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Contribution of Addis Ababa Light Railway Project for Technology Transfer Process in Ethiopia

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RAILWAY ENGINEERING

**CONTRIBUTION OF AA LRT PROJECT FOR TECHNOLOGY
TRANSFER PROCESS IN ETHIOPIA**

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Declaration

I hereby declare that the work which is being presented in this thesis entitled “Contribution of AA LRT Project for Technology Transfer Process in Ethiopia” is original work of my own, has not been presented for a degree in any other university; and that all the sources of the material used for the thesis have been duly acknowledged.

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ABSTRACT

Technology has gained increasingly importance in achieving the desired development objectives of a nation. Technology transfer is a process of learning to understand, use and replicate, including the capacity to select and adapt to local conditions and integrate it with indigenous technologies for further achievement of technology development and innovation process. In order to minimize a continuous dependence on foreign finance and technology to respond the ever growing demand for efficient and modern means of transportation as well as to develop other basic infrastructures, it is imperative to work strongly on technology transfer process. If the production frontiers of the country is to expand by increasing labor and capital productivity; technological advancement has got a vital role to play and without use of technology the desired level of economic development could not be imagined.

The underlying objective of the study is to assess the contribution of Addis Ababa light rail transit project for technology transfer process by using the Technology Transfer Life Cycle model and identified criteria in it since it is a newly introduced technology as city passenger transportation option and comprises of latest rolling stock with electric traction and train controlling system which cope up with current international standard gauge of rail way system.

The research used secondary data like feasibility study, conceptual design, contract agreement, different reports and personnel data of the project archive and primary data like interview and questionnaire were utilized. Descriptive method was used to analyse the case since the study is new to Ethiopia and also for that the qualitative data all over the project cycle were utilized.

The result of the analysis indicated that: most of the criteria that contributes to technology transfer process were not considered; technology supplier selection was biased to financial issues; there was no technology transfer agreement and plan; there is no systematic and tactical transfer implementation process to informally achieve technology transfer; and according to data obtained from overall project implementation process knowledge and skills were generated like how to design, select, fix and operate rail way systems. The knowledge and skills obtained following the implementation of the project could be helpful and required to be engaged in work in a planned way with having a responsible nominees (may be firms or associations). Moreover, during implementation of public projects technology transfer process would be considered by using Technology Transfer Life Cycle model which was used for the purpose of this study and the identified criteria can contribute to successful technology transfer process.

Key words: AA Light Rail Transit project, contribution, technology transfer, technology transfer model

CONTENTS

ACKNOWLEDGEMENTS	i
ABSTRACT.....	ii
LIST OF TABLES	v
LIST OF FIGURES	vi
GLOSSARY OF THE ABBREVIATION.....	vii
CHAPTER ONE	1
1. INTRODUCTION	1
1.1 Background of the Study	1
1.2 Problem Statements	4
1.3 Basic Research Questions	6
1.4 Objective of the Thesis	6
1.5 Structure of the Thesis	7
CHAPTER TWO	8
2. LITERATURE REVIEW	8
PART ONE: TECHNOLOGY TRANSFER	8
2.1 An Introduction to Technology Transfer	8
2.2 Definitions of Technology Transfer.....	9
2.3 Modes and Mechanisms of Technology Transfer.....	11
2.4. Popular Technology Transfer Models.....	14
PART TWO: LIGHT RAIL TRANSIT SYSTEMS	23
2.5 An Introduction to Light Rail Transit	23
2.6 Light Rail Defined	23
2.7 Light Rail as a Spectrum.....	24
2.8 Where the Rails and Wheels Meet the Road.....	25
2.9 The Regulatory Environment.....	26
SUMMARY OF LITERATURE REVIEW	27
CHAPTER THREE	28
3. SELECTTING QUALITATIVE PROCESS BASED TECHNOLOGY TRANSFER MODEL	28
3.1 Common Technology Transfer Problems	28
3.2 Life Cycle Approach for Technology Transfer Process	31
3.3 Criteria Developed From the TTLC Model	40
3.4 Summary	42
CHAPTER FOUR.....	44

4. RESEARCH METHODOLOGY AND DESIGN	44
4.1. Introduction.....	44
4.2. Research Design.....	44
4.3. Methodology.....	44
4.4. Study Area	45
4.5 Scope of the Study	46
CHAPTER FIVE	47
5. SURVEYING AA LRT PROJECT TECHNOLOGY AND TECHNICAL DESCRIPTION	47
5.1 Introduction.....	47
5.2 Basic Requirement for Rolling Stock	47
5.3 Track Design and its Construction.....	54
5.5 Summary of Existing AA LRT Technology Discussion.....	64
CHAPTER SIX.....	65
6. RESULTS AND DISCUSIONS	65
6.1 Technology Assessment or Technology Approach.....	65
6.2 Focusing on Technology and Supply Selection	70
6.3 Negotiation and Effecting Agreement	74
6.4 Technology Transfer Implementation Plan.....	75
6.5 TT Process Implementation during AA LRT Execution	76
6.6 Technology Transfer Process Impact Assessment.....	78
6.7 Technology Transfer Mode and Mechanism Analysis the Case of AA LRT	79
6.8 Summary of the Major Findings	81
CHAPTER SEVEN	84
7 CONCLUSION AND RECOMMENDATION	84
7.1 Conclusion	84
7.2 Recommendation	85
7.3 Limitation during the Thesis Work.....	86
7.4 Future Work.....	86
REFERENCES	87

LIST OF TABLES

Table 1: Possible taxonomy of technology transfer mechanisms 13

Table 2: Technology transfer criteria development from the adopted model..... 40

Table 3: Widening values for Track Gauge in Curved Track..... 56

Table 4: Number of Gauge Tie-Road 60

Table 5: Characteristics of N- S Route Stations 63

Table 6: Comparing the criteria from the model and used during the selection process..... 67

Table 7: The criteria relation with each technology candidate 70

Table 8: The criteria contribution to technology focusing..... 73

Table 9: Personnel assignment to work category/task of the project..... 77

Table 10: The training conducted on AA LRT 78

Table 11: Mechanisms of TT in AA LRT 80

LIST OF FIGURES

Figure 1 Technology development chains of transferor and transferee..... 12

Figure 2: The bar-zakey model of technology transfer..... 15

Figure 3: Five model of international technology transfer 19

Figure 4: The life cycle approach for technology transfer..... 33

GLOSSARY OF THE ABBREVIATION

DCEO	Deputy Chief of Executive Officer
TTLC	Technology Transfer Life Cycle
TT	Technology transfer
AA LRT	Addis Ababa Light Railway Transit
MNC	Multinational Company
TNC	Transnational Company
ODN	Original Design Manufacturing
ITT	International Technology Transfer
APTA	American Public Transport Association
LRT	Light Rail Transit
DMU	Diesel Mechanical Units
FRA	Federal Railroad Administration
ADAAG	American with Disability Act Access abilities Guide line
UNIDO	United Nations Industry Development Organization
NIS	National Innovation System
CVD	Core Value Determinants
SME	Small and Medium Enterprise
TTSC	Technology Transfer Steering Committee
DCF	Discounted Cash Flow
BSC	Balanced Score Card
ERC	Ethiopian Railway Corporation
IEC	International Electric Commission
ISO	International Standard Organization
DC	Direct Current
KN	Kilo Newton
FRP	Fiber Reinforced Plastic

SIV	Static Inverter Voltage
GB	Great Britain
BRT	Bus Rapid Transit
ART	Automatic Rapid Rail Transit
EPRDF	Ethiopian People Republic Democracy Federation
METEC	Metal Engineering Corporation
MIE	Mesfin Industrial Engineering
GC	General Contractor
CNR	China Railway Company
CASCO	China Automatic Control System and Signaling Co. Ltd...
HXYEC	Hunan Xiang Yang Electric Co. Ltd...
CREC	China Railway Engineering Corporation
JV	Joint Venture

CHAPTER ONE

1. INTRODUCTION

Technology is by far important for achieving the desired development of a nation. In developing country in order to answer specific need and to bring the overall development as much as possible very quickly, the work of technology transfer process aggressively is essential. Since AA LRT is a new project to Ethiopia as city transit option by incorporation of new technologies in it, assessment of its contribution for technology transfer process in Ethiopia is rigorously important. Thus the main purpose of the study is to assess the contribution of AA LRT for technology transfer in considering the whole project cycle by using the appropriate method and means.

1.1 Background of the Study

The term "technology transfer" (Bozeman, 2005) is a broad set of processes covering the flows of know-how, experience and equipment for necessity and development amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions, individuals and firms. Therefore, the treatment of technology transfer is much broader than that of any particular terms of convectional saying like transfer of new material (product) or acquire of hardware of technologies. The broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It covers technology transfer processes between developed countries, developing countries and countries with economies in transition, amongst developed countries, amongst developing countries and amongst countries with economies in transition. It comprises and much emphasis was given to the process of learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies.

There is a distinction between developed and developing countries. Although economies in transition are included as developed countries they may have characteristics in common with both developed and developing countries to enable the flow of technology from one to the other.

Firms have many ways of exploiting their technological assets for profitability and growth. While internal exploitation of technological assets, through designing, developing, manufacturing, and selling products and processes continues to be important, interest in their external exploitation through technology transfer has intensified in recent years. This may be attributed mainly to the globalization of business, liberalization of many developing economies, and greater emphasis on the protection of intellectual property after the formation of the World Trade Organization (WTO). Indeed, today, the transfer of manufacturing technology has become an important part of the international business strategy of firms.

But the international flow of technology and its successful integration into domestic production and management processes are central to the ability of developing countries to compete in the global economy and to narrow the technological gaps they face compared to developed countries. Technological change is a principal source of sustained growth in living standards and is essential for transformation and modernization of economic structures. In most instances developing countries find it cheaper and faster to acquire foreign technologies than to develop them with domestic resources. One reason is that such technologies may "spill over" into wider improvements in productivity, generating a multiple benefit.

However, the importance of technology transfer from a development perspective is nothing new. More than three decades back, Mansfield (1975) pointed out that, “One of the fundamental processes that influence the economic performance of nations and firms is technology transfer. Economists have long recognized that the transfer of technology is at the heart of the process of economic growth, and that the progress of both developed and developing countries depends on the extent and efficiency of such transfer. In recent years economists have also come to realize (or rediscover) the important effects of international technology transfer on the size and patterns of world trade.”

Transportation system contributes for global warming by emitting carbon dioxide since it uses fossil fuel for its power system in most cases and these are least flexible to change the emission due to its almost complete dependence on petroleum-based fuels. Lots of researches were conducted to transform the energy mode for the sector and hence the rail way system was

practically proved and the most suitable mode of transportation that uses electric power and this energy is freely obtained from the carbon emission free source.

Light Rail Transit (LRT) train systems can operate in shared rights-of-way with private cars and city buses in same selected lines especially at crossing, very seldom exceed three cars per train, and speeds as low as 10 mph [16 km/h] are tolerated in revenue service track. These differences usually mean that LRT can be constructed at far lower cost than metro rail transit, although the passenger throughput capacity of the latter is also much higher.

Ethiopia owns rail way system (of track gauge of 1.1m and diesel powered locomotives) that operates from Djibouti to Addis Ababa which was now out of operation due to its inconvenience for our economic achievement and other reasons. Starting from 2011 the Ethiopian government has planned to construct around 5000km all over the country at different project phases and light rail transit system for passenger transportation in its capital city Addis Ababa by two project phases. Currently ERC is undertaking light rail transit system for the passenger transportation in Addis Ababa by its first phase which covers around 37km from East-West and North-South of the city to enjoy light rail transit technology that the researchers and developers were introduced for the world. Unfortunately, this is a good opportunity for developing countries like Ethiopia to see another option in addressing high transport demand.

The development of the new rail way system was built under the control of Ethiopian Railway Corporation which was constructed by Chinese Railway Engineering and Construction Corporation (CREC) under the supervision of Swiss Road International Company and the Rolling stock was supplied by NRC through future strategic plan to be partially manufactured by METEC. Since it was the start of new technology in the case of our country, the government set the systematic way to achieve the technology transfer plan in the area selected to be addressed by the local technology recipients.

The main purpose of this paper targeted to see the technology transfer strategy, policies, and procedures and contractual ways of our country while developing AA LRT systems through international experiences in comparison even though there are lots of barriers that hinders the country from this achievement. Many countries have very good experiences for the technology

transfer of fast and rapid electric traction rail way system along the world from their technology predecessor, for example it is better to list Indonesia, Indian, China, South Korea etc . . .

Thus it was justifiable to study the technology transfer for the AA LRT project since every of its systems are new to Ethiopia because there was on light rail transit system for city passenger transportation before a day in Ethiopia and also the system incorporates the current technology. It was also ambitious to see acquired technology of electric rail way system at country level. It is highly desired technology area for it is environmentally friend, fast, reliable, economically suit for mass and bulk mode of transportation for passenger and freight and its economic generator ability. In country such as Ethiopia infrastructure development like Rail Way systems are extremely too late to be developed or can be said not yet developed so that it is mandatory to acquire knowledge for fast accomplishment of such infrastructure development.

Therefore, the main purpose of this thesis is to see the contribution of AA LRT for the technology transfer using the eclectic model adopted from different scientific literature perspectives.

1.2 Problem Statements

There are several gaps in literature and practice that resulted in for the purpose of research works. In this context, the purpose of this study is to assess the contribution of AA LRT project for technology transfer process during project execution from the company that built the whole system. This study is useful as it insights how properly selected, planned, and managed the newly undertaken public project by contributing its benefits to the development of the country on the other side of its advantage through technology transfer.

From different study conducted by Ethiopian Transport Authority and Ethiopian Railway Corporation there is high extra demand that increases from time to time for passenger transportation in towns and cities and across or between cities within the country and for also bulk or mass fright transportation of imported and export goods and distribution of imported and in house produced goods within the country. Starting from this fact and continuous development of the country’s economy the reliable, safe, economical and environmentally friend that was

recommended from different scenarios is railway transportation system which is also convenient as it uses reliable mode of energy for means of traction.

In order to solve the above high demand on transportation a long kilometers of railway track line is planned to be constructed and a large number of rolling stock wanted to be supplied. Also by now more than 5000 km railway track line plan by the government in the country is a witness of the above assertion.

But to-date the first phase of Addis Ababa Light Rail Transit project and the railway root from Sebeta town to Djibouti at country level were built by foreign companies and technologies and it might be continued to be built by same way because of the financial and technological gap existing in-house. Excessive dependence on foreign finance and technology cannot be a reliable source to achieve the ever growing demand for efficient means of transportation. Besides the debt burden of the country would surpass the minimum debt threshold in which debt-growth relationship may be adversely affected. This embarks unnecessary huge and tremendous socio-economic and cost burden on the country if the plan is not achieved. For this reason in order to address rail way network expansion plan of the country on sustainable basis, realization of technology transfer as fast as possible from the projects that are executed at very early period or by its first phase was indispensable.

Therefore from overall cycle of the project accomplishment it was mandatory to see what, how and in what way the technology, knowledge or knowhow is gained and generated from the overall systems, at this context it means to say the technologies embedding in Addis Ababa Light Rail Transit project of its first phase, and recommending the suitable way, method and strategy for technology transfer processes from the public projects during the whole cycle of the project.

Practically now the foreign personnel and companies are designing, planning, constructing, supplying, and operating the AA LRT projects and the level of local or indigenous personnel or company involvement is not pronounced or less in number. The financial and technological incapableness enforces us to fully depend on the foreign companies and supplier to answer the transportation problem of the city as well as the country suiting the convenient and environment friend technology. On the contrary of that the respective authorized body of the government has the responsibility for systematic and strategic set up towards technology transfer before, during,

and after development of AA LRT and other new engineering and infrastructure projects. Ultimately new job, new company and new area of knowledge for citizens merely created and the national economy become boosted if technology transfer is achieved properly.

Diversified disciplines and area of application is an opportunity for the companies like working on railway infrastructure development, rolling stock and part manufacturing, working on signaling and communication, and designing of each system.

1.3 Basic Research Questions

From the problem discussed above the following basic questions were deduced for further discussion and were answered after the study was conducted.

1. What method is suitable for assessing AA LRT project's contribution for the technology transfer process?
2. What were the contributions of AA LRT project in technology transfer process?
3. What are technologies and skills, knowledge, and knowhow that are transferred during AA LRT project implementation process?

1.4 Objective of the Thesis

General Objective

The general objective of the thesis is to explore the contribution of AA LRT project in technology transfer process from the project initiation to operation.

Specific Objectives

- To select suitable model for assessing the technology transfer in AA LRT Project.
- To identify critical factors or criteria those are important to assess AA LRT project's contribution for TT process.
- To assess contribution of AA LRT project for TT process using the selected model.

- To explore technologies, skills, knowledge or (and) knowhow which were realized or transferred during implementation of AA LRT project.

1.5 Structure of the Thesis

The thesis consists of the following basic sections.

Firstly, the introduction to the research, it will highlight the objectives of the research as well as introduce the research questions shaped from research gaps identified. The key components of the methodology adopted for the research will also be explained.

