

Annexure 6.1

[Section 6: Scope of Work]

SALIENT FEATURES OF DELHI-KARNAL NAMO BHARAT CORRIDOR

0.1 Introduction

This is the executive summary of the revised DPR for Namo Bharat corridor between Sarai Kale Khan to Karnal via Panipat with a length of about 136.30 km.

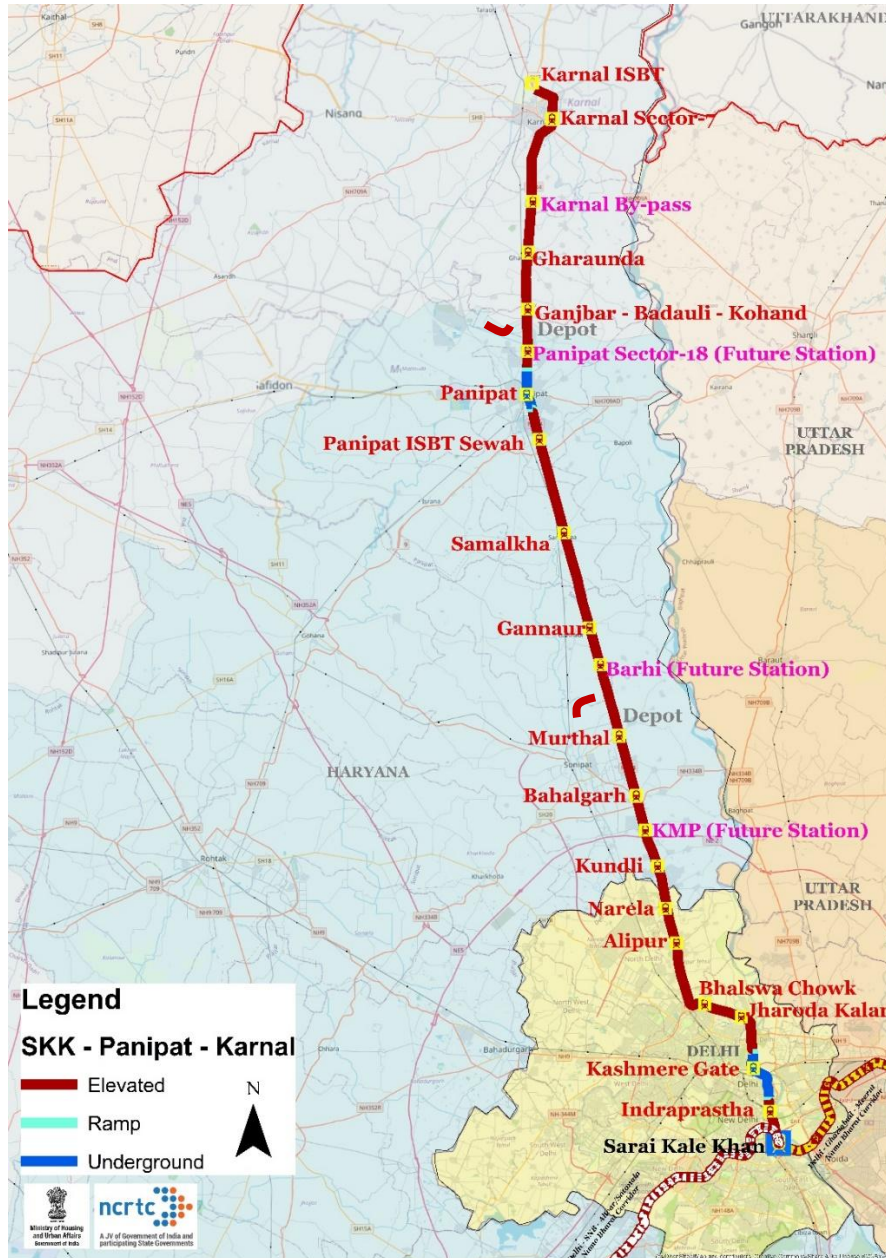
0.2 Proposed Alignment & Route Connectivity

Alignment of Delhi (Sarai Kale Khan) – Panipat – Karnal Namo Bharat Corridor: The brief description of the proposed route alignment is given below:

1. The alignment of Delhi – Panipat – Karnal Namo Bharat corridor starts from Sarai Kale Khan Namo Bharat Station, which is already developed as part of the Delhi – Meerut Namo Bharat Corridor. From there, the corridor traverses northwards predominantly along the Ring Road in Delhi upto Mukarba Chowk from where the corridor turns towards NH-44 and runs along the highway all the way through Panipat and upto Madhuban in Karnal; for a small stretch between Madhuban and Tau Devi Lal Chowk in Karnal, the alignment runs along the Old Mughal Canal, after which the alignment again runs along NH-44 upto new Karnal ISBT.

