ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

ASSESSMENT OF OPERATION AND STATION FACILITY OF LIGHT RAIL TRANSIT: - A CASE STUDY AALRT.

A Thesis in Railway Engineering

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A Thesis

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

The undersigned have examined the thesis entitled '**Assessment of operation and station facility of light rail transit, A case study Addis Ababa light rail transit (AALRT)** presented by **Kefale Fufa Goboto**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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UNDERTAKING

I certify that research work titled "Assessment of operation and station facility of light rail transit, a case study Addis Ababa light rail transit (AALRT**)**" is my own work. The work has not been presented elsewhere for assessment.

Signature of Student

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ABSTRACT

Light rail transit is less costly to build and operate than other fixed-guide way modes. It represents a viable solution to a very large range of transportation problems and to provide room for incremental growth in capacity. For this reason Ethiopia select this type of transit system to response high demand of passenger transportation in Addis Ababa. Hence the investigation is made to study the facility, capacity and operation incorporated in light rail transit

Based on this study, station facility and function of the Addis Ababa light rail transit meet basic objectives like minimizing the transportation shortage and facilities. But due to some problem of operations and planning the transportation demand are not fully responded; such that the comfortable and average operating speeds are limited.

As a result passenger and vehicle crossing at grade on some station increase head on time that made service quality to class **C**; number of train planned cannot balance efficiently demand of passenger which affect comfort and result in level of service to class **E**, and unavailable separated power supply system has also it is own impact on operation.

Key words:-Station, Capacity**,** Operation, Time, Light rail transit, Service quality and Facility.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1 INTRODUCTION

1.1 General

Light Rail Transit (LRT) is a mode of passenger transportation utilizing a fixed guide way system based upon standard railway technology modified as necessary to comply with specific site requirements and generally employing electricity from an external source as a means of propulsion. L.R.T. is a versatile option with significant differences in performance and capacity from system to system and even from line to line within a given system. It represents a viable solution to a very large range of transportation problems, and to provide room for incremental growth in capacity.

A formal definition was adopted in 1989 and placed in the Transportation Research Board's Urban Public Transportation Glossary: - "A metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally, in streets and to board and discharge passengers at track or car floor level." LRT is designed to accommodate a variety of environments, including streets, freeway medians, railroad rights-of-way (operating or abandoned), and pedestrian malls, underground or aerial structures, and even in the beds of drained canals. It is this characteristic that most clearly distinguishes it from other rail modes. Because of this design flexibility, LRT generally is less costly to build and operate than other fixed-guide way modes. (*Published by the Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, November 2000.*)

There is a strong public demand or a variety of projects related to railway station facilities. However, consideration to passenger utility: time, capacity and operation have been minimal in most of the existing station facilities. The problem of their business profitability has been the biggest obstacle to the expansion of such facilities. The financial problems of railway companies make it difficult to construct new railway facilities due to the increase of costs. In addition to this, the development of station facilities has not been included in urban development projects.

The operations and maintenance center is the focal point of an LRT system. It includes a control room from where operations are coordinated, accommodations for train crews preparing for duty, and a maintenance facility where the cars are inspected, cleaned, and repaired. The center can also include administrative and management offices.

Two basic elements comprise the electric power supply: a network of traction power substations and a distribution system. The power substations receive high-voltage commercial electrical power and convert it to medium- voltage direct current. The distribution system delivers that converted power from the substations via overhead wires to the individual LRT cars as they travel along the line. The movement of the cars or trains is guided by **signals**. On some systems all of the signals are located alongside the track way. These trackside signals may include, or be coordinated with, traffic signals along the line. On other systems only certain signals are installed trackside, while others are displayed on a console in front of the train operator.

Signals have aspects and indications. Aspect is the visual appearance of the signal where as indication is the meaning. The various objectives of providing & operating signals are:-

- To provide facilities for the efficient movement of trains
- To provide facilities for the maximum utility of track
- To provide facilities for safe and efficient shunting operations
- To guide the trains movement during maintenance and repair of tracks

Communications facilities link the operations and maintenance center with the train operators and other personnel. These facilities range from conventional telephone lines to the very newest wireless technologies. It also includes communication of customers with schedule and time table.

1.2 Objective

General Objectives

Assessment of station facility and its function based on different constraints like accessibility with other mode, capacity, facility and operation of AALRT.

Specific Objectives

The specific objectives of Projects are:

- To find the prospects of station facilities and their related functions to the local community
- To studying passenger rail station connection with other transportation system.
- Investigation on the capacity and operation of AALRT station service.

1.3 Scope of the Assessment and Limitation

The scope of project mainly based on the following basic qualitative assessment concerning Addis Ababa rail transit; - Adequacy or capacity of the train with demand of passenger at control points like station, operation issue to maximize the efficiency of the transit focused on time, comfort and station facility to increase utility and integration.

The project is mainly focused on qualitative assessment of transit based on time and comfort approach rather than design by using quantitative data.

1.4 Method of Analysis

The primary and secondary data for the case study are the following:-

Primary data

- Field observation of station at all most 80% AALRT station and recording each individual parameter; like head on time, dwell time, operation, demand of passenger, facility provide for passenger like toilet, weather protection, communication problem and etc.
- Direct interviewing the focus group by preparing some points considered in this study.

Secondary Data

- Design data and facility concerning the study from Addis Ababa light rail transit office.
- Reviewing different standards and manual for light rail transit.

Method of analysis made in this project is done by comparing proper evaluation of the existing condition such that practical observed data with design value which is forecasted during initial time and referring standard, manual values result in recommending the merit and demerit of the Addis Ababa light rail transit.

CHAPTER 2 LITERATURE REVIEW

2.1 Capacity Review

Many rail transit capacity calculations add constants, multipliers, reductive factors, or other methods to correlate theory with practice. In this project emphasis has been placed on the number of qualifications, describing and explaining adjustments between theory and practice in determining rail transit capacity. In Ethiopia the development of railway system is started construction from Djibouti in 1897 and it reaches Addis Ababa in 1917.The modern era of Ethiopian railway system is launched in 2007 and nation railway development is established in regulation No. 141/2007 and ERC (Ethiopia Railway Corporation) is established.