Next it consists of the literature reviews, of which part one of it is about the technology transfer definition, modes and models. The part two part introduces highlight about the technology going to be discussed.

Then identification of suitable method is proposed and design of the thesis is performed. Also discussed the way to select the qualitative model called TTLC and establishment of the TT criteria or factors, surveyed and discussed, the now built or the existing technology of AA LRT systems is discussed for the case of AA LRT's technology transfer issues using the selected model during project execution period.

Finally, conclusion, recommendation and future works of the thesis were drawn from the whole thesis work of the author.

CHAPTER TWO

2. LITERATURE REVIEW

PART ONE: TECHNOLOGY TRANSFER

2.1 An Introduction to Technology Transfer

Interest in technology transfer goes back to over six decades. During the colonial era, technology transfer by colonial powers to production entities in their colonies was mainly in the primary sector such as mining, plantation and agriculture (Ramanathan 1989). Those transfers were aimed at the development of methods and techniques in order to obtain the maximum output in export industries such as mining and plantation agriculture and the development of infrastructure for such industries. After independence, in the late 1940s and early 1950s, many governments in the newly independent countries showed great interest in acquiring technology for import-substitution and often relied heavily on firms from their former colonial rulers to gain access to the technologies needed (Bar-Zakay 1971; Ramanathan 1989). In this era, transfer of technology by multinational companies (MNCs) and transnational companies (TNCs) became common, and public international bodies and not-for-profit organizations also became involved in such activities with the aim of improving living conditions in the recipient country by producing goods to be sold in the local market (Robinson 1988). However, the transfer of technology of MNC and TNCs, through foreign direct investment and licensing, became controversial, and considerable literature emerged that was highly critical of their motives and mode of operations (Robinson 1988; Ramanathan 1989; Takii 2004). In fact, technology transfer became so controversial that attempts were made by UNCTAD to develop a “code of conduct” for technology transfer. In recent times great changes have taken place in the global setting. The demise of the former soviet union, the emergence of many new CIs nations, the opening up of china and India, the transition of many countries from centrally planned to market-oriented economies, and the privatization or breaking up of large state-owned enterprises in many developing nations have provided opportunities for international technology transfer to take place on an unprecedented scale (Radosevic 1995; Sadowski 2001).

2.2 Definitions of Technology Transfer

Even though technology transfer is not a new business phenomenon, the considerable literature on technology transfer that has emerged over the years agrees that defining technology transfer is difficult due to the complexity of the technology transfer process (Robinson 1988; Spivey *et al.* 1997). The definitions depend on how the user defines technology and in what context (Chen 1996; Bozeman 2000).

The term technology transfer can be defined as the process of movement of technology from one entity to another (Souder *et al.* 1990; Ramanathan 1994). The transfer may be said to be successful if the receiving entity, the transferee, can effectively utilize the technology transferred and eventually assimilate it (Ramanathan, 1994). The movement may involve physical assets, know-how, and technical knowledge (Bozeman, 2000). Technology transfer in some situations may be confined to relocating and exchanging of personnel (Osman-Gani 1999) or the movement of a specific set of capabilities (Lundquist 2003). Technology transfer has also been used to refer to movements of technology from the laboratory to industry, developed to developing countries, or from one application to another domain (Philips 2002). In a very restrictive sense, where technology is considered as information, technology transfer is sometimes defined as the application of information into use (Gibson & Rogers 1994). In a similar vein economists such as Arrow (1969) and Dosi (1988) have analyzed technology transfer on the basis of the properties of generic knowledge, focusing particularly on variables that relate to product design. Mittleman and Pasha (1997) have attempted a broader definition where they state that technology transfer is the movement of knowledge, skill, organization, values and capital from the point of generation to the site of adaptation and application.

It may be useful to examine the distinction between technology transfer and technology diffusion. Sociologists such as Rogers and Shoemaker (1971) and Rogers (2003) have defined technology transfer in the context of diffusion of innovations. This has led to confusion where many researchers, and even practitioners, refer to the terms technology transfer and technology diffusion interchangeably. The literature on technology diffusion, in general, suggests that the term refers to the spreading, often passively within a specific technological population, of technological knowledge related to a specific innovation of interest to that population. Technology transfer, on the other hand, is a proactive process to disseminate or acquire

knowledge, experience and related artefacts (Hameri 1996). Furthermore, it is intentional and goal-oriented but not a free process (Autio and Laamanen 1995). Transfer also presupposes agreement and therefore involves agreement, unlike diffusion (Ramanathan 1991; Hameri 1996). The work of Hayami and Ruttan (1971) and Mansfield (1975) provide some of the earliest insights on the modes of technology transfer which are of relevance even today. Mansfield (1975) classified technology transfer into vertical and horizontal technology transfer. Vertical transfer refers to transfer of technology from basic research to applied research to development and then to production respectively and horizontal technology transfer refers to the movement and use of technology used in one place, organization, or context to another place, organization, or context. Souder (1987) refers to the former as internal technology transfer and the latter as external technology transfer. Souder further elaborates upon vertical technology transfer as a managerial process of passing a technology from one phase of its life cycle to another. This elaboration is valuable because it serves to reinforce the fact that it may be possible to horizontally transfer technology at any stage of the technology life cycle. Hayami and Ruttan (1971) and Mansfield (1975) refer to “material transfer, design transfer, and capacity transfer.” Material transfer refers to the transfer of a new material or product while design transfer corresponds to the transfer of designs and blueprints that can facilitate the manufacturing of the material or product by the transferee. Capacity transfer involves the transfer of know why and know-how to adapt, and modify the material or product to suit various requirements. While Hayami and Ruttan focused on agricultural technology transfer, Mansfield emphasized manufacturing technology.

The formal and informal technology transfer has not always been defined in a mutually exclusive way. Link et al. (2007), for example, define informal technology transfer as a mechanism facilitating the flow of technology knowledge through informal communication processes or non-contractual interaction which could comprise technical assistance, consulting or collaborative research. In contrast to formal technology transfer mechanisms which often aim at transferring a specified research outcome or technology like a patent, informal mechanism do not, and there is usually no expectation that they will and is governed by contractual interaction. In this sense, formal technology transfer is conceived as a way to allocate property rights whereas those are of much less importance in informal technology transfer.

2.3 Modes and Mechanisms of Technology Transfer

The above technology transfer concepts were put in perspective by Amsden (1989) and Habibie (1990). Amsden (1989) argued that while in developed countries the technology/product cycle took the route; {Research to development to design to production} whereas in technologically less advanced developing countries, it tends to take the route, {production to design to development to research}.

According to Amsden, learners do not innovate and must compete initially on the basis of low wages, state support, high quality and productivity. The route that must thus be pursued should be based on transfer, absorption, and adaptation of existing technology. This viewpoint fits in with the material, design, and capacity transfer progression. Habibie (1990), often referred to as the architect of the Indonesian aircraft industry, states that, “technology receivers must be prepared to implement manufacturing plans on a step-by step basis, with the ultimate objective of eventually matching the added-value percentage obtained by the technology transferring firm.” He refers to such an approach as “progressive manufacturing” and popularized the slogan, “begin at the end and end at the beginning” implying that a transferee firm should start with production and move backwards to research as also pointed out by Amsden.

Steenhuis (2000) has combined these ideas and developed the concept of “the technology building.” The technology building has two wings; the innovation wing consisting of the research, development, production, and distribution stages of the transferor; and the exnovation wing that consists of the distribution, production, development, and research stages of the transferee. The innovation and exnovation wings refer to the technology development stages of the transferor and transferee respectively in accordance with the Amsden and Habibie models of technology development. Steenhuis points out that transfer of technology can take place between the stages of both wings of the technology building in a variety of combinations. The terms innovation and exnovation, as used by Steenhuis, while useful, may cause confusion to practitioners since the term innovation is used in many different contexts. Thus, in this paper the technology development stages of the transferor and transferee will be referred to as “technology generation” and “technology assimilation” respectively.

To avoid looking at technology transfer in a restrictive manner it may thus be useful to view technology transfer possibilities between the “generations” and “assimilation” processes of the transferor and transferee (Ramanathan, 2000). This is shown schematically in figure 2.1.

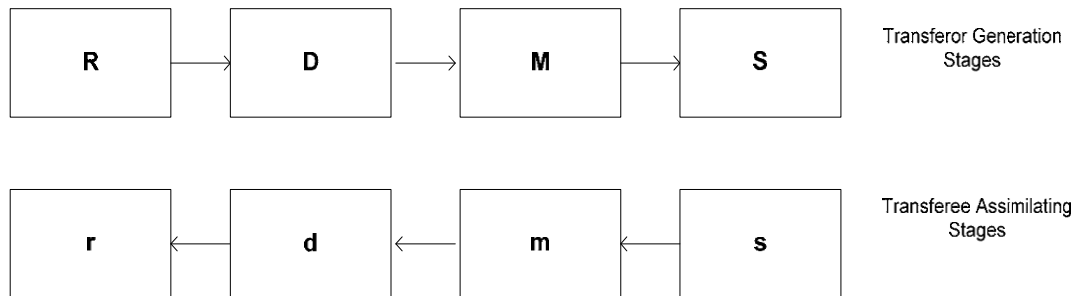


Figure 1: The technology development chains of the transferor and transferee

Using the “technology development chain” concept outlined in figure 1 above, Ramanathan (2000) points out that the simplest form of technology transfer could be said to take place when an owner of technology (the transferor) transfers the technology needed by a business partner (the transferee) to sell and service a product produced by the owner. This may be depicted as an [s: s] mode of transfer. The representation within parentheses implies that a product at the end of the “generation” stage is simply being sold and serviced by the transferee. The technology likely to be transferred here is that needed by the transferee to sell, repair, and provide other elements of after-sales service to customers buying the product. The objective of the transfer is to effectively maximize the sales of the product in the region managed by the business partner. Another possible variation is [m: s] if the transferee is the sole distributor of the product made by the transferor. These two types of technology transfer arrangements with a predominantly sales focus may be referred to as a “sales intensive mode” of technology transfer.

Based on similar considerations of business objectives, Ramanathan (2001) provides a classification of possible modes and possible transfer mechanisms that may be used. These are summarized below.

Table 1: Possible taxonomy of technology transfer mechanisms

Transfer mode	Possible transfer mechanisms
<u>Sales intensive</u>	Sales and service agreement either as an agent or sole distributor
<u>Manufacturing intensive</u>	Subcontracting arrangements, original manufacturing arrangements, production licensing, and joint ventures
<u>Design intensive</u>	Original design manufacturing (ODM), production licensing, joint ventures
<u>Research intensive</u>	Joint r & d and production, university – industry licensing, government r & d institute – industry licensing

Source: adapted from Ramanathan (2001)

The term “mode” is used to refer to the transfer links between the phases of the technology development chains of the transferor and transferee while the term “mechanism” is used to describe popular business arrangements that are deployed to transfer technology. The classification does not include the transfer of technology by multinationals to their wholly-owned subsidiaries operating in other locations. The classification proposes that technology transfer arrangements to be examined under four main groups namely: sales intensive; manufacturing intensive; development intensive; and research intensive. Each of these categories involves different strategic issues from a business perspective:

- Commercial technology transfer may be defined as a mutually agreed upon, intentional, goal oriented, and proactive process by which technology flows from an entity that owns the technology (the transferor) to an entity seeking the technology (the transferee). The transfer involves cost and expenditure that is negotiated and agreed upon by the transferee and transferor. The transfer may be said to be successful if the transferee can successfully utilize the technology for business gains and eventually assimilate it.
- Technology transfer can be vertical or horizontal technology transfer. Vertical transfer refers to transfer of technology from basic research to applied research, development, and production respectively and horizontal technology transfer refers to the movement and use of technology used in one place, organization, or context to another place, organization, or context.

- In today’s globalized and liberalized business setting, many technology transfer modes could be deployed depending on how the technology development chains of the transferor and transferee are linked. Technology transfer can commence from a simple level to a much more comprehensive one with time. The mode chosen would depend on the corporate strategies of the transferor and transferee and the technological capability of the transferee.

2.4. Popular Technology Transfer Models

This part is some of the popular models of technology transferor that have been developed over the years to help transferees and transferors of technology understand the technology transfer process better.

Since the early 1970s, considering the difficulties and complexities faced by managers of technology transfer projects, researchers, consultants, and practitioners of technology transfer have been proposing models of technology transfer that could facilitate the effective planning and implementation of technology transfer projects. Both qualitative and quantitative models have been proposed. Jagoda (2007) points out that, “qualitative” models often have as their objective the delineation of activities involved in managing technology transfer and the elicitation of factors and issues that can influence the success and/or effectiveness of technology transfer. Quantitative models, on the other hand, aim at quantifying parameters of significance in technology transfer and analyzing them with a view towards minimizing goal incompatibility between the transferors and transferees of technology.” In this paper, emphasis will be on the qualitative models. The mathematics involved in the quantitative models will not be elaborated upon and only their major findings will be presented.

A Qualitative Process Based TT Models and Their Limitations

(I).The bar-zakay model: bar-zakay (1971) developed a rather comprehensive technology transfer model based on a project management approach. He divided the TT process into the search, adaptation, implementation, and maintenance stages. He depicted the activities, milestones, and decision points (go or no-go) in each of these stages as shown in figure 2. The upper half of the figure delineates the activities and requirements of the transferor (referred to as the “donor” by bar-zakay) and the lower half that of the transferee or the “recipient.” The activities to be carried out are specified in detail in this model and the importance of both the

transferor and transferee acquiring skills to undertake technological forecasting, long-range planning, and gathering of project-related intelligence is emphasized. The model uses the term “donor” for the transferor giving the impression that the owner of technology is giving away a valuable asset out of altruistic reasons! This is clearly not the case and the use of such terms must be avoided.

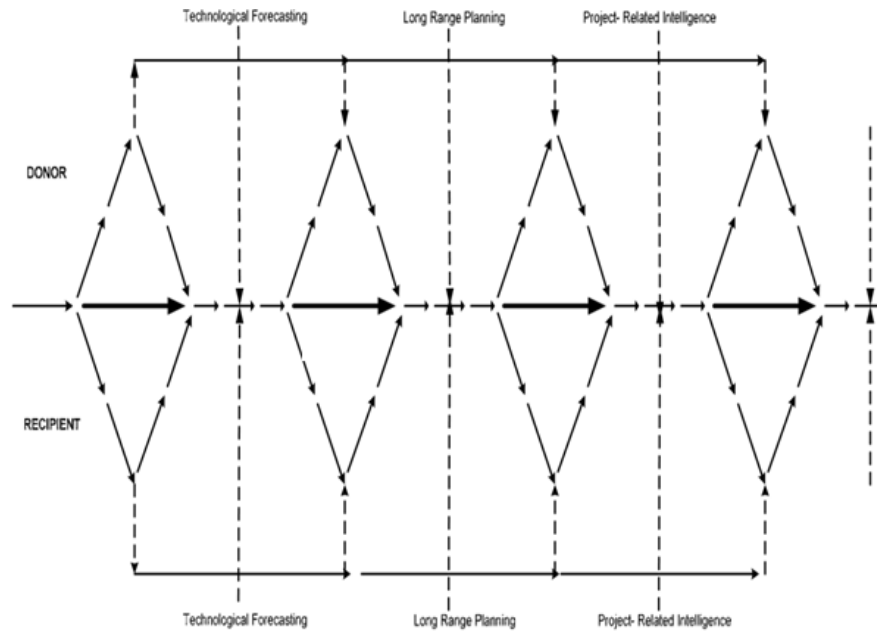


Figure 2: The bar-zakey model of technology transfer

Source: Jagoda (2007)

The bar-zakay model also suffers from another disadvantage. Jagoda (2007) points out that, “the model has limited relevance today since many of the activities, terms, and ideas expressed reflected the setting of the late 1960s to early 1970s, when buyers of technology were mainly passive recipients who depended greatly on aid programs for the purchase of technology. It was also an era when government controls were instrumental in determining the rate, direction, and scope of technology flows.”

The lessons that can be learnt from the bar-zakay model are the following:

- There is a need for a comprehensive examination of the entire technology transfer process from “search” right through to “post-implementation” activities.

- A process approach must be adopted in planning and implementing technology transfer projects.
- It is important to have milestones and decision points so that activities can be strengthened, mistakes corrected, or even the project terminated at any point in time.

(II). The Behrman and Wallender model: Behrman and Wallender (1976) have proposed a seven stage process for international technology transfer that may be more relevant to multinational corporations. The seven stages are:

- Manufacturing proposal and planning to arrive at decisions regarding location and preparing a business case including good resource assessments.
- Deciding the product design technologies to be transferred.
- Specifying details of the plant to be designed to produce the product and other aspects related to construction and infrastructure development.
- Plant construction and production start-up.
- Adapting the process and product if needed and strengthening production systems to suit local conditions.
- Improving the product technology transferred using local skills.
- Providing external support to strengthen the relationship between the transferor and transferee.

