Ministry of Transport,
National Authority for Tunnels
The Arab Republic of Egypt

JICA Preparatory Survey
On
Greater Cairo Metro Line No.4
In
the Arab Republic of Egypt

FINAL REPORT

Volume 3
(Feasibility Study Report 3/4)

1 of 2

JUNE 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
JAPAN RAILWAY TECHNICAL SERVICE
NIPPON CIVIC CONSULTING ENGINEERS CO., LTD

EID
JR
10-125

Ministry of Transport,
National Authority for Tunnels
The Arab Republic of Egypt

JICA Preparatory Survey On Greater Cairo Metro Line No.4 In the Arab Republic of Egypt

FINAL REPORT

Volume 3
(Feasibility Study Report 3/4)

1 of 2

JUNE 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
JAPAN RAILWAY TECHNICAL SERVICE
NIPPON CIVIC CONSULTING ENGINEERS CO., LTD

JICA Preparatory Survey
on
Greater Cairo Metro Line No.4
in
the Arab Republic of Egypt

CONTENTS OF FINAL REPORT

Exchange Rates

1.00 LE = JPY17.28
USD1.00 = JPY95.25
USD1.00 = 5.512 LE

Preface

In response to the request from the government of the Arab Republic of Egypt, the Government of Japan decided to conduct “JICA Preparatory Survey on Greater Cairo Metro Line No.4”, and entrusted the study and to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team consisted of Nippon Koei Co. Ltd., Japan Railway Technical Service (JARTS) and Nippon Civic Consulting Engineer Co. Ltd, headed by Mr. Hiroshi Izawa, between February 2009 to May 2010.

The team conducted field surveys at the study area and held discussions with the officials concerned of the Government of the Arab Republic of Egypt. Having completed them, now the team prepared this final report.

I hope that this report will greatly contribute to the construction and operation of the Metro Line No.4 for the urban transportation in Greater Cairo, as well as to enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation to the project.

June 2010

Kiyoshi Kodera
Vice President
Japan International Cooperation Agency

LOCATION MAP

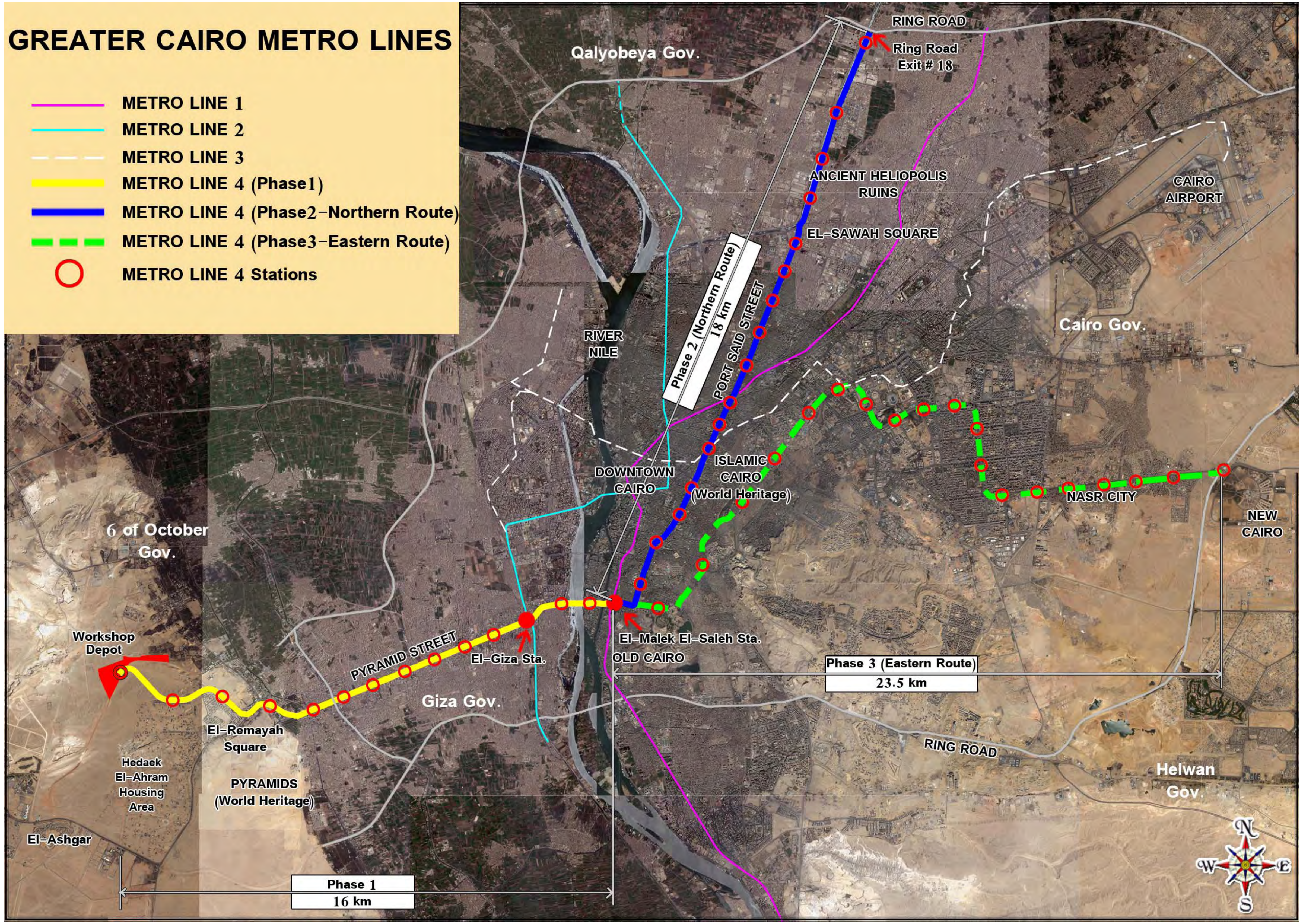


TABLE OF CONTENTS

JICA PREPARATORY SURVEY
ON
GREATER CAIRO METRO LINE NO.4
IN
THE ARAB REPUBLIC OF EGYPT

Final Report
Volume 3

Preliminary design on Greater Cairo Metro Phase 1
and
Economic Financial Analysis

Volume 3 1 of 2

TABLE OF CONTENTS

Volume 3 2 of 2

LIST OF ANNEXES

LIST OF APPENDICES

LIST OF TABLES AND FIGURES

GROSSARY OF ABBREVIATIONS AND MEASURING UNITS

GLOSSARY OF ABBREVIATIONS AND MEASURING UNITS

ABBREVIATIONS

A

AASHTO	American Association of State Highways and Transportation Officials
AB	Absolute Block
ABS	Automatic Block Signals
A/C	Air Conditioning
AC	Alternating Current
ACE	Arab Consulting Engineers
ACij	Access Length
ADT	Average Daily Traffic
AF	Audio Frequency
AFC	Automatic Fare Collection (system)
AfDB	African Development Bank
AG	Automatic Gate
AGT	Automated Guide-way Transit
AHU	Air Handling Unit
AM	Amplitude Modulation
am	Ante meridian
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance Association
ARS	Automatic Route Setting
ASCII	American Standard Code for Information Interchange
asl	Above Sea Level
ASTM	American Society for Testing and Materials
AT	Auto Transformer
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
ATS	Automatic Train Stop
Ave.	Average

B

BAS	Building Automation System
BCC	Beginning of Circular Curve
BCR	Benefit Cost Ratio
BD	Basic Design
BNC	British National Connector
BP	Brake Pipe
BRT	Bus Rapid Transit
BS	British Standard
BSE	Base Station Equipment
BT	Booster Transformer
BTC	Beginning of Transition Curve

C

CA	Certification Authority
CAA	Competent Administrative Authority
CAD	Computer Aided Design
C&I	Criteria & Indicator
CAPMAS	Central Agency for Public Mobilization and Statistics
CAPW	Construction Authority for Portable Water and Wastewater
CBD	Central Business District
CBTC	Communication Based Train Control
CCIR	International Radio Consultation Committee
CCITT	Consultative Committee for International Telephone and Telegraphs
CCP	Central Control Point
CCTV	Closed Circuit Television
CCU	Central Control Unit
CCU	Communication with Central Control Unit
CD ROM	Compact Disc Read Only Memory
CDR	Compact Disc Recordable
CIP	Central Interface Panel
CENELEC	European Committee for Electrotechnical Standardization
CI	Computerized Interlocking
CICC	Contactless IC Card
CIPF	Card Initiation and Personalization Function
CIPS	Card Initiation and Personalization System
CMH	Cubic Meter per Hour
CML	Cairo Metro Line

CMO	Cairo Metro Organization
CMOS	Complementary Metal Oxide Semiconductor
CNG	Compressed Natural Gas
COP	Crew Operation Panel
CPEE	City Unit Cable
CPM	Critical Path Method
CREATS	Cairo Regional Area Transportation Study
CRT	Cathode Ray Tube
CS	Cab Signal
CSC	Contactless Smart Card
CTA	Cairo Transport Authority
CULTNAT	Cultural and National Heritage
CV	Curriculum Vitae
CWO	Cairo Wastewater Organization
CWR	Continuously Welded Rail

D

DB	Dry Bulb (Ventilation)
D&B	Design and Build
DC	Direct Current
DC	Direct Cost
DCF	Discount Cash Flow
DF	Depot Facility
DIN	Deutsche Industry Norm (German Industrial Standard)
DO	Dissolved Oxygen
DOS	Disk Operating System
DSRSC	Design Standards for Railway Structures and Commentary
DWG	Drawing

E

E&M	Electrical and Mechanical
ECC	End of Circular Curve
ECM	Egyptian Company for Metro
ECMOU	Egyptian Company for Maintaining and Operating the Underground
ECS	Environmental Control System
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
Egij	Egress Length

EGP	Egyptian Pound
EGSA	Egyptian General Survey Authority
EHF	Extremely High Frequency (mill-meter wave)
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIRENE	European Integrated Railway Radio Enhanced NEtwork
EIRR	Economic Internal Rate of Return
ELCB	Earth Leakage Circuit Breaker
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EMU	Environmental Management Unit (Governorate)
EMU	Electric Multiple Unit
ENIT	Egypt National Institute of Transport
ENPV	Economic Net Present Value
ENR	Egyptian National Railway
EPBM	Earth Pressure Balanced Machine
EPI	Environmental performance Indicator
ER	Electric Room
ERs	Executive Regulations
ERTMS	European Railway Traffic Management System
ETC	End of Transition Curve
ETCS	European Train Control System
ETHERNET	Computer Cabling System
EU	European Union
EUA	EU emission Allowance

F

FCC	Federal Communications Commission
FIRR	Financial Internal Rate of Return
FM	Frequency Modulation
FOB	Free On Board
FOC	Fiber Optic Cable
F/S	Feasibility Study
FS	Fail Safe
FSK	Frequency Shift Keying
FSR	Feasibility Study Report
FTP	File Transfer Protocol
FY	Fiscal Year, Financial Year

G

GARBLT	General Authority for Roads, Bridges and Land Transport
GC	General Consultant
GCA	Greater Cairo Area
GCR	Greater Cairo Region
GDP	Gross Domestic Product
GEM	Grand Egyptian Museum
GHG	Greenhouse Gas
GIS	Geographic Information System
GL	Ground Level
GNI	Gross National Income
GOE	Government of Egypt
GOJ	Government of Japan
GOPP	General Organization for Physical Planning
GPS	Global Positioning by Satellite System
GRDP	Gross Regional Domestic Product
GSM	Global System for Mobile communications
GSM-R	Global System for Mobile communications for Railways
GUI	Graphical User Interface

H

HB	Home Based
HFC	Hydro-Fluoro-Carbon
HIS	Home Interview Survey
HMI	Human Machine Interface
Hz	Hertz
hr	hour
HS	Hindrance Sensor
HTTP	Hyper Text Transfer Protocol
HVL	High Voltage Line
HVS	High Voltage Station

I

IBA	Important Bird Area
IBC	International Building Code
IBRD	International Bank for Reconstruction and Development
IC	Integrated Circuit
ICEA	Insulated Cable Engineers Association
IDC	In-Direct Cost

IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IMF	International Monetary Fund
IP	Implementation Program
IRJ	Insulated Rail Joint
IRR	Internal Rate of Return
IS	Information System
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
IT	Information Technology
I-Tax	Import Tax
ITU	International Telecommunication Union
ITV	Industrial Television
IUCN	International Union for Conservation of Nature and Natural Resources

J

JARTS	Japan Railway Technical Service
JBIC	Japan Bank for International Cooperation (former name of JICA)
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JNR	Japanese National Railways
JPY	Japanese Yen
JST	JICA Study Team

K

kCal	kilo-Calory
kV	kilo Volt
kVA	kilo Volt Ampere

L

LAN	Local Area Network
LCD	Liquid Crystal Display
LCU	Local Control Unit
LCX	Leaky Coaxial Cable
LE /L.E.	Egyptian Pound
LED	Light Emitting Diode
LPS	Lighting and Power Station

LRT	Light Rail Transit
LRV	Light Rail Vehicle
LRU	Line Replaceable Unit
LT	Link Traffic
LV	Low Voltage
LWR	Long Welded Rail

M

MCA	Multi-Criteria Analysis
MCBF	Mean Cycle Between Failure
MCP	Manual Control Panel
MCPC	Monitoring and Control Personal Computer
MCS	Manual Control Switch
MDB	Manual Door Opening Button
M&E	Mechanical and Electrical
MDBF	Mean Distance Between Failure
MDOP	Manual Door Operation Panel
MH	Maintenance Hatch
MIL	Military Specification
min.	minute
MIS	Management Information System
MJC	Misr Japan Alled Company for Rolling Stock Maintenance and Renweal
MLIT	Ministry of Land Infrastructure, Transport and Tourism / Japan
MOH	Ministry of health (Egypt)
MOT	Ministry of Transport (Egypt)
MP	Mimic Panel
MPU	Motive Power Unit
MPU	Micro Processor Units
MRT	Mass Rapid Transit
MSEA	Ministry of State for Environmental Affairs
MSK	Minimum Shift Keying Modulation
MT	Matting Transformer
MT	Magnetic Ticket (AFC)
M4N	Metro Line 4 North section (Phase 2)
M4W	Metro Line 4 West Section (Phase 1)
MW	Mega Watt