L.R.T. provides a capacity between that of the trolley, bus and the metropolitan railway, i.e., between 3,000 and 30,000 passengers per direction per hour, with capacities in the lower range being provided by single cars, and higher capacities being achieved by operation in trains. The practical advantage of this large range is to enable L.R.T. to satisfy transit needs over the long term, with opportunities for progressive upgrading of facilities as and when required.(Guide lines for designing light rail transit station facility in edmonton Robert R. Clark, retired ETS supervisor of special projects, 1984)

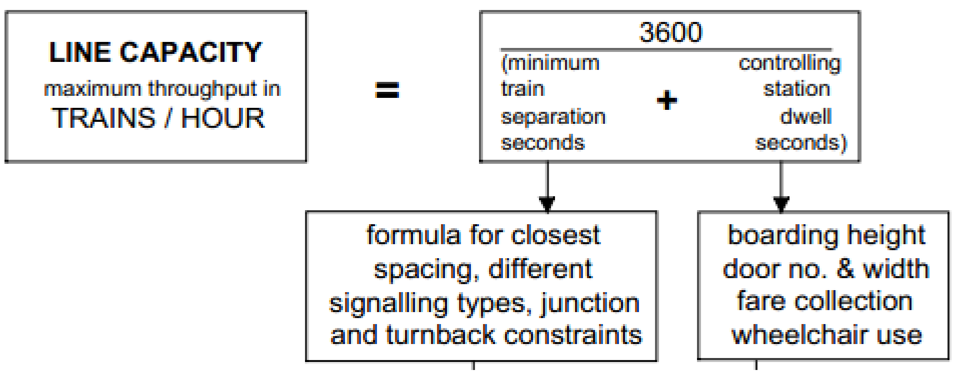
A surface LRT track way may be physically separated from vehicle and pedestrian traffic by means of bridges or underpasses. It may also cross roadways and walkways at grade, in which case the conflicting movements are temporarily separated by appropriate control devices, usually automatic crossing gates or traffic signals to increase the capacity of line. LRT track age may also be constructed along a street right-of-way, commonly in segregated `lanes but occasionally within vehicle lanes used by general traffic. Sub-surface track ways are generally positioned below streets and follow the street pattern, but they can also follow an independent alignment and pass under structures, parks, bodies of water, or other railways. Aerial track ways may also follow street patterns, but are more likely to trace a different alignment, crossing above streets, rivers, and other rail lines.

2.1.1 Design Capacity

The design capacity is maximum number of passengers passes a single point in an hour, in one direction on a single track. It is similar to or the same as, maximum theoretical capacity. It also makes no allowance for whether those spaces going by each hour will be used they would be fully used only if passengers uniformly filled the trains throughout the peak hour. This does not occur and a more practical definition is required. Achievable capacity takes into account that demand fluctuates over the peak hour and that not all trains, or all cars of a train are equally and uniformly full of passengers. (Current Transit Capacity and service quality manual of North America.)

Design capacity has two factors, line capacity and train capacity, and can be expressed as:

$CD = CL\ X\ CT$, where CD is design capacity (p/h), CL is line capacity (trains/h) and CT is train capacity (p/train)



Design capacity, in passengers per hour per direction (pphpd), is based on the following factors:-

- number of seats per car,
- Number of standees per car (= standing area x standee density),
- Number of cars per train, and
- Train headway (minimum headway determined by a combination of the signaling system, station dwell and terminus constraints).

Factors that reduce the *actual* number of regular riders that the system can sustain are:-

- Standing densities vary; people will crowd in more tightly in some situations than in others.
- In a multi-car train; some cars carry more passengers on average than others.
- Many factors reduce train performance (propulsion faults or differences, door problems, operator variation), which may not only increase the sustainable average headway, but will increase the variation in headway, and consequently the passenger load waiting for that train.

Figure 2.1 At grade crossing at Adey - Ababa station which may increase head on time.

- Minimum headway, by definition, leaves no margin for schedule recovery from even minor delays, leaving the system susceptible to more variation in service.
- Passenger demand is unevenly distributed within the peak period; there may be predictable “waves” of demand, corresponding to specific work start and finish times. The capacity rate requirement for the peak 10 to 15 minutes may have to be higher than the average for the peak hour.

- There is day-to-day fluctuation in demand. Some may be associated with the day of the week (peaks have become lighter on Mondays and Fridays as more people move into shorter or flexible work weeks), seasonally (lighter in the summer and at Christmas time), weather and special events.
- Passengers are resilient to a degree, and will tolerate overcrowding or delay on occasion. This permits systems at capacity to accommodate special events or recover from service delays.

SERVICE HEADWAY

Design (minimum) train operating headway is a function of:

- Signaling system type and characteristics, including block lengths and separation;
- operating speed at station approaches and exits or other bottlenecks such as junctions; and
- Train length and station dwells.

TRAIN CAPACITY

Train capacity is the product of passengers per car and the number of cars, adjusted to achievable capacity using a diversity factor to compensate for uneven car loadings over multiple-car trains.

