



Japan International Cooperation Agency (JICA)



The Study on Strengthening Intermodal Transfer Functions of Urban Railway Systems



Main Text



September 2009



Value Planning International, Inc.

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Table of Contents

Executive Summary

1. Study Objectives and Study Approaches.....	1
1.1 Introduction.....	1
1.2 Technical Approaches	5
2. Underlying Issues on Intermodal Functions at Railway Stations	13
2.1 Overview of Major Urban Railway Projects Supported by Japanese ODA	13
2.2 Identification of Planning Issues on Delhi Metro.....	17
2.3 Identified Development Issues of Intermodal Transfer (through the Questionnaire Survey).....	21
3. Improvement Measures by Station Type	33
3.1 Current Issues on Existing Intermodal Transfer Facilities at the Delhi Metro Stations	33
3.2 Possible Measures Implied from Advanced Experiences in Japan	36
3.3 Proposed Improvement Measures for Delhi Metro Intermodal Function.....	39
4. Proposed Measures for the Improvement of Intermodal Functions.....	63
4.1 Short-term Measures.....	63
4.2 Medium- and Long-term Measures.....	65
4.3 Organizational Mechanism.....	68...
5. Knowledge Sharing and Information Dissemination	75
5.1 Conduct of the Delhi Workshop	75
5.2 Proceedings of the Workshop	76
6. Recommendations	87
6.1 Intermodal Development at New Stations in Phases 3 and 4	87
6.2 Coherence of Rail and Urban Development.....	90
Appendices.....	93
Presentation Materials by the JICA side	

List of Tables

Table	Page
Table 1.2.1 Categorization of Railway Stations (Provisional) -----	6
Table 1.2.2 The distance pedestrians are willing to walk or wait and the psychological time limit -----	9
Table1.2.3 Perceived times for different behaviors at station indicating a passenger’s feeling of dislike-----	11
Table2.1.1 Representative Yen Loan Projects in the Railway Sector-----	14
Table 2.2.1 Profile of Delhi Metro Phase 1 -----	17
Table2.2.2 Selected Representative Stations and Their Characteristics-----	18
Table2.2.3 Profiles of the Target Stations-----	19
Table 3.1.1 Summary of Identified Issues on Intermodal Functions ----- at Four Representative Stations	34
Table 3.3.1 Issues and Measures for Improvement of the ----- Shahdara Station	40
Table 3.3.2 Issues and Measures for Improvement of the ----- Janak Puri West Station	46
Table 3.3.3 Issues and Measures for Improvement of the ----- Uttam Nagar West Station	52
Table 3.3.4 Issues and Measures for Improvement of the ----- Rajiv Chowk Station	58
Table 4.3.1 Proposed Stakeholder Groups for the ----- “Delhi Metro Intermodal Transport Conference (DMITC)”	68

List of Figures

Figure	Page
Figure 1.1.1 Case Study Area Being Served by the Delhi Metro System -----	2
Figure 1.1.2 Basic Structure of the Study-----	4
Figure 1.2.1 A Relation Between Development of Transfer Facilities ----- and Control Capacity of Railway Access Traffic	6
Figure 1.2.2 Functional Locations of Transportation Means in Relation ----- Between Trip Distance and User Density	10
Figure 2.2.1 Locations of Selected Stations -----	18
Figure 3.1.1 Overall Issues for Intermodal Facilities Improvement ----- of Delhi Metro	33
Figure 3.3.1 Issues for Improvement of the Shahdara Station-----	41
Figure 3.3.2 Proposed Improvement Directions of the Shahdara Station -----	42
Figure 3.3.3 Short-tem Actions – Road indication example -----	43
Figure 3.3.4 The trouble spots of the present situation around ----- Janak Puri West Station	47
Figure 3.3.5 Proposed Improvement Directions of the----- Janak Puri West Station	48
Figure 3.3.6 Short-tem Actions – Road indication example -----	49
Figure 3.3.8 Issues for Improvement of the Uttam Nagar West Station-----	53
Figure 3.3.9 Proposed Improvement Directions of the----- Uttam Nagar West Station	54
Figure 3.3.10 Short-tem Actions – Road indication example-----	55
Figure 3.3.11 Proposed Improvement Directions of the ----- Uttam Nagar West Station	56
Figure 3.3.12 Proposed Improvement Directions of the Rajiv Chowk Station ---	60
Figure 4.1.1 A Conceptual Structure of Bus Service Network -----	64
Figure 4.3.1 Proposed Functional Structure of DMITC -----	69
Figure 4.3.2 Proposed Functional Framework for Integrated Management----- System of Public Transportation	71
Figure 4.3.3 Main Reasons of Non- Metro Users -----	72
Figure 4.3.4 Concept of Zone Fare System -----	73

List of Acronyms/Abbreviations

CBD	Central business District
DDA	Delhi Development Authority
DF/R	Draft Final Report
DMC	Delhi Municipal Corporation
DMRC	Delhi Metro Railway Corporation
DTC	Delhi Transport Corporation
F/R	Final Report
GNCTD	The Government of National Capital Territory of Delhi
ISBT	Inter State Bus Terminal(This is one of three ISBTs of Delhi)
IC/R	Inception Report
IT/R	Interim Report
JICA	Japan International Cooperation Agency
MoUD	Ministry of Urban Development
MoR	Ministry of Railway
MCD	Municipal Corporation of Delhi
NDMC	New Delhi Municipal Corporation
NMCD	Municipal Corporation of New Delhi
ODA	Official Development Assistance

Executive Summary

“Study on Strengthening Intermodal Transfer Functions of Urban Railway Systems”

1. Study Objectives

This study was conducted by Japan International Cooperation Agency to identify current problems and vital issues of intermodal transfer functions at railway stations and to formulate improvement measures for the intermodal transfer functions to facilitate more passengers' use of the railway systems. The target of this study is to build an effective promotion policy for public transportation usage in Delhi Metropolitan Area, by improving intermodal transfer functions of the stations, and the expected outcome is to prepare strategic projects and / or programs to implement the above policy. The outcomes of this study are expected to be a model for other cities.

2. Awareness of Issues for Intermodal Transfer Functions of Delhi Metro Stations

The residents and employees around four (4) Metro Stations in different category groups of Metro stations were interview-surveyed and the following issues were identified.

Table 1 Awareness of Issues of Metro Users

Station	Priority Issue	Other Issues
Station Category 1 (SHAHDARA)	Insufficient Access Bus Service (Route, Frequency, Punctuality)	<ul style="list-style-type: none"> • Space for Auto Rickshaw / Rickshaw Stand / Drop-Off; • Private Vehicle Facilities / Parking
Station Category 2 (JANAK PURI WEST)	Insufficient Access Bus Service (Route, Frequency, Punctuality)	<ul style="list-style-type: none"> • Free Passage with Escalator / Elevator in the Station; • Pedestrian Facilities
Station Category 3 (UTTAM NAGAR WEST)	No Wide Road for Feeder Buses	<ul style="list-style-type: none"> • Space for Auto Rickshaw / Rickshaw Stand / Drop-Off; • Private Vehicle Facilities / Parking
Station Category 4 (RAJIV CHOWK)	Space for Auto Rickshaw/ Rickshaw Stand / Drop-Off	<ul style="list-style-type: none"> • Space for Access Bus Facilities; • Security Check Line

Source: JICA Study Team

Table 2 Reasons for Non-Metro Users not to Use the Metro

Station	Priority Issue	Other Issues
Station Category 1 (SHAHDARA)	Travel Cost	Insufficient Access Transport Means; Discomfort of the Metro
Station Category 2 (JANAK PURI WEST)	Travel Cost	Insufficient Access Transport Means; Frequency of the Metro
Station Category 3 (UTTAM NAGAR WEST)	Insufficient Access Transport Means	Travel Cost; Inconvenience of Transfers
Station Category 4 (RAJIV CHOWK)	Travel Cost	Insufficient Access Transport Means; Discomfort of the Metro

Source: JICA Study Team

Table 3 Awareness of Issues of Transfer Passengers with Other Modes

Transfer Mode	Priority Issue	Other Issues
To/from Indian Railway	Station Facilities (New Ticket Vending Machine, Waiting Facility, Security Line, Escalator, etc.)	Insufficient Indian Railway Service (Frequency, Punctuality, etc.) Pedestrian Facilities
To/from DTC Bus	Station Facilities (Same as above)	Insufficient Access Bus Service (Route, Frequency, Punctuality) Pedestrian Facilities
Motorcycle Park & Ride	Private Vehicle Facilities / Parking	Station Facilities (Same as above) Pedestrian Facilities
Car Park & Ride	Private Vehicle Facilities / Parking	Station Facilities (Same as above) Pedestrian Facilities

Source: JICA Study Team

3. Improvement Measures

The improvement measures were studied based on the requirements identified by the survey. The major issues in the suburban stations are how to enhance the bus service level by providing effective bus route and bus stops with more frequency and punctuality to enable to attract more Metro users, and how to restructure and redevelop the intermodal transfer spaces around the stations for the bus going in/out and car / motorcycle parking based on the intermodal demand. On the other hand, the major issues in the central business district are how to provide the spaces for auto rickshaw / rickshaw and access buses to enhance the accessibility to / from the Metro station.

Table 4 Improvement Requirement identified by the Survey

Station	Access Road and Feeder Bus System	Intermodal Transfer Functions around Station
Station Category 1 (SHAHDARA)	Enhancement of Bus Service Level (New Routes & Stops, Frequency, Punctuality, etc.)	<ul style="list-style-type: none"> • Provide More Spaces for Auto Rickshaw / Rickshaw Stand / Drop-Off • Private Vehicle Facilities / Parking
Station Category 2 (JANAK PURI WEST)	Enhancement of Bus Service Level (New Route & Stop, Frequency, Punctuality)	<ul style="list-style-type: none"> • Provide Free Passage with Escalator / Elevator in the Station • Develop Pedestrian Facilities
Station Category 3 (UTTAM NAGAR WEST)	Urban Development for Providing Bus Roads	<ul style="list-style-type: none"> • Space for Auto Rickshaw / Rickshaw Stand / Drop-Off • Private Vehicle Facilities / Parking
Station Category 4 (RAJIV CHOWK)	Provision of Access Bus Facilities near Station	<ul style="list-style-type: none"> • Provision of Auto Rickshaw / Rickshaw Stand / Drop-Off Facility near Station • Improve Security Check Line System
Transfer Functions with Other Modes	<ul style="list-style-type: none"> • Improve Station Facilities (New Ticket Vending Machine, Waiting Facility, Security Check Line, Escalator, etc.) • Enhance Indian Railway Service Level (Frequency, Punctuality, etc.) • Improve Access Bus Service (New Route & Stop, Frequency, Punctuality, etc.) • Provide More Private Vehicle Facilities / Car & Motorcycle Parking • Provide Comfortable Pedestrian Facilities with Green Shelter • Review the Fare System and Synchronize the Timetable of Different Modes 	

Source: JICA Study Team

4. Implementation System

It is important to review the existing urban master plan both on the land use and transport for the redevelopment of the catchment influence area of the station. The intermodal transfer functions should be incorporated as one of the important urban facilities. The legally authorized planning and implementation system is expected to be organized for developing the intermodal transfer functions together with the financial support system of the government. The citizen's participation in the development of intermodal transfer functions is inevitable and the utilization of private vitality has to be studied for the redevelopment of the station area. The following two organizations are expected to be established to promote and strengthen the intermodal transfer functions of the urban railway system.

Figure 1 Proposed Organization of “Delhi Metro Intermodal Transfer Committee (DMITC)”