N

NAT	National Authority for Tunnel, Ministry of Transport
NATM	New Austrian Tunneling Method
NFPA	National Fire Prevention Association
NGO	Non-Governmental Organization
NHB	Non-Home Based
NOUH	National Organization for Urban Harmony
NOx	Nitrogen Oxides
NPV	Net Present Value
N-Sta.	North line Station (Phase 2)
NUC	New Urban Community

O

OA	Outside Air (Ventilation)
OCC	Operation Control Centre
OCS	Overhead Contact System
OD / O/D	Origin and Destination
ODA	Official Development Assistance
OFC	Optical Fibre Cable
OHC	Over Head Catenary
O&M	Operation and Maintenance
OP	Operation Policy
ORC	Overhead Rigid Conductor

P

p.a.	per annum
P&L	Profit and Loss
PA	Public Announcement/ Public Address
PAP	Project Affected Person
Pax	Passenger
PBX	Private Automatic Branch Exchange
PC	Pre-stressed Concrete
PC	Personal Computer
PCP	Power Control Point
PCU	Passenger Car Unit
p/h	person per hour
PHPDT	Peak Hour Peak Direction Trips
PID	Passenger Information Display
PKI-SAM	Public Key Infrastructure - Security Access Key

pm	post meridian
PM	Particulate Matter
PMSM	Permanent Magnet Synchronous Motor
PPHPD	Passengers Per Hour Per Direction
PPM	Planned Preventive Maintenance
PRC	Programmed Route Control
PRJ	Projector
PSD	Platform Screen Door
P.T.	Piaster
PT	Person Trip
PTC	Programmed Traffic Control
PPM	Parts Per Million
PSO	Public Service Obligation
PVC	Poly Vinyl Chloride
PVU	Portable Verification Unit
PW	Permanent Way

Q

QA	Quality Assurance

R

RA	Returned Air
RAMS	Reliability, Availability, Maintainability and Safety
RAP	Resettlement Action Plan
RBO	Regional Branch Offices
RC	Reinforced Concrete
RCS	Radio Central Control System
Rd.	Road
RF	Radio Frequency
Rf	Rectifier equipment
RH	Relative Humidity
RI	Relay Interlocking
Rij	Railway Length
RL	Rail Level
ROE	Return On Equity
ROI	Return On Investment
ROW	Right Of Way
RP	Revealed Preference
RPS	Revealed Preference Survey

	RPF	Resettlement Policy Framework
	RS	Rectifier Station
	RS	Rolling Stock
	RT	Refrigeration Tons
	RTU	Remote Terminal Unit
	RTRI	Railway Technical Research Institute, Japan
	R/W	Read and Write
S		
	SA	Supply Air
	SAM	Security Access Module
	SCA	Supreme Council of Antiquities
	SCADA	Supervisory Control and Data Acquisition
	SCU	Station Control Unit
	SDH	Synchronous Digital Hierarchy
	SDMP	The Strategic Urban Development Master Plan Study for a sustainable Development of the Greater Cairo Region in the Arab Republic of Egypt
	Sec.	Section
	sec.	second
	SEVP	Signal Polyethylene Vinyl Cable
	SF	Stored Fare (Ticket)
	SHF	Super High Frequency (centimeter wave)
	SI	Systeme Internationale d'Unites (SI Unit)
	SI	Sensitive Indicator
	SIFE	Students in Free Enterprise
	SL	Screen Line
	SM	Single Mode
	SO_2	Sulfur Dioxide
	SOFRETU	Société Française d'études et de réalisations de transports urbains
	SP	Stated Preference
	SPAD	Signal Passing At Danger
	SPF	Shadow Pricing Factor
	SPS	Stated Preference Survey
	SPT	Standard Penetration Test
	SQEE	Signal Quad Polyethylene Cable
	sq.m.	square meter

SSOP	Station Staff operation Panel
STA / Sta.	Station
STRASYA	Standard Urban Railway System for Asia
STEP	Special Terms for Economic Partnership
SV	Switching Value
S/W	Scope of Work
SWWT	Spine Waste Water Tunnel

T

TAC	Track Access Charge
TAZ	Traffic Analysis Zone
TBM	Tunnel Boring Machine
TD	Train Detection
TD	Tender Document
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TEF	Tunnel Exhaust Fans
TETRA	Terrestrial Trunked Radio
TIS	Ticket Initialization Unit
TOM	Ticket Office Machine
TOR	Terms Of Reference
TR	Ticket Reader
TV	Television
TVF	Tunnel Ventilation Fans
TVM	Ticket Vending Machine

U

UNDP	United Nations Development Programme
UIC	Union International des Chemins de fer (International Union of Railways)
UPS	Uninterruptible Power Supply
USRT	United States Refrigeration Tons

V

V	Volt
VAT	Value Added Tax
VHF	Very High Frequency
VOC	Vehicle Operating Cost
VOT	Value Of Travel Time
VVVF	Valuable Voltage Valuable Frequency

W

W	Watt
WB	World Bank
WB	Wet Bulb
W/D	Workshop/Depot
W/S	Work Station
WS	Wayside Signal
WAN	Wide Area Network
WWW	World Wide Web
WYSIWYG	What You See Is What You Get

UNITS OF MEASURE

A	Ampere
Amp	Ampere
BTU	British Thermal Unit
dB	Decibel
dBA	Decibel on the 'A' weighted scale
FC	Foot-candles
g	Acceleration due to Gravity (32.2 ft/s2 =9.81 m/s2)
H	Hour
Hz	Hertz
In	Inch
J	Joule
ha	Hectare
kg	Kilogram
kHz	Kilohertz
km	Kilometer
km^2	Square Kilometer
km/h	Kilometer per hour
kWh	Kilowatt hour
kV	Kilovolt
I	Liter
L.E.	Egyptian Pound
m	Meter
m^2	Square Meter
mg/l	Milligram per Litter
MHz	Mega Hertz
min	Minute
mm	Millimeter
MW	Megawatt
MVA	Mega Volt Ampere
mV	Millivolt
ìV	Microvolt
N	Newton
NYU	Nephelometric Turbidity Unit
ppm	parts per million
RT	Refrigeration Tons

sec	Second
ug/m^3	Microgram per cubic meter
USRT	United States Refrigeration Tons
V	Volt
Vac	Volt alternating current
Vdc	Volt direct current
wt	weight
° C	Degree Celsius
° F	Degree Fahrenheit

EXECUTIVE SUMMARY OF VOLUME 3

EXECUTIVE SUMMARY OF VOLUME 3

1. Introduction

1.1 Background and Purpose of the Study

The Greater Cairo Region is the premier city in Egypt. It is rich in history and boasts of a large number of historical structures. It is the largest city in the African Continent and the Middle Eastern Region with a population of over 18 million, representing 25% of the total population of Egypt.

As the population of the Greater Cairo Region is envisaged to increase to 20 million by the year 2017 according to the SDMP Report, the Government of Egypt (GOE) is reforming the urban structure, changing from a mono-centric form to a decentralized form, notably through the development of New Urban Communities (NUCs), such as the 10th of Ramadan City and 6th October City. However, the increasing transport demand has not been accompanied by a substantial solution to urban problems such as road traffic congestion, insufficient public transportation services and air pollution.

At present two metro lines are in service and one metro line is under construction. As a long-term strategic development plan, the General Organization for Physical Planning (GOPP) has prepared “the Cairo Vision 2050”. This vision document proposes 14 metro routes as the main public transport system in the Greater Cairo Region.

Under this circumstance, GOE has decided to construct, as early as practicable, the Metro Line 4, and requested the Government of Japan (GOJ) to implement the “Development Study on Greater Cairo Metro Line No.4 Project in October 2008, by the Government of the Arab Republic of Egypt”. The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of GOJ’s programs, has had discussions with the National Authority for Tunnels (NAT) of the Ministry of Transport and has agreed to conduct a feasibility study for the proposed Metro Line 4. The document for the Scope of Work was signed on 21st December 2008.

1.2 Implementation of the Study

The JICA Preparatory Survey on the Greater Cairo Metro Line No.4 was undertaken in March 2009, based on the Scope of Work agreed among the NAT, the Ministry of Transport, and the JICA. The study was carried out by the JICA Study Team (JST), which is the consultant team hired by JICA for the implementation of this study. The JICA Preparatory Survey consists of the following two major studies.

- New Transportation Study on Greater Cairo Metro Line No.4, including selection of the routes for Phase 1 and Phase 2, considering future transport demand up until the year 2050.
- A complete Feasibility Study for the combined Phase 1 and Phase 2 selected route, including Preliminary Design for Phase 1, considering future transport demand up until the year 2050.

2. Main Study Components of Volume 3

The main components to be covered in Volume 3 are as follows;

1) Review and Updating Demand Forecast for Metro Line 4
2) General Features and Main Characteristics
3) Preliminary Design for Phase 1
4) Outline Design for Phase 2
5) Operation and Maintenance Management Plan
6) Project Cost and Packaging
7) Planning of Project Implementation Program
8) Environmental and Social Considerations
9) Resettlement Action Plan (RAP) Framework Study
10) Archaeological Assessment Study
11) Economic and Financial Analysis

3. Review and Updating Demand Forecast for Metro Line 4

The forecasting reference years for demand estimation are set up on the basis of the construction schedule, i.e., as of 2020, 2023, 2027 and 2050. The year 2020 is the starting year of the Metro Line 4, Phase 1 section operation, while 2023 is the starting year of that of the Phase 2 section. The year 2027 is the base year of the projection and the year 2050 is the target year for facility planning. The results of the demand forecast and daily/peak hour passengers for Metro Line 4 are summarized in the tables below.

Table 1 Projected Passenger by Transportation Mode

	Private Mode (Passenger Car, Taxi)	Public Bus Mode (Bus, Shared Taxi)	Public Rail Mode (Metro, LRT)	Total
Year 2020	7,317,081	12,815,802	3,946,918	24,079,801
	30.4%	53.2%	16.4%	100.0%
Year 2023	8,292,396	12,607,342	4,388,364	25,288,102
	32.8%	49.9%	17.4%	100.0%
Year 2027	9,561,250	12,364,875	4,776,201	26,702,326
	35.8%	46.3%	17.9%	100.0%
Year 2050	19,222,178	16,017,445	7,961,171	43,200,794
	44.5%	37.1%	18.4%	100.0%

Unit: person-trip per day
Source: JICA Study Team

Table 2 Number of Passengers Per Day for Metro Line 4

	Summary of Number of Passenger Per Day			
	Year 2020	Year 2023	Year 2027	Year 2050
Phase1 Section	1,011,900	1,100,700	1,594,900	2,041,500
Phase2 Section	0	1,475,800	1,681,600	1,874,400
Total	1,011,900	2,576,500	3,276,500	3,915,900

Note: The passengers who ride on both Phase 1 and 2 sections on Metro Line 4 are counted as the passengers of Phases 1 and 2, respectively. Therefore, the number of passengers for Line 4 in total is smaller than the simple summation of Phase 1 and Phase 2 sections.

Source: JICA Study Team

Table 3 Summary of Metro Line 4 Section Maximum Passengers

Year		Phase 1 Section	Phase 2 Section
2020	Sec Pax (section passenger both direction per day)	427,700	-
	PPHPD (passenger per hour per direction)	29,940	-
2023	Sec Pax (section passenger both direction per day)	447,700	725,100
	PPHPD (passenger per hour per direction)	31,340	50,760
2027	Sec Pax (section passenger both direction per day)	584,700	763,800
	PPHPD (passenger per hour per direction)	40,930	53,470
2050	Sec Pax (section passenger both direction per day)	784,700	796,400
	PPHPD (passenger per hour per direction)	54,930	55,750

Source: JICA Study Team

4. General Features and Main Characteristics

The main technical characteristics for the railway system proposed for Metro Line 4 are shown in Table 4 below

Table 4 Main Technical Characteristics

No.	Description	Details	
		Phase 1	Phase 2
1	**Alignment**		
		El Malek El Saleh Sta. (Line 1) – El Giza Sta. (Line 2) - El Remayah Square - Workshop/Depot	El Malek El Saleh Sta. (Line 1) - Ghamrah - El Sawaha Square - Ring Road Exit #18
2	**Route length**		
	Total route length	16.1km	17.9km
	- Underground section length	16.1km	12.5km
	- Elevated section length	0km	5.4km
3	**Stations**		
	Total number of stations	15 stations	16 stations
	- Number of underground stations	15 stations	12 stations
	- Number of elevated stations	0 stations	4 stations
4	**Operation status**		
	Estimated number of passengers/day - In year 2020 (Opening) - In year 2050	0.69 million (Phase 1 only) 2.04 million (Phase 1+ Phase 2)	
	Headways in peak hour	4 minutes 00 seconds in 2020 2 minutes 09 seconds in 2050	
	Maximum operation speed - Underground section - Elevated section - Inside depot	80 km/hr 100 km/hr 25 km/hr	
	Average speed	32.2 km/hr	