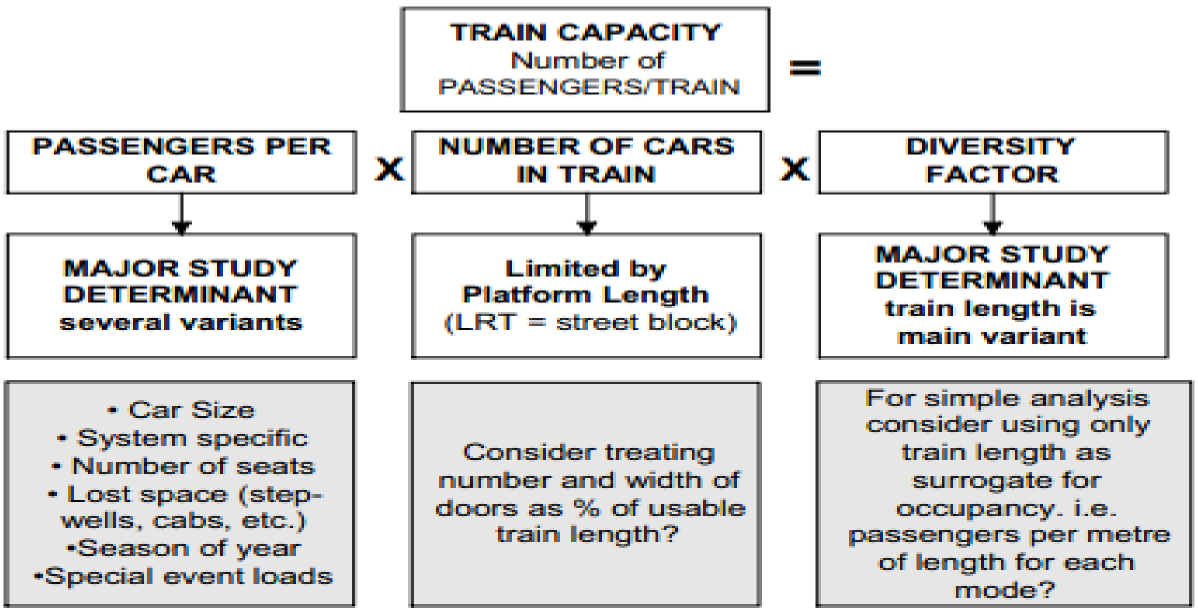


Diagram showing factor affecting the train capacity.

(Current Transit Capacity and service quality manual; North America.)

Design train capacity is simply the product of car capacity and the number of cars per train. The number of cars is limited by platform length, or, for light rail with on-street operation, by the shortest city block length. The only true means of measuring achievable car capacity is on those systems where pass-ups occur. That is where passengers wait for the next train rather than crowd onto the one in their station. Determining full car capacity and pass-up capacity depends on interior arrangements, type of system, old or new, and time of peak loading.

CAR CAPACITY

Design-Specific Capacity of car

If a specific car design has already been chosen, capacity calculation is relatively straight forward. Space used for seats, cabs, wheelchair, stroller or bicycle positions, baggage racks, step wells, and other equipment is deducted from the interior floor area and the remaining, “standing” space assigned an appropriate standing density.

2.1.2. Achievable Capacity

It is the maximum number of passengers that can be carried in an hour in one direction on a single track allowing for the diversity of demand. Achievable capacity (sometimes called practical capacity) refers to capacity in one direction on a single track. The capacity of four track lines is not a simple multiple of two single tracks and varies widely with operating practices such as the merging and dividing of local and express services and trains holding at stations for local- express transfers. The result is that four tracks rarely increase capacity by more than 50% over a double track line and often less. A third express track does not necessarily increase capacity at all when restricted to the same station close-in limitations at stations with two platform faces.(Transit Capacity and service quality manual of North America.)

$CA = CDXPHF$ Where,

CA = achievable capacity (p/h);

CD = design capacity (p/h);

PHF = Peak hour factor.

2.2 Operation review

There is considerable uniformity of performance of the electrical multiple-unit trains by the wide spread introduction of electronic controls and automatic driving. However there still can be up to a 10% difference in performance between otherwise identical trains due to manufacturing tolerances, aging of components, and variances in set-up parameters and in particular on manually driven systems, due to variation in driving techniques and between drivers. *Train Control and Signaling, Station, Dwell Times,* and *Passenger Loading Levels* affect Operating issues, discussed in this chapter.

To accommodate these routine irregularities, two allowances are made in rail transit operations planning and scheduling. An operating margin is added to the minimum train separation time and maximum load point station dwell time to create a minimum headway. This operating margin is effect, the amount of time a train can run behind schedule without interfering with the following trains. The operating margin is an important component in determining the maximum achievable capacity. The second allowance is schedule recovery, an amount of time added to the terminal turnaround time to allow for recovery from accumulated delays on the preceding trip. Schedule recovery time has some effect on achievable capacity and has economic implications as it can increase the number of trains and staff required to transport a given volume of passengers.

The more segregated L.R.T. becomes, the more difficult it is to integrate it into the community. The general standard for reasonable accessibility established for bus services is 400 meters to the nearest bus stop. It has been amply demonstrated that a fixed guide way system will attract patrons from a larger radius so that for L.R.T. it is reasonable to postulate a catchment area perhaps half as large again around the stations. Beyond this distance it is necessary to provide feeders of some sort if the mode split potential of the area is to be realized, thus radically increasing the cost of service, and extending travel time. Factors which militate in favors of the close integration of L.R.T. into a community, whether it is new or established, are its relative unobtrusiveness of scale and its quietness. The guide way or track occupies only the width of one traffic lane per direction no matter how much traffic it has to carry, and the external noise produced by the vehicles is considerably less than that of motor traffic even when no noise suppression measures are taken. (Guide lines for designing light rail transit station facility in edmonton Robert R. Clark, retired ETS supervisor of special projects, 1984)

Key parameters of railway passenger transport operation includes: -

- Parameters for passenger volume.
- Parameters for operation quality and utility.
- Parameters for safety.
- Parameters for convenience.
- Parameters for comfort ability.
- Other parameters.

Figure 2.2 Peak hour passenger volume at grade separated areas.

Since Ethiopia resurgence of LRT is recent, operating experience generally might has been unfavorable, particularly in some metropolitan areas that previously had been without rail transit service. Adding an LRT component to a transit system does not drain passengers from the bus lines as some observers have claimed. Rather, it encourages more people to use both bus and rail transit. Adding LRT trunk lines and coordinating them with a region’s buses to create a multimodal, multi destination transit system results in growth for both modes even in the low-density.

2.2.1 OPERATING MARGINS

A starting point for recommending suitable operating margins to incorporate into the determination of the maximum achievable capacity are the operating margins incorporated into the schedules of existing systems. The maximum load point, peak-period, station dwell time, and headways for several rail transit lines also determine the maximum operating margin.

Figure 2.3 Starting point of train at Kality station

2.2.2 ESTIMATING MARGINS

Although there is no clear relationship between existing rail transit operating margins and other operating criteria, this important factor, and the related terminal recovery or lay-over time, cannot be discounted. The inevitable headway irregularities and the need for reasonable operating flexibility require the greatest possible operating margin and recovery time to ensure reasonably even service and to achieve maximum capacity. Selecting a recommended operating margin is a dilemma, as too much reduces achievable capacity, but too little will incur sufficient irregularity that it may also serve to reduce capacity.

It is recommended that a range be considered for an operating margin. A reasonable level for a system with more relaxed loading levels, where all of the capacity is not needed, should be 35 seconds.

