Paper No. 816

UPGRADATION OF PAKISTAN RAILWAYS MAIN LINE-1 (ML-1) – A CPEC PROJECT

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By

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ABSTRACT

The proposed rehabilitation and upgrading of Ml-1 under CPEC, would provide a unique opportunity to Pakistan to integrate with regional developments and become a hub for trade and manufacturing. Connectivity by rail is an important and vital aspect of the corridor. It was therefore considered necessary to improve/upgrade the existing railway network in Pakistan, particularly its main line-1 (ML-1) extending from Karachi to Peshawar via Lahore.

The paper presents the different stages of the development of the project of Upgradation of Pakistan Railways Main Line-1(ML-1) under CPEC including its feasibility study, preliminary design, preparation of bidding documents for EPC Contract, and sanction of PC-1 by the Government of Pakistan for its implementation.

The paper also includes a review of some of the important components of the feasibility study including current &upgraded line capacity of ML-1 & its utilisation level, upgrading of current signalling system, upgrading of existing obsolete telecommunication system, upgradation/rehabilitation of existing track infrastructure under traffic, re-prioritization of different projects included in the PC-1, to accord first priority to the construction of Karachi-Kotri new double line and the electrification of the Karachi-Lahore section as part of its upgradation to optimize the benefits expected to accrue from the proposed upgradation of ML-1 under CPEC.

In order to accommodate the above referred high priority projects the upgradation of those sections wherein the upgraded line capacity is forecasted to remain under- utilised for quite some time, their upgradation can be deferred.

1. Introduction

1.1 Project Background

Pakistan Railways network is an important part of the transport sector of Pakistan for the movement of people and goods. However, it requires structural changes to meet the challenges of the growing economy. Currently it picks up less than 4% of the traffic of Pakistan. Government of Pakistan plans to increase to at least 20%.

China Pakistan Economic Corridor (CPEC) offered a unique opportunity to Pakistan to integrate with regional developments and become a hub for trade and manufacturing. Connectivity by rail is an important and vital aspect of the Corridor. It was therefore considered necessary to improve the existing railway network in Pakistan, particularly its main line-1 (ML-1), extending from Karachi to Peshawar via Lahore.

The proposed rehabilitation and upgrading of Ml-1 under CPEC, would provide relief to the businesses of high cost of domestic transportation of goods to and from Karachi. At present bulk of such traffic is transported by trucking fleet causing immensecongestion,

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damaging carbon footprint, fatal accidents and ever increasing maintenance cost of deteriorating highways under heavy axle loads.

1.2 Existing Network of Pakistan Railways

Pakistan Railways has a network extending from the ports of Karachi in the south to LandiKotal near the Afghanistan border in the Northwest. It extends to Taftan in the West near the Iran border and connects the Indian border in the East at Wagha near Lahore and at Khokhrapar in the Southeast.

The network, comprising of 7,791 route kilometres and 11,881 track kilometres, includes three main lines namely, Main Line -1 (ML -1), Main Line -2 (ML -2) and Main Line -3 (ML -3) and a number of other railway lines of smaller lengths.

A plan of the Pakistan Railways Network showing ML-1, ML-2, ML-3 and other railway lines included in the Network is placed as Figure-1on next page.

1.3 The Brief Description of Ml-1

ML-1extends from Keamari (Karachi) in the south to Peshawar in the northwest, covering 1,726 kilometres and passing through Hyderabad, Rohri (Sukkur), Multan, Lahore and Rawalpindi stations.

ML-1, also includes 91 km chord line between Lodhran and Khanewal and the 55 km section between Taxila and Havelian.

Thus ML -1 extends over a total of 1,872 kilometres. The entire railway track on ML -1 is broad gauge (1,676 mm or 5 feet 6 inches)

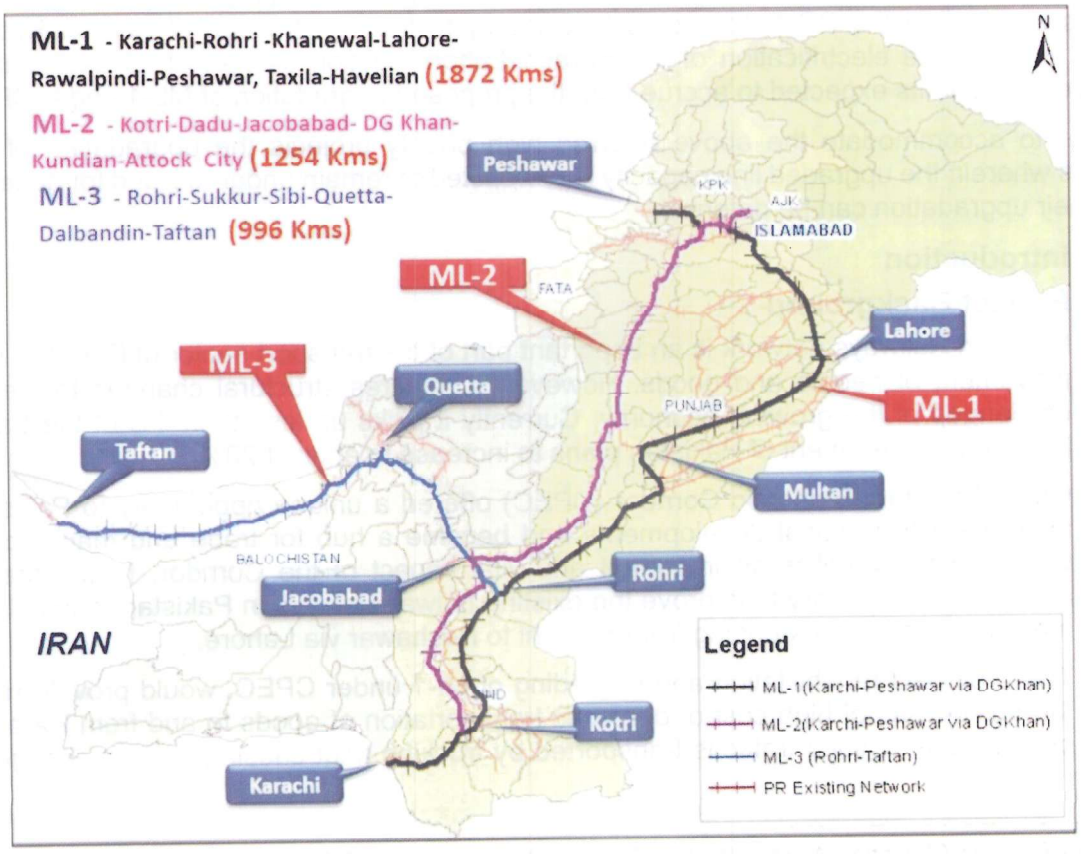


Figure-1: Pakistan Railways Network

1.4 Sections/Segments of ML -1

For the sake of the feasibility study and the execution of the project, the infrastructure of ML -1 has been divided into the sections/segments shown in Table 1 below:

Table-1: Sections/Segments of ML-1

S.N.	Section/segment	Length (Km)	Existing Track Parameters
1	Keamari - Hyderabad	182	Double track fit for speed of 110 km/h and axle load of 23.3 tons
2	Hyderabad - Multan	748	Double track fit for speed of 110 km/h and axle load of 23.3 tons
3	Multan - Lahore	334	Double track fit for speed of 110 km/h and axle load of 23.3 tons
4	Lahore - Lalamusa	132	Single track fit for speed of 105 km/h and axle load of 22.86 tons
5	Lalamusa - Peshawar	330	Single track fit for speed of 105/80/65 km/h and axle load of 22.86 tons
6	Lodhran – Khanewal (chord line)	91	Single track fit for speed of 110 km/h and axle load of 23.3 tons
7	Taxila - Havelian	55	Single track fit for speed of 30 km/h and axle load of 17.24 tons
	Total	**1872**	

2. Feasibility Study of THE Project

2.1 Sanction of PC-II for the Feasibility Study of the Project

1st meeting of Joint Working Group of National Railway Administration (NRA), China and Ministry of Railways, (MOR) Pakistan on "Transport Infrastructure" was held from 9th to 11th January, 2014 in Pakistan. In the meeting, the two sides reached consensus to conduct comprehensive feasibility study of Prioritized Projects/Early Harvest Project (EHP) i.e. ML-1 of Pakistan Railways.

In the second meeting of the Joint Working Group held on 19th February, 2014 in Beijing, up-gradation of ML-1 and construction of Havelian Dry Port was included as Prioritized Project.

PC-II for carrying out the Feasibility Study of "Up-gradation / Rehabilitation of Main line (ML-1) from Karachi to Peshawar & Establishment of new Dry Port at Havelian was sanctioned by CDWP on 25th June, 2014.

2.2 Signing of First Frame Work Agreement for Feasibility Study

The First Frame Work Agreement (FWA) between National Railway Administration (NRA), China and Ministry of Railways, (MOR) Pakistan was signed on 20th April, 2015 for

carrying out the Joint Feasibility Studyof Up-grading Pakistan Railways Main Line-1 (ML-1).