No.	Description	Details	
		Phase 1	Phase 2
	Dwell time at intermediate stations	30 seconds	
	Round trip time	70 minutes	137 minutes (Phase 1+ Phase 2)
	Daily operation hour	05:00h – 01:00h	
	Train size	8 cars in a train-set	
	Driver system	Single driver operation	
	Location of CCP	El Malek El Saleh	
5	**Standards of construction**		
	Gauge	1,435 mm	
	Track center distance	3.5 m at elevated section	
	Tracks	Vibration-reducing track	
	Design Axle load	16 tonnes max.	
	Rail	UIC 54 kg/m	
	Max. gradient	4%	
	Min. horizontal curve radius	Main line: 250 m Main line turnout curve: 160 m Workshop / depot line: 160 m Workshop / depot line turnout curve: 120 m Platform section: 1,000 m	
6	**Tunnel structure**		
	Type of tunnel	Single track Double tube	
	Diameter	6.2 m (Inner diameter)	
7	**Station structure**		
	Number of Platform - Island type - Side type	11 stations 4 stations	16 stations 0 stations
	Platform width	12.0 m (island type)	
	Platform height	1100 mm	
	Platform length	170 m	
8	**Depot**		
	Stabling capacity	35 train sets	35 train sets
	Facilities	Stabling and maintenance facilities	Stabling facilities
9	**Rolling stock**		
	Type of rolling stock	EMU (Electric Multiple Unit)	
	Train formation	M-N1-T-N2-N2-T-N1-M or Tc-N3-N1-N3-N1-N3-N1-Tc	
	Passenger capacity (AW2: 7 person/m2)	2,000 passenger/train	
	Train dimensions - Car length (over coupler faces) - Car width - Car height -Train length (8-car unit)	20.0 m 2.88 m 4.1 m 160 m	
	Propulsion System - Circuit control system - Traction motor - Motor output power	Inverter with IGBT PMSM[*1] or Induction motor 140 kW/motor	
	Car body material	Lightweight stainless steel	
	Doors	8 doors per car (4 on each side)	
	Kinetic performance - Initial acceleration ratio - Max service deceleration	0.9 m/s^2 1.1 m/s^2 (ability 1.3 m/s^2)	
	Air conditioning - Type of air conditioning - Capacity	Roof-mounted with line-flow fan 40,000 kcal/h/car	

No.	Description	Details Phase 1	Details Phase 2
10	**Power supply and traction system**		
	Electrification system	1500VDC	
	Type of centenary system	OHC (Tunnel: Overhead rigid conductor)	
	Voltage - Nominal voltage - Max. voltage - Nin. voltage	1500VDC 1800VDC 1000VDC	
	HVS (High Voltage Station) - Number of stations - Transformer capacity	1 HVS 80MVA	1 HVS 80MVA
	RS (Rectifier Station) - Number of stations - Capacity	5 RS 6MW	6 RS 6MW
	LPS (Lighting Power Station) -Number of stations	1 LPS/station and Depot	
11	**Signalling and Telecommunications system**		
	Signals - Main line including between main line and stabling in Depot - Inside of Depot	On-board signal Wayside signal	
	Train detection system	Track circuit	
	Route Control system - Interlocking - Point machine	Electrical interlocking Electrical point machine	
	Train Interval control system	ATP(Automatic Train Protection, Continuous control) PTC (Programmed Traffic Control)	
	Train operation support system - System - Accuracy	ATO (Automatic Train Operation) Stopping accuracy: Approx. plus minus 350mm	
	Backbone transmission network system - System - Transmission media	SDH (Synchronous Digital Hierarchy) Optical fibre transmission system	
	Train radio system - System - Antenna	VHF*2 TDM/TDMA*3 LCX (Leaky Coaxial Cable)	
	CCTV (Closed Circuit Television) system including on-board monitoring system	Monitoring of platform, concourse, ticket gate, elevator, escalator, others	
	Passenger Information system	PIDS (Passenger Information Display System) PA (Public Address System) Clock system	
12	**Station Facilities**		
	AFC (Automatic Fare Collection) system - Type of ticket media - IC chip standard - Card size	Magnetic Ticket (MT), Contactless IC ticket ISO/IEC 14443 (Type-A) ISO 7810	
	PSD (Platform Screen Door) system - Full height PSD - Half height PSD	For underground stations, except El Remayah station For elevated stations, including El Remayah station	
	Other major facilities	Elevator, Escalator, Air conditioner, Air intake & Exhaust system, Fire protection system, etc.	

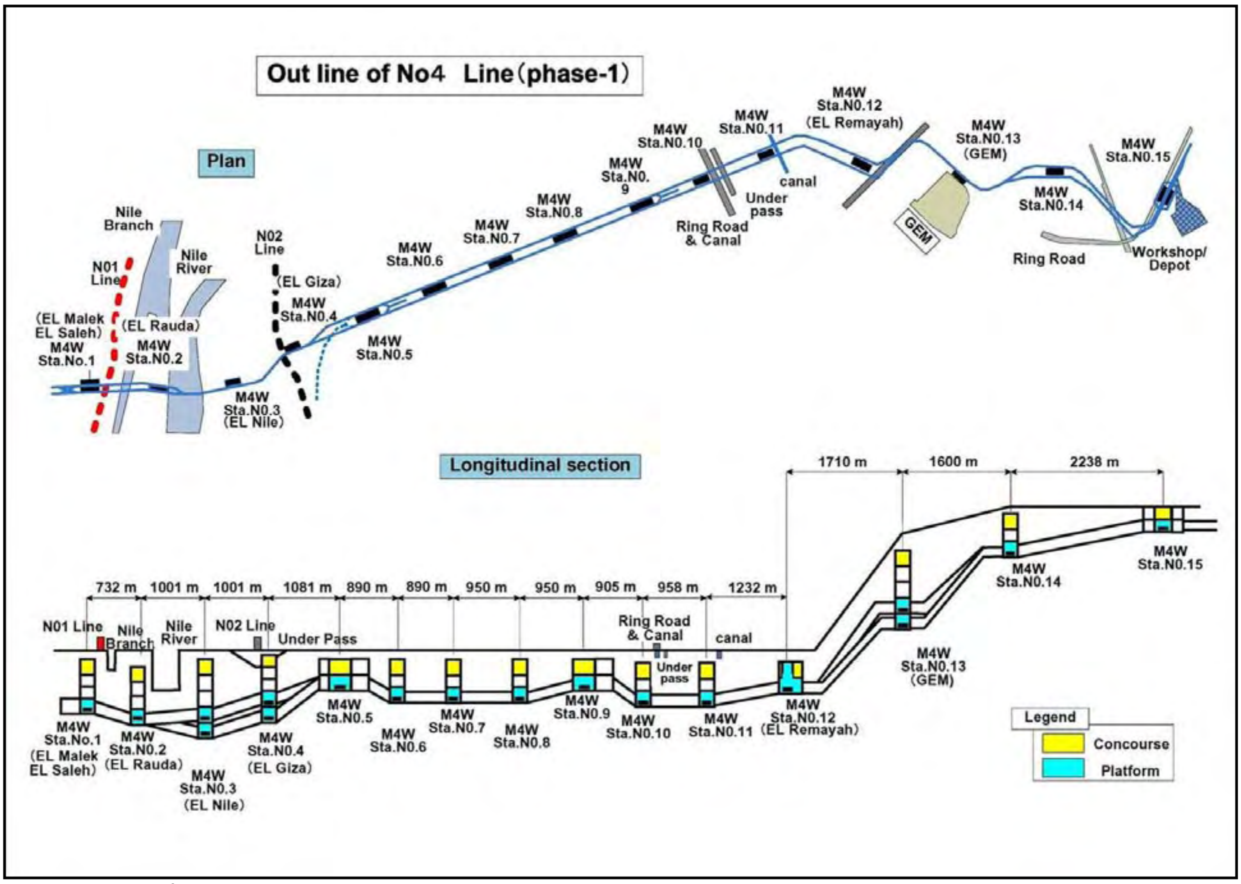
*1: PMSM: Permanent Magnet Synchronous Motor
*2: VHF: Very High Frequency
*3: TDM/TDMA: Time Division Multiplex/Time Division Multiple Access
Source: JICA Study Team

5. Preliminary Design for Phase 1

The feasibility study route on Metro Line 4 Phase 1 consists of the Phase 1A section (El Malek El Saleh – El Remayah Square), Phase 1B section (El Remayah Sq. – Hedaeck Al Aharam – Workshop/Depot). The Phase 1A study was undertaken at a full-scale level. The Phase 1B study was carried out on a preliminary level, with limited material and data because of the delay in finalizing the location of the workshop/depot and the alignment route. Preliminary design was consist of following plans.

- Train operating plan
- Disaster prevention & security plan
- Rolling stock plan
- Civil works plan
- Architectural works plan
- System and facilities & equipment plan
- Workshop/Depot plan

Outline of Metro Line 4 is shown in following figure.



Source: JICA Study Team

Figure 1 Outline of Metro Line 4

5.1 Train Operating Plan

Estimated daily number of trains (working day, one-way) and train-kilometres are shown in Table below. The required number of train-sets is 20 in 2020, 66 in 2023 (starting year of Phase 2 operation), 68 sets in 2027, and 70 sets in 2050.

Table 5 Estimated Daily Number of Trains (Working day, One-way) and Train-kilometres

Items	Year	2020	2023	2027	2050
Number of trains per hour per direction	A	15	26	27	28
Number of trains per direction per day (Working day)	B	198	343	353	367
Number of trains per day (Holidays)	C	127	223	233	240
Train-km (Working day)	D = 2 x B x Route km	6,376	23,118	23,792	24,736
Train-km (Holidays)	E = 2 x C x Route km	4,089	15,030	15,704	16,176
Train-km per year (000)	F = 52 x (6 x D + E)	2,202	7,994	8,240	8,559

Route km: = 16.1 km (2020), = 16.1 + 17.6 = 33.7 km (2023, 2027, 2050)
Source: JICA Study Team

5.2 Disaster Prevention & Security Plan

In order to operate the metro properly and safely, the management and countermeasure for the emergency/disaster incident are very important issues. Fire, flooding, strong wind (at grade or elevated section), etc. are considered as the emergency/disaster incidents for the metro. Especially, fire and its management/countermeasure is most crucial matter for the underground section of metro operation. Therefore, JICA Study Team has studied and compared the fire management and countermeasure to be applied for Metro Line 4. Basically, JICA Study Team proposed Japanese standard and regulations with consideration of NFPA and local regulations.

5.3 Rolling stock plan

JICA Study Team proposes the rolling stock for Metro Line 4 on the basis of the customer satisfaction, efficiency, reliability, maintenance reduction, environmental friendliness and application of up-to-date technology. Main specification of rolling stock is described in the above technical characteristics table.

5.4 Civil Works Plan

5.4.1 5.4.1. Tunnel Section

JICA Study Team has proposed Single Track Double Tunnel (STDT) type with the shield TBM for the Metro Line 4 tunnel section. The STDT has many advantages in construction, environment, cost and operation. The application of the STDT is increasing all over the world, including Europe.

In addition, STDT can change the location of two tunnels flexibly from horizontal to vertical. It is possible for STDT to avoid existing structures and pass narrow spaces. In some areas, the foundation/piles of existing structures are closely situated and the space between them is very narrow. STDT can provide less impact to the surrounding environment.

5.4.2 Station Section

JICA Study Team has studied and proposed three types of standard station structure with consideration of the surrounding condition, neighbouring structures, convenience and economical advantages. On the other hand, five stations are located in the densely populated and congested area and there are constrains of the land use of the ground level. In order to avoid some structures or minimize the land acquisition the station structures in the said area are different from that of the standard stations. The major features of Metro Line 4 station structure are as follow.

- All stations of the Metro Line 4 (phase 1) are underground.
- Tunnel structure type of the Metro Line 4 is single track double tunnels.
- The platform of Metro Line 4 is mainly island type except for the two-storey platform stations, namely, El Nile station and El Giza station.
- PSD is installed at all stations of Metro Line 4.

JICA Study Team has also studied and described construction method with typical traffic management plan for special stations.

5.5 Architectural Works Plan

As for the station design concept, JICA Study Team has classified in to three types as “Signature Station”, “Modal Interchange Station” and “Typical Station”.

5.5.1 Signature Station

Metro Line 4 will be a gateway line to the world heritage Pyramids and the Grand Egyptian Museum (GEM). El Remayah Station, a terminal station for Phase 1, is important for foreign visitors and to those who travel to 6th October City from the station using public buses, taxis and private cars. This station will be the signature station for Line 4, and will be designed to emphasize a great expectation for the world heritage concept. Not only the annexed structures are above ground, but also the interior design of the station’s public areas will be in harmony with the image of this great heritage.

5.5.2 Typical Station

Because of the similarity of geographic, topographic and social environment conditions, the stations located in Pyramids Road will be designed as typical stations.

A typical station has three underground floors with a minimum length of 190 m required for both technical and station operation facilities. This figure of 190 m is derived the sum of 170 m platform length (160m train length plus 5m of clearance for both ends of the train) and an 10 m from both ends of the platform, which is added for the provision of rooms required for station operation.

5.5.3 Modal Interchange Station

Four stations are proposed as modal interchange stations, which need to provide short and medium distance bus terminals and facilities for taxis and private cars. JICA Study Team has developed conceptual master plans for those four stations: First of these is for a underground temporary terminal and transfer to Metro Line 1 at El Malek El Saleh Station with a proposal of redevelopment for commercial and other facilities. Second is M4W Sta. No.4 (El Giza Station) for a underground transfer to Metro Line 2 and the ENR with a proposal for underground development and a transportation plaza. Third is M4W Sta. No.12 (El Remayah Station) for a large and shallow underground station including a bus terminal to 6th October City, multi level car parking and underground commercial development. The fourth plan is M4W Sta. No.15 as a terminal station, with a large open car park and bus terminals to and beyond 6th October City, in view of further development and growing populations.