The alignment gets underground at Kashmere Gate and Panipat stations of the Namo Bharat Corridor.

2. The alignment is planned with 13 stations in Sarai Kale Khan – Panipat Sector-18 section with provision for additional 3 stations and 4 stations in Panipat Sector-18 to Karnal new ISBT section with provision for 1 additional station. In all there will be 21 stations which includes provision of 4 future stations.
3. Along the route, the alignment integrates with Delhi Metro network at Indraprastha, Kashmere Gate, Jharoda Majra, Bhalswa and Kundli.
4. The Delhi – Panipat – Karnal Namo Bharat corridor is strategically aligned to serve dense population catchments and key nodes, including industrial and economic hubs. Along the way, it will connect key regional centres in Delhi and Haryana like Sonipat, Ganaur, Samalkha, Panipat, Gharaunda and Karnal bringing rapid transit to Haryana's vital urban centres.
5. Enroute, the alignment of Delhi – Karnal Namo Bharat corridor crosses Indian Railways and Metro tracks, traversing dense urban areas in Delhi. The Delhi – Karnal Namo Bharat alignment is designed to optimize existing infrastructure, utilizing the Right of Way (RoW) of PWD roads and National Highway's (NH-44) green belt or demarcated green belt and service roads where feasible.



Schematic Map: Sarai Kale Khan (Delhi) – Panipat Sector-18 (Panipat) – Karnal new ISBT (Karnal) Namo Bharat Corridor

6. Investigations showed that at grade alignment is not possible and therefore the Namo Bharat corridor will be a double line standard gauge, rapid railway system, built on elevated viaducts with few underground tunnel sections in heavily populated areas of Delhi and Panipat.
7. **Route Length:** The total length of the section between Sarai Kale Khan upto Panipat Sector-18 is 102.85 km, which excludes 0.9 km connection to Murthal depot. The length of elevated corridor in this section is 91.37 km (88.84%), and underground section is 11.48 km (11.16%). Further, the length of the section between Panipat Sector-18 up to Karnal New ISBT is 33.45 km, which excludes 1.77 km elevated connection to Ganjbar depot. The entire section of 33.45 km is elevated.

The total length of Delhi – Panipat – Karnal Namo Bharat Corridor is 136.3 km. Table below shows the details of alignment.

Table 1: Route Length

Corridor details	Underground (km)	Elevated (km)	Total (km)
SKK (Delhi) – Panipat Sector-18			
Route length	11.48	91.37	102.85
Route Percentage	11.16%	88.84%	100%
Panipat Sector-18 – Karnal New ISBT			
Route length	0.00	33.45	33.45
Route Percentage	0%	100%	100%
SKK (Delhi) – Panipat Sector-18 – Karnal new ISBT			
Route length	11.48	124.82	136.30
Route Percentage	8.42%	91.58%	100%

Table 2: Alignment State-wise bifurcation

S.No.	States	Under Ground (km)	Elevated (km)	Total (km)
Sarai Kale Khan to Panipat Sector-18 (Future)				
1	Delhi	6.50	29.65	36.15
2	Haryana	4.98	61.72	66.70
	Sub-Total	11.48	91.37	102.85
Panipat Sector-18 (Future) to Karnal new ISBT				
3	Delhi	0	0	0
4	Haryana	0	33.45	33.45
	Sub-Total	0	33.45	33.45
Sarai Kale Khan – Panipat Sector-18 – Karnal new ISBT				
5	Delhi	6.50	29.65	36.15
6	Haryana	4.98	95.17	100.15
	Grand Total	11.48	124.82	136.30

Integration with other Nammo Bharat Corridor Tracks: Sarai Kale Khan is designed as an interoperable station for other two Nammo Bharat corridors namely Delhi – Panipat & Delhi – Meerut and hence integration and interoperability among all three corridors will be provided at Sarai Kale Khan.

