Japan International Cooperation Agency (JICA)
Syrian Arab Republic

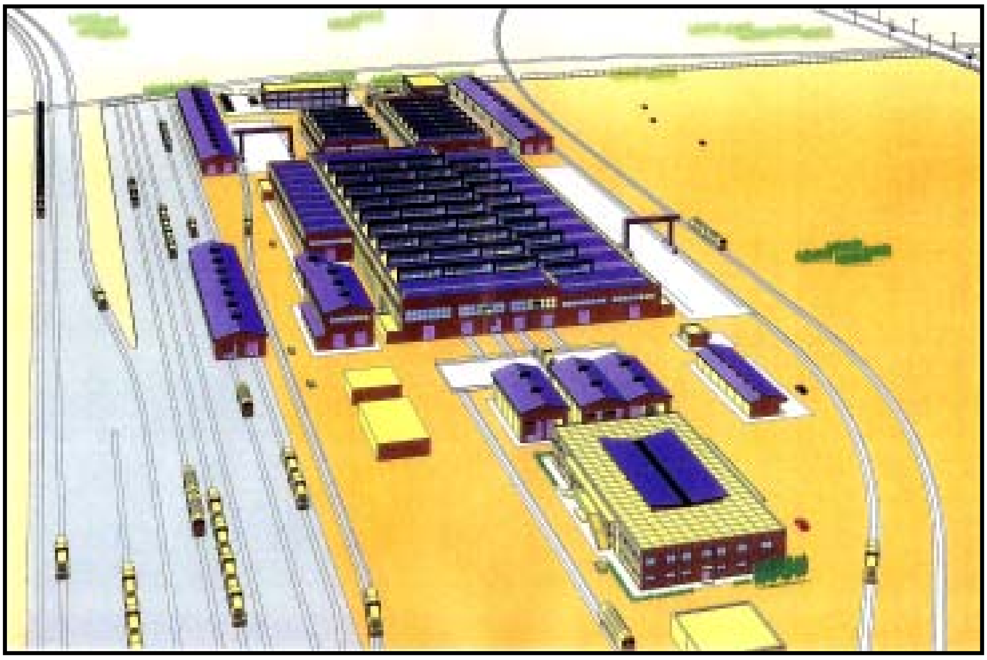
No.

The Master Plan Study on The Development of Syrian Railways in The Syrian Arab Republic

Volume III

Feasibility Study on the Locomotive Workshop Modernization

Final Report



August, 2001

Japan Railway Technical Service (JARTS)
Yachiyo Engineering CO.,LTD(YEC)

SSF
JR
01-120 (3/6)

Exchange Rate of Currency

1US$=46Syrian Pounds

1US$=¥115

1 Syrian Pounds=¥2.5

January, 2001

PREFACE

In response to a request from the Government of the Syrian Arab Republic, the Government of Japan decided to conduct a Master Plan Study on the Development of Syrian Railways in the Syrian Arab Republic and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Dr. Sadaaki Kuroda of Japan Railway Technical Service, and consist of Japan Railway Technical Service and Yachiyo Engineering Co., Ltd. to the Syrian Arab Republic, 3 times between April 2000 and August 2001.

In addition, JICA set up an advisory committee headed by Mr. Hiroshi Saeki, Director, Environmental Office, Railway Bureau, Ministry of Transport (present Ministry of Land, Infrastructure and Transport) between April 2000 and August 2001, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Syrian Arab Republic and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the 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 Syrian Arab Republic for their close cooperation extended to the Team.

August 2001

Kunihiko Saito
President
Japan International Cooperation Agency

August, 2001

Mr. Kunihiko SAITO
President
Japan International Cooperation Agency

Dear Sir,

Letter of Transmittal

We have the pleasure of submitting herewith our Report for the Master Plan Study on the Development of Syrian Railways in the Syrian Arab Republic. The report describes the results of the Study carried out by Japan Railway Technical Service and Yachiyo Engineering Co. Ltd., as per the contract with Japan International Cooperation Agency.

The Study Team conducted field surveys three times during the period from April 2000 to August 2001. The Team held sufficient consultations with the Syrian governmental agencies concerned regarding the results of the field surveys and study activities in Japan, and drew up a master plan for the rehabilitation and modernization of the nationwide railway for the year 2020; phased rehabilitation and modernization plans for 2005 (short term), 2010 (medium term), and 2020 (long term); and two plans, as short-term urgent projects, on the rehabilitation and modernization of Tartous, Homs and Al-Sharqia section and on the locomotive workshop modernization. In close coordination with the Syrian side, the Team thereafter studied the feasibility of these plans from technical, environmental, economic, and financial aspects, and drew up this report.

From the standpoint of reinforcing the transport infrastructures necessary for the social and economic development of Syria, we would like to recommend the early implementation of the two projects: rehabilitation and modernization of the railway section between Tortous, Homs and Al-Sharqia; and locomotive workshop modernization.

We wish to express our sincere gratitude to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and the Japanese Embassy and JICA Office in Syria for the kind assistance and guidance extended to us in executing the Study.

Yours faithfully,

Sadaaki KURODA, Dr. Eng.
Leader
The Study Team for the Master Plan Study on the Development of Syrian Railways in the Syrian Arab Republic

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Qazvīn
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An Nāşirīyah
Al 'Amārah
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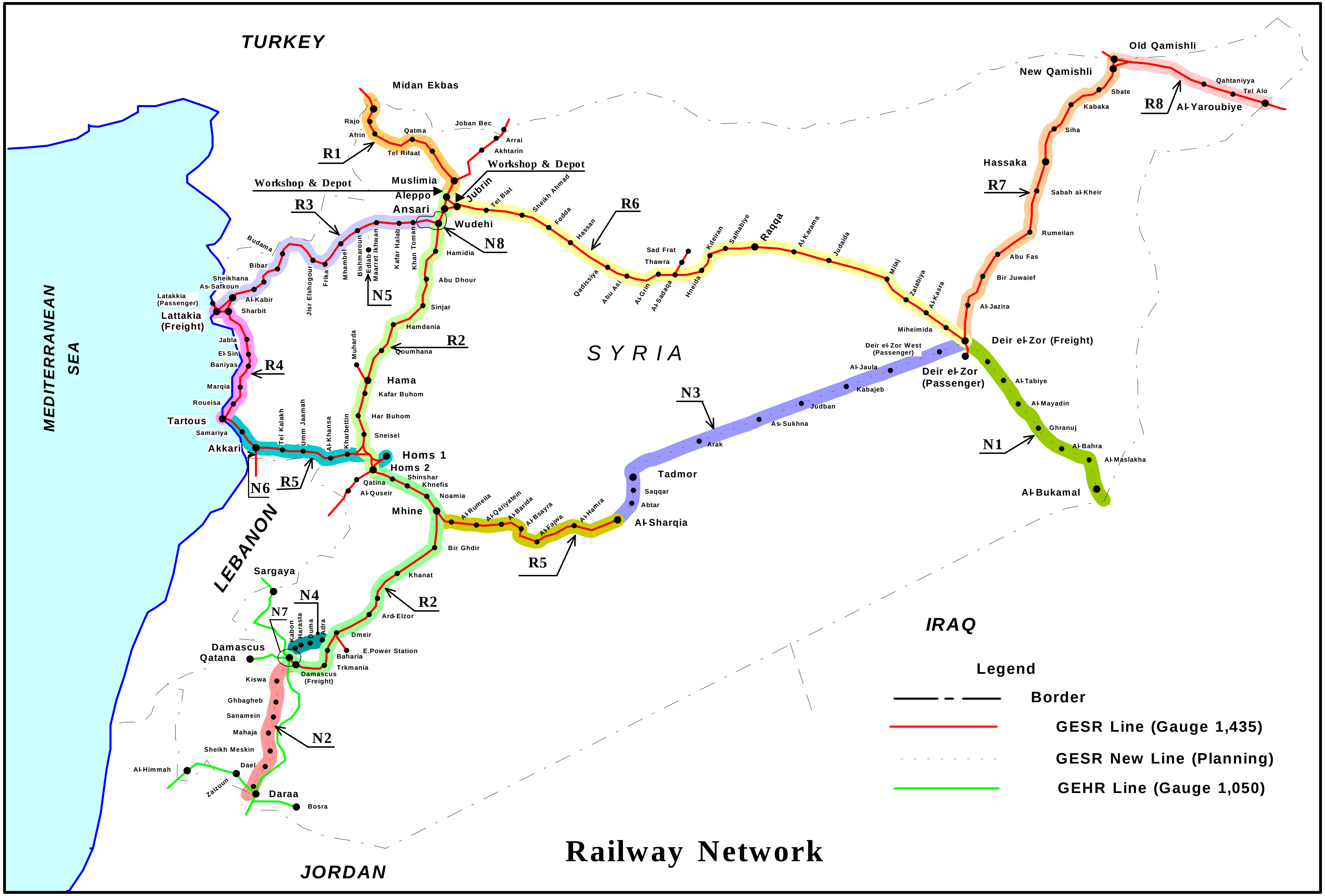
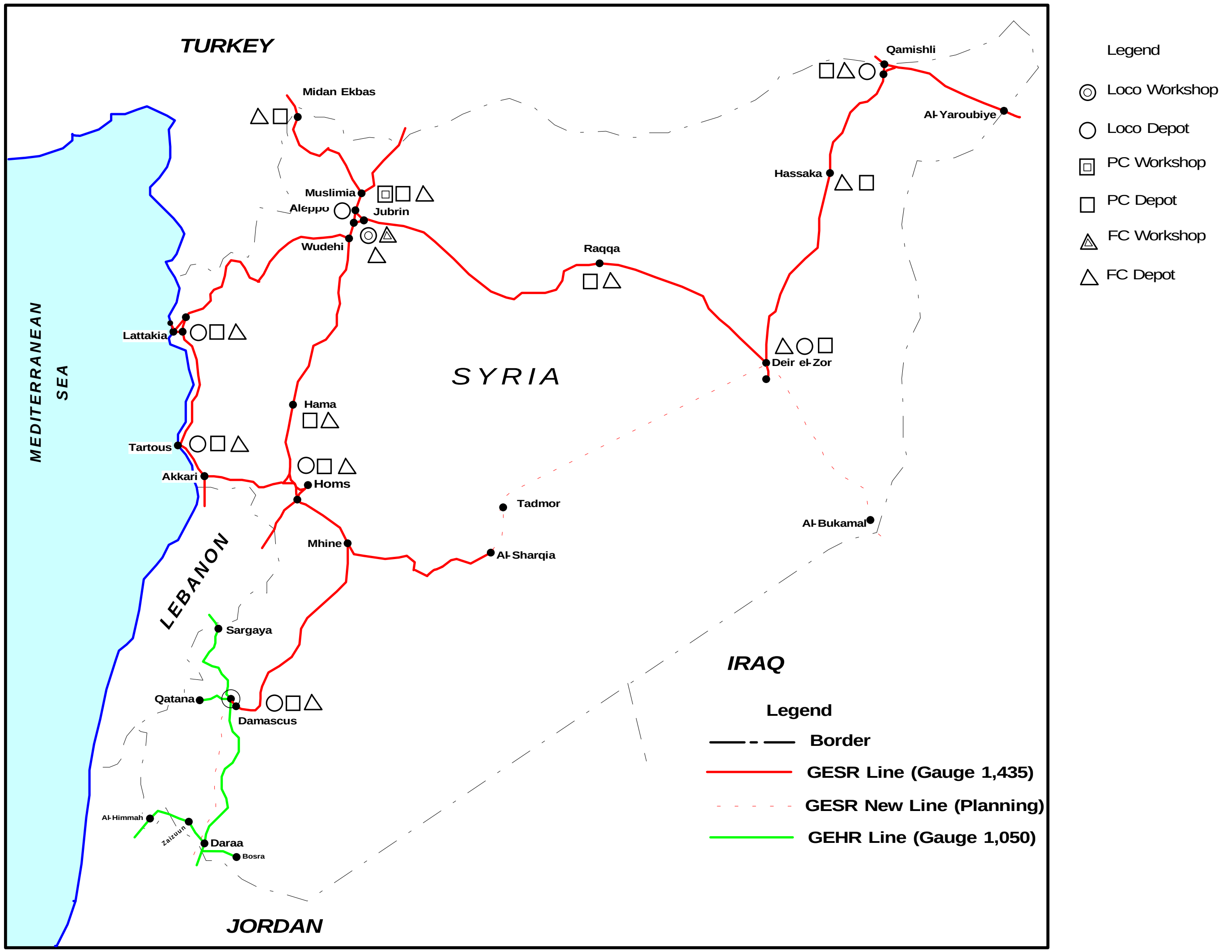
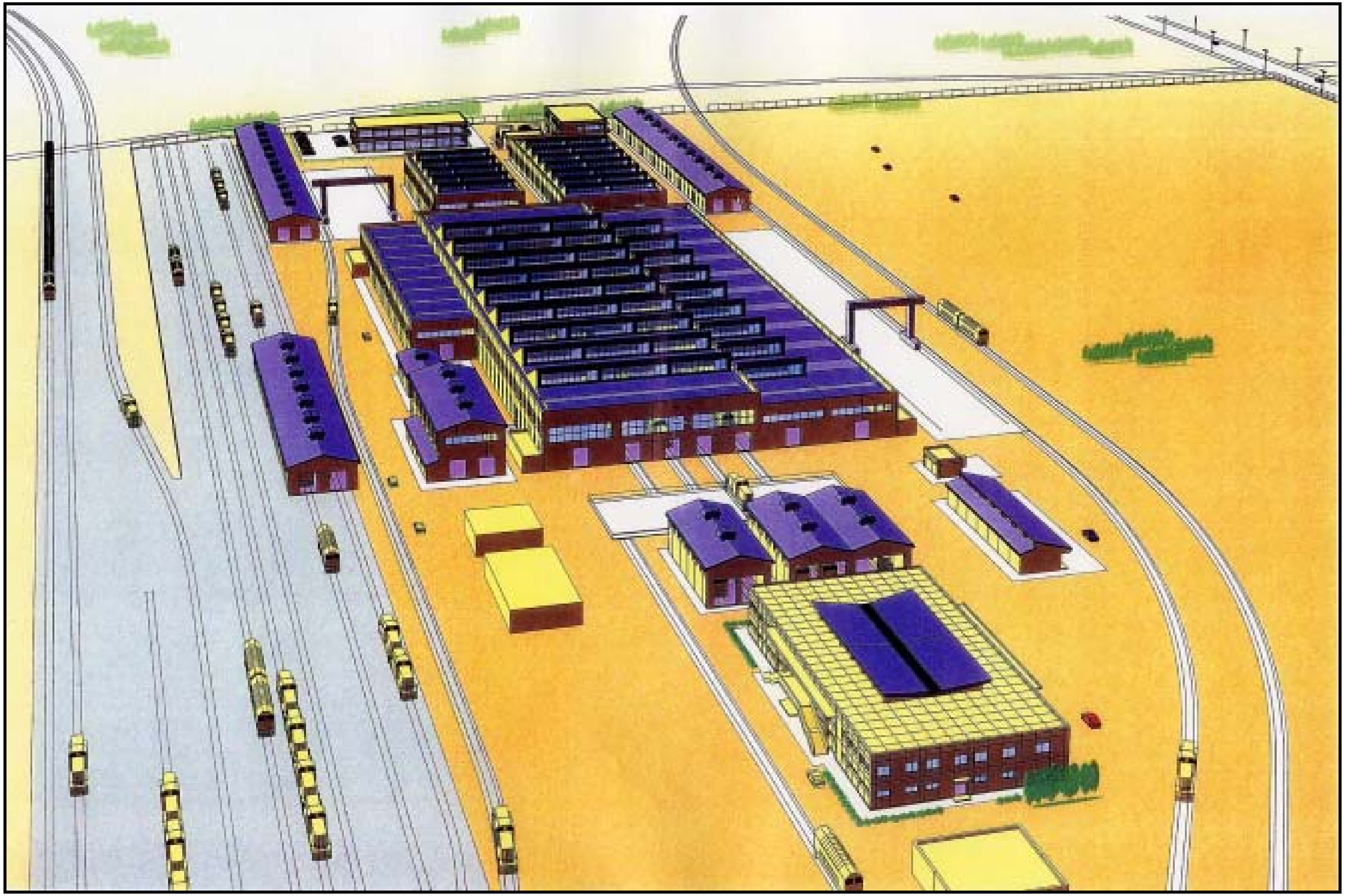


Railway Network



Site of Workshop and Depot



Musulimia Workshop

The Master Plan Study on the Development of Syrian Railways
Volume Ⅲ

The Feasibility Study on the Locomotive Workshop Modernization (Executive Summary)

Study period : Apr,2000～Aug, 2001
Accepting Organization : Ministry of Transportation(MOT). General Establishment of Syrian Railways(GESR)

1. Purpose

Conduct the feasibility study on the modernization of the locomotive workshop, which is the short term urgent project included in the master plan study on the development of Syrian Railways. Technical transfer of the technique on rolling stock maintenance and production control was carried out through the execution of the project.

2. Method of Study

(1) In order to grasp the current situation of Jubrin locomotive workshop and the foundry shop of Aleppo passenger car workshop, conducted the additional site study besides the master plan study.