5.6 System and Facilities & Equipment Plan

5.6.1 Signalling

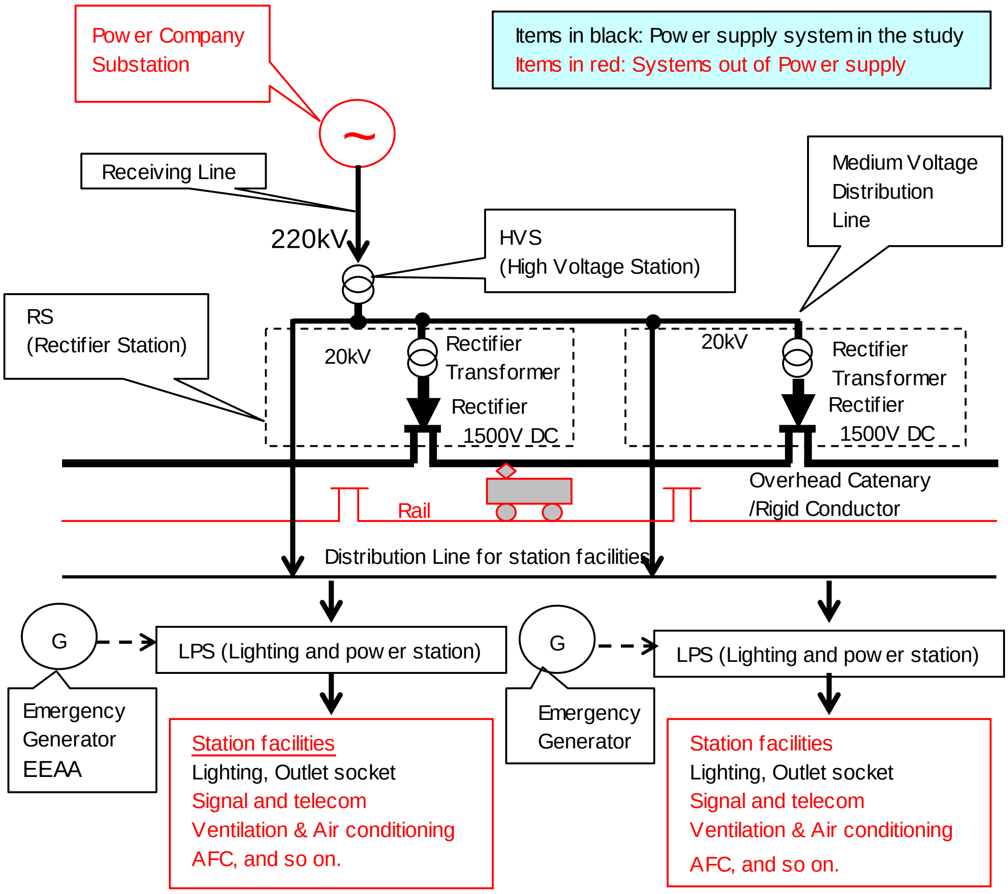
The signal system comprises the “Route control function”, “Remote route control function”, “Train interval control function”, “Train operation support device”, “Signal cables” and “Power supply equipment”. JICA Study Team has proposed to install computerized interlocking devices (CI) and electric point machines for traffic control function. Controls of the entire routes of entire stations are performed by remote control from a single CCP.

5.6.2 Telecommunication

The communication system comprises the “Communication line equipment”, “Optical carrier equipment”, “Train radio equipment”, “Platform monitoring system”, “Video monitoring system”, “Station communication equipment”, “Depot communication equipment” and “CCP communication equipment”. JICA Study Team has proposed Optical Fibre Cable (OFC) and CCP are laid as the backbone transmission system throughout all lines. Digital radio system is used for the train radio, and leaky coaxial cable (LCX) will be used inside the tunnel.

5.6.3 Power Supply

The power supply system includes all electrical systems for receiving electricity from a power company's substation, and feeding rolling stocks and station facilities. An overall view of the power supply system is as shown in Figure 2 Main features of the power supply system for Metro Line 4 are shown in Table 6.



Source: JICA Study Team

Figure 2 Overall View of the Power Supply System

Table 6 Key Features of the Power Supply System for Metro Line 4

Item		Metro Line 4 Phase 1	Metro Line 4 Phase 2
Nominal voltage of contact line		1,500 V DC	
Type of contact line		Overhead Rigid Conductor	Overhead Rigid Conductor (Tunnel section)/ Overhead catenary (Elevated section)
High Voltage Station (HVS)	Number and receiving voltage	One HVS (220/20kV)	One HVS (220/20 kV)
	Transformer capacity	80[MVA]	80[MVA]
Rectifier Station (RS)	Receiving voltage	20 kV from HVS	
	Number of RS	Five RSs for the main line, one for workshop/depot	Six RSs for main line, one for workshop/depot
	Rectifier capacity	8.0 [MW] for each RS	
	Back-up power supply for RS	Power supply from 11kV distribution grid	
Lighting and Power Station (LPS)	Receiving voltage	20 kV from HVS	
	Number of LPS	One LPS for each passenger station and workshop for power supply to the facilities in low voltage	
	Back-up power supply for station facility	Two 20 kV feeders for each LPS, and emergency generator in each underground passenger station UPS system for signal and telecom and other essential equipment	

Source: JICA Study Team

5.7 Workshop/Depot Plan

The Metro Line 4, Phase 1 depot yard is divided into two distinct parts. One part is associated with stabling and cleaning and another part is dedicated to maintenance and repair. In addition to these two complexes, there are buildings for administration, signalling and control as well as for traction power supplies.

In addition to the train washing, stabling, light maintenance and heavy maintenance facilities, there are yard facilities provided for the re-profiling of wheels by a ground wheel lathe; stabling, maintenance and repair of two diesel shunting locomotives; stabling, maintenance and repair of on-track plant for track maintenance and other works.

The ultimate capacity of the workshops is intended to permit the throughput of 20 full trainsets, annually, for 3-yearly and 6-yearly planned maintenance and overhaul during full 24-hour shift operation. This capacity should be adequate to cater to the needs of the Phase 1 initial fleet and for its later expansion to 30 trains as well as for the future needs of the Phase 2 fleet, projected to be additional 30 trains.

6. Outline Design for Phase 2

The study of the Phase 2 Northern Route section between El Malek El Saleh and Ring Road Exit #18 via El Sawaha Square along Port Said Street was carried out at the level of an outline design. The solutions and countermeasures for the risks and consideration of tunnel construction, especially the section of the route which runs in parallel with the Spine Waste Water Tunnel (SWWT) are also studied.

7. Operation and Maintenance Management Plan

Following plans are studied and described.

- System operations plan especially for CCP as well as train drivers and station staff, including fire fighting and evacuation plan
- Maintenance plan
- Organization plan (managed by ECM)
- Estimation of staff numbers for Metro Line 4
- Training plan (Japanese training system for drivers is introduced)

Estimations of staff numbers for Metro Line 4 is shown in Table 7.

Table 7 Estimated Total Staff Requirement on Metro Line 4

Categories		Y2020	Y2023	Y2027	Y2050
Route km		16.1	33.7	33.7	33.7
Number of Stations		15	31	31	31
Number of Rolling Stock		160	528	544	560
Number of Staff Required					
Operation	Drivers	79	286	295	306
	Drivers in the depot	23	46	46	46

Categories		Y2020	Y2023	Y2027	Y2050
	CCP controllers	24	38	38	38
	Station Staff	290	595	595	595
	Sub total	416	965	974	985
Maintenance	Civil and Track	50	104	104	104
	Rolling Stock	95	312	321	331
	Electrical Equipment	75	157	157	157
	Sub total	220	573	582	591
Administrative staff		131	131	131	131
Total		767	1,669	1,687	1,708
Total number of staff without the staff dispatched to the maintenance outsourcing companies		647	1,305	1,687	1,708

Source: JICA Study Team

8. Project Cost and Packaging

8.1 Project Cost

The project cost consists of the initial capital cost and the O&M cost. It should be noted that initial capital costs include only the costs of infrastructure (civil works, track work and electrical and mechanical installations) and rolling stock provision, incurred during the construction period. Table 8 shows the summary of estimated initial cost for STEP Loan and Table 9 shows the total O&M cost for Metro Line 4.

Table 8 Summary of Estimated Initial Cost (STEP Loan)

	Descriptions	Phase-1				Phase-2				TOTAL			
		F/P	L/P	Total		F/P	L/P	Total		F/P	L/P	Total	
		M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)
1	Construction Cost												
	Civil Works (Tunnel)	124.1	157.9	281.9	8%	68.3	87.0	155.3	3%	192.4	244.8	437.2	5%
	Civil Works (Elevated)	0.0	0.0	0.0	0%	22.4	43.5	65.9	1%	22.4	43.5	65.9	1%
	Station (Civil)	269.9	524.0	794.0	22%	249.9	485.2	735.1	16%	519.9	1,009.2	1,529.1	18%
	Track	10.9	49.7	60.6	2%	7.9	35.8	43.7	1%	18.8	85.5	104.2	1%
	Depot / Workshop	48.2	85.7	133.8	4%	7.2	12.8	20.0	0%	55.4	98.5	153.8	2%
	Station Facilities	210.4	123.6	334.0	9%	202.6	119.0	321.7	7%	413.1	242.6	655.7	8%
	Power Supply & Electrification	73.8	60.4	134.2	4%	76.2	62.3	138.5	3%	150.0	122.7	272.7	3%
	Signal & Telecom.	115.7	45.0	160.7	4%	119.4	46.4	165.8	4%	235.1	91.4	326.5	4%
	Total Construction Cost (①) :	853.0	1,046.2	1,899.2	53%	754.0	892.0	1,646.0	35%	1,607.0	1,938.2	3,545.2	43%
2	Procurement Cost												
	Rolling Stock	428.7	0.0	428.7	12%	918.7	0.0	918.7	20%	1,347.5	0.0	1,347.5	16%
	Total Procurment Cost (②) :	428.7	0.0	428.7	12%	918.7	0.0	918.7	20%	1,347.5	0.0	1,347.5	16%
	Total of ①+②	1,281.8	1,046.2	2,328.0	64%	1,672.7	892.0	2,564.7	55%	2,954.5	1,938.2	4,892.7	59%
3	③Consultancy Service (① of 7%)	59.7	73.2	132.9	4%	52.8	62.4	115.2	2%	112.5	135.7	248.2	3%
4	Physical Contingency (①+②+③ of 5%)	67.1	56.0	123.0	3%	86.3	47.7	134.0	3%	153.3	103.7	257.0	3%
	Total-1(④):	126.8	129.2	256.0	7%	139.1	110.2	249.2	5%	265.8	239.4	505.2	6%
5	Land acquisition & Resettlement	0	30.8	30.8	1%	0	34.5	34.5	1%	0	65.3	65.3	1%
6	Diversion of Public Utility	0.4	41.4	41.8	1%	0.3	24.9	25.1	1%	0.7	66.3	67.0	1%
7	General Administration (① of 3%)	0	57.0	57.0	2%	0	49.4	49.4	1%	0.0	106.4	106.4	1%
8	Price Escalation	526.9	373.7	900.6	25%	1,127.5	606.6	1,734.1	37%	1,654.5	980.2	2,634.7	32%
	Total-2:	527.4	502.9	1,030.3	29%	1,127.8	715.3	1,843.1	40%	1,655.2	1,218.2	2,873.3	35%
	Grand Total:	1,935.9	1,678.3	3,614.2	100%	2,939.6	1,717.5	4,657.0	100%	4,875.5	3,395.8	8,271.3	100%

Source: JICA Study Team

Table 9 Total O&M Cost for Metro Line 4

Items	Unit	Y2020	Y2023	Y2027	Y2050
Personnel costs	LE'000	12,293	24,795	32,053	32,452
Power cost	LE'000	12,500	30,040	30,500	30,960
Maintenance cost					
Maintenance cost	LE'000	21,971	27,578	1,659	1,687
Parts cost	LE'000	44,035	130,397	133,771	137,150
Cleaning cost	LE'000	1,266	3,622	3,703	3,785
Other costs					
Security cost	LE'000	7,587	15,679	15,679	15,679
Other costs	LE'000	1,981	3,555	3,587	3,619
Total	LE'000	101,633	235,666	220,952	225,332

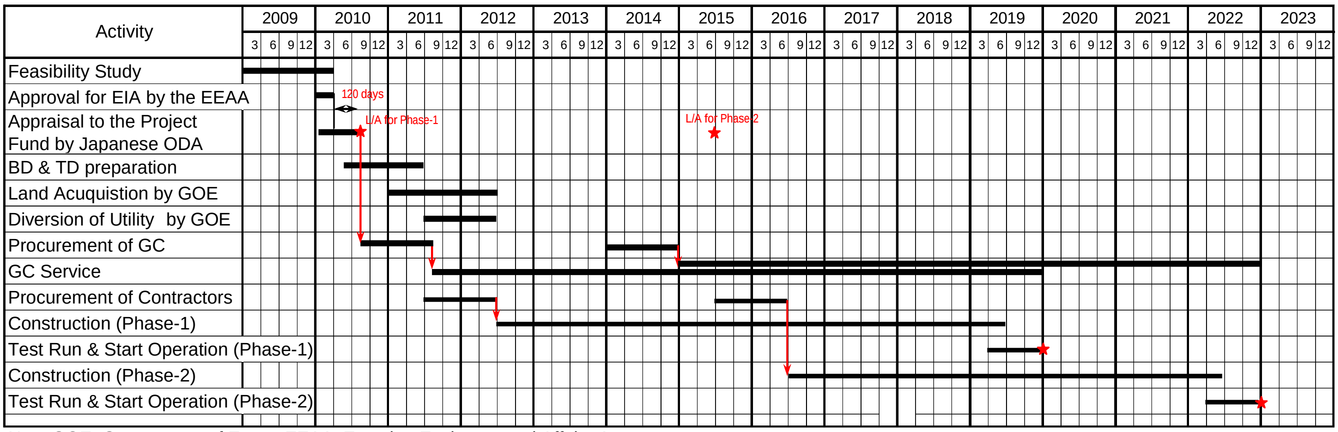
Source: JICA Study Team

8.2 Packaging

JICA Study Team has proposed three packages for civil works, one package for railway system which includes electric and mechanical works, including station facilities and depot/workshop facilities, and one package for rolling stock.

9. Planning of Project Implementation Program

The implementation schedule is shown in Figure 3.



