CHAPTER III

Selection of Technologies

The selection of the technologies for the Project (Phase I of the MRTS) was very important because based on them benchmarks were to be established for the subsequent phases of the MRTS as well as for the other Metro projects planned to be constructed in various parts of the country. The results of the examination of records pertaining to technologies selected and implemented for the Project conducted by audit with the assistance of IIT are narrated below.

3.1 Civil engineering

3.1.1 The major portion of the Project has been constructed on elevated viaducts (totalling 47.43 kms), which were built on single piers mostly at a height of 10 metres from the ground using the segmental construction technique. Adoption of underground corridor for Line 2 (11 kms) and a small stretch on Line 3 (2.17 kms) was necessitated due to concentration of buildings, presence of archaeological structures and two major railway yards at New Delhi and Delhi Railway stations.

3.1.2 The selection of corridors and technology used for construction of stations, viaducts, buildings, depots, tunnels and allied works was examined by the IIT and was found appropriate in general.

3. 2 Selection of gauge

3.2.1 RITES, the company and the General Consultant (GC) were in favour of adopting standard gauge (SG) for the Project as it was a proven technology in Metros across the world and had advantages of off-the-shelf availability of the rolling stock and prospects of export potential. The Group of Ministers, however, decided (August 2000) on adoption of broad gauge (BG) to achieve the following objectives:

(a) Indian Railway’s ability to provide infrastructure support for the Project;

(b) Back up support by Indian Railways at the time of disasters/accidents;

(c) Possibility of intersection and inter-operability with mainline Railways; and

(d) Development of indigenous capabilities.

3.2.2 Accordingly, the company adopted the BG in Phase I. However, it was not ensured that the associated systems were planned and implemented to meet the stated objectives as shown below:

- Elevated structures of the Metro have been designed with axle loading of 16.5 ton, which is not compatible with the Indian Railway standard of Electrical Multiple Unit (EMU), which is 20 ton.
- Metro stations have been designed for 3.20 metre wide coaches while the coach width of mainline coaches including EMU coaches of Indian Railways is 3.66 metre.

- Platform length of a Metro station is designed for trains of eight coaches whereas the number of coaches in the mainline trains and EMU are generally more than eight.
- There is no intersection between the mainline Railways and the MRTS network and at a time of crisis, the Railways cannot mobilise back-up support for the MRTS network.

3.2.3 While confirming that inter-operability and inter-connectivity with the mainline Railways was not possible, as the loading standards, moving dimensions, signal systems and operating philosophy of the Project were different, the management stated (February 2008) that the objectives were unachievable as these were based on wrong premise and high maintenance costs would result as spares relating to the BG cars were not available off-the-shelf. Based on their engineering judgment, the management had informed (December 2003) the MoUD that the adoption of the BG had resulted in an additional cost of Rs. 260 crore ***(Annexure II)***. The company also anticipated additional energy consumption of Rs. 2.26 crore *per annum* ***(Annexure III)*** due to adoption of the BG rolling stock and as such has decided to adopt the SG for all new lines in Phase II except for the extensions of the existing lines. The IIT concurred with the views of the management and confirmed that adoption of the BG would cause losses in terms of additional infrastructure required to maintain the system.

Recommendation No. 4

(i) ***The Government of India needs to analyse the reasons for and effects of non-achievement of objectives of adopting the broad gauge as envisaged by the Group of Ministers in August 2000.***

(ii) ***The company needs to document all factors which were involved in deciding on the broad gauge so that pros and cons of adopting any gauge by future projects are adequately identified.***

3.3 Electrical engineering

3.3.1 Traction system

The company draws power from three sources, *viz.*, the Northern Grid, Indraprastha Gas Turbine Plant and the mainline Railway system in case of emergency. Besides, all stations of the Metro are equipped with inverters and generators to act as back-up in emergency. All the three lines of the Project run on 25 kV AC traction system (TS).