2.2.3 SKIP-STOP OPERATION

Skip-stop service is used on several of the high capacity rail transit operations in Japan, New York, and Philadelphia, and until recently, in Chicago. Skip stops provide faster travel times for the majority of passengers with less equipment and fewer staff. They do not increase capacity as the constraint remains the dwell time at the maximum load point station at which, by definition, all trains must stop. In fact, capacity can be slightly reduced as the extra passengers transferring between *A* and *B* trains at common stations can increase dwell times. Skip-stop operation is only applicable if the headways are sufficiently short that the “up to two-headway wait” at minor stations is acceptable to passengers. (Transit Capacity and service quality manual of North America.)

Most of the operation of railway lines is vested on the following points:

a. Train Control and Signaling, developed the methodology for the train control system maximum throughput in three situations:-

- the close-in time at the busiest station,

  To respond the society demand in large amount the train assignment should be depend on the number of passenger at that specific time, such in the case of Addis Ababa light rail transit.

- Junctions, and if the rail line is at grade signaling and control system should be provided.

- Turn backs. In new grade-separated rail systems capacity should not be limited by junctions or turn backs.

2.3 Facility and Function review

The question of how to provide the new cultural effects means designing a station able to provide a chance of exchange between people, things, and information by improving its ability to attract users, by making a cultural contribution to the region along its railway line in order to promote new development of the cities where the stations are located. Connection with other transportation systems and improving convenience for users by facilitating easy and smooth transfers to other lines and means of transportation are important roles of a station as a transit point. (Journal of the Eastern Asia Society for Transportation Studies, Volume' l, No' l, Autumn' 1995)

LRT cars can be especially friendly to passengers with disabilities. Some cars carry lifts like those in new buses to assist the boarding and alighting of mobility-impaired passengers. Others have stationary lifts at the stations. However, an increasing number of LRT systems are being designed to provide easy access through level boarding. This type of boarding assures that the floor of the car at all or most of the doors match the height of the station platform. Until recently, in order to achieve level boarding it was necessary to design stations with platforms about one meter above the rails because that was the traditional car floor height. These high platforms exist in two forms. The more common is a full-length version that provides level boarding at every door. The less common form is the mini-high platform (sometimes called a high block), which serves only the front door. (Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418)

Passenger transportation facilities include passenger station building (ticket hall, waiting room), passenger platform, rain shed, pass equipment (the overpass, the subway, the intersection). A **railway platform** is sections of pathway, alongside rail tracks at a railway station, at which passengers may board or alight from trains. Almost all rail stations have some form of platform, with larger stations having multiple platforms. (AREMA Manual for Railway Engineering Volume 2 Lanham, MD: American Railway Engineering and Maintenance-of-Way Association, 2008).

Length of the platform shall be subject to the recent passenger number and train length and enlargement needs. When passenger number is relatively small and the train is relatively short, the platform length may be reduced properly. The widths of platform depend on the number passenger. Platform can be divided into two distinct categories for the purposes of capacity assessment: **Platforms functioning as waiting** areas – need sufficient capacity to accommodate all waiting passengers without obstructing the walking route for passengers alighting from trains or passengers wishing to walk along the platform to board at the platform ends. ***Platforms functioning as passageways*** – at some termini stations, passengers are required to wait on the station concourse rather than on the platform. They are then called to the train once the platform is announced and the train is in situ.

Figure 2.4 Light rail station facility to show extreme weather condition resistance.

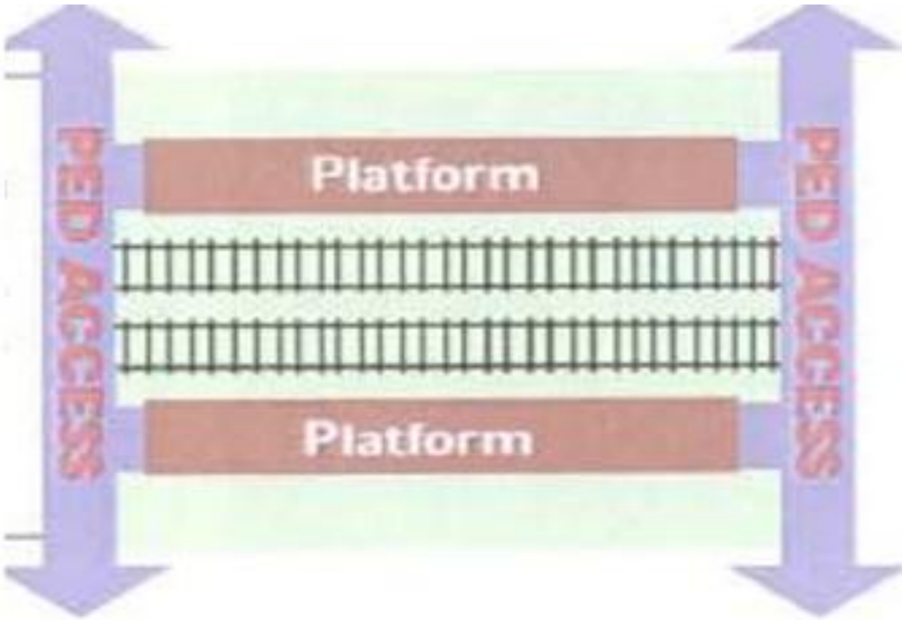


Figure 2.5 Platform type widely practicing in AALRT is side platform

The main problem is the way the passenger cross the main road for vehicle and gain the platform is not assessable at some areas. The sign provide only for train to stop and departure on road for vehicle, not provide for passenger.

Access to the station from Underground/ Metro services, buses, trams, taxis, car pick up/set down, car parking, pedestrian routes, and cycle and motorcycle parks, should be as level as possible allowing full step-free access where needed. It should be via clearly signed entrances which are wide enough to cope with the flows. Walking distances must be as rational and convenient as possible. Security is an important aspect of the design of the area around a railway station and the various forms of access arrangements.

(Moorthy, N.V.R., 1997. Planning of integrated transit network for bus and LRT; Journal of advanced Transportation 31(3)).