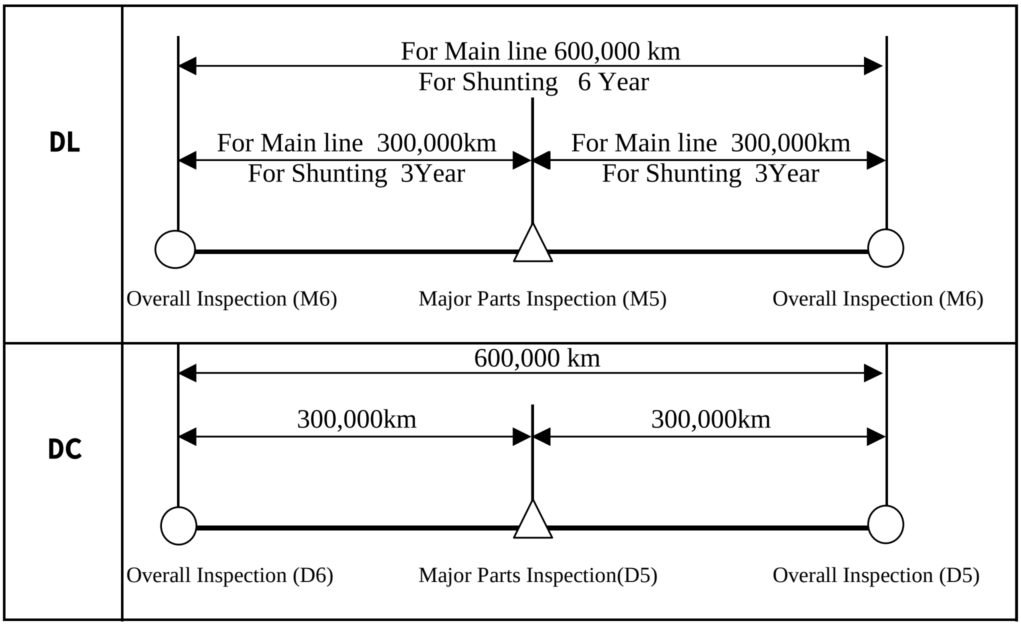
Based on these site study and results of master plan study, the feasibility study was carried out and the report was prepared under the guidance of JICA.

(2) The necessary number of rolling stock were estimated so as to meet the transport demand. In planning new works, the periodic inspection cycle, the standard process of the periodic inspection at workshop, and other fundamental matters were studied, based on the master plan study. They are as follows.

Table 2.1 Necessary number of rolling stock

	2005	2010	2015	2020
DL	116	151	221	321
DC	55	85	195	290
Total	171	236	416	611

Note : DL ------Diesel locomotive
DC-------Diesel railcar



Note ; M5,M6 ---Periodic inspection for DL D5,D6 ----Ditto for DC
In 2020, 300,000 km and 600,000 km will be extended to 450,000 km and 900,000 km respectively.

Fig 2.1 Periodic inspection cycle

Table 2.2 Standard process at workshop

(Actual work day)

	DL		DC	
	M5	M6	D5	D6
Staying period (day)	30	40	22	30

3. Outline of the project

3.1 Basic policy on locomotive workshop modernization

(1) JICA team examined two alternatives on the way of modernization, one is the expansion of Jubrin locomotive workshop, and the other is construction of new workshop. Two alternatives were compared with respect to their contents of construction, construction costs, GESR long term plan on rolling stock maintenance, etc.

As a result, the construction of new workshop was selected and the feasibility study on it was conducted.

In addition, at the new workshop, brake shoes for all rolling stock in GESR would be cast besides periodic inspection of DLs and DCs.

(2) Necessary number of DLs and DCs to be inspected was estimated, based on Table 2.1 and Fig 2.1, with some allowance for examination of building, facilities and equipment plan, and with severe one in a likely way for examination of rolling stock maintenance work. Casting quantity of brake shoes were assumed based on the current consumed ones and necessary number of rolling stock.

3.2 Main outline of the plan

(1) For the planning of buildings, facilities and equipment, 144 DLs and the same number of DCs were assumed to be maintained per year and 3,400 tons per year for brake shoes casting.

(2) For the examination of work volume, personnel, organization and so forth, the number of DLs and DCs to be inspected and casting quantity of brake shoes as shown in Table 3.2.1 and Table 3.2.2 were assumed.

Table 3.2.1 Yearly number of DLs and DCs to be inspected

		2006	2010	2015	2020
DL	Periodic inspection	44	55	66	107
	Temporary inspection	23	30	44	64
DC	Periodic inspection	22	34	89	122
	Temporary inspection	11	17	39	58
Total	Periodic inspection	66	89	155	229
	Temporary inspection	34	47	83	122

Reference : Max. maintenance capacity of Jubrin locomotive workshop (2000)
35 LDE2800s M5or M6 per year

Table 3.2.2 Quantity of brake shoes casting (t/year)

	2006	2010	2015	2020
Total	1,500	2,100	3,400	5,400

(3) Outline of new workshop scale

1) The new workshop will be built in the area of about 38 ha, adjacent to Muslimia station.

2) Main shop area, facilities and equipment for rolling stock maintenance and those attached to buildings are as shown in Table 3.2.3.

Table 3.2.3 Workshop building, facilities and equipment

	New workshop	(Reference) Jubrin locomotive workshop
Main shop area (m^2)	34,000	11,000
Facilities and equipment for rolling stock maintenance (Piece, set)	1,020	125
Casting capacity (ton /year)	3,400	-
Lightning protection (set)	1	-
Waste water treatment plant (set)	1	(-)
Incineration equipment (set)	1	-
Others	Omitted	

3) General layout for the new workshop

General layout for the new workshop is shown in Fig 3.2.1.

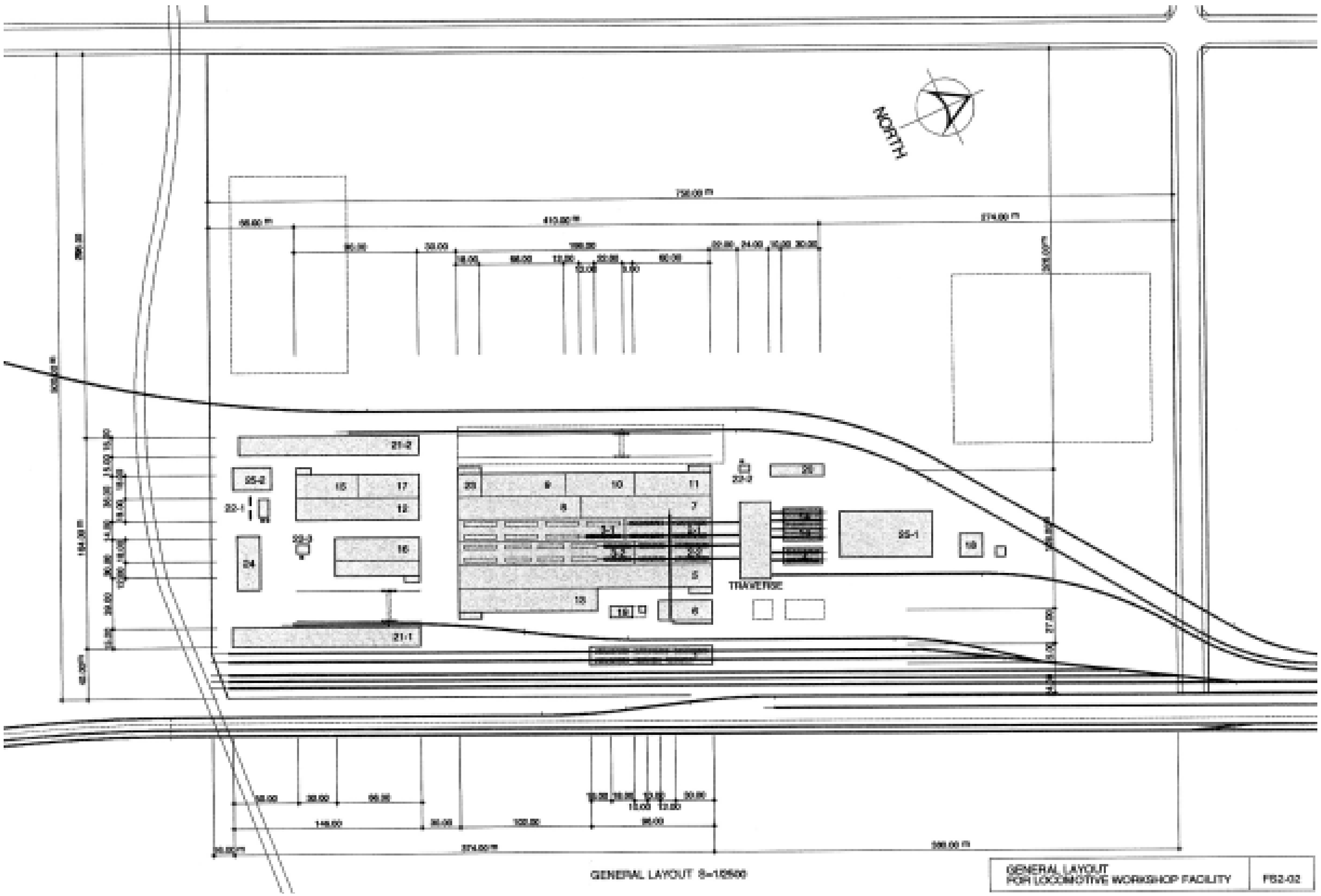


Fig 3.2.1 General layout for the new workshop

4) Organization and personnel

Based on the organization and daily working hour at Jubrin locomotive workshop, seven sections were allocated including one in charge of casting under the workshop manager. Personnel assumption is shown in Table 3.2.4.

Table 3.2.4 Personnel assumption

(person)

	2005	2006	2010	2015	2020
Total	420	420	530	770	1,150

Note ; Allocate 420 persons for Oct. to Dec. in 2005 to prepare the start of workshop operation in 2006

5) Management and operation cost

Table 3.2.5 Management and operation cost (1000sp/year)

	2005	2006	2010	2015	2020
Total	4,347	50,314	57,833	73,650	94,492

6) Construction cost

Table 3.2.6 Construction cost

Unit;1,000SP

Item		Cost		
		FC	LC	Total
Construction of new work shop	Land		37,500	37,500
	Civil work	106	228,249	228,355
	Track work	118,449	67,003	185,452
	Building work	377,505	1,522,149	1,899,654
	Mechanical work	5,017,833	314,479	5,332,312
	Subtotal	5,513,893	2,169,380	7,683,273
Engineering fee (5%)		384,164		384,164
Contingency (5%)		294,903	108,469	403,372
Total		6,192,960	2,277,849	8,470,809

(4) Economic and financial evaluation

Table 3.2.7 Economic and financial internal rates of return

Economic internal rates of return (EIRR)	Financial internal rates of return (FIRR)
21.0%	6.4%

(5) Environmental impact assessment

Examination of 23 related items resulted in that a little impact will be expected for seven items and their further study with the progress of the project would be necessary, however, as far as the environmental impact assessment is concerned, the project is feasible.

4. Comprehensive evaluation of the project (Conclusion)

(1) The project of new workshop construction at the site adjacent to Muslimia station to conduct the maintenance work for DLs and DCs, and brake shoes casting for all of rolling stock in GESR, will cope with the GESR's long term plan on rolling stock maintenance. It will also contribute to the GESR management.

(2) The following effects are expected in the execution of the project.

- Execution of rolling stock periodic maintenance in accordance with the yearly plan.
- Decrease of staying days at workshop for maintenance.
- Improvement of maintained rolling stock quality
- Improvement of technique on rolling stock maintenance, production and production control.
- Decrease of rolling stock maintenance cost
- Decrease of environmental impact

(3) The EIRR of the project from the national economic standpoint is 21.0%. The project is considered to be feasible.

(4) The FIRR of the project from the enterprise view of GESR is 6.4%. The project can be judged as financially viable in case reasonable interest loan is applied to investment.

(5) For the effective implementation of the project, some recommendations are made concerning the effective management of workshop.

Contents

Abbreviation and Glossary

ADT	Average Daily Traffic
AOC	Administration and Operation Cost
ATP	Automatic Train Protection
ATS	Automatic Train Stop
B/C	Benefit Cost Ratio
BOD	Biochemical Oxygen Demand
CCITT (ITU-T)	International Telecommunication Union
CIF	Cost, Insurance and Freight
COD	Chemical Oxygen Demand
CONOCO	Continental Oil Company
CT	Closed Track Circuit
CTC	Centralized Traffic Control
DC	Diesel Car
DEL (LDE)	Diesel Electric Locomotive
DGMO	Director Generals of Middle East Railways
DHL	Diesel Hydraulic Locomotive
DL	Diesel Locomotive
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
FC	Freight Wagon
FIRR	Financial Internal Rate of Return
FS（F/S）	Feasibility Study
GCEA	General Council for Environmental Affairs
GDP	Gross Domestic Products
GEHR	General Establishment of Hidjaz Railways
GESR	General Establishment of Syrian Railways
GORS	General Organization of Remote Sensing
GRDP	Gross Regional Domestic Products
HID	High Intensity Discharge
HMIS	Highway Maintenance and Inspection System
HVAC	Heating, Ventilation and Air Conditioning
IEC	International Electro Technical Commission
IRI	International Roughness Index
ISO	International Standard Organization
JICA	Japan International Cooperation Agency
JR	Japan Railway

LED	Light Emitting Diode
MOF	Ministry of Finance
MOT	Ministry of Transport
MP（M/P）	Master Plan
MRT	Mass Rapid Transport
NDP	Net Domestic Products
NEAP	National Environmental Action Plan
NEEDS	Nikkei Economic Evaluation Data System
NPV	Net Present Value
OD	Origin-Destination
OJT	On the Job Training
OLTC	On Load Tap Changer
OT	Open Ticket Circuit
PABX	Private Automatic Branch Exchange
PC	Passenger Coach
PC sleeper	Prestressed concrete sleeper
ROC	Rail Operating Cost
ROI	Return on Investment
ROE	Return on Equity
ROUC	Rail Operating Unit Cost
ROW	Right of Way
SDH	Synchronous Digital Hierarchy
SL	Steam Locomotive
SS	Suspended Solides
TQC	Total Quality Control
TTC	Travel Time Cost
TTUC	Travel Time Unit Cost
TTUC	Travel Time Unit Value
UIC	International Railway Union
UN	United Nations
UNDP	United Nations Development Programme
VOC	Vehicle Operating Cost
VOUC	Vehicle Operating Unit Cost

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Back ground of the project

In the Master Plan Study on the Development of Syrian Railways, in addition to the renewal of rolling stock, the modernization of rolling stock maintenance has been adopted, hoping that the modernization of rolling stock maintenance will contribute to the management of GESR through the efficient and economical execution of rolling stock maintenance.

From this point of view, the modernization of Jublin locomotive workshop has been designated as the short term urgent project for the feasibility study.

1.2 Urgency and importance of this project

At present, 177 diesel locomotives (DL) are owned by the GESR, and large-scale scheduled inspection and large-scale unscheduled repairs of these locomotives are carried out at the Jubrin locomotive workshop. However, the workshop is narrow, its layout is inefficient, and facilities are old. Therefore, sufficient repair of locomotives is impossible, and the availability of the total locomotives is only 45 %.

In the modernized workshop, the periodic maintenance of DLs and DCs to be introduced and brake shoes casting for all rolling stock in GESR will be carried out, and it is aimed to reduce the number of days necessary for regular inspections and to reduce the number of rolling stock failures and to reduce the number of temporarily repairs. It is also aimed to enhance availability of locomotives and diesel cars. At the same time, by the implementation of this project, it will become possible for the GESR to acquire the benefit of the technology transfer related to inspection and repair of rolling stock, quality control and the spare parts control system etc.

Chapter 2

Demand Forecast

Chapter 2 Demand Forecast

2.1 Implementation methodology

The workflow for the demand forecast practice is divided into four tasks, which are subsequently divided into 13 sub-tasks as shown in Fig. 2.1.1. For all the tasks the data for 10 years was collected. The ten-year period was selected because during that period the Syrian economy has been gradually changing from a centrally planned economy to a free market one. There are two zoning systems; large zones which confirm to the administrative governorates boundaries, and small zones which group a number of main stations. The road transport OD has been prepared based on the traffic counts at stations on the governorate borders. The rail transport OD has been prepared based on the GESR data concerning transport between the stations. In addition the pipeline OD and air transport OD have been prepared on the basis of the pipeline and air networks respectively. The UN classification for commodities has been adopted in this study with some minor adjustment to reflect certain conditions particular to Syria.

Trip production, generation and attraction volumes were calculated for passengers, while for the commodities the production and consumption amounts were calculated. Trip distribution followed the present pattern because of the following reasons:

a. No drastic changes in the land use pattern in Syria are anticipated
b. Amount changes in the 32 commodity types are reflected in the OD table

Based on the results of a separate survey the passenger transport modal split model was prepared. For the freight transport, another survey revealed that the main criteria for mode selection was the minimum cost and accordingly the modal split model was prepared.

The future indicators were mainly produced from the econometric model and the population model. In addition a sub-model was developed to forecast supplementary indicators.

Assignment of the traffic was done on the basis of the small zones. In the freight OD and in the passenger OD, pipeline transport and air transport respectively were treated independently. The modal split model was used to assign the passengers traffic on the bus and rail modes and the freight traffic on the truck and rail modes.

The workflow is briefly described in the Fig 2.1.1. Details of the work are voluminous and are represented in the Appendix 7 of Volume I.