One of the weaknesses of this model is that, during the first three stages, the transferor develops the technology transfer project with minimal involvement of the transferee thereby reinforcing dependency. However, in the fifth and sixth stages there is considerable scope for the transferee to assimilate and improve both product and process technology. This serves to emphasize the fact that technology transfer does not stop with commencement of production and unless there is a mechanism to foster assimilation the project cannot be considered to have delivered.

The lessons that can be learnt from this model are the following:

- There is a need for the transferee to be involved right from the beginning in the planning and implementation of a technology transfer project.
- A technology transfer project does not end with commencement of production.
- Unless explicit measures are in place to ensure assimilation of the transferred technology, the technology transfer cannot be said to have been successful.

(III). The Dahlman and Westphal model: Dahlman and Westphal (1981) carried out considerable work in the republic of Korea and, based on their experience in rapidly industrializing countries during the 1980s, in the far east, have proposed a nine stage process model as follows:

- Carry out pre-investment feasibility to gather information and carry out a techno-economic analysis to establish project viability.
- Carry out a preliminary identification of technologies needed, based on the feasibility study.
- Carry out basic engineering studies that involve the preparation of process flow diagrams, layouts, material and energy balances and other design specifications of the plant and machinery and the core technology to be transferred.
- Carry out a detailed engineering study that involve the preparation of a detailed civil engineering plan for the facility, including construction and installation specifications and identification of the peripheral technology needed to make the transfer effective.
- Carry out the selection of suppliers for equipment and subcontracting services to assemble the plant and machinery and plan for the co-ordination of the work among various parties
- Prepare and execute a training and education plan, in consultation with the suppliers of technology, for the workers who would be employed in the technology transfer project.
- Construct the plant.
- Commence operations.
- Develop trouble-shooting skills and put in place arrangements to solve design and operational problems as they arise, especially during the early years of operation.

This model may be regarded as an improvement of the Behrman and Wallender model with great emphasis on transferee involvement at all stages of the technology transfer project. Its major weakness is that it assumes that the transferee will have access to high-level engineering skills. This may not be true in many developing countries. It also pays very little attention to negotiation and post-implementation assimilation initiatives.

The important lessons that this model presents include the following:

- A technology transfer project is best studied using a sequential process perspective.
- Any technology transfer project should not be commenced without a careful feasibility study since such projects often require heavy resource commitments.
- The transferee should be involved in the planning right from the beginning.
- It is important for transferees to develop sound engineering and project management skills without which the TT process cannot be managed effectively.

(IV). The Schlie, Radnor, and Wad model: Schlie *et al.* (1987) proposes a simple, generic model that delineates seven elements that can influence the planning, implementation, and eventual success of any technology transfer project. These seven elements are listed below.

- The transferor, which is the entity selling the technology to the recipient.
- The transferee, which is the entity buying the technology.
- The technology that is being transferred.
- The transfer mechanism that has been chosen to transfer the chosen technology.
- The transferor environment which is the immediate set of conditions, in which the transferor is operating. Attributes of the transferor environment that can influence the effectiveness of the transfer process include, among others, economic status, business orientation (inward versus outward), stability, attitude and commitment to the transfer project, and operating policies.
- The transferee environment which is the immediate set of conditions under which the transferee is operating. Attributes of the transferee environment that can influence the absorptive capacity of the transferee include physical and organizational infrastructure, skills availability, attitude and commitment to the transfer project, technological status, business orientation (inward versus outward), economic status, and stability.
- The greater environment which is that surrounding both the transferor and the transferee. There may be layers of this environment that are sub-regional, regional, and global. Even if the immediate operating environments of the transferor and the transferee are favorable to the technology transfer, if the layers of the greater environment are not supportive, then cross-border and international technology transfer could be adversely

affected. Factors in the greater environment such as political relationships between countries, exchange rates, investment climates, trade negotiations, balance of trade, relative technological levels, and the status of intellectual property protection regimes could have a great influence on the success of a technology transfer project.

The seven elements of this model are valid even in today’s business setting. The way that they manifest themselves can however change with time. The weakness of this model is that it offers no guidelines as to what a transferee should do.

The valuable lessons that emerge from this model are as follows:

- The many changes that have taken place and are taking place in the global business setting today have made it imperative for managers of technology to gain good insights into the transferee environment, transferor environment, and the greater environment when planning and implementing a technology transfer project.
- The choice of the technology transfer mechanism should be based on a sophisticated understanding of the other six elements.

(V). The Chantramonklasri model: the Dahlman and Westphal model has been further improved by Chantramonklasri (1990) who proposes a five phase model as shown in figure

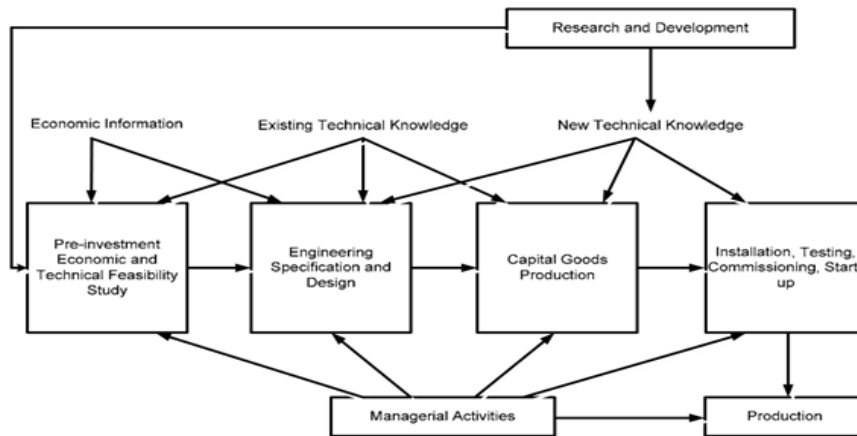


Figure 3: Five model of international technology transfer

Source: Jagoda (2007)

The five phases of this model are as follows:

- Carrying out a pre-investment and feasibility study
- Developing engineering specifications and design based on the feasibility study
- Commence capital goods production based on the engineering specifications and designs that have been developed.
- Commissioning and start-up including comprehensive of the workforce
- Commence commercial production

While the first two phases of this model are valid it is not clear whether the required capital goods can be produced within the transferee setting unless the transfer arrangement also includes the transfer of technology needed to manufacture these. While this may be valid in large, technologically advanced countries such as china and India, it may not be so in other smaller developing countries. As in the Dahlman and Westphal model the negotiation and assimilation elements are missing. The lessons that may be learnt in this case are similar to those of the Dahlman and Westphal model.

(VI).Other qualitative models of technology transfer: there are several other models that have been developed. However, due to limitations of space these will only be described briefly.

Lee *et al.* (1988) have developed a longitudinal model of technology transfer based on a study of developing and rapidly industrializing countries. They point out those transferee firm needs to put in place strategies to be able to go through the stages of acquisition, assimilation, and eventual improvement. As the firm advances technologically, it needs to choose appropriate mechanisms of transfer, depending on the stage of the life cycle of the technology and their own technological capability profile. They also note that the mechanisms chosen by the transferor to transfer technology will depend on the relative newness of the technology, its strategic importance to the transferor firm, and the level of intellectual property protection needed.

Reddy and Zhao (1990), in a model similar to that of Schlie *et al.* (1987) state that any international technology transfer (ITT) project should examine three main components, which they refer to as the home country component, host-country component, and transaction component. The home country is that of the transferor and the host country is that of the transferee. The home-country component involves an examination of issues such as home-country government policies on technology transfer (restrictions etc.), the role and strategy of

transferring firms from a foreign direct investment point of view, the nature and importance of technology to be transferred, and the firm’s global research and development investment strategy. The host country component involves issues such as host-country government policies related to foreign investment and technology transfer, the relative suitability of the technology being considered for transfer, the technological capability of the transferee and the scope for upgrading, mechanisms of transfer being considered, and the scope for assimilation of the transferred technology. The transaction component consists of important business issues such as the pricing of technology, intellectual property protection, payment modalities, potential conflicts, and measures for ensuring effective transfer.

Keller and Chinta (1990) argue that effective technology transfer would be determined by the extent to which the transferor and transferee manage the barriers that impede transfer and strengthen initiatives that facilitate it. The facilitating initiatives refer to the willingness of the partners to adapt their respective strategic and operational postures to ensure a “win-win” outcome. The barriers could be political, legal, social, cultural, economic, and technological. They also stress the importance of selecting the correct mechanism to transfer the technology.

The UNIDO (1996) model, in what appears to be an endorsement of the bar-zakay approach, suggests that, in the manufacturing sector, once the need for a technology transfer project is established, the steps of search, evaluation, negotiation, contract execution, and technology adaptation and absorption should be followed sequentially to ensure effectiveness.

Durrani *et al.* (1998) have proposed a generic model consisting of five steps:

- Establishing market-place requirements
- Identifying technology solutions
- Classifying the identified technology solutions
- Establishing sources from where the desired technology could be acquired
- Finalizing the technology-acquisition decision

This model stops with the technology acquisition decision. Its major lesson is that it stresses the importance of establishing the need for a technology transfer project and the need for identifying multiple sources of technology for enabling a better choice of transferor.

Bozeman (2000) has proposed a contingent effectiveness model of technology transfer. While the emphasis is on technology transfer from universities and government laboratories to industry,

the model is also relevant to inter-firm technology transfer. In this model, the key elements of the transfer process are:

- The transfer agent (the transferor)
- The transfer mechanism
- The transfer object (the content and form of the technology being transferred)
- The transfer recipient (the transferee)
- The demand environment (market and non-market factors vis-à-vis the need for the technology).

This model also stresses importance of establishing the need for a technology transfer project and the need for identifying multiple sources of technology for enabling a better choice of transferor. Six “out-the-door” measures are proposed. These are market impact, economic development, political benefits, opportunity costs, and development of scientific and human capital as a result of the transfer. The importance of impact assessment is a valuable lesson that this model imparts.

Kassahun Y. Kebede, Karel F. Moulder (2007) developed a model that focuses on the early steps of technology transfer process by considering basically two crucial steps and critical factors of TT process;

1. Need assessment

- The needs and their dynamics
- Owners of these needs
- Strategic policies and plans for fulfilling these needs

2. Technology assessment

- Technical factors
- Economical factors
- Institutional factors
- Environmental factors

The model exhaustively works on the early stage of TT process. The technology transfer implementation process was not elaborated in the same manner.

PART TWO: LIGHT RAIL TRANSIT SYSTEMS

2.5 An Introduction to Light Rail Transit

Light rail transit evolved from street car technology. Electric street cars dominated urban transit in just about every significant American city up through World War II (Especial Report by APTA, 2013). But once the war was over, “old-fashioned” trolley lines were converted to bus operation in droves, all in the name of “modernization.” By 1965, only a handful of legacy street car systems still survived. The genesis of the terminology “light rail transit” in the United States dates to the late 1960s when planning efforts were underway at what was then called the Urban Mass Transit Administration (today’s Federal Transit Administration) to procure new vehicles for legacy trolley lines in Boston and San Francisco. The principals working on that program recognized that, because of the wholesale abandonment of streetcar lines in the previous two decades, the words “streetcar” and “trolley” had stigmas with likely negative political consequences for the program. Therefore, the term “light rail vehicle” was coined, borrowing from British vernacular.

2.6 Light Rail Defined

Tracks for light rail transit are generally constructed with the same types of materials used to construct “heavy rail,” “commuter rail,” and railroad freight systems. Also, light rail vehicles may be as massive as transit cars on heavy rail systems. Consequently, the term “light rail” is somewhat of an oxymoron and often misunderstood. Therefore, for the purposes of this study, it is appropriate to define light rail transit.

The American Public Transportation Association (APTA) defines light rail transit as (TCRP, 2000). *An electric railway system characterized by its ability to operate single or multiple car consists along exclusive rights-of-way at ground level, on aerial structures, in subways or in streets, able to board and discharge passengers at station platforms or at street, track, or car-floor level and normally powered by overhead electrical wires.*

To expand that definition:

- Light rail is a system of electrically propelled passenger vehicles with steel wheels that are propelled along a track constructed with steel rails.

- Propulsion power is drawn from an overhead distribution wire by means of a pantograph or other current collector and returned to the electrical substations through the rails.
- The tracks and vehicles must be capable of sharing the streets with rubber-tired vehicular traffic and pedestrians. The track system may also be constructed within exclusive rights-of way.
- Vehicles are capable of negotiating curves as sharp as 25 meters [82 feet] and sometimes even sharper, in order to traverse city streets.
- Vehicles are not constructed to structural criteria (primarily crashworthiness or “buff strength”) needed to share the track with much heavier railroad commuter and freight equipment.

2.7 Light Rail as a Spectrum

While, as noted above, the railway track engineering for a wide spectrum of railway systems, its principal focus is light rail transit. LRT itself is a broad spectrum and ranges from single unit streetcars running in mixed traffic within city streets at speeds as slow as 25 mph [40 km/h] and even lower up through multiple car trains running on a totally exclusive guide way at speeds of 60 mph [100 km/h] or faster. The streetcar lines in New Orleans are representative of the lower end of this spectrum while the Metro link system in St. Louis is a good example of the upper end. In much of Europe, these two extremes are often called “trams” and “metros.” In Germany, the terms “strassenbahn” (“street railway”) and “stadtbahn” (“city railway”) are commonly used.

It is important to note how, along any given light rail transit line, one might reasonably include guide way and track elements that are very much like a strassenbahn while a short distance away the route’s character might radically change into that of a stadtbahn. LRT is a continuum and, within the framework of the operating requirements of a given project, the LRT track designer can incorporate appropriate elements from each of the mode’s extreme characteristics plus just about anything in between.

Light rail lines are fairly distinct from metro rail systems (often called “heavy rail”). The latter are always entirely in exclusive rights-of-way, are usually designed to handle long trains of vehicles (6 to 10 cars per train is common) and have a relatively high absolute minimum operating speed along the revenue route (usually 45 mph [72 km/h] or higher). By contrast, LRT trains can operate in shared rights-of-way; very seldom exceed three cars per train and speeds as

low as 10 mph [16 km/h] are tolerated in revenue service track. These differences usually mean that LRT can be constructed at far lower cost than metro rail transit, although the passenger throughput capacity of the latter is also much higher.

If there is any one single characteristic that defines “light rail,” it is likely the ability of the vehicle to operate in mixed traffic in the street when necessary. This draws a line between the St. Louis example above and a light metro rail operation such as SEPTA’s Norristown high speed line. The operational characteristics of each route are virtually the same, but only the St. Louis vehicle could actually operate in the street if necessary. It is a very fine distinction, and, while purists may quibble with some of the finer points of this definition.

Several rail transit projects have utilized diesel-powered light railcars (also known as “diesel mechanical units” or “DMUs”), which do not meet FRA buff strength criteria. Except for the propulsion system, many of these vehicles and the guide ways they run upon closely resemble the stadtbahn end of the LRT spectrum.

The words “railroad” and “railway” will appear. By “railroad” mean standard gauge rail operations that are part of the general system of railroad transportation.

This includes freight railroads and passenger railroads (such as Amtrak and the commuter rail operations in many cities). The word “railway,” on the other hand, is intended as a broader term that includes all transportation operations that utilize a vehicle guidance system based on the use of flanged steel wheels riding upon steel rails.

2.8 Where the Rails and Wheels Meet the Road

Arguably, the two most important defining elements of track work for light rail systems are the construction of track in streets and the interface between the wheel of the light rail vehicles and the rails. Track in streets requires special consideration, especially with regard to the control of stray electrical current that could cause corrosion. These embedded tracks also need to provide a flange way that is large enough for the wheels but does not pose a hazard to other users of the street.

Light rail vehicle wheels do not necessarily match those used in freight railroad service. Wheel diameters are usually much smaller, and the wheel tread is often much narrower. Light rail wheel

flanges are often shorter and have a radically different contour than railroad wheels. These variations require special care in track design, especially in the design of special track work such as switches and frogs. The compatibility of the vehicle and track designs is a central issue in the development of a light rail system if both components are to perform to acceptable standards.

While light rail may need to share right-of-way (R/W) with pedestrians and vehicles, the designer should create an exclusive R/W for light rail tracks wherever possible. This will make operation more reliable and maintenance less expensive. Exclusive R/W can also simplify compliance with the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and similar requirements in other countries.

2.9 The Regulatory Environment

Virtually every aspect of the operation and maintenance of railroads in the United States is closely regulated by the Federal Railroad Administration (FRA) of the U.S. Department of Transportation. However, very few rail transit operations are subject to any level of FRA oversight and regulation. In fact, as of 2010, the U.S. federal government does not exercise any direct oversight of rail transit operations. Instead, through 49 CFR, Part 659, *Rail Fixed Guideway Systems: State Safety Oversight*, the U.S. government delegates that responsibility to the states. Therefore, it is a must to familiarize themselves with any applicable regulations in anywhere the light rail transit line will be constructed and operate.