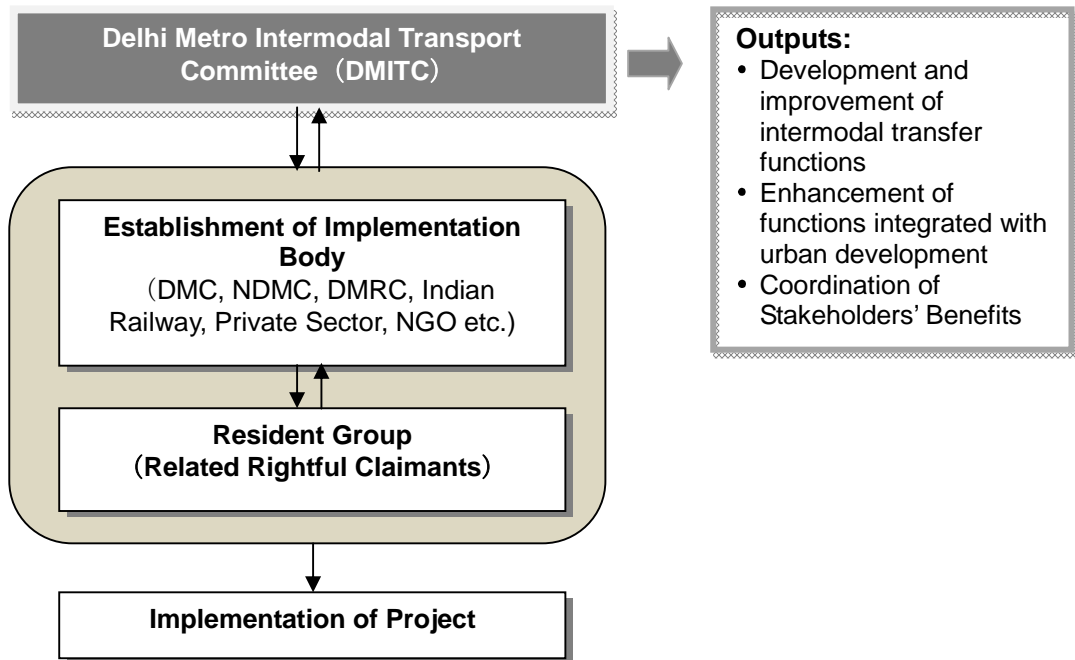
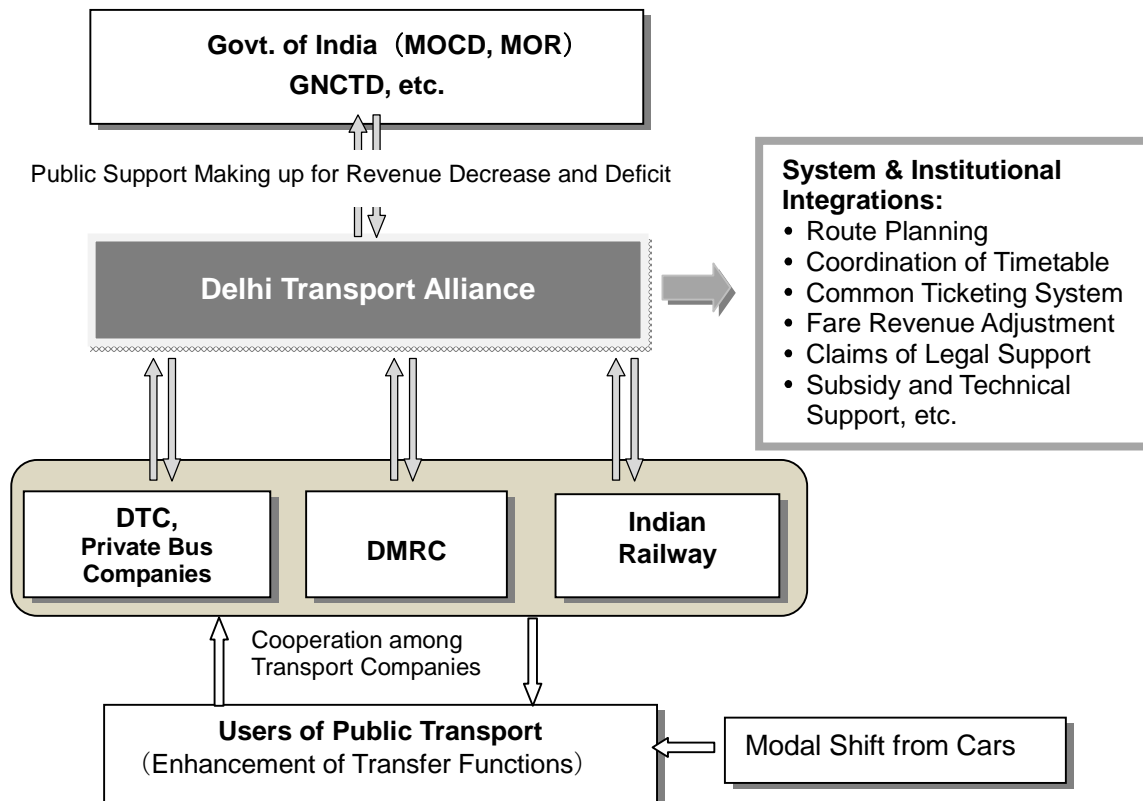


Figure 2 Proposed Organizational Structure of “Delhi Transport Alliance (DTA)”



1. STUDY OBJECTIVES AND TECHNICAL APPROACHES

1.1 Introduction

1.1.1 Study Objectives

The main objective of this study is to identify current problems and vital issues of intermodal transfer functions at railway stations in the railway systems developed by the Yen loans, and to formulate improvement measures for the intermodal transfer functions to facilitate more passenger use of the railway systems.

Existing reference materials and data/information on intermodal transfer functions of railway stations were collected, and successful examples in Japan and other developed countries were analyzed.

As a case study, the current situation of the Delhi Metro stations was investigated, and a Questionnaire Survey was conducted to identify actual usage of passengers of Delhi Metro and potential demands on facilities and services to improve transfer activities. Based on this case study, improvement measures for the intermodal transfer function in Delhi Metro were examined, especially taking into account strengthening of integration with feeder transport systems including pedestrian facilities.

An organizational structure was explored to promote coordination among public transport service providers (railway, the Metro, bus, taxi, etc.) and the city government authorities in charge of urban development and environmental administration. Consequently, strategic projects and/or programs have been proposed. The results of this study will be applicable to not only Delhi Metro but also other railway projects.

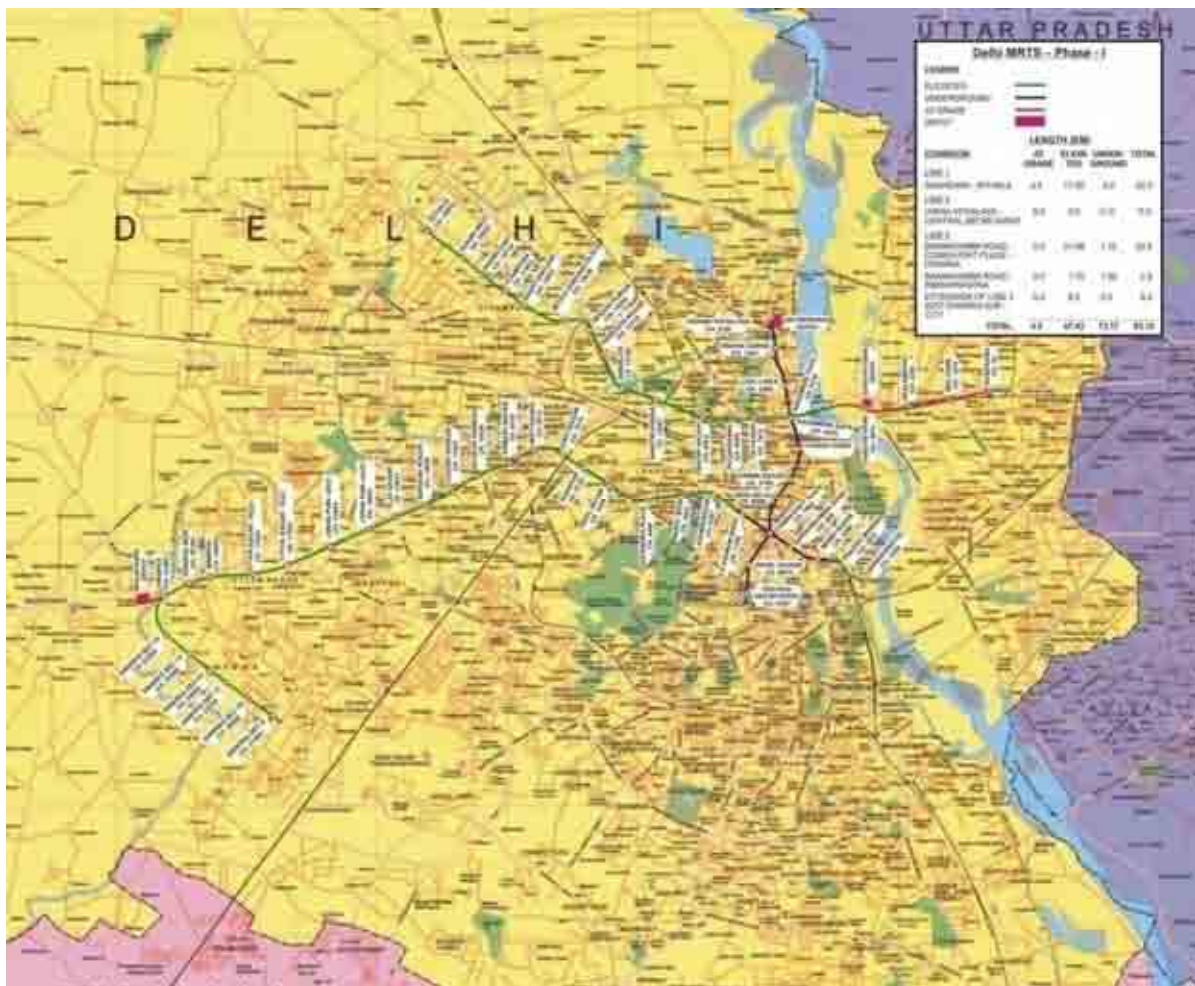
Target of the Study: to build an effective promotion policy for public transportation usage in Delhi Metropolitan Area, by improving the intermodal transfer function of the stations

Expected Outcomes: to prepare strategic projects and/or programs to implement the above policy. The outcome of this study is expected to be a model for other cities.

This Study was conducted by Value Planning International, Inc. headed by Dr. Katsuhide Nagayama, under the consultancy service contract with Japan International Cooperation Agency (JICA).

1.1.2 Study Area

A literature study covers the worldwide discussion relevant to railway intermodal transfer systems, and a case study shall focus on Delhi Metropolitan Area being served by the Delhi Metro System, which has three lines with a combined route length of 65 km and 59 stations in Phase 1.



Source: Web-site of DMRC

Figure 1.1.1 Case Study Area Being Served by the Delhi Metro System

1.1.3 General Characteristics of the Case Study Area, Delhi

Delhi Metropolitan Area, with a population of 16.3 million as of 2006, has developed a public transportation network system with the bus, Metro, taxi, and paratransit systems. In particular, the bus is the prime mode of transport, accounting for approximately 30%-35% of the total demand.

The Delhi Metro System, which consists of both with underground structure in the central business district (CBD) and elevated structure in suburban areas, has been well developed and rapidly expanded to widen the service areas. This system does/will play a prime role in

the overall public transport network under the condition that chronically heavy traffic congestions always take place on roads. Also, the Metro System is expected to contribute to mitigate the ambient air pollution.

Phase 1 of the Delhi Metro System Project (65.1 km long) had been financially supported by Japanese Yen Loan since 1996 with a total loan amount of JYN162 billion. The whole Phase 1 section was completed and opened for commercial operation in November 2006, and it is reported that about 800,000 passengers are currently using the system every day.

At present, in order to meet the increasing demand, Phase 2 of the Project has been implemented to construct 83 km more with an additional financial support (JYN 178 billion), and it is scheduled to be completed by 2011. Including Phase 3 and Phase 4, the total length of the Metro network will be 414 km in 2021.



1.1.4 Basic Structure of the Study

This study was carried out in a phased manner, as shown in Figure 1.1.2. In Phase 1, current situation and existing problems for intermodal transfer functions were identified through status analysis, case studies and questionnaire surveys. In Phase 2, findings from Phase 1 were scrutinized, focusing on strengthening of railway transfer facilities, integration with feeder transport systems and ideal intermodal transfer functions development according to characteristics of each local area. Proposals on organizational structure and strategic projects and programs were also studied. Technical findings and knowledge gained through these phases were shared and discussed in a Seminar in Delhi, attended by stakeholders as well as officials concerned. This was a main event in Phase 3.

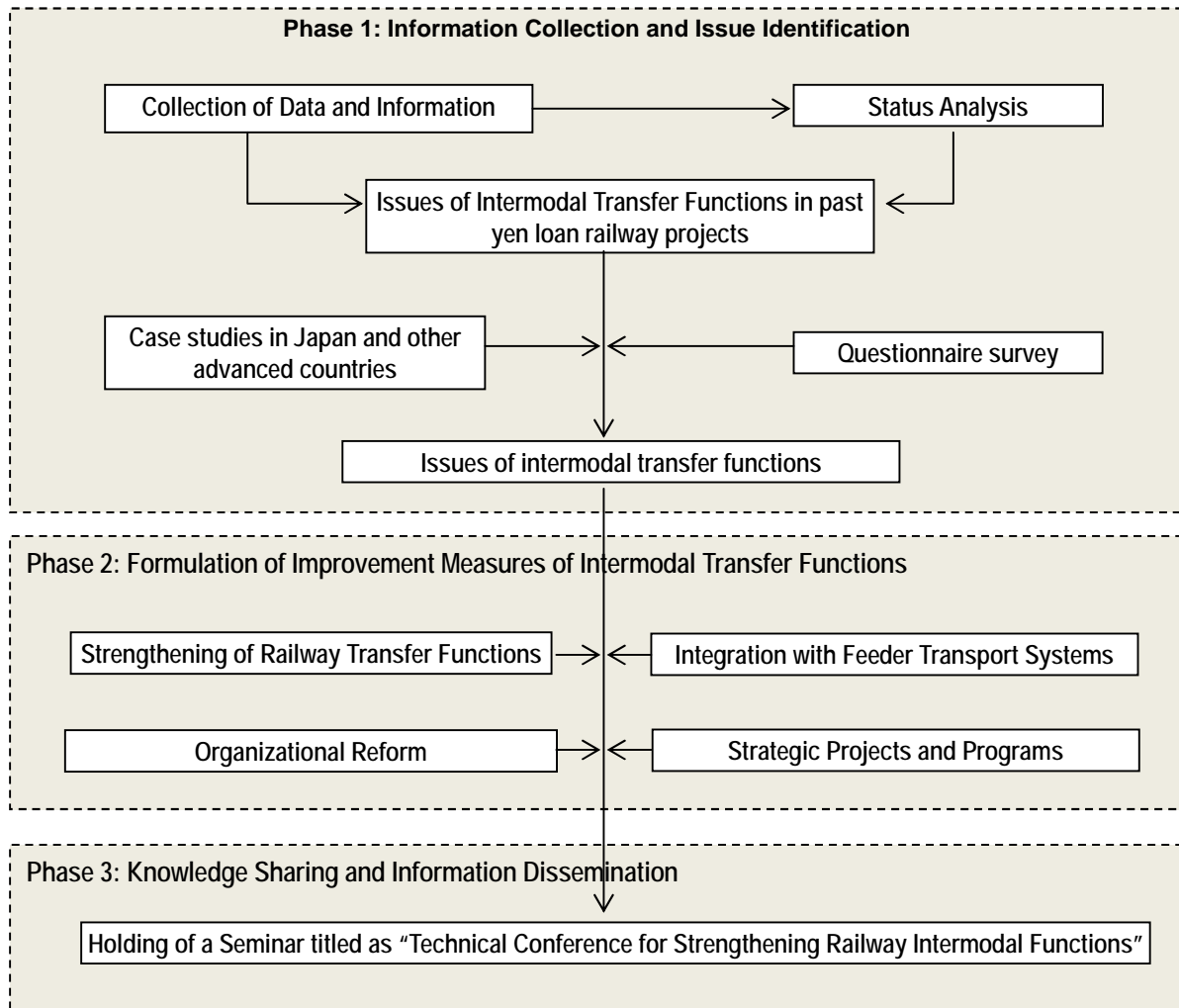


Figure 1.1.2 Basic Structure of the Study

1.2 Technical Approaches

Three topics, which are shown below, are regarded important as technical issues for this study, and the basic policies for study of these topics are described thereunder.

