

Successes and Failures of Sri Lanka Railways in International Technology Transfer

D. G. Hemachandra and A. K. W. Jayawardane

Abstract: This paper analyzes successes and failures of two foreign funded international technology transfer (ITT) projects carried out for Sri Lanka Railways (SLR) using an integrated conceptual model which is a combination of the concepts of technology capability enhancement, polytrophic components of technology, Stage-Gate model and Seven factor model.

The results show that the project implemented in 1959 was successful due to the selection of appropriate technology, suitable technology supplier and high level of commitment of the transferee.

However the recent ITT project implemented in 1997 was a failure since the transferee was unable to enhance the technological capabilities to the required levels. Poor acquisition process, lack of knowledge & capabilities in modern technologies and low level of commitment of the transferee were the major contributory factors for the failure in ITT.

Due consideration in selecting the technologies and getting all components transferred at appropriate levels was found to be vital for effective technology transfer, since the "State of the art technology of the transferor need not always be the most appropriate technology for the transferee".

Present regulations and the guidelines enforced for the procurement of goods and services do not focus on the technological aspects to guide successful technology transfer. Therefore the public sector needs a more "comprehensive check list" to evaluate and select appropriate technology suppliers and a "Steering Committee" to effectively implement international technology transfer projects in addition to the usual Technical Evaluation Committees and the Tender Boards.

Key Words: International Technology Transfer, Successes and Failures, Technological Capability Enhancement, Sri Lanka Railways.

1. Introduction

Sri Lanka Railways (SLR) has been playing a major role in land transport in Sri Lanka since its inception in 1864. It has been operating profitably until about 1945 except for a brief period from 1935 to 1940. Since then SLR has been making operating losses and now the operating losses have exceeded 150%. Further, its market share has reduced due to competition from road transport. However, it has to continue its role in fulfilling the social, economic and political needs and expectations.

Rail transport systems mainly consist of Infrastructure, Motive Power and Rolling Stock and Operation & Commercial activities. Therefore, various technologies of all major engineering disciplines have been used to achieve the business objectives of SLR. Since such technologies connected with infrastructure, motive power and rolling stock have not been developed in Sri Lanka, International

Technology Transfer (ITT) is a vital factor for SLR, in its survival and development.

Existing procedures for purchasing of equipment have not been able to guide the ITT projects in SLR, in order to meet the needs and expectations. Therefore, the absence of a formalized criteria and guidelines has caused the technology transfer to be incomplete and inappropriate in some recent ITT projects thus preventing the technological capability enhancement and making the investment unjustifiable.

For example, one of the factors which has contributed adversely on the performance of SLR, besides the road competition and disturbances, is "excessively varied and some

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times 'ill advised' equipment purchasing policies driven by foreign assistance where the technology choice has imposed an impossible maintenance burden and inventory requirement on the SLR" [1].

The problems of SLR have been accumulated in the past due to purchasing of plant and equipment based on the availability of credit lines rather than justifying them economically or operationally [1].

Also, SLR has not been able to provide a satisfactory passenger and freight service even after spending huge sums on infrastructure, motive power and rolling stock [2].

It is extremely important to give due consideration to ITT when making heavy investments since the influence of technological capability on the long term objectives is critical.

Therefore, identifying the drawbacks of the previous ITT projects and formation of guidelines will help in solving one of the biggest problems in the SLR.

With the above background a research project was implemented to review successes and failures of International Technology Transfer Projects carried out by the SLR, to identify the factors that affected the ITT of Signalling technology and to develop better guidelines for successful ITT in the future.

This paper provides the key findings of this investigation together with the broad guidelines developed. *The same guidelines can be used for other public sector organizations as well.*

2. Technological Capabilities and Technology Transfer

2.1 Understanding Effective Technology Transfer

Technology Transfer is an important business strategy today because the technology provides the competitive advantage for a firm or a nation in producing goods and services.

Technology Transfer (TT) can be referred to as technology flows or diffusion of technology which implies movements of technology from one entity to another. Further, it states that if the receiver does not understand and use the

technology effectively, the transfer is considered to be incomplete [3]. However, the introduction of technologies effectively into the organization and reaping the benefits is more complex [4].

The term 'international technology transfer' is used as the equivalent of the acquisition of the technological mastery from the foreign sources. Although there are several ways to look at technology it may be defined as knowledge and methods, which are necessary for the implementation and improvement of the existing ways of production of goods and services. It follows that technological capabilities refer to the ability to comprehend, utilize, adapt, modify and develop technology. Thus technological mastery is achieved when technology recipients have built up technological capabilities [5], to use local labour force of the recipient country to effectively utilize, adapt and modify the transferred technology. In such situations the imported technology is fully absorbed by the local workforce [5].