Ticket-issuing Arrangements: will vary depending on a range of factors including:

- **Station category** – higher categories are more likely to have a greater range of ticket-issuing facilities including ticket machines as well as separate ticket-issuing windows for travel on the day of purchase and for travel at a later date.
- **Passenger demand at stations** – stations with very low patronage are unlikely to have any staffed ticket-issuing arrangements and may even have no machines, whereas stations with high patronage are more likely to have both machines and windows.
- **The nature of the passenger demand at stations** – stations with a high proportion of commuters will require fewer ticket-issuing facilities than stations with a low proportion of commuters but similar overall patronage.
- **The nature of the train services at the station** – stations served by long-distance services are more likely to have staffed ticket windows, whereas commuter stations are more likely to have ticket machines

CHAPTER 3 STANDARDS OF FOREIGN EXPERIENCE

3.1 Capacity

Passenger loading level and recommended space requirement to determine capacity in direction of comfort**; r**ecommends comfort levels for public transport vehicles and provides details of the projected body space of passengers in various situations. Transit Cooperative Research Program 2101 Constitution Avenue, NW, Washington, D.C. 20418 explains the capacity in the direction of level of service as follow:-

Level Of Service	Average Pedestrian Area	Average Inter-Person Spacing	Description
A	≥ 1.2 m^2 (13 ft^2) per person	≥ 1.2 m (4 ft)	Standing and free circulation through the queuing area possible without disturbing others within the queue.
B	0.9-1.2 m^2 (10-13 ft^2) per person	1.1-1.2 m (3.5-4 ft)	Standing and partially restricted circulation to avoid disturbing others within the queue is possible.
C	0 7-0.9 m^2 (7-10 ft^2) per person	0.9-1.1 m (3-3.5 ft)	Standing and restricted circulation through the queuing area by disturbing others is possible; this density is within the range of personal comfort.
D	0.3–0.7 m^2 (3-7 ft^2) per person	0 6–0.9 m (2-3 ft)	Standing without touching is impossible; circulation is severely restricted within the queue and forward movement is only possible as a group; long-term waiting at this density is discomforting.
E	0.2- 0.3 m^2 (2-3 ft^2) per person	≤ 0.6 m (2 ft)	Standing in physical contact with others is unavoidable; circulation within the queue is not possible; queuing at this density can only be sustained for a short period without serious discomfort.
F	≤ 0.2 m^2 (2 ft^2) per person	Close contact	Virtually all persons within the queue are standing in direct physical contact with others; this density is extremely discomforting; no movement is possible within the queue; the potential for panic exists.

Table 3-1 Level of service for a given design capacity and transit comfort.

The key factors to be considered are:

- Headway control
- Vehicle characteristics
- Signaled sections.
- On-street operation and performance. Capacity effects are strongly related to the degree of priority given to light rail vehicles relative to other traffic.
- Private right-of-way with grade crossings

❖ Four basic factors determine the maximum passenger capacity:

1. The maximum number of vehicles per transit unit
2. The passenger capacity of the individual transit vehicles;
3. The minimum possible headway or time spacing between individual vehicles or trains; and
4. The number of lanes or passenger-loading positions available.

Pedestrian Level of Service

Level-of-service standards provide a useful means of determining the environmental quality of a pedestrian space. Pedestrian service standards related to walking are based on the freedom to select desired walking speeds and the ability to bypass slower moving pedestrians. Other measures related to pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in the reverse direction of a major pedestrian flow, and to maneuver without conflicts and changes in walking speed. Level of service standards for queuing areas are based on available standing space and the ability to maneuver from one location to another. Because pedestrian level of service standards are based on the amount of pedestrian space available, these standards can be used to determine desirable design features such as platform size, number of stairs, and corridor width.

3.2 Operation issue and time

Controlling station dwell time is the combination of dwell time and a *reasonable* operating margin the dwell time during a normal peak hour that controls the minimum regular headway. Controlling dwell takes into account routine perturbations in operations but not major or irregular disruptions. The sum of controlling dwell and the train control system's *minimum train separation time* produces the maximum train capacity throughout without headway interference.

Dwelling time depends on many factors: -

- Human behavior
- Operating policy and practice
- Mobility
- Weather

Arrive time and Departure time

Arrive time is the time at which a train reaches a station. Arrival time for a train at any station is the summation of operating time (running time) of a train and dwelling time from or at preceding station. Departure time is the time at which train leave the station. Departure time of train at any station is the summation of operating time (running time) of train and dwelling time at proceeding station and dwelling time at same station. It is the summation of arrival time plus dwelling time of either proceeding or at same station.

Station Dwell Time Components

Dwell time is comprised of the time passenger flow occurs, a further time before the doors are closed, and then a time while waiting to depart with the doors closed. Each of the rail transit systems serving the particular stations has a different operating philosophy. This is evident from the exhibit which shows two services, including a short turn service with shorter dwells that ends about half way down. All data represent the heaviest used doorway(s) on the train.

The three main components of dwell times are:

- Passenger flow time;
- Door open time after flow ceases; and
- Waiting to depart time after doors close

An important objective of a transit station is to provide adequate space and appropriate facilities to accommodate projected peak pedestrian demands while ensuring pedestrian safety and convenience. Previous efforts have involved designing transit stations on the basis of maximum pedestrian capacity without consideration of pedestrian convenience. Recent research has shown.

Dwell Time (s)	Bus/h
15	116
30	69
45	49
60	38
75	31
90	26
105	23
120	20

Table 3-2 Transportation researcher board proposed dwell time for LRT

Light rail scheduled in Toronto Transit Service

Urban scheduled transit service includes all scheduled service within a city, as well as service between cities within a larger metropolitan area. The service frequency, LOS measure for urban scheduled transit service is *headway;* however, for convenience, LOS both by headway and by the corresponding number of vehicles per hour is stated below. Although headways are given as continuous ranges for the purposes of determining LOS, passengers find it easier to understand schedules when clock headways are used. When clock headways are used, transit vehicles arrive at the same times each hour.