- Topic 1: Classification of railway stations for a better understanding of the characteristics of stations and their catchment influential areas
- Topic 2: Integration with feeder systems, including the distance pedestrians are willing to walk for transfers
- Topic 3: Seamless intermodal transfer between the railway and other transport means

1.2.1 Classification of Railway Stations for a Better Understanding of the Characteristics of Stations and their Catchment Influential Areas

(1) Recognition of the Issue

At the railway stations in Japan, where they have many populations within their catchment influential areas and many railway passengers boarding and alighting, the station plaza or similar intermodal transfer functions, such as bus terminals, bus bays on the arterial roads, car parks for “park and ride”, and bicycle parks, have been usually developed.

However, the physical conditions and functions for intermodal transfer facilities are determined by the population within the station influence area, the land availability, and the needs of social capital development. The station plaza and other intermodal transfer facilities will take a role to promote the increase of population smoothly within the station influence area, by removing the restriction of traffic functions and by activating the local development potential.

In general, railway stations can be classified into several types of categories, depending on existence of station plaza, attributes of catchment influential areas, existence of intermodal functions and number of passengers. Table 1.2.1 shows an example of classification of railway stations, based on Tokyo Metropolitan Area. Four (4) types are recognized in the Japan case, which imply differences in the capacity of railway access traffic.

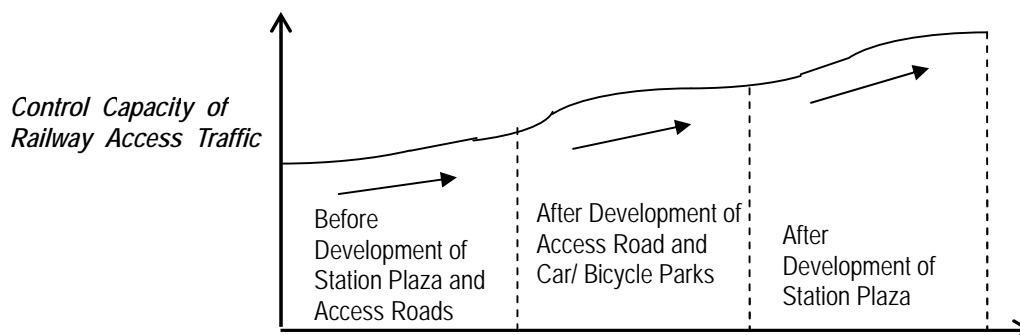
The capacity of railway access traffic is relatively determined by the development of facilities such as a station plaza and access roads. This relation is conceptually shown in Figure 1.2.1.

Table 1.2.1 Categorization of Railway Stations (Provisional)

Category	Characteristics of Railway Station	Station Plaza	Catchment Area	Intermodal Function	Number of Passengers
Type 1	The station whose influence area expanded after the development of the station plaza and the number of passengers boarding and alighting increased as a result, and also the commercial & business district was built up around the station plaza.	Large	↑	Multi	↑
Type 2	The station whose influence area did not change so much even after the development of the station plaza and the number of passengers boarding and alighting also did not change due to the existence of the competitive railway nearby. However, the traffic service level improved and the development as a city gate promoted.	Large	→	Multi	→
Type 3	The station that has no station plaza but has equivalent intermodal transfer functions nearby, and the influence area of the station is expanding with the huge traffic congestion and the increasing number of boarding and alighting passengers, reaching the limits of the station's capacity.	Small	↑	None	↑
Type 4	The station whose influence area is limited within the walking area, although housing development is promoted beyond the walking area; it has no station plaza and the station is reaching capacity in the near future,	Small	→	None	→

Source: A Study on the Station Plaza Analysis of Private Railways (Japan)

Figure 1.2.1 A Relation Between Development of Transfer Facilities and Control Capacity of Railway Access Traffic



Source: A Study on the Station Plaza Analysis of Private Railways (Japan)

(2) Study Approach

In order to study the improvement measures of intermodal transfer functions with the access traffic of railway stations in terms of the promotion of the railway usage, it is required to clarify a relationship with the local characteristics represented by the development levels of social capitals, the sphere of influence area of stations, the development potential, the future urban development plan, etc. And it is also important to categorize the railway stations, based on the analysis of the station characteristics represented by the development level of the intermodal transfer functions, the trend of the number of boarding and alighting passengers, etc. The other notable factors are local characteristics such as land use, population, access roads and trend of the city planning and development. The railway stations will be classified taking into account the above mentioned conditions/factors.

Based on the above discussion, the information and data collection will be conducted for analyzing the station characteristics and the local characteristics of the influence area of stations, in “Yen Loan” railway projects, especially focusing on Delhi Metro, and it will be an input into the first field study in Delhi. The improvement models of intermodal transfer functions in Japan and other developed countries will also be collected as reference information, for the aforesaid station categorization. The basic procedures of analysis are described as follows:

- Station characteristics in the railway systems, developed by “Yen Loan” railway projects, will be analyzed in terms of the present situations of the intermodal transfer functions and the trend of the passengers boarding and alighting, based on the information and data within the scope of existing materials and documents.
- In the Delhi Metro project, the more precise information and data required to analyze the station characteristics and local characteristics of the influence area of stations will be collected.
- Based on the above analysis, stations will be categorized into four or five groups, and representative stations will be selected for the questionnaire survey conducted in the field survey. The categorization will target not only the stations in suburban areas but also the stations in the CBD, where many passenger trips will be generated and absorbed.
- As for the improvement of railway intermodal transfer functions, some advanced systems will be introduced in association with the traffic demand management (TDM) to regulate car traffic in CBDs in the U.S.A. and Europe, the high level terminal complex in Japan, etc. Among them, the most applicable improvement measures are studied together with the authorities in charge.

(3) Expected Results

Railway stations will be generally categorized in terms of station characteristics and local characteristics in their influence areas. Improvement models for the intermodal transfer functions will be proposed for each category of station. The representative stations will be selected in each category, based on this analysis.

1.2.2 Integration with Feeder Systems, Including the Distance Pedestrians are Willing to Walk for Transfer

(1) Recognition of the Issue

In order to enhance the intermodal transfer functions with access traffic of railway stations, it is important to look into the present situation and the future plan of the surrounding social capital development for pedestrians and non-motorized modes such as bicycles, which may share the biggest portion in all access trips. In this regard, the following findings in Japan are noted:

- The percentages of walking trips in all access trips of railway stations are 88% in Tokyo, 60% to 70% in Yokohama City, Kawasaki City and Chiba City adjacent to Tokyo, and 30% to 40% in Saitama North district, Ibaragi South district and Chiba East district, according to “Tokyo Metropolitan Area Person Trip Survey” conducted in 1988.
- The percentage of walking access trips from home to station was 71% in 1975, but fell to 63% in 1985, according to “Mega-City Transportation Census” in Japan. This phenomenon was due to a rise of bicycle trip share, from 4% in 1975 to 17% in 1985. During this time, there were many bicycles illegally parked around railway stations and caused traffic congestions.
- The average access trip time of walking, bicycle, motorcycle and car from home to station is 6 to 10 minutes, and that of bus is 11 to 15 minutes. When the walking trip time will be beyond 10 minutes, the transportation means show a tendency to shift from walking to bicycle, motorcycle, car and bus.
- Eighty percent (80%) of the walking trip distance is within 1.0 km, while the bicycle trip distance is within 2 km to 3 km on the average. People are likely to select bus or car in traveling a distance beyond 3 km. More or less 20% of all access trips take 11 to 15 minutes, 40% take 16 to 20 minutes and 60%, over 20 minutes.

Thus, the number of walking access trips has the most shares in railway usage. Table 1.2.2 shows the distance pedestrians are willing to walk. It should be noted that such sense of distance is different by local characteristics like the surrounding environment and a person’s age. In cities where the climate is hot, the distance that pedestrians are willing to walk tends to be relatively short.

Meanwhile, Figure 1.2.2 shows an overall picture of transportation means in relation with the magnitude of “user density” and “trip distance”. In general, there are three (3) domains of transport modes to connect one to another transportation means, namely, A, B and C in

this figure. These represent “access transport modes” to support smooth intermodal transfer activities.

Table 1.2.2 The distance pedestrians are willing to walk or wait, and the psychological time limit

Items		Distance or Time willing to Walk or Wait	Source
Cities in Europe	Ordinary city roads	400 m	Sweden Runto Technology Institute
	Rainy and cold climate	200 m	
	Comfortable roads	30% to 50% increase	
	Congested roads	150 m	U.K. Road & Transportation Research Institute
Tokyo		300 m	Transportation Economy Research Institute, Japan
Cities in South-East Asia (in midsummer)		100 m to 200 m	
Interval of bus stops and car parks		200 m	Research in the U.S.A. & Europe
Crosswalk		20 m from the crosswalk	Survey in France
Traffic signal		Less usage for narrower roads	
Waiting time for railway crossing		40 seconds	Japan National Railway
Average walking distance by aged persons		100 m	

Source: JICA Study Team

(2) Study Approach

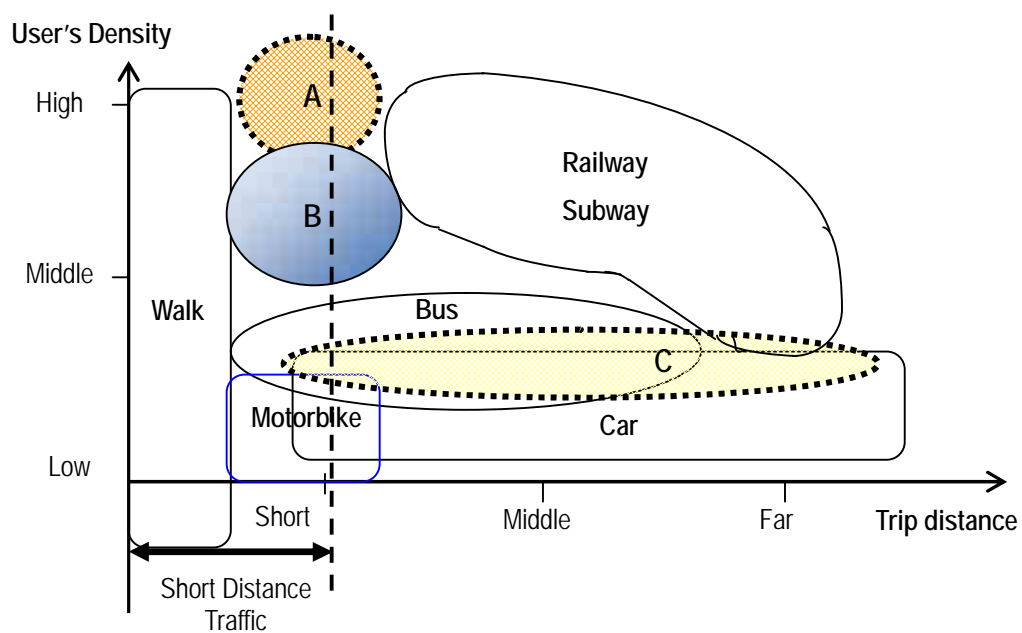
The increase and decrease of railway usage is largely affected not only by the intermodal transfer facilities but also by the distance of access traffic. Especially in hot cities, the dislike of long distance walking seems considerably high, thereby affecting the railway usage.

In light of the above, it is required in the questionnaire survey to investigate the major transport means of daily trips, the reason of railway usage and non-railway usage in connection with the dislike of railway usage, access transport means, etc., and to study improvement measures in terms of how to combine the most suitable short distance traffic system for better access to the railway station, taking into account the following:

- In the questionnaire survey for residents in suburban areas, the sampling was distributed into three (3) levels of distance between home and the nearest railway station:
 - Walking areas within 1.0 km from the nearest station
 - Areas between 2 km and 3 km from the station, where it is assumed that the bicycle will be the major transportation means (in case of Japan)

- Areas beyond 3 km from the station, where it is assumed that the bus and car will be the major transportation means (in case of Japan)
- In the questionnaire survey for workers in the CBD, the sampling will be distributed into two (2) levels of distance between the office and the station:
 - Walking areas within 300 m from the station
 - Areas beyond 300 m from the station, where it is assumed that the bus and other modes will be the major transportation means

Figure 1.2.2 Functional Locations of Transportation Means in Relation between Trip Distance and User Density



- **A:** New transit systems, for instance, for the middle domain between railway and bus
- **B:** Consecutive transportation systems to connect CBD and railway station
- **C:** Demand bus systems, for instance, to serve the domain in which the transportation density is low and cars are the most popular transportation means

Source : "Easy Urban Traffic" by Urban Traffic Survey Dept., Ministry of Land and Transportation, Japan

(3) Expected Results

Ideal and possible systems with short distance access traffic will be considered in order to remove the dislike for the railway usage, in connection with local characteristics of the influence area of the station.