2.2 Assessment of Technological Capabilities as a Measure of Successful TT

Technological capability enhancement can be considered as a measure of determining the success of an ITT project and, hence, it is important to consider what specific capabilities are required for a particular firm to succeed.

Even though a firm can purchase technology resources, technological capability has to be gradually acquired by self-learning, because it is not an item tradable in the market. It is also important to mention that 'self learning' which is an outcome of commitment, plays a vital role in enhancement of technological capabilities. Therefore the recipient's commitment is essential in successful TT [6].

The TT capabilities required for a productive enterprise can be considered as follows:

1. Converting/Transforming capabilities: Technology needed to convert input to output/products.
2. Acquiring capabilities: capabilities needed for the successful acquisition of Technologies.
3. Vending capabilities: Technology needed for marketing and servicing.

4. **Modifying capabilities:** Capabilities needed for modifying and improving the technology.
5. **Generating/Innovative capabilities:** Capabilities needed for technological innovations.

It should be stated that every business does not require all these capabilities at the highest level. Even though the capabilities have been specified for the productive sector, they can be applied to the technologies related to the infrastructure and service sectors as well.

In order to have successful transfer of technology, the recipient firm should identify the technological capabilities that should be enhanced and their minimum levels.

The capabilities described above are analyzed further and modified to suit the infrastructure sector.

2.3 Review of Technology Components as a Measure of Technology Transfer

Purchasing hardware alone is not sufficient to gain the types of capabilities described above, but different levels of capabilities need different technology components at different levels. Enhancement of technological capability levels of a recipient also depends on his needs and capabilities.

The knowledge required for modifying and refining the technology is much more than the knowledge required for operation and maintenance of the technology [7]. However, the different levels of the knowledge required will have to be decided by the receiver, according to his capabilities and expectations.

The definition of 'Polytrophic components' of manufacturing technology identified as Technoware, Humanware, Orgaware and Inforware can facilitate better management of the technology transfer process [4].

Technologies in the service sector and infrastructure sector also have hardware (technoware) with controlling devices; operating and maintenance personnel; information related with operation, maintenance and modifications; and the organizational work.

Therefore polytrophic components can be applied with little modifications for the analysis

of the components of the signalling technology too, as mentioned below.

Technology Components as Applicable to SLR

TECHNOWARE

1. **System components** - All hardware needed for successful implementation and operation of the signalling system and all software in case of computer controlled systems.
2. **System tools** - Tools, testing equipment, measuring instruments needed for installation, operation, maintenance, upgrading and training of personnel.
3. **Spare parts** - Minimum spare parts required to operate the system for an agreed period.

HUMANWARE

1. **Contact humanware** - Operating personnel
2. **Support humanware** - Maintenance personnel
3. **System humanware** - Personnel for developing the system.

The component of system humanware is a new addition to the standard components of humanware to suit service sector.

ORGWARE

Since the items described under orgaware are already available with SLR the orgaware component is not considered in this analysis of assessing the transferred level of technology.

INFORWARE

1. **Technical Specifications**
2. **Operating Instructions**
3. **Maintenance Instructions**
4. **Installation Instructions**
5. **System design information**
6. **System Management Information**

2.4 Technology Transfer Process

Skillful management of the technology transfer process is important in order to harness the maximum benefits from the technology transfer because the technology does not transfer automatically once a transfer channel has been



sought. Negotiating capability and knowledge of the receiving party can improve or worsen the terms and conditions of the transfer [5].

Stage-Gate model has been used successfully by Jagoda and Ramanathan [8] for TT projects.

The same model has been modified by Ramanathan [9] for the application of TT in the private sector; therefore the Stage-Gate model can be further modified to suit the TT process in the public sector. Table 1 shows the modified Stage -Gate model to suit the TT process in SLR.

2.5 Other Relevant Factors Influencing the International Technology Transfer

As discussed earlier, the process plays an important role in successful TT in order to ensure the acquisition and assimilation of all relevant technological components which lead to the enhancement of technological capabilities to the required level.

The seven factor model describes seven major factors affecting TT [10] irrespective of the type of project, whether manufacturing, infrastructure or service because these factors are common to any sector.