3.3.2 Belated decision to adopt 25 kV AC system in the underground corridor

3.3.2.1 For the underground corridor, the DPR (1995) envisaged a 750 V DC TS which was subsequently changed to 1500 V DC TS with the approval of the Ministry of Railways. The GC also recommended (February 1999) adoption of 1500 V DC TS with 5800 millimetre (mm) diametre tunnel as a 25 kV AC TS for underground corridor would require a diametre of at least 6200 mm with higher cost of construction. Accordingly, the company awarded two “design and build” metro corridor contracts in February 2001 with stipulations that the minimum finished internal diametre of the tunnel should be 5600 mm and 1500 V DC TS should be used.

3.3.2.2 After the award of the contracts, the company permitted the civil contractor to use a tunnel-boring machine (TBM) which could give a minimum finished internal diametre of 5700 mm at no extra cost. Based on this and the fact that the Heathrow Express Rail Link, commissioned in 1998 with a tunnel diametre of 5700 mm, ran on a 25 kV AC TS, the company decided to implement 25 kV AC TS for the underground corridor. So, due to non-consideration of these facts by the GC while making recommendation in 1999, the company incurred additional expenditure of Rs. 26.59 crore towards design cost for the 1500 V DC TS and extra conversion cost of 17 trains from 1500 V DC to 25 kV AC ***(Annexure IV)***.

3.3.2.3 The management stated that a 25kV AC TS was a proven technology with a tunnel size of 6200 mm but with such a size of tunnel the Project cost would have increased by Rs. 100 crore. Further, the height of the Heathrow rolling stock was 4015 mm against the specified height of 4250 mm. Adoption of the 25 kV AC TS in the underground corridor was made possible because the contractor could give finished tunnel of 5700 mm internal diametre. The reply is not tenable because 25 kV AC TS in a tunnel diametre of 5700 mm was in use since 1998. Further, the IIT opined that the option of adopting 25 kV AC TS could have been explored at the initial stage of planning.

3.4 Signals & Telecommunication

3.4.1 Signalling system is used to control traffic and to ensure safe operation of trains. The parameters of the system used in the Project have been worked out keeping in mind the smaller headway of train operations and consequent safety requirements. The three main co-ordinates of Signal & Telecommunication (S&T) systems are Automatic Train Protection (ATP), Automatic Train Supervision (ATS) and Automatic Train Operation (ATO). Apart from these features the company has adopted computer based Solid State Interlocking (SSI) system for safe passage of trains.

3.4.2 Based on their study, the IIT opined that:

(i) The ATP, the ATO, the ATS and the SSI are essential safety technologies and must be used on all lines of the Metro. While the ATP and the ATS have been provided for all three lines, the ATO has been provided only in Line 2. The management stated that introducing the ATO on large scale at the first stage itself would have been an unacceptable risk due to lack of experience in India and the Kolkata Metro experience for introduction of the ATO was not successful. In Phase II, the ATO was being implemented on all the new lines. The reply is not tenable because the ATO was not a new technology.

(ii) The S&T works should be tendered separately for competitive bidding and better participation by indigenous bidders.

(iii) A new technology of Communication Based Train Control (CBTC) is under development for metro application. Such systems envisage headway of train operation from 5 minutes to under 60 seconds and are economically feasible. It is suggested that the CBTC may be considered for adoption in future metro lines as soon as the technology is fully developed.

Recommendation No. 5

The company should consider installation of the Automatic Train Operation system on all lines to ensure safer operation of trains.

3.5 Automatic fare collection system

For fare collection, the company has installed an automatic fare collection (AFC) system which offers smart card format for regular travelers and single/return journey contact-less tokens for occasional passengers. All fare collection equipment are connected to a local area network, controlled by a station server which is further linked to a central computer at the operational control centre through optic fibre. The IIT found the AFC system to be suitable, safe and economical. They, however, suggested acquiring the source code for the AFC system in the interest of long term software maintenance and for making necessary changes in the system. The management assured (April 2008) that it will encourage the use of open source service software wherever feasible.