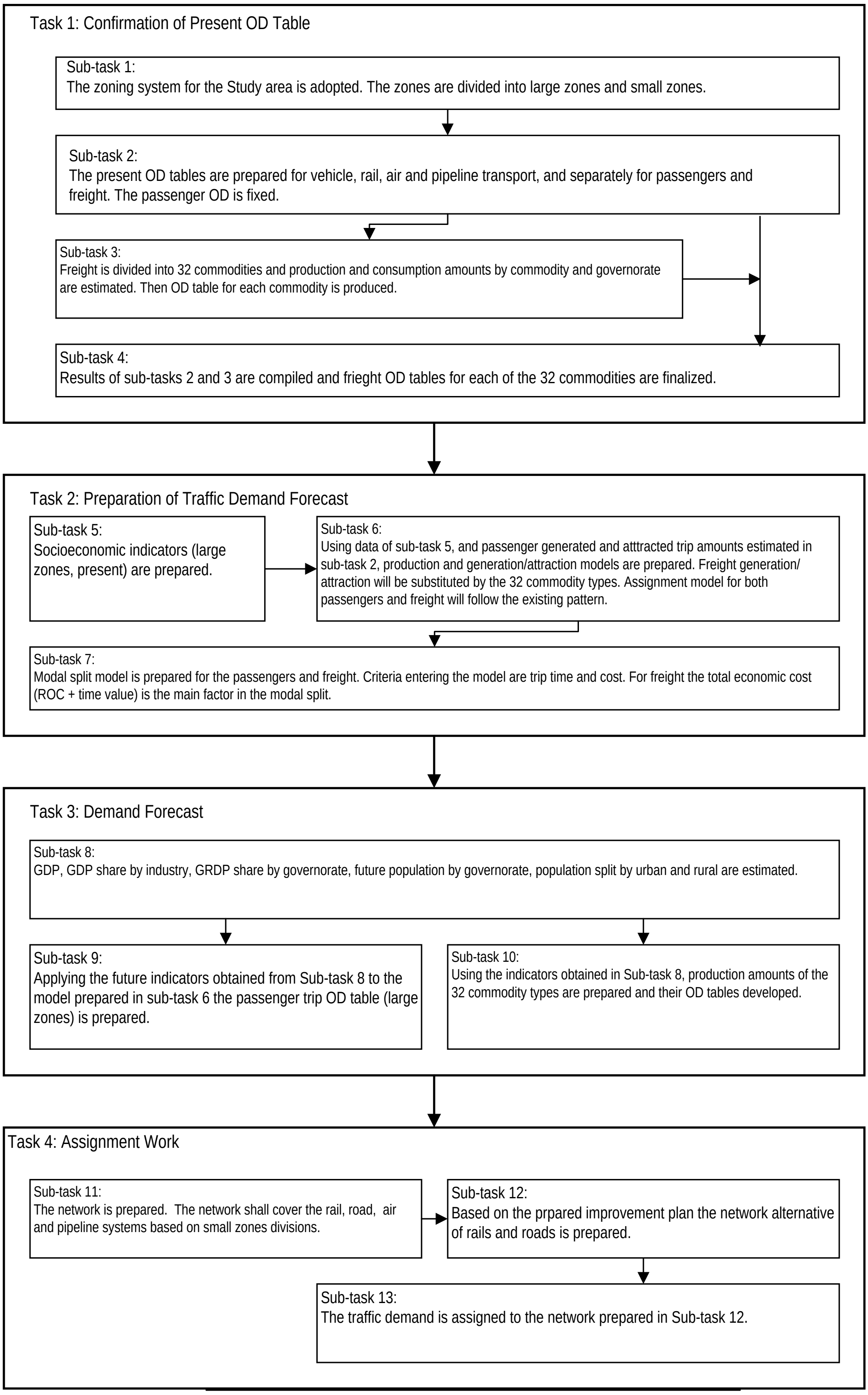


Fig. 2.1.1 Flow chart for demand forecast work

2.2 Zoning

(1) Large Zones

The boundaries of the large zones correspond to the Governorate boundaries in order to facilitate data collection. Outer zones are Turkey, Iraq, Jordan, Lebanon and the Mediterranean Sea and each of these zones represent the traffic from other countries passing through them as well as the traffic from them.

(2) Small Zones

The small zones correspond to major stations and their spheres of influence. Stations include those along the planned lines as well. Areas outside the railways' sphere of influence are considered as one zone. Large and Small zones are shown in Fig. 2.2.1 and are tabulated in Appendix Table 2.

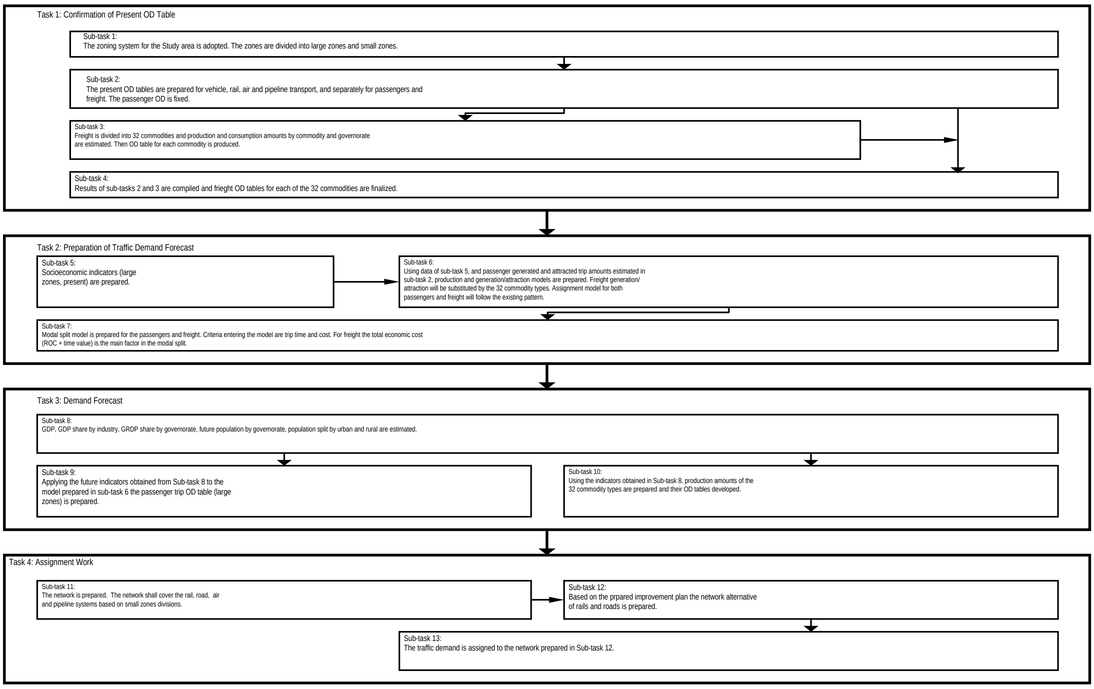


Figure 7.1.1 Flow Chart for Demand Forecast Work

Fig. 2.2.1 Large and small zones map

2.3 OD (Large zones, 1999)

2.3.1 Passenger

Road passenger OD obtained from road traffic observation at the Governorate borders and Rail passenger OD represent the OD traffic between one governorate and another. Passenger OD terminated in the same Governorate is estimated using the results of agricultural zones of the Home Interview Survey done for the Damascus Urban Transport Study, JICA 1997-1999.

2.3.2 Freight

(1) The production/consumption tables for the 32 commodity types were obtained.

(2) The Fratar method was applied to the 32 commodity types production/consumption tables and the OD tables (large OD base) were obtained by commodity item.

2.4 Model

2.4.1 Trip production model

There are two trip production units, namely trip production unit estimated from vehicle counts crossing governorate borders (inter large-zonal trip production unit) and trip production unit on the analogy of trip production unit of agricultural zones of the Damascus Urban Transport Study (intra large-zonal trip production unit). The former unit is 29.8 trips per 1,000 persons and the latter is 0.437 trips per person (inner large-zonal trips only). In the following calculations for the large zones passengers OD pairs the trip production figure of 0.0298 trip/person shall be used and for the large zones intra-zonal trip production rate the figure of 0.437 trip/person is used.

Trip Production and Trip Generation/Attraction Models of Freight are not prepared due to existence of the production/consumption projection.

2.4.2 Trip generation/attraction model

For the trip generation and attraction model between governorates, applied are the parameters of population, urbanization indicators ((secondary industry GDP + tertiary industry GDP) / primary industry GDP), and seaport region flag (seaport region flag 1, other regions 0). Furthermore the amount of generated and attracted traffic for each zone OD pair is the same in terms of going and return traffic. Due to this, the generation and attraction models are the same type.

TRIPga = 0.01566 x POP + 521.4 x UBN + 20,353.0 x PORT + 6053.2 (R^2=0.924)

Where, TRIPga : Trip Generation/Attraction

POP : Governarate Population

UBN : Urban Indicator

PORT : Seaport Flag

2.4.3 Trip distribution model

The passenger trip distribution model has been done in two steps: between large zones and between small zones. The present pattern was used for distributing traffic between the large zones. This is done assuming that there will be no significant changes in the land use in Syria up to the year 2020 (development will continue while maintaining balance of the present inter-regional conditions).

The passenger traffic of the large zones was distributed amongst the small zones based on the analysis of satellite photographs in order to determine each station weight through its surrounding urbanized area.

2.4.4 Modal split model

(1) Passenger

The modal split will first be done for the air and passenger car transport modes, and the remaining traffic demand will then be divided amongst the bus and rail transport modes.

The growth of air passengers has been projected by means of a regression model with GDP/Capita as the independent variable. The results are shown in Table 2.4.1.

Table 2.4.1 Forecast of domestic air transport passengers

Year	2000	2005	2010	2015	2020
Air transport passengers	302,015	438,382	648,201	971,033	1,467,750

The number of passenger car users was estimated using the present estimates and applying the expected growth in passenger car number (refer to Table 2.4.2). In the estimation equation the passenger car/capita was well defined by the GDP/capita as the variable (P-Car/Cap = 0.651238 x GDP/Cap - 5.96306, $r^2 = 0.88$).

Table 2.4.2 Rate of increase of car transport

Year	Number of passenger cars	Increase to year 2000
2000	413,009	1.0000
2005	604,276	1.4631
2010	899,513	2.1780
2015	1,354,203	3.2789
2020	2,058,933	4.9852

The modal split for bus and rail was done using the modal choice survey result summarized in Table 2.4.3.

Table 2.4.3 Major reasons for selection of train/bus modes

Reason	Train Passenger	Bus Passenger
Safe including “Can sleep”	24	0
Cheap	11	0
Destination is near from station	14	5
Fast	0	22
Comfortable	6 (can smoke 4)	7

Controllable variables in Table 2.4.3 are fare and speed. Converted time of travel cost was formulated using the said 100 samples on difference of travel time of two transport modes (train and bus) and difference of travel cost (fare).

-0.0349 x TT + 0.02768 x TC + 3.031829 = 0…..(1)

Where, TT = difference of travel time (Train - Bus, minutes)

TC = difference of travel cost (Train - Bus, Syrian Pound)

From Equ. (1)

$TT = 0.7931 \times TC + 86.8719$ …. (2)

The conversion rate due to improvement of the railway is obtained from the conversion curve developed by US Highway Research Board, which is

$CR (\%) = 100/(1+t^6)$ …….. (3)

Where, t = (required time of new route / required time of old route).

Assume "required time of new route" is train travel time (TTT) + converted time of travel cost difference (TC) using Equ. (2), and "required time of old route" is bus travel time (BTT), then Equ. (3) becomes:

$CR (\%) = 100 / (1 + ((TTT + 0.7931TC + 86.8719) / BTT)^6)$ ….. (4)

(2) Freight

The pipeline transport amount was considered independently from the freight transport. The pipeline network transports total amount of crude oil and natural gas, and a part of the petroleum products. The remaining petroleum products transport demand within the large zones is transported by trucks. Subsequently only the transport demand between the large zones shall be subject to competition between trucks and rail.

In preparing the modal split model for the freight transport it was first necessary to analyze the present transport conditions and the circumstances, mostly administrative under which these conditions came about. There is the principle that the rail transport has priority over other transport modes. It first appeared in an official order decreed by the prime minister in 1987. This principle was enforced by a number of decrees.

Recently there is a move within the government to shift from the planned transport system to the competitive system whereby rail transport would compete with other transport modes for freight transport.

Consignors notify GESR at the start of the year the amount of freight they intend to transport by rail. GESR compares these amounts to the actual amounts they have transported up to the end of the year. These data can indicate which consignors willingly use rail transport (actual amount transported/planned amount = high) and those that prefer to use truck transport (actual amount transported/planned amount = low). The results, compiled in Table 2.4.4 show that with the exception of phosphates, consigners prefer to transport most commodities by trucks rather than rail.

Table 2.4.4 Freight transport achievement rate (unit: ton)

Commodity type	Planned transport amount	Actual transport amount	Achievement rate
Petroleum products	10,954,000	462,934	0.04
Construction materials/ cement	8,563,000	715,143	0.08
Phosphate ore	2,574,000	3,416,462	1.33
Metal (primary products)	3,817,000	204,912	0.05
Agricultural goods	16,713,000	835,216	0.05
Industrial goods	12,532,000	573,411	0.05

Source：GESR

In the case of freight if delay in delivery time is permissible then it is common practice to determine the modal split based on the optimum cost. The trade off between delay of delivery and transport cost becomes the actual issue. Based on these considerations, the railway freight share model is formulated as follows:

Railway freight modal share $= m_{jk} \times f(n_I) \times (100/(1 + (RTC/TTC)^6))$

where, m_I: Freight transport achievement rate of commodity I

n_I: Days of delay of commodity

RTC: Railway transport tariff (in SP)

TTC is the truck transport tariff (in SP)

The f (n) depends on the commodity i. General pattern of f (n) is as follows;

Table 2.4.5 General pattern of f (n)

Travel Time of Truck - Travel Time of Train	f (n)
Less than or equal 6 hrs	1
More than 6 hrs and less than (or equal) 24 hrs	0.5
More than 24 hrs and less than (or equal) 36 hrs	0.25
More than 36 hrs and less than (or equal) 48 hrs	0.1
More than 48 hrs	0

2.5 Demand forecast

2.5.1 Zonal indices (Years 2000, 2005, 2010, 2015 and 2020)

(1) Large Zone (Passenger)

The indicators of the passenger attraction and generation model are shown in Table 2.5.1 for population, followed by Table 2.5.2, which shows the indicators by urbanization degree. In terms of indicators by regional characteristics Lattakia and Tartous, with seaports are attached the Figure 1 as a dummy variable, while the remaining governorates are attached the Figure 0.

Table 2.5.1 Passenger generation/attraction model indicators 1 (population)

Population	2000	2005	2010	2015	2020
Damascus	3,584,266	4,266,311	5,294,311	6,879,901	9,157,240
Aleppo	3,566,549	4,272,706	5,313,723	6,891,485	9,118,363
Homs	1,415,916	1,659,883	2,020,006	2,563,544	3,319,059
Hama	1,273,089	1,488,834	1,807,459	2,288,253	2,955,463
Lattakia	823,571	928,616	1,086,941	1,326,749	1,652,181
Deir el-Zor	896,149	1,113,100	1,435,234	1,929,855	2,647,358
Idlib	1,076,114	1,281,220	1,583,522	2,040,976	2,683,721
Hassaka	1,202,499	1,419,972	1,740,645	2,225,120	2,901,903
Raqqa	662,230	792,650	984,893	1,276,174	1,687,006
As'sweida	295,269	331,955	387,415	471,505	585,439
Daraa	747,522	913,903	1,159,877	1,535,099	2,072,749
Tartous	640,510	716,228	831,403	1,006,434	1,242,924
Qunaitra	63,316	80,623	106,571	146,904	206,593
Total	16,247,000	19,266,000	23,752,000	30,582,000	40,230,000

Table 2.5.2 Passenger generation/attraction model indicators 1 (urbanization degree)

Urbanization	2000	2005	2010	2015	2020
Damascus	12.620	11.612	10.724	9.995	9.298
Aleppo	2.921	2.678	2.475	2.316	2.172
Homs	3.052	2.848	2.660	2.506	2.344
Hama	0.876	0.818	0.768	0.727	0.685
Lattakia	4.172	3.835	3.543	3.306	3.079
Deir el-Zor	0.523	0.481	0.445	0.416	0.388
Idlib	0.897	0.832	0.777	0.733	0.689
Hassaka	0.818	0.756	0.701	0.656	0.610
Raqqa	0.823	0.775	0.730	0.692	0.650
As'sweida	1.478	1.372	1.275	1.192	1.107
Daraa	1.720	1.574	1.446	1.343	1.242
Tartous	1.537	1.424	1.324	1.243	1.160
Qunaitra	1.373	1.309	1.246	1.194	1.130

(2) Small Zone (Passenger and Freight)

The indicators used to distribute the generation and attraction volumes of freight by large zones are shown in Table 2.5.3.

Table 2.5.3 Distribution of freight attraction and distribution volumes on small zones

	Commodity type	Generation volume	Attraction volume
0	Passengers	Urban area development	Urban area development
1	Crude oil	—	—
2	Petroleum products	Refinery location	Population distribution
3	Natural gas	—	—
4	Cement	Urban area development	Population distribution
5	Construction materials	Urban area development	Population distribution
6	Phosphate	Extraction facilities	Existing receiving shares
7	Iron	Production facilities	Existing receiving shares
8	Coal and cork	—	—
9	Other minerals	—	—
10	Wheat	Cultivated area distribution	Population distribution
11	Cereals	Cultivated area distribution	Population distribution
12.1	Vegetables	Cultivated area distribution	Population distribution
12.2	Fruits	Cultivated area distribution	Population distribution
13	Sugar beet	—	—
14	Rice	Present import origins	Population distribution
15	Cotton	Cultivated area distribution	Population distribution
16	Livestock	Cultivated area distribution	Population distribution
17	Animal products	Cultivated area distribution	Population distribution
18	Other agricultural products	Cultivated area distribution	Population distribution
19	Sugar	Production facilities	Population distribution
20	Food oil	Production facilities	Population distribution
21	Animal fodders	Cultivated area distribution	Cultivated area distribution
22	Beverages	Production facilities	Population distribution
23	Other food products	Urban area development	Population distribution
24	Chemical products	Production facilities	Urban area development
25	Metal products	Production facilities	Population distribution
26	Textiles and goods	Production facilities	Population distribution
27	Fertilizers	Production facilities	Cultivated area distribution
28	Paper products and pulp	Production facilities	Population distribution
30	Other manufactured goods	Urban area development	Population distribution
31	Mixed commodities	Present forwarding area and other city areas	Population distribution
32	Cork and wood	Present forwarding area	Urban area development

2.5.2 Future trip demand (Years 2000, 2005, 2010, 2015, and 2020)

(1) Passenger

The passenger indicators described in section 2.5.1 were applied to the model detailed in section 2.4 and the demand was forecast for the years 2000, 2005, 2010, 2015 and 2020. The demands for the years in between were estimated by interpolation.