2.3 Award of Contract for the Feasibility Study

Under the above referred FWA, a Commercial Contract was signed on April 23, 2015 between Pakistan Railways and a Joint Venture comprising CREEC, China (Lead Partner) and NESPAK and PRACS (Partners), referred to hereafter as Consultants, for the Feasibility Study of Upgrading Pakistan Railways' existing Main Line (ML -1) and establishment of Havelian Dry Port.

2.4 Scope of Consultancy Services for the Feasibility Study

The scope of the consultancy services to be provided under the consultancy contract referred to in para1.6 above, was as under:

a) The study would ascertain the existing condition of the infrastructure of ML -1, and submit recommendations for up gradation of the track so as to facilitate operations of passenger trains at 160 km/h and freight trains at 120 km/h.

b) As far as possible, the up graded track would primarily follow the existing alignment, except where sharp curves are to be eased out or eliminated to allow higher speed. Wherever possible, but without compromising on safety of train operations, the up gradation process should make use of the existing structures and materials.

c) The study would also examine the prospects of construction of a new railway line between Keamari and Kotri/Hyderabad. This 163km long would facilitate the heavy movement of trains from the port city of Karachi to up country destinations in the future.

d) Study would also examine the physical and academic up gradation of Pakistan Railways Academy at Walton so as to ensure capacity building of the human resources of Pakistan Railways.

e) The study would also examine the possibility of integrated commercial development of 8 railway stations along ML -1, namely, Karachi, Hyderabad, Rohri (Sukkur), Multan, Lahore, Rawalpindi, Peshawar and Quetta for commercially exploiting the land near the stations. The passenger facilitation for these stations shall continue to be provided during up gradation of ML -1.

f) Electrification of the entire ML -1 would be examined and recommendations submitted for its implementation.

2.5 Time Frame and List of Agreed Projects of ML-1 for the Feasibility Study

As mutually agreed between the governments of the People's Republic of China and the Islamic Republic of Pakistan, and as approved by the JCC meeting on 12th November, 2015 at Karachi, the following projects shall be taken up during the agreed timeframes.

2.5.1 Short Term (2015 - 2020) - Phase I (Up to Dec.2017)

i. Multan - Lahore Section (334km):Up gradation and speeding up to 160 km/h, including up gradation of passenger facilities at Lahore and Multan Stations

ii. Hyderabad - Multan Section (748 km):Overhaul of track and civil works, including up gradation of passenger facilities at Rohri (Sukkur) Station

iii. Keamari- Hyderabad Section (182 km):Up gradation and speeding up to 160 km/h, including up gradation of passenger facilities of Karachi Cantonment and Hyderabad Stations

iv. Establishment of a Dry Port near Havelian

v. Academic and physical up gradation of Walton Railway Academy, Lahore.

2.5.2 Short Term (2015 - 2020) – Phase II (Up to 2020)

i. Hyderabad- Multan Section (748 km):Up gradation and speeding up to160km/h

ii. Havelian Branch Line (55 km):Up gradation of track between Taxila and Havelian for speeding up to 120 km/h

iii. Lahore - Lalamusa Section (132 km):Track doubling and speeding up to 160km/h

iv. Lalamusa - Peshawar Section: (330 km):Track doubling and speeding up to 120km/h, including passenger facilitation of Rawalpindi and Peshawar stations

v. Karachi-Kotri/Hyderabad new line (163 km):Construction of new line

2.5.3 Medium Term (2020 - 2025)

i. Further up-gradation of Pakistan Walton Academy

ii. Lodhran-Khanewal Section via Chord (91 km):Upgradation and speeding up to 160 km/hr

iii. Complete electrification of ML-1

iv. Comprehensive commercial development of eight railway stations along ML -1, namely, Karachi, Hyderabad, Rohri (Sukkur), Multan, Lahore, Rawalpindi, Peshawar and Quetta

2.6 Submission of the Feasibility Study Report

The Consultants completed the first draft of Feasibility Study Report of ML-1 and submitted it to Pakistan Railways on 25th August, 2015. The Study was jointly reviewed by the representatives of the Consultants and Pakistan Railways from 27th August, 2015 to 25th September in Pakistan and the review comments were conveyed to the Consultants on 8th October, 2015.

The Consultants revised the Feasibility Study Report according to the above referred review comments and submitted the final draft of the Feasibility Study Report including its Executive Summary to Project Implementation Unit (PIU) under Ministry of Railways on January 16, 2016.

2.7 Updating of the Feasibility Study & Preparation of Business Plan

The Consultants and the Project Implementation Unit ML-1 (PIU/ML-1) decided in year 2018-19 to update the above referred Final Feasibility Study Report which was based on the traffic and financial projections made with base year 2010-11, because due to lapse of more than three years and consequent changes in the economic landscape and

government policies, there was a need to review the assumptions and consequent financial projections for the project.

Therefore, a thorough review of the Final Feasibility Study Report was conducted by the Consultants during April 2019 which incorporated the impact of the changes in the government policies and time lines. The traffic projections were updated with base year 2018-19 and based on these new projections, revised Financial and Economic Analysis (Business Plan) was prepared by the Consultants and submitted to PIU/ML-1 during October 2019.

3. PRELIMINARY DESIGN OF THE PROJECT, INCLUDING ITS REVIEW BY THIRD PARTY

3.1 Signing of Second Frame Work Agreement

The Second Frame Work Agreement (FWA) for the implementation of ML-1 Project was signed on 15th May, 2017 in Beijing. The salient features of this FWA were as under

- ML-1, a strategic project with loan on favourable terms
- Preliminary Design by same Consortium
- Competitive bidding among Chinese firms
- Construction Supervision by International Consultant

3.2 Award of Contract for the Preliminary Design of ML-1 Project

The Contract for the Preliminary Design of ML-1 project was signed in April, 2015, between Pakistan Railways and the JV comprising CREEC, China (Lead Partner) and NESPAK and PRACS (Partners), referred to hereafter as Design Consultants, in accordance with the provision of Second Frame Work Agreement (FWA), referred to in paragraph 2.7(ii) above.

3.2.1 Scope of Consultancy Services for the Preliminary Design

The Design Consultants shall prepare the preliminary design/drawings for all the projects included in the scope of upgradation of Ml-1 under CPEC.

After the completion of the design/drawings bidding documents shall also be prepared for the appointment of EPC Contractor(s) for the execution of aforesaid works.

3.3 Award of Contract for the Review of Preliminary Design

Another Contract for the Review of the above referred Preliminary Design was signed on 15th May, 2017between PIU/ML-1 and JV comprising MMP Pakistan, CRIMSON Pakistan and CANARAIL Canada, (referred to hereafter as Review Consultants.

3.3.1 Scope of Consultancy Services for the Review of Preliminary Design

The Review Consultants shall review and vet the preliminary design/drawings and contract documents prepared by the Design Consultants for the award of EPC Contract (s) for the execution of the project of upgradation of ML-1in different phases.

The purpose of the review shall be to point out deficiencies (if any), suggest improvements and finally vet the whole preliminary design/drawings and EPC bidding contract documents.

The Design Consultants were also required desired to provide consultancy services (technical support) during entire bidding process for appointment of EPC Contractor(s).

3.4 Revised List of Agreed Projects for the Preliminary Design

The list of agreed projects described in paragraph 2.5 above was revised as under for the preliminary design, with the mutual agreement between the governments of the People's Republic of China and the Islamic Republic of Pakistan, and with the approval by JCC.

3.4.1 Package – 1

i. Nawabshah - Rohri (183 km)
ii. Multan – Lahore (339 km)
iii. Lahore - Lalamusa (132 km)
iv. Kaluwal – Pindora (52 km)
v. Walton Academy

3.4.2 Package – 2

i. Keamari-Hyderabad (183 km)
ii. Hyderabad-Multan
(Excluding Nawabshah-Rohri) (566 km)

3.4.3 Package – 3

i. Lalamusa-Rawalpindi(105 km)
ii. Rawalpindi-Peshawar (174 km)
iii. Establishment of Havelian Dry Port

3.5 Submission of Preliminary Design and its Review by the Third Party

The work was initially started on preliminary design of the projects included in Package-1, referred to in paragraph 3.4.1 above and its review by the third party. It was followed by work onPackage-2 and Package-3, referred to in paragraph 3.4.2&3.4.3 above, respectively.

3.5.1 Preliminary Design of Projects included inPackage-1& its Review

The Draft Preliminary Design of the Projects included in Package-1 above was submitted by the Design Consultants on June, 2017 and Final Preliminary Design was approved by the PIU/ML-1 in June, 2019, after its review and vetting by the . Review Consultants.

3.5.2 Preliminary Design of Projects in Package-2& its Review

The Preliminary Design of the Projects included in Package-2, submitted by the design Consultants was approved by the PIU/ML-1 in June, 2020, after its review and vetting by the Review Consultants.

3.5.3 Preliminary Design of Projects in Package-3& its Review

The preliminary design of the projects included in Package-3, submitted by Design Consultants, was approved by the PIU/ML-1 in June, 2019, after its review and vetting by the Review Consultants.

4. Approval of PC-1 OF THE PROJECT &PROPOSED Schedule for Execution

4.1 Submission and Approval of PC-1

4.1.1 Submission of 1st PC-1

The 1st PC-1 for the execution of the agreed works of ML-1, referred to in paragraph 2.5 above at a cost of US$ 8,212 million, was submitted for approval in May, 2016.