SUMMARY OF LITERATURE REVIEW

The literature review consists two parts the first part exhaustively present on the technology transfer concepts and the models that were popularly used in frequent manner. The technology transfer was defined, modes and mechanisms for technology transfer study were reviewed, the models with their draw back also reviewed to adopt a model that are going to be used in seeing the contribution of AA LRT for technology transfer process. From the models which were reviewed at this chapter some of the models like the Bar-Zakey, the Berham & Wallender and the Dahma & Westpal were mainly concerned and worked on the key activities of the TT process rather than project cycling approach while others like K.Kebede, K.Moulder deal exhaustively on early stage of the project cycle and ignoring or giving less attention to the middle and post stages of the project cycles in TT implementation process.

The another part of the literature review is the technology part as it was necessary to define what is light rail transit, what is its technical spectrum, what is its regulatory environment, etc. to see the actual existing technology of AA LRT systems and the technology preference one over the other towards realization of technology transfer from the evidences the other world experiences on the same issues.

Thus next chapter deals with the selection and adoption process of qualitative model from the context of concerned matter, i.e. qualitative process based model that covers the whole project life cycle. It is not work for scattered activities of the TT process. The model selection process is therefore for the merit of the AA LRT project and hence it has to cover the project life cycle of the said project.

CHAPTER THREE

3. SELECTING QUALITATIVE PROCESS BASED TECHNOLOGY TRANSFER MODEL

The first part of this chapter will go to analyze a common problems faced by companies starting from early selection, selection, planning and implementing technology transfer projects.

3.1 Common Technology Transfer Problems

This part commences with a brief presentation of common technology transfer problems faced by companies and enterprises.

Based on the work of Jagoda (2007) and Ramanathan (2007), problems faced by companies and enterprises in selecting, planning, implementing, and managing technology transfer may be classified into three categories namely, technology transfer process issues, corporate capability issues, and operating environment and NIS issues. The problems are described below.

3.1.1 Technology transfer process issues

Problems during the technology justification and selection stage

- Wrong selection of technology based on misjudgments when preparing a business case for a technology transfer project
- The cost of buying, installing, operating, and maintaining the technology is too high
- The technology selected is too complex for easy understanding and assimilation of the transferee
- The technology needs considerable adaptation to suit local conditions
- Obsolescence of technology while the transfer is in progress

Problems during negotiations

- Differences in negotiation approaches and strategies
- Lack of trust between the transferor and transferee
- Goal incompatibility during negotiations
- Inability to reach agreements on pricing, product, and marketing strategies
- Both parties try to achieve results in an unrealistically short period of time

Problems during the planning stage

- Transferor (seller) underestimates the problems in transferring the technology to a developing country setting
- Transferor does not fully understand transferee needs
- Transferee managers are not involved in the planning which is carried out only by the transferor
- Too much attention is paid to the hardware to be purchased and not enough attention is paid to skills and information acquisition
- Overestimation of the technological capabilities of the transferee by the transferor thereby leading to unrealistic expectations on how well the transferee can meet target dates
- Poor market demand forecasting by the transferee of the outputs to be produced by using the transferred technology
- The objectives of the transferor and transferee are not compatible
- Mechanisms chosen for implementing the transfer are not appropriate

Problems during technology transfer implementation

- Shortage of experienced technology transfer managers
- Lack of trust in transferor developed systems by the transferee
- Inability to achieve quality targets
- Delay in obtaining supplementary materials, needed for quick implementation, from the local environment
- High cost and poor quality of locally available materials needed to implement the technology transferred
- Inadequate tracking of the technology during implementation
- Cost overrun due to poor implementation

3.1.2 Corporate capability issues

Problems due to inadequate skills

- Inability of the transferee to attract the required skills due to financial and industrial restrictions

- Lack of experience of the transferee’s workforce and absence of required skills at the industry level
- Lack of training of transferee personnel
- Absence of incentive systems at the transferee firm for learning and assimilating new technologies
- Language barriers that inhibit effective communication between transferor and transferee personnel and restrict effective transmission and assimilation of relevant information

Problems due to ineffective management

- Lack of visible and committed top management support for the project
- Lack of top management guidance to decide the type of the technology to be acquired, remuneration, incentives associated with the transfer, and the control of the flow of information.
- Differences in working methods and practices between the transferor and transferee managers
- Individual or organizational competition for the ownership of the technologies and the presence of the “not-invented-here” syndrome
- Failure of top management to identify transferee and transferor personnel who would work closely from project initiation through to full implementation

3.1.3 Operating environment and national innovation system (NIS) issues

- Shrinking of local markets due to adverse changes in the economic levels of the country
- Poor physical infrastructure
- Inadequate supportive institutional infrastructure to provide support in terms of finance, information, skill development, and technology brokering
- Inadequate mechanisms for intellectual property protection
- Lack of local suppliers who can deliver quality supplies and lack of policies to develop such suppliers
- High dependency on foreign suppliers and imports
- Lack of good education and training institutions to upgrade skills

- Ineffective legislation and incentives such as tax holidays, tariff adjustments, and industry parks to promote technology transfer
- Bureaucratic delays at various levels of government in obtaining approvals and clearances for finalizing technology transfer agreements
- Ineffective and sometimes excessive government intervention and regulation
- Foreign exchange restrictions
- Inability of new ventures to compete with former monopolies, often owned by government
- Uncertain tax environments

However, what may be noted is that there is no model that tries to capture all of these important considerations. An eclectic model that presents all this wisdom in a process-oriented approach would be very useful to managers of technology transfer project. Such a model must also have the capacity to address many of the problems faced by firms, when selecting, planning and implementing technology transfer. Therefore there is proposed model for technology transfer which is called life cycle approach for planning and implementing technology transfer project.

3.2 Life Cycle Approach for Technology Transfer Process

The “life cycle approach for selecting, planning and implementing a technology transfer project” is based on the stage-gate structure developed by Jagoda (2005) and then Ramanathan (2005) for developing a systematic approach for selecting, planning and managing TT projects. For the sake of convenience and expository ease, henceforth this model will be referred to as the TTLC (technology transfer life cycle) approach.

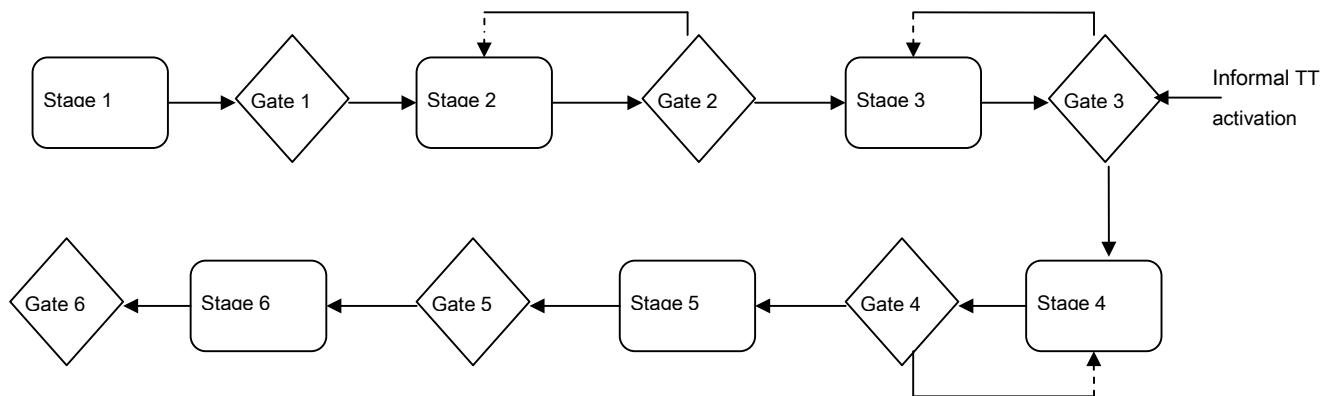
The TTLC approach takes a holistic view of a technology transfer project from its “conception” right up to its “conclusion” and is based on the recognition of the fact that a life cycle of a technology transfer project can be looked at from a process perspective as consisting of **six major stages** as follows.

- **Searching Identifying the technology needed and making a business case to obtain corporate approval**
- **Focusing possible technology sources and assessing offers**
- **Negotiating with short-listed suppliers and finalizing the deal**
- **Preparing a technology transfer implementation plan**

- **Implementing and assimilating**
- **Assessing the impact of the technology transfer project**

This life cycle has been developed based on the lessons learnt from the study of popular models of technology transfer that have been reviewed. The major stages in the life cycle are shown schematically in figure. It can be seen that, in this generic framework, each stage is associated with a gate. The stages are made up of prescribed tasks with cross-functional and simultaneous activities. The gate or controlling point is at the entrance to each stage. Using the information generated at each stage, in-depth and critical evaluation is carried out at the gate that follows the stage. Based on the evaluation, a decision may be taken to go forward, kill the project, put it on hold, or recycle it. It is envisaged that, through this approach, proactive measures could be taken to avoid or minimize problems thereby enhancing the chances of successful technology transfer. The main advantage of such an approach is that it could ensure that major activities are not carried out carelessly or even missed.

The model was accepted by introducing a little modification as the model have no deal with informal TT approach in case of the negotiation fails to reach an agreement for TT.



Stage 1: Identifying CVD enhancing technologies

Stage 2: Focused technology search

Stage 3: Negotiation

Gate 1: Confirming identified technologies

Gate 2: Technology and supplier selection

Gate 3: Finalizing & approving the TT agreement or activation of informal TT

Stage 4: Preparing a TT project implementation Gate 4: Approving the implementation plan
 plan
 Stage 5: Implementing technology transfer Gate 5: Implementation audit
 Stage 6: Technology transfer impact assessment Gate 6: Developing guidelines for a new
 project

Figure 4: The life cycle approach for technology transfer

Stage 1: Identifying CVD enhancing technologies

All enterprises whether they are large firms and companies or SMEs can compete effectively only on the basis of “customer value creation.” Customer value may be defined as a function of quality, delivery, flexibility, convenience, and cost (Ramanathan, 2001). Quality represents how well a specific good or service meets customer expectations. Speed describes the time needed to design, produce, and deliver the good or service as characterized by determinants such as cycle time and speed to market. Flexibility reflects how easily and quickly the firm can modify goods or services to meet customer needs in terms of aspects such as options and extent of customization possible. Creating convenience for the customer implies not only speed of service, but also self-service, process visibility, and easy to use, streamlined, consistent, and reliable customer service. Lastly, cost refers to all objective and subjective costs that the customer incurs to acquire, use, and dispose of the good or service and includes dimensions such as discounts, rebates, and incentives. Customer value is enhanced as quality, speed, flexibility, and convenience increases while cost decreases. These five determinants of customer value creation may be referred to as core value determinants (CVDs) (Ramanathan, 2001). To ensure sustainable competitive advantage a firm must offer its customers a CVD profile that sets it apart from its competitors. Thus, in stage 1 what is important is for the transferee firm to decide what technology or technologies it needs to create a unique CVD profile that will enhance its competitive edge vis-à-vis its competitors. The key activities that must be carried out at this preliminary stage of the technology transfer project are the following:

- An informal technology transfer steering committee (TTSC) is set up to study how competitors are using technology to enhance customer value and what technologies are available that could deliver even greater value.

- A list of technologies needed is developed and technology roadmaps are constructed to understand future trends of these identified technologies.
- Information for this is obtained through internet searches, study of technical publications, exchange of
- Examines market size, market potential, and likely market acceptance of the proposed communication with potential suppliers of technology, contacts with universities etc.
- A quick market assessment that initiatives are carried out, mainly through the use of marketing expertise and contacts with key users.
- A technical assessment is also carried out to estimate, approximately, the resources and capabilities needed to adopt the new technologies, time needed, costs involved, likely risks, and possible barriers (including policy, legal and regulatory aspects).

Gate 1: Confirming Identified Technologies

Gate 1 is a “critical but supportive” screen. The decision-makers, usually a top management team, develop a set of “**must meet**” criteria to review the proposal. The criteria could include:

- ☞ Strategic alignment
- ☞ Project feasibility in terms of technical and resource considerations
- ☞ Magnitude of opportunity
- ☞ Regulatory, legal, and policy factors

Financial returns are usually assessed at this gate using simple financial calculations such as payback period. The decision-makers will, at this gate, modify, confirm the composition of the TTSC which will then be in charge of the project.

Stage 2: Focused Technology Search

This is probably the most important stage where detailed investigation is carried out by the TT bodies. It is here that a strong business case for the technology transfer is built. This includes specifying in detail the following:

- ☞ How the technology sought is expected to enhance customer value by influencing the CVDs
- ☞ What components of technology are needed (hardware, skills, information, and organizational arrangements)

- The extent to which the abilities to use the technology are available in-house and what gaps have to be bridged
- The resource commitments needed and the expected benefits
- Prioritized short listing of suppliers for the technology based on their business strategy, technological capabilities, experience in handling technology transfer projects, past performance, and cross cultural expertise.
- Competitive analysis to assess the impact of the technology sought on competitiveness

Based on a consideration of these aspects, a business case is developed that includes clear technology specifications, discounted cash flow (DCF) analysis, project justification, and business plan. Development of this business case requires multidisciplinary interaction and cross-functional cooperation. If this stage is carried out poorly it could have adverse impacts at the remaining stages and cause serious difficulties.

Gate 2: Technology and supplier selection

This is the final gate prior to the formal negotiation and launch stage where the project can be killed before it enters a heavy spending phase. This gate gives the go-ahead for a “heavy spend.” Gate 2 critically examines the analysis of stage 2 and rechecks against the major criteria used in gate 1. The following steps need to be followed very carefully at this gate:

- All suggestions with regard to technology choice, components of technology needed, and capability gaps to be bridged, resource commitments needed, expected benefits, and supplier profile ratings are critically examined.
- The technology will be assessed very rigorously using techno-economic, socio, and politico-legal factors.
- The preferred supplier ranking will be reassessed rigorously based on strategic fit and process support capability and may be modified from the ranking proposed in stage 2.
- The financial analysis (DCF) is rechecked very rigorously here.
- The TT body may have to revise the analysis in the light of the critical evaluations (as indicated in the figure) and submit the new analysis for further evaluation.

Stage 3: Negotiation

This is a critical stage where the TTSC now negotiates with the shortlisted suppliers. A critical issue in technology transfer negotiation is the valuation of the technology to be transferred. The extent to which both parties can influence price depends on their respective bargaining power. The transferor’s power arises out of the resources possessed such as ownership of a desired technology, brand name, reputation, management expertise, capital, and international market access. Transferee power often tends to have its roots in local knowledge and networks, access to local markets, raw materials and low cost labor, and political connections. To ensure effective negotiation, frequent contact and communication between both parties is imperative. The following activities need to be carried out at this stage.

- Agreeing upon a basis for the valuation of the technology and reaching agreement on issues related to payments and intellectual property protection – both short-term and strategic benefits have to be examined.
- Delineation of each party’s contribution and responsibilities towards the technology transfer project
- Discussion of issues and methods related to the transfer of codified and uncoded aspects of technology including training
- Creation of effective channels of communication between both parties including visits to each other’s facilities
- Consultation with government authorities to ensure concurrence with government policies and identification of possible barriers, likely policy changes and government support available.
- Finalizing the most appropriate mechanism(s) for transferring the technology components sought.
- Preparation of a detailed transfer agreement with emphasis on ensuring intellectual property protection reaching agreement upon payment amounts, procedures, and time frames.

Gate 3: Finalizing and Approving agreement or Activation informal TT process

This gate is operationalized once the negotiations have reached a satisfactory level and the parties express the desire to finalize the agreement through the drawing up of a legal agreement. This gate will critically evaluate the following:

- The comprehensiveness of the detailed transfer agreement
- The adequacy of intellectual property protection arrangements
- The appropriateness of the proposed mechanism(s) for transferring the technology
- The suitability and affordability of the payment amounts, procedures, and time frames.

If the negotiation process fails to reach an agreement the informal TT process is activated and only informal TT plan is proceed as public project is necessarily implemented.

Stage 4: Preparing a technology transfer project implementation plan

At the beginning of this stage a transferor of technology would have been chosen and since the creation of a sound organizational infrastructure is critical to the implementation of TT, this stage focuses on making organizational arrangements to receive the technology. The main activities during this stage are the following:

- Identification of changes to be made to the organizational structure and work design based on an understanding of the transfer components
- Identification of changes to be made in the knowledge management system and policy regimes to accommodate the new technology
- Development of pragmatic training and education schedules for the workforce that matches with the components to be transferred
- Formulation of measures to build good relationships between the transfer personnel
- Formulation of a realistic technology transfer project implementation plan that can form the basis of a working relationship between the transferor and transferee
- Milestones are specified to help strengthen project management and control.

Gate 4: Approving the implementation plan

At this gate, the following aspects will be carefully scrutinized:

- ☞ Whether agreement has been reached with the transferor with respect to the schedule
- ☞ Adequacy of the training arrangements
- ☞ Adequacy of the modification of the infrastructure
- ☞ Intellectual property protection measures
- ☞ Durations of critical activities
- ☞ Quality assurance procedures

ገጽ Payment schedules

If these are satisfactory then a go-ahead signal will be given. Otherwise revisions will be needed. At this gate an initial payment to the transferor, if specified in the agreement, will also be approved.