These seven elements are as follows:

1. Transferor
2. Transferee
3. Technology
4. Transfer mechanism
5. Transferor's environment
6. Transferee's environment
7. Greater environment

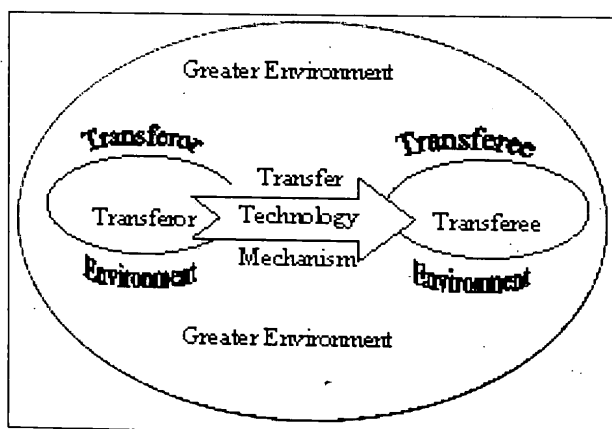


Figure 1. Seven Factor Model

The success of any TT depends on the selection and manipulation of the aforementioned factors. A Diagrammatic form of the Seven Factor model is shown in Figure 1.

2.6 Integrated Conceptual Model for Successful Technology Transfer

Based on the above discussion, successful TT can be conceptualized as shown in Figure 2.

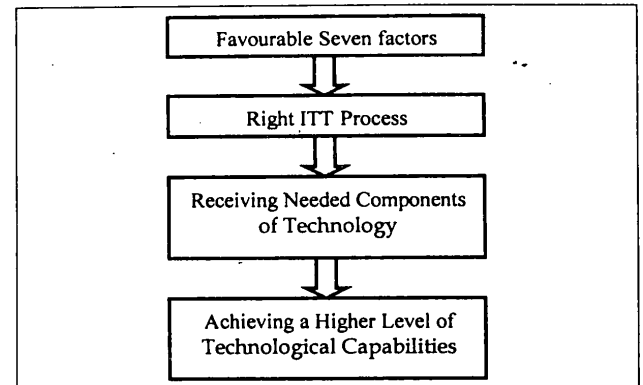


Figure 2: Integrated Conceptual Model for Successful ITT

3. Research Design and Implementation

Success of a Technology Transfer (TT) project depends on the level of technology capability enhancement of a firm after acquiring the technology. The transferred technology components and their levels are vital factors in gaining the expected technological capabilities. Even though the expected levels of the above requirements are at higher levels, the TT process and the influence of the relevant factors can affect the end results greatly.

Therefore it is necessary to have an integrated approach in analyzing the ITT projects. As such this study used a research design consisting of four steps as shown in Figure 3.

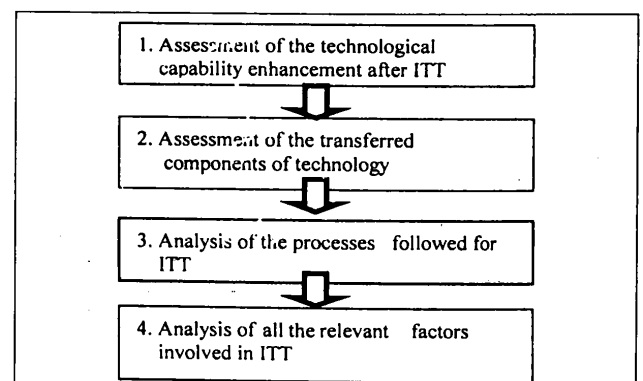


Figure 3. Integrated Conceptual Model for Analyzing ITT Projects

3.1 Data Collection and Analysis

Necessary data were collected on the following ITT projects carried out under foreign assistance.

- Introduction of Colour Light Signalling in suburban railways - 1959
- Rehabilitation of Signalling on the Coastal line - 1997

The following documents were used for data collection.

- Project proposals, relevant correspondence, evaluation reports and the contract agreement.
- Annual reports, Standing orders and fortnightly notices issued by the SLR.
- Working timetables.
- Minutes of the operational review meetings.

Further information was collected to supplement the above data by interviewing twenty three persons at various levels in the relevant sub departments in SLR and six persons retired from SLR. Out of the twenty nine personnel, seven were senior executives, eleven were middle level executives and the balance were operating level officers.

The following Tools and Models were used to analyze the data found in the above projects related to Signalling technology in the SLR.

1. Assessment of the technological capability enhancement

Technology Capability Assessment Score method given in [6] was used to assess the technological capability enhancement after the ITT.