(2) Freight

On the basis of the present OD tables for each of the 32 study commodity types and the estimation formulas shown in Table 2.5.4, provisional figures for future transport demands were prepared. In a different way the estimated future GDP by industry sector (Table 2.5.5 shows the estimation formulas for the GDP and Table 2.5.6 the estimates) were used as control totals and after adjustment the future traffic demand volumes were fixed.

Table 2.5.4 Estimation formula by commodity type

Item	Independent Variable	Coefficient of I.V.	Constant	R2
1-Crude oil	GDP/Cap	1105.97281	-14232252.64000	0.86
2-Petroleum products	GDP Manufacturing	21.56341	9780602.86800	0.99
3-Natural gas	Study Team Estimate		1.10000	Times
4-Cement	GDP Construction	140.66944	1030151.11700	0.72
5-Construction materials	Cement Production	6.86133	6975341.76400	0.48
6-Phosphate	Rate of Increase of Phosphate		1.01151	Times
7-Iron ore	Constant		1079.00000	
8-Coal and coke	Constant		130949.00000	
9-Other minerals	GDP Manufacturing	1.10386	166267.08190	0.45
10-Wheat	GDP Agriculture	37.96656	-2625627.59300	0.73
11-Cereals	GDP Agriculture	14.98662	-617625.57710	0.66
12-Vegetables	Rate of Increase of Vegetables		1.01714	Times
13-Fruit	GDP Agriculture	9.97260	504240.88990	0.73
14-Suger Beet	GDP/Cap	80.56825	-1994578.35600	0.58
15-Rice	Rate of Increase of Population		1.03225	Times
16-Cotton	Population	33.73627	-274417.02110	0.65
17-Livestock	Rate of Increase of Livestock		1.01561	Times
18-Animal Products	Rate of Increase of Animal Prod.		1.03837	Times
19-Agriculture Products	Rate of Increase of Agricultural products		1.03791	Times
20-Sugar	Sugar Beat		1.03861	Times
21-Food Oil	GDP Agriculture	1.01967	-35680.93071	0.66
22-Animal Fodders	GDP Agriculture	11.70600	-573317.95420	0.84
23-Beverages	GDP Total	0.35927	-120646.02700	0.78
24-Other Food Products	GDP Manufacturing	40.35405	-883867.19270	0.86
25-Chemical Products	GDP/Cap	4.95739	-94108.94823	0.66
26-Metal products	GDP Manufacturing	1.53094	-3844.22509	0.70
27-Textiles and clothes	GDP Manufacturing	2.64251	-58244.47873	0.87
28-Fertilizer	Rate of Increase of Fertilizer		1.00040	Times
29-Pulp for paper	GDP Manufacturing	0.95307	-52000.78785	0.85
30-Manufactured goods	GDP/Cap	4.72944	-123331.72110	0.89
31-Mixed commodities	GDP Manufacturing	0.29517	7356.07410	0.60
32-Cork and wood	GDP Manufacturing	1.45155	-75614.89127	0.76

Table 2.5.5 Coefficients for estimation of GDP by industrial sector

Item/Year	Constant	Population	GDP	GDP/cap	R2
Agriculture	-21,631.6	0	0.33572	0	0.95
Mining & Manufacturing	-172,426.0	18.21934	0	0	0.94
Building & Construction	-31,240.4	3.83558	0	0	0.96
Wholesale & Retail Trade	46,856.3	0	0.15372	0	0.70
Transport & Communication	-112,551.0	12.47000	0	0	0.95
Finance & Insurance	-22,082.5	0	0	1.19478	0.92
Social & Personal Service	-9,314.4	1.46963	0	0	0.89
Government Services	30,378.7	0	0	0.57889	0.67
Private Non Profit Services	-319.2	0.03718	0	0	0.97

Table 2.5.6 Forecast of future GDP by industrial sector

(Unit: million SP)

Item/Year	2000	2005	2010	2015	2020
Agriculture	247,931	369,259	561,964	865,155	1,350,684
Mining & Manufacturing	127,022	188,901	284,011	432,038	650,758
Building & Construction	31,941	45,119	65,310	96,634	142,873
Wholesale & Retail Trade	171,867	229,122	319,249	459,889	684,372
Transport & Communication	92,554	135,070	200,349	301,838	451,747
Finance & Insurance	36,483	49,080	63,646	78,711	96,072
Social & Personal Service	14,968	20,097	27,921	40,008	57,825
Government Services	59,897	67,230	75,654	84,263	94,238
Private Non Profit Services	293	420	615	918	1,366
Total	782,956	1,104,297	1,598,721	2,359,453	3,529,935

(3) Summation of the traffic demand

Under the master plan the number of passengers and amount of freight transported by rail in the year 2020 are expected to increase by 6.3 times and 6.8 times the present figures for each respectively. The shares of rail transport of the total land based transport in 2020 are predicted to be 5% for passengers and 9% for freight (see Table 2.5.7).

Table 2.5.7 Summation of Traffic Demand Forecast excluding Intra-zonal Volume

Indicators	1999	2005	2010	2015	2020
GESR					
Passenger/day	2,323	4,182	6,186	9,860	14,546
Passenger-km/day	512,329	1,511,601	2,522,666	3,934,874	5,664,719
Ton/day	14,918	22,494	35,291	62,409	103,118
Ton-km/day	4,320,548	6,991,714	11,904,130	21,300,641	35,944,313
Road					
Passenger/day	129,973	138,985	189,029	211,867	303,546
Passenger-km/day	34,111,692	38,318,171	46,257,908	58,489,459	76,211,042
Ton/day	215,612	259,379	554,240	587,486	1,066,510
Ton-km/day	51,509,893	73,191,522	107,202,860	162,601,950	245,610,890

Passenger and freight railway traffic volumes in year 2020 are shown in Fig. 2.5.1 and Fig. 2.5.2.

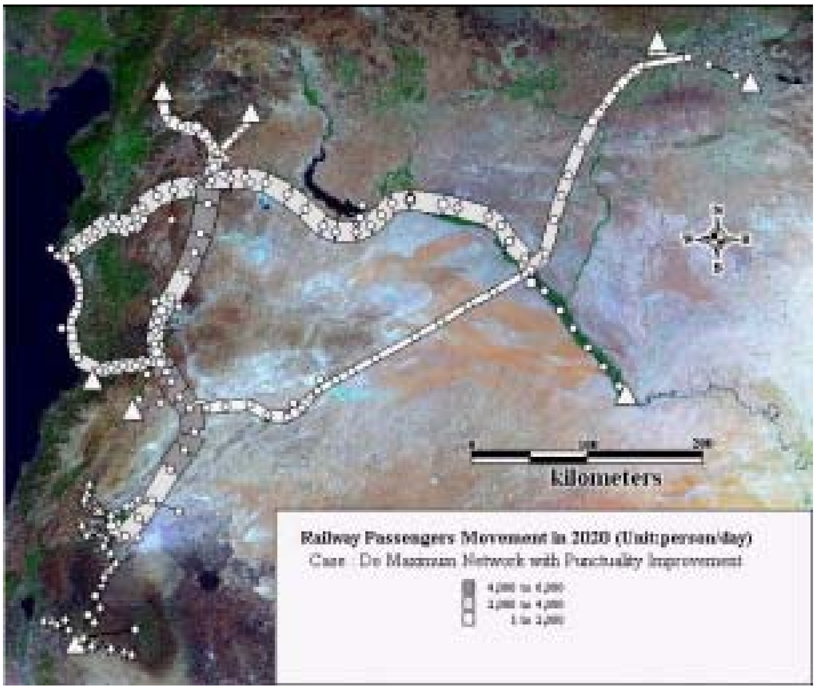


Fig. 2.5.1 Passenger railway traffic assignment in 2020

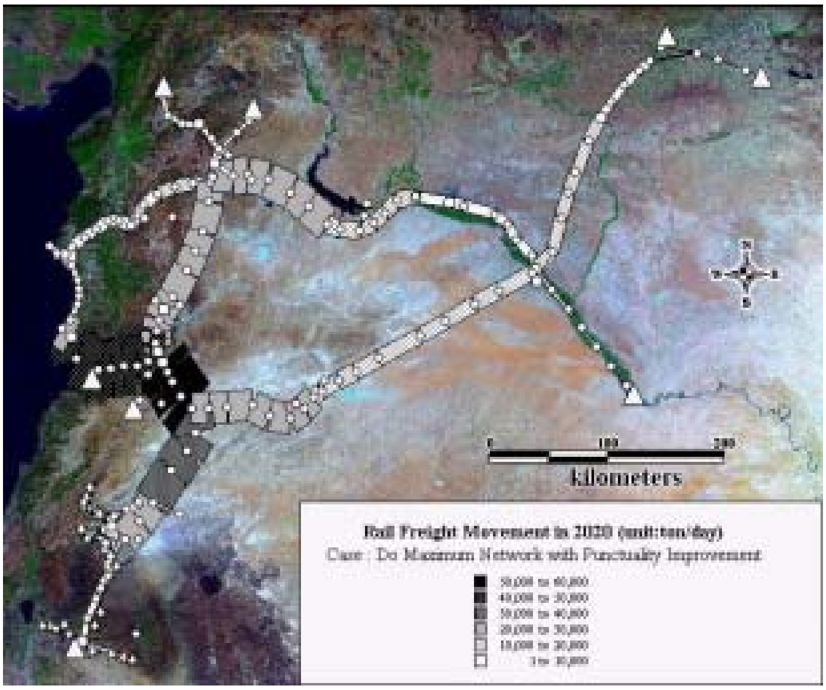


Fig. 2.5.2 Freight railway traffic assignment in 2020

Chapter 3

Transport Plan

Chapter 3 Transportation Plan

3.1 Concept on transportation plan

To secure safety is essential item for all transport industries. At the same time, improvement of efficiency is required, as well.

On setting up total plan of rehabilitation and modernization of GESR, the railways should be well improved so as to cope with users' requirement and to fully display the role of railway, bearing in mind the above mentioned policy of securing safety and improvement of efficiency.

3.2 Fundamental premises for setting up transportation plan

Transportation plan is set up as follows based on above mentioned concept.

3.2.1 Targeted lines and operating speed

Set up plan is for almost all existing lines in GESR and proposed new lines. The operating maximum speed by line is as in Table 3.1.

Table 3.1 Section of respective line and maximum speed

	Line Name	Section	Distance (km)	Maximum Speed		Remarks
				Passenger Train	Freight Train	
1	Jubrin- Midan Ekbas	Jubrin – Midan Ekbas	133.2	130	100	
2	Jubrin- Damasucus	Jubrin – Damascus	401.9	130	100	
3	Muslimiyya-Arrai	Muslimiyya-Arrai	85.9	130	100	
4	Jubrin –Lattakia- Homs 1	Jubrin –Lattakia	204.9	130	100	
		Lattakia- Tartous	85.9	130	100	
		Tartous- Homs 1	95.3	130	100	
5	Jubrin- Qamishli-Al Yaroubiye	Jubrin- Deir el-Zor (passenger)	323.0	130	100	
		Deir el Zor-New Qamishili	198.6	130	100	
		New Qamishli -Al Yaroubiye	79.5	130	100	
6	Mhine- Al Sharqia	Mhine- Al Sharqia	110.7	130	100	
7	New Line	Al-Sharqia-Deirl-Zor(passenger)	238.5	130	100	
		Deir el Zor-Al Bukamal	140.1	130	100	
		Damascus(Freight) - Darra	97.5	130	100	
Total			2,195.0			

However, the permissible speed of locomotive hauled passenger train is 100km/h.

3.2.2 Signaling system

Signaling system which is a fundamental condition of train operation, should be an automatic blocking system.

On single track section, install track circuit fully in the station and on the track between stations, install the detecting track on both ends of station to detect arriving and departing of train to secure blocking between stations.

The multi-color light signal currently used is to be applied for home and departure signal, and home signal is to be with distant signal for single track section.

Traffic side of train operation is to be on the right side traffic.

3.2.3 Driving power system

As for powering system, diesel engine is adopted, but electrification which requires big investment will not be adopted. Overnight sleeper train a part of daytime passenger coach train are to be hauled by diesel electric locomotive (DEL). Day time operating train is to be by diesel railcar (DC) train which makes possible small formation and frequent service.

Regarding day time train, DEL traction passenger coach train and Diesel car train are co-used by 2010, but after 2010, all day time passenger trains are to be by small formation of diesel railcar (DC) train to perform frequent service.

3.2.4 Kind of train and formation

(1) Kind of train

Kind of train is passenger train and freight train, and passenger train is consisted of express train and local train. Night sleeper express train is to be programmed on the trunk lines.

Freight train is planned only as a kind of through train without stopping between principal stations.

(2) Train formation

1) Passenger train

Referring to the result of forecasted transportation demand, the formation of sleeper train is 9～11 coaches and daytime passenger coach train is 2～4 coaches and that of DC train is 1～5 cars considering frequent service.

The formation of sleeper train is consisted of sleeping coach, 1st class seating coach, dining car and baggage car.

・ Night sleeping car train

Sleeper Train

1	2	3	4	5	6	7	8	9	10	11
Baggage Car	Sleeping car	Sleeping car	Sleeping car	Sleeping car	Sleeping car	Dining car	1st class seating car	1st class seating car	1st class seating car	1st class seating car

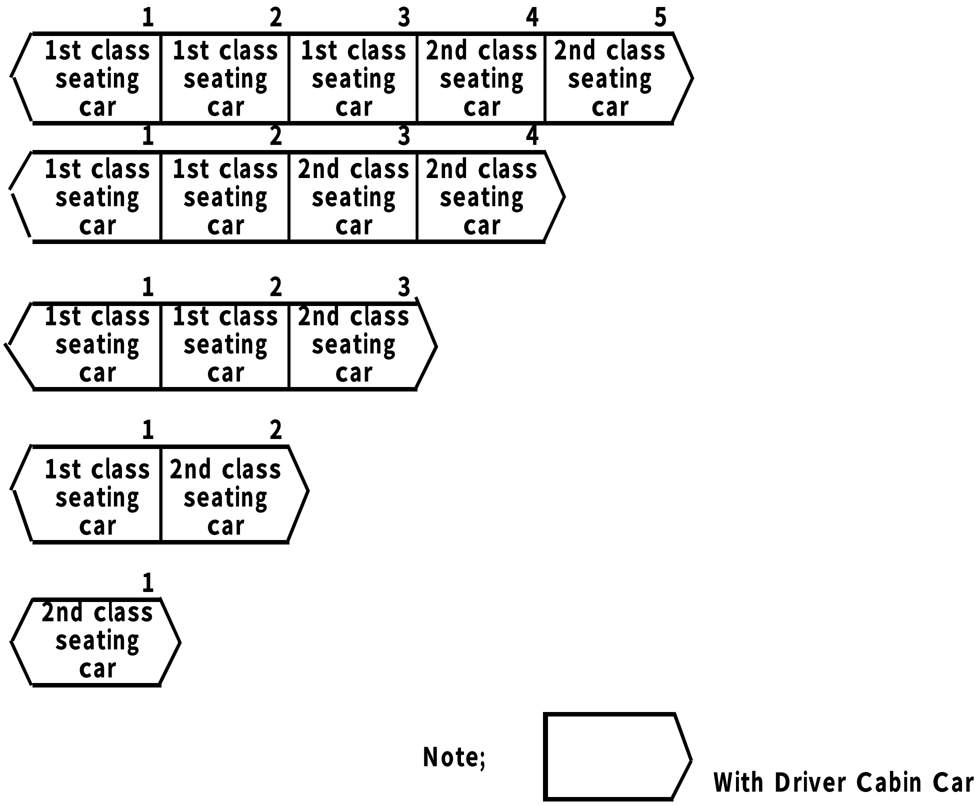
1	2	3	4	5	6	7	8	9
Baggage Car	Sleeping car	Sleeping car	Sleeping car	Sleeping car	Dining car	1st class seating car	1st class seating car	1st class seating car

・ Daytime passenger train

1	2	3	4
1st class seating car	1st class seating car	2nd class seating car	2nd class seating car

1	2
1st class seating car	2nd class seating car

- Diesel railcar train



2) Freight train

   The single headed operation is the principle of freight train and hauling capacity is to be 1400 ～ 2000 tons with 70% of hauling efficiency and 60% of loading factor, referring to the current actual performance.

   In addition to above, if the hauling capacity become half due to steep gradient, double headed operation is planned.

(3) Train operation

1) In case of passenger train, usually two men crew, driver and conductor, is planned on a train except sleeping train. In case of sleeping train, servicing staff is to be assigned other than two men crew.
2) On freight train, only driver is assigned but no conductor.

3.2.5 Rolling stock and its characteristics

The aged rolling stock are to be phased out. The ordinary passenger train excluding night sleeper train and international train is formed by only DC with possible maximum speed of

130km/h to increase operating efficiency.

In case of locomotives, weeding out smaller output locomotives, high output locomotives will be assumed on the condition that the track will be renovated to secure above mentioned hauling capacity.

3.2.6 Transportation demand

Result of transportation demand study is as follows. Cross sectional traffic volume is in the Appendix 3.

Year	1999	2005	2010	2015	2020
Passenger/day	2,323	4,182	6,186	9,860	14,546
Passneger-km/day	512,329	1,511,601	2,522,666	3,934,674	5,664,719
Ton/day	14,918	22,494	35,291	62,409	103,118
Ton-km/day	4,320,548	6,991,714	11,904,130	21,300,641	35,944,313

3.2.7 Riding factor and hauling factor

(1) Riding factor

The riding factor of passenger train is premised as 70%. Formation of ordinary train does not include dining car nor baggage car but consists of seating car.

Seating capacity of 1st class coach is 60 and 2^{nd} class is 80, while the capacity of sleeping car is 22.

(2) Hauling factor

Based on the actual result, hauling factor of freight car is to be 70% and 60% of hauling capacity is loading weight.