It was not processed for approval and PIU/ML-1was asked to submit revised PC-1 only for works included in Phase-1 of the Project, as detailed in paragraph 2.5 above.

4.1.2 Submission of 2ndRevised PC-1

The 2nd revised PC-1 for the execution of works included only in Phase-1 of ML-1 Project (referred to in paragraph 2.5)at a cost of US$ 3,400 million, was submitted for approval in March, 2018.

It was also not processed for approval and PIU/ML-1was asked to re-submit revised PC-1 for the execution of works included only in Package-1 of ML-1(referred to in paragraph 2.10.1 above).

4.1.3 Submission of 3rdRevised PC-1

The 3rd revised PC-1 for the implementation of only the works included in Package-1 of ML-1 Project (referred to in paragraph 2.10 above) at a cost of US$ 2,389 million, was submitted for approval in June, 2019.

It was also not processed for approval and PIU/ML-1was asked to submit revised PC-1 for execution of works included in all the 3 Packages (Package-1, Package-2 and Package-3), referred to paragraph 2.10 above.

4.1.4 Submission of 4thRevised PC-1

The 4th revised PC-1 for the implementation of works included in Package-1, Package-2 and Package-3, (referred to in paragraph 2.10 above) was submitted for approval in October, 2019, for an amount of US$ 9.248 million,

It was also not processed for approval and PIU/ML-1was asked to re-submit revised PC-1 after complying with the observation/comments made by CDWP.

4.1.5 Submission 5thRevised Umbrella PC-1

The 5th Up-dated Umbrella PC-1 for the implementation of works included in Package-1, Package-2 and Package-3, was submitted to Planning Commission for approval on 6th June, 2020, for an amount of US$ 9,172 million.

CDWP recommended the above referred up-dated Umbrella PC-1 on 5th August, 2020 for an amount of US$ 6,806 million, after rationalisation of its cost.

ECNEC accorded the final approval to the Umbrella PC-1 on 5th August, 2020 for the rationalised amount of US$ 6,806 million.

4.1.6 Rationalisation of the Cost of Umbrella PC-1 by Planning Commission

According to PIU/ML-1, the original cost of the updated umbrella PC-1 was rationalised as under by the Planning Commission while according approval, as stated in paragraph4.1.5 above.

Cost of original PC-I (Million USD)	–	9,172 million
Cost of rationalized PC-I (Million USD)	–	6,806 million
Difference (Million USD)	–	2, 366 million
%age reduction	–	25.80%

4.1.6.1 Components of PC-1 deleted during Rationalisation

Components Rationalised	Amount Million US$	
Contingency	(4%)	295

Price Escalation	(6%)	478
Security	(1%)	80
Rolling Stock		407
Misc. items	(3%)	284
Exchange Rate Reduction	(9%)	822
Total		2,366

4.2 Financial Analysis (with & without project basis)

- Net Present Value (NPV) = 7,115 million USD (at WACC: 3.3%)
- Financial Internal Rate of Return (FIRR) = 8.03%
- The project is financially viable

4.3 Economic Analysis

- Economic Net Present Value (ENPV) =14,085 million USD (at WACC:3.3%)
- Economic Internal Rate of Return (EIRR)=14.95%
- The project is economically beneficial

4.4 Proposed Schedule for Execution of ML-1, as per Approved PC-1

4.4.1 Package-1

i. Estimated Cost — US $ 2,705 million

ii. Implementation Period

- Commencement Date January 2021
- Duration — 05 years

4.4.2 Package-2

i. Estimated Cost — S $ 2,675 million

ii. Implementation Period

- Commencement Date — July 2022
- Duration — 07 years

4.4.3 Package-3

i. Estimated Cost — US $ 1,376 million

ii. Implementation Period

- Commencement Date — July, 2022
- Duration — 04 years

4.5 Preparation/Issue of Bidding Document for Package-1 of ML-1

The Design Consultants have prepared the bidding documents for projects included in Package-1, based on EPC/Turnkey Contract and submitted them to Client (PIU/ML-1) in June, 2021, after their review and vetting by the Review Consultants.

Work is in progress on the preparation/approval/review of bidding documents for the projects included in Package-2 and Package-3, referred to in paragraph 4.2 above.

4.6 Issue of Bidding Documents of Package-1 to Pre-qualified EPC Contractors

The issue of the bidding documents for projects included in Package-1, referred to in paragraph 4.2 above, is held up due to non-commitment of required loan from the Chinese side.

In the above context, the loan negotiation process between the Financing Committees of China and Pakistanis still in progress.

5. REVIEW of Some of the Important Components OF THE Feasibility Study

5.1 Current & Upgraded Line Capacity of ML-1 &its Utilisation Level

5.1.1 Train Operation on Pakistan Railways

Train are operated on Pakistan Railways by using the following two signal block systems.

5.1.1.1 Absolute Block System

This system ensures the safe operation of a railway by allowing only one train to occupy a defined section of track at a time. The object of the Absolute Block System is in itself defined fairly simply-"to prevent more than one train being in a block section on the same line at the same time". In this system, a block section is a section of railway line between outer most signals of two stations.

5.1.1.2 Automatic Block System

This system is a railroad communication system consisting of a series of signals that divide a section into a series of sections or "blocks". The movement of trains between the blocks is controlled by using automatic signals. The system is designed to allow trains operating in the same direction to follow each other in a safe manner without risk of rear end collision. The most common form of Automatic Block System is implemented on double track rail in high-density area that has exceeded the capacity provided by manual or other forms of signalling.

5.1.2 Determination of Line Capacity of a Section

5.1.2.1 For Trains Working on Absolute Block System

The line capacity of a section of railway line means the number of trains that can be run on that section in 24 hours.

The following two methods are used by Pakistan Railways for the calculation of line capacity of a section of its railway, where trains are operated on the Absolute Block System of Signalling, referred to in paragraph 5.1.1.1 above.

- Scott's formula

Line Capacity C= 1440/ (T) x 0.7

Where 1440 is the number of minutes in a day and T in critical block section refers to the maximum across all block sections of the time (in minutes) spent by any freight train. The factor of 70% accounts for the loss of capacity due to the presence of maintenance blocks and other factors. The above referred line capacity is not appropriate for sections where traffic is mixed, i.e. trains are of both freight and passenger type. The above referred line capacity is called "raw line capacity".

In case of mixed traffic, the line capacity calculated by using the above referred Scott's formula is further multiplied by a factor which depends upon the difference of maximum speed of passenger trains and minimum speed freight trains. The resultant line capacity is called "mixed line capacity".

- Charting Method

Charting method is the most reliable method of calculating the line capacity. The train paths are plotted in a time-distance graph for 24 hours. Firstly, the paths of all Scheduled Express/Passenger trains are plotted. Then Scheduled goods trains are plotted and after that other paths are plotted as many as possible in the Chart.

The Line Capacity calculated by Charting method is more accurate as this method takes into account all the peculiarities of a given section. This value should not be less than the line capacity as per Scott Formula, which is based on the slowest moving train over the critical section.

5.1.2.2 For Trains Working on Automatic Block System of Signalling

The sections of Pakistan Railways where trains are operated on Automatic Block System of Signalling, referred to in paragraph 5.1.1.2, above the following formula is used for the calculation of its line capacity.

Line capacity= (24x60-t)/I pairs/day

Where:

t is time spent on daily routine maintenance of infrastructure. It has been taken as 70 minutes in the Feasibility Study Report for Upgradation of ML-1

I is the interval time between the two auto block signals. This will depend upon the distance between two automatic block signals and the running speed of the freight train. In the above referred Study it has been taken as 70 km/hr.

The line capacity calculated from the above formula is also not appropriate for the mixed traffic. For mixed traffic the calculated line capacity shall be multiplied by a factor which depends of the difference between the speeds of freight train and passenger trains.

5.1.3 Current Passenger Traffic Volume on Pakistan Railways

Prior to the 1980s, the annual average passenger traffic of Pakistan Railway exceeded 120 million passengers, and railway transportation used to play a significant role in Pakistan's land transportation system. Lack of maintenance and upgrading of the infrastructure has resulted in decreasing transport speed and capacity. Besides, the rapid development of the highway network has caused more and more passengers to choose to use this convenient and efficient mode of transportation.

The railway traffic was on a constant decline from 2010 onward, primarily due to shortage of locomotives. Pakistan Railways carried in year 2014-15 about 53 million passengers, whereas the average for the year 2005-10 was 80.557 million passengers.

The average lead of a passenger was 490 kilometres during 2018-19, while it was only 80.5 km during 1975-80. This reflects that PR has been increasingly meeting the demand for long distance travel and short distance passengers have been reduced; a good step for the financial health of Pakistan Railways.

5.1.4 Current Freight Traffic Volume on Pakistan Railways

According to the above referred Feasibility Study Report, during the year 2014-15, Pakistan Railways carried 3.6 million tons of freight, whereas the average for the years 2005-10 was 6.491 million tons. In 1965-70, PR managed to carry more than 14 million tons of cargo. This data reflected that PR had the potential of moving bigger volumes of

freight but due to severe shortage of locomotives during 2010 to 2015 it could not meet the ever present demand of the freight traffic.