2. Assessment of the transferred components of technology

Polytrophic components described by Ramanathan [4] were used along with a suitable marking scheme for meeting the requirements of the SLR.

3. Analysis of the processes followed by SLR for ITT

Stage-Gate Model given by Ramanathan [9], which is a modified version of Jagoda and Ramanathan model [8] was used, to analyze the process followed by the SLR.

4. Analysis of all relevant factors involved in ITT

Analysis was carried out using Seven Factor Model considering the entire scenario [10].

4. Research Findings

Table 2 shows the summarized results of the assessment of transferred technology components after implementation of the TT project.

Table 1: Implementation of Stage-Gate Activities for TT Projects in SLR

	Activity	Responsible
Stage 1	Identifying Core Value Determinant enhancing technologies	SC
Gate 1	Confirming identified technologies	
Stage 2	Focused technology search	
Gate 2	Project confirmation	LM/NPD
Stage 3	Negotiation	TEC/TB
Gate 3	Finalizing and approving agreement	TB/CATB/COM
Stage 4	Preparing a project implementation plan	SC
Gate 4	Approving implementation plan	
Stage 5	Implementing technology transfer	
Gate 5	Implementation audit	
Stage 6	Technology transfer impact assessment	
Gate 6	Developing guidelines for new project	

SC Steering Committee

TB Tender Board

LM Line Ministry

CATB Cabinet Appointed Tender Board

NPD National Planning Department

COM Cabinet of Ministers

TEC Technical Evaluation Committee



Table 2: Assessment of the Transferred Level of Technology Components

Component of technology	HLE	Case1			Case2		
		MLE	LA	Remarks	MLE	LA	Remarks
1. Technoware	5	3.88	5.00	Above	3.88	2.77	Below
2. Humanware	5	4.16	4.16	MLE	4.16	3.30	MLE
3. Inforware	5	3.33	3.58		3.33	1.58	
Total	15	11.37	12.74		11.37	7.65	
Technology Transfer (Average)	5	3.79	4.24		3.79	2.55	

HLE - Highest Level Expected MLE - Minimum Level Expected LA - Level Achieved

Note 1: See Exhibit 3 for Marking Scheme for Assessment of Transferred Components of Technology

Table 3 shows the results of the assessment of the capability enhancement after implementation of the TT project.

Table 3: Assessment of Capability Enhancement

Status of Technology Capabilities	HLE*	Case 1		Case 2	
		LA**	Remarks	LA	Remarks
Converting Capabilities	10	10.0	'Best'	4.0	'Secondary'
Acquiring Capabilities	10	7.0	'Advanced'	5.0	'Secondary'
Vending Capabilities	10	9.0	'Superior'	4.0	'Secondary'
Modifying Capabilities	10	9.0	'Superior'	3.0	'Elementary'
Generating Capabilities	10	7.0	'Advanced'	0.0	'Worst'
Total	50	42.0	"Superior"	16.0	'Secondary'
Average	10	8.4		3.3	

* HLE - Highest Level Expected ** LA - Level Achieved

From 0 - 1 Worst case From 5 - 7 Advanced

From 1 - 3 Elementary From 7 - 9 Superior

From 3 - 5 Secondary From 9 - 10 Best case

Note 2: See Exhibit 4 for Marking Scheme for Assessment of Technological Capabilities

Tables 4 and 5 show the summarized results of the complete analysis of cases 1 and 2 respectively.

Table 4: Summary of the Analysis (Case1)

Step	HLE	MLE	LA	Remarks
1. Technological Capability Enhancement	10	-	8.4	'Superior'
2. Technology Component Transfer Level	5	3.79	4.24	84.8% Technology Transfer
3. Stage-Gate Analysis	Not carried out due to lack of information. Note 3: However it should be mentioned that the process followed in this ITT could not be poor as the transferee was able to enhance the technological capabilities to a higher level by getting a higher level of technology components transferred and to maintain long relationships with the transferor.			
4. Seven Factor Analysis				
Transferor	Potential supplier of signalling systems			All relevant factors were favourable and supportive for a successful TT
Transferee	High level of commitment, Searching for technology as a business strategy			
Technology	Right Technology, Right components			
Transfer Mechanism	Best Transfer mechanism			
Transferor's Environment	Favourable for the transferee			
Transferee's Environment	Favourable, High commitment,			
Greater Environment	Fully Supportive			



Table 5: Summary of the Analysis (Case2)

