ትምህርት ቤት
- ☐ ወደ ገበያ ስፍራዎች
- ☐ ወደ መዝናኛ ስፍራዎች (ለመዝናናት)
- ☐ ወደ ተለያዩ ስፍራዎች(ለህክምና፣ዘመድ ለመጠየቅ..)

ይህንን መጠይቅ ለመሙላት ዉድ ጊዜዎትን በመስጠት ስለተባበሩ እናመሰግናለን፡፡

APPENDIX C

CHECKLISTS FOR PEDESTRIAN-RAIL CROSSINGS

Checklists for the AALRT pedestrian-rail crossings safety assessment

Paths

- Are there appropriate travel paths and crossing points for pedestrians, cyclists and the disabled (wheel chairs)?

☐ Yes ☐ No

Barriers and Fencing

- Where necessary, are pedestrian maze treatments and/or gates installed for pedestrians and cyclists?

☐ Yes ☐ No

- Are associated signing and/or warning lights and audible warning devices installed?

☐ Yes ☐ No

Surface

- Are rail tracks flush with the road and/or path surface to avoid tripping by pedestrians and dislodgment of cyclists?

☐ Yes ☐ No

Elderly and Disabled

- Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages (e.g. holding rails, curb and median crossings, ramps)?

☐ Yes ☐ No

- Where necessary, are hand rails provided and are they adequate?

☐ Yes ☐ No

Lighting

- Is appropriate lighting installed?

☐ Yes ☐ No

- Is all lighting operating satisfactorily?

☐ Yes ☐ No

Signs

- Are signs placed so as not to restrict sight distance?

☐ Yes ☐ No

Pavement Marking

- Is all necessary pavements marking installed?

☐ Yes ☐ No