In case of informal TT the internal plan that could have been prepared only by transferee is preceded. The plan could have been then also approved and the remaining issues for TT is done systematically by transferee side only (there might be assigned body).

Stage 5: Implementing technology transfer

Technology transfer implementation requires good project management. Changes to product, process, or technology may be sometimes as a result of the successful implementation of a technology transferring process.

At the beginning of this stage a transferor of technology would have been chosen and since the creation of a sound organizational infrastructure is critical to the implementation of TT, this stage focuses on making organizational arrangements to receive the technology. The main activities during this stage are the following:

- Identification of changes to be made to the product or process to suit local conditions and making the necessary adaptations.
- Recruitment and selection of personnel not already available within the organization and conducting training programs for existing staff.
- Development of improved remuneration plan to facilitate change management.
- Formulation of arrangements with ancillary suppliers of materials, parts and services based on a make vs. Buy analysis
- Maintaining links with government authorities to keep track of policy changes
- Commissioning the transferred technology on or before schedule.

Gate 5: Implementation audit

At this gate the scheduled activities and the goals set for the technology transfer project are evaluated. The focus should be on gaining an understanding of barriers to the successful implementation of technology transfer. The audit may focus on the evaluation of project implementation with respect to critical factors such as:

ገጽ Commitment displayed

- ጊግ Conflicts experienced
- ጊግ Time frames
- ጊግ Cost incurred (only for formally negotiated TT)
- ጊግ Quality achieved
- ጊግ Extent of learning and skill upgrading
- ጊግ New knowledge generated
- ጊግ Communication effectiveness

The compilation of a comprehensive audit report outlining the lessons learned and identifying critical success and failure factors is important at this gate so that future technology transfer projects could benefit from these insights.

Stage 6: Technology transfer impact assessment

Assessing the impact of a technology transfer project is difficult because it is a complex process with multiple outcomes that could emerge throughout the life of a project. Also, the intangible benefits of a technology transfer project are difficult to evaluate. However, a well-structured impact assessment could be extremely beneficial and the impacts need to be assessed from customer, market, financial, technological, and organizational perspectives. The following activities are proposed for this last stage:

- Development of a “balanced score card (BSC)” approach to assess impacts.
- Identification of the variances (if applicable) between actual and expected outcomes and the formulation of organizational corrective measures is done.
- Examining the feasibility of improving the transferred technology.
- Identification of new or complementary technologies that could be transferred to consolidate the gains made.

Gate 6: Developing guidelines for post-technology-transfer activities

At this gate important decisions have to be taken as to whether to continue to use the technology by improving it incrementally or go for another technology transfer project. Successful technology transfer projects can lead to strong and long partnerships between the transferor and the transferee and new projects could be initiated in a variety of ways. At this gate guidelines may be formulated, based on the experience gained at all the previous stages and gates for post-technology-transfer activities such as:

- ☞ A new technology transfer project
- ☞ Internal development
- ☞ A mix of both in partnership with the transferor.

These decisions can then be fed into the corporate planning process of the organization.

3.3 Criteria Developed From the TTLC Model

The model basically works for the projects that are going to be implemented. The study was simply targeting to assess AA LRT project’s contribution for TT process since the project exists at its completion state. Therefore to perform the case study it is important to identify the critical criteria in the six stages of the model.

Table 2: Technology transfer criteria development from the adopted model

	From TT Criteria
1	Technology Selection
1.1	Complexity of technology to understand and assimilate
1.2	The newness of technology
1.3	Priority given towards acquisition of skill or information than purchase of hardware
1.4	Organized or responsible body assignment for TT project implementation purpose
1.5	Environmentally friend technology
1.6	Reasonable Cost of acquiring and operation
1.7	Convenience to be modified and customized
1.8	Safe for the users or community as it is public project
2	Technology supplier selection
2.1	Level of in- house ability of AA LRT actors to use the technology in LRT system
2.2	Technology suppliers capability and experience towards TT
2.3	Technology suppliers culture & willingness towards TT
2.4	The level of local resource(human and non-human) available for project implementation
2.5	Opportunities and availability of market here(Ethiopia) and even at the regional level for encouraging the owner of technology
2.6	Bilateral relationship between the two country

2.7	Financing policy for the technology owner country
3	TT agreement
3.1	Agreement made between party for addressing TT
3.2	Mode of Payment arrangement for TT during AA LRT execution in agreement
3.3	Presence of significant TT barriers for the project
3.4	Conducive policy arrangement for TT to be effective
3.5	Presence of strong IPR protection law in the country (Ethiopia)
3.6	TT mechanisms Proposed during Project implementation
3.7	JV or other mode (mechanism) arrangement for local firms in the contract agreement
4	TT planning
4.1	Organizational structure established for purpose of TT
4.2	Schedule with its mile stone for TT
4.3	Regular monitoring and evaluation program set up to achieve TT effectively
4.4	Knowledge management scheme for new technology in AA LRT project
4.5	Mode of communication between transferor & transferee for sake TT
4.6	Training arrangement for the purpose of TT enhancement
5	TT implementation
5.1	Level in contribution of local knowledge during implementation of the project
5.2	Incentives and remuneration arrangement for TT personnel in line with achievement of the plan
5.3	Level in contribution of materials manufactured and supplied by local firms during project
5.4	Regular monitoring and evaluation conducted in enhancing TT
5.5	Training conducted in realizing TT and assimilating it
5.6	Conflict between parties so far observed regarding TT
5.7	Quality approval procedure with high involvement of local experts or firms
5.8	Prominence in level of learning and skill upgrading
5.9	Significance in knowledge and knowhow generated
5.10	Level of effective communication and transparency towards TT

5.11	Language barrier for TT
5.12	Standardization adopted for the railway system including the rolling stock
5.13	Parts of rolling stock manufactured locally
5.14	Level in involvement of local experts for the manufacturing of rolling stocks
5.15	Manufacturer of concrete slippers emerged
5.16	Manufacturer of the rail emerged
5.17	Designing firm for the rail way system emerged
6	TT implementation audit
6.1	Whether AA LRT project laid a significant lesson or not for TT
6.2	Is that previously expected that AA LRT project brings TT
6.3	Whether ERC plans or not new TT project from the background of AA LRT
6.4	New areas of skill and knowledge spillover acquired
6.5	Cost advantages for the customer /users realized or not for transport service
6.6	Life become easy and easy access to transport realized or not
6.7	Whether the project has contributed significantly to broadening understanding of government officials about TT in future or not
6.8	Readiness for operation and maintenance was realized immediately after completion of the project or not
6.9	Availability of maintenance and operation manuals are at full and confident level or not.

3.4 Summary

The most qualitative models presented in the literature review fails addressing the problems of three basic categories namely:

1. During technology transfer issues
 - i. Problems at technology justification and selection stage
 - ii. Problems at negotiation stage
 - iii. Problems at planning stage
 - iv. Problems at implementation stage

2. Corporate capability issues
 - i. Problems due to inadequate skills and knowledge
 - ii. Problems due to ineffective management
3. Operating environment and NIS (National Innovation Systems) issues

Even though it is impossible to address each and every of the problems in the process of technology transfer the eclectic and holistic qualitative model called Life Cycle approach for Technology Transfer process (TTLC) was selected and adopted through going in the above three basic categories short coming of technology transfer models. Particularly the adopted model relays on the first category.

The model has a six stage from start of the project to the end. In each stage very important criteria that are directly contribute to or affecting technology transfer are described. While saying this it is not to say no criteria left that contributes or affects technology transfer process.

A good TT project is not basically because of working on the key activities regarding the TT process rather it is a matter of performing on the continuous process oriented that join ending to the beginning in forming the cyclic process. As AA LRT project is a project that starts at the generation of its idea and ends at its lesson from impact of TT to introduce the similar or rejecting it and searching for other option regarding the TT process issues. Hence the TTLC approach was best fitted model that selected for assessing the contribution of AA LRT project for TT process. The model was modified because of its limitation to address the informal part of TT process in the project cycle. Thus the adopted TTLC model is an eclectic model that presents and includes all wisdoms in a process-oriented approach in helping the TT project managers and stakeholders by addressing many of the problems faced by them when approaching, selecting, planning and implementing & assessing impacts of TT and again it covers the whole project life cycle of the project (AA LRT).

Therefore this chapter was laid a foundation for the work of the whole thesis work as the research objectives and questions are addressed partially here since the qualitative model was adopted and criteria contributing to or factors affecting technology transfer process were developed.

CHAPTER FOUR

4. RESEARCH METHODOLOGY AND DESIGN

4.1. Introduction

In order to address the research gap, a TTLC approach was selected with little modification because it is eclectic and holistic process based approach enabling the researcher to cover the whole cycle of the project and also it address the demerit of other qualitative process based model as discussed at the above section. The gaps which were recognized include a need to identify the right criteria to be used for analyzing the TT process and conducting the study. AA LRT project was chosen as the case to be assessed along with consideration of the whole system of the project by using the model selected and the criteria developed. The focus of this chapter is to design the whole research and to approach the research questions along with the combination of the chosen methods.

4.2. Research Design

Owing to the qualitative research approach, the research design is descriptive as a research is carried out in answering research question starting by ‘what’ and is case study as the research is addressed in conceptualizing the events or the cases. In this context the case is AA LRT project’s contribution for TT process from start of its right up concept to operation or the whole project cycle. Thus, the study is the case study and the design is descriptive as a whole.

4.3. Methodology

This section covers the methodology chosen for the purpose of this study. This includes data collection and analysis and respondent selection methods. As the research approach is qualitative, a combination of methods was used and this was particularly useful when qualitative data was obtained through different approaches from multiple sources in order to address research questions and objectives. Hence primary and secondary data sources were utilized.

For addressing stages of **technology selection and supplier selection** process (stages first and second) mainly secondary data sources like feasibility study, conceptual design and different reports were utilized.

For **negotiation stage** (stage three) secondary data sources like contract agreement and bid processing documents were surveyed and primary data like in depth interviews with the selected respondents were used.

For **planning stage** (stage four) secondary data sources like the AA LRT project plan and different correspondence letters were surveyed and primary data like interview was conducted.

For **implementation stage**(stage five) secondary data sources like different reports during project execution period, project execution manual, personnel file, and training data were utilized and primary data like open ended questionnaires were conducted.

For **impact assessment stage** (stage six) secondary data source like observation and primary data like questionnaires were utilized.

Respondent selection method for interviews and questionnaires was non probability sampling technique and convenient respondent selection method were utilized and as a sample is small in size it was believed that no need of describing the respondents here.

The analysis techniques were from the perspective of data collection as well as the nature of the study and hence the method for analysis was therefore descriptive type of data analysis which means describing it as it is with no control variables.

4.4. Study Area

The thesis was mainly concerned on the AA LRT’s contribution for technology transfer process by formal contractual issue and at some time informally through strategic set up by the concerned or responsible body and through participatory approach to capable of individual skill and institutional capability to wards this new technology by adopted model. The government or representing body, individual skills and private institution were addressed to be tested the real presence of the technology transfer on the selected technology areas.

The policy and strategic issues or manuals for technology transfer process through implementation plan of AA LRT project were assessed and criticized against technology transfer agenda of the eclectic model only starting from selection to post implementation phase

of the project as respective organization. And hence only the AA LRT project actors in the project life cycle were concerned.

4.5 Scope of the Study

The thesis work was mainly concerned on to see the contribution of AA LRT systems for technology transfer process i.e. the way to gain knowledge, skill, and knowhow formally and informally from very beginning of technology assessment stage to post implementation stage. To analyze the case and to perform the discussion the appropriate TT model called TTLC model was selected and the critical criteria from the model were identified at the chapter three.

Thus only by using the model and criteria from the model, the currently implemented AA LRT systems contribution for technology transfer process from starting of its idea to its post implementation phase was going to be assessed thoroughly as it was new public project for city transportation option but before doing this the actual technology of first phase of AA LRT project which was already constructed and started its operation was going to be surveyed and discussed.

CHAPTER FIVE

5. SURVEYING AA LRT PROJECT TECHNOLOGY AND TECHNICAL DESCRIPTION

5.1 Introduction

The technology entitled is AA LRT project, which includes the phase 1 of E-W route and N-S route. This project, including viaducts, under passing and grade lines, has the total length about 34.33 Km. Within a section of 2.8 kilometers two rails share the same track. The technology is cumulative components of the systems which comes together form a complete system. And they are described below as following according to the document from ERC:

5.2 Basic Requirement for Rolling Stock

The proposed rolling stocks are estimated to be used for 30 years. These rolling stocks maintain high safety, advanced performance, economic utility, convenient maintenance, favorable shape as well as comfortable ride. The design, manufacture, all subsystem and materials of these rolling stocks should conform to the standards as follows:

- IEC Standard
- ISO Standard
- UIC Standard
- JIS Standard

Utilizing Context

Altitude: $\leq 2500\text{m}$

Temperature: $+10^{\circ}\text{C}—+28^{\circ}\text{C}$

Relative Humidity: 95%

Main Parameters

- 1、 Gauge: 1435mm
- 2、 Minimum Curve Radius: 50m for mainlines, 30m for parking garage
- 3、 Minimum Vertical Curve Radius: 1000m
- 4、 Maximum Gradient: 50‰

Parameters for Power Supply

- Rated Voltage: DC1500V
- Current Collection Method: Overhead Contact System

Component and Marshalling of the Vehicles

- The vehicle is formed by three modules, which are Mc, T and Mc. Under the Mc module of the vehicle a bi-axial power bogie is installed, and a bi-axial driven bogie with independent wheel is installed under the T module of the vehicle.
- The vehicles for LRT are operated in two directions, and are 6-axle double-articulated 70% low-floor Light Rail tramcar. (see attached figure 1 for vehicle arrangement)
- No more than three coupled tramcar marshalling are allowed to be operated on the track.

Loading Capacity

- Seats: 64
- Rated Passengers: 6 persons /m², 286 persons in one tramcar in total.

Tramcar Size

- 1、 The outside dimension of the tramcar should conform to the metro gauge requirements.
- 2、 Tramcar Length: 28400mm
- 3、 Tramcar Width: 2650mm
- 4、 The Distance between Coupler Central Line and the Rail Surface: required.
- 5、 The Distance between Tramcar Floor and Track Top:
 - Low-Floor Area: 365mm
 - High-Floor Area: 865mm
 - Low-Floor Rate: 70%
- 6、 The Distance between Track Top and Tramcar Top: ≤ 3700 mm
- 7、 Wheel Diameter:
 - Motor Wheel: 660mm (half-wear: 640mm)
 - Driven Wheel: 600mm (half-wear: 580mm)

Tramcar Performance

- The Highest Speed: 80Km/h
- Weight of Tramcar: 43t
- Weight of Axis: ≤ 11 t
- Average Acceleration for Start-Up: 1m/s^2 (0-40Km/h)
- Average Deceleration for Braking: from 80Km/h to stop

1) The Average Deceleration of Normal Braking with Rated Load (including control response time) : $\geq 1.0\text{m/s}^2$

2) The Average Deceleration of Emergent Braking with Rated Load (including control response time) : $\geq 1.5\text{m/s}^2$

- Ratio of Acceleration and Deceleration: 0.75m/s^3
- Ride Index:

According to the standards and methods from GB5599-85 in Railway Vehicles Specification for Evaluation the Dynamic Performance and Accreditation Test, the Ride Index $W \leq 2.5$.

- Operation Stability (Safety)

Derailment Coefficient ≤ 1.0

Where P_1 is the vertical force KN from climbing rail wheel to rail;

Q_1 is the transverse force KN from climbing rail wheel to rail.

- Criteria for Noise Control

1) when the tramcar is operated on the flat-straight rail at the speed of 60Km/h, the noise of the area where cab center is 1.5m away from floor should be ≤ 70 dB (A)

2) when the tramcar is operated on the flat-straight rail at the speed of 60Km/h, the noise of the area where passenger compartment center is 1.5m away from floor should be ≤ 75 dB (A)

3) when the tramcar is operated on the flat-straight rail at the speed of 60Km/h, the noise of the area 7.5m away from train center should be ≤ 82 dB (A)

Vibration and Impact

1、 Vibration

The longitudinal, transverse and vertical vibrations of the tramcar should all conform to IEC60077 standard. If the vibration is sine wave, the frequency of the vibration should be within 1Hz-50Hz:

$$a = 25/f \text{ mm } 1 \text{ Hz} \leq f \leq 10 \text{ HZ}$$

$a=250/f^2 \text{ mm } 10 \text{ Hz} \leq f \leq 50 \text{ HZ}$

2、 Impact

The tramcar’s ability to sustain impact should conform to the IEC60077 standard: The greatest acceleration which the tramcar equipment could bear without any permanent damage or deform from every direction is } $3g$ ($g=9.8 \text{ m/s}^2$).