Step		HLE	MLE	LA	Remarks	
1. Technological Capability Enhancement		10	-	3.3	“Secondary”	
2. Technology Component Transfer Level		5	3.79	2.5	50% Technology Transfer	
3. Stage-Gate Analysis						
Stage-Gate Analysis	Stage 1	Not gone through			ITT process followed by SLR was extremely poor and not able to get the right components of technology transferred. Transferee has played a Passive role in this project	
	Gate 1	By passed				
	Stage 2	Poor performance and low level of commitment				
	Gate 2	Project confirmed because of the availability of foreign funds				
	Stage 3	Extremely poor level negotiation				
	Gate 3	Final approval without critical analysis				
	Stage 4	Implementation plan prepared by the transferor did not meet the SLR requirement				
	Gate 4	Transferee was compelled to approve the implementation plan prepared by the Transferor				
	Stage 5	Not much gain to the transferee during the implementation period				
	Gate 5	Implementation auditing has not been carried out				
	Stage 6	Post TT impact assessment not done				
Gate 6	Preparation guidelines for future projects not done					
4. Seven Factor Analysis						
Seven Factors Analysis	Transferor		Not the Right Source			Five factors out of seven have not been favourable enough for the ITT project to be successful.
	Transferee		Low level of commitment			
	Technology		Mostly Technoware. Technology not appropriate			
	Transfer Mechanism		Suitable, but not effective			
	Transferor’s Environment		Not favourable for the transferee			
	Transferee’s Environment		Not favourable. Low level of commitment			
	Greater Environment		Supportive			

5. Conclusions

This research concludes that:

1. The first project carried out in 1959 was successful in international technology transfer since the technological capabilities were enhanced to a higher level.

The following major factors have contributed for its success.

- (a) Matching the technology with business needs and proper selection of technology;
 - (b) Selection of a potential supplier having a favourable environment for technology transfer; and
 - (c) Higher level of commitment of the transferee. Implementation has not been skillfully managed;
2. The second project carried out in 1997 was a failure in international technology transfer since the technological capabilities were not enhanced to the expected level, because:
 - (a) The decisions on technology were not objectively oriented;

- (b) A systematic and proper process in acquisition of international technology has not been followed;

- (c) Implementation has not been skillfully managed;
- (d) Due considerations for the technological capability of the local staff has not been given;
- (e) Negligence of local capabilities and the techno- economic aspects of technology transfer projects have resulted in inflow of inappropriate technology to SLR; and
- (f) Very low level of commitment of the transferee.

3. The major factors that affected international technology transfer of SLR are identified as:

- (a) Poor process followed by the transferee and non-availability of proper guidelines needed for successful technology transfer;
- (b) Lack of :
 - Knowledge in modern technologies
 - Technological capabilities;
 - Managerial capabilities; and



Poor identification of technology components; and

(c) Lack of commitment by transferee

6. Recommendations

Based on the findings of the research the following guidelines are recommended for consideration for successful ITT in the SLR.

6.1 Improvements to International Technology Transfer Process

Amend the Guidelines on Government Tender Procedure in order to ensure effective technology transfer in ITT projects by carrying out the following.

(a) Creation of a Steering committee

Create provisions for the appointment of a Steering Committee (SC), for implementation of technology transfer projects and the SC shall be responsible for:

- Pre negotiation activities (See Exhibit 1)
- Assist TEC in negotiations
- Implementation of ITT project
- Post TT impact assessment
- Documentation of Lessons learned.

(b) Pre-qualification of Technology Suppliers

The process of pre-qualification of technology suppliers of all tenders related to technology transfers should be essential and a pre-condition.

(c) Use of Stage-Gate Model

Transferee to follow the Stage-Gate model shown in Table 1 in order to ensure the right process of ITT.

6.2. Improvements to Capabilities

In order to improve the technology transfer capabilities of SLR the following support systems and tools for decision making are recommended.

- (a) Technology Information: Provide facilities for gathering technology information for improving the knowledge in modern technologies.
- (b) Technology Capability: Make arrangements to improve the technological capabilities through proper training.

(c) Technology Management: Improve managerial capabilities of SLR by providing training in the areas of technology management to all executive staff involved in managing technologies.

(d) Technology Components: Improve the identification of the required components of technology by identifying them correctly, under Technoware, Humanware, Orgaware and Inforware discussed earlier.

Sample checklist of technology components given in Exhibit 2 could be used for this purpose.

6.3. Improvement in the Levels of Commitment

Exhibit the highest level of commitment by top management in any project involving technology with priority to methodology and modalities in place for successful and effective transfer of technology rather than confining themselves to adherence to procedures and government regulations.