0.3 Permanent Way

1. **Track Gauge:** Standard Gauge of 1435 mm.
2. **Speed & Axle Load:** The track should fit for 160 kmph operational speed and 180 kmph design speed. The design axle load is finalized as 17 tonnes and track structure is designed accordingly.
3. **Rails:** For ballast less, track 60 kg (UIC)/60E1 Head Hardened rails procured on 18m or longer length shall be provided. These rails shall be joined by mobile flash

butt welding plant at site to provide CWR track. Switch expansion joints shall be provide as required.

4. **Sleepers/Slab:** The track on main line shall be designed to be laid as ballast less track over a suitably designed track structure at a uniform spacing of 600 mm centre to centre of fastenings.
5. In Depot area PSC sleepers at 650 mm spacing on ballasted track are proposed.
6. **Ballast:** In depot area, ballasted track with 250 mm (minimum) cushion of stone ballast below sleepers as per specifications will be provided.
7. **Ballastless Track in Tunnel:** The tunnels bored mechanically are usually of circular type. The invert of the tunnel will have to be concreted to achieve flat horizontal surface and ballast less track with necessary drainage system will be laid.

The track structure is proposed to be ballastless, proven for design speed of 180 kmph and above for main line and for connecting lines to depot is plinth type. Further, it is proposed to use suitable elastic fastening system for both types of ballastless and ballasted track structure complying with laid down standards. The toe load design for the clips is to be finalized at the detailed design stage.

Ballastless track structure may be adopted in such a manner so as to ensure that major governing parameters of civil structures are optimised. Moreover, it is possible to use the same/different track technologies on elevated & underground sections, to achieve the best results & meet the desired objectives.

Table 3: Proposed Track Structure

S. No.	Item	Description
1	Rails	60 kg UIC head-hardened rails on main line and 60 kg 90 UTS rails for the depot area
2	Track Structure	Ballast less track will be provided on elevated and tunnel sections with fastening spacing at 600 mm centre to centre or as per detailed design. In depot area, Ballasted track with 250 mm (minimum) cushion of stone ballast below sleeper as per RDSO specifications (as applicable)
3	Sleepers	PSC Sleepers at 650 mm centres on ballasted track in depot area
4	Points and Crossings	1 in 9 Points and Crossings, canted on running lines. 1 in 7 points and crossings canted in depot lines and yards All turnouts will be provided with weldable CMS crossings and thick web switches.
5	Rail Cant	Canted (tilted inward) at a slope of 1 in 20

0.4 Station Planning and Transit Oriented Development

0.4.1 Station Planning

6-Coach Stations are planned for the corridor. Station box dimensions would be approximately 140 m in length for elevated stations and approximately 187 m (including 1 m Diaphragm walls on both sides) in length for underground stations, which may vary as per site context and operational requirement. The width of every station varies depending on the peak hour passenger traffic figures, operational requirements, and number of rail tracks provided.

At the concourse level, all stations have ticketing facilities and entry/exit turnstiles at extremities along the length to enable division into unpaid and paid areas. The unpaid area is where commuters enter the facility, and use retail services like ticketing on ground

level, whereas the paid area in the concourse and the platforms are the areas where the passengers can go only after purchase of tickets. The paid area begins with entry/exit turnstiles at extremities along the length. Additionally, the restricted zone comprises station operational areas such as the Station Control Room, Station Master's Office, Staff Accommodation, Plant, Signalling and Operations Rooms, Heating Ventilation Air Conditioning (HVAC) handling units, etc.

Station Typologies: The type of station at each location is determined based on specific requirements. Various facilities have been identified and incorporated at each station. Platform size is assessed at each station considering passenger load and expected train length. Stations are designed to include provisions for commercial spaces to generate revenue. Public areas, comprising platforms, concourse, vertical circulation, and property development, have been envisaged within the station layout along with operational areas. Additionally, planning consideration for Multimodal integration, interchanges with existing transit modes parking, drop-off points, entry/exits, subways, and foot overbridges/ Subway have been envisaged within the station premises.

The Namo Bharat corridor will have Two (2) numbers of underground stations and Nineteen (19) numbers of elevated stations including Four (4) stations provisioned for future and excluding Sarai Kale Khan station (part of Delhi Meerut Namo Bharat corridor).