Note:GOE: Government of Egypt, EEAA: Egyptian Environmental Affairs Agency

Source: JICA Study Team

Figure 3 Project Implementation Schedule

10. Environmental and Social Considerations

Environmental Impact Assessment (EIA) was conducted with consideration of the Egyptian environmental regulations as well as the JICA Guideline for Environmental and Social Considerations, and ex-JBIC Guidelines for Confirmation of Environment and Social Considerations (hereinafter the Guidelines, or Guidelines of JICA and ex-JBIC) as donor policies.

11. Resettlement Action Plan (RAP) Framework Study

Resettlement Action Plan (RAP) Framework was prepared by reflecting regional conditions, which are studied through site reconnaissance and a socio-economic interview survey, and by considering donor policies such as JICA and ex-JBIC Guidelines as well as World Bank Operational Polices 4.12 on Involuntary Resettlement and Egyptian regulations.

12. Archaeological Assessment Study

Preservation of the archaeological and cultural properties as well as their landscapes was prioritized in this study. In line with this policy, with all available information, JICA Study Team was examined the archaeological assets of the area along the proposed routes for the Metro Line 4. This study was aims to eventually propose the risk assessment and countermeasures for the buried cultural properties.

13. Economic and Financial Analysis

The economic and financial appraisals of the Metro Line 4 construction project were undertaken both for the case of Phase 1 route only (i.e. without the addition of the second phase route) and for the case of an entire metro route comprising both the Phase 1 and Phase 2 route components.

13.1 Economic Appraisal

The result of the economic appraisal, such as Economic Internal Rate of Return (EIRR), Economic Net Present Value (ENPV), and Benefit Cost (BCR) are shown in table below.

Item	Phase 1	Phase 1 + Phase 2
EIRR	17.10%	15.04%
ENPV	6,751.4 L.E. million	5,165.5 L.E. million
BCR	1.96	1.45

Source: JICA Study Team

13.2 Financial Appraisal

The result of the financial appraisal was measured by the following six indicators, which were estimated both for the Phase 1 only and the combined Phases 1 and 2 projects.

- Project FIRR, before financing
- Project FIRR, after financing
- Return on Equity (ROE)
- NPV at 12% rate of discount, before financing
- NPV at 12% rate of discount, after financing
- NPV to Equity at 12% rate of discount

The financial results of the comparison of the two project financing alternatives are given in Table 10.

Table 10 Comparison of Financial Results for STEP Loan vs. Normal Loan with Standard Conditions - Financing of Phase 1 project

Loan Type	Project FIRR	Project NPV (LE million)	ROE	NPV to Equity (mille million)
STEP Loan	2.85	-7,400	13.89%	163
Normal Loan	1.96	-8,502	Negative	9

Source: DCF Model of JICA Study Team

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Greater Cairo Region is the premier city in Egypt. It is steeped in history and containing large numbers of historical structures. It is the largest city in the African Continent and the Middle Eastern Region with a population of over 18 million, representing 25% of the total population of Egypt. The Cairo Metro, the only specialized metro system in operation in the African Continent, commenced construction in 1981. Its design was based on the "Plans for Construction of Cairo Metro 3 Lines", developed by SOFRETU in 1973 to improve road traffic congestion.

The current status of the Cairo Metro is as follows.

Metro Line 1	Phase 1 (28 km) started operation in 1987. The whole line (44 km) in full service by 1989.
Metro Line 2	Phase 1 (8 km) started operation in 1996. The whole line (21.6 km) in full service by 2005.
Metro Line 3	Phase 1 (4.3 km) under construction, scheduled to start operation in 2011. The whole line is 34.2 km.

Metro Line 3 was proposed in the "New Public Transportation Study of the Great Cairo Area" conducted by SYSTRA in 1998-2000 and in the "Cairo Regional Area Transportation Study" (CREATS) conducted under a JICA Study in 2000-2002.

As the population of the Greater Cairo Region is envisaged to increase to 20 million by the year 2017 according to the SDMP Report, the Government of Egypt (GOE) is reforming the urban structure, changing from a mono-centric form to a decentralized form, notably through the development of New Urban Communities (NUCs), such as the 10th of Ramadan City and 6th October City. However, the increasing transport demand has not been accompanied by a substantial solution to urban problems such as road traffic congestion, insufficient public transportation services and air pollution.

As a long-term strategic development plan, the General Office of Physical Planning (GOPP) has prepared "the Cairo Vision 2050". This vision document proposes 14 metro routes as the main public transport system in the Greater Cairo Region.

As a consequence, the Government of Egypt has decided to construct, as early as practicable, the Metro Line 4 as initially proposed by CREATS, and in October 2008, requested the Government of Japan (GOJ) to implement the "Development Study Fisical Year 2008 on Greater Cairo Metro Line 4 Project made by the Government of the Arab Republic of Egypt". The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of GOJ's programs, has had discussions with the National Authority for Tunnels (NAT) of the Ministry of Transport and has agreed to conduct a feasibility study for the proposed Metro Line 4. The document for the Scope of Work was signed on 21st December 2008.

1.2 Objective of the Study

The primary objective is to conduct a feasibility study for Metro Line 4 (line length approximately 35 km), from a depot adjacent to the interchange of Alexandria Desert Road and Ring Road to El Sawaha square or Nasr City via the Grand Egyptian Museum (GEM), El Giza Station of Metro Line 2 and El Malek El Saleh station of Metro Line 1. This feasibility study will adopt suitable approaches for the mitigation of urban transport congestion and contribute to the sustainable development of the Greater Cairo Region. Four key objectives will form the foundation of the study:

- To formulate a proposed route for Metro Line 4
- To assess the justification of the project
- To plan the project appropriately, from the perspectives of its technical, economical and financial, environmental and social aspects
- To carry out technology transfer to the Egyptian counterpart personnel in the course of the study

The feasibility study, namely the "JICA Preparatory Survey on Greater Cairo Metro Line No.4", consists of three reports. The main tasks and activities to be covered in these reports are as follows;

1) Feasibility Study Report 1 (Volume 1)

- Data collection, diagnosis of the existing public transport system and urban development hypothesis;
- Collection of relevant data about the existing and foreseen public utilities;
- Collection of relevant socio-economic data; and
- Collection of relevant data for preliminary design.

2) Feasibility Study Report 2 (Volume 2)

- Analysis of all collected data for the generation of O/D Matrices and development of a transportation study of Metro Line 4.
- Recording of all the data concerning vehicles and all transport modes and performing a field traffic survey in the study area and a review of the demand forecast.
- Comparison and evaluation of two alternative corridors regarding Metro Line 4 alignment

3) Feasibility Study Report 3/4 (Volume 3)

- Preparation of design guidelines & criteria and general features of the Metro Line 4 Phase 1.

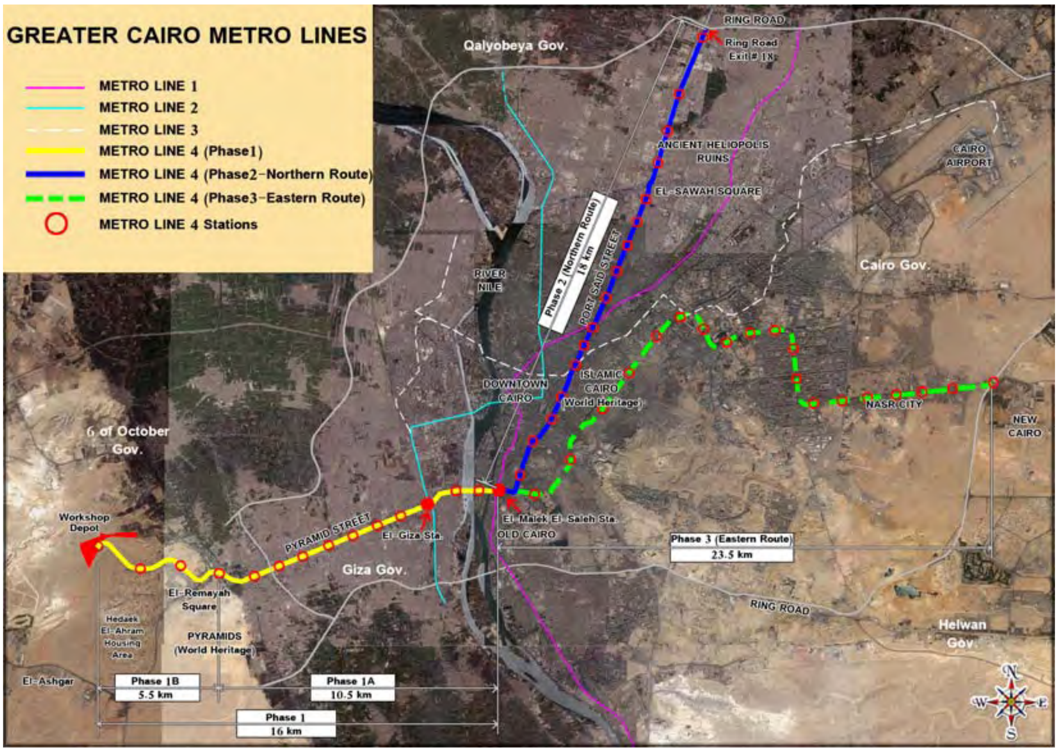
- Preparation of the general design specifications of Metro Line 4.
- Submission of the final results and pertinent analysis showing the feasibility of the implementation of the whole project from both economic and financial perspectives.

The present document is the combined **Feasibility Study Reports 3/4 (Volume 3)**, and is based on the results of Feasibility Study Reports 1 and 2 (Volume 1 and 2).

1.3 Study Area and Concept of Feasibility Study Report 3/4

1.3.1 Study Area

The Study Area is defined as follows: Phase 1 of the proposed Metro Line 4, running from a depot/workshop via the Grand Egyptian Museum (GEM) to El Malek El Saleh Station, with a length of about 16 km; and Phase 2 route is between El Malek El Saleh via El Sawaha Square and directly to Ring Road Exit #18, with a length of about 18 km, referred to as the "northern route". In addition, an alternative Phase 2 route, starting from El Malek El Saleh to Nasr City, with a length of about 23.5 km, referred to as the "eastern route", was evaluated and compared with the originally proposed northern route. Figure 1-1 shows the Phase 1 route and the two alternative routes considered for Phase 2.



Source: JICA Study Team

Figure 1-1 Study Area

1.3.2 Concept for the Feasibility Study Report 3/4

(1) Route Selection for Phase 2 Section

The results of the comparison of the two alternative routes for Phase 2 are presented in *Volume 2*. These results show that both routes are feasible in terms of the future transportation demand. However, the transportation demand of Northern Route is larger than that of the Eastern Route in the year 2022, and a study of the rehabilitation of tramway line and its transformation into a Super-Tram from Abbasia to Nasr City to connect with Metro Line 3 has been started. In this context, the JICA Study Team recommended giving priority to the northern route as the route for construction in the second phase of Metro Line 4 project. Accordingly, JICA Study Team has carried out the feasibility study on the basis of a northern route for Phase 2.

(2) Workshop/Depot Location

The final location of the workshop/depot as well as of the route of Metro Line 4 between the workshop/depot and El Remayah Square was informed officially through NAT on 20th October 2009. JICA Study Team has carried out the feasibility study on this location and route.

(3) Concept for the Feasibility Study on Metro Line 4

The feasibility study route on Metro Line 4 consists of the Phase 1A section (El Malek El Saleh – El Remayah Square), Phase 1B section (El Remayah Square – Hadayek Al Aharam – Workshop/Depot), and Phase 2 northern route, as shown in Figure 1-1. The feasibility study has been carried out in accordance with following concept:

- The Phase 1A study was undertaken at a full-scale level. The Phase 1A route is as defined in NAT Letter No. PL/402/700, dated 11th May 2009.
- The Phase 1B study was carried out on a preliminary study with limited material and data because of the delay in finalizing the location of the workshop/depot and the alignment route. The location of the workshop/depot is as defined in NAT Letter No. PL/1428/700, dated 19th October 2009. The Phase 1B route is as defined in NAT Letter No. PL/1439/700, dated 20th October 2009.
- The Phase 2 study was carried out as a preliminary level study on the northern route, which was recommended in Feasibility Study Report 2. This route is planned to run under/above Port Said Street, where the existing Spine Wastewater Tunnel is located.

Based on the above concept, the following component studies were carried out as part of the Metro Line 4 Feasibility Study. In this respect, Feasibility Study Reports 3 and 4 were combined into one report.

- Review & updated demand forecast
- Alignment plan

- General features and design concept/criteria
- Train operating plan
- Disaster prevention & security plan
- Rolling stock plan
- Civil works plan
- Architectural works plan
- System and facilities & equipment plan
- Workshop/depot plan
- Operation and maintenance management plan
- Project cost and packaging
- Project implementation plan
- Environmental and social considerations
- Resettlement action plan framework study
- Archaeological assessment study
- Economic and financial analysis

In addition to the above, the following studies have been carried out and are included in appendices to this report.

Appendix 1 : Preliminary work and remarks on Basic Design Stage
Appendix 2 : Preliminary study for extension line connecting to 6th October City
Appendix 3 : NAT comments with JST response on draft Report 3/4

1.4 Remarks toward the Basic Design Stage

After the submission of the draft Report 3/4 in the end of December 2009, NAT made some major decisions on certain components, as enumerated below:

1) Final workshop/depot location and Phase 1B route was finalized.

- Phase 1B route was changed from the route defined in NAT Letter No. PL/1428/700 dated on 20th October 2009, by verbal instruction from NAT in early January 2010. Subsequently, the final decision has been made through NAT Letter No. PL/203/700 dated on 10th March 2010.
- Station No.13 (Grand Egyptian Museum) was shifted from behind to the front of the museum entrance.
- A new station was requested between Station No.13 and Station No.14.

2) Power supply system of Metro Line 4 will be 3rd rail system, instead of the overhead rigid conductor system.

- The decision has been made through NAT's comments on draft Report 3/4 in NAT Letter No. EMD/3 dated 18th January 2010.

3) HVS and administration buildings are shifted from inside the workshop/depot to a new location between the military officers housing area and the Hadayek Al Ahram housing area.