(3) Fluctuation of transportation

Based on the actual result, seasonal fluctuation of passenger train is to be 30% in section between Aleppo～Lattakia and 10% in other sections, and for freight train 10%.

(4) Turn round of freight wagon

Expecting the following items; shortage of time for loading and unloading, increase of train speed, establishment of freight wagon relay system, and increased availability of wagon by strengthened information system; and considering transport distance, turn round of wagon is to be 7 days and exclusive wagon for phosphate, 1.3 days.

3.3 Transportation plan

(1) Train operation plan

1) Calculation of train operation time

Besides above mentioned premises, and taking into account, line condition such as curvature, gradient, location of turnouts and performance of diesel car and diesel locomotive, the train running curve is drawn to decide theoretical train operation time, then margin is added to obtain practical train operation time.

・ Operating speed limit of turn out is assumed as 40km/h for branch track side and 100km/h for straight track side
The location of turnout is assumed to be at 500m from center of station in the Study, although actual location of turn out is unknown.

・ Speed restriction on curved track is as stipulated by GESR.

・ Speed restriction on down gradient is set based on stipulation of Japanese Railways (115km/h on 20‰ down gradient)

・ As for diesel railcar, Japanese railcar for limited express (model 181, 3960PS, 319tons, formed with 7 coaches) is applied. As for locomotive, performance of locomotive with 2800PS working in GESR was applied to calculate the hauling capacity on respective line.

・For proposed new line, train operation time is so planned as to obtain the schedule speed of about 100km/h for passenger train and about 80 km/h for freight train although line condition of track is not clear. Furthermore, considering feeder transport facilities at terminals, departure time of overnight sleeper train is to be before 23 o’clock and arriving time, after 5 o’clock.

Table 3.2 and Table 3-3 indicate planned passenger or freight train operation time on respective lines

Table 3.2 Operating time for Passenger train

Section		Schedule Time (h:m)	Distance (km)	Schedule Speed (km/h)	Stooping Time(m)	Stopping Station	Present schedule Time(h:m)
Aleppo～Damascus(Hijaz)	Sleeping	8:00	399.8	49.9			5:55
	Express	4:00	399.8	99.9	2	Homs, Hama	
	Local	6:35	399.8	60.7	53		
Aleppo～Qamishli	Sleeping	9:00	530.9	58.9			7:29
	Express	5:15	530.9	101.1	6	Rakka,Deir el Zor,Hassaka	
	Local	7:15	530.9	73.2	50		
Aleppo～Lattakia	Express	2:15	205.0	91.1	0	Non	2:41
	Local	3:20	205.0	61.5	25		
Damascus(Hijaji)～Lattakia	Sleeping	8:00	391.7	48.9			5:40
	Express	4:15	391.7	92.2	4	Homs Tartous	
	Local	6:20	391.7	61.8	50		
Aleppo～Midan Ekbas	Local	1:45	116.6	66.6	10		2:48
Musli,ia～Arrai	Local	0:45	45.2	60.2	4		
Damascus(Hijaji)～Darra	Express	1:00	96.9	96.9	4		
	Local	1:30	96.9	65	12		
Mhine～Sharqia～Deir el Zor	Express	3:50	360	93.9	6	Sharqia Tadomor Deir el Zor(w)	
Deir el Zor～Bukamal	Local	2:15	140	62.2	10		
Qamishili～Yaroubiye	Local	0:55	79.4	86.6	4		

Table 3.3 Operating time for freight train

Section	Schedule Time (h:m)	Distance (km)	Schedule Speed (km/h)	Stopping Station	Present schedule Time(h:m)
Ansari～Homs	2:50	188.3	66.5	Hama,Sinjar	3:29
Homs～Damascus	3:10	194.1	61.3	Noamia	3:27
Homs～Lattakia	3:10	184.7	61.6	Tartous	3:41
Mhine～Sharqia	1:40	110.7	66.4		1:54
Sharqia～Del el Zor(F)	3:10	254.8	80.5	Tadomor	
Jublin～Deri el Zor	4:00	316.5	79.1	Raqqa	5:15
Deir el Zor～Qamishili～Al yaroubiye	4:15	287.2	67.6	Hassake,Qamishili	5:34
Ansari～Lattakia	3:30	189.1	54.0	Muhanbel	4:31
Damascus～Darra	1:15	97.5	78.0		
Deir el Zor～Al Bukamal	1:45	140.1	80.0		

2) Planning of transportation

Transportation capacity is planned based on cross sectional transportation volume, OD table and pre-mentioned train operation plan.

(a) Passenger train operation plan

Passenger train is planned as in Table 3.4 and Fig. 3.1 with frequent operation as far as possible to obtain improved service.

Table 3.4 Passenger train operation plan by section

Year		2005				2010				2015				2020			
Section	Train Type	DC		PC	Total	DC		PC	Total	DC		PC	Total	DC		PC	Total
	Class	1st	2nd			1st	2nd			1st	2nd			1st	2nd		
Aleppo ～ Damascu	No. of car/Train	2	2	9		2	2	9・4		3	2	11		3	2	11	
	Aleppo-Hama	4		4	8	6		2	8	12		2	14	16		2	18
	Hama-Homs	4		4	8	8		2	10	14		2	16	16		2	18
	Homs-Mhine	6		6	12	8		4	12	18		4	22	22		4	26
	Mhine-Damascus	6		6	12	10		8	18	18		6	24	22		6	28
Aleppo～ Midan Ekbas・ Arri	No. of car/Train		1	2		1	1	2	3	1	1			1	2		
	Aleppo-Muslimia	2		4	6	4		2	6	6			6	6			6
	Muslimia-Midan Ekbas	2		4	6	4		2	6	6			6	6			6
	Muslimia-Arrai	2			2	2			2	2			2	2			2
Mhine～ Deir el Zor	No. of car/Train							9・4		3	2	11		3	2	11	
	Mhine-Tdmor	0			0			4	4	4		2	6	4		2	6
	Tadmor-Deir el Zor	0			0			4	4	4		2	6	4		2	6
Homs～ Lattaia	No. of car/Train	1	1	9・4		2	2	9・4		2	2	11		3	2	11	
	Homs-Tartous	4		4	8	4		4	8	8		2	10	10		2	12
	Tartous-Lattakia	4		4	8	4		4	8	8		2	10	8		2	10
Aleppo～ Lattakia	No. of car/Train	2	2	4		3	2	5		3	2			4	4		
	Aleppo-Jisr Elshogour	10		2	12	10		2	12	18			18	20			20
	Jisr Elshogour-Lattakia	10		2	12	10		2	12	18			18	20			20
Aleppo～ Deir el Zor	No. of car/Train	2	2	9・4		2	2	9・4		2	2	11		2	2	11	
	Aleppo-Raqqa	2		6	8	4		4	8	8		2	10	18		2	20
	Raqqa-Deir el Zor	2		6	8	4		4	8	8		2	10	16		2	18
Deir el Zor ～ Qamishili	No. of car/Train	1	1	9		2	2	9・4		2	2	11		2	2	11	
	Deir el Zor-Hassaka	2		8	10	4		6	10	6		4	10	10		4	14
	Hassaka-Qamishili	2		8	10	4		6	10	6		4	10	10		4	14
	No. of car/Train			2				2			1			1	1		
	Qamishili-Al-Yaroubiye			4	4			4	4	4			4	4			4
	No. of car/Train										1			1	1		
	Damascus ～Darra									6			6	6			6
	No. of car/Train			2				2			1				1		
	Deir el Zor～Al Bukamal			2	2			2	2	2			2	2			2

a) Aleppo～Damascus

The formation of sleeper train is tow couple of trains (go and return) consisting of 9 cars (in 2020, 11 cars) including 1st class seating car, dining car and baggage car.

One of them is from Qamishili via Apello and one of them is from Aleppo.

One train, Qamishili～Damascus via Aleppo, is planned to change the train route to Qamishili～Tadmor～Al-Shrqia～Mhine, making use of new line between Deir el Zor ～Tadmor on and after 2010.

Homs～Damascus is one couple of trains (go and return) with 9 cars starting from Lattakia.

○Yearly day time train (go and return) is as follows.

- 2005 Aleppo～Damascus, 2 couple of through train with 4 coaches formation
- 2010 Aleppo～Damascus, 3 couple of through train with 4 coaches formation

Hama～Homs, one couple of local train with 4 coaches

Homs～Damascus, one couple of train from Lattakia with 4 coaches formation

Mhine～Damascus, one couple of train from Qamishili with 4 coaches formation (hauling by DEL)

・2015 Aleppo～Damascus, 6 couple of through trains with 5 coaches formation

Hama～Homs, one couple of local train with 5 coaches

Homs～Damascus, tow couple of train from Lattakia with 5 coaches formation

Homs～Mhine, one couple of train for Qamishili with 5 coaches formation

Mhine～Damascus, one couple of train from Qamishili with 5 DC coaches formation

・2020 Aleppo～Damascus, 8 couple of through trains with 5 coaches formation

Homs～Damascus, tow couple of train from Lattakia with 5 coaches formation

Homs～Mhine, one couple of train for Qamishili with 5 coaches formation

Mhine～Damascus, one couple of train from Qmamishili with 5 coaches formation

b) Aleppo～Mida Ekbas, Arrai

・2005 Aleppo～Midan Ekbas, one couple of trains with one DC coach formation and tow couple of trains with tow PC coach formation

Muslima～Arrai, one couple of train with one DC coach formation

・2010 Aleppo～Midan Ekbas, one couple of trains with one DC coach formation and tow couple of trains with tow PC coach formation

Muslima～Arrai, one couple of train with one DC coach formation

・2015 Aleppo～Midan Ekbas, 3 couple of trains with 2 coaches formation

Muslima～Arrai, one couple of train with 2 coaches formation

・2020 Aleppo～Midan Ekbas, 3 couple of trains with 3 coaches formation

Muslima～Arrai, one couple of train with 3 coaches formation

c) Mhine～Al sharqia～Tadomr～Deir el Zor

- 2010 one couple of trains with 4 PC coaches formation for directly operate to Damascus
- 2015 two couple of trains with 5 DC coaches formation but one couple of train directly operate to Damascus and other train directly operate to Homs
- 2020 two couple of trains with 5 DC coaches formation but one couple of train directly operate to Damascus and other train directly operate to Homs

d) Homs～Lattakia

○ Sleeper train is to be operated until Damascus as it is, the formation is 9 coaches at beginning, 11 coaches on and after 2010

○ Daytime train is ;

- 2005 one couple of trains with 4 PC coaches formation and 2 couple of trains with 4 DC coaches formation, one couple of DC train directly operate to Damscus
- 2010 one couple of trains with 4 PC coaches formation and 2 couple of trains with 4 DC coaches formation, one couple of DC train directly operate to Damscus
- 2015 4 couple of trains with 4 coaches formation, tow couple of train directly operate to Damscus
- 2020 5 couple of trains with 5 coaches formation, 3 couple of train directly operate to Damscus

e) Aleppo～Lattakia

- 2005 5 couple of trains with 4 DC coaches formation and one couple of trains with 4 PC coaches formation
- 2010 5 couple of trains with 4 DC coaches formation and one couple of trains with 4 PC coaches formation

- 2015 9 couple of trains with 5 coaches formation
- 2020 10 couple of trains with 5 coaches formation

f) Aleppo～Deir el Zor

○ Sleeper train Aleppo～Qamishili two couple of train with 9 coaches formation(11 coaches formation on after 2015),one couple of them is to be operated to Damascus, on after 2010, one couple train is planned to change the train route detouring Qamishili ～Tadomor ～ Mhine～Damascus without dropping at Aleppo.

○ Day time train

- 2005 Aleppo～Deir el Zor one couple of trains with 4 PC coaches formation and one couple of trains with 4 DC coaches formation
- 2010 Aleppo～Deir el Zor one couple of trains with 4 PC coaches formation and two couple of trains with 4 DC coaches formation
- 2015 Aleppo～Deir el Zor 4 couple of through trains with 4 coaches formation
- 2020 Aleppo～Deir el Zor 8 couple of through trains with 4 coaches formation
  Aleppo～Raqqa one couple of train with 4 coaches

g) Deir el Zor ～Qamishili

○ Sleeper train from Aleppo and Damascus two one couple of train

○ Day time train

- 2005 2 couple of trains with 2 PC coaches formation and one couple of trains with 2 DC coaches formation
- 2010 one couple of trains with 2 PCcoaches formation, and 2 couple of trains with 4 DC coaches formation, one couple is through train for Aleppo and one couple is through train for Damascus via Tadomor.
- 2015 3 couple of trains with 4coaches formation, two couples are through train for Aleppo and one couple is through train for Damascus via Tadomor

・2020 5 couple of trains with 4coaches formation, two couples are through train for Aleppo and two couples are through train for Damascus and Homs via Tadomor

h) Qamishili～Al Yaroubiye

2 couple of local train with one coach formation

i) Mhine～Tadmor～Deir el Zor

◯ Sleeper train one couple of train with 9 coaches formation(11 coaches formation on after 2015) is to be operated to Damascus.

◯ Day time train

・2010 one couple of PC coach train with 4 coaches formation is through train for Damascus

・2015 2 couple of trains with 5 coaches formation, one couple is through train for Damascus and one couple is through train for Homs

・2020 2 couple of trains with 5 coaches formation, one couple is through train for Damascus and one couple is through train for Homs

j) Damascus～Darra 3 couple of local trains with one coach formation

k) Deir el Zor～Al Bukamal 1 couple of local train with one coach formation

Fig. 3.1 indicates line-wise operating system of passenger train

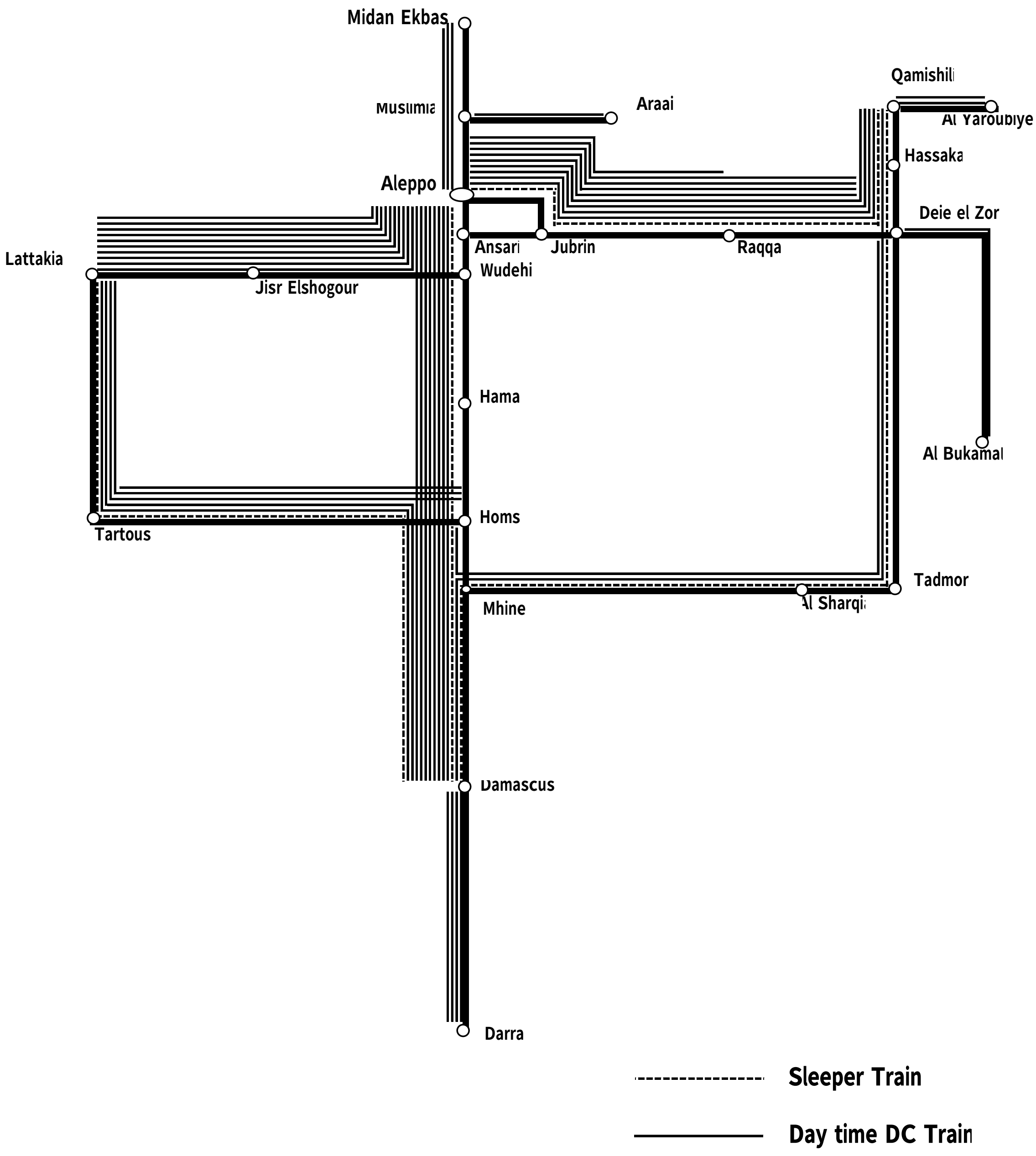


Fig. 3.1 Line wise operation plan of Passenger train

(b) Freight train operation plan

Set up the freight transportation plan to cope with transportation demand.

Yearly and sectional train operation plan is as indicated in Table 8.5.