Safety and Fire fighting

- 1、 The tramcar has effective devices to protect personal safety from high voltage and electric equipment.
- 2、 The tramcar has good fireproof performance. All the wires and cables are flame retardant type and flame resisting type. All the equipment and fittings adopt flame retardant and flame resisting materials.
- 3、 Tramcar is equipped with fire extinguisher. Once the fire breaks out and no power supplies, the door of tramcar could be opened with the power from battery, thus passengers could be evacuated soon.

Standards

The design, manufacture and test of the tramcar should conform to Chinese standards, professional standards and relative international standards.

Tramcar Body

- Tramcar body adopted modular structure. The materials for tramcar body are low alloy structural steel and stainless steel. The structure of tramcar body is divided into two parts: power module and middle module. The modules are welded by plates and beams with low weight and high strength. The modules adopted bearing structure, whose surface is coated.
- Interior Decoration of the Tramcar: Decoration design of the passenger compartment adopts the guideline of eye-pleasant, delightful and generous appearance. Simple, comfortable and effective interior decoration would provide passengers with nice, comfortable and safe environment. The interior wall and roof are connected with and shaped by Fiber Reinforced Plastics (FRP) and molding PC alloy plate in all shapes and

standards. The materials used for the interior walls and roof should conform to the specifications of firefighting and safety according to Chinese standard. The space between insulation materials and sound insulation materials. Two longitudinal ventilating grills are lying at the roof center of power module for air-condition. Outside the grills and overhead the seats are two longitudinal lighting areas. There is no ventilating grill on the roof of middle module. Both ventilating grill and lamp shade adopt the articulated method to connect in order to conveniently clean ventilation duct, maintain and replace bulbs.

- Calculated with finite element method, all the stresses of each module are under the specification of permissible stress in both full load and overload conditions.
- Each modular articulated tramcar with 6-axis has four doors along the carriage. The doors are electric sliding doors. The effective opening of the door was not more than 1250mm, and its effective height was not more than 1850mm. The door adopted high-strength aluminum alloy materials and the interlayer aluminum is in honeycomb structure. The doors and windows use hollow coating toughened glass. The doors maintain many advantages, such as high strength, high stiffness, and low weight, good thermal and sound insulation.
- Automatic couplers are equipped at the both ends of the tramcar. The driver cabin has access to passenger compartment.
- Both sides of the passenger compartment have windows. The windows in non-frame structure should be as large as possible without effect the strength, stiffness and effective opening. The windows use safety glass, bonded to the tramcar.
- The seats in the passenger compartment are in longitudinal and transverse arrangement. Along the central line the seats are arranged symmetrically against the side walls. The materials for seats are flame retardant type and flame resisting type with antiskid surface. The handrail uses stainless steel pipe. The tramcar is not equipped with handling rings. The columns are arranged symmetrically along the center of the tramcar. The columns link the floor and roof of the tramcar, which also connect the handrail at the same level.
- The middle module has low floor which is in drive-through type. The transitional area from low floor to high floor in power module is placed with steps. Exclusive windshield

in drive-through type is placed among three different modules. There are rotating disks and split-type ferry board between two windshields on the floor.

- Under the bogie in the power module an apron board is placed, with which the low-floor area forms an integral part in order to easily open the apron board.
- The joints of three modules are equipped with rotating articulated equipment, as well as longitudinal hydraulic shock absorber on both left and right sides.
- The buffers on both ends of the tramcar are able to restore energy absorption.

Bogie

Bogies are divided into two types: power bogie and trailer bogie.

- Power bogie is two-axis conventional bogie, adopting bolster structure.
- Trailer bogie adopted independent wheel structure.
- Bogie frame was profiled steel board, adopting welded structure. The frame would not appear crack or wearing damage during its usage.
- Bogie adopts secondary suspension system. The primary suspension uses laminated rubber with V-shaped spring, which is symmetrically arranged. The secondary suspension uses rubber spring and helical spring.
- Wheels use plastic type with conical rubber insert. The diameters of the wheels are as follows:

Power wheel: 660mm (half- wearing: 640mm)

Driven wheel: 600mm (half-wearing: 580mm)

- Wheel Base: 1900mm for power bogie, 1600mm for driven bogie.
- Fundamental Brake Equipment

1、 The equipment adopts disc brake in the shape of shaft disk. The brake shoe uses synthetic materials.

2、 Power bogie was equipped with magnetic track braking system in order to meet the emergent demand for braking.

Air Braking System

- The braking system of the tramcars adopts electro pneumatic braking system.
- The brake of the tramcar is able to coordinate and combine the mechanical based braking system and electro-pneumatic braking system.

Traction and Electro Brake

- Tramcar uses VVV F inverter controlled by microcomputer to adjust the speed, ac driving system driven by squirrel-cage three-phase induction motor, and IGBT inverter components.
- Each tramcar is equipped with two VVVF inverters to control four traction motors, which is 1C2M. The inverter is the products of Hunan Xiang Yang Electric Co.Ltd...
- The controlling system of the tramcar has many fundamental controlling systems, such as traction, regenerative braking system and resistance braking system.
- With monitoring function, Traction and Braking system tests the main operation condition of the main loop and displays the information of static tests.
- Traction Motor

1. Three phase ac asynchronous traction motor has been proved to be good traction motor with great performance used in similar environment.
2. The motor uses gear coupling to connect reduction gearbox and hollow shaft, thus transmit power.
3. The insulation grade of the traction motor is H, which could prevent the temperature from surpassing the permissible temperature under the worst operation condition (overload, the lowest voltage) and the worst environmental condition.

Low-Voltage Power Supply of Auxiliary System

- **Static Inverter (SIV)**

1. Two static inverters provide 380V three-phase ac low voltage and 110V dc low voltage.
2. Static inverter has independent system to provide controlling, adjusting and protection functions.

- **Battery**

1. Lead acid battery without maintenance is adopted. Nominal voltage of the batteries is 96V.
2. Batteries are charged with dc 110V from the static inverters.

Lighting and Indicator

- The tramcar is equipped with ac lighting system. Power for ac lighting is supplied from inverter and battery. The luminosity of the area 800mm away from passenger compartment floor should not be less than 200Lx.
- Three loops are designed for lighting system, two of which are for normal lighting and the rest is for emergent lighting.
- The indicator, signal and lighting of the driver cabin should be clear everywhere when the tramcar is operated. The lighting of the driver cabin should not disturb the signal in this cabin.
- Headlight, taillight and destination light are placed. The lighting system outside the tramcar should have water proof. The inside bulb should be replaced outside the tramcar without any special tools. Metal lampshade should not be damaged by detergent.

Ventilation and Heating System

- Ventilation system should be equipped in both driver cabin and passenger compartment.
- Electro-aided heating system should be equipped in both driver cabin and passenger compartment.

Signal and Communication

- Broadcast and station report system should be equipped in the tramcar in order to provide the passenger compartment with information.
- Wireless communication system should be equipped on board. Tramcar manufacturer only undertakes the responsibility to install, connect and debug the system.

5.3 Track Design and its Construction

Design Principle and Technique Standards

1. The structure of the track should ensure the safe operation, smooth travelling and comfortable ride and have enough strength, stiffness, stability, durability and proper elasticity in order to reduce maintenance.
2. Track structure should be as simple as possible, whose components should be effective, general and interchangeable. Therefore it would be better to adopt standard components which will be easy to load and unload and convenient for construction and maintenance.

3. Based on the experiences of municipal rail transport projects home and abroad and other projects this project intends to adopt reliable and economical scheme for track structure.

Major Technique Standards

I. Route plan

- 1) Number of Mainlines: two lines
- 2) The Highest Speed of Travelling: 80km/h
- 3) Average Travelling Speed: 18km/h
- 4) Minimum Curve Radius:
 - (1) The Mainline Interval: 50 meters in general, 30 meters in difficult sections.
 - (2) Auxiliary Line: 30 meters

II. Route Longitudinal Profile

1. Route Longitudinal Gradient

- The Greatest Longitudinal Gradient in Mainline Section: 50‰
- The Greatest Longitudinal Gradient in Auxiliary Line: 50‰
- The longitudinal gradient for elevated station is level grade.

2. When the gradient algebraic difference between two adjacent slopes is not less than 2‰, vertical curve should be placed in the shape of circular curve to connect the two slopes.

3. Vertical Curve Radius: 1000 meters

4. Gauge of Track: 1435mm

5. Load: axis weight of the tramcar is not more than 11 tons; wheel base: 1900mm for power bogie, 1600mm for driven bogie.

6. The total length of one unit marshalling of the train is 28.4 meters.

7. The surface of ballast bed should be 30-40mm lower than the supporting rail surface of the sleepers. The transverse gradient for drainage in the ballast bed should not be less than 1.5%.

The longitudinal gradient for drainage in the ballast should be consistent with the gradient of the line. The gradient of level grade in the section should not be less than 3‰.

8. Geometric Dimension of Curved Track

The widening value should decrease by degrees within transition curve. If there is no transition curve, the widening value should decrease by degrees the straight line. The decrease rate should be no more than 2‰ in general and no more than 3‰ in difficult sections.

The maximum super elevation is 120mm. If the super elevation is not enough, a transverse acceleration of 0.4m/s² which is not counteracted is permitted. The curve Super elevation should be set in the way of increasing the super elevation in outer rail. See Table 5.1-1 for widening values of track gauge in curved track

Table 3: Widening values for Track Gauge in Curved Track

Curve Radius (m)	Widening Values (mm)		Track Gauge
	Low-Floor Light Rail Tramcar		Low-floor Light Rail Tramcar
200 ≥ R > 150	5		1440
150 ≥ R > 100	10		1445
100 ≥ R	15		1450

The super elevation should make linear transit by degrees within transition curve. If there is no transition curve, it should decrease by degrees the straight line.

Rail, Fastener, Ballast Bed and Turnout

I Rail

Based on the requirement the total annual weight from single direction travelling should be no more than 800 billion tons and according to *Code for Metro* (TB10082-2005) , mainlines and auxiliary lines adopt 50kg/m PD3 rails.

1) The weight of 50kg/m rail is 15% heavier than that of 43kg/m. The type of 50kg/m rail can significantly promote track strength, reduce track deformation and stress. In the same operating condition the duration of 50kg/m rail is 1.5-2 times of 43kg/m. Therefore the adoption of 50kg/m rail can extend the maintenance cycle of the rail track and reduce vibration, which can enhance the stability of the rail track and reduce daily work for maintenance. Furthermore rail can also play function as current return circuit for tractive power supply. Therefore rail of large section can enhance the conduction of electricity. Moreover Chinese rail manufacturers have not

produced 43kg/m rail as common product. The adoption of 43kg/m rail will make difficulties for material supply and rail placing. And rigid fastener 70# or arched shrapnel fastener 76# have to be adopted when 43kg/m rail is placed, which are difficult for procurement in China. And joint bars as well as other fittings for 43kg/m rail are also difficult for procurement.

2) As the minimum operation interval of long-term LRT project in Addis Ababa is 2 minutes, it is recommended to use hot rolled rail PD3 with standard length of 25m. Jointed track and common joint bar are adopted.

3) The maximum super elevation of outer rail in the curved section is 120mm. The centrifugal acceleration of 0.4m/s^2 which is not counteracted is permitted. Curve super elevation is set in the way of increasing super elevation in the outer rail, which is realized with linear transition in transition curve. If there is no transition curve, it can be realized with linear transition in the straight line of curve end.

II Fastener and Sleeper

The fastener should in simple structure and installed conveniently. It should also have enough clamping force, anti-creeping capacity, elasticity, electric insulation and can meet the requirements of adjusting distance and height, reducing vibration and noise and protecting current from straying.

After analyzing the fastener type and practical operation, railway spring bar fastener I is recommended. The static stiffness of rubber cushion is $50 \sim 70\text{kN/mm}$.

Underground track and elevated track will adopt reinforced concrete short sleeper, railway spring bar fastener I and the rubber cushion is $50 \sim 70\text{kN/mm}$.

Outside depot the concrete sleeper II, railway spring bar fastener I and rubber cushion with $50 \sim 70\text{kN/mm}$ are adopted. Inside the depot the same concrete sleeper *Design (GB50157-2003)* and relative regulation in *Code for Design of Rail Track* and railway spring bar fastener I are adopted.

According to the track condition of this project, every kilometer of the mainline and auxiliary lines will use 1520 bars of sleepers. Elevated support rail bed should use 1600 sleepers each kilometer.

III Ballast Bed

(1) Ballast Bed for Underground Track

Underground mainlines adopt monolithic track bed with reinforced concrete short sleepers. The solid track bed with reinforced concrete short sleepers maintains the characteristics of mature techniques, simple structure, long duration, simple construction and can ensure good quality, convenient operation and maintenance.

(2) Ballast Bed for Grade Track

Ballast bed with pre stressed reinforced concrete sleeper will be adopted for grade track. The double-layered gravel ballast bed has a thickness of 450mm. The layer of top ballast has a thickness of 25cm, and the layer of sub-ballast has a thickness of 20cm. The material for sub-ballast layer should be mixed asphalt ballast with a certain compaction. This layer can protect the surface of sub-grade from the gravel disturbing, drain rainwater easily and distribute the load further.

3) Elevated Ballast Bed

Elevated track adopts longitudinal bearing block type solid track bed. This ballast bed is to put precast reinforced concrete short sleeper into concrete bed. A strip reinforced concrete structure combined with support rail bed and bridge beam should be laid along the track under each rail. It has a combination of track base and beam. It also has good strength, stability, drainage performance, and conforms to the requirement of city image.

(4) Ballast Bed in Depot

The turnout area outside depot adopts the same concrete sleeper ballast bed as the grade track. The ballast bed inside the depot should adopt solid ballast bed. And the rail joint will use rubber filler stripe.

(5) Transition Section

Transition section should be set between solid bed without ballast and solid ballast bed. This section has the length of 15 meter, locating in the tunnel inside opening and on the division base between bridge and grade line. This section adopts the transition way of changing the thickness of bed ballast by degree. The height of track structure has a linear addition of 100mm.

IV Turnout

(1) The mainlines and auxiliary lines all adopt 1/6 turnout used for Chinese railway with wooden sleeper and 50kg/m rail.

(2) The depot adopts 50kg/m rail and 1/5 turnout.

Auxiliary Equipment for Tracks

I Bumper Post

In order to prevent the trains from colliding with the terminals of mainline, crossover line, parking line and safety siding bumper post safeguarding equipment is placed at the terminal of the lines. It is recommended sliding bumper post for this project, which is widely used in railway stations and metro crossover line. Sliding bumper post has a simple structure, and is convenient for maintenance. It can also be designed according to tramcar weight, travelling speed and safety requirement, and can force the tramcars to stop when the tramcars are out of control and safeguard the tramcar and passengers. In order to reduce the length of tunnel the total sliding resistance of bumper post should be no less than 20 tons.

Sliding bumper post should not be placed in curve, and no rail joint should be within the sliding range. Furthermore other line terminals adopt fixed bumper post.

II Line and Signal

(1) According the regulations in *Byelaw of Railway Transport Safety Protection* safety and protection indicators and warning are set up in the areas along the tracks and should be conformed to relevant specifications.

(2) The indicators along the track include kilometer post, half-kilometer post, hundred meter post, benchmark post, curve sign, the start and end of circular curve and transition curve, bridge post, culvert post, tunnel post, gradient post, displacement observation pile, etc.

All the indicators along the track (except property line post and displacement observation pile) should be set up on the left side of calculating mileage direction and in the place no less than 2 meters outside rail head. The indicators lower than the top of rail can be set up in the place on less than 1.35 meters outside rail head.

(3) Signals include station limit sign, warning sign, spot sign for cart citers, whistle sign for drivers, spot sign for retarding, etc.

Signals and indicators should be set up on the left side of travelling.

III Gauge Tie-Rod

In the track with concrete sleeper the road section whose curve radius is no more than 600 meters should set up insulation gauge tie-rod according to the following table.

Table 4: Number of Gauge Tie-Road

Curve Radius (m)	Gauge Tie-Rod (bar)
	25m rail
$R \leq 350$	10
$350 < R \leq 450$	10
$450 < R \leq 600$	10

5.4 Station Construction

Construction Standard

1. Major Principles

1) The guidelines of safety, reliability, economic and effectiveness are carried out in order to save energy resource and endeavor to meet the requirements of “saving investment and enhancing efficiency”. Based on these guidelines the LRT project fitting with Ethiopian domestic situation should be constructed.

2) The location of station should meet the requirements of Addis Ababa city plan and transportation, especially railway transportation network plan. Integrated with the surrounding areas and land usage, the station should be conditioned by surrounding space and arranged effectively to attract traffic flow as much as possible and to provide convenience for traffic transfer among different traffic system and to finally realize the integration of public transportation. The selection of station location should well deal with the relationship among city traffic, ground architectures, under grade lines and pipes and underground structures. The

selection of station location should try to reduce building demolition, pipes and lines relocating and the effects to ground architecture, traffic and residents.

3) The scale of station design is based on long-term traffic flow control, and is also fixed with comprehensive considerations about the importance of station location and the long-term development of this area.