- The decision has been made through NAT Letter No. PL/203/700 dated 10th March 2010.

4) Location of Stations No.10 and No.11 are shifted.

- The decision has been made in the meeting with the NAT Chairman held on 28th January 2010 in Japan.
- Station No.10 (El-Maryoteya Station) is shifted next to the Ring Road viaduct on El Maryoteya Canal.
- Station No.11 (El-Ahramat Station) is shifted as close to the Pyramid side as possible.

5) Connection with ENR Line is cancelled.

- The decision has been made in a meeting held on 7th February 2010.
- The rolling stock transportation plan and access to the depot with the handling facilities study will be carried out in the basic design stage.

Basically, the above decisions have not been reflected in this Report 3/4 in terms of study period. These modifications will be studied in the basic design stage.

In addition to the above decisions, JICA Study Team has received NAT comments on the draft Report 3/4 in the beginning of February 2010. JICA Study Team and NAT had several technical meetings on NAT's comments in February 2010 to clarify all the items. As a result, modification of the report and additional information or data have been added in the final edition of Report 3/4 or provided separately. However, some of the comments require further study to meet NAT's requirements. Therefore, JICA Study Team and NAT have agreed to conduct the remaining and additional items of study in the basic design stage.

The above results, based on the discussion with each NAT department, are attached in Appendix 3 of this Report (Volume 3).

Moreover, general information and remarks related to the change from the 1,500V DC overhead rigid conductor system to the 750V DC 3rd rail system are presented in Appendix 1 of this Report (Volume 3).

CHAPTER 2
UPDATING FUTURE DEMAND FOR METRO LINE NO.4

CHAPTER 2 UPDATING FUTURE DEMAND FOR METRO LINE NO.4

2.1 Methodology of Updating Future Metro Demand

Based on the final alignment and location of the stations, the future passenger demand for the Metro Line 4 has been projected and is presented in this chapter. The methodology of the demand forecast is the same as that described in *Feasibility Study Report 2 (Volume 2)*. This methodology involves application of the conventional "four-step" approach and transportation models described in *Feasibility Study Report 2 (Volume 2)*.

2.2 Summary of Person-Trips by Travel Mode

The forecasting reference years for demand estimation are set up on the basis of the construction schedule, i.e., as of 2020, 2023, 2027 and 2050. The year 2020 is the starting year of the Metro Line 4, Phase 1 section operation, while 2023 is the starting year of that of the Phase 2 section. The year 2027 is the base year of the projection and the year 2050 is the target year for facility planning. The results of the demand forecast are summarized in the table below. Based on Cairo Vision 2050, the number of metro and LRT passengers includes the passenger volume forecast for the existing, on-going, planned and under-planning lines up to 2050.

Table 2-1 Projected Passenger by Transportation Mode

	Private Mode (Passenger Car, Taxi)	Public Bus Mode (Bus, Shared Taxi)	Public Rail Mode (Metro, LRT)	Total
Year 2020	7,317,081	12,815,802	3,946,918	24,079,801
	30.4%	53.2%	16.4%	100.0%
Year 2023	8,292,396	12,607,342	4,388,364	25,288,102
	32.8%	49.9%	17.4%	100.0%
Year 2027	9,561,250	12,364,875	4,776,201	26,702,326
	35.8%	46.3%	17.9%	100.0%
Year 2050	19,222,178	16,017,445	7,961,171	43,200,794
	44.5%	37.1%	18.4%	100.0%

Unit: person-trip per day
Source: JICA Study Team

2.3 Daily Station and Section Passenger Volumes for Metro Line 4

Future numbers of station and section passengers per day for Metro Line 4 were projected by assigning metro and LRT trips based on the updated O/D matrixes to the future Metro & LRT network. The forecasted daily passengers are summarized in Table 2-2. "Sta. Pax" represents the number of passengers both boarding and alighting at each station and "Sec. Pax" means the volume of passengers passing through line section between stations. The station passenger in Table 2-2 is the summation of boarding and alighting passengers by each station respectively. The demand forecast basically targets daily passengers. Therefore, the boarding and alighting passengers in each station are logically equal.

Boarding passengers, and also alighting passengers, are 50% of the total station passengers in Table 2-2,.

Table 2-2 Number of Passengers Per Day for Metro Line 4

	Summary of Number of Passenger Per Day			
	Year 2020	Year 2023	Year 2027	Year 2050
Phase1 Section	1,011,900	1,100,700	1,594,900	2,041,500
Phase2 Section	0	1,475,800	1,681,600	1,874,400
Total	1,011,900	2,576,500	3,276,500	3,915,900

Note: The passengers who ride on both Phase 1 and 2 sections on Metro Line 4 are counted as the passengers of Phases 1 and 2, respectively. Therefore, the number of passengers for Metro Line 4 in total is smaller than the simple summation of Phase 1 and Phase 2 sections.

Station No	Number of Passengers by Station / Between Station (Section) Per Day							
	Year 2020		Year 2023		Year 2027		Year 2050	
	Sta. Pax.	Sec. Pax	Sta. Pax.	Sec. Pax	Sta. Pax.	Sec. Pax	Sta. Pax.	Sec. Pax
Phase2 Sta. 17	-	-	191,000		229,100		255,000	
	-	-	↓↑	191,000	↓↑	229,100	↓↑	255,000
Phase2 Sta. 16	-	-	102,800		130,900		137,300	
	-	-	↓↑	267,700	↓↑	294,100	↓↑	359,500
Phase2 Sta. 15	-	-	74,700		83,200		93,500	
	-	-	↓↑	385,200	↓↑	414,000	↓↑	508,500
Phase2 Sta. 14	-	-	61,100		69,300		76,500	
	-	-	↓↑	418,800	↓↑	455,500	↓↑	550,600
Phase2 Sta. 13	-	-	111,000		121,400		123,000	
	-	-	↓↑	534,500	↓↑	562,800	↓↑	524,900
Phase2 Sta. 12	-	-	90,800		101,200		116,500	
	-	-	↓↑	584,400	↓↑	623,600	↓↑	635,600
Phase2 Sta. 11	-	-	49,400		59,300		65,300	
	-	-	↓↑	646,900	↓↑	674,000	↓↑	708,200
Phase2 Sta. 10	-	-	61,800		71,200		79,800	
	-	-	↓↑	671,700	↓↑	709,600	↓↑	744,100
Phase2 Sta. 09	-	-	68,700		75,800		82,400	
	-	-	↓↑	725,100	↓↑	763,800	↓↑	796,400
Phase2 Sta. 08	-	-	130,500		141,500		148,700	
Transfer Line 1/4	-	-	214,500		258,900		275,700	
	-	-	↓↑	553,100	↓↑	571,600	↓↑	611,000
Phase2 Sta. 07	-	-	49,300		51,800		62,600	
	-	-	↓↑	543,400	↓↑	573,400	↓↑	614,400
Phase2 Sta. 06	-	-	31,200		32,700		34,500	
Transfer Line 3/4	-	-	256,200		261,300		266,900	
	-	-	↓↑	239,200	↓↑	381,200	↓↑	522,100
Phase2 Sta. 05	-	-	33,700		36,900		44,600	
	-	-	↓↑	224,300	↓↑	366,800	↓↑	502,300
Phase2 Sta. 04	-	-	34,800		39,800		47,700	
	-	-	↓↑	227,500	↓↑	370,900	↓↑	506,500

Phase2 Sta. 03	-	-	34,700		36,700		44,800	
	-	-	↓↑	216,000	↓↑	359,900	↓↑	490,900
Phase2 Sta. 02	-	-	34,700		36,700		44,800	
	-	-	↓↑	232,700	↓↑	359,900	↓↑	490,900
Phase1 Sta. 01	66,900		72,500		81,300		97,900	
Transfer Line 1/4	156,000		169,200		189,800		228,400	
	↓↑	222,900	↓↑	275,400	↓↑	382,600	↓↑	461,100
Phase1 Sta. 02	26,900		28,500		30,000		30,600	
	↓↑	209,900	↓↑	262,800	↓↑	371,600	↓↑	449,000
Phase1 Sta. 03	99,800		104,700		110,100		137,900	
	↓↑	267,900	↓↑	322,800	↓↑	434,100	↓↑	527,200
Phase1 Sta. 04	89,800		95,200		103,100		129,500	
Transfer Line 2/4	264,500		270,400		307,000		363,600	
	↓↑	427,700	↓↑	447,700	↓↑	584,700	↓↑	784,700
Phase1 Sta. 05	40,000		42,300		47,600		53,700	
	↓↑	421,300	↓↑	441,000	↓↑	575,900	↓↑	772,900
Phase1 Sta. 06	61,100		63,500		66,700		80,600	
	↓↑	388,900	↓↑	408,400	↓↑	570,900	↓↑	766,200
Phase1 Sta. 07	122,800		129,100		149,800		179,500	
	↓↑	301,500	↓↑	314,500	↓↑	561,200	↓↑	754,700
Phase1 Sta. 08	81,200		86,000		103,700		119,600	
	↓↑	293,900	↓↑	306,600	↓↑	547,200	↓↑	735,900
Phase1 Sta. 09	74,800		75,300		84,600		86,400	
	↓↑	240,600	↓↑	253,600	↓↑	512,400	↓↑	698,100
Phase1 Sta. 10	106,000		110,700		140,100		172,700	
	↓↑	174,000	↓↑	183,900	↓↑	465,300	↓↑	633,800
Phase1 Sta. 11	47,400		47,900		53,100		83,800	
	↓↑	136,700	↓↑	146,600	↓↑	436,800	↓↑	593,000
Phase1 Sta. 12	48,200		50,400		63,300		64,800	
	↓↑	92,200	↓↑	100,600	↓↑	401,200	↓↑	552,500
Phase1 Sta. 13	38,700		40,900		48,600		95,100	
	↓↑	50,900	↓↑	57,000	↓↑	367,600	↓↑	455,400
Phase1 Sta. 14	25,800		27,200		44,600		76,100	
	↓↑	27,700	↓↑	32,500	↓↑	336,400	↓↑	402,100
Phase1 Sta. 15	27,700		32,500		40,500		85,600	
	-	-	-	-	↓↑	359,500	↓↑	438,300

Remarks: Sta. Pax. = Station passenger (boarding and alighting),
Sec Pax. = Section passenger both directions between stations
Source: JICA Study Team

2.4 Determination of Peak Hour Passenger Distribution and Ratio

The peak hour distribution and ratio assumed for the metro operation were established on the basis of the CREATS home interview survey data, as follows. Departure time distributions are listed in Table 2-3 and shown as hourly histograms in Figure 2-1. Arrival time distributions are listed in Table 2-4 and shown as hourly histograms in Figure 2-2. Analysis of these tables and figures shows the following:

- Morning peak: On a boarding time basis, the highest traffic volume was seen between 6:00-8:00 and daily traffic volume ratio was 13.1% (the average rate from 6:00 to 8:00). On an alighting time basis, the highest traffic volume was seen between 7:00-9:00 and the daily traffic volume ratio was 13.7% (the average rate from 7:00 to 9:00).

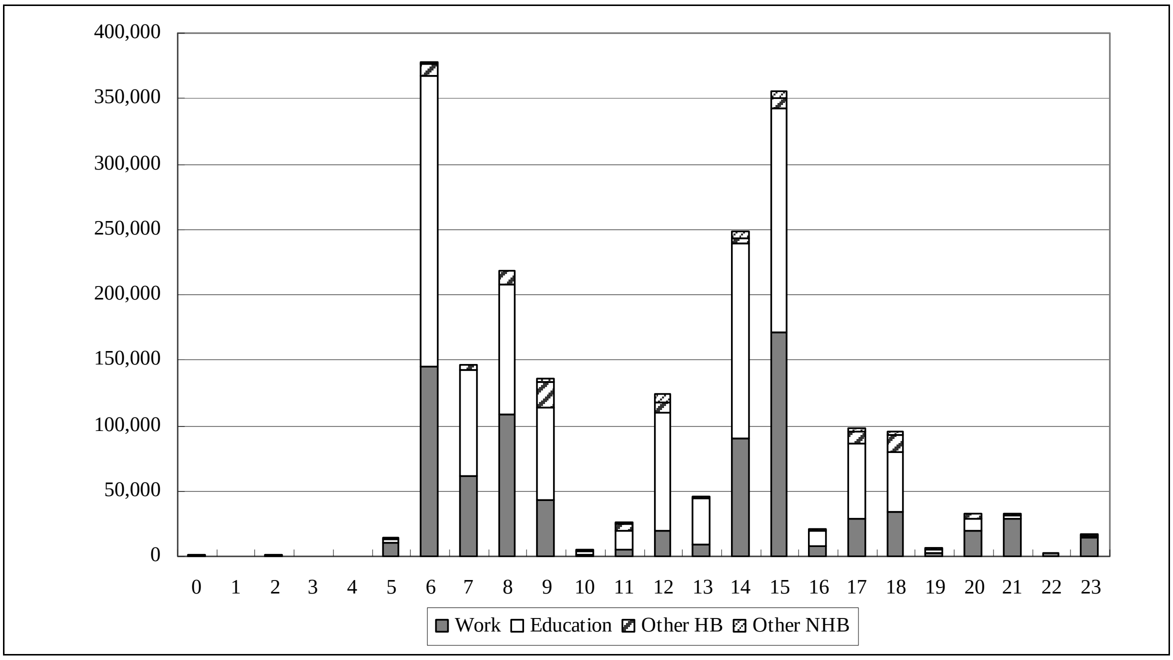
- Afternoon peak: On a boarding time basis, the highest traffic volume was seen between 14:00-16:00 and the daily traffic volume ratio was 15.1% (the average rate from 14:00 to 16:00). On an alighting time basis, the highest traffic volume was also seen between 14:00-16:00 and the daily traffic volume ratio was 11.3% (the average rate from 14:00 to 16:00).