1.2.3 Seamless Intermodal Transfer between Railway and Other Transport Means

(1) Recognition of the Issue

According to the study on the dislike (or psychological impedance) of passengers for intermodal transfer conducted by the French National Research Institute, given an hour for a ride on the railway and a minute to transfer to bus, the passenger's perceived time for the transfer will seem like much longer than the one minute, even though the transfer does not actually take more than a minute to accomplish. This means that it is more effective to shorten the waiting time to 30 seconds than to shorten the ride for 1 minute, because the transfer at the railway station is more likely to cause irritation to passengers. Table 1.2.3 shows such perceived times, compared to the actual riding duration, for different behaviors at the station. Therefore, it is vital to study the seamless transfer system to lessen transferring time, providing not only the hardware but also the software measures.

Table 1.2.3 Perceived times for different behaviors at station indicating a passenger's feeling of dislike

Case	Perceived time, given an hour for a ride on railway and bus
When walking to the station and bus stop	1.75 times
When transferring	2 times
When waiting	3 times

Source: The French National Research Institute

(2) Study Approach

Based on the results of the questionnaire survey conducted in the suburban area and CBD, an analysis was made on the extent the dislike for the intermodal transfer obstructs the railway usage. The necessary improvement measures to shorten the transfer time will be studied, referring to the software and hardware examples in developed countries. The following are the major viewpoints for the study on the seamless transfer.

- The transfer issues will include one of vital elements of the dislike for railway usage; therefore, people's suggestions on mitigating such dislike against the transfer will be investigated in the survey.
- It is required to introduce a smooth transfer system not only for the horizontal movement but also for the vertical movement to shorten the transfer time from one platform to another, or one transport mode to another.
- When well-coordination for smooth transfer is necessitated among different transport companies, some systematic improvement measures are introduced, for instance, an IT-based common ticketing system, a transfer fare discount system, a timetable

adjustment system between one mode and another mode to shorten waiting time, etc.

(3) Expected Results

The importance and the necessity for a time-conscious improvement for seamless and smooth intermodal transfer functions will be commonly recognized by analyzing to what extent the inconvenience of the transfer between one station and another station, and between one platform and another platform will affect the railway usage. Improvement measures of the software and hardware will be examined.

2. UNDERLYING ISSUES ON INTERMODAL FUNCTIONS AT RAILWAY STATIONS

2.1 Overview of Major Urban Railway Projects Supported by Japanese ODA

2.1.1 Overall Profile of Urban Railway Projects by Japanese Yen Loans

Railway improvement projects by Japanese official development assistance (ODA) started in Korea, and thus far, a total of 205 yen loan projects in the railway sector have been carried out in several countries, totaling JYN 2,390,503 million from 1966 to 2008.

Among them, 67 projects with JYN 633,481 million loan have been carried out in **China**, sharing 26.5% of the total, followed by **Thailand** (21 projects, JYN 391,085 million, 16.4% share); **India** (16 projects, JYN 346,762 million, 14.5% share); and **Indonesia** (40 projects, JYN 266,942 million, 11.2% share) . These four countries accounts for 68.5% of the total yen loan projects in the railway sector.



Manila LRT



Thailand Blue Line



Beijing Subway



Chongqing Monorail



Jabotabek Railway



Kolkata Metro



Delhi Metro



Delhi Metro

Among the 205 yen loan railway projects, the following seven urban railway projects are particularly noted in terms of scale and functions. The characteristics of these projects are summarized in Table 2.1.1.

Table 2.1.1 Representative Yen Loan Projects in the Railway Sector

Country	Project	Period	Amount of Yen Loan	Length	Characteristics
China	Beijing Subway Project, Phase 1 and 2	1988~89 1991~94	JYN 4 bill. (88-89); JYN 15.7 bill. (91-94)	199 km	The project was planned to ease traffic congestions and air pollution; the 1 st Line enters directly into the Beijing downtown; Inadequate transfer facilities due to the station's location in deep underground; difficult to move between ground level and station.
China	Chongqing Monorail Project	2001 - 2007	JYN 22.8 bill.	17.4 km	First monorail system in China with inconvenient access to the service due to the stations' locations in residential area of city and topographical conditions; use of Japanese technology aimed to mitigate traffic congestions and air pollution.
Indonesia	Jabotabek Rail Modernization Project, Phase 1 - 9	82/05/31-9 2/10/08	JYN 1,049 bill.	161.9 km	Outstanding Yen loan project that continued for 20 years. First project with a long-term master plan, supported by Japanese technical assistance; introduction of used-rolling stock from Japan; and integration of both utilization of existing railways and developing new urban railway.
Philippines	Metro Manila LRT Project	1993 - 2005	JYN 1,048 bill.	15 km	Three (3) LRT lines are introduced by Belgium, Japan, and the Czech Republic, therefore, creating difficulty to assure an integrated operation of the entire railway network. Line 1 has faced chronic congestion.
Thailand	Bangkok Blue Line Project, Phase 1-5	1996 - 2000	JYN 193 bill.	20 km	Introduction of a subway system under swampy soil conditions, based on the Greater Bangkok Master Plan. Construction was started in 1997. The total construction cost of US\$2.7 billion was mostly provided by yen loans.

(cont'd)

Country	Project	Period	Amount of Yen Loan	Length	Characteristics
India	Kolkata Metro Construction Project	1983~1992	JYN 4.8 bill.	5.0 km	The project has no long-term plans and faces serious problems such as delay in the construction and expansion of the budget. Ridership is considerably lower than expected; its operation is irregular, there is delay in development of the East-West Line; poor coordination with feeder bus services and so on. Given a longer network of the Metro with East-West Line, the ridership of the Metro as a whole is expected to grow, as its network utility increases.
India	Delhi Metro System Development Project	1997~2008	JYN 2,633 bill.	75.3 km	Step by step development, based on a long term plan. Integrated management for user promotion such as feeder bus, car parking in stations, and real estate development at main stations. Technical assistance for the operation and management has been associated with infrastructure development project. The station facilities are well developed with a high standard, but station plaza and intermodal facilities still remain for further improvement.

Source: JICA Study Team

2.1.2 Underlying Issues on Urban Railway Project

In reviewing the seven urban railway projects whose implementations were/are being financially supported by Japanese Yen loans, it is found that some vital issues exist for the improvement of their railway systems in order to make full use of the functions.

(1) Needs of Long-term Plans

A considerably long-term perspective or vision should be delineated for the public transport network system, prior to starting of the railway project. Otherwise, a functional total network could not be structured as shown in the following cases.

- **Manila LRT:** Three LRT systems were introduced by Belgium, Japan and the Czech Republic separately. Therefore, the Manila LRT system cannot be operated under an integrated network system. This causes an imbalance in ridership distribution such that Line 1 has faced chronic congestions, while Line 3 is underutilized.
- **Kolkata Metro:** This subway cannot be operated as a network system with the East-West Line, because of a fatal delay in the construction and critical increase of the construction cost. As a result, the ridership cannot reach the level as expected, thereby resulting in financial difficulties for a sound operation. It is necessary that the project is

commenced with a deliberate plan on a long-term perspective.

(2) Need of Integrated Development with Intermodal Transfer Facilities

Some projects such as **Beijing Subway**, **Chongqing Monorail** and **Kolkata Metro**, have encountered a problem that passengers are enforced to put up with inconvenient intermodal transfer systems.

In case of the Beijing Subway, the platforms are located in deep underground, and stairs connecting with the platforms are narrow. As for the Chongqing Monorail, the approach to stations is of long distance and steep stairs from the down town, because the stations are located at middle points in the mountainous areas. There is a severe natural constraint due to its topographical configuration. For the Kolkata Metro, many bus services are available along the Subway corridor, and both are competing with each other. Bus services need to be rerouted to structure a functional feeder system.

(3) Needs to Coordinate with Urban Planning Administration

Because the main purpose of the yen loan projects is placed on the construction of railways, inter-governmental coordination with urban planning and urban development-related administration seems not to be sufficient in the design stage and/or prior to the implementation. Often transferring to another mode of transportation is not considered. In many cases, any budgetary sharing system was not established for the intermodal facilities and feeder transport service improvement.

(4) Need to Establish Operational Systems to Assure Seamless Transfer

Nowadays, new technologies are available to assure a seamless transfer, that is, an integrated ticketing system with other transportations is one of promising systems which is necessary to be introduced. Applied technologies for this purpose vary from a simple to a sophisticated system. Therefore, the most appropriate system can be selected in consideration of the practical conditions. A synchronized timetable with transferring modes is also a planning issue to be facilitated.

(5) Multi-functional Management Combined with Rail and Off-rail Business

Railway operation business may be combined with the real estate development business in the station and/or its vicinities. This multi-functional management of the railway business should be pursued in order for the railway operator to create a financially sustainable environment. This orientation has emerged in the Bangkok Blue Line as well as in Delhi Metro

2.2 Identification of Planning Issues on Delhi Metro

2.2.1 Main Objectives of the Questionnaire Survey in Delhi Metro

The Questionnaire Survey on Delhi Metro and Intermodal Transfer Facilities aims at understanding current usage of the Metro and clarifying what aspects Metro users are satisfied with and dissatisfied with, especially focusing on the intermodal transfer function of each Metro station. Metro stations should be located and designed to promote the shift to the Metro from other transportation modes and to maximize Metro users' utility level. More concretely, this survey was conducted to identify:

- Usage of Delhi Metro of residents and employees within the Metro service corridors; and
 - Level of satisfaction of Metro users and non-metro users in terms of intermodal transfer facilities and services and their improvement needs.

Table 2.2.1 shows a general profile of Delhi Metro Phase I Project. Total length is 74.56 km with 3 lines and 67 stations.

Table 2.2.1 Profile of Delhi Metro Phase 1

	Total (km)	At grade (km)	Elevated (km)	Underground (km)	Station
Line 1	25.1	4.5	17.50	0.0	21
Line 2	17.36	0.0	0.0	17.36	15
Line 3	32.1	0.0	29.93	2.17	31
Total	74.56	4.5	53.79	13.17	67

Source: DMRC

2.2.2 Target Stations for the Survey

(1) Target Stations for the Survey

The Metro stations are classified into several groups based on the characteristics of each station. A representative station has been selected from each group and the Questionnaire Survey has been conducted around this station as the main target.

The selected representative stations from four groups are: SHAHDARA; JANAK PURI WEST; UTTAM NAGAR WEST; and RAJIV CHOWK, and these stations' location characteristics are as shown in Table 2.2.2, and their general profiles, in Table 2.2.3.

Table 2.2.2 Selected Representative Stations and Their Characteristics

	SHAHDARA	JANAK PURI WEST	UTTAM NAGAR WEST	RAJIV CHOWK
Location	Suburban	City	City	Central Business District
Station Plaza	Existing	No	No	No
Car Parking	Existing	Existing	No	No
Surrounding Development by DMRC	Existing	No	No	No

Source: JICA Study Team

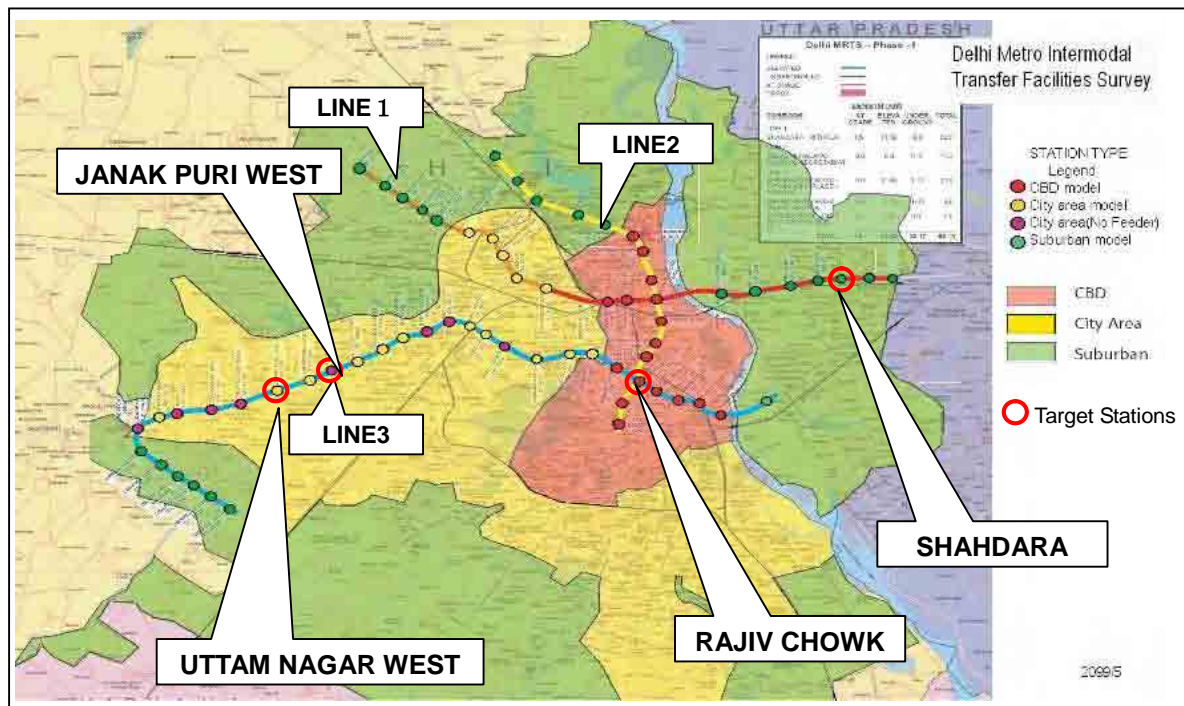

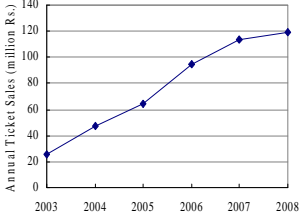


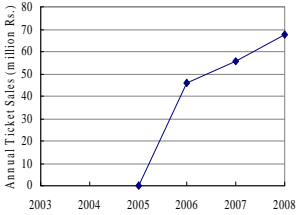


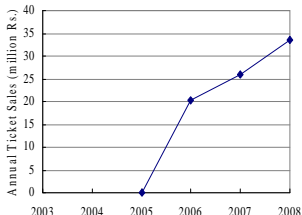


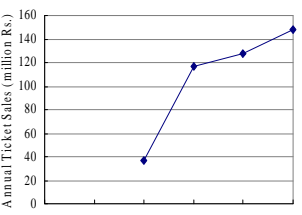
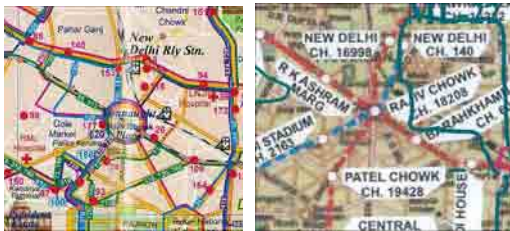