The average kilometre a tonne of freight was carried was 991 kilometres during 2018-19, while it was only 643 km during 1975-80. This reflects that Pakistan Railways has been increasingly meeting the demand for long distance freight traffic.

5.1.5 Current Line Capacity & Utilisation Level of ML-1

The current line capacity and utilization level of ML-1 line is tabulated below.

Table-2: Current Line Capacity and Utilization Level of ML-1 Line

Section	Number of Tracks	Governing Block Section	Length of Governing Block section (km)	Maximum carrying capacity of the line (pair/day)	Actual utilization level (pair/day)	Surplus capacity (pair/day)
Karachi–Kotri	Double	MTG-BOL	20.87	38	27	11
Kotri-Rohri	Double	SRH-NWS	17.19	41	25	16
Rohri–Khan Pur	Double	RTE-WLR	18.37	32	26	6
Khan Pur –Lodhran	Double	FRA-LQP	23.77	32	26	6
Lodhran–Khanewal (Via Loop)	Double	SJB-SSH	24.63	34	16	18
Lodhran–Khanewal(Via Chord)	Single	KUZ-JAI	17.02	20	6	14
Khanewal –Lahore	Double	CCE-HAP	21.9	35	10	25
Lahore –Lalamusa	Single	IMBD-GRW	11.63	25	11	14
Lalamusa–Rawalpindi	Single	SIH-CKL	11.63	25	12	13
Rawalpindi–Peshawar	Single	PII-PBI	10.75	26	5	21

Source: Executive Summary of Final Feasibility Study for Upgrading of ML-1

According to the Summary of Feasibility Study Report, the above stated maximum carrying capacity/line capacity of various sections of ML-1 was calculated by using Scott's formula, referred to in paragraph 5.1.2.1 above, which is based on slowest freight train speed of 70 km/hr and the governing /longest block sections in the segment, as indicated in table-2 above

The line capacity of 75 pairs/day for Karachi-Kotri section, referred to in the Feasibility Study Report was based by the Consultants on existing automatic block signalling on the section, but according to Railway Administration this capacity was not available on ground due to unsatisfactory condition of aged automatic block signals. As such, the line capacity based on absolute block system has been calculated by the Railway Administration as 38 pairs/day only.

According to the data tabulated above the existing carrying capacity of different sections of ML-1 was generally far more than the actual requirement.

5.1.6 Forecasted Passenger Traffic Volume on ML-1

5.1.6.1 Base Year Assumptions

The passenger traffic on Pakistan Railways was on a constant decline from 2010 onward, primarily due to shortage of locomotives, as stated earlier in paragraph 5.1.1 above. The

traffic again started increasing in year 2015 with the introduction of new locomotives. This means that Pakistan Railways did have the demand for traffic during 2010-15 but could not pick it up due to locomotive constraints. It was as such decided to take year 2010 as base year for the forecasting of passenger traffic for ML-1. The Final Feasibility Study Report submitted by the Consultants in January, 2016 was prepared with base year as 2010.

It was however noted later on that after 2013 the passenger volume had gradually started to increase due to serious efforts by the government and reached a level of 60.3 million in 2018-19. It was as such decided by the Consultants that for the preparation of Financial and Economic Analysis Report (Business Plan), the base year for the forecasting/projection of passenger traffic on ML-1may be taken as 2018-19, instead of year 2010 assumed in the above referred Feasibility Study Report, as stated earlier in paragraph 2.7 above.

5.1.6.2 Forecasted Total Passenger Traffic Volume of Pakistan

In Pakistan, there are mainly three modes of transport namely, highway transport, railway transport and air transport. In different regions of Pakistan, these three modes of transport represent a different percentage in the total passenger transport volume. The mode of transport, which the residents want to use, is closely related to the regional economic development level, residents' traveling purposes and income levels, and the ticket prices and traveling times of different transportation modes.

The Consultants after making comparison with China's experience in terms of the percentage represented by railway transport in total passenger transport volume and collecting information on the economic development level, ticket prices and travelling times of different modes of transport in small traffic zones in Pakistan, made calculations on the percentages represented by different modes of transport in the total passenger transport volume of Pakistan, based on relevant investigation and analysis.

According to the predictions made by the Consultants the total passenger volume of Pakistan is expected to reach 1.56 billion in 2020, 1.89 billion in 2025, 2.09 billion in 2030 and2.55billion in 2040.The share of railway passenger traffic was assumed to be about 6% of passenger traffic volume of Pakistan.

5.1.6.3 Forecasted Passenger Traffic Volume on ML-1, as per Feasibility Study Report

The ML-1 Line is mainly located in densely populated areas, as concluded from Pakistan's current population distribution map. All of the cities with a population above one million in Pakistan are located within the vicinity of the line. The population living in the areas along the line accounts for about 90% of the country's total population. Through traffic distribution, the volume of passengers carried by ML-1railway line accounts for about 80% of Pakistan's total railway passenger volume.

According to para 3.5 of Part-2 of the Final Feasibility Study Report, based on the survey and study of the stations on line, the forecasted passenger traffic volume for years 2017, 2020, 2025 and 2030 was estimated as 69.09 million, 75.49 million, 96.35 million and 111.7 million respectively. According to data given in table 3-17 of Part-2 of the Final Feasibility Study Report, the density of passenger volume in year 2017 was 13.08 million for Karachi-Hyderabad section and 10.63 million for Hyderabad-Rohri, Rohri-Lodhran and Lodhran-Khanewal sections.

5.1.6.4 Forecasted Passenger Traffic Volume on ML-1,as per Business Plan

The Consultants further analysed, in the above referred Business Plan, the passenger volumes and passenger kilometres travelled on Pakistan Railways during the five years from 2013-14 to 2018-19, which is reproduced in table 3 below.

Table-3: Passenger Traffic during the years 2013-14 and 2018-19

Year	No. of Passengers Carried (in millions)	Total Passenger kilometres (in millions)
2013-14	47.690	19,778.557
2014-15	52.951	20,288.038
2015-16	52.192	21,200.910
2016-17	52.388	22,475.697
2017-18	54.907	24,903.778
2018-19	60.387	29,595.246

Source; Pakistan Railways Year Book- Year 2018-19

According to the data tabulated above 60.387 million passengers travelled on Pakistan Railways in year 2018-19, out of which its 80% i.e. 48.3million travelled on trains operating on ML-1.

Keeping in view the difficulty in managing train operation during construction period, Consultants assumed a 2% increase from 2018-2019 to 2027-2028 i.e. till the completion of project in 2027-2018.,resulting in the forecasted traffic of 57.73 million passengers in year 2027-28. On the expected completion of upgradation of the track from Karachi to Peshawar by year 2027-28, 10% increase per annum in passenger traffic was assumed up to year 2030-31, resulting in forecasted passenger traffic volume of 76.84 million in that year.

After gaining the confidence of the travelling public due to providing better service during 2027 to 2030, a 5% increase per annum in passenger traffic has been assumed up to 2040 i.e. for 10 years, and as such the total passenger traffic volume on ML-1 would increase to 125.17 million in 2040-41. After that, an increase of 2 % per annum is assumed in passenger volumes for the life of project i.e. till 2048-49, as summarized in Table-4 above.

Table-4: Forecasted Passenger Traffic Volume on ML-1
(Unit: million passengers/passenger kilometres)

Year	Passenger Volume (millions)	Total Passenger kilometres (in millions)
2020-21	50.26	25,508.21
2025-26	55.49	31,493.90
2027-28	57.73	32,766. 25
2030-31	76.84	43,611.88
2040-41	125.17	71,039.16
2048-49	146.66	83,233.70

Source: Financial & Economic Analysis (Business Plan) for ML-1, 2019

5.1.7 Forecasted Freight Traffic Volume on ML-1, as per Feasibility Study Report

ML-1 after its up-gradation, will prove to be life line of freight operation in Pakistan as it extends all the way from Karachi ports to up country. Most of the major urban centres in Pakistan i.e. Karachi, Hyderabad, Sukkur, Multan, Lahore, Faisalabad, Rawalpindi and Peshawar, are in its vicinity. The potential and capacity of upgraded ML-1 in freight operation across Pakistan, will be unmatched and will act as backbone of freight transport sector in Pakistan.

In the Feasibility Study Report, year 2010 was also taken as the base year for the sake of traffic forecasting of freight traffic on PR. It had also been presumed therein that 80% of the freight trains used ML-1 for reaching up country destinations and that the pattern of freight traffic would generally remain the same in the future, as today; i.e. loaded freight trains would depart from the ports of Karachi to up country destinations and mostly empty rakes will be hauled back in the down direction. For the sake of forecasting, 15% of the freight trains would be loaded in the down direction in 2025 and 25% loaded freight trains would be operated in down direction by 2030.

5.1.7.1 Forecasted Freight Traffic Volume on MI-1, as per Business Plan

The Consultants also re-analysed the freight traffic volumes carried on Pakistan Railways during the four years, i.e. from year 2014-15 to 2018-19 for the purpose of its forecasting, as shown in table 5 below.