- Considering that the morning peak is much more critical for passengers who are concerned not to miss their trains, the alighting base is much more stable because although the loading station is different, the alighting station is usually a common destination. Based on the data shown in Table 2-4 for the period between 8:00 and 9:00, **14% (the average of 17.1 and 11.0) is adopted as the peak hour ratio).**

Table 2-3 Hourly Peak Ratio of the Metro (Boarding Time-Based)

Departure Time	Trip Purpose					Share (%)
	Work	Education	Other HB	Other NHB	Total	
0	1,018	67	0	0	1,085	0.1
1	25	0	0	0	25	0.0
2	604	689	0	0	1,293	0.1
3	332	199	80	0	611	0.0
4	309	0	0	0	309	0.0
5	10,738	2,882	463	0	14,083	0.7
6	144,580	223,155	8,090	1,598	377,423	18.8
7	61,998	80,328	4,367	0	146,693	7.3
8	108,103	100,034	9,563	0	217,700	10.9
9	43,202	70,229	20,107	1,999	135,537	6.8
10	1,077	2,763	1,489	117	5,445	0.3
11	5,597	14,191	4,416	1,559	25,762	1.3
12	19,776	89,421	8,412	7,207	124,815	6.2
13	9,789	34,306	930	973	45,999	2.3
14	89,693	149,559	3,804	5,683	248,739	12.4
15	170,843	171,419	7,626	5,972	355,860	17.7
16	8,085	10,993	1,362	0	20,440	1.0
17	28,858	56,811	9,272	3,275	98,216	4.9
18	34,538	44,642	13,824	1,860	94,864	4.7
19	2,768	2,809	801	0	6,378	0.3
20	20,118	8,208	4,199	763	33,288	1.7
21	28,750	2,152	1,639	263	32,805	1.6
22	2,024	0	348	0	2,372	0.1
23	14,377	1,660	489	0	16,525	0.8
Total	807,202	1,066,517	101,281	31,269	2,006,267	100.0
	40.2%	53.2%	5.0%	1.6%	100.0%	

Source: CREATS HIS (2002) as analyzed by the JICA Study Team
Note: HB = Home Based, NHB = Non-home Based



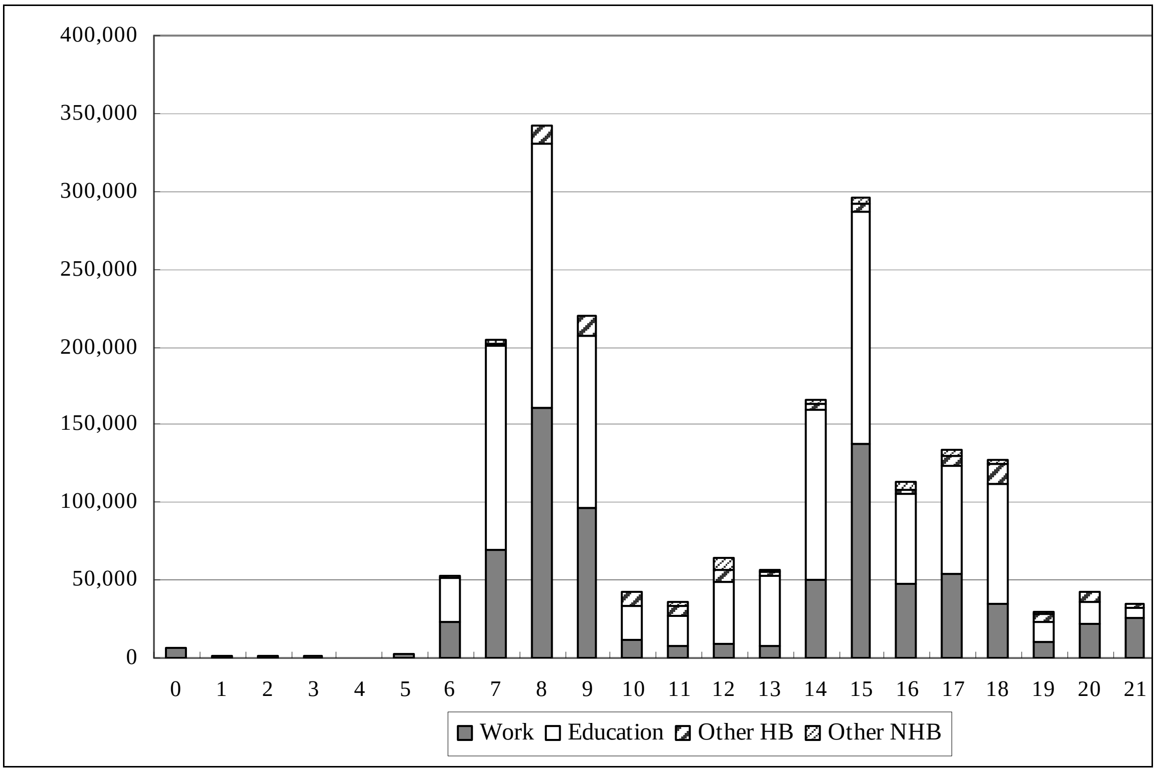
Source: CREATS HIS (2002) as analyzed by the JICA Study Team

Figure 2-1 Hourly Distribution of Metro Passengers (Boarding Time-Based)

Table 2-4 Hourly Peak Ratio of the Metro (Alighting Time-Based)

Arrival Time	Trip Purpose					Share (%)
	Work	Education	Other HB	Other NHB	Total	
0	6,255	67	182	0	6,504	0.3
1	1,641	0	69	0	1,710	0.1
2	666	638	0	0	1,304	0.1
3	553	213	0	0	766	0.0
4	134	0	16	0	150	0.0
5	2,725	190	180	0	3,095	0.2
6	23,058	28,645	1,067	0	52,771	2.6
7	69,664	130,340	2,408	1,598	204,009	10.2
8	160,651	170,260	11,624	0	342,536	17.1
9	95,963	111,477	13,018	0	220,458	11.0
10	11,202	22,768	8,291	657	42,917	2.1
11	8,135	18,831	6,895	2,569	36,430	1.8
12	9,174	39,815	7,616	7,361	63,966	3.2
13	7,973	44,958	2,889	517	56,337	2.8
14	50,465	108,637	3,656	3,538	166,297	8.3
15	137,926	148,382	5,566	3,367	295,242	14.7
16	48,172	57,213	3,288	4,281	112,953	5.6
17	53,663	70,255	6,545	2,838	133,301	6.6
18	34,893	76,366	13,449	2,824	127,532	6.4
19	10,265	13,116	5,265	497	29,143	1.5
20	21,641	14,674	5,971	405	42,691	2.1
21	25,946	6,810	1,691	701	35,148	1.8
22	8,991	776	818	0	10,585	0.5
23	17,445	2,087	774	117	20,422	1.0
Total	807,200	1,066,517	101,280	31,268	2,006,266	100.0
	40.2%	53.2%	5.0%	1.6%	100.0%	

Source: CREATS HIS (2002) as analyzed by the JICA Study Team
Note: HB = Home Based, NHB = Non-home Based



Source: CREATS HIS (2002) as analyzed by the JICA Study Team

Figure 2-2 Hourly Distribution of Metro Passengers (Alighting Time-Based)

2.5 Estimation of Station and Section Peak Hour Passenger Volumes

Based on the application of a peak hour ratio of 14%, the station and section peak hour passenger volumes for Metro Line 4 were estimated as shown in Table 2-5 below.

Table 2-5 Number of Passengers at Peak Hour and PPHPD for Metro Line 4

	Peak hour station passenger (boarding + alighting)				PPHPD (passenger per hour per direction)			
Station No	Year 2020	Year 2023	Year 2027	Year 2050	Year 2020	Year 2023	Year 2027	Year 2050
Phase2 Sta. 17	0	26,740	32,070	35,700				
		↓↑	↓↑	↓↑	0	13,370	16,040	17,850
Phase2 Sta. 16	0	14,390	18,330	19,220				
		↓↑	↓↑	↓↑	0	18,740	20,590	25,170
Phase2 Sta. 15	0	10,460	11,650	13,090				
		↓↑	↓↑	↓↑	0	26,960	28,980	35,600
Phase2 Sta. 14	0	8,550	9,700	10,710				
		↓↑	↓↑	↓↑	0	29,320	31,890	38,540
Phase2 Sta. 13	0	15,540	17,000	17,220				
		↓↑	↓↑	↓↑	0	37,420	39,400	36,740
Phase2 Sta. 12	0	12,710	14,170	16,310				
		↓↑	↓↑	↓↑	0	40,910	43,650	44,490
Phase2 Sta. 11	0	6,920	8,300	9,140				
		↓↑	↓↑	↓↑	0	45,280	47,180	49,570
Phase2 Sta. 10	0	8,650	9,970	11,170				
		↓↑	↓↑	↓↑	0	47,020	49,670	52,090
Phase2 Sta. 09	0	9,620	10,610	11,540				
		↓↑	↓↑	↓↑	0	50,760	53,470	55,750
Phase2 Sta. 08	0	18,270	19,810	20,820				
Transfer Line 1/4	0	30,030	36,250	38,600				
		↓↑	↓↑	↓↑	0	38,720	40,010	42,770
Phase2 Sta. 07	0	6,900	7,250	8,760				
		↓↑	↓↑	↓↑	0	38,040	40,140	43,010
Phase2 Sta. 06	0	4,370	4,580	4,830				
Transfer Line 3/4	0	35,870	36,580	37,370				
		↓↑	↓↑	↓↑	0	16,740	26,680	36,550
Phase2 Sta. 05	0	4,720	5,170	6,240				
		↓↑	↓↑	↓↑	0	15,700	25,680	35,160
Phase2 Sta. 04	0	4,870	5,570	6,680				
		↓↑	↓↑	↓↑	0	15,930	25,960	35,460
Phase2 Sta. 03	0	4,860	5,140	6,270				
		↓↑	↓↑	↓↑	0	15,120	25,190	34,360
Phase2 Sta. 02	0	4,860	5,140	6,270				
		↓↑	↓↑	↓↑	0	16,290	25,190	34,360

Phase1 Sta. 01	9,370	10,150	11,380	13,710				
Transfer Line 1/4	21,840	23,690	26,570	31,980				
	↓↑	↓↑	↓↑	↓↑	15,600	19,280	26,780	32,280
Phase1 Sta. 02	3,770	3,990	4,200	4,280				
	↓↑	↓↑	↓↑	↓↑	14,690	18,400	26,010	31,430
Phase1 Sta. 03	13,970	14,660	15,410	19,310				
	↓↑	↓↑	↓↑	↓↑	18,750	22,600	30,390	36,900
Phase1 Sta. 04	12,570	13,330	14,430	18,130				
Transfer Line 2/4	37,030	37,860	42,980	50,900				
	↓↑	↓↑	↓↑	↓↑	29,940	31,340	40,930	54,930
Phase1 Sta. 05	5,600	5,920	6,660	7,520				
	↓↑	↓↑	↓↑	↓↑	29,490	30,870	40,310	54,100
Phase1 Sta. 06	8,550	8,890	9,340	11,280				
	↓↑	↓↑	↓↑	↓↑	27,220	28,590	39,960	53,630
Phase1 Sta. 07	17,190	18,070	20,970	25,130				
	↓↑	↓↑	↓↑	↓↑	21,110	22,020	39,280	52,830
Phase1 Sta. 08	11,370	12,040	14,520	16,740				
	↓↑	↓↑	↓↑	↓↑	20,570	21,460	38,300	51,510
Phase1 Sta. 09	10,470	10,540	11,840	12,100				
	↓↑	↓↑	↓↑	↓↑	16,840	17,750	35,870	48,870
Phase1 Sta. 10	14,840	15,500	19,610	24,180				
	↓↑	↓↑	↓↑	↓↑	12,180	12,870	32,570	44,370
Phase1 Sta. 11	6,640	6,710	7,430	11,730				
	↓↑	↓↑	↓↑	↓↑	9,570	10,260	30,580	41,510
Phase1 Sta. 12	6,750	7,060	8,860	9,070				
	↓↑	↓↑	↓↑	↓↑	6,450	7,040	28,080	38,680
Phase1 Sta. 13	5,420	5,730	6,800	13,310				
	↓↑	↓↑	↓↑	↓↑	3,560	3,990	25,730	31,880
Phase1 Sta. 14	3,610	3,810	6,240	10,650				
	↓↑	↓↑	↓↑	↓↑	1,940	2,280	23,550	28,150
Phase1 Sta. 15	3,880	4,550	5,670	11,980				

Source: JICA Study Team

2.6 Passenger- and PCU[1]-km and -hours for "With" and "Without" Project Cases

Estimates of passenger-km, passenger-hours, PCU-km and PCU-hours for the "With" and "Without" project cases were required as inputs for the measurement of economic benefits in the economic appraisal of the project (see Chapter 13 for the application of these indicators). These estimates were achieved by means of simulation, and the results are shown in Table 2-6.

[1] "PCU" means "Passenger Car Unit", a standard unit for measuring traffic volume, which results from expressing different vehicle types as in terms of an equivalent number of PCU, e.g. a large truck or a large bus is equivalent to 2.5 PCU, a motorcycle is equivalent to 0.3 PCU, and so on.