3.6 Rolling stock

3.6.1 The company has procured 3.2 metre wide lightweight fully vestibuled, air-conditioned stainless steel cars designed for fast acceleration-deceleration with advanced features like the ATP, regenerative braking, automatic door operation and inter-communication facility between the driver and passengers. Though one of the prime objectives behind adoption of the broad gauge was the availability of the BG rolling stock technology in the country, these customised cars for the broad gauge tracks had to be imported from a foreign consortium. The management stated that the initial import of these cars was inescapable because facilities for design and manufacture of modern metro rolling stock planned to be used were not available in the country. However, the contractor tied up with a local manufacturer and progressively produced coaches indigenously. Though the indigenisation of the BG rolling stock was one of the prime considerations, it is seen that even in Phase II of the project, the BG coaches were still being imported.

3.6.2 The IIT observed the following deficiencies in these cars:

(a) Noise tests conducted by the IIT on cars on 6 February 2008[♣] by using state of the art instrumentation and measurement systems revealed (***Annexure V***) that the noise levels were beyond the permissible limits on all the lines under various conditions despite the fact that the trains were not run at full operating speed of 80 Kms per hour. The management stated (April 2008) that as the tests were carried out under actual conditions, the noise level measured by the IIT was bound to give erroneous results and thus could not be accepted. Further, only one parameter of the noise was beyond the permissible limit.

(b) The IIT observed premature wear and cracking in the wheel and floor of the rolling stock raising doubts on the stipulated 30 years design life unless appropriate corrective steps are taken. The management stated (May 2008) that cracks in wheels were experienced in varying degrees world wide and the company had engaged an independent consultant to determine the cause. Admitting a few cases of cracks in the floor of the rolling stock, the management stated that the supplier had been advised to carry out strengthening of floors.

[♣] ***It was not possible to stick to perfect conditions as the measurements were taken during normal running hours.***

(c) During collision analysis of train, the IIT observed that simulation time was short/inadequate and conclusions were apparently drawn on the basis of only a couple of simulations. The management replied (May 2008) that in case of collision, the deformation of the coach is normally completed in a few hundred milliseconds and carrying out LS dyna simulation for 2.25 seconds was, therefore, considered quite adequate. The IIT did not agree with the reply as maximum stress was not adequately revealed in simulation of 2.25 seconds.

Recommendation No. 6

The company should carry out tests under standard conditions and take corrective action if coaches experience higher levels of noise. As premature cracks in wheels are linked with safety issues, the company should carry out in-depth analysis and work out a technical solution.

3.7 Ventilation and air-conditioning

For the comfort of the passengers, trains and all underground stations are air-conditioned and tunnels are ventilated. The IIT observed that:

- The cooling load calculation procedures adopted for air-conditioning was generally in line with the industrial practice.
- An assessment of various air conditioning technologies for train and station air-conditioning was not carried out.
- It is possible to improve upon the energy savings by rationalising the inside design conditions, while maintaining similar levels of comfort. The management stated (May 2008) that various options of air conditioning were explored based on the studies of RITES and IIT, Delhi; and in hindsight many things could be reviewed in a different way. However, there was nothing on record to show that various options were explored for air conditioning.
- The operation and maintenance of the centralised Building Management System may be looked into carefully to ensure its proper operation at all times to get the anticipated energy savings and also to take care of emergency situations. Further, the study of load patterns may help in deciding the design and selection of upcoming high voltage air conditioning plants. The management has noted (April 2008) the suggestion.
- A well documented comparison of systems and operational methodologies adopted by various Metros in the world would help in evolving better system designs.

3.8 Emergency evacuation and fire fighting arrangement in trains

During a live demonstration of train operations, arranged for Audit and the IIT on the midnight of 3 November 2007, emergency evacuation arrangements were found to be in place. Similarly, adequate fire fighting arrangements in the form of dousers and water sprinklers in the tunnel and platforms and fire extinguishers in the cars existed. The signage for fire extinguishers in the cars was however, not adequately displayed; and the fire alarms in Rajiv Chowk station were not kept operational. The management assured (April 2008) to take corrective action.

Recommendation No. 7

The company should create a knowledge database relating to inputs required for all its activities to facilitate decision-making. To help develop a qualified technical human resource base, the company may like to partner institutions of higher learning.