Table 4: Station Details (Delhi-Panipat-Karnal Namo Bharat Corridor)

Station Names	Station Type	Centre line Chainage in (km)	Inter Station Distance in (km)	No of Tracks	Platform Type
Sarai Kale Khan	Elevated	-0.52	-		
Indraprastha	Elevated	3.25	3.777	2	2 Side
Kashmere Gate	Underground	9.439	6.189	2	1 Island
Jharoda Majra	Elevated	16.389	6.940	2	2 Side
Bhalaswa	Elevated	20.756	4.377	2	2 Side
Alipur	Elevated	30.007	9.251	2	2 Side
Narela	Elevated	33.712	3.705	2	2 Side
Kundli	Elevated	39.336	5.624	2	2 Side
*KMP (Future Station)	Elevated	43.910	4.574	-	-
Bahalgarh	Elevated	47.871	3.961	2	2 Side
Murthal	Elevated	55.347	7.476	2	2 Side
Murthal Depot (Non passenger facility)	-		-	-	-
*Barhi (Future Station)	Elevated	64.057	8.710	-	-
Ganaur	Elevated	68.461	4.404	2	2 Side
Samalkha	Elevated	80.502	12.041	2	2 Side
Panipat ISBT Sewah	Elevated	91.616	11.114	2	2 Side
Panipat	Underground	97.216	5.600	2	1 Island
Panipat Sector-18 (Future)	Elevated	102.288	5.072	-	-
Ganjbar-Badauli-Kohand	Elevated	107.470	5.182	3	1 Side & 1 Island
Gharaunda	Elevated	113.902	6.432	2	2 Side
Karnal Bypass (Future)	Elevated	120.310	6.408	-	-
Karnal Sector-7	Elevated	130.241	9.931	2	2 Side
Karnal new ISBT	Elevated	135.803	5.562	2	2 Side

0.5 Multimodal Integration: Integration with other modes of transport will be provided at the following locations:

Table 5: Table showing Integration with other modes of transport

Namo Bharat station	Mode of transport with which integration provided
Sarai Kale Khan	Sarai Kale Khan Metro Station on Pink Line of Delhi Metro, Hazrat Nizamuddin Railway station of Indian Railways and Sarai Kale Khan ISBT.
Indraprastha	Indraprastha Metro Station on Blue Line and upcoming extension of Green Line (in Phase-IV) of Delhi Metro network
Kashmere Gate	Kashmere Gate Metro Station on Red, Yellow and Violet Line of Delhi Metro and Kashmere Gate ISBT.
Jharoda Majra	Jharoda Majra Station on upcoming extension of Pink Line (DMRC Phase-IV) of Delhi Metro.
Bhalaswa	Bhalaswa Station on upcoming extension of Magenta Line (in Phase-IV) of Delhi Metro network.
Kundli	Nathupura Metro Station of upcoming extension of Red Line (in Phase-IV) of Delhi Metro Network.
Ganaur	Bus Stand
Samalkha	Bus Stand
Panipat ISBT Sewah	Panipat ISBT
Panipat	Panipat Railway Junction
Gharaunda	Gharaunda Bus Stand
Karnal	Karnal New ISBT

Feeder Buses: 45 routes with 315 AC Electric Feeder buses have been proposed.

0.6 Rolling Stock

After examining various options for the size, seating capacity, number of doors etc, the broad details of the EMU type rolling stock were finalized for Namu Bharat corridor. These are given in the table below:

Table 6: Details of the proposed Namu Bharat Rolling stock

S. No.	Parameter	Details
1	Gauge (Nominal)	1435mm
2	Traction system	
2.1	Voltage	25kV AC
2.2	Method of current collection	Overhead Current Collection System
3	Train composition:	
3.1	6-car Train:	DMC-TC-MC=MC-TC-DMC
4	Coach Body	Stainless Steel/Aluminium
5	Coach Dimensions	
5.1	Height	4.12 m (approx.)
5.2	Width	3.2 m
5.3	Length over body (approx)	
	Driving Motor Car (DMC) / Trailer Car (TC) / Motor Car (MC)	22.34 m
	Maximum length of coach over couplers/buffers:	23m (depending upon Kinematic Envelop and SOD) *The length of the driving cars may increase beyond the specified value by maximum 2.5 m
5.4	Locked down Panto height (if applicable)	4120 mm (approx.)