Table-5: Freight Traffic Volume of Pakistan Railways-2013-14 to 2018-19

Year	Tonnes of Freight carried (in millions)	Total Tonne Kilometres (in millions)
2014-15	3.600	3,301.438
2015-16	5.001	4,773.548
2016-17	5.630	5,031.315
2017-18	8.355	8,080.353
2018-19	8.376	8,303.590

Source: Pakistan Railways Year Book -Year 2018-19

According to the data tabulated above,8.376 million tonnes of freight was carried on Pakistan Railways in year 2018-19, out of which its 80% i.e.6.685 million tons was carried on ML-1.

Year 2018-19 was taken as base year in this case also. The freight traffic volume in year 2018-19 was assumed to increase at 5% per annum till the completion of project in 2027-28. After the completion, an increase of 20% per annum is assumed for three years till 2030-31. This is because of increased line capacity availability after completion of the project. For the next 10 years i-e 2040, this traffic will go up by 10% per annum. An increase of 5% is assumed till the life of project in 2048.

Based upon the above stated growth rates the revised forecasted railway freight traffic volume on ML-1, shall be as tabulated below.

Table-6: Forecasted Freight Traffic Volume on ML-1
(Unit: million Tonnes/Tonnes-kilometres)

Year	Tonnes of Freight carried (in millions)	Total Tonne Kilometres (in millions)
2020-21	7.94	10,035.71
2025-26	14.34	13,309.43
2027-28	14.76	14,230.29
2030-31	20.45	21,233.01
2040-41	34.55	38,529.74
2048-49	45.51	51,969.95

Source: Financial & Economic Analysis (Business Plan) for ML-1, 2019

5.1.8 Number of Trains required to carry the Forecasted Volume of Traffic on Ml-1

5.1.8.1 Number of Required Pairs of Passenger Trains/day.

A typical long distance passenger train on Pakistan Railways comprises of 17 to 18 coaches and operates at a maximum speed of 110 km/h. On the average, each train has a capacity of carrying about 900 to 1,100 passengers. According to the foresaid parameters, the annual transport capacity of long distance passenger train is 350,000 to 400,000 passengers.

The number of passenger train pairs required to carry the forecasted passenger traffic volume on ML-1, have been tabulated in the Business Plan and are re-produced in Table 4 below:

Table-7: Forecasted Number of Pairs of Passenger Trains/Day

Section of ML1	2020-21	2025-26	2030-31	2040-41	2048-49
Karachi-Hyderabad	27	30	42	68	80
Hyderabad-Rohri	24	27	38	61	71
Rohri-Lodhran	24	27	38	62	72
Lodhran- Khanewal	25	28	38	62	72
Khanewal-Lahore	24	27	38	61	71
Lahore-Rawalpindi	26	24	34	55	64
Rawalpindi-Peshawar	5	5	7	12	13

Source: Financial & Economic Analysis (Business Plan) for ML-1, 2019

The data for year 2020-21 and 2048-49 was not available in the above referred Business Plan and has been interpolated.

However, according to data given in Table 3-17 of Part-2 of the above referred Final Feasibility Study Report, 13.08 million passengers, referred to earlier in paragraph 5.1.6.3 above, shall be carried on Karachi-Hyderabad section during year 2017,for which 32 pairs of trains/day shall be required. In case the annual transport capacity of long distance passenger train is taken as 350,000 passengers as stated above, the number of trains required per day to carry 13.08 million passenger shall be 37.4 trains/day or 19 pairs of trains/day, which is current number of passenger trains originating from Karachi per day for up country.

Similarly, according to table-5 above, 55.49 million passengers shall be carried on ML-1 during the 2025-06 out of which its 19% i.e. 10.54 million shall be carried on Karachi-Hyderabad section. Based on average annual carrying capacity of a passenger train as 350,000, the number of pair of trains for this section, shall be 30, which is equal to 15 pairs of trains and not 30 pairs of train/day as indicated in table-7 above.

The above referred disparity in the calculation of number of pairs of passenger trains/day needs to be looked into and data given in this respect in table 7 above be re-examined by the Railway Administration.

5.1.8.2 Number of Required Pairs of Freight Trains/day

The existing trailing load of freight trains on PR is 2400 tons, out of which 1656 tons is the pay load whereas the rest is tare of the wagons and brake van. After up gradation, the trailing load would increase to 3400 tons, with 2400 tons as payload and the rest as tare.

The existing maximum speed of a freight train with four wheeler stock is 70 km/h, whereas after up gradation the speed would be 100 km/h for loaded and 120 km/h for empty rake of freight trains.

As already stated above, year 2018-19 has been kept as Base year and ML-1 carried around 8.376 million tonnes of traffic during that year, as indicated in table -5 above. This volume is assumed to increase at 5% per annum till the completion of project in 2027-28.

After the completion, an increase of 20% per annum is assumed for three years till 2030-31. This is because of increased line capacity availability after completion of the project. For the next 10 years i-e up to year 2040-41, this traffic will go up by 10% per annum. An increase of 5% is assumed till the life of project in 2048-49.

The number of freight trains required to carry the forecasted freight traffic volume on ML-1 given in Table 6 above is tabulated below.

Table-8: Forecasted Number of Freight Trains/day on ML-1

Section of ML-1	2020-21	2025-26	2030-31	2040-41	2048-49
Karachi- Hyderabad	11	20	27	44	58
Hyderabad-Rohri	08	14	21	37	49
Rohri-Lodhran	08	14	21	36	47
Lodhran-Khanewal	07	13	20	34	45
Khanewal-Lahore	07	13	18	30	40
Lahore-Rawalpindi	02	04	06	12	16
Rawalpindi-Peshawar	01	01	01	02	03

Source: Financial & Economic Analysis (Business Plan) for ML-1, 2019

The data for year 2020-21 and 2048-49 was not available in the business plan and has been interpolated.

5.1.8.3 Total Number of Forecasted Passenger and Freight Trains &Line Capacity Required to Operate the Forecasted Mixed Traffic

The forecasted number of passenger and direct freight trains (including pick up and drop trains) which shall operate during the study period, included in table 7 and table 8 above respectively and the required carrying capacity of ML-1 during the year 2025-26 and year 2040-41 has been summarized in Table 9 below:

Table 9: Number of Passenger and Freight Trains & Required Carrying Capacity

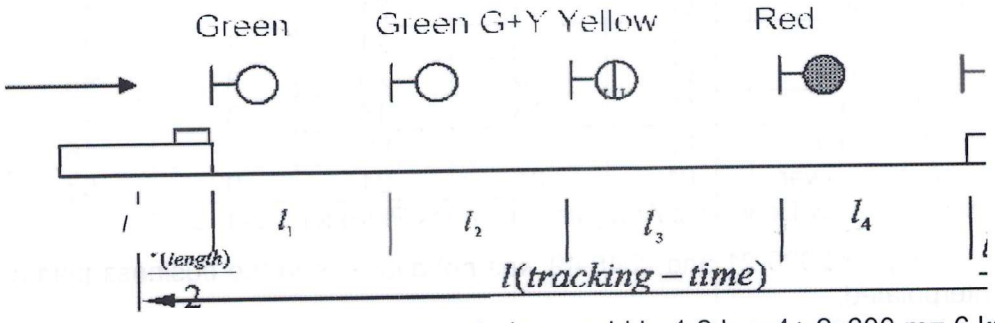
Section	2025-26				2048-49			
	Passenger Trains	Direct Freight Trains	Total Trains	Carrying Capacity required	Passenger Trains	Direct Freight Trains	Total Trains	Carrying Capacity required
Karachi–Hyderabad	30	20	50	72	80	58	138	193
Hyderabad–Rohri	27	14	41	60	71	49	120	168
Rohri–Lodhran	27	14	41	60	72	47	119	166
Lodhran-Khanewal	28	13	41	60	72	45	117	164
Khanewal-Lahore	27	13	40	58	71	40	111	155
Lahore–Rawalpindi	24	04	28	40	64	16	80	112
Rawalpindi–Peshawar	5	01	06	09	13	03	16	22

5.1.9 Comparison of Available Line Capacity and Required Line Capacity for Forecasted Mixed Traffic

5.1.9.1 Available Line Capacity on ML-1 with Automatic Block System proposed by Consultants

According to the initial ML-1 construction scheme, Karachi- Peshawar section was to be upgraded by adopting Chinese four-color (green, green yellowish, yellow and red) displays double line automatic blocking system. The particulars of the proposed automatic block sections shall be as under:

- Running speed of freight train is about 70km/h.
- The average distance between 2 trains would be about 6km.
- The distance between 2 signals is about1.2km.
- The adequate distance shall be 600m.
- Signal shall be set at the tracking interval of 8 minutes including 3 minutes slack margin.



The average distance between two trains would be1.2 kmx4+ 2x600 m= 6 km.

Now, the line capacity shall be calculated as under:

- Line Capacity=((24x60)-t))/ tracking interval

  Where,

t=70 minutes per day for maintenance of track, and

- Tracking interval= 6 km x (60 /70) +3 minutes=8 minutes
- Line Capacity= ((24x60)-70)/8=171 pairs/day

The above mentioned line capacity of 171 pairs/day, called raw capacity is applicable on the sections where all the trains are running with uniform speed and is not appropriate for the sections where both freight and passenger trains operate or the traffic is mixed.