Figure 2.2.1 Locations of Selected Stations

Table 2.2.3 Profiles of the Target Stations

<p>Shahdara Station (Line 1) Location: (Suburban Area) Station Plaza: (Yes), Car Parking: (Yes) Surrounding Development by DMRC: (Yes)</p>  	<p>Connecting Bus Routes: 6 routes (1 feeder bus and 5 DTC/private bus routes) (with DTC Bus Routes) (with DMRC Feeder Bus Routes)</p> 
<p>Janak Puri West Station (Line 3) Location: (Suburban Area) Station Plaza: (No), Car Parking: (Yes) Surrounding Development by DMRC: (No)</p>  	<p>Connecting Bus Routes: 6 routes (4 feeder bus and 2 DTC/private bus routes)</p> 
<p>Uttam Nagar West Station (Line 3) Location: (Suburban Area) Station Plaza: (No), Car Parking: (No) Surrounding Development by DMRC: (No)</p>  	<p>Connecting Bus Routes: 0 routes</p> 
<p>Rajiv Chowk Station (Line 2 and Line 3) Location: (Central Business District) Station Plaza: (No), Car Parking: (No) Surrounding Development by DMRC: (No)</p>  	<p>Connecting Bus Routes: 6 routes (0 feeder bus and 6 DTC/private bus routes)</p> 

2.2.3 Samples of the Questionnaire Survey

(1) Types of the Survey

There are two main types of respondents for the Questionnaire Survey: residents around the stations in the suburban area, and employees of establishments in the central business district (CBD).

- **Residents Living around Stations in Suburban Area:** For sampling of residents living around the three representative stations in the suburban area, they should be evenly divided into those living within 1 km of the station where walking is considered as the main access mode to the station, and those living in the range of 1 km – 3 km from the station where the probability of using other transport modes is higher. Surveyors visited each sampled household and interviewed each household member (of age 18 or over) to fill in the questionnaire. The survey asked questions about the most frequent Metro trip for each respondent among several purposes (to work, to school, shopping, or for other private purpose). For those who do not use the Metro, the survey asked questions about the most frequent trip to the city center for each respondent among several purposes (to work, to school, shopping, or for other private purpose).
- **Employees of Establishments around Stations in CBD:** For sampling of establishments around the representative station in the CBD (i.e., Rajiv Chowk Station), they should be evenly divided into those located within 300 m of the station and those located farther than 300 m from the station. Surveyors visited each sampled establishment and interviewed each employee to fill in the questionnaire. The survey asked questions about the most frequent work-based Metro trip. For those who do not use the Metro, the survey asked questions about the most frequent work-based trip around the city.
- **Supplemental Survey at a Selected Station (Shahdara Station):** A supplemental survey was conducted at the Shahdara Station by directly interviewing Metro passengers transferring to/from Indian Railways and other access transport modes (i.e., DTC bus and park & ride). The questions focus on: 1) their satisfactory levels on facilities and services available at the station; and 2) their requirements/needs to improve the transfer functions.

(2) Sample Size

A total of 500 sample households were randomly selected for the four representative stations, that is, 125 samples for each type of the station. As mentioned above, samples were selected in consideration of the conditions of their residential places in terms of physical distance from the stations, availability of feeder bus services, convenience of their transportation modes, and so on. For the supplemental survey, an additional 400 Metro passengers were interviewed.

2.3 Identified Development Issues of Intermodal Transfer (through the Questionnaire Survey)

The current issues of the intermodal transfer functions held by the Delhi Metro System were identified through the Questionnaire Survey from the users' point of view.

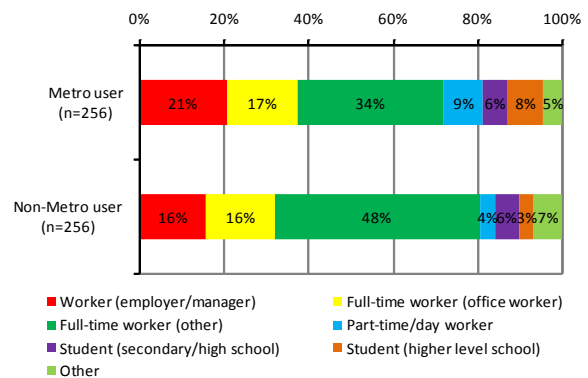
2.3.1 Characteristics of Metro Users and Non-Metro Users

The questionnaire survey for residents and employees around the representative stations was conducted through home-visit face-to-face interviews. Individual attributes as well as household attributes were surveyed from the Metro users and non-Metro users who make trips to/around the central business district (CBD). General characteristics of the questionnaire respondents were first analyzed by user type (i.e., Metro users and non-Metro users).

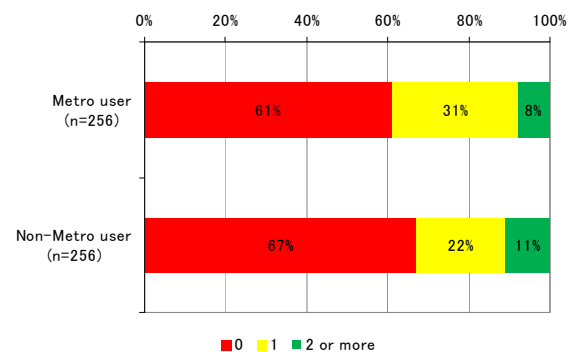
Over 80% of the respondents of both Metro users and non-Metro users are workers. Workers of Metro users consist of a variety of classes from employers/managers to part-time/ day workers. In addition, relatively more students are observed in the Metro users.

Although car-owning households are less than half, a larger share of car-owning households is observed in Metro users' households. Meanwhile, motorcycle-owning households take about 70% with a higher motorcycle-owning share in Metro users' households.

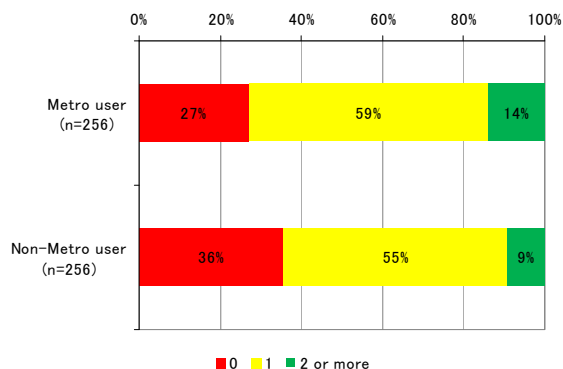
As for average monthly household income, the shares of households of middle-income classes are larger in Metro users. This may be due to the fact that lower-income people



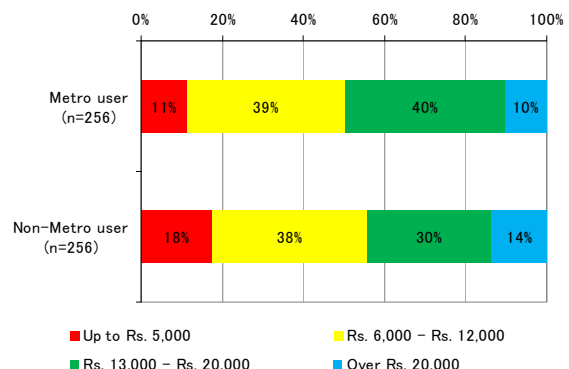
Status of the Questionnaire Respondents



Car Ownership of the Questionnaire Respondents



Motorcycle Ownership of the Questionnaire Respondents



Average Monthly Household Income of the Respondents

cannot afford to take the Metro while higher-income people prefer to use private travel modes such as cars.

2.3.2 Metro Users' Improvement Needs for Intermodal Transfer Functions

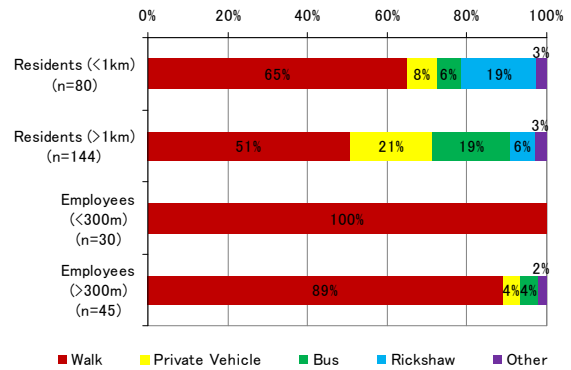
(1) Access Modes

Metro users' access mode to the stations was analyzed by distance from the station. Among suburban residents, while larger shares of access modes other than walk (i.e., private vehicles and buses) are observed in Metro users living over 1 km from the station, walk still takes around 50%. As described earlier, this may be because a considerable number of Metro users have no other option than to walk to the station under the current conditions.

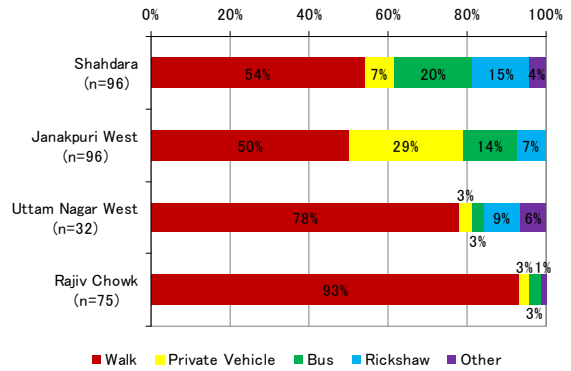
Meanwhile, Metro users' access mode varies in each representative station of which conditions are different in terms of availability of station plazas, feeder buses, DTC buses, car parks, and so on. However, walk takes at least 50% at all the stations. At Rajiv Chowk Station, in particular, walk takes the overwhelming majority. In the suburbs, access by bus or rickshaw takes relatively larger shares at Shahdara Station, which has a variety of access transport modes as well as a station plaza. On the other hand, access by walking takes nearly 80% at Uttam Nagar West Station, where few access modes are available.

(2) Users' Satisfactory Levels

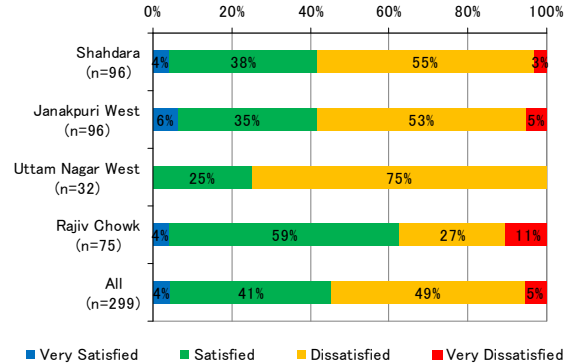
In terms of Metro users' satisfaction level of intermodal transfer functions at the station, more than half of them are dissatisfied with some intermodal transfer functions of their suburban station except for Rajiv Chowk Station in the CBD, which is accessed by walk in most cases. The share of dissatisfaction is the largest at Uttam Nagar West Station, in



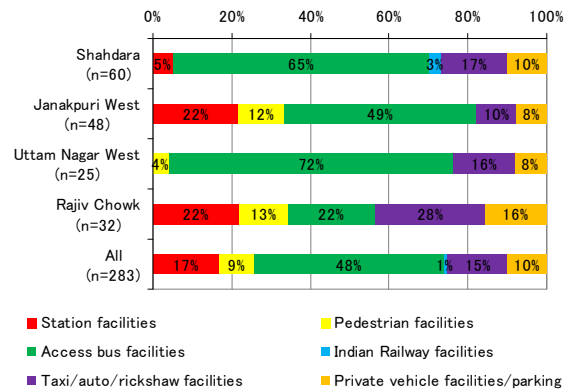
Metro Users' Access Mode to Stations (by Distance)



Metro Users' Access Mode to Stations (by Station)



Metro Users' Satisfaction Level of Intermodal Functions

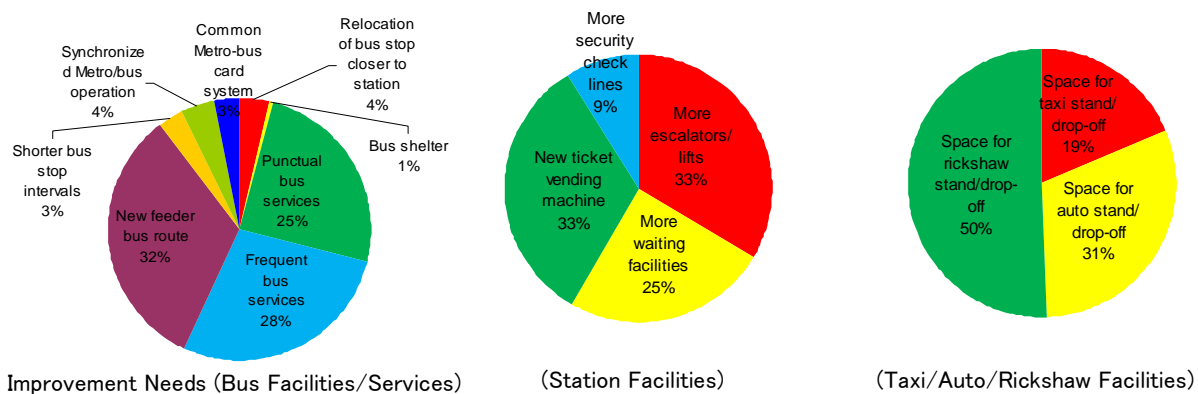


Facilities/Services that Metro Users are Dissatisfied with

which few access modes are available.