Head on time LOS

LOS	Headway (min)	Veh/h	Comments
A	<10	>6	Passengers don't need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during hour
F	>60	<1	Service unattractive to all riders

Table 3-3 Transportation researcher board proposed dwell time for LRT

Hours of service LOS

LOS	Hours per Day	Comments
A	19-24	Night or owl service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	Daytime service provided
E	4-11	Peak hour service/limited midday service
F	0-3	Very limited or no service

Fixed route: number of hours per day when service is provided at least once an hour
Paratransit: number of hours per day when service is offered

Table 3-4 Hours of service LOS

The proportion of dwell time productively used for passenger movements ranges from 31 to 64% of the total dwell time. This presents a challenge in determining dwell times from the passenger volumes. Dwells also vary depending on the operating practices of each system. Several North American light rail and heavy rail systems are notably more expeditious at station dwells than their counterparts, contributing to a faster and so more economic and attractive operation. Ironically, several automatically driven systems have sluggish station dwells in which expensive equipment and staff sit and wait long after all passenger movement has ended. The high-capacity rail systems in Europe and Asia, particularly those of Russia and Japan, are noted for their efficient management and control of station dwells.

3.3 Facility to be incorporated at station

This study examines the following basic concepts: - Creation of a good relationship between the station and the town, provision of New Cultural effects, connection with other transportation systems and facility expected on station.

The concept of how to create a good relationship between the station and the community is to give the station community identity as a city landmark and strengthen the functions of station facilities so that local residents and visitors will find them user-friendly and accessible. Journal of the Eastern Asia Society for Transportation Studies include the station facility and function as follows:-

1. Creation of the relationship between station with the town

- Improving functional aspects
- A Station where it is easy to find the way to the station
- In Harmony with the environment
- Consideration to the space design
- Improving station facilities
- Providing open space
- Taking elderly and disabled people into consideration

2. Connection with other transportation system.

- A station with smooth transfers to feeder transportation
- User oriented consideration for facility planning
- A station that is easy to use
- A station with clean facilities

3. Provision of new cultural impact.

- A place for exchange of information and culture
- A station where symposiums and cultural activities can beheld
- Exhibition of local cultural work
- Plentiful provision of information of local facilities
- Holding events at the station concourse

- A place for interaction with goods and service
- A station with facilities for commercial business and a marketplace

4. Other public facilities

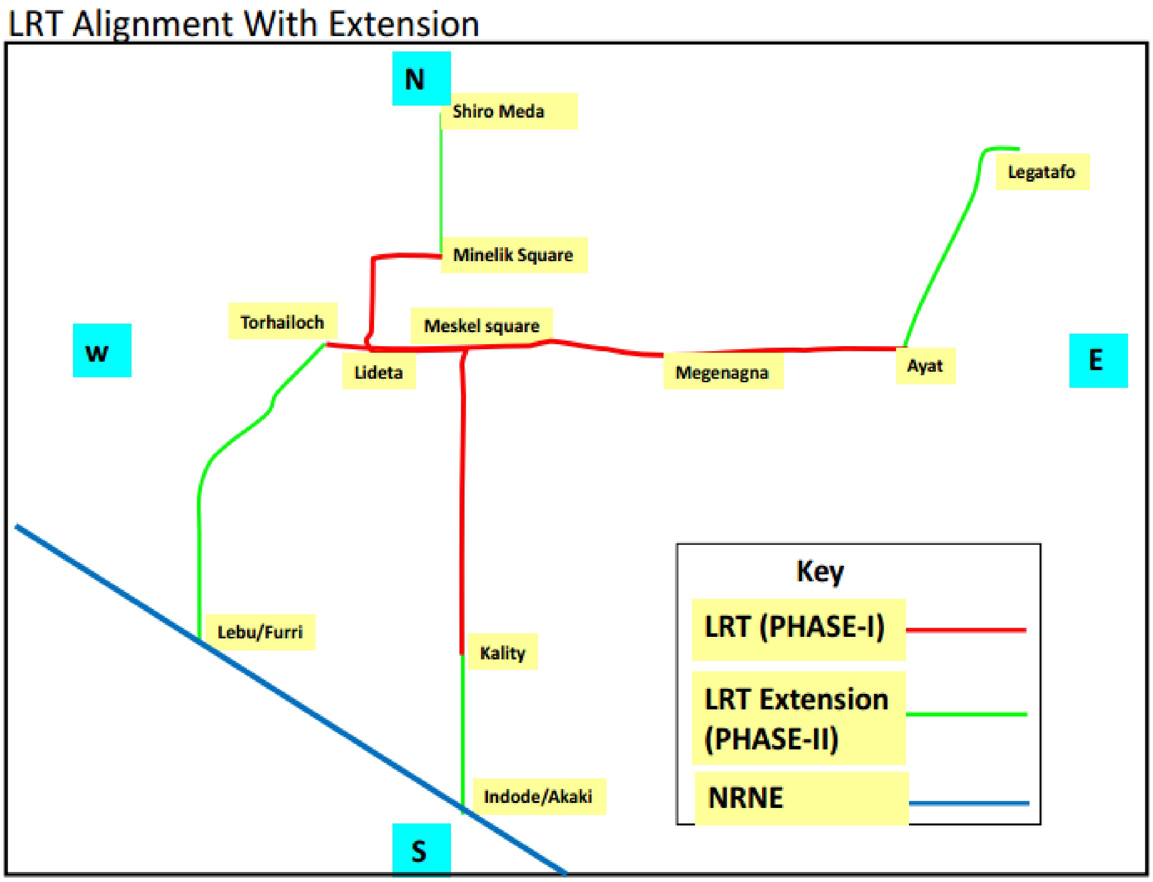
Amenity	Advantages	Disadvantages
Shelters	• Provide comfort for waiting passengers • Provide protection from climate-related elements (sun, glare, wind, rain, snow) • Help identify the stop	• Require maintenance, trash collection • May be used by graffiti artists
Benches	• Provide comfort for waiting passengers • Help identify the stop • Low cost when compared with installing a shelter	• Require maintenance • May be used by graffiti artists
Vending Machines	• Provide reading material for waiting passengers	• Increase trash accumulation • May have poor visual appearance • Reduce circulation space • Can be vandalized
Lighting	• Increases visibility • Increases perceptions of comfort and security • Discourages “after hours” use of bus stop facilities by indigents	• Requires maintenance • Can be costly
Trash Receptacles	• Provide place to discard trash • Keep bus stop clean	• May be costly to maintain • May be used by customers of nearby land use (i.e., fast-food restaurant) • May have a bad odor
Telephones	• Convenient for bus patrons • Provide access to transit information	• May encourage loitering at bus stop • May encourage illegal activities at bus stop
Route or Schedule Information	• Useful for first-time riders • Helps identify bus stop • Can communicate general system information	• Must by maintained to provide current information • May be used by graffiti artists

Table 3-5 Public amenity service impacts

CHAPTER 4 AALRT ASSEEESSMENT AND RESULTS

4.1 Capacity assessment

Transit quality of service the overall measured or perceived performance of transit service from the passenger's point of view is important to all communities. Transit quality of service measures reflects two important aspects of transit service: (1) the degree to which transit service is *available* to given locations and (2) the comfort and convenience, or *quality*, of the service provided to passengers. The AALLRT assessment also focused on this statement.