The traffic on all sections of ML-1 shall be mixed. The line capacity applicable to the mixed traffic is called mixed line capacity and shall be about 70% of the raw line capacity, depending upon the difference in the speeds of passenger and freight trains running on the same section, as shown in Table-9 above.

Based on the data given in table 9 above, the above stated raw line capacity of 171 shall reduce to about 120 for mixed traffic. As such, according to the data included in table 9 above, the raw line capacity of 171 shall generally be adequate for traffic forecasted up to 2048-49.

5.1.9.2 Revision of the Automatic Block System Proposed by the Consultants

The above referred Automatic Block System comprising 4 aspect signals with distance of 1.2 km between them was modified by the Consultants on the request of Railway Administration to bring it at par with signalling system which was already being installed on 433 km long Lodhran-Shahdara section of ML-1 and comprised CRSC's three aspect signals with average distance of 4 km between them. This system has accordingly been adopted for all the sections of ML-1.

Based on the formula given in paragraph 5.1.9.1, the line capacity with 3 aspect signals and average 4.0 km spacing between the auto block shall be as under:

- The average distance between two trains
- with speed of 70 km/hr = 3x4km+ 1.2 km= 13.2 km
- Line Capacity= ((24x60)-t))/ tracking interval

Where

t=70 minutes per day for maintenance of track, and

- Tracking interval= 13.2km x (60 /70) +3 minutes=14.3 minutes
- Thus Line Capacity= ((24x60)-70)/14.3 =95 pairs/day

Based on the assumption made in para 5.1.9.1 above, the available line capacity for mixed traffic with 3 aspect auto block signals at average spacing of 4 km shall be about 67 pairs/day only. According to position brought out in table 9 above, the required carrying capacity for Lodhran-Lahore (Shahdara) section shall be 62 pairs/day during the year 2025-26 and 164 pairs/day for the year 2048-49. As such, the above referred available capacity of 67 pairs/day shall be much less the required line capacity.

A similar situation will result on other sections of ML-1, which are proposed for upgradation under CPEC.

The Consultants have pointed out the above inadequacy/short fall in the available line capacity, in the feasibility study report but have not provided a viable solution for this situation on different sections of ML-1.

5.1.9.3 The Available Line Capacity with Absolute Block System.

The Absolute block system of block signalling is currently being used on the main line of Pakistan Railway network for the last many years. The studies carried out by different railways indicate that line capacity of section where there is mixed traffic, the mixed/available line capacity with Automatic Block system and Absolute Block system will be nearly same, provided in case Absolute Block System, the distance between block stations in kept at 8km to 15 km and intermediate block stations are also provided if considered necessary.

5.2 Upgrading of Existing Signalling System

5.2.1 Brief Description of existing Signalling System on ML-1.

i. Karachi-Landhi double-track section.

There are 8 stations in this section, and relay interlocking, automatic block and CTC are adopted.

ii. Landhi - Kotri (ex.) double-track section.

There are 11 stations in this section, and relay interlocking and automatic block are adopted.

iii. Kotri - Tando Adam (ex.) double-track section.

There are 8 stations in this section, and standard III mechanical interlocking signalling equipment and semaphore is adopted. Tyre's equipment is adopted for block.

iv. Tando Adam - Mirpur Mathelo double-track section.

There are 21 stations in this 347.24 km long section. Bombardier's computer-based interlocking equipment is adopted in the stations and China Railway Signal & Communication Corp. (CRSC)'s axle counting block system is adopted in the block sections.

v. Mirpur Mathelo - Lodhran double-track section.

There are 20 stations in this section. Relay interlocking is adopted in 10 stations, and standard III mechanical interlocking signalling equipment and semaphore is adopted in the other 10 stations. Tyre's equipment is adopted for block.

vi. Lodhran - Shahdara Bagh double-track section.

There are 31 stations in this 433 km long section. Bombardier's computer-based interlocking equipment is adopted in the stations and CRSC's three aspect automatic block system is adopted in the block sections with average distance of 4.0 km between auto block signals.

vii. Shahdara Bagh - Chaklala single-track section.

There are 66 stations. Standard III mechanical interlocking signalling equipment and semaphore is adopted. Siemens' token less block system is adopted.

viii. Lodhran - Khanewal via chord single-track section

There are 7 stations in this section. Standard III mechanical interlocking signalling equipment and semaphore is adopted. Siemens' token less block system is adopted.

5.2.2 Signalling System Recommended for Up-gradation of ML-1

The signalling system recommended in the final feasibility study shall briefly comprise the following:

i. The reconstruction of communications and signalling systems at the 31 stations between Lodhran and Shahdara and 21 stations between Tando Adam and Mirpur Mathelo is underway, as stated in paragraph 5.2.1 (iv) and (vi) above.

ii. Three-aspect automatic block system between Lodhran and Shahdara is recommended, utilizing existing signalling equipment at the 52 stations, referred to in (i) above.

iii. New CTCs at Lodhran-Shahdara section as well as the new CTCs and automatic block equipment at Tando Adam - Mirpur Mathelo section require interconnection with the interface of the existing signalling system.

iv. Three-aspect automatic block signalling system will be provided on the remaining sections of Ml-1 also according to the required speed, and the signalling system would include Computer Based Interlocking (CBI) with Centralized Traffic control (CTC), and Auto Train Protection (ATP).

v. The line capacity of each section of ML-1 with 4 aspect auto block signals 1.2 km apart was calculated by the Consultants as 171 pairs of train/day, as detailed in sub-section 5.1.9.1 above, whereas it shall reduce to 95 pairs of trains/day with the adoption of 3 aspect automatic block signals, at average distance of 4 km. The possible adverse impact of the adoption of the latter system has been indicated in paragraph 5.6.1 above.

vi. In the face of the position stated above, the above referred decision of the Railway Administration to adopt 4 km apart automatic block signal needs to be reviewed and possibility of adoption of Absolute Block system on all remaining be investigated, as detailed in

5.3 Upgrading of Existing Telecommunication System

5.3.1 Brief Description of existing Telecommunication Facilities on ML-1

i. Main Transmission System:

Microwave system is adopted between major stations, and UHF transmission equipment is adopted between major station and minor station.

ii. Transmission Line:

There is no transmission line for the whole ML1 except for Lahore-Rawalpindi section, where there are some buried cable or overhead open wire, totally 60km in length. For the whole line, there is no cable for telecommunication purpose. Lodhran-Multan-Shahdara section is 427.7km long, which is under signal upgrading by Bombardier, and 24-core optical fibre cable is proposed.

iii. Radio Telecommunication System:

VHF radio equipment is used by stations, cab drivers and mobile workers.

iv. Telephone Switching:

There are electric switching machines of the early 1980s in Pakistan Railways, which use the 120~1000 subscriber line. Besides, there are common-battery telephone switchboards (manpower) and step switchboards. Urban telephone system is provided in stations and offices, but railway telephones and urban telephones are not connected.

v. Dispatching Telephone:

Audio numerical selection telephone, which adopts microwave + UHF channels. Inter-station telephone adopts magneto one.

vi. Station-yard Telephone:

Magneto telephone.

vii. Level Crossing Telephone:

Magneto telephone.

5.3.2 Telecommunication Systems Considered for Up-gradation of ML-1

According to the Feasibility Study Report, the Consultants had originally proposed the provision of DMR for the upgradation of Ml-1 under CPEC, but later on it was first changed to GSM-R and finally to LTE-R, on the request of Railway Administration.

The LTE-R system has now been proposed for all the sections of ML-1, from Karachi to Peshawar. It shall be primarily used for communication of data to the driver in the locomotive cab and to communicate between different operational points/groups. In the above context, the telecommunication used by major railways of the world are briefly described in the following sub-paragraphs. In this context, the telecommunication systems used by other major railways are described briefly in the following paragraphs.

5.3.2.1 The Telecommunication Systems used by Major Railways of the World

The following three telecommunication systems are used on long distance railway main lines by most of the advanced railways.

i. GSM-R (Global System for Mobile Communication-Railways):

This system carry extra ordinary data of voice, picture and digital data and can travel through the obstructions. Now-a-days railway companies through such wireless practices, aim at an integrated communication and signalling system in case of high speed trains for,

- More efficient use of frequency resources

- Decreasing the operation and maintenance costs
- Increasing interoperability between different railway networks

ii. DMR-VHS System

Digital Mobile Radio (DMR) is an international digital radio standard developed by the European Telecommunication Standard Institute (ETSI). DMR aims and provide an affordable, low complexity digital standard to replace analogue radio. It is an advanced one chip radio which auto-senses digital or analogue transmission. Many makes of this system offer up-to 2000 channels.

During manufacturing of DMR, special attention was drawn to the fact to have in it as many GSM- R like functions as possible, in order to be able to offer an excellent alternative to the GSM-R standard. The great advantage for railway customers was to obtain a similar high-end technical product at a much more reasonable price level.

iii. LTE-R (Long Time Evolution):

GSM-R System works in narrowband of radio spectrum frequencies and provide reliable support for voice and data transmission but has limited capacity as compared to LTE-R which operates in broadband.