Table 3-5 Yearly and sectional freight train operation plan

Year			Houling	2005			2010			2015			2020		
Section			Capacity	Phosphate	Other	Total	Phosphate	Other	Total	Phosphate	Other	Total	Phosphate	Other	Total
Jubrin-Damascus	Jubrin-Aleppo		1400		2	2		4	4		8	8		16	16
	Jubrin-Ansari		1400		12	12		12	12		32	32		58	58
	Aleppo-Ansari		1400		4	4		10	10		18	18		32	32
	Ansari-Wudehi		1400		18	18		24	24		50	50		90	90
	Wudehi-Abu Dhour		1400		14	14		16	16		36	36		64	64
	Abu Dhour-Sinjar		1400		12	12		16	16		32	32		56	56
	Sinjar-Hama		1400		12	12		14	14		30	30		52	52
	Hama-Homs		1400		14	14		18	18		36	36		62	62
	Homs-Mhine		1400	14	16	30	18	36	54	22	65	87	26	110	136
	Mhine-Khanat		1400		16	16		30	30		56	56		94	94
	Khanat-Dmeir		1400		18	18		30	30		58	58		98	98
	Dmeir-Damascus(f)		1400		6	6		8	8		10	10		12	12
Dmeir-Kaboun	Dmeir-Adra		1400		8	8		8	8		34	34		60	60
	Adra-Kaboun		1400		8	8		8	8		34	34		60	60
Aleppo-Midan Ekbes-Arral	Aleppo-Muslimia		1400		10	10		10	10		22	22		38	38
	Muslimia-Qatma		1400		2	2		4	4		10	10		14	14
	Qatma-Midan Ekbes	W	1250		2	2		6	6		10	10		18	18
	Muslimia-Arral	W	1250		2	2		4	4		8	8		14	14
Mhine-Tadmor-Deir el Zor	Mhine-Al Fajiwa		1400	14	2	16	18	12	30	22	20	42	26	36	62
	Al Fajiwa-Al Sharqia		1400	12	2	14	14	12	26	18	20	38	22	36	58
	Al Sharqia-Tadmor		1400		2	2		12	12		22	22		38	38
	Tadmor-Deir el Zor(f)		1400		0	0		12	12		20	20		36	36
Homs-Lattakia	Homs-Tartous	W	1400	14	26	40	18	46	64	22	68	90	24	102	126
	Tartous-Sharbit		1400		4	4		4	4		8	8		14	14
	Sharbit-Lattakia (p)		1400		4	4		4	4		8	8		14	14
Wudehi-Lattakia	Wudehi-Bishmaroun		2000		4	4		6	6		10	10		18	18
	Bishmaroun-Mhambel		2000		4	4		6	6		12	12		20	20
	Mhambel-Frika		1400		6	6		8	8		16	16		28	28
	Frika-Sheikhana		1400		6	6		8	8		16	16		26	26
	Sheikhana-Arkabir		1400		6	6		6	6		12	12		20	20
Jubrin-Deir el Zor-Yaroibiye	Jubrin -Tel Blat		2000		8	8		8	8		14	14		28	28
	Tel Blat-Sheikh Ahmad		2000		8	8		8	8		14	14		26	26
	Sheikh Ahmad - Qadissiya		2000		8	8		8	8		14	14		26	26
	Qadissiya-Al Grin		2000		8	8		8	8		14	14		26	26
	Al grin-Raqqa		2000		6	6		6	6		12	12		24	24
	Raqqa-Deir el Zor(f)		2000		6	6		4	4		8	8		16	16
	Deir el Zor(f)-Hassaka		2000		4	4		8	8		12	12		22	22
	Hassaka-New Qamishli		2000		2	2		4	4		6	6		10	10
	New Qamishli-Qahtaniyya		2000		2	2		4	4		6	6		2	2
	Qahtaniyya-Tel Alo		2000		2	2		2	2		2	2		2	2
	Tel Alo-Al Yaroubiye		2000		0	0		0	0		2	2		2	2
Damascus(f)-Daraa	Damascus-Alkesweh		1400		0	0		1	1		34	34		58	58
	Alkesweh-Sanamein		1400		0	0		0	0		16	16		28	28
	Sanamein-Daraa		1400		0	0		0	0		14	14		24	24
Deir el Zor-Bukamal	Deir el Zor-Tabiye		1400		6	6		6	6		8	8		10	10
	Tabiye-Mayadin		1400		2	2		4	4		6	6		10	10
	Mayadin-Al Bukamal		1400		2	2		2	2		4	4		6	6

Note: "W" is assisting run of a locomotive

The train exclusively transporting phosphate rock is planned to operate on the section of Tartous～Homs～Mhine～Al-Sharqia, and other freight train is planned as general freight transporting train.

After completion of new line between Deir el Zor～Al Sharqia in 2010, goods flow between Deir el Zor～Jubrin～Lattakia is to be shifted to Deir el Zor～Al Sharqia～Mhine～Homs～Tartous.

3) Train kilometer and car kilometer

Table 3.6 indicates daily train kilometer and car kilometer calculated by yearly transportation plan.

Table 3.6 Train kilometer and car kilometer

	Year	1999	2005	2010	2015	2020
Passenger/day		2,323	4,182	6,186	9,860	14,546
Passneger-km/day		512,329	1,511,601	2,522,666	3,934,674	5,664,719
Ton/day		14,918	22,494	35,291	62,409	103,118
Ton-km/day		4,320,548	6,991,714	11,904,130	21,300,641	35,944,313
Train km /Day	Passenger Train	2,931.5	14,223.2	16,340.4	22,790.8	28,866.6
	Freight Train	11,453.4	18,448.3	30,853.9	53,039.6	86,478.1
	Total	14,384.9	32,671.5	47,194.3	75,830.4	115,344.7
DC	Train Km/day	0.0	6,151.8	8,446.0	18,712.2	24,788.0
	Car km/day	0.0	21,318.2	34,563.6	80,034.2	120,717.6
PC	Train km/day	2,931.5	8,071.4	7,894.4	4,078.6	4,078.6
	Car km/day	18,141.9	50,989.2	50,036.4	41,781.0	41,781.0
F C	Car km/day	174,268.6	280,414.9	468,979.3	806,201.9	1,314,467.1
LOC Car km/day	For Passenger train		8,878.5	8,683.8	4,486.5	4,486.5
	For freight train		21,096.7	35,426.4	60,908.1	99,803.4
	Total	14,767.1	29,975.2	44,110.2	65,394.6	104,289.9

3.4 Necessary number of rolling stock

3.4.1 Concept on rolling stock plan

Currently, passenger transportation is carried out by the diesel locomotive hauled train with 2～8 coaches, and three round trips between Aleppo～Lattakia but for other direction, one round trip only. To compete against road traffic, frequent service with small scale train (short train formation) is the most recommendable.

For non-electrified section, diesel railcar is the best fit for frequent service with small scale train, all trains are to be consisted of 1～5 diesel railcar other than night sleeping car train and some of day time train before 2010.

As for freight train, apply the similarly rated locomotive with passenger train locomotive currently used with 2,800PS output.

3.4.2 Basic pattern of train formation

(1) Passenger train hauled by diesel locomotive

1) Sleeping car train

- Sleeping coach, the first class coach, dinning car and baggage van
- 9 coaches formation for 2005～2010
- 11 coaches after 2015

2) Daytime train

- 2～4 coaches formation by transportation demand

(2) DC

- In case of one coach operation, apply both end cab car (double ended car).
- As a general, formation is by the second class coach
- In case of 2 cars formation, apply 2 single end cab railcars coupled each other.
- Formation is to be the second class coach or the first and second class coaches.
- In case of more than three cars formation, 1～3 cars are to be coupled between two single cab cars.

(3) Freight train

1) Train transporting phosphate

- Train composed with 18 wagons exclusive for phosphate hauled by the locomotive type DEL 2800 (hauling 1,400tons, 270m train length).

2) Other train

The hauling load is to be within locomotive hauling capacity.

3.4.3 Necessary number of rolling stock

(1) Passenger coach

Train kilometer is calculated based on the passenger transportation plan, and passenger car kilometer is calculated based on the number of cars in the train formation.

Daily car kilometer is assumed as 400km and rate of reserve, 50% (30% after 2015) considering operation of occasional train.

Applying above assumptions, the necessary number of coach is calculated.

(2) DC

Car kilometer is calculated based on DC train operation plan.

Necessary number of DC is calculated based on the assumption of 500km for daily car kilometer and 20% for reserve rate.

(3) Wagon

Based on transportation amount on 2020, necessary number of wagon are calculated.

- Yearly transportation volume 40,000,000tons
- Daily transportation volume 103,000tons
- Average loading weight of wagon 50tons
- Wagons necessary for one day 103,000/50=2,060 wagons
- Turn round of wagon 7days
- Reserve rate 20%

2,060 wagons/day × 7days × 1.2 18,000 wagons

Necessary number of wagons is approximately 18,000 wagons.

(4) Locomotive

The locomotive kilometer is calculated based on the sleeping train operation plan and freight train operation plan. Then necessary number of locomotive is calculated with the assumption of 450km for daily locomotive kilometer and 20% of reserve rate.

(5) Table 3.7 indicates necessary number of rolling stock by year.

Table 3.7 Necessary number of rolling stock by year

Year	2005	2010	2015	2020
PC	190	190	140	140
DC	55	85	195	290
DL(Main Line)	80	115	185	285
DL(Shunting)	25	35	55	85
FC	5,000	7,500	10,800	18,000

Note; Number of locomotives for shunting was estimated at 30% of the one for main line.

Chapter 4

Maintenance Plan

Chapter 4 Maintenance Plan

4.1 Number of vehicle to be inspected in a year and standard process (2006, 2010, 2015 and 2020)

4.1.1 Yearly number of vehicle to be inspected

The necessary numbers of DLs and DCs mentioned in the report on the Master Plan Study on the Development of Syrian Railways are shown in the following table.

Table 4.1.1 Necessary number of DLs and DCs by year

			2005	2010	2015	2020
DL	For main line	LED 2800(N)	32	32	32	32
		3200	30	30	30	30
		3500	18	18	18	18
		New (1)		35	35	35
		New (2)			70	70
		New (3)				100
		Sub total	80	115	185	285
	For shunting	LED 1500	25	25		
		1200	6	6	6	
		2800(O)	5	5		
		New (1)			30	30
		New (2)				6
		Sub total	36	36	36	36
	Total		116	151	221	321
DC		Prototype	55	55	55	55
		New (1)		30	30	30
		New (2)			110	110
		New (3)				95
		Total	55	85	195	290

Note ; Refer to the Chapter 5, 5.10.1.

(1) Interval of inspection

Interval of inspection is stated in Master plan as follows. However, it is preferable to extend the interval of maintenance after familiarization of work and able to maintain the performance of vehicle.

1) Inspection cycle of locomotive

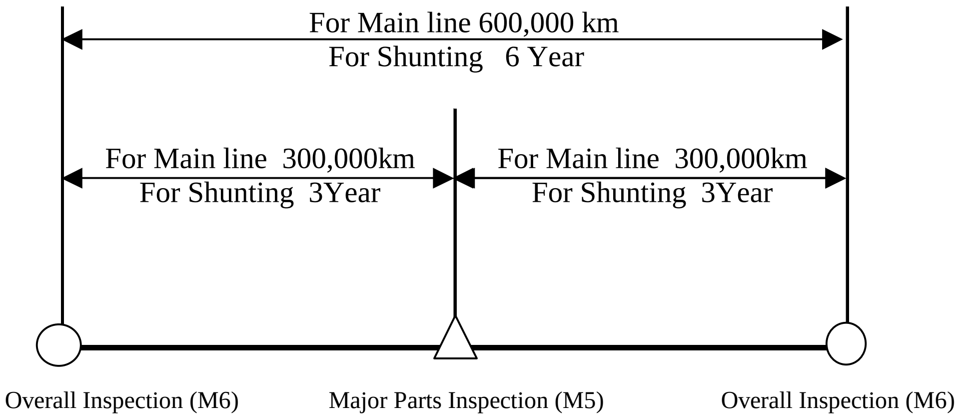
Major parts inspection (M5)	Main line locomotive	300,000km
	Shunting locomotive	3 years
Overall inspection (M6)	Main line locomotive	600,000km
	Shunting locomotive	6 years

2) Inspection cycle of diesel railcar

Major parts inspection (D5)	300,000km
Overall inspection (D6)	600,000km

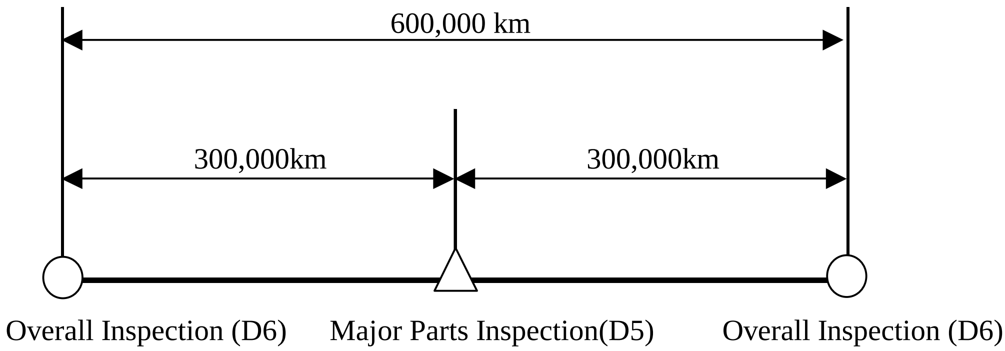
(2) Maintenance system

Fig. 4.1.1 and Fig. 4.1.2 indicate maintenance systems of diesel locomotive and diesel rail car after 2006, respectively, based on the inspection cycle.



Note ; In 2020, 300,000 km for M5 and 600,000 km for M6 will be extended to 450,000 km for M5 and 900,000km for M6.

Fig 4.1.1 Maintenance system of diesel locomotive



Note; In 2020, 300,000 km for D5 and 600,000 km for D6 will be extended to 450,000 km for D5 and 900,000km for D6.

Fig. 4.1.2 Maintenance system of diesel rail car

(3) Rate of shop in

Rate of shop in is to be studied in case of running kilometer base type and in case of time base type, and adopt bigger rate of shop in.

The shop in rate of overall inspection is calculated and indicated in Table 4.1.2.

Table 4.1.2.Rrate of overall inspection

Kind of Car \ Item		2006～2019	
		Time base	kilometer base
Locomotive	For main line	—	0.31
	For shunting	0.18	—
Diesel railcar		0.18	0.34

Note; In 2020, 0.31 will be decreased to 0.21 and 0.34 to 0.23.

1) Shop in rate of running kilometer base type

Toleration of running distance is to be 10%.

2) Shop in rate of time base type

Toleration of time is to be 5%.

(4) Annual number of vehicles to be inspected

1) Annual number of vehicles to be inspected are calculated as "assigned number of vehicles×rate of shop in". 10% of fluctuation rate, however, is to be considered due to the capacity of workshop facilities. Accordingly, annual number of vehicles to be inspected is calculated by following equation.

Annual number of vehicles to be inspected= assigned number of vehicles x rate of shop in×1.1

As seen in Fig. 4.1.1 "Maintenance system of diesel locomotive" and Fig. 4.1.2 "Maintenance system of diesel railcar", number of major parts inspection and one of over all inspection are identical.

The result of calculation is as indicated in Table 4.1.3 Number of rolling stock inspected in a year.

Table 4.1.3 Number of rolling stock inspected in a year

Year		Type of Car	Locomotive For main line	Locomotive For shunting	Locomotive Total	Diesel car
2006	Assigned number of car		80	36	116	55
	Number of car to be inspected	Overall inspection (M6)	28	8	36	21
		Major parts inspection (M5)	28	8	36	21
		Total	56	16	72	42
2010	Assigned number of car		115	36	151	85
	Number of car to be inspected	Overall inspection (M6)	40	8	48	32
		Major parts inspection (M5)	40	8	48	32
		Total	80	16	96	64
2015	Assigned number of car		185	36	221	195
	Number of car to be inspected	Overall inspection (M6)	64	8	72	72
		Major parts inspection (M5)	64	8	72	72
		Total	128	16	144	144
2020	Assigned number of car		285	36	321	290
	Number of car to be inspected	Overall inspection (M6)	98	8	106	109
		Major parts inspection (M5)	98	8	106	109
		Total	196	16	212	218

Note; Figures in 2020 are based on the same inspection cycle as those in 2006～2019, for the convenience of study.

2) Related to the examination on construction and installation of buildings, facilities and equipment, the number of DLs and DCs to be inspected as mentioned above was estimated with some allowance to avoid additional construction and installation work, if any, caused by the difference between planning and actual situation in future.

However, on maintenance systems, such as work volume, personnel allocation, management and operation cost, and so forth, their number was estimated in much likely way, under consideration of the following items.

- DLs for main line and DCs undergo their periodic inspection, M5, M6, D5, D6, with intervals of about 2.2 year and 2 years one after the other respectively.
- DLs for shunting, with 3 years for M5 and 6 years for M6.
- Estimated the constant number of LDE 2800 to shop in for inspection per annum.
- Actual maintenance work would be leveled to some extent, so adopted the average numbers of DLs and DCs to be inspected for 5 years period, respectively.

Number of vehicles to be inspected based on the maintenance system is as in the Table

4.1.4 (1)～Table 4.1.4 (5). However, figures in 2020～2024 are based on the same inspection cycle as those in 2006～2019, for the convenience of study.