Furthermore, which facilities/services Metro users are dissatisfied with was asked. Though the result varies by station, dissatisfactions with bus facilities/services take the largest share in the suburban stations. Those who use DTC bus or DMRC feeder bus as an access mode to the station take less than 20%; however, dissatisfactions with bus facilities/services take a much larger share. It implies that, since bus services are not available to some Metro users at present, they have to take other access modes such as walk.

With respect to bus facilities/services, station facilities, and taxi/auto rickshaw/rickshaw facilities with which Metro users are most dissatisfied, their improvement needs were aggregated. Thus, requests regarding improvement of bus services take the majority. For station facilities, additional escalators/elevators, additional waiting facilities such as benches, and additional services to reduce the queues for ticket purchase and security check are needed. As for taxi/ auto rickshaw/rickshaw facilities, requests for more rickshaw space take the largest share. It may imply that the respondents request for improvement of traffic congestion caused by rickshaws waiting at the roadside due to the lack of a station square.

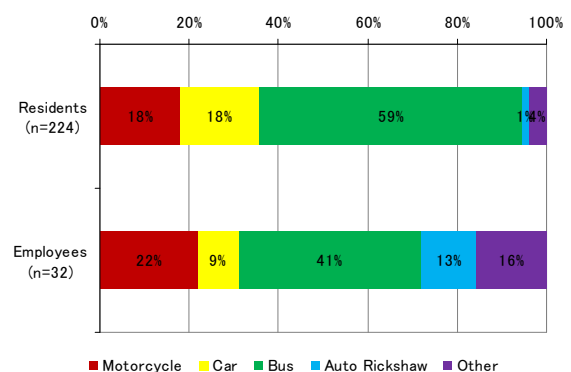


2.3.3 Non-Metro Users' Improvement Needs for Intermodal Transfer Functions

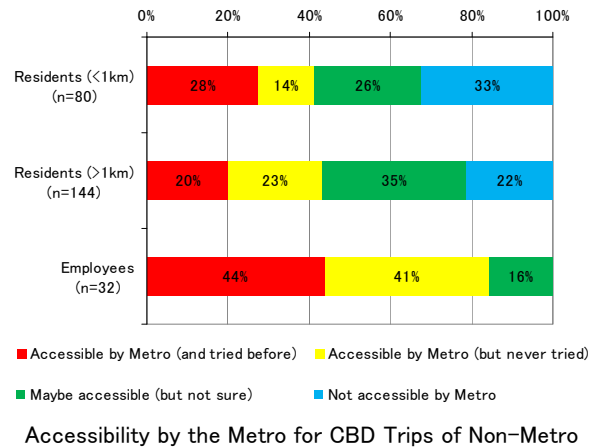
(1) Alternative Modes by Non-Metro Users

Around 60% of suburban non-Metro users take bus to go to the tCBD. As for CBD employees, while about 40% of them take bus, shares of motorcycles, auto rickshaws, and rickshaws are relatively larger.

For trips to/around the CBD made by non-Metro users, nearly half of suburban

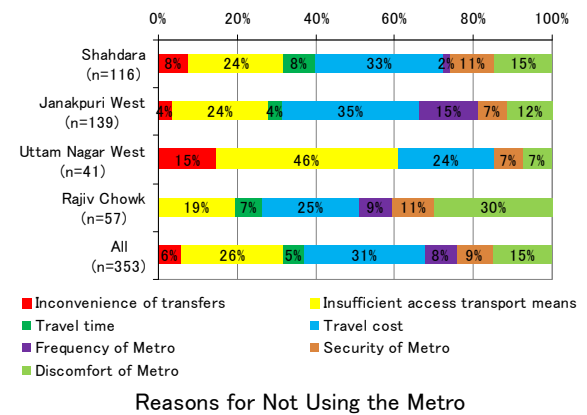


residents admit that their destinations are accessible by the Metro, whether they live within 1 km of the station or not. It may be natural that those who live within 1 km of the station have a larger share of having tried the Metro before. As for CBD employees, they have a higher probability that their destinations are accessible by the Metro because their workplace is relatively closer to the station. As a whole, there are not so many cases in which the Metro cannot be used for trips to/around the CBD (e.g., the destinations are physically inaccessible from Metro stations).



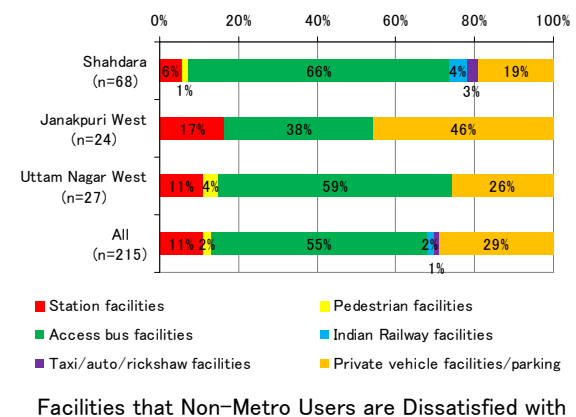
(2) Reasons of Non-Metro Users

Regarding reasons why non-Metro users do not use the Metro, there are a considerable number of respondents who stated that the total cost including the Metro fare is higher than that of the current travel mode at each representative station. However, about the same shares of non-Metro users pointed out dissatisfactions with intermodal transfer functions such as inconvenience of transfers and insufficient access transport means. Those shares are especially large at Uttam Nagar West Station, which has a problem in accessibility to the station. On the other hand, as for Rajiv Chowk Station, which is located in the CBD, there are a significant number of employees who answered discomfort of the Metro as a reason for not using the Metro. This may be partly because the Metro is crowded particularly in the CBD.



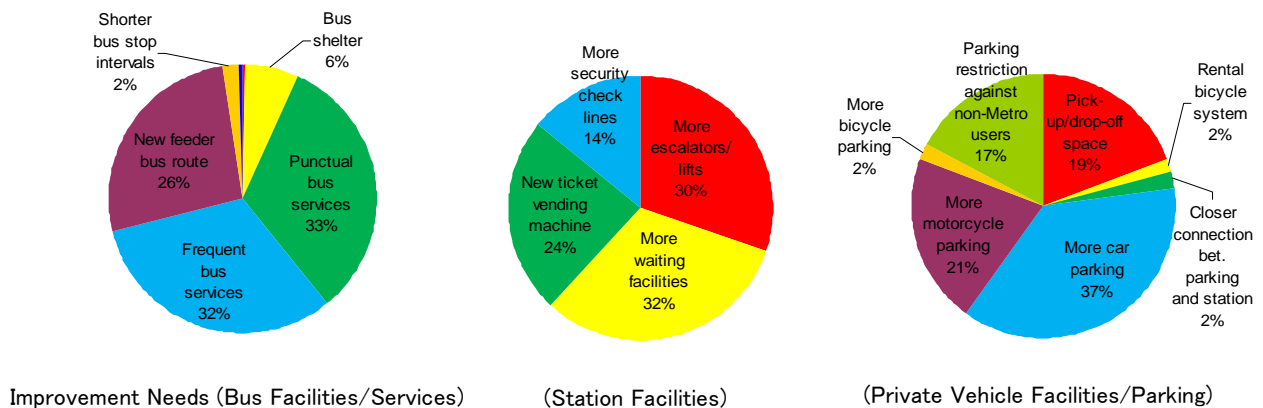
(3) Dissatisfactory Facilities Pointed Out by Non-Metro Users

Regarding which facilities/services non-Metro users are particularly dissatisfied with, dissatisfactions with bus facilities/services take the largest share. This implies that current non-Metro users also have a great potential of using the Metro if DTC buses or DMRC feeder buses become more easily available for access to the stations. For non-Metro users, dissatisfactions with private vehicle facilities/parking take the second largest share, followed by those with station facilities. It may be because, at present, there are many private vehicle users going to the CBD. Therefore, it can be inferred that improvement of private vehicle facilities and



parking is extremely important to encourage non-Metro users to shift to the Metro.

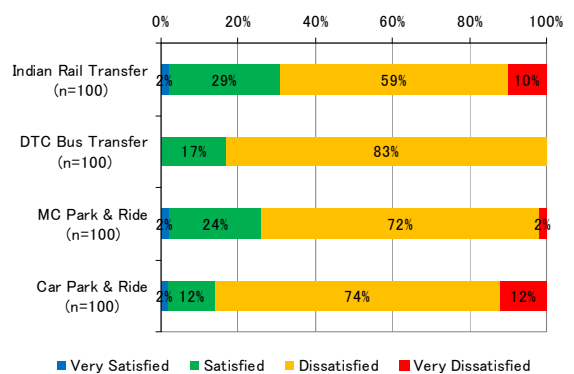
With respect to station facilities, bus facilities/services, and private vehicle facilities/ parking with which non-Metro users are most dissatisfied, their improvement needs were aggregated. For improvement needs in terms of bus facilities/services, a similar trend is observed as in the case of Metro users. That is, requests regarding improvement of bus services take the majority. While other requests include construction of bus shelters (equipped with waiting facilities and information boards), requests that are related to enhancement of intermodal transfer functions between bus and the Metro take only a small share. As for station facilities, the result is nearly the same as that of Metro users. That is, additional escalators/elevators, additional waiting facilities such as benches, and additional services to reduce the queues for ticket purchase and security check are needed. For private vehicle facilities/parking, requests that are related to expansion of car and motorcycle park & ride facilities, in which congestion is currently severe, take the majority. Parking restriction against non-Metro users is also requested by non-Metro users themselves. Thus, alleviation of congestion at parking facilities is an important issue. Current non-Metro users also have a great potential of shifting to the Metro if this problem was solved. There is also a significant share of requesting pick-up/drop-off space for private vehicles as one of the functions of station plazas.



2.3.4 Transferring Metro Users' Improvement Needs for Intermodal Transfer Functions

(1) Satisfactory Levels for the Intermodality

As a supplemental questionnaire survey, improvement needs of intermodal transfer functions were asked of Metro users transferring to/from Indian Railways and other access transport modes (i.e., DTC bus and park & ride) at Shahdara Station. Many Metro users who transfer to/from other modes are dissatisfied with

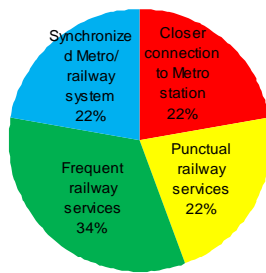


Satisfaction Level of Transfer Functions for Metro Users who Transfer to/from Other Access Modes

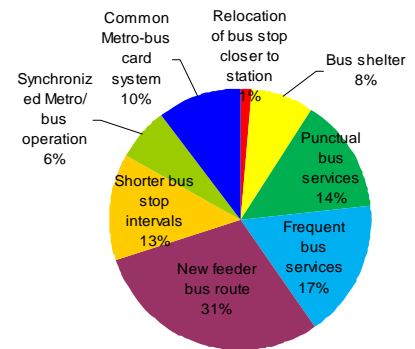
intermodal transfer functions at the station. The share of dissatisfaction is larger compared to the result of general Metro users, partly because this questionnaire survey was conducted at/around the station.

(2) Needs for the Improvement

Major improvement needs in terms of Indian Railway facilities/services are related to improvement of the railway service itself such as more frequent and punctual railway services. In addition, requests that are related to enhancement of intermodal transfer functions between Indian Railways and the Metro, including shortcuts to transfer to/from Indian Railways through a dedicated passage, synchronized Metro-railway operation, and so on.



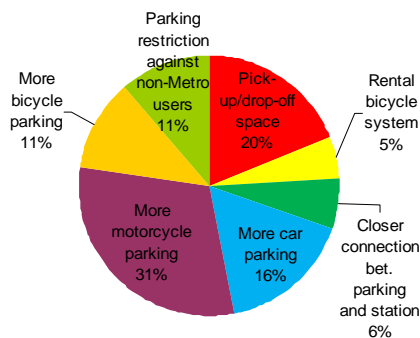
Transferring Metro Users' Improvement Needs (Indian Railway Facilities/Services)



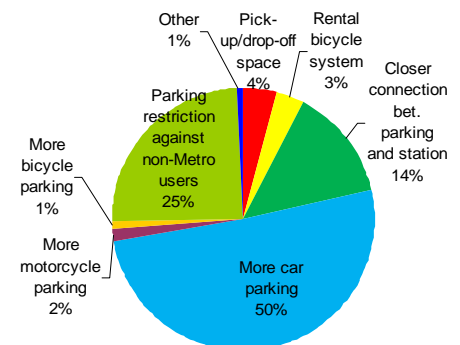
(Bus Facilities/Services)

Besides the major improvement needs of bus services such as new feeder bus routes, more frequent bus services, and punctual bus services, requests that are related to further enhancement of the convenience are more remarkable including shorter bus stop intervals, construction of bus shelters, synchronized Metro-bus operation, and introduction of a common Metro-bus card system.