LTE-R provides high speed, high security, and high bandwidth capacity making it well suited for high speed trains and to support passenger facilities needs along with safety critical operational applications.

LTE-R communication system is still in the development stage and it has not been used by most of the major railways for their high speed lines.

5.3.2.2 Comparison between GSM-R, DMR-VHF and LTE-R for Upgradation of ML-1

The merits and demerits of GSM-R, DMR-VHF and LTE-R communication systems are as under:

i. For the trains running at design speeds up to 160 km/hr. communication between drivers, guards, station- masters and control etc. is not required to be necessarily through GSM-R but can preferably be through DMR - VHF or TETRA systems at a much lesser cost.

ii. Majority of functions to be performed by GSM-R / LTE-R will remain unutilized for trains running at speed up-to 160 km/hr.

iii. Some of the passenger facilities offered by GSM-R/LTE-R have already been implemented, some can be performed by DMR-VHS and most of the remaining facilities are not considered necessary to be implemented.

iv. Cost of GSM-R / LTE-R is around five times the cost of DMR-VHS system.

5.3.2.3 The Telecommunication System Recommended for ML-1

The adoption of DMR-VHS communication system was recommended by the Consultants in their Draft Feasibility Study Report, but it was replaced by the Consultants initially with

GSM-R and later on with LTE-R for whole length of ML-1, on the request of Railway Administration.

In view of the position brought out in paragraph 5.3.2.2 above, and the fact that the cost of DMR-VHS is about five times less than that of LTE-R, the adoption of DMR-VHS is recommended for the whole length of ML-1. It will result in substantial saving in the estimated cost of the project, without causing any adverse impact on the performance of the prescribed telecommunication services.

5.3.2.4 Use of 96 core Optical Cable, instead of 48 core recommended by the Consultant

The Consultants had recommended in their draft Feasibility Study Report the provision of 48 core optical cable. However, during the review of this Report by Railway Administration it was recommended that its capacity be increased to 96 core optical cable. The Consultants accordingly included the provision of 96 core optical cable, in their Final Feasibility Study Report.

In the above context, it may be added that as per paragraph 5.3.1 above, 24 core optical fibre core has been proposed for signal upgrading by Bombardier on 427.7km long, Lodhran-Multan-Shahdara section of ML-1.

In the above circumstances the provision of 96 core optical cable instead of 48 core cable needs to be reviewed by the Railway Administration.

5.4 Upgradation/Rehabilitation of Existing Track Structure under Traffic.

The upgradation of the existing infrastructure of ML-1 will comprise the following main activities.

i. The dismantling/removal of the existing track structure, including rails, sleepers and ballast etc.

ii. Removal of defective sub-grade, its treatment and re-construction/raising of sub-grade where required as per design levels, including their compaction.

iii. Laying of sub-ballast and ballast including its compaction.

iv. Laying of the new track structure

v. Rehabilitation/re-construction of bridges.

vi. Construction of under passes and Road over bridges to replace the existing level crossing.

According to the construction plan included in the feasibility study report, all the above referred activities on the double tracks shall be carried out initially on one track on which train operation shall be blocked over a maximum length of about 60 km, for which single line working shall be resorted to on the second track as per prescribed rules and regulation. On the completion of work on one stretch of 60 km, it will be repeated on next stretch and so on.

Once the upgradation work is completed on one track then it shall be repeated on the second track. In case the upgradation work is to be carried out on two or three sections of ML-1 at a time, the single line working shall have to be resorted to at each such site. In addition to single line working, diversion tracks shall have to be laid for construction of major bridges.

The above stated construction plan involving single line working will involve much longer construction time, heavy additional expenditure, delayed train services etc.

The other possible construction plan for up grading of double track particularly for Karachi - Rohri-Lodhran can be laying a new double line track adjacent to the existing double line within existing railway ROW and then dismantle the existing double line. The cost of this plan may be slightly higher but it will be compensated by substantially reduced construction period for all upgradation works and normal train operation on both tracks throughout the construction period.

The Consultants and the Railway Administration need to examine the above referred alternate construction plan also, by discussing at length the merits and de-merits of each plan.

5.5 Re-prioritization of different projects included in ML-1

The upgradation/rehabilitation of the track infrastructure of different sections of ML-1, listed in paragraph 3.4 above are proposed to be carried out as per following schedule given in paragraph 4.4 above.

a. Package-1: (Completion Period-5 years)
   - i. Nawabshah – Rohri (183 km)
   - ii. Multan – Lahore (339 km)
   - iii. Lahore – Lalamusa (132 km)
   - iv. Kaluwal – Pindora (52 km)

b. Package – 2 (Completion Period-7 years)
   - v. Keamari-Hyderabad (183 km)
   - vi. Hyderabad-Multan (Excluding Nawabshah-Rohri @ (i) above) (566 km)

c. Package – 3(Completion Period-4 years)
   - vii. Lalamusa-Rawalpindi (105 km)
   - viii. Rawalpindi-Peshawar (174 km)

JCC had also approved the following two projects for execution under CPEC, as stated in paragraph 2.5 above.

i. Karachi-Kotri/Hyderabad new line (163 km): Construction of new line, (Short Term-Phase –II (2015-20)

ii. Complete electrification of ML-1, (Medium Term (2020-25)

In the following paragraphsthe justification for including the above stated two projects in above listed Package-1&2 above, has been elaborated.

5.5.1 Construction of Karachi-Kotri/Hyderabad new line

The project of provision of Karachi-Kotri new line (163 km) long, was approved by the JCC meeting held on 12th November, 2015. According to paragraph 2.5 above this project was planned to be executed during Phase-II of Short Term. It was accordingly included in the Feasibility Study Report of Up-gradation of ML-1 under CPEC, but was excluded at the stage of its Preliminary Design.

The current line capacity of Karachi-Kotri section is only 38 pairs of trains/day as indicated in table -2 above. According to the forecasted number of passenger and freight pairs of trains/day given in table-9, the mix line capacity required for Karachi-Hyderabad section during 2020-21 shall be 38 pairs of trains, 50 pairs of train/day during 2025-26, which shall increase to 69 trains pairs/day in 2030-31 and 112 pairs/day in 2040-41, against the current available capacity of only 38 train pairs/day.

According to the summary of Feasibility Study Report, in view of the topography of the terrain, complicated track geometry and ground realities, it is a difficult section to be upgraded to higher speed of 160 km/h. Moreover, major realignment works would also be required during up gradation resulting in serious disruption of train operations.

In view of the position explained above and to avoid major setback to train operations and inconvenience to the travelling public, it was proposed by the Consultants that the work on Keamari - Hyderabad Section (182 km) for up gradation and speeding up to 160 km/h should be deferred for the time being. It was further proposed that construction of the new Karachi - Hyderabad track may be initiated on priority. Once this line is completed, the passenger trains will be shifted to the new line whereas the existing line will be dedicated for freight traffic, due to its connectivity to KPT, Port Qasim and marshalling yards at Pipri, Keamari and RG oil terminal at Karachi.

Railway Administration is already investigating the feasibility of construction of a new double line between Karachi Port and Marshalling Yard Pipri. This line can be extended further up to Kotri along the existing alignment as recommended by Consultants in above paragraph.

5.5.2 Electrification of Karachi-Lahore Section of ML-1

The project of electrification of complete ML-1 was also approved by the JCC meeting held on 12th November, 2015. According to paragraph 2.5 above it was planned to be executed during medium term. It was accordingly included in the Feasibility Study Report of Up-gradation of ML-1 under CPEC, but was excluded at the stage of Preliminary Design.

It is considered that the electrification of at least Karachi-Lahore section should be made part of Package-1 and Package-2, in the face of the justification given in the following paragraphs. The first package can be from Karachi to Rohri and second from Rohri to Lahore.

5.5.2.1 Advantages of Electric Traction over Diesel Traction

The electric traction has the following advantages over diesel traction which have been endorsed by different studies carried out on European, American and Indian Railways.

a) The thermal efficiency of electric locomotive is 85 to 90% against 25 to 27% thermal efficiency of Diesel Locomotives and thus the operating costs of electric locomotives are relatively much low.

b) It has got a very advantageous power weight ratio of 50 lbs./horse power, which is almost half of diesel locomotive.

c) It has better acceleration than diesel locomotive, particularly on grades and on high overloads.

d) It is more stable on track and causes less wear on track

e) It costs slightly less than diesel locomotive but has life of about 40 years against 30 years life of diesel electric locomotive

f) It has re-generation braking which feeds back current to the system.

g) According to an internet site "Railway Electrification and Railway Productivity-A Study Report", a seven members TRB Committee on electrification conducted a study about the performance of Electric Traction on 10 different European and American railways with the following conclusions.