Table 4.1.4(1) Number of DLs (for main line) for periodic inspection

(car/year)

			1	2	3	4	2005	6	7	8	9	2010	11	12	13	14	2015	16	17	18	19	2020	21	22	23	24
DL (For main line)	LDE2800 (N)	M5					8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
		M6					8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	LDE 3200	M5					30						30						30						30	
		M6								30						30						30				
	LDE 3500	M5							18						18						18					
		M6										18						18						18		
	New (1)	M5												35						35						35
		M6															35						35			
	New (2)	M5																	70						70	
		M6																				70				
	New (3)	M5																						100		
		M6																								
	Sub total	M5					38	8	26	8	8	8	38	43	26	8	8	8	108	43	26	8	8	108	108	43
		M6					8	8	8	38	8	26	8	8	8	38	43	26	8	8	8	108	43	26	8	8
	Total						46	16	34	46	16	34	46	51	34	46	51	34	116	51	34	116	51	134	116	51
	Average annual number for five years period	Sub total M5					18	18	18	18	18	25	25	25	25	25	39	39	39	39	39	55	55	55	55	55
		Sub total M6					14	14	14	14	14	18	18	18	18	18	19	19	19	19	19	39	39	39	39	39
		Total					32	32	32	32	32	43	43	43	43	43	58	58	58	58	58	94	94	94	94	94

Table 4.1.4 (2) Number of DLs (for shunting) for periodic inspection

(car/year)

				1	2	3	4	2005	6	7	8	9	2010	11	12	13	14	2015	16	17	18	19	2020	21	22	23	24
DL (Shunting)	LDE1500		M5					4	4	4	4	4	4	4	4	4	4										
			M6					4	4	4	4	4	4	4	4	4	4										
	LDE 1200		M5					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
			M6					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
	LDE 2800 (0)		M5					1	1	1	1	1	1	1	1	1	1										
			M6					1	1	1	1	1	1	1	1	1	1										
	New (1)		M5																		30						30
			M6																					30			
	New (2)		M5																							6	
			M6																								
	Sub total		M5					6	6	6	6	6	6	6	6	6	6	1	1	1	31	1	0	0	0	6	30
			M6					6	6	6	6	6	6	6	6	6	6	1	1	1	1	1	0	30	0	0	0
	Total							12	12	12	12	12	12	12	12	12	12	2	2	2	32	2	0	30	0	6	30
	Average annual number for five years period	Sub total	M5					6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7
			M6					6	6	6	6	6	6	6	6	6	6	1	1	1	1	1	6	6	6	6	6
		total						12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	13	13	13	13	13

Table 4.1.4 (3) Number of DLs (for main line and shunting) for periodic inspection

(car/year)

			1	2	3	4	2005	6	7	8	9	2010	11	12	13	14	2015	16	17	18	19	2020	21	22	23	24
For main line		M5					38	8	26	8	8	8	38	43	26	8	8	8	108	43	26	8	8	108	108	43
		M6					8	8	8	38	8	26	8	8	8	38	43	26	8	8	8	108	43	26	8	8
		Sub total					46	16	34	46	16	34	46	51	34	46	51	34	116	51	34	116	51	134	116	51
Shunting		M5					6	6	6	6	6	6	6	6	6	6	1	1	1	31	1	0	0	0	6	30
		M6					6	6	6	6	6	6	6	6	6	6	1	1	1	1	1	0	30	0	0	0
		Sub total					12	12	12	12	12	12	12	12	12	12	2	2	2	32	2	0	30	0	6	30
Total		M5					44	14	32	14	14	14	44	49	32	14	9	9	109	74	27	8	8	108	114	73
		M6					14	14	14	44	14	32	14	14	14	44	44	27	9	9	9	108	73	26	8	8
		Total					58	28	46	58	28	46	58	63	46	58	53	36	118	83	36	116	81	134	12	81
	Average annual number for five years period	M5					24	24	24	24	24	31	31	31	31	31	46	46	46	46	46	62	62	62	62	62
		M6					20	20	20	20	20	24	24	24	24	24	20	20	20	20	20	45	45	45	45	45
		Total					44	44	44	44	44	55	55	55	55	55	66	66	66	66	66	107	107	107	107	107

Table 4.1.4 (4) Number of DC for periodic inspection

(car/year)

		1	2	3	4	2005	6	7	8	9	2010	11	12	13	14	2015	16	17	18	19	2020	21	22	23	24
Prototype	D5							55				55				55				55				55	
	D6									55				55				55				55			
New (1)	D5												30				30				30				30
	D6														30				30				30		
New (2)	D5																	110				110			
	D6																			110				110	
New (3)	D5																						95		
	D6																								95
Sub total	D5							55				55	30			55	30	110		55	30	110	95	55	30
	D6									55				55	30			55	30	110		55	30	110	95
Total						0	0	55	0	55	0	55	30	55	30	55	30	165	30	165	30	165	125	165	125
Average annual number for five years period, Sub total	D5					11	11	11	11	11	17	17	17	17	17	50	50	50	50	50	64	64	64	64	64
	D6					11	11	11	11	11	17	17	17	17	17	39	39	39	39	39	58	58	58	58	58
	Total					22	22	22	22	22	34	34	34	34	34	89	89	89	89	89	122	122	122	122	122

Table 4.1.4 (5) Number of DLs and DCs for temporary inspection (car/year)

	2006～2009	2010～2014	2015～2019	2020～2024
D L	23	30	44	64
D C	11	17	39	38

Note; Estimated at 20% of necessary number of DLs and DCs respectively.

4.1.2 Standard process

The standard process is as in master plan when the maintenance facilities plan is build up. However, after the maintenance work comes to be well under way, the days of standard process is to be shortened.

Days of standard process are planned as follows. Fig. 4.1.3 and Fig. 4.1.4 indicate standard process of 2006～2019 and 2020, respectively.

Inspection Type / Number of Day	DEL			DC		
	M5		M6	D5		D6
1			: Shop-in inspection			: Shop-in inspection
2			: Draw out water & fuel oil			: Draw out water & fuel oil
3	E		E: Engine lowering	E		E: Engine lowering
4	<		<: Car-body lifting	<		<: Car-body lifting
5	▌		▌: Car-body washing & air-blow	▌		▌: Car-body washing & air-blow
6						
7						
8						
9						
10						
11			: Car-body maintenance			: Car-body maintenance
12						
13						
14				>		
15				E		
16				8		
17				8		
18				8		
19				║		
20				║		
21				◎	>	: car-body lowering
22				△	E	: Engine mounting on body
23	>					8: Car-body painting
24	E					8: Car-body painting
25	8					8: Car-body painting
26	8					8: Car-body painting
27	║					║ Adjustment
28	║					║ Adjustment
29	◎					◎Trial run in workshop & adjustment
30	△					△ Shop-out
31						
32		>	: car-body lowering			
33		E	: Engine mounting on body			
34			8: Car-body painting			
35			8: Car-body painting			
36			8: Car-body painting			
37		║	Adjustment			
38		║	Adjustment			
39			◎Trial run in workshop & adjustment			
40			△ Shop-out			

Fig. 4.1.3 Standard process of 2006～2019

Inspection Type / Number of Day	DEL M5	DEL M6	DC D5	DC D6
1		Shop-in inspection		Shop-in inspection
2		: Draw out water & fuel oil		Draw out water & fuel oil
3	E	E: Engine lowering	E	E: Engine lowering
4	<	<: Car-body lifting	<	<: Car-body lifting
5	▌	▌: Car-body washing & air-blow	▌	▌: Car-body washing & air-blow
6				
7				
8				
9				
10				
11		: Car-bodymaintenance		: Car-body naintenance
12				
13			>	
14			E	
15			8	
16			8	
17			8	
18			‖	
19			‖	> : car-body lowering
20			◎	E : Engine mounting on body
21			△	8 Car-body painting
22	>			8 Car-body painting
23	E			8 Car-body painting
24	8			8 Car-body painting
25	8			‖ Adjustment
26	‖			‖ Adjustment
27	‖			◎Trial run in workshop & adjustment
28	◎			△ Shop-out
29	△	> : car-body lowering		
30		E : Engine mounting on body		
31		8 Car-body painting		
32		8 Car-body painting		
33		8 Car-body painting		
34		‖ Adjustment		
35		‖ Adjustment		
36		◎Trial run in workshop & adjustment		
37		△ Shop-out		
38				
39				
40				

Fig. 4.1.4 Standard process of 2020

(1) Day of standard process of locomotive

	2006～2019	2020
Major parts inspection (M5)	30days	29days
Over all inspection (M6)	40days	37days

(2) Day of standard process of diesel railcar

	2006～2019	2020
Major parts inspection (D5)	22days	21days
Over all inspection (D6)	30days	28days

4.2 Annual quantities of major parts to be inspected

4.2.1 Major parts of DLs and DCs

Quantities of major parts to be inspected in the periodic and temporary inspections are shown in the following tables.

Table 4.2.1 Annual quantities of DL major parts to be inspected

(Piece, set/year)

	Installed pcs, set/car	2006~2009		2010~2014		2015~2019		2020~2024	
		Periodic	Temporary	Periodic	Temporary	Periodic	Temporary	Periodic	Temporary
Engine	1	44	2	55	3	66	4	107	6
Generator	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Fuel apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Lubrication apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Cooling apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Radiator	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Super charger	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Electric apparatus for engine	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Traction motor	6	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
T. Motor blower	1	264	12	330	18	396	24	642	36
Control apparatus	1	44	2	55	3	66	4	107	6
Electrical devices for controller	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Brake apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Car body	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Bogie truck	2	88	4	110	6	132	8	214	24
Wheel set	6	264	12	330	18	396	24	642	36

Note:

1. Numbers of major parts installed on DL are based on LDE2800.
2. Estimated the quantities for temporary inspection parts at 10% of the major parts installed on the temporarily inspected DLs.
3. Figures in 2020～2024 are based on the same inspection cycle as those in 2006～2019, for the convenience of study.

Table 4.2.2 Annual quantities of DC major parts to be inspected

(Piece, set/year)

	Installed pcs, set/car	2006~2009		2010~2014		2015~2019		2020~2024	
		Periodic	Temporary	Periodic	Temporary	Periodic	Temporary	Periodic	Temporary
Engine	1	18	1	27	1	71	3	98	5
Fuel apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Lubrication apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Cooling apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Intake and exhaust apparatus	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Hydraulic transmission	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Propeller shaft	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Reverse gear	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Power source	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Starter motor	1	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
Control apparatus	1	7	Ditto	10	2	27	4	37	6
Lighting apparatus	1	22	Ditto	34	2	89	4	122	6
Bogie truck	2	44	2	68	4	178	8	244	12
Wheel set	4	88	4	136	8	356	16	488	24
Brake apparatus	1	22	1	34	2	89	4	122	6
Car body	1	22	1	34	2	89	4	122	6

Note:

1. Numbers of major parts installed on DC are estimated making reference to Japanese cases.
2. Numbers of engines and starter motors to be inspected are estimated in consideration that 20% of total DCs are engineless.
3. Assumed that 30% DCs have one driver cab on an average.
4. Estimated the quantities for temporary inspection parts at 10% of the major parts installed on the temporarily inspected DCs, approximately.
5. Figures in 2020～2024 are based on the same inspection cycle as those in 2006～2019, for the convenience of study.

4.2.2 Casting volume of brake shoes

Brake shoes for DL have been casted in Aleppo PC workshop and those for PC and FC purchased from a tractor manufacturing co. in Aleppo, however, brake shoes installed on all of the rolling stock in GESR are to be casted in the DL・DC maintenance work shop after its completion.

(1) Necessary annual quantity of brake shoes;

Estimated through the calculation of the following formulas.

1) For DL, PC, FC

$$Q_{DL2005} = Q_{DL\,2000} \times \frac{N_{DL2005}}{N_{DL2000}} \times \frac{L_{DL2005}}{L_{DL2000}}$$

Q_{DL2005} : Necessary annual quantity of DL brake shoes in 2005. (t)
Q_{DL2000} : The same one as the above in 2000. (t)
N_{DL2005} : Necessary number of DLs in 2005.
N_{DL2000} : Available number of DLs in 2000.
L_{DL2005} : DL Car km/day/car in 2005.
L_{DL2000} : The same one as the above in 2000.

Q_{DL2010}, Q_{DL2015}, Q_{DL2020}, Q_{PC2005}, Q_{FC2005},・・・were calculated similarly.

2) For DC

Necessary quantity of DC brake shoes were estimated based on the corresponding results for PC as follows , because of no DC in GESR so far.

$$Q_{DC2005} = Q_{PC2000} \times \frac{N_{DC2005}}{N_{PC2000}} \times \frac{L_{DC2005}}{L_{PC2000}} \times \frac{W_{DC}}{W_{PC}}$$

Q_{DC2005} : Necessary annual quantity of DC brake shoes in 2005. (t)
Q_{PC2005} : The same one as the above for PC in 2005. (t)
N_{DC2005} : Necessary number of DCs in 2005.
N_{PC2000} : Available number of PCs in 2000.
L_{DC2005} : DC Car km/day/car in 2005.
L_{PC2000} : The same one as the above for PC in 2000.
W_{DC} : Tare weight of DC
W_{PC} : The same one as the above for PC.

Q_{DC2015} and Q_{DC2020} were calculated similarly.

(2) Necessary data for calculation of the above formulas are shown in the following tables and items.

Table 4.2.3 Quantity of brake shoe in 2000

	Actual quantity cast at Aleppo PC workshop in 2000 (t)	Purchase contract for 16 June 1999 to 31st Dec. 2000 (18months). (kg)	Necessary quantity in 2000. (t)
DL	250		250
PC		130,430	87
FC		968,353	646
Total	250 (t)	1098, 783 (kg)	983 (t)

Note: Number of passenger trains operated in 2000 was about the half of ordinary ones.

Table 4.2.4 Car km/day/car

(km/day/car)

	Car km/day (1999)	Available number of rolling stock (2000)	Car km/day/car (1999,2000)	Estimated Car km/day/car	
				(2005,2010)	(2015,2020)
DL (For main line)	14,767.1	42	352	375	375
DL (Shunting)		43		375	375
PC	18,141.9	436	42	267	308
FC	174,268.6	4,807	36	60	74
DC				417	417

Note:

1. Estimated Car km/day/car for DL and DC are from the Table 4-1.
2. Though, Car km/day/car of DLs (Shunting) is smaller than the one of DLs (For main line) actually, estimated the same numerical value as the one of DLs (Train Operation), since brake operation is applied frequently in shunting and the consumption of brake shoes is likely similar to DLs (For main line).
3. Car km/day/car of PC were estimated based on the spare rates in 3-4-3 (1).
4. Car km/day /car of FC were estimated as the average values of the one in 2005 and 2010, and in 2015 and 2020 respectively, derived from Table 8-6 and 9-2-1.
5. Assumed the Car km/day/car in 2000 is equal to the one (1999, 2000).

As for W_{DC}, assumed 45ton/car regardless of engine installation, and for W_{PC}, 43ton/car, the median of 42 and 44ton, which are the tare weights of BM, BHM, BH, BP types accounting for about 70 percent of all PCs in 2000.

In addition, took the tare weight into consideration, as one of factors of calculation formulas specially for DC, since no actual data on DC were available.

(3) Necessary quantity of brake shoes to be cast in total

Estimated 80 percent of calculated quantities as the necessary ones to be cast in respective year, taking the following items into consideration, which would result the decrease of brake shoes consumption.

- Installation of electric brake on DLs, use of composite brake shoes and exhaust

brake on DCs around hereafter
- Betterment of the quality of brake shoes

Moreover, the quantity of brake shoes to be cast would decrease hereafter, because of improvement of casting yield on brake shoes.

Table 4.2.5 Total quantity of brake shoes to be cast

(t/year)

	2006	2010	2015	2020
Total	1,500	2,100	3,400	5,400

4.3 Inspection work for main parts

4.3.1 Current situation of inspection work at Jubrin locomotive workshop

(1) According to the inspection cycle mentioned in Table 3-2-3-2 of the report on The Master Plan Study on the Development of Syrian Railways, M5 and M6 inspection of DLs are being held with no difference between inspection works of them.

(2) Work volume (Man-hour) of inspection and its cost

1) Work volume

Actual results of M5 or M6 inspection for LDE 2800 vary from 7,500 to 9,000 Man-hours par car.

One example of them is shown in the following table.

Table 4.3.1 Man-hours of LDE2800 (M5)

(Man-haur/car)

Parts	Man-hour		Parts	Man-hour	
Engine	3,700	45%	Mechanical parts	1,000	12%
Traction generator	2,000	24	Electrical parts	500	6
Brake parts	400	5	Painting	150	2
Resistor	200	2	Others	150	2
Battery	160	2			
Total				8,260	100%

Reference; 1 Man-hour: 43SP

2) Cost of supplies

The cost of supplies for LED 2800 411 (M5) (Inspection started on 26th Sep.1999 and finished on 29th May 2000) resulted in 892,000 SP.

(3) Staying periods at the workshop requested for inspection

Actual results of LDE2800 DLs for M4, M5 and M6 are shown in the following table.

Table 4.3.2 Actual staying period of LDE2800DLs. (1999)

Staying period	≦1 year	1 year~2 years	2 years~6 years	More than 6 years	Total
Number of DLs (Car)	7	3	7	2	19
Average period	5.7 months	16 Months	4 years and 7 months	10 years and 3 months	—

(4) Stop of operation for periodic inspection based on the prescribed inspection period and the inspection plan

DLs for main line will be separated from the operation fleet to undergo the periodic inspections, after their accumulated running kilometer will reach the prescribed limits.

Table 4.3.3 shows the actual number of LDE2800s, which stopped the operation for the periodic inspection M5 or M6, after its accumulated running kilometer reached the limit.

Table 4.3.3 Number of LDE 2800 for M5 or M6

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
M5		2			1		2	1	2		1		9
M6	1						1		4	1	1		8
Total	1	2	-	-	1	-	3	1	6	1	2	-	17

They have the annual plan of periodic inspections for DLs, regardless of the actual DLs, reached the prescribed limits for inspection in the former year of planning. There would be no direct correspondence between the plan and the result. It seems that some DLs would be picked up for the periodic inspection M5 or M6 in the annual inspection plan, from the DL fleet waiting for inspection, based on some points, for instance, cyclic use of spare parts and others. The actual planning of periodic inspection would be too complicated to understand.

(5) Maintenance work to be improved

Necessary items on the maintenance work to be improved are shown in Table 4.3.4.