4) LRT stations should provide passengers with safe and comfortable ride, and also have good interior and exterior environments.

5) Station design should conform to city master plan and city railway transport network plan, and take the link with railway hub and bus station into consideration in order to realize the integration of public transportation.

6) The location of station entrance and exit should be reasonably arranged according to surrounding environment and city plan requirement. And the locations of entrance and exit should be favorable to attract and dismiss passengers.

10) Station design should meet the requirement of non-obstacle travelling.

12) The elevated station should maintain the characteristics of modern architecture. The architecture mass should be effectively controlled; the equipment and operation modes should be simplified; the architecture shape should be concise, novel and easy to be noticed; the structure should be light, permeated and colorful.

The station should coordinate with the surrounding image in the city.

13) The decoration of the station should meet the requirements of firefighting, moisture proof, anticorrosion and scrubbing resistance.

2. Major Standards for Design

1) Ground Station

(1) the length of canopy in platform: 60000mm

(2) the width of canopy in platform: 3000mm

(3) the gradient of ramp for the handicapped: 1:12

2) Underground Station

- (1) the calculated length of platform: 60000mm
- (2) the minimum width of side platform: 2500mm
- (3) the effective vertical clearance of the effective platform length in public area: 3000mm
- (4) the vertical clearance from platform surface to rail top in public area: 380mm
- (5) the distance between the central lines of effective platform track to platform edge: 1400mm

3) Elevated Station

- (1) the distance between platform surfaces to canopy: $\geq 3000\text{mm}$
- (2) the distance between the grounds to the bottom of overhead girder: $\geq 5000\text{mm}$

3. Calculating Method for Side Platform Width

The width of side platform is fixed on the basis of the long-term traffic flow in the peak hours within the station, the interval of tramcar travelling and etc.

4. Stairs

The width of stairs should not only meet the requirement for common pass but also be able to evacuate passengers and staffs in tramcar and on the platform to safe area within 6 minutes in emergent situations.

5. The design of non-obstacle station mainly adopts ramps.

The Type and Function of Construction and Station Arrangement

The first phase of N-S route project includes 22 stations, 9 of which are elevated stations (5 elevated stations are shared with E-W route), 2 of which is underground station. The rest 11 stations are ground stations.

Overpasses to rail station shall be constructed on both sides of each elevated station. For the sake of investment cost, Pedestrian overpass is not considered; the passenger may cross the street directly on ground.

The types, platform width, station scale etc. of each station are indicated in Table 5

Table 5: Characteristics of N- S Route Stations

No	Station Type	Platform Type	Station Width (m)	Station Length/ Width in Standard Section)	Construction Area for Station Main Body/ Additional Construction Area	Elevator/ Escalator (Set)
1	Ground Station	Side Platform	3	69.2/12.8	886/0	0/0
2	Elevated Station	Side Platform	3	60/13.3	798/0	2/0
3	Underground Station	Side Platform	2.5 for standard Section / 5.2 in special section	101.6/13.4 (18.8 for the width in special section)	1708/140	2/4

The Integral Design for Public Transport

1. Design Principles

1) After design for integral public transport, LRT project can enhance the capacity of attracting and dismissing passengers in this city, provide the passengers with quick, convenient, comfortable and safe ride environment, offer a good transportation and development to the traffic convergence area in the city. And the best efficiency of comprehensive passenger transportation system in this city can be finally realized.

2) Railway transportation and conventional public transportation in passenger transportation system can be supplemented to each other and develop together in order to promote the proportion of public transportation in passenger transportation.

5.5 Summary of Existing AA LRT Technology Discussion

According to the existing technology of AA LRT which was discussed above, systems of the components were in conforming APTA’s LRT technical requirements and the Light Rail Spectrum of the literature review was also satisfied. AA LRT’s whole technology was also conforms America Hand Cup and Disability Standard.

The technology of AA LRT systems as discussed through this chapter at all systems or components there were lots of knowledge gained for designing and selection of each system since detail technical and technological issues were clearly seen. Specifically the interesting issue dealing with technology transfer was focusing on the project life cycle of AA LRT as project. This is clearly discussed on the next chapter but the manufacturing of the rolling stock was ignored to be cased because the author believes it cannot be realized to be transferred during project life but not forgot there were a lot of lessons were gained and the issue of technology transfer process was going on by legally separated entity that was not part of AA LRT project phase. Simply as said before important lesson captured regarding rolling stock was already analyzed as light vehicle or rolling stock is component of the AA LRT project.

The author also considered the signaling and power supply systems were transferred in line with the railway track development but the communication and automatic train control system parts were assumed because these were came late to the transfer realization of rolling stock according to the experience of the late developed countries like China, South Korea etc. on rail way system technology transfers.

CHAPTER SIX

6. RESULTS AND DISCUSSIONS

Following are the findings of the study based on TTLC model that consists of six stages that leads to successful TT process and the AALRT project is not exception. In order to understand the contribution of the project under consideration for TT it required to go through all the satages of the model.

6.1 Technology Assessment or Technology Approach

Introduction

According to the study conducted by ERC committee during the project initiation, the prime justification for the introduction of LRT in Addis Ababa was the provision of major improvements to public transport in the city. Particularly with reference to greatly increases:

- Carrying capacity
- Reduced pollution
- Improved speed of operation

A large number of LRSs have been built in the towns and cities worldwide during the past 40 years. Although most of them have been developed from original city tramway systems, it is equivalent to modern design of LRV comprises electrically driven carriage with steel wheels running on steel rails. Using modern technology (e.g. resilient wheels on resiliently supported rails) modern vehicles are virtually silent in operation and with low maintenance costs.

Alternative Transport System Seen During the Study for AA Light Transport System

Bus systems in dedicated lane called Bus Rapid transport is proposed but inferior in LRV's due to:

- Poor quality in ridding (passenger comfort)
- Slower speed
- Smaller capacity
- Use polluting diesel

Construction of metro system (underground railway) in Addis Ababa/Ethiopia dated now do not justified due to its extremely high cost. Therefore LRT was recommended for that it provide an optimal balance between minimizing cost of construction with an attractive alternative than to travel by bus or private car.

From perspective of traffic engineering and management LRT was also very convenient than bus systems according to the study carried on by feasibility study committee assigned by ERC.

System Requirements in LRT

The following system components of the technology were integrated to fulfill the function of LRT;

- Power supply and distribution system
- Signaling and train control communications
- Automatic fare collection system
- Track works
- Rolling stocks

After the study was carried on, the feasibility study committee concluded that the light railway for city transport service was chosen as preferred transit option for it is:

- Cost effective
- Fast
- Flexible, and
- Efficient

AA LRT Is Transit Option by Operating Requirements

From the feasibility study document studied by ERC committee, it was confirmed as suitable types of technology for city passenger transportation for that it could provide transit services according to the transport service requirements. Hence the following table compares the criteria assumed by the feasibility study committee and the criteria considered from the model.

Table 6: Comparing the criteria from the model and used during the selection process

No.	Criteria Assumed During Study by ERC	Criteria from the Model
1	Capacity	Meeting customer need
2	Operational speed	Delivery (time to complete)
3	Reliable frequent speed	Flexibility
4	Capital cost*	Serviceability
5	Operational cost*	Process visibility
6	Accessible	Easy to use
7	Noise levels	Streamlined to condition
8	Proven technology*	Consistent
9	Aesthetics	Reliability
10	Development catalyst*	Cost to acquire
11	Local industrial growth*	Cost to operate and dispose
12	Modal city	Market opportunity
13	System sustainability*	Resource available in house
14		Capabilities to adopt
15		Likely risk occurrence
16		Possible barriers
17		Newness (proven technology)

From the above table we have seen most of the critical criteria considered from the model for TT process enhancement were missed to be treated during technology selection process which was conducted by the feasibility study committee.

Categories of Transit Systems Are Reviewed Below

It was done only based on the feasibility study conducted by ERC;

Bus Systems:

- Buses in Mixed Traffic
- Buses on Dedicated Lanes
- Bus way/Bus Rapid Transit (BRT)
- Guided Buses

New Technologies:

- Rubber Tyred Electrical Guided systems

Urban Rail Systems:

- Tramways
- Light Rail Transit (LRT)
- Fully elevated Automatic Rapid Rail Transit
- Metro

Light Rail Transit (LRT)

Light rail transit has developed into a convenient rail transit alternative in the last three decades. Traditional metro (‘Heavy’ Rail) transit does provide a greater capacity than light rail, but at a much higher cost.

There are several advantages with light rail systems. These advantages have resulted in many cities in Europe, Asia, and America to decide on this technology over other rail transit technologies for their public transport systems. Some of the advantages are:

- Light rail vehicles are greatly improved from their traditional tram versions, with high, 70% or even 100% low level boarding, articulated vehicle design, improved acceleration and speed and greater horizontal and vertical flexibility than their heavy rail counterparts.
- They are readily adaptable to underground, elevated and at-grade modes of operation, and can operate in both segregated and non-segregated modes e.g. Edmonton, Minneapolis, and Calgary. They are also able to negotiate vertical grades greater than 6% and horizontal radii as low as 25 meters.
- The cross-section of an elevated guide way can be as little as 6 meters (dual) and with side platforms, the section can be a minimum of 12 meters wide.
- When segregated, the system can support automatic train control operation, providing capacities similar to that of heavy rail at a minimum of 90 second headways. This is equivalent to an increase in the theoretical capacity from 20,000 to 35,000 passengers per hour per direction.

Automatic Rapid Rail Transit Systems (ART)

Automatic Rail Transit Systems have been used for over 25 years worldwide and are a proven technology in the urban rail transit industry. Vancouver and Kuala Lumpur has the longest fully automated urban rail systems in the world. They transport transit passengers safely without the need for any manual control. This technology allows for very short headways and has a low operating cost. The ART system must be fully segregated and be protected from intrusion to

avoid damage and injury to passengers. However, the capital cost of such a system can be higher.

Metro systems

Metro railways provide the highest capacity of urban rail systems; they are completely segregated and primarily operate underground. They have a capacity of up to 45 000 passengers per hour per direction depending on the signaling technology and rolling stock being used. Stations are usually between 1 and 2km apart. They are used primarily in very densely populated areas and provide an exceptionally reliable service. However, capital costs are still very much higher.

Technology Assessment Final Recommendation

According to the study conducted by the study committee, it was considered that LRT is the most acceptable technology for Addis Ababa because LRT:

- can provide the minimum required corridor capacity of 20,000 people per hour per day
- will operate at an average speed of 30 to 40 km/h
- can provide frequent headways from the required 6 minutes down to 2 minutes and provide a reliability factor of over 98%
- can be constructed at a moderate capital cost in the range of US\$ 5 to 10million per km
- optimizes operational costs
- provides a most accessible mass transit mode
- is proven in service in similar conditions world-wide
- will stimulate commercial developments in the LRT corridor
- could assist with the creation of opportunities for local suppliers in Addis Ababa, to expand their businesses elsewhere in Ethiopia where LRT systems could be implemented
- can operate over/under grade-separated structures
- Can ‘turn short’ of the main termini in order to serve heavily used line with a more frequent service. (Also can provide ‘peak’ services at the Stadium and Meskel Square after major events.

According to the study conducted by feasibility study committee the technology selection process was arrived at proposing LRT as appropriate and acceptable public city transportation project and they were concluded that LRT service was cost effective, fast, flexible, and efficient.

The selection process didn’t elaborate the effect of each of all assumed criteria against candidate technologies. Each alternative technology was not subjected to all critical criteria on the step by step bases in the same way. It would have been better if technology assesment have been done by listing the criteria and the rival technologies in the same table to justify the appropriatness of the technology in line with the listed criteria as shown below in the table 7.

Table 7: The criteria relation with each technology candidate

No.	Criteria to be considered	BRT	LRT	Metro	ART
1	Meeting customer need				
2	Delivery (time to complete)				
3	Flexibility				
4	Serviceability				
5	Process visibility				
6	Easy to use				
7	Streamlined to condition				
8	Consistent				
9	Reliability				
10	Cost to acquire				
11	Cost to operate and dispose				
12	Market opportunity				
13	Resource available in house				
14	Capabilities to adopt				
15	Likely risk occurrence				
16	Possible barriers				
17	Newness & (Proven technology)				

Before making decision in proposing the chosen technology the above table must be filled by going through serious analyses to prioritize the criteria for each rival technology. The decision process could be performed using any relevant decision techniques and software.

6.2 Focusing on Technology and Supply Selection

Customer Value Enhancement

AALRT project was again checked and rechecked to see how it enhances customer values. In order to make sure this the contribution of technology owners having tough project accomplishment to the following merits:

- offer reasonable price for service
- give high level of comfort
- provide good transport alternative by reducing waiting time for transport and time along journey

Thus the above conditions could be satisfied if only the project accomplishment performance of the contractor could be accomplished in line with the schedule. The Chinese company CREC project accomplishment in terms of speed to complete the schedule slippage was only less than one year over the project target duration and also this dalliance was not due to reasons aligned with the contracting companies but it was due to employers’ weakness in solving right of ways and other issues according to the performance report surveyed from the project office.

Technology Components

Components of technology that were proposed to be transferred during the feasibility study by study committee whatever it was hard or soft technology was analyzed at this stage. According to AALRT project conceptual design the following hardware parts of technology were given attention for assessment:

- track work
- rolling stock
- signaling and communication
- fare collection, and operation system

According to the assessment made, in all of documents which were studied by consulting firms or anybody assigned by ERC or steering committee of ERC, only the rolling stock components of the technology were assumed as preferred TT focused areas in long term strategic plan. This could be said because they tried to give the direction for the government to manufacture the rolling stock in long term strategic plan. Accordingly the government did all the necessary preparation for manufacturing of rolling stock. For doing this the locomotive manufacturing industry was already established under EPRDF METEC and exerted lots of efforts in doing the same.

Extent of Technology of Available In-House and Gaps Bridged

- There were almost none railway engineering professionals available at the beginning of the project that of course have too much role during TT process in AALRT project.
- Materials that are used for concrete work are fully available in-house as more of track work is making use of it. But the way to manufacture pre-stressed re-enforced slippers and concrete girders could be bridged during project execution. Hence the knowhow of such technology was part of TT process which ultimately bridged.
- Companies like METEC, MIE Co Ltd and other similar companies, private GC Grade I Contractors, and other companies may have enjoyed an opportunity to work with the selected foreign company. On the other hand the absence of companies working on electric and communication system area were become a problem to create a linkage mechanisms.

Selection of Suppliers for Technology

Technology transferor is examined and thoroughly assessed in the following basic issues particularly with respect to TT achievement before reaching an agreement.

- business strategies
- socio-economic perspectives
- technological capabilities
- experience in handling TT projects
- past performances
- cross cultural expertise

In the case of AALRT project the Chinese company CREC was selected to design and build the project. Thus critics regarding the selection process against TT process were made according to the above setting.

First this company's business strategy was not set to make TT rather its ultimate goal was to accomplish simply the physical ensues of the project according to the project schedule and the final design. It had no any more experience on TT project from past performance information even though it had good technological capabilities. And though it had reputable project

performance history, the expertise cross cultural setting were not suitable for TT process as there was great language barrier observed.

The developer of this technology was preferred by the government from the priority given towards socio-economic relationship between Ethiopian government and the Chinese government and at the same time the readiness and suitability of the financial source of that country since the 85% of the cost of investment was targeted to be arranged from loan outside this country according to the data obtained during conducting interview with top management body of ERC.

Therefore business case development analysis was carried out with:

- ✓ no clear technical specification
- ✓ no DCF analysis carried
- ✓ no project justification in case of TT
- ✓ But there was simple business plan development

Thus the technology focus was activated and being focused from the results such as convenience of financial source for loan and the good relationship for socio- political economy between the two countries and other matters which were affirmatively concerned.

The discussions of the critical issues contributing in enhancement of TT process were summarized in the following table:

Table 8: The criteria contribution to technology focusing

No.	... to be considered during focusing technology	... considered during study by ERC
1	What technology component from where...	Not considered
2	Ability to use in-house resources and capabilities (technological)	Not elaborated
3	Business strategy of transferor	Not justified
4	Technological capabilities of transferor	Considered
5	Experience of handling TT projects	Not presented
6	Past performance history in same issue	Not described
7	Cross cultural expertise	Not justified
8	Impact of the technologies in competitiveness	Not elaborated

6.3 Negotiation and Effecting Agreement

Through serious of discussion an agreement on the following must be reached and should be clearly stated on contract document regarding TT process:

- ✓ Payment for TT
- ✓ Intellectual property protection
- ✓ Parties contribution during TT process
- ✓ Codified and un codified technologies for separate treatment
- ✓ Channels of communication during TT process
- ✓ Mechanisms, channels, and modes for TT process

According to existing AA LRT project agreement and current contract document, nothing was said up on payment condition for TT; which means because of there is no payment, there is no enforcement for TT achievement. In Ethiopia there is intellectual property right protection so that it could not be seen as a series problem for TT transferor. In the contract document, the parties' contribution, responsibility and mandate or scope in any areas of the technology for the project is not clearly stated. Therefore, it could be said no transferee in this context of agreement.