While the major request made by Metro users transferring to/from motorcycle park & ride is expansion of motorcycle parks, there are also significant shares of requests for expansion of car parks and bicycle parks. This implies that motorcycle park & ride users may switch to car or bicycle for access to the station depending on the situation. In addition, there is also a significant share of requesting pick-up/drop-off space for private vehicles as one of the functions of station plazas. Other requests include introduction of a rental bicycle system.



Motorcycle Park & Ride Users (Private Vehicle Facilities/Parking)

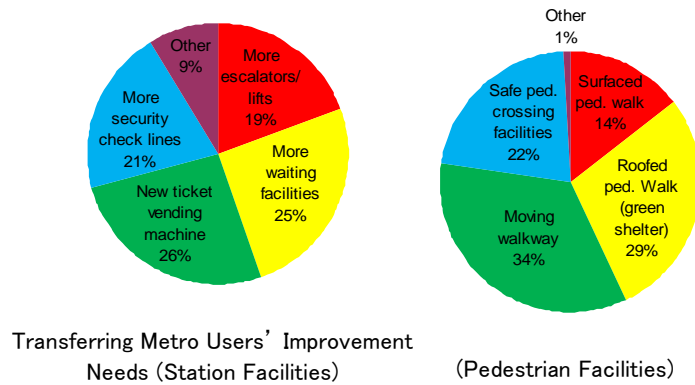


Car Park & Ride Users (Private Vehicle Facilities/Parking)

The major request made by Metro users transferring to/from car park & ride is expansion of

car parks only. In addition, parking restriction against non-Metro users is also requested by many car park & ride users. Other requests include closer connection between parking facilities and the station as well as more pick-up/drop-off space for cars.

There are also many requests for improvement of station and pedestrian facilities from the above-mentioned transferring Metro users. In terms of station facilities, there are particularly many requests for additional services to reduce the queues for ticket purchase and security check. Since Shahdara, in which the supplemental survey was conducted, is a transfer station with various transport modes, a heavy concentration of passengers can be expected.



With respect to improvement of pedestrian facilities, there are many requests for installation of roofs (including green shelters) or moving walkways for pedestrian passages to be used for transfers. In addition, there are many requests for safe pedestrian crossing facilities or dedicated pedestrian pavements. Over half of requests of pedestrian facilities made by Metro users transferring to/from DTC bus are especially concentrated on such pedestrian crossing facilities because they often get on/off the bus beside the trunk road.

2.3.5 Overall Issues on Intermodal Transfer Functions of Stations

Based on the site survey and the analysis of the above-mentioned questionnaire survey, overall issues and measures on intermodal transfer functions of stations of Delhi Metro are identified and sorted by relevant facility/service type as follows.

(1) Station Facilities

Although escalators and elevators have been installed in all the Delhi Metro stations, there are further requests for more escalators and elevators. It may be because escalators or elevators are not available in certain exits/directions or because escalators and elevators are often not installed to connect with station plazas or roads outside the station. It may be one of the factors in not using the Metro.

Congestion occurs for ticket purchase and security check before the ticket gate, and the queues become especially long at major stations in the CBD as well as in the suburbs during peak hours. This congestion is one of the deterrent factors in taking the Metro. Thus, additional security check lines and new automatic ticket vending machines are important issues to solve the current congestion problem.

In the stations, due to security reasons, there are few waiting facilities such as benches

even on the platforms. For enhancement of convenience for users, these waiting facilities need to be added.

(2) Pedestrian Facilities

Since Delhi Metro was constructed by often making use of the space over or beside existing roads, space for a station plaza was hardly available at many stations. Consequently, distances to access transport modes tend to be long, and thus it is important to secure comfort in walking between the access modes and the station. The fundamental solution is to provide dedicated and secure pedestrian pavements, and other options should also be considered such as covered pedestrian walkways (including green shelters) and moving walkways.

In cases where pedestrian passages are not well provided to connect the station and the road, some Metro users are obliged to cross the road to take access transport modes. While pedestrian crossings are often provided, traffic signals and pedestrian overpasses are not provided and it is difficult to cross the road in most cases. Thus, safe pedestrian crossing facilities are necessary.

(3) Bus Facilities/Services

Improvement in bus services as an access mode to Metro stations is requested by most respondents whether they currently use the bus or not. Major improvement needs are new feeder bus routes, more frequent bus services (including DTC buses), and punctual bus services.

Current Metro users make use of not only DMRC feeder buses but also conventional DTC buses as an access mode to Metro stations. Since improvement of bus transport to Metro stations is often requested by Metro users who currently take other access modes as well as by non-Metro users, not only DMRC feeder buses but also DTC buses should be targeted for improvement of the entire bus services to enhance the intermodal transfer functions of urban railway systems.

While DMRC feeder buses pick up and drop off passengers close to Metro stations, DTC bus stops tend to be located a little far from the stations. In future, it is necessary to improve the convenience of access bus users through relocation of bus stops closer to the stations, to construct bus shelters (including waiting facilities and information boards), and so on by reviewing the layouts of space around Metro stations or by securing the space for station plazas.

Overall, access bus service levels around Metro stations are currently not very high. Therefore, shorter bus stop intervals (i.e., shorter than the current standard of 1 km intervals) need to be considered to reduce the reluctance to use the Metro.

In terms of the system issues, improvements should include synchronized Metro-bus operation, common Metro-bus card system (with a discount for transfers), and so on in order to enhance the connectivity between the Metro and the bus.

(4) Taxi/Auto Rickshaw/Rickshaw Facilities

Space for a taxi or auto rickshaw stand is provided in station plazas of only limited number of stations such as transfer stations to Indian Railways. Such space is not available at other stations. Even if space for a station plaza is available, it is not well planned to cope with the access traffic and consequently taxis and auto rickshaws are often one of the causes of traffic congestion. Thus, it is necessary to study how to provide the space for a taxi or auto rickshaw stand.

Rickshaws are more frequently used around suburban stations. However, if there is no space for a station plaza, rickshaws occupy space beside the access road, creating traffic congestion. It is important to secure the pick-up/drop-off space for rickshaws for smoother traffic flow of other access transport.

(5) Private Vehicle Facilities/Parking

As car and motorcycle parking areas around many Metro stations are heavily congested, expansion of parking facilities is requested not only by Metro users but also by non-Metro users. Increase in parking capacity is an important issue, and parking buildings are being planned at some stations. If parking space becomes more easily available, it is hoped that a significant number of non-Metro users who currently use private vehicles all the way to the destinations will shift to the Metro.

As one of the measures to alleviate congestion at car and motorcycle parks, there are many requests for parking restriction against non-Metro users. At present, holders of a Metro Smart Card have free access to bicycle parks. A similar checking system should also be applied to car and motorcycle parks.

As one of the measures to enhance the intermodal transfer functions of the Metro, there are many requests for providing pick-up/drop-off space for cars and motorcycles. In addition, as for passage between parking facilities and stations, comfort and safety should be considered.

The share of motorcycle-owning households is relatively high, and it is assumed that motorcycle users easily shift to cars or bicycles depending on the situation. Therefore, current situation of usage of park & ride as well as the situation around stations needs to be studied in detail. Shifting to bicycles is preferable to shifting to cars from a viewpoint of efficient use of the limited space around stations. Thus, it is necessary to study the expansion of bicycle parking space and the potential for widespread use of rental bicycle systems as measures to improve the intermodal transfer functions.

(6) Indian Railway Facilities/Services

As for transfer between Delhi Metro and Indian Railways, though the Metro station and the Indian Railway station are located not too far apart from each other, total walking distance

including inside the large railway station tends to be long enough to cause reluctance to transfer. Hence, there are requests for shortcuts to transfer to/from Indian Railways in order to alleviate this sense of reluctance. Measures such as direct connection between the Metro and Indian Railways and synchronized Metro-railway operation are desirable for this purpose.

Commuter train service frequency of Indian Railways is currently one or two trains every hour. Thus, improvement in service frequency and punctuality is desired rather than the walking distance to transfer. Although improvement of Indian Railway services is out of the scope of this study, it is an important issue for the purpose of enhancing the usage of the entire public transportation system.

2.3.6 Identification of Issues of Each Representative Station

Based on the analysis of the questionnaire survey, issues on intermodal transfer functions at each representative station are summarized as follows.

(1) Shahdara Station

Improvement needs of bus facilities/services take more than half of the total improvement needs for both Metro users and non-Metro users at Shahdara Station, which is a representative station of Category 1 with a station plaza and connections with various transfer modes. Major improvement needs are related to improvement of bus services such as new feeder bus routes, more frequent bus services, and punctual bus services. Meanwhile, requests that are related to further enhancement of the convenience are more remarkable including shorter bus stop intervals, construction of bus shelters (including waiting facilities and information boards), introduction of a common Metro-bus card system, and synchronization of the Metro-bus operation.

As for the second most improvement needs after bus facilities/services, while Metro users request more space for an auto rickshaw/rickshaw stand, non-Metro users' improvement needs are related to private vehicle facilities/parking. In fact, while car users request expansion of car parking areas, motorcycle users often request expansion of car, motorcycle, and bicycle parking area. In addition, there are also significant shares of requests for parking restriction against non-Metro users, pick-up/drop-off space for private vehicles, closer connection between parking facilities and the station, and so on.

Furthermore, with respect to improvement of pedestrian facilities, there are requests for installation of roofs (including green shelters), moving walkways for pedestrian passages to be used for transfers, and safe pedestrian crossing facilities partly because walking distance between the station and the access modes tends to be long at Shahdara Station. In fact, over half of requests of pedestrian facilities made by Metro users transferring to/from DTC bus are especially concentrated on such pedestrian crossing facilities.

(2) Janak Puri West Station

Janak Puri West Station, which is a representative station of Category 2, is a medium-scale station with feeder bus services as well as parking facilities. However, the station has no station plaza, and hence it is considered that facilities/services of each access transport mode need to be improved.

The majority of requests made by Metro users are related to bus facilities/services such as new feeder bus routes, increase in service frequency and improvement in punctuality. On the other hand, improvement needs about private vehicle facilities/parking are relatively large especially among non-Metro users. In fact, it is larger than the share of bus facilities/services. As for access mode shares of Metro users, private vehicles take about 30%, which is larger than those of the other stations. Major requests for improvement include expansion of the car and motorcycle parks, provision of pick-up/drop-off space, parking restriction against non-Metro users, and so on.

The share of those who are dissatisfied with station and pedestrian facilities is greater than those of the other stations, and there are requests for additional security check lines, automatic ticket vending machines, and waiting facilities such as benches. Furthermore, while the station has an elevated structure over the trunk road, there is no passage available through the station. Thus, there are also requests for pedestrian facilities.

(3) Uttam Nagar West Station

Uttam Nagar West Station, which is a representative station of Category 3, has no station plaza. Feeder bus services and parking facilities are also non-existent; thus, 80% of Metro users access the station by walking and the remaining are likely to use rickshaws. Available services and facilities for access transport are thus limited. Therefore, the share of Metro users who are dissatisfied with intermodal transfer functions is the largest of the four representative stations. Regarding reasons why non-Metro users do not use the Metro, while the major reason is that the total cost including the Metro fare is higher than that of the current travel mode at the other three stations, what the non-Metro users pointed out most regarding Uttam Nagar West Station is dissatisfaction with intermodal transfer functions such as inconvenience of transfers and insufficient access transport means.

Since at present there are no DTC bus or feeder bus services for Uttam Nagar West Station, the share of complaints about bus facilities/services is overwhelmingly large among both Metro users and non-Metro users. Although it may imply that new (feeder) bus services are requested as an access mode to the station, the roads are currently not wide enough for buses to pass through the urban areas around the station.

Furthermore, Metro users request more pick-up/drop-off space of rickshaws, which are virtually the only access transport mode available. In addition, from both Metro users and non-Metro users, there are improvement needs about private vehicle facilities/parking

including provision of car and motorcycle parks as well as pick-up/ drop-off space in front of the station.

(4) Rajiv Chowk Station

Although Rajiv Chowk Station, which is a representative station in the CBD, has no station plaza, the Metro users' level of satisfaction in terms of intermodal transfer functions is relatively higher compared to that of the suburban representative stations. The number of passengers who use this station is very large, and walk is the dominant access mode with a 90% share. Meanwhile, there are a variety of access modes, and the questionnaire survey revealed complaints about those facilities/services. Thus, intermodal transfer functions need to be enhanced.

Taxis and auto rickshaws are often used as an access mode to Rajiv Chowk Station. Thus, there are relatively more complaints about taxis and auto rickshaws compared to the suburban stations. In fact, improvement needs for taxis and auto rickshaws take the largest share among Metro users, including providing taxi bays, securing space for pick-up/drop-off, and so on.

The share of complaints about bus facilities/services is relatively small as compared to the suburban stations. In addition to the basic improvement needs for new feeder bus routes, more frequent bus services, and punctual bus services, accessibility between the station and the bus terminals located outside the ring road is an issue which is also related to pedestrian facilities.

In terms of station facilities, since many passengers concentrate at this station, there are relatively more requests for additional security check and ticket vending facilities and equipment to reduce the queue of passengers compared to the other stations. Furthermore, as the platforms and trains are always crowded with passengers, alleviation of this congestion is also requested.