Table 2-6 (1) Analysis of "With" and "Without" Project Cases of Metro Line 4
Phase 1 + Phase 2

		Unit	Year 2020		Year 2023	
			With	Without	With	Without
No of Trip	Pax Car	Person trip	7,317,081	7,323,339	8,292,396	8,310,657
	Bus	Person trip	12,815,802	13,116,175	12,607,342	13,170,879
	Acc. Shared Taxi	Person trip	1,561,461	1,439,039	1,686,191	1,453,928
	MRT+LRT	Person trip	3,946,918	3,640,287	4,388,364	3,806,566
	Total	Person trip	25,641,262	25,518,840	26,974,293	26,742,030
Person * km	Pax Car	Person * km	110,825,670	110,923,052	125,798,503	126,072,588
	Bus	Person * km	152,824,967	157,130,172	152,021,340	160,966,522
	Acc. Shared Taxi	Person * km	8,334,435	8,446,811	7,804,841	8,678,409
	MRT+LRT	Person * km	82,021,068	77,928,168	90,967,960	79,964,661
	Total	Person * km	354,006,139	354,428,203	376,592,644	375,682,180
Person * hrs	Pax Car	Person * hrs	4,826,426	4,835,980	5,627,104	5,650,138
	Bus	Person * hrs	6,441,170	6,632,212	6,539,874	6,957,027
	Acc. Shared Taxi	Person * hrs	342,875	349,317	329,473	369,346
	MRT+LRT	Person * hrs	2,417,079	2,296,374	2,682,170	2,361,624
	Total	Person * hrs	14,027,550	14,113,883	15,178,621	15,338,135
PCU (Car, Bus, Acc)	PCU	PCU Trip	6,319,292	6,340,900	7,009,287	7,055,503
	PCU*km	PCU*km	98,731,961	99,121,495	110,374,324	111,320,065
	PCU*Hours	PCU*hrs	4,282,355	4,303,933	4,916,638	4,968,689
	Ave Travel km	km	15.62	15.63	15.75	15.78
	Ave Travel time	min	40.66	40.73	42.09	42.25
	Average Speed	km/hour	23.06	23.03	22.45	22.40

Source: JICA Study Team

Table 2-6 (2) Analysis of "With" and "Without" Project Cases of Metro Line 4
Phase 1 + Phase 2

		unit	Year 2027		Year 2050	
			With	Without	With	Without
No of Trip	Pax Car	Person trip	9,561,250	9,586,006	19,222,178	19,275,792
	Bus	Person trip	12,364,875	12,944,028	16,017,445	16,730,764
	Acc. Shared Taxi	Person trip	1,838,061	1,596,994	2,474,074	2,167,889
	MRT+LRT	Person trip	4,776,201	4,172,292	7,961,171	7,194,238
	Total	Person trip	28,540,387	28,299,320	45,674,868	45,368,683
Person * km	Pax Car	Person * km	153,070,132	153,343,242	297,113,020	297,906,717
	Bus	Person * km	135,185,866	145,245,958	168,793,102	180,952,655
	Acc. Shared Taxi	Person * km	8,281,379	8,880,433	10,435,943	10,914,641
	MRT+LRT	Person * km	108,472,661	95,911,703	148,973,078	132,996,211
	Total	Person * km	405,010,038	403,381,336	625,315,143	622,770,224
Person * hrs	Pax Car	Person * hrs	7,103,095	7,124,956	15,689,296	15,758,641
	Bus	Person * hrs	6,050,484	6,523,895	8,682,574	9,339,298
	Acc. Shared Taxi	Person * hrs	363,230	392,621	532,945	561,935
	MRT+LRT	Person * hrs	3,260,617	2,905,900	4,509,937	4,061,174
	Total	Person * hrs	16,777,426	16,947,372	29,414,751	29,721,047
PCU (Car, Bus, Acc)	PCU	PCU Trip	7,856,480	7,909,136	14,319,533	14,404,359
	PCU*km	PCU*km	130,692,469	131,680,555	246,472,181	248,000,050
	PCU*Hours	PCU*hrs	6,046,580	6,100,306	12,996,878	13,100,593
	Ave Travel km	km	16.63	16.65	17.21	17.22
	Ave Travel time	min	46.18	46.28	54.46	54.57
	Average Speed	km/hour	21.61	21.59	18.96	18.93

Note: PCU = passenger car unit
Source: JICA Study Team

2.7 Station Context Planning (Multimodal Interchanges)

Stations of a metro line are integrated into the urban settings of a city. Therefore, their implementation needs to be studied at the metro station level itself. However, it is also crucial to study the surrounding environment in order to provide good access to the station, not only for other public transport modes and pedestrians, but also to improve urban space quality.

This issue is addressed in this part of the report through various objectives set to define the principles of the station context planning around each station of Metro Line 4. This part is divided into three sections:

- Definition of station classification
- Typology of spatial arrangement according to the station classification
- Station context planning and space organization for each station

Concerning the definition of the Metro station classification, three different criteria are identified to plan a station and its setting. Even though these are somehow interrelated, they appear at different stages of the station context planning process.

(1) Level of Traffic

This criterion integrates the number of forecast boarding and alighting for the station and is related to the population, employment and student densities around the station. It will have an impact not only on the dimensioning of the underground station but also on the ground level conditions around the station to design pedestrian accesses to the station.

- Category A: Total traffic of In and Out passengers during peak period is greater than 30,000 passenger per hour
- Category B: Total traffic of In and Out passengers during peak period is between 15,000 and 30,000 passenger per hour
- Category C: Total traffic of In and Out passengers during peak period is lower than 15,000 passenger per hour

This item is consistent with the demand forecast in this study. It allows classifying the stations for their underground sizing according to their maximum forecast frequentation. This maximum forecast frequentation is generally the horizon 2050. Some stations are also upgraded to the higher traffic category when they are major inter-modal nodes, or act as transfer points with the existing Metro stations.

(2) Inter-modality

Inter-modality integrates the role of the station in the public transport network. Stations are classified according the level of inter-modality, assessed by the diversity of modes and number of lines stopping at the station. This criterion is essential to organize and size the inter-modal facilities. For this item, stations are classified into two categories.

- Inter-modal Station: connected with more than two modes or routes.
- Simple Station: connected with one mode or not connected to another public transport network.

The criterion will reflect the fact that some stations have a major role in the network, such as connection to a mass rapid transit system or a metropolitan arterial outward city.

(3) Urban Context

Greater Cairo is a very heterogeneous city. Therefore, the urban form varies significantly along the Metro corridors. These different urban environments thus impact the spatial organization proposed around each station. This criterion takes into account the local urban context by the type of buildings and road networks.

- Category 1: High-rise area served by a wide and organized street network
- Category 2: Densely built area with quite low-rise buildings (5-6 floor average) served by a narrow road network
- Category 3: Military area

All these categories will be associated with the typology for spatial organization. Table 2-7 presents the outcome of the analysis, as the classification according to the three abovementioned criteria.

Table 2-7 Line 4 Phase 1 Station Classification

Stations	Level of Traffic	Inter-modality	Urban Context
No.1 (El Malek El Saleh)	A	Inter-modal station	2
No.2 (El Rauda)	C	Simple station	2
No.3 (El Nile)	B	Simple station	2
No.4 (El Giza)	A	Inter-modal station	1
No.5	C	Simple station	1
No.6	C	Simple station	1
No.7	B	Simple station	1
No.8	B	Simple station	1
No.9	C	Simple station	1
No.10	B	Simple station	1
No.11	C	Simple station	1
No.12 (El Remayah)	C	Simple station	1
No.13 (GEM)	C	Simple station	2
No.14	C	Simple station	3
No.15	C	Simple station	1

Source: JICA Study Team

CHAPTER 3

GENERAL FEATURES AND MAIN CHARACTERISTICS

CHAPTER 3 GENERAL FEATURES AND MAIN CHARACTERISTICS

3.1 General Features of Metro Line 4

Metro Line 4 will be designed to provide a high-capacity, safe, reliable and cost-effective urban railway service in Greater Cairo. Its main function will be to connect presently under-served, but fast growing, new urban communities in western Cairo with the central city area. Commuters joining the railway at its extreme western end will be able to travel the 16 km to El Malek El Saleh Station (the interchange station with Metro Line 1) in 30 minutes, whereas the same trip by bus could take more than 1 hour in present traffic conditions.

Because the new railway will be required to offer high standards of safety, reliability and system performance and availability, it will be equipped with state-of-the-art technology, designed to automate route setting, provide fail-safe train operation and control, provide superior riding comfort, and cope effectively with emergencies.

3.2 Main Technical Characteristics of Metro Line 4

The railway system to be introduced must be capable of offering safety and reliability, as well as cost-effective operation throughout its entire service life cycle. Accordingly, it is extremely important to the ongoing operation of the existing railway system that these fundamental requirements be met, even if the initial capital cost is slightly more expensive.

The main technical characteristics for the railway system proposed for Metro Line 4 are shown in Table 3.1. Detailed explanations of these characteristics are given in Chapter 4 of this report (Volume 3).

Table 3.1 Main Technical Characteristics

No.	Description	Details	
		Phase 1	Phase 2
1	**Alignment**		
		El Malek El Saleh Sta. (Line 1) – El Giza Sta. (Line 2) - El Remayah Square - Workshop/Depot	El Malek El Saleh Sta. (Line 1) - Ghamrah - El Sawaha Square - Ring Road Exit #18
2	**Route length**		
	Total route length	16.1km	17.9km
	- Underground section length	16.1km	12.5km
	- Elevated section length	0km	5.4km
3	**Stations**		
	Total number of stations	15 stations	16 stations
	- Number of underground stations	15 stations	12 stations
	- Number of elevated stations	0 stations	4 stations
4	**Operation status**		
	Estimated number of passengers/day - In year 2020 (Opening) - In year 2050	0.69 million (Phase 1 only) 2.04 million (Phase 1+ Phase 2)	

No.	Description	Details: Phase 1	Details: Phase 2
	Headways in peak hour	4 minutes 00 seconds in 2020 2 minutes 09 seconds in 2050	
	Maximum operation speed - Underground section - Elevated section - Inside depot	 80 km/hr 100 km/hr 25 km/hr	
	Average speed	32.2 km/hr	
	Dwell time at intermediate stations	30 seconds	
	Round trip time	70 minutes	137 minutes (Phase 1+ Phase 2)
	Daily operation hour	05:00h – 01:00h	
	Train size	8 cars in a train-set	
	Driver system	Single driver operation	
	Location of CCP	El Malek El Saleh	
5	**Standards of construction**		
	Gauge	1,435 mm	
	Track centre distance	3.5 m at elevated section	
	Tracks	Vibration-reducing track	
	Design axle load	16 tonnes max.	
	Rail	UIC 54 kg/m	
	Max. gradient	4%	
	Min. horizontal curve radius	Main line: 250 m Main line turnout curve: 160 m Workshop / depot line: 160 m Workshop / depot line turnout curve: 120 m Platform section: 1,000 m	
6	**Tunnel structure**		
	Type of tunnel	Single track Double tube	
	Diameter	6.2 m (Inner diameter)	
7	**Station structure**		
	Number of Platform - Island type - Side type	 11 stations 4 stations	 16 stations 0 stations
	Platform width	12.0 m (island type)	
	Platform height	1,100 mm	
	Platform length	170 m	
8	**Depot**		
	Stabling capacity	35 train sets	35 train sets
	Facilities	Stabling and maintenance facilities	Stabling facilities
9	**Rolling stock**		
	Type of rolling stock	EMU (Electric Multiple Unit)	
	Train formation	M-N1-T-N2-N2-T-N1-M or Tc-N3-N1-N3-N1-N3-N1-Tc	
	Passenger capacity (AW2: 7 person/m2)	2,000 passenger/train	
	Train dimensions - Car length (over coupler faces) - Car width - Car height -Train length (8-car unit)	 20.0 m 2.88 m 4.1 m 160 m	
	Propulsion System - Circuit control system - Traction motor - Motor output power	 Inverter with IGBT PMSM*1 or Induction motor 140 kW/motor	
	Car body material	Lightweight stainless steel	

No.	Description	Details Phase 1	Details Phase 2
	Doors	8 doors per car (4 on each side)	
	Kinetic performance - Initial acceleration ratio - Max service deceleration	$0.9\ m/s^2$ $1.1\ m/s^2$ (ability $1.3\ m/\ s^2$)	
	Air conditioning - Type of air conditioning - Capacity	Roof-mounted with line-flow fan 40,000 kcal/h/car	
10	**Power supply and traction system**		
	Electrification system	1500VDC	
	Type of centenary system	OHC (Tunnel: Overhead rigid conductor)	
	Voltage - Nominal voltage - Max. voltage - Nin. voltage	1500VDC 1800VDC 1000VDC	
	HVS (High Voltage Station) - Number of stations - Transformer capacity	1 HVS 80MVA	1 HVS 80MVA
	RS (Rectifier Station) - Number of stations - Capacity	5 RS 6MW	6 RS 6MW
	LPS (Lighting Power Station) -Number of stations	1 LPS/station and Depot	
11	**Signalling and Telecommunications system**		
	Signals - Main line including between main line and stabling in Depot - Inside of Depot	On-board signal Wayside signal	
	Train detection system	Track circuit	
	Route Control system - Interlocking - Point machine	Electrical interlocking Electrical point machine	
	Train Interval control system	ATP(Automatic Train Protection, Continuous control) PTC (Programmed Traffic Control)	
	Train operation support system - System - Accuracy	ATO (Automatic Train Operation) Stopping accuracy: Approx. plus minus 350mm	
	Backbone transmission network system - System - Transmission media	SDH (Synchronous Digital Hierarchy) Optical fibre transmission system	
	Train radio system - System - Antenna	VHF[*2] TDM/TDMA[*3] LCX (Leaky Coaxial Cable)	
	CCTV (Closed Circuit Television) system including on-board monitoring system	Monitoring of platform, concourse, ticket gate, elevator, escalator, others	
	Passenger Information system	PIDS (Passenger Information Display System) PA (Public Address System) Clock system	
12	**Station Facilities**		
	AFC (Automatic Fare Collection) system - Type of ticket media - IC chip standard - Card size	Magnetic Ticket (MT), Contactless IC ticket ISO/IEC 14443 (Type-A) ISO 7810	
	PSD (Platform Screen Door) system - Full height PSD - Half height PSD	For underground stations, except El Remayah station For elevated stations, including El Remayah station	

No.	Description	Details	
		Phase 1	Phase 2
	Other major facilities	Elevator, Escalator, Air conditioner, Air intake & Exhaust system, Fire protection system, etc.	

*1: PMSM: Permanent Magnet Synchronous Motor
*2: VHF: Very High Frequency
*3: TDM/TDMA: Time Division Multiplex/Time Division Multiple Access
Source: JICA Study Team