Table 4.3.4.Item to improved

Items to be improved	Remark
1. Cleaning before inspection, removal of rust, smear	Truck, body and their parts
2. Non-destructive inspection (Ultrasonic flaw, liquid penetrant, magnaflux flaw test)	Engine parts, truck parts, wheel axle
3. Dielectric strength test (Insulation resistance, tan δ test etc.)	Electrical parts, electric circuit, others
4. Characteristic check	Spring, electric, pneumatic, hydraulic parts, others
5. Workers' skill	Maching, welding, heat treatment, metalling for engine parts, others
6. Preparation and good use of manuals of maintenance work	Reference to manufacturers' instructions, work experiences
7. Distinction between M5 and M6	For efficient maintenance

4.3.2 Inspection plan at the new workshop

(1) Improvement of rolling stock maintenance work

Equipment, apparatus and devices necessary to the improvement of DL maintenance work mentioned in Table 4.3.4 and of DC as well, are planned to be installed at the workshop, as shown in Appendix Table 5.2.1. Some of them are reprinted from it, as follows,

・ Cleaning and washing:	Car-body washing and air blow equipment, Bogie frame washing equip., Shot blast equip., Wheel set washing equip., Jet washing equip., Water jacket pickling device, Ultrasonic washer, Air blast equip., Air blow dust collecting equip. Seat cushion washing equip. Vacuum cleaner, Washing booth, etc.
・Non- destructive inspection:	Magnaflux flaw detector, Ultrasonic flaw detector
・Testing	Overall circuit testing apparatus, Withstand voltage testing apparatus, Brake testing equipment, Reversing gear testing equip., Wheel set rotating test machinery, Fuel injection pump testing machine, Speed governor testing machine, Balancing machine, Hydrostatic device testing machine, etc.

The rest is omitted.

(2) Maintenance work volume (Man-hour) and cost

1) Assumed, in planning , the bases of work volume, as shown in the following tables.

Table 4.3.5 DL Maintenance work volume

(Man-hour)

DL		M5	M6	Remark
For main line	LDE2800 (N)	6,300	9,000	1. M5 : M6 = 0.7:1
	3,200	5,000	7,000	2. LDE3200 / 3500 / New(1)~(3) : LDE2800 (N) =0.8:1
	3,500	5,000	7,000	
	News (1) ~ (3)	5,000	7,000	
Shunting	LDE1500	4,400	6,300	3. LDE1500 / 1200 :LDE2800 (N) =0.7:1
	1200	4,400	6,300	
	2800 (O)	6,300	9,000	4. Shunting New(1), (2) : LDE1500 / 1200 =0.8:1
	New (1) ~ (2)	3,500	5,000	

Note : Assumed the items of Remark, referring to the progress of rolling stock technology and Japanese cases.
The same values are estimates for LDE 2800(N) and 2800(O).

Table 4.3.6 DC Maintenance work volume

	D5	D6	Remark
DC	2,200	3,200	D5 : D6 = 0.7:1 LDE2800 (N):DC = 1:0.35

Note: Assumed the items of Remark referring to Japanese cases, and the work volumes of Prototype, New (1) and New (2) are the same value.

In addition, the work volume of DL and DC for temporary inspection were estimated as follows

DL; 180 Man-hour/car (2% of LDE2800/M6)

DC; 60 Man-hour/car (2% 0f D6)

2) Assumed, in planning, the bases of maintenance cost, as shown in the following table.

Table 4.3.7 Maintenance costs of DL and DC

(SP/car)

		DL (M5, M6)						DC (D5, D6)
		For main line			Shunting			
		LDE2800(N)	LDE3200 3500	New (1)~(3)	LDE2800(O)	LDE1500 1200	New (1), (2)	Prototype New(1), (2)
Personal cost	M5/D5	271,000	215,000	215,000	271,000	189,000	151,000	95,000
	M6/D6	387,000	301,000	301,000	387,000	271,000	215,000	138,000
Cost of supplies	M5/D5	630,000	500,000	500,000	630,000	440,000	350,000	220,000
	M6/D6	900,000	700,000	700,000	900,000	630,000	500,000	320,000
Other	M5/D5	450,000	358,000	358,000	450,000	315,000	250,000	157,000
	M6/D6	644,000	501,000	501,000	644,000	450,000	358,000	229,000
Total	M5/D5	1,351,000	1,073,000	1,073,000	1,351,000	944,000	751,000	472,000
	M6/D6	1,931,000	1,502,000	1,502,000	1,931,000	1,351,000	1,073,000	687,000
Temporary inspection		58,000	45,000	45,000	58,000	41,000	32,000	21,000

Note: Assumed the following items,

1. 1Man-hour: 43sp
2. Cost of supplies for M6 of LDE2800: 900,000sp. (equal to the actual cost of supplies for M5 of LDE2800 411)
3. The ratio of M5 to M6: 0.7 to 1
4. Others = $\frac{1}{2}$ (Personal cost + cost of supplies)
5. Temporary inspection cost: Estimated at 3% of M6 and D6 respectively.

4.4 Quality control for rolling stock maintenance

(1) Indication in the Volume Ⅰ of Master Plan Study on the Development of Syrian Railways on rolling stock quality.

Some problems on DL quality, such as train delay and cancel caused by insufficient maintenance of DLs, temporary inspection and repair, and insufficient quality of brake shoes are shown in the above-mentioned report.

Table 4.4.1 (1) Insufficient quality of DL and brake shoes

		Cause	Chapter indicated in Volume Ⅰ
Train	Delay	DL break down	3.1.2 (4)
	Cancel	Shortage of available DL	3.1.7 (2)
Train failure		Rolling stock breakdown	3.1.2 (5)
Small operation ratio of DLs		Too many DLs under repair	3.2.1 (1)
		Too many DLs temporarily inspected	3.2.2 (1)
Decrease of operation ratio of LDE 2800s		Shortage of spare parts	3.2.4 (1)
Long period required for maintenance of LDE2800s, 1500s, 1200s at the workshop			3.2.4 (2)
Frequent machining and replacement of wheels		Insufficient quality of brake shoes	3.2.4 (1)

Table 4.4.1 (2) Improvement of maintenance work

	Items to be improved	Chapter indicated in Volume Ⅰ
Countermeasure for rolling stock breakdown	Investigation of causes and execution of countermeasures, information to workers	9.4 (1)
Effective maintenance work	Information on rolling stock situation, from depots to workshop	9.4 (1)
	Execution of spare parts control	9.4 (3)
Improvement of brake shoes	Effective use of brake shoes and decrease of expense	9.4 (5)

The all indication above mentioned strongly point out the necessity of betterment of DL maintenance quality and brake shoes one.

(2) Quality of maintained rolling stock

Concrete items of maintained rolling stock quality will mainly be as shown in Table 4.4.2.

Table 4.4.2 Quality of maintained rolling stock

Quality	Concrete items
Function	1. Possible operation in accordance with transport purpose 2. Possible operation without failure
Economical efficiency	1. Preservation of designed performance and less operation cost 2. Proper maintenance and less maintenance and less maintenance cost
Service for customers	1. Good riding quality (Vibration, noise, accommodation, etc.) 2. Good freight service (Cargo deterioration and breakdown, others)
Impact to environment	Vibration, noise, exhaust gas and liquid, etc.

(3) Quality of rolling stock maintenance work

1) Similarly to the above, concrete items of maintenance work to realize the maintained rolling stock quality are shown in Table 4.4.3.

Table 4.4.3 Quality of rolling stock maintenance work

Quality	Concrete items
Recovery of maintained rolling stock quality	Realization of maintained rolling stock quality mentioned in Table 4-4-2
Economical efficiency	Decrease of maintenance cost (Including operation cost of workshop)
Conformity to train operation	1. Execution of rolling stock maintenance plan 2. Decrease of staying days at workshop for maintenance
Impact to environment	Consideration of vibration, noise, waste disposal, etc. for maintenance work

2) It is desirable that Total Quality Control (T.Q.C) is to be introduced to rolling stock maintenance work, which is widely prevailed in the world, to improve the work not only in the workshop but in the head office and rolling stock depots.

It would be effective to start the improvement of the following three items at top priority, among various ones to be improved.

- Decrease of rolling stock breakdown to get rid of train delay and cancel.
- Execution of the periodic inspection work at workshop in accordance with the yearly plan.
- Shortening of the staying period at workshop for periodic inspection.

(4) In solving the problem, its causes must be found to take the countermeasures for them. In case that causes and effects are intertwined complicatedly, a characteristic diagram or cause and effect diagram would be convenient to arrange and understand the relation between causes and effect. The characteristic diagram on train delay is shown in Fig. 4.4.1, as a sample.

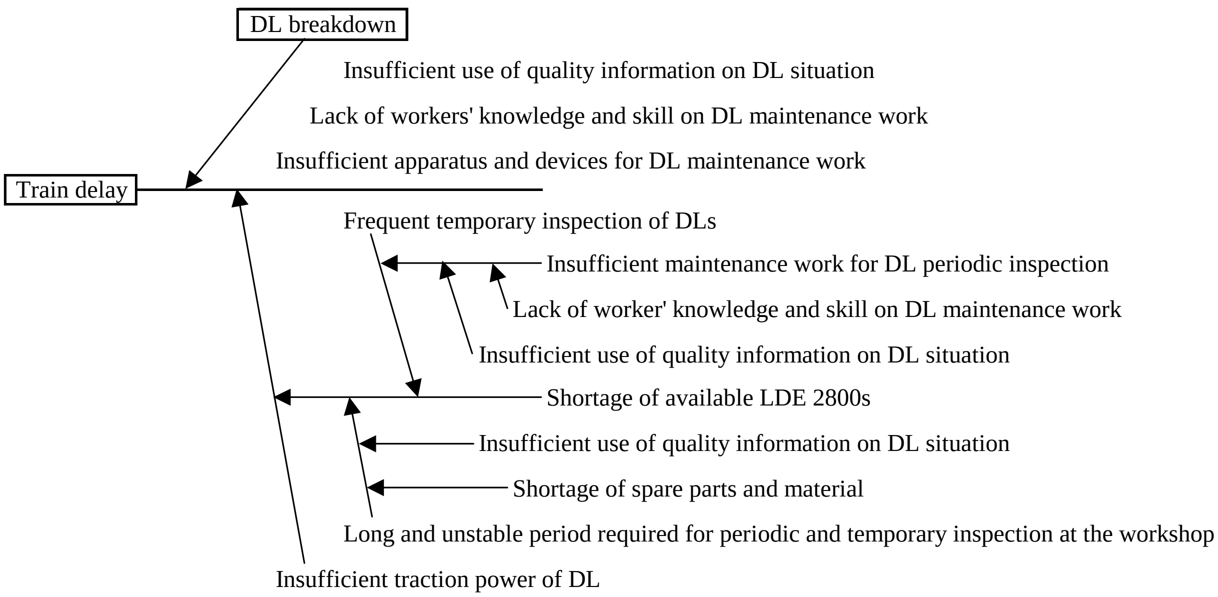


Fig. 4.4.1 Characteristic diagram on train delay (Maintenance work)

1) Good use of quality information on DL situation

Mutual communication on DL situation between workshop and depots in advance, would be necessary to prepare spare parts, materials and others, to be in time for their next shop-in.

Those would result in smooth execution of periodic inspection at workshop.

2) Enrichment of workers' knowledge and skill

It would be necessary to train workers to have sufficient knowledge and skill on DL structure, function, performance, examples of DL breakdown, accidents, etc. in the past, in hopes of maintenance work fulfillment.

3) Preparation of facilities and equipment for maintenance work

Necessary facilities and equipment for maintenance work revealed by the above 2) and others would be desirable to be arranged in accordance with the plan.

4) Procurement of spare parts and materials

Shortage of spare parts and materials would seem to be the top priority item to be solved for the long and unstable staying period at workshop.

What, when, how many or how much on spare parts and materials would have to be procured must be clear, based on the thorough examination and analysis of the past examples.

Necessary spare parts and materials must be prepared in accordance with purchase plan.

With the execution of the above concretized items, decrease of DL breakdown, increase of available LDE2800 DLs and elimination of DL traction power shortage would result in no train delay.

In addition, Pareto diagram would conveniently indicate the priority of problems to be solved in data analysis.

(5) There would be the cycle of actions called Management Cycle namely, the cycle of Plan, Do, See (or Check) and Action in turn. Execution and repeat of the cycle, would be inevitable to the betterment of items or solution of problems.

4.5 Spare parts control (Inventory control)

Roughly speaking, there would be two groups in spare parts, one is the major parts used in circulation, such as engine, traction motor, bogie truck, wheel set, etc. and the other is the spare parts consumed almost each time of inspection, such as piston ring, valve, spring, packing, seal, etc. Their control actions would be as follows.

(1) Kinds and quantities of stored spare parts

Fix the kinds and quantities of spare parts to be stored, mainly in consideration of the past experiences for maintenance work.

1) Spare parts used in circulation

They would somehow belong to the following categories.

- Major parts which would require the longer periods for their maintenance work than those like Part A in Fig 4.5.1 to be in time for their mounting on a rolling stock in its whole staying period at workshop.

- Major parts which are prepared in advance to be exchanged for another ones installed on al rolling stock to be temporarily maintained, and the separate maintenance work of the spare parts removed from the rolling stock would be advantageous.

- Major parts of which separate maintenance work would be effective in usage of facilities and equipment for rolling stock maintenance, and in leveling the uneven work at the workshop.

2) Spare parts consumed each time of inspection

Spare parts which are consumed almost each time of inspection at workshop, should be reserved, specially based on the actual situation of consumed kinds and quantities of spare parts in the past.

(2) Retainment of spare parts quality during the storage

Take necessary measures against deterioration of spare parts quality during their storage.

(3) Replenishment of spare parts (Retainment of reserve quantity)

Replenish periodically the consumed quantities of spare parts compared with the quantity to be reserved, and screen the reserved quantities, if necessary, corresponding to change of spare parts subject to reservation.

(4) Increase of spare parts turnover ratio

It would be necessary that reserved spare parts in circulation are effectively used and their turnover ratio will be increased. Here, the turnover ratio is defined as the ratio of yearly accumulated used quantity of a spare part to its reserved quantity, for respective spare parts. Regardless to say, the turnover ratio of spare parts is for the spare parts in circulation, and every spare part in circulation has its turnover ratio.

The simplified model shown in Fig. 4.5.1 would show the following items.

- In case of Fig. 4.5.1, namely, DLs to be periodically maintained would shop-in every three days in succession, and the whole maintenance work of DLs would require 20 days with installation of Part A on the 14^{th} day and finish of Part A maintenance work on the 18^{th} day, it would be necessary to prepare, in advance, two spare parts A in circulation, for DL No.1 and DL No.2.

- The spare part turnover ratio is one, since two Part As are used in circulation annually, for the reserved quantity two. Some examples in Japanese cases show the ratio of about 20 and 5.

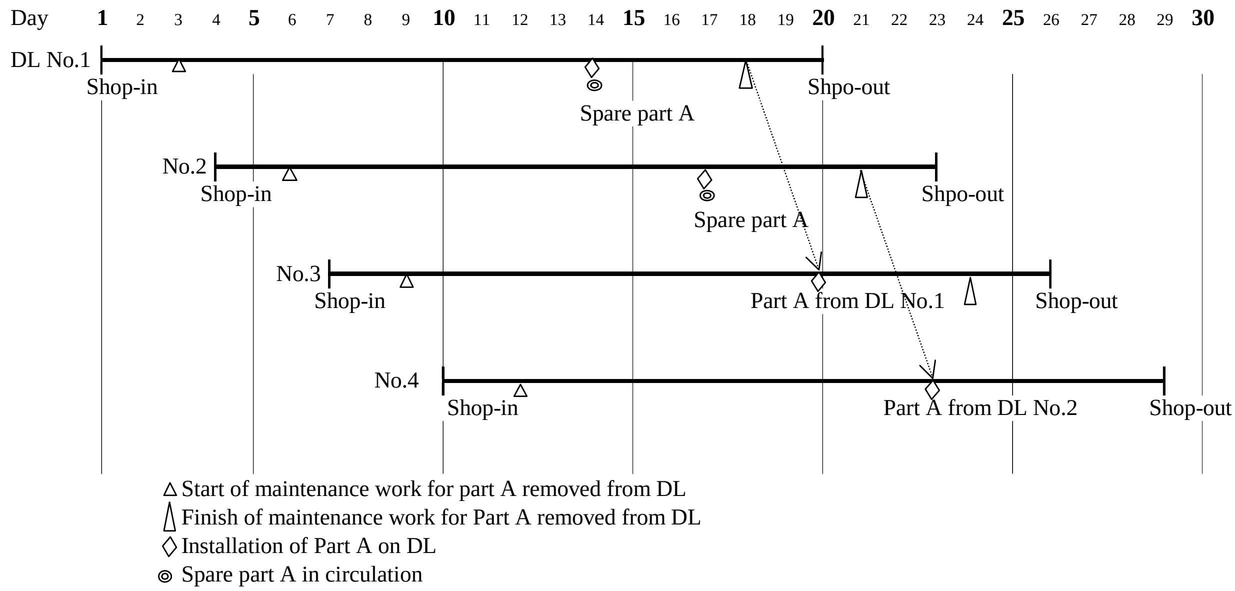


Fig. 4.5.1 Spare parts usage in circulation for periodic maintenance
(Annual number of DL periodic inspection: 98)

(5) Actually, the kinds and quantities of reserved spare parts in circulation should be empirically fixed in consideration of temporary inspection, failure, accident, unstable work volume of maintenance at workshop, etc.

In addition, for the increase of DLs and DCs to be maintained in 2020, some spare parts in circulation would be necessary to shorten the staying periods of periodic inspections at workshop, to cover the whole number of DLs and DCs to be maintained in 2020, with facilities and equipment for rolling stock maintenance work in 2015.

(6) Heaps of major parts for DLs stored here and there at Jubrin locomotive workshop to be fixed should be prepared and stored in accordance with the preparation plan, under consideration of gaps of routine maintenance work for shop-in DLs.

(7) In order to improve the spare parts control, the following measures have to be considered.

- Analysis of the past experience on the use of spare parts, on the stand points of “What”, ”How many or how much” and “When”.
- Setting up the way of control or the control program which is suitable to the actual situation.

Some amount of expenses for that purpose are included in the engineering fee of Table 5.9.1 and Table 6.1.1.