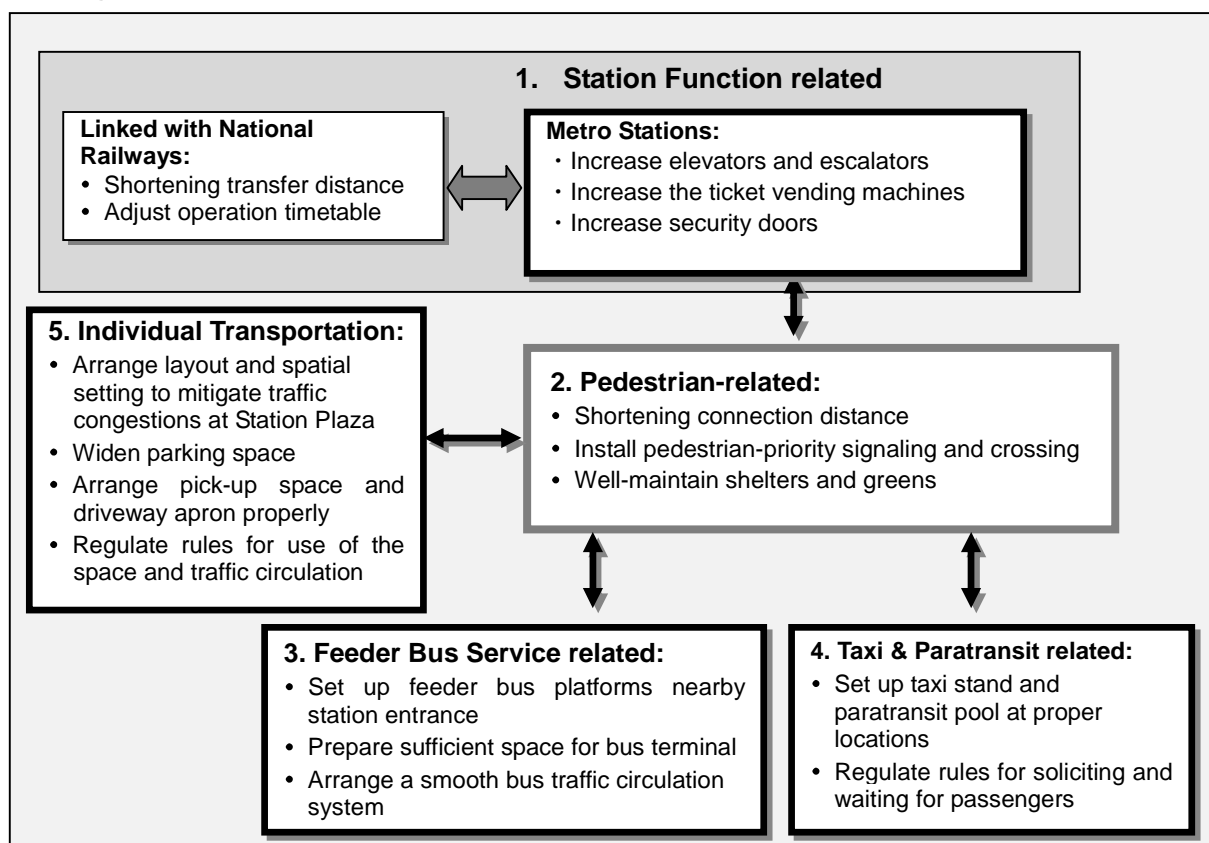
3. Improvement Measures by Station Type

3.1 Current Issues on Existing Intermodal Transfer Facilities at Delhi Metro Stations

Based on the Interview Survey and the site reconnaissance survey, overall issues facing Delhi Metro are summarized as shown in Figure 3.1.1. Referring to the overall issues, individual peculiar issues observed at the target stations are tabulated in Table 3.1.1.

As shown in Figure 3.1.1, the development issues are categorized into five (5) groups of facilities, that is, 1) Station function related; 2) Pedestrian-related; 3) Feeder bus service connection related; 4) Taxi & paratransit related; and 5) Private transportation related.

Figure 3.1.1 Overall Issues for Intermodal Facilities Improvement of Delhi Metro



Source: JICA Study Team

Table 3.1.1 Summary of Identified Issues on Intermodal Functions at Four Representative Stations

Item	Shahdara Station	Janak Puri West Station	Uttam Nagar West Station	Rajiv Chowk Station
Outline	It is a representative station of Category 1 with a station plaza and connections with various transfer modes. A supplemental survey was also conducted by directly interviewing Metro passengers transferring to/from Indian Railways and other access transport modes.	It is a representative station of Category 2. Though it is a medium-scale station with feeder bus services as well as parking facilities, it has no station plaza and hence it is considered that facilities/services of each access transport mode need to be improved.	It is a representative station of Category 3. It has no station plaza, and feeder bus services and parking facilities are also non-existent; thus, 80% of Metro users access the station by walking and the remaining are likely to use rickshaws. Non-Metro users also pointed out dissatisfaction with intermodal transfer functions rather than travel cost.	It is a representative station in the CBD. Metro users' satisfaction level in terms of intermodal functions is relatively higher. The number of passengers who use this station is very large, and walk is the dominant access mode with a 90% share. There are also a variety of access modes, and intermodal functions need to be enhanced.
Station Facilities		The share of Metro users who are dissatisfied with station and pedestrian facilities is greater than those of other stations. There are requests for additional security check lines, automatic ticket vending machines, and waiting facilities such as benches.		Since many passengers concentrate at this station, there are relatively more requests for additional security check and ticket vending facilities and equipment to reduce the queue of passengers. As the platforms and trains are always crowded with passengers, alleviation of congestion is also requested.
Pedestrian Facilities	There are requests for installation of roofs (including green shelters), moving walkways for pedestrian passages to be used for transfers, etc., partly because walking distance between the station and the access modes tends to be long. Over half of requests of pedestrian facilities made by Metro users transferring to/from DTC bus are especially concentrated on safe pedestrian crossing facilities .	While the station has an elevated structure over the trunk road, there is no passage available through the station . Thus, there are requests for pedestrian facilities.		

(cont'd)

Item	Shahdara Station	Janak Puri West Station	Uttam Nagar West Station	Rajiv Chowk Station
Bus Facilities/ Services	<p>Improvement needs of bus facilities/services take up half of the total improvement needs for both Metro users and non-Metro users. Major improvement need is for bus services such as new feeder bus routes, and more frequent and punctual bus services. Requests that are related to further enhancement of the convenience are remarkable including shorter bus stop intervals, construction of bus shelters (including waiting facilities and information boards), introduction of a common Metro-bus card system, and synchronized Metro-bus operation.</p>	<p>The majority of requests made by Metro users are related to bus facilities/services such as new feeder bus routes, increase in service frequency, and improvement in punctuality.</p>	<p>The share of complaints about bus facilities/services is overwhelmingly large among both Metro users and non-Metro users. Though new (feeder) bus services are requested as an access mode to the station, the roads are currently not wide enough for buses to pass through the urban areas around the station.</p>	<p>The share of complaints about bus facilities/services is relatively small as compared to the suburban stations. In addition to the basic improvement needs for new feeder bus routes, more frequent bus services, and punctual bus services, accessibility between the station and the bus terminals located outside the ring road is an issue which is also related to pedestrian facilities.</p>
Taxi/ Auto Rickshaw/ Rickshaw Facilities	<p>Metro users request more space for an auto rickshaw/rickshaw stand.</p>		<p>Metro users request more pick-up/drop-off space of rickshaws, which are virtually the only access transport mode available.</p>	<p>Taxis and auto rickshaws are often used as access modes. Improvement needs for taxis and auto rickshaws take the largest share among Metro users, including providing taxi bays, securing space for pick-up/ drop-off, etc.</p>
Private Vehicle Facilities/ Parking	<p>Many non-Metro users request more private vehicle facilities/parking. While motorcycle park & ride users often request expansion of motorcycle parks, car parks, and bicycle parks, car park & ride users request expansion of car parks only. There are also significant shares of requests for parking restriction against non-Metro users, pick-up/drop-off space for private vehicles, and closer connection between parking facilities and the station.</p>	<p>As for access mode shares of Metro users, private vehicles take about 30%, which is larger than those of the other stations. Improvement needs about private vehicle facilities/parking are relatively large especially among non-Metro users. Major requests for improvement include expansion of the car and motorcycle parks, provision of pick-up/drop-off space, parking restriction against non-Metro users, etc.</p>	<p>From both Metro users and non-Metro users, there are improvement needs about private vehicle facilities/parking including provision of car and motorcycle parks as well as pick-up/ drop-off space in front of the station.</p>	

Source: JICA Study Team

3.2 Possible Measures Implied from Advanced Experiences in Japan

The Delhi Metro stations are all well-designed with a considerably high standard in terms of the station function itself, but it is observed that facilities and systems to assure convenient intermodal mobility are still at a substandard level. Some possible measures to tackle the identified issues in the preceding section can be implied from Japanese experiences as follows:

(1) Pedestrian-related Facilities:



Elevated Pedestrian Deck connecting the Station with Commercial Building

Elevated Pedestrian Deck to/from the Station

(2) Feeder Bus and Tram Connection



Bus Berth attached to Railway Station



Tram System directly linked with a Railway Station

(3) Taxi Stand and Pool:

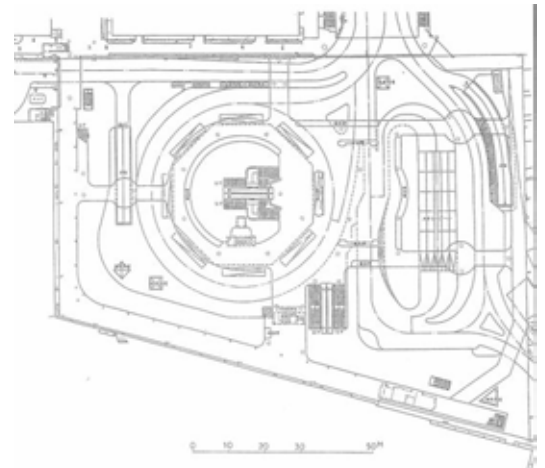


Taxi Stand and Shelter

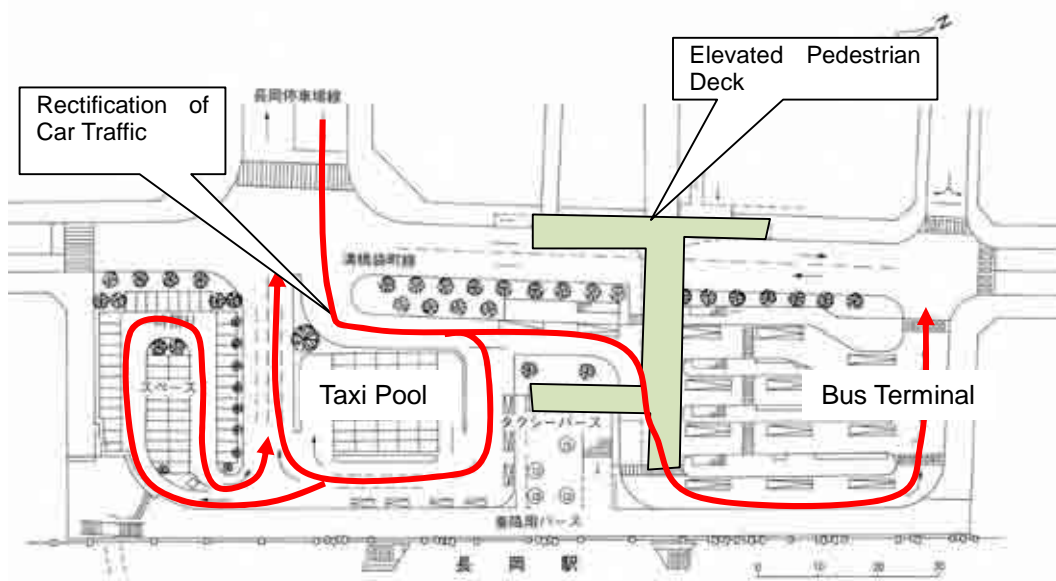
(4) Parking Facilities



Parking Building attached to the Station Building



(5) Traffic Circulation System at Station Plaza (Nagaoka Station, Japan Railways)



Station Concourse

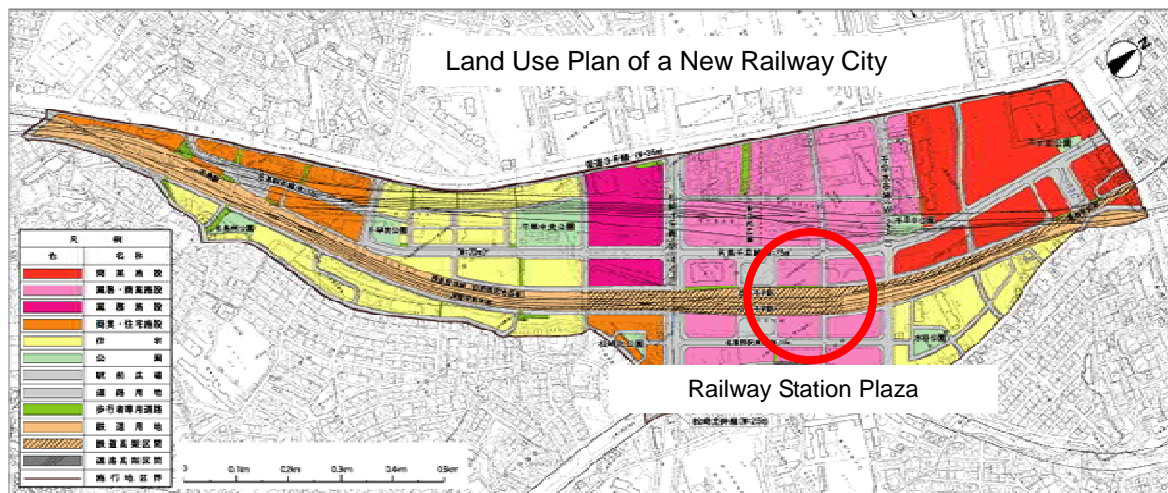
(6) New Urban Functions Attached to Stations



Joint Development of the Station Plaza and Commercial and Business Centers



Joint Development of the Station Plaza and Cultural and Exhibition Centers



Integrated Development of the Station Plaza and Urban Development at the surrounding area based on the Land Readjustment System (LRS)