- The average availability on Europe and North American railroads for electric Locomotives was 94% and of diesel electric locomotives it was 84%.
- The number of failures of electric locomotives was 50% of the failures of diesel electric locomotives, resulting in better reliability of electric locomotives.
- Average maintenance cost of an electric locomotive for hauling same gross ton mile is 20% t0 40% as compared to D. E. Locomotives

h) The maximum axle load for locomotives to be used for normal rail traffic has been restricted to 25 tonnes in the European, Chinese and Indian Bridge Rules/Codes. This axle load restricts the use of diesel locomotives with maximum 5000 HP, whereas Electric Locomotives of 6000 to 8000 HP have been manufactured with maximum axle load of 25 tonnes.

It is presumably in the backdrop of the above stated clear advantages that Indian Railways have already electrified about 65% of their broad gauge main line tracks and plan to raise this figure to 90%.

5.5.2.2 The Limitations of Diesel Traction on Pakistan Railways

The diesel traction was introduced on Pakistan Railways in late 50s. The new diesel locomotives had performed very well during the initial years, but during the subsequent years the undue delays in the procurement of their spare parts and the replacement of overage locomotives started having adverse effects on the train operation, as stated below.

The number of imported spare parts of each type/make of diesel locomotives, the inventory of which is required to be maintained for the operation and maintenance of such locomotives as per their prescribed schedules is about 12000. This required uninterrupted availability of foreign exchange for the regular import of the above referred spares.

Since the required amount of foreign exchange was usually not allocated due to one reason or the other, the availability of the desired number of spares etc. for the scheduled/non-scheduled repairs was never more than 60% of the requirement. This situation adversely affected the availability of required number of fit locomotives, resulting initially in the delay/closure of some of the scheduled passenger and freight train services and ultimately in the closure of most of these services particularly freight services.

The situation worsened when most of the available locomotives became overage and their spares were also not made available and such locomotives are also not replaced in time. Such situations were first experienced in late 90s and again in 2007, when the train operation particularly freight train operation almost came to stop. The situation was controlled on both occasions by emergent imports of new locomotives by the then governments.

The only viable soluble to the above referred situation created occasionally by the train operation with diesel traction, is to switch over to electric traction as early as possible, because electric locomotives will not require maintenance of that huge inventory of spare parts. Resultantly the electric locomotives are much cheaper to maintain in addition to the availability of other significant advantages listed above.

5.6 Recommendations

Based on the position brought out in Paragraph -5 above, in respect of proposed upgradation of different sections/components of ML-1 under CPEC, the following recommendations are submitted.

5.6.1 Current & Upgraded Line Capacity of ML-1 & its Utilisation Level

The number of pair of trains calculated in Table-9 for Karachi-Hyderabad and other sections of ML-1 do not reconcile with the corresponding forecasted passenger traffic volume, in the face of the average annual carrying capacity of a passenger train take therein as 350,000. Resultantly the number of trains in the above referred table-9 appear to be high and needs to be looked into.

a) The number of pair of trains calculated in Table-9 for Karachi-Hyderabad and other sections of ML-1 do not reconcile with the corresponding forecasted passenger traffic volume, in the face of the average annual carrying capacity of a passenger train take therein as 350,000. Resultantly the number of trains in the above referred table-9 appear to be high and needs to be looked into.

b) The Consultant had initially recommended in the feasibility study report the adoption of 4 aspect automatic signals 1.2 km apart for all the sections of Ml-1 from Karachi to Peshawar. The line capacity of each section was calculated by the Consultants as 171 pairs of train/day, as detailed in sub-section 5.1.9.1 above. According to the data given in Table-9 above, this line capacity shall be adequate for the number of train pairs /day forecasted up to year 2048-49 for all sections of from Karachi to Lahore, except Karachi-Hyderabad, where the required shortfall can be met with by the construction of proposed new double track in this section. The available line capacity after proposed upgradation on Lahore-Rawalpindi and Rawalpindi will be surplus for the forecasted traffic.

c) The above situation will drastically change with of adoption of CRSC's 3 aspect auto block signals at average distance of 4 km, on all sections of ML-1. With this modified automatic block system, the line capacity shall reduce from 171 pair of trains/day to 95 pair of trains, which shall be inadequate for the traffic forecasted for year 2030-31 on ward for most of the sections of Ml-1.

d) In the face of the position stated above, the above referred decision of the Railway Administration to adopt 4 km apart automatic block signal needs to be reviewed.

5.6.2 Upgrading of Existing Signalling System

a) It has already stated in paragraph 5.6.1 above that with the adoption of 3 aspect automatic signals at average distance of 4 km shall reduce the line capacity to 95 pairs of trains/day as against 171 pairs of trains/day with the adoption of 4aspect automatic block signals, at average distance of 1.2 km. The possible adverse impact of the adoption of the latter system has been indicated in paragraph 5.6.1 above.

b) In the face of the position stated above, the above referred decision of the Railway Administration to adopt 4 km apart automatic block signal needs to be reviewed and possibility of adoption of Absolute Block system on all remaining be looked into.

c) The Absolute Block System of signalling is currently being used on the main line of Pakistan Railway network for the last many years. The studies carried out by different railways indicate that line capacity of section where there is mixed traffic, the line capacity with Automatic Block system and Absolute Block system will be nearly same. However, in case Absolute Block System, the distance between block stations should be kept at 8km to 15 km and the provision of intermediate block stations be also considered if necessary.

5.6.3 Upgrading of Existing Telecommunication System

5.6.3.1 Adoption of DMR-VHS instead of LTE-R

a) The adoption of DMR-VHS communication system was recommended by the Consultants in their Draft Feasibility Study Report, but it was replaced by the Consultants initially with GSM-R and later on with LTE-R for whole length of ML-1, on the request of Railway Administration.

b) In view of the position brought out in paragraph 5.3.2.2 above, and the fact that the cost of DMR-VHS is about five times less than that of LTE-R, the adoption of DMR-VHS is recommended for the whole length of ML-1. It will result in substantial saving in the estimated cost of the project, without causing any adverse impact on the performance of the prescribed telecommunication services.

5.6.3.2 Use of 96 core Optical Cable, instead of 48 core recommended by the Consultant

a) The Consultants had recommended in their draft Feasibility Study Report the provision of 48 core optical cable. However, during the review of this Report by Railway Administration it was recommended that its capacity be increased to 96 core optical cable. The Consultants accordingly included the provision of 96 core optical cable, in their Final Feasibility Study Report.

b) In the above context, it may be added that as per paragraph 5.3.1 above, 24 core optical fibre core has been proposed for signal upgrading by Bombardier on 433 km long, Lodhran-Multan-Shahdara section of ML-1.

c) In the above circumstances the provision of 96 core optical cable instead of 48 core cable needs to be reviewed by the Railway Administration.

5.6.4 Upgradation/Rehabilitation of Existing Track Structure under Traffic.

a) According to the construction plan included in the feasibility study report, the construction activities on the double tracks shall be carried out initially on one track on which train operation shall be blocked over a maximum length of about 60 km, for which single line working shall be resorted to on the second track as per prescribed rules and regulation. On the completion of work on one stretch of 60 km, it will be repeated on next stretch and so on.

b) The above stated construction plan involving single line working will involve much longer construction time, heavy additional expenditure, delayed train services etc.

c) The other possible construction plan for up grading of double track particularly for Karachi - Rohri-Lodhran section can be laying a new double line track adjacent to the existing double line preferably within the existing railway ROW and then dismantle the existing double line. The cost of this plan may be slightly higher but it will be compensated by substantially reduced construction period for all upgradation works and continuous normal train operation on both tracks throughout the construction period.

d) The Consultants and the Railway Administration need to examine the above referred alternate construction plan, by discussing at length the merits and de-merits of each plan.

5.6.5 Re-prioritization of Projects included in the Upgradation of ML-1 under CPEC

5.6.5.1 The Construction of New Double Line between Karachi and Kotri

a) The project of provision of Karachi-Kotri new line (163 km) long, was approved by the JCC meeting held on 12th November, 2015. According to paragraph 2.5 above this project was planned to be executed during Phase-II of Short Term. It was accordingly included in the Feasibility Study Report of Up-gradation of ML-1 under CPEC, but was excluded at the stage of its Preliminary Design.

b) The construction of the proposed new double line between Karachi and Kotri by re-prioritization of the projects included in the sanctioned PC-1, is considered necessary to carry the forecasted up country traffic, particularly when the upgradation of existing Karachi –Kotri line is not possible due to site constraints pointed out by the Consults, referred to in Paragraph 5.5.1 above.

5.6.5.2 Electrification of Karachi-Lahore section of Ml-1

a) The project of electrification of complete ML-1 was also approved by the JCC meeting held on 12th November, 2015. According to paragraph 2.5 above it was planned to be executed during medium term. It was accordingly included in the Feasibility Study Report of Up-gradation of ML-1 under CPEC, but was excluded at the stage of Preliminary Design.

b) It is considered that the electrification of at least Karachi-Lahore section should be made part of Package-1 and Package-2, in the face of the justification given in the paragraph 5.5.2 above.

5.6.5.3 Deferment of Projects/Components of the Projects of Lower Priority.

a) In order to accommodate the above referred high priority projects the upgradation of those sections wherein the upgraded line capacity is forecasted to remain under-utilised for quite some time, can be deferred.

b) Secondly the provision of very costly telecommunication system LTE-R be replaced with equally efficient DMR-VHF and provision of 96 core cable instead of 48 core be also reviewed.