Since the decision on purchasing of technology taken at a higher level on the recommendations of the transferee, the top management of the transferee should not simply take technology decisions just as a solution to an existing problem or for solving a long standing problem, because of the availability of a foreign funded technology proposal or credit facilities. All efforts should be taken to study the long-term effects of the proposed technology on the business and it is essential to consider the local capabilities.

Exhibit 1: PRE-NEGOTIATION ACTIVITIES

1. Identify the technology needs
2. Identify the available technologies
3. Evaluation of technologies
4. Selection of the appropriate technology
5. Identify and specify the suppliers' capabilities.
6. Identify the technology components to be transferred
7. Identify the structural changes
8. Identify the new staff needed and their qualifications, scheme of recruitment
9. Identify the local training needs before the transfer
10. Preparation of cost estimates
11. Decide the most suitable transfer mechanism
12. Method of payments
13. Mechanism to ensure the technology transfer before payments
14. Preparation of specifications and tender conditions



Exhibit 2: SAMPLE CHECKLIST OF TECHNOLOGY COMPONENTS

System Components & Materials (Technoware)	Remarks
- All hardware components required for achieving the expected performance of the system - Tools and testing equipment - Spare parts - Training equipment - Operating software - Application software - Programming tools - Office equipment, vehicles etc	Quantity, Specifications,
Training of Personnel & Expert Services (Humanware) - Operator Training - Top, Middle & Lower levels - Maintainer Training - Top, Middle & Lower levels - System Training - Top & Middle level - Project Training - Top Level	Content of the training, expected level to be achieved, medium of instruction, duration, number of trainees and the locations to be specified
Services of Specialists - Design - Installation - Top, Middle & Lower level - Testing & Commissioning - Operation and Management - Top, Middle & Lower level	Number, Duration, Working language, Qualifications, Experience
Information (Inforware) - Installation Manuals - Operating manuals - Maintenance Manuals - Layout diagrams (as installed) - Circuit Diagrams - Specifications - System Design Information - Technical Brochures - Source Codes of Application software - Data Tables - Work organization - Management procedures	Number of hard copies, Electronic copies if necessary

Exhibit 3: MARKING SCHEME FOR ASSESSMENT OF TRANSFERRED COMPONENTS OF TECHNOLOGY

Component	Marks	
	HLE	MLE
Technoware		
Equipment for: - Wayside Signalling - Interlocking System - CTC System	5.0	5.0
Tools for: - Maintenance - System upgrading - Training	5.0	10/3
Spare parts for: - Wayside Signalling - Interlocking System - CTC System	5.0	10/3
Average Total for Technoware	5.0	3.88
Humanware		
Training in System operation	5.0	5.0
Training for maintenance (Wayside equipment, Interlocking system, Controlling system)	5.0	5.0
Training in system Modifications and Development	5.0	2.5
Average Total for Humanware	5.0	4.16
Inforware		
Specifications: - Wayside Equipment - Interlocking Equipment - Controlling Equipment	5.0	3.0
Hard copies of operating Instruction and software required	5.0	5.0
Maintenance instructions of wayside equipment, Manuals, software if needed	5.0	5.0
Design diagrams for: - The System - Signalling equipment	5.0	2.5
Theoretical knowledge in Railway signalling	5.0	2.5
Design calculations, formulae, data	5.0	2.0
Average Total for Inforware	5.0	3.33



Exhibit 4: MARKING SCHEME FOR ASSESSMENT OF TECHNOLOGICAL CAPABILITIES

Technological Capability	Marks (HLE)
Converting Capability	10
Efficient operation of the system	10/3
Efficient maintenance of the system	10/3
Use computerized information and control system to provide information support for service operation.	10/3
Acquiring Capability	10
Justify and specify clearly the required system components & technologies	10/3
Identify the sources of technology, especially for alternatives	10/3
Undertaking project planning and execution for system improvements and new system	10/3
Vending Capability	10
Optimum utilization of the system	10/3
Developing the system in new areas	10/3
Maintenance of the system meet the service requirement	10/3
Modifying Capability	10
Substitution of equipment and spare parts	10/5
Adapt installed technoware and orgaware for better efficiency	10/5
Carry out improvements for superior quality outputs	10/5
Further training of personnel in operation and maintenance	10/5
Expansion of the system	10/5
Generating Capability	10
Reverse engineering acquired technology	10/2
Introduce system innovations	10/2

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