Addis Ababa light rail transit distribution.

4.1.1 Practical comparison of design with operational capacity of AALRT

i. Practical

i. Number of station in AALRT

Number of stations;

- East – West corridor = 22
- North to south corridor =22
- Five station are common for both corridor

ii. Capacity of train and demand of society

Numbers of passenger per day. (AALRT records for design)

- East –west route = 60,760
- West East Route = 60,751
- North – south =60,283
- South – North =60,274

Distance:-

- West – East corridor = 16.764km
- South – North corridor =16.274 km

Train capacity and description

- Doors are four on both side two for alighting and two for boarding
- Number of seating is sixty five
- Rate capacity =254(when six person stand per meter square)
- Over capacity =317(when eight person stand per meter square)
- Length = 30m

Speed

- Maximum operating speed =70kmphr
- Average travelling speed =20kmphr

4.1.2. FEATURES OF THE PROJECT (Design feature from AALRT office)

- Nominal Track Gauge: 1435mm
- Maximum Service Speed: 80 km/h
- Maximum Grade, typical: 5%

Capacity

- 15,000 pphpd, total 80,000pph

Reliability

- Headway =(difference in time interval between two vehicles, trains, or ships travelling in the same direction along the same route)-6min initially and can be reduced to 90 seconds at ultimate capacity
- Working hours, 16-18 hours per day

Affordability

- Fare based on passenger-km coverage
- Considerate of paying capacity of residents

Comfort/environment

- Pleasant and attractive.

Figure 4.1 Light rail transit track at grade crossing and operation.

4.1.3 Capacity assessment summary

Calculating the capacity of light rail transit lines is a complex process because of the varieties of rights-of-way which can be employed for the mode. The basic approach is to find the limiting factor or *weakest link* on the line and base the capacity on this point. The limiting factor for each line could be street-running with long traffic signal phases, a section of single track, or the length of signal blocks where block signaling is used.

- Capacity can be estimated by comfortable; in AALRT the passengers per square meter is greater per meter square which is more congested. When the researcher compare the level of service of the Addis Ababa light rail transit with the transportation research board standard specified in chapter three is level of service:- LOS **E**

  Average pedestrian are is <= 0.2-0.3m^2 per person

  Average interpersonal spacing is 0.6m.

  Circulation within the queue is not allowed.

  Standing physical contact with other is not avoidable.

- Capacity also determine by dwell time.

Dwell Time (s)	Bus/h
15	116
30	69
45	49
60	38
75	31
90	26
105	23
120	20

The dwell time needed by train on station determined during design for Addis Ababa light rail transit is 35minute which can serve 55 bus per hour whereas now practically what I observe is minimum of 2 minute this may result in increased number of passenger in station which is the inconvenience and minimize the line capacity to 20 bus per hour. This is indicating that management of time increase the capacity..

- The signaling equipment efficiency also decreases the capacity of train in this case.

Underestimate traffic while forecasting is also the problem encountered in this city rail transit such that the number of train estimated to serve this population is 41, but I observe that greater number of train is demanded by passenger. This is corrected if only if the signaling system is more efficient and monitoring body is strong.

4.2 Operation in case of AALRT

The time passenger spends waiting for transport is the very critical element for evaluating passenger service level as we see in Addis Ababa. Typically, the railway passenger faces different types of waiting due to different causes such as:

- Shortage of rolling stock at peak hour result in congestion inside train which is not secured even for standing.
- Long waiting time due to increase head times of train.
- Allocation problem (unable to identify the peak hour direction and place)

Also the organization of station operations required：

- Carry on section block；
- Ready the route for receiving-departure；
- Open and close home signal or starting signal；
- Pass the running taken when not using semi- automatic block and automatic block);
- Receive or send trains and instruct train

1. Arrive and Departure time

Since the average distance between successive stations is 0.77km and as mentioned the average speed is 20kmph then the arrival time of a train at any station is 3-4 min. Departure time of train at any station is the summation of operating time (running time) of train and dwelling time at proceeding station and dwelling time at same station that become approximately 4-5 min. It is the summation of arrival time plus dwelling time of either proceeding or at same station.

Figure 4.2 Stadium Station of AALRT the place both south- north rail meat west- east line which is common station for both line.

Generally the working time is as describe below,

- Working length of time per day

5:00am to 11:pm = 18 hour per day

- Peak hour

7:00 -9:00 A.M

5:00-7:00 P.M

- Dwell time

25-35se

- Head on time

4 min for peak hours and 7.5 min off peak hour.

2. Headway

Headways are given as continuous ranges for the purposes of determining LOS; passengers find it easier to understand schedules when clock headways are used. As specified in chapter three of this document.

LOS	Headway (min)	Veh/h	Comments
A	<10	>6	Passengers don't need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during hour
F	>60	<1	Service unattractive to all riders

From above table

AALRT has design head on time within LOS- A

But the practical average head on time the researcher record is

- 15-20 minute and level of service class:-C

This show the vehicle per hour in number 3-4 expected on control point result in maximum desirable time to wait if train missed is actually practiced in AALRT.

3. Operation of AALRT summary

Aspect	AALRT Operating Plan Details
Route Type/Structure	All-stop service on established corridors serving major generator nodes. Express routes shall be instituted if demand warrants and passing tracks exist.
Span of Service	6:00 AM to 10:00 PM — may be extended for special events or on weekdays for commuters
Operating Period	Monday through Sunday
Minimum Headways	6 minutes in the peak, but now greater 15 minutes currently
Minimum Average Operating Speed	~20 mph
LRT Station Spacing	0.75-1.00 miles (on average) – may be shorter to serve key activity nodes
Operating Coordination with Other Transit Providers	Local feeder bus coordinated to arrive prior to scheduled LRT departures and conversely these routes depart after scheduled LRT arrivals. Especially important during the off-peak, when service is less frequent.
Fares	Currently manual ticketing and in future off board ticketing .
Operating Cost and Fare Revenue Assessment	AALRT Totally gain good revenue since the demand of passenger is greater than which expected the is over revenue. For discrete new LRT lines, operating cost and fare revenues assessed versus performance on existing LRT lines. For new extensions of existing LRT lines, performance of the extended segments assessed versus that on the original LRT segment.