Moreover, Codified and un-codified technologies were not determined and defined in the contract agreement. Coded technology in AA LRT could be defined as the technologies which are not freely available to any or couldn't be disclosed freely but could be used for the purpose of requirement according to special treatment made on patent right which put in contract document by justifying it.

With regards to channel of communication between parties; it was not clearly stated in the contract agreement, in which the transferor and transferee pass through for the process of technologies to be transferred and followed strictly to the interests of both parties in addressing core concepts. Therefore since there is no established channel for communication the transferor has no or little incentive if there is any to be transparent regarding TT process.

As evidence from observation of the documents relating AA LRT project in ERC shows, in any cases there was no Government policies change made for the sake of inducing any possible barriers in achievement of TT process during AA LRT project implementation.

Finally, any mechanisms, channels, and modes of TT process were not proposed as part of contract agreement. There was no joint venture local company in contract document, no any sub contract arrangement for local companies and firms in any areas of subcontracting works, and also no local suppliers considered on AA LRT project’s contract agreement and this is also reflected during project execution except the supply of extreme local materials like gravel, sand, cement and rarely power cables.

6.4 Technology Transfer Implementation Plan

In this section the plan of AALRT project contribution towards TT process has been discussed as implementation was started by establishment of tough organizational structure that was focusing on receiving the technologies. The following main deals were synthesized and had been put in the plan:

- ✚ Changes made during the planning process that were identified
 - To organizational structure to suite TT process
 - To work and design process to suite TT process
 - To knowledge management scheme
 - To policy regimes to accommodate TT
- ✚ Pragmatic training and education schedule for work force that matches component of transferred technologies
- ✚ Relationship formulated between parties
- ✚ Realistic TT process implementation plan
- ✚ TT Milestones that were specified

According to the reviewed plan and action taken during process for the planning of AA LRT project, TT process matters relating to the above points of discussion were addressed and well discussed. In the process of planning where project organization plan, what were the work design changes experienced, how knowledge was managed, what ERC policy was changed in this regard should be adressed. Thus the result indicated us the work of technology transfer process was disdain on these issues.

The training for staffs has been clearly stated in the plan of the ERC and accordingly on job training was organized and also training in china for the selected staffs was conducted.

The organizational structure of AA LRT project didn't incorporate the direct engagement of AA LRT TT process unit/team, as a result no significant modification was carried out as it was required to be done. Though there was little design modification that creates new area of knowledge; it was not done because of the exclusion of TT process unit from its organizational structure. Moreover the knowledge management scheme and provision for policy change of ERC were not included in the plan. The plan didn't indicate the technologies and areas of it for informally addressing the TT as well as didn't include systematic implementation strategy that enhances TT.

6.5 TT Process Implementation during AA LRT Execution

As these phase requires well and organized project management work, issues of discussion here revolves around the management issue. Since tough organizational structure was assumed to be developed and verified in the previous discussion, the main focus was given to make well organizational and personnel arrangements to receive the technologies. Accordingly the following main activities were seen seriously as points of discussion;

- ✚ Identification of changes made to suite local condition for making necessary adaptation
- ✚ Assigning of personnel not existing or training arrangement for existing staffs.
- ✚ Training conducted during project implementation
- ✚ The local persons/experts assigned in project execution
- ✚ Developed remuneration to facilitate change management
- ✚ Evaluation and monitoring program at project, corporation, and country level

From observation and survey of data like reports from different sides of AA LRT project actors and also project office archive, there were no significant changes made to suite the local condition for the purpose of TT process achievement and the adoption of this technology.

The personnel assigned and the pragmatic training conducted during project implementation was summarized in the following tables. The table for personnel work assignment data was not filled completely as this data was not readily available. But from the interview conducted with project office engineer, work categories entitled as #1 professional expert while #2, #3, #4, #5, #6 and #7 deploy more local personnels that were mostly unskilled and semi-skilled. So that inevitably this was brought the skill acquisition in some extent and the level of it wasn't quantified at this

study scope due any other limitation like data, scope & rating factor valuation which was not treated in this paper. Thus, it could be considered as spill over of the project which is beyond the scope.

Table 9: Personnel assignment to work category/task of the project

No.	Description of the work by categories	No. DL	No. skilled & semi-skilled	No. Professional experts	Total local persons	Total person involved
1	Office engineering work					
2	Track line bed and ballast work					
3	Track line concrete work					
4	Girder manufacturing work					
5	Slipper manufacturing work					
6	Slipper & rail fixing work					
7	Other accessory civil works					
8	Power supply line work					
9	Signaling and train control work					
10	Rolling stock commissioning work					
	Total					100%

The training which are directly related to the study topic were eighteen titles out of total twenty titles and these eighteen titles were summarized as development, engineering, construction, operation and maintenance planning and management of rail way systems project in general and also specifically on electrical and mechanical system of rolling stock, signaling system, control system and fare collection system were given in abroad and total of five training titles which were transformational leader ship, customer service, maintenance planning and management, office management and graphics design were given locally.

Table 10: The training conducted on AA LRT

FOREIGN TRAINING CONDUCTED	Quantity	LOCAL TRAINING CONDUCTED	Quantity
Total training title	18	Total training title	5
Training Hrs by title	2334	Training Hrs by title	750
Training Hrs by persons	16722	Training Hrs by persons	3006
Total Persons trained	102	Total Persons trained	63
Hr by person over Hr by title	7	Hr by person over Hr by title	4

There was no remuneration arrangement for employees to enhance TT process achievement and also there is no the monitoring and evaluation activities made with regard to TT process achievement with respect to level of management body according to the report surveyed in project office. Likewise; as per the execution report, there were no any comments on strength and weakness regarding the process of TT during the AA LRT project execution at the project office or ERC head office.

From the personnel assignment to work categories as discussed above in the table and training conducted as also discussed above, the office work related activities like how to design the rail track system and how to select the rest of the rail transit system and field work activities like fixing and building rail track line system, and operation and maintenance of it at some level were a source for the generation of the new skill and knowledge for the local persons. But it is not to say these skill and knowledge were fully realized since the study approach and technique didn't tell us or not in approaching the level of realization rather simply describing the new knowledge and skill generated from the evidence obtained during interview with the AA LRT project office.

6.6 Technology Transfer Process Impact Assessment

In this section TT process impact of AA LRT project will be discussed as follows:

- New area of knowledge created in how to design the track profile and select the technologies in railway systems including skills, experts and management were become

familiarized about specification of the rolling stock and hence able to select the acceptable system in suiting the local condition.

- Even though there were a number and a type of skills and knowledge generated after the project execution, it was not well discussed and elaborated briefly because of data limitation and thesis work budget limitation.
- Local firm specialization emerged or company evolved: even though not realized at AA LRT project ending time, manufacturing partially the rolling stock at METEC locomotive manufacturing industry was doing a lot of arrangement and preparation to manufacture the locomotive for the LRT and metro systems.
- Lessons conduced: it was believed that the stakeholders learnt a lot after wards from the technology transfer perspective even if that was not done well before, during and after the project.
- New technology proposed was not defined.
- Internal development realized: from the observation of the assessed document the ERC office capacitates itself organizationally now because the agreement entered with other Chinese company for operation of the already built technology was from the fear of not to repeat the TT incompleteness in achievement during execution of the project.
- Partnership with technology owner strengthened: from perspective of evaluation in achievement of TT ERC should have to say something that about this company’s relationship because of the success exists in it but since not the reverse was predictable.

6.7 Technology Transfer Mode and Mechanism Analysis the Case of AA LRT

Contract was entered between ERC and CREC to design and build AA LRT project of the whole package. The project was categorized under turn-key project as the contractor could perform every of the work to the convenient of the client ‘ERC’ and finally gives “key” by the final stage at which the whole systems of the project were ready for function i.e. to on the key for operation. This contractor or builder gave the component or sub components of the work for other companies and hence they were described on the following table below.

Table 11: Mechanisms of TT in AA LRT

No.	Description of the technology	Contracting company relation	Mode/Mechanism linkage	Justification
1	The whole AA LRT project as turnkey	CREC – ERC	Main or root contract	Chinese with client(ERC)
2	Manufacture, supply and commissioning of rolling stock	CNR – CREC	Joint Venture	Chinese with Chinese
3	Designing, developing standards, and future manufacturing set up for rolling stock	METEC – ERC	Turnkey	Local with Local
4	Signaling systems work	CASCO – CREC	Sub contract	Chinese with Chinese
5	Communication system work	HUAWEI – CREC	Sub contract	Chinese with Chinese
6	External Power cable supply partial	METEC – CREC	Supply	Local with Chinese
7	External Power cable supply partial	BMNET	Supply	Ethiopian based turkey with Chinese
8	Supply, installation and commissioning of traction and electro brake control system	HXYEC	Supply	Chinese with Chinese

Also as we have seen from the table the critical technologies (rolling stock, signaling, communications and traction systems) in AA LRT project were delivered by other Chinese companies which were out sourced. Where us the main contractor was responsible to manage the

whole components of the project and development of the infrastructure like sub grade work, concrete works of over pass and under pass track line, manufacture and laying of pre stressed concrete girders ,manufacture and fixing of pre stressed concrete slippers, supply and fixing of rails. From this observation the main contractor works out strongly on technologies which were locally suitable and copied with short period of time. Regardless the huge cost share and suitability of the technology (development of infrastructure) to be transferred in short duration, there were no linkage of local companies as it was seen from table above.

From the table only #3 and #6 issues that assist TT process wisely were linked to the local companies. In literature review such phenomena was given emphasis for that it had a great contribution during TT process implementation.

6.8 Summary of the Major Findings

From the discussion made so far concerning the contribution of AA LRT project for the technology transfer we have come up with the following findings:

- The technology searching, identifying and selection process was made and decided to select LRT as Addis Ababa city passenger transport option. However, during the selection process more criteria listed for the TT process were not considered.
- While making the selection of technology owner, the priority was given to financial issues (cost and availability) without considering the success history of the technology supplier. This is mainly said because the supplier of the technology have no anymore history on technology transfer and not exist at its technology saturation phase. Moreover the financial sector of the host country as well as the government is eager to have access to soft loan meant for the purpose from information obtained through interviewing top management body of ERC .
- On the contract agreement there was no detail regarding the level and scope of technology transfer and there was no proposed mode and mechanism of technology transfer and which is contractually binding. Given this, it can be easily inferred AA LRT project was not TT project.
- Because agreement made between the two parties lacks official TT agreement, and hence there was no formal TT plan. However; the informal TT plan would have been there

which in the analysis made so far there is nothing that could be come across. Therefore, these inevitably confirm TT process achievement which was ignored in this case.

- Informal TT team was not established that went foot by foot of the technology owner to informally addressing TT in desired areas.
- From overall project implementation process there is new knowledge and skills which is generated but not to say fully realized since the study is not in approaching the level of skill or knowledge realization rather simply describing new knowledge and skill generated according to the above discussion. These include: how to design rail track system, how to select rolling stock, power system, signaling communication, how to manufacture slippers and concrete girders, how to fix tracks and other concrete works, how to construct sub grade structure, how to operate somehow since the personnel were assigned. This all skills and knowledge generated come to function and serve country if utilized and engaged in work deliberately in well-structured and well organized way.

This is possible by establishing the TT Division in the office of ERC.

Many European and other developed country companies are keen to enter the developing countries market and develop long-term partnerships. In order to achieve this, they are often willing to transfer their latest technology to developing countries subsidiaries of developed countries firms and joint-venture partners. Such technology transfer may unwillingly result in a loss of competitiveness and market share in the mid to long term. Therefore ERC should pay particular attention to the following common situations:

1. Joint ventures

For access to the countries market in some sectors, such as developing railway system, manufacture of railway locomotives and rolling stock, foreign companies must enter into joint ventures with these countries companies. Approval to form a joint venture or to operate may depend on the supply of specific technology, including future improvements of this technology

2. Design institutes

For many projects, in particular the development of rail track, the manufacture of rail automotive and rolling stock, wide-ranging review of industrial drawings and designs by Ethiopian design institutes are mandatory. These drawings and know-how may later be used for other projects which wish to duplicate and use the design in other locations of country. In addition to

transferring detailed technical documentation, foreign companies often have to train Ethiopian staff so that, in future, they can design it independently.

3. Contracts/procurements

In order to take part in public tenders, foreign companies must ensure that part of their production is local (in some cases this can be up to 80%) especially in china's technology transfer case from European mostly like Germany. Production by foreign subsidiaries in Ethiopia is can often not considered as local. Instead, foreign firms have to work with an Ethiopian general contractor/company, to which their technology has to be transferred in full.

4. Certification and licenses

Many products or systems have to be certified by an Ethiopian certification institution or are subject to a license by an Ethiopian Certification Authority before they are allowed to be introduced or used. Some certification procedures require inspections of production plants in right holders' home countries. In some cases, the Ethiopian or other foreign hired inspectors may come from competitor companies and they may ask technical questions which are not strictly necessary for certification.

CHAPTER SEVEN

7 CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The study demonstrated how the AA LRT project contributes to the technology transfer process. This was achieved through by selecting the process based TT model. Using the selected model the research was conducted and hence drawing a conclusion from the above discussion accordingly.

From survey of the existing technologies put on ground that is in this case AA LRT project, the technology embodied and the built systems were clearly seen in suiting the conceptual design of it become a witness for it was the result of a scientific justification and great work indication. But this could be become a beneficial public project accomplishment in every dimension and in all aspect but in this case not since importantly things that were relating to TT process were not done well and thus it would have been even better to be backed up with sucessful TT achievement then after.

For the method to consider the AA LRT project’s technology transfer contribution, the qualitative process based TTLC model was selected by introducing a little modification from the literature review findings and by addressing the drawback of other qualitative models. Under the identified criteria’s in the model, the way of AA LRT project’s contribution for technology transfer process in Ethiopia was assessed and the following results have been obtained: technology assessment and selection process missed most of the criteria in favor of TT process, technology supplier selection show biasness on financial issue, there was no agreement & plan for formally addressing technology transfer process, and hence there was no mechanism & mode for technology transfer process to local firms except the main contract and contract for partial supply of external power supply cable. Moreover, there was no informal technology transfer plan and team or committee assigned. In general the formal TT agenda and informal TT agenda along a process could not be addressed well since there was no formal negotiation on TT process as well as there was no plan and organized staff or committee and there was no strategic implementation direction to informally realize and achieve technology transfer in AA LRT

project. Likewise there was no especial focus given for technology transfer on component of technologies.

During the project execution as a whole the technologies and skills, knowhow, and knowledge were realized to some extent especially in areas of design & construction of tracks and station with its facilities, selection of rolling stocks and signaling & communication and how to manage the whole system somehow since more local personnel were assigned and engaged there.

7.2 Recommendation

From the above findings, it is recommended that for the public projects implementing body or agency or corporation it was for the real benefit of that country to think another dimensional scenarios' like technology transfer during operation on similar projects or any other public projects. Also the technology transfer process from early stage of project initiation phase would have been properly handled well to learn a lot of lessons and to address the desirable development objectives of a country in sustainable manner. The selected and modified TTLC model and the factors and critical criteria identified from the model would have contributed a lot for TT process achievement and better again to work strongly on it.

For ERC, the recommendation was skills and knowledge generated from the implementation of AA LRT project could be optimally serve the country by utilizing and engaging in work deliberately in well-structured and well organized way. To do this the TT process team or division under ERC Corporation would have to be established and would be responsible for TT process in every contract accomplishment.

For similar public projects to enhance TT process achievement JV or any linkage mechanisms for local companies can be arranged, local design institutes would be established, in contract agreement specific amount in percentage of the whole work or product would have to have a local input or technology, and the quality assurance or product certification procedure would have to have significant local expertise or knowledge involvement.

7.3 Limitation during the Thesis Work

The study was conducted using qualitative model and analyzed qualitatively. This needs in any of the most cases the secondary data from different sources and actors of the project. Since this is highly appreciated in requirement of availing information or data from the important sources and responsible body, the task was not easy and followed by cumbersome tactic. But during the work of the study a lot of shortcomings and difficulties were happened. From these, one is the lack of organized documents in the office which was cased. The second was the persons asked for the document were regularly feel the busy zone and as the result response was delayed. Thirdly, the willingness problems also observed and faced.

The other limitation areas were lack of the documents of similar previous work on the similar culture and environment and problems of literatures on similar TT public projects cause time constrain as the work started from the scratch.

7.4 Future Work

The technology transfer life cycle approach is a very important tool or model for transferring technology from process based point of view as it is holistic it is convenient and could be applied on the other public projects or any other projects. Since it composes six stages which comes one after the other sequentially flow according to project process phase with having detail criteria to measure TT or factors responsive for TT in each stage, very important to work strongly on it. Therefore as said above it is again important to ratify the stages and criteria in each stage using appropriate method of analysis. Thus weighting each stage using criteria in it by weighting the criteria also to measure how importance of one over the other so to analyze the TT quantitatively can be a future work.

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