The operating issue is the one which is the critical points to be considered. The Addis Ababa light rail transit now at its early stage in the future by giving exposure for passenger or user of the transit by increasing efficiency of signaling equipment, increase number of train the demand of the customer may be answered and the city development may be achieved.

Figure 4.3 Access provided for elevated stadium station of AALRT

4.3 Passenger Facilities

The question of how to provide the new cultural effects means designing a station able to provide a chance of exchange between people, things, and information by improving its ability to attract users, by making a cultural contribution to the region along its railway line, in order to promote new development of the cities where the stations are located less practiced. Connection with other transportation systems and improving convenience for users by facilitating easy and smooth transfers to other lines and means of transportation are important roles of a station as a transit point is 50% practiced thus its facilitated with road but with air post its postponed to next phase. The basic facility like toilet, some entertainment areas is not provide for at grade station due to right of way problem but for underground station its provided like at st. gorgis station. Generally weather protection is provided but communication, ticketing issue is currently less attractive.

Since the town like Cmc, Ayat, laga tafo in some extent the East – West direction is integrate the future development city context. But integration with other mode of roadway is good but integration with airport is more or less considered in next face; but currently it's not provided

Retailing opportunities should be maximized without impeding essential passenger flows or accumulation areas

Advertising/Sponsorship shall not interfere visually with directional signing or other 'way finding' mechanisms is in some extent inconvenient.

Public toilets – stations shall be assessed for need on an individual basis but its provided at underground station i.e St giorgis

Platform furniture – platforms shall have not provided with adequate seating facilities, but these impede movement along platforms or through concourse spaces

Generally facilities incorporated into station of Addis Ababa rail transit include:

- weather protection
- Clear segregation of pedestrians and vehicles as much as possible.
- Level, step-free access
- Train service information in some extent.
- Ongoing travel information, timetables not provide for passenger.
- Locality information
- Station identification signage
- Secure, identifiable boundaries
- Station clock not provide for passenger
- Secure cycle and vehicle parking in closest proximity is not provided at all station.

Figure 4.4 Platform furniture at stadium station in Addis Ababa city

CHAPTER 5 CONCLUSIONS AND RECCOMENDATIONS

5.1. Conclusion and Recommendation

❖ Assessment of railway station operation management increase station efficiency and Safety, because of large number of trains use the line or section of railway, with high degree of freedom for movement.

❖ The comfort while alighting, standing inside train, boarding from Addis Ababa light rail transit train, is not as such easy because per meter square a number of passengers standing are beyond maximum capacity.

❖ The facility and function provided on station for passenger starting from scheduling and time tabling is not definite. For example the dwelling time practically the AALRT use is 3-4 min which is greater than design value 35-45 se as well as current oriented value by managers 1-2 minute that may be decrease the efficiency and capacity of the station as well as the line. Also the head on time(the consecutive time interval for train) is not achieved, i.e. 6 min during peak hour and 7.5min during off peak hour, that may also other constraint for safety and result in congestion; this problem of time can minimized by providing good signal, strong management and automatic block of crossings traffic when train is approached.

❖ At last the drawback of the AALRT for operating in accordance with expected value are ; passenger vehicle crossing at grade specially at Adey Abeba and Gurd shola branch made traffic confusion ,number of train planning problem that is 41 which cannot balance demand of passenger, and unavailable separated power supply which may be a problem one day.

- A number of measures to maximize capacity. First, where passenger flows are heavy, dual-faced platforms can be provided. Second, where changing ends is a limitation, then crew set-backs should be used. Third, greater operational flexibility and improved failure management is obtainable by providing turn-back capability both ahead of and behind the station with a storage track for spare or out-of-service rolling stock. Fourth and finally, a three-track terminal station can handle exceptional passenger flows from trains on headways below 90 seconds. Based on this study, station facility and function of the Addis Ababa light rail transit meet basic objectives like minimizing the transportation shortage and facilities. But due to some problem of operations and planning the transportation demand are not fully responded; such that the comfortable and average operating speeds are limited.
- As a result passenger and vehicle crossing at grade on some station increase head on time that made service quality to class C; number of train planned cannot balance efficiently demand of passenger which affect comfort and result in level of service to class E, and unavailable separated power supply system has also it is own impact on operation.

Feature of the Work

- Passenger and vehicle crossing at grade on some station increase head on time that reduce service quality to lower class.
- Number of train planned cannot balance efficiently demand of passenger which affect comfort and result in minimization of level of service.
- Ineffective signaling systems which reduce the efficiency of operation and minimize utilization of track by increasing dwelling time, head on time and arrival time.
- The operation of train is disturbed if there is no continues power supply system; such that separated power supply should be provide
- More intensified educational and enforcement campaigns may be necessary to convince all pedestrian users that are illegal crossing track to increase capacity of track.

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APPENDIX A

Some question used for the outlining interview.

1. Is the Addis Ababa light railway integrating the station with future town development for the Ethiopian context; reason?

2. Compare the demands of the city people with the capacity of Addis Ababa light rail transit at station on peak hour (when demand is high) and in average .i.e. number of population with available train number.

3. How about the comfortable of this transport nowadays?
   0a) Good b.) Very good c) Excellent d). Poor e). Satisfactory

4. Is there basic facility on each individual Stations concerning with Some basic need, Communication, Climate protection conditioned

5. Concerning with time efficiency write the design speed, currently or working speed, maximum speed nowadays in the world to transport passenger in city.
....
6. Explain the causes of delay on Addis Ababa rail transit station operation?
....
7. What are the drawbacks of this AALRT on station?
8. Explain the operating issue in general.
9. Dwelling time and head on time of AALRT on station.
10. Function and Facility of AALRT with other mode of transport.