S. No.	Parameter	Details
5.5	Floor height (approx.)	1180 mm (to be decided during design stage)
6	Designed- Passenger Loading	
6.1	Design of Propulsion equipment	8 Passenger/m ²
6.2	Design of Mechanical systems	10 Passenger/m ²
7	Carrying capacity- @8 standees/sqm	
7.1	Coach carrying capacity	
	DMC	300 (seating – 60; standing – 240)
	TC/MC	332 (seating – 72; standing – 260)
7.2	Train Carrying capacity	
	6-Car train (Namo Bharat Train)	1928 (seating – 408; standing – 1520)
8	Weight (Tons)	
	Tare weight (approx.)	
8.1	Driving Car	44
	Non-Driving Car	44
8.2	Passenger Weight in tones	@0.065 T per passenger Further 0.015 T Luggage weight to be considered for 1/3 rd of passengers
	DMC	21.00 (@ 8 persons per sqm of standee area)
	TC/MC	23.24 (@ 8 persons per sqm of standee area)
8.3	Gross weight in tonnes (approx.)	
	DMC	65.00 (@ 8persons per sqm of standee area)
	TC/MC	67.24 (@ 8persons per sqm of standee area)
9	Axle load (T) (@8 persons per sqm of standee area)	16.62 (System should be designed for 17T axle load for carrying passenger @8 person/sqm of standee area during peak hour between certain sections)
10	Maximum Train Length – Approximate	
10.1	6-car trainset	≈138m
11	Speed	
11.1	Maximum Design Speed	180 kmph
	Maximum Operating Speed	160 kmph
12	Wheel Profile	Wheel profile shall be decided by the manufacturer/supplier
13	Noise Limits (ISO 3381and 3095 -2005) Vibration (ISO-2631-1 1997, ISO 2631-4 2001)	
13.1	Interior Noise Level	
13.1.1	Stationary (Elevated and at grade)	
	(a)All cars except in driving console	LpAEq20sec 68 dB(A)
	(b)Driving console	LpAEq20sec 68 dB(A)
13.1.2	Stationary (Underground)	
	(a)All cars except in driving console	LpAEq20sec 75 dB(A)
	(b)Driving console	LpAEq20sec 72 dB(A)

S. No.	Parameter	Details
13.1.3	Running at 160 kmph (Elevated and at grade)	
	(a)All cars except in driving console	LpAEq20 sec 75 dB(A)
	(b)Driving console	LpAEq20 sec 78 dB(A)
13.2	External Noise Level (At 7.5 m from centreline of track)	
	Stationary	LpAEq20sec 67 dB(A)
	Running at 160 kmph	LpAEq20sec 89 dB(A)
14	Average Acceleration (0-40 kmph) (0-120 kmph) (0-160 kmph)	1.00 m/s ² @ 8 person/sqm 0.50 m/s ² @ 8 person/sqm 0.35 m/s ² @ 8 person/sqm
15	Service Brake Deceleration	1.0 m/s ² @8 persons/sqm
	Emergency brake	1.2 m/s ² @8 persons/sqm
16	Type of Bogie	Fabricated
17	Secondary Suspension springs	Air
18	Brakes	<ul style="list-style-type: none"> • An electro-pneumatic (EP)service friction brake • An electric regenerative service brake • Provision of smooth and continuous blending of EP and regenerative braking • A fail safe, pneumatic friction emergency brake • A spring applied air-release parking brake. • Tread Brakes/disc brake • Brake Electronic Control Unit (BECU)-Independent for each bogie
19	Coupler	
	Driving Cab end of cars	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
20	Detrainment Door	Saloon Doors nearest to the end coach
21	Type of Doors	Bi-parting plugged type
22	Lighting	LED based with dimmer control
23	Passenger Seats	Cushioned
24	Cooling	
24.1	Transformer	Forced
24.2	CI&SIV	Self/Forced
24.3	Traction Motor	Self-ventilated/Forced Cooled
25	Control System	Train based Monitor & Control System (TCMS)
26	Traction Motors	3 phase VVVF controlled
27	Temperature Rise Limits	
27.1	Traction Motor	Temperature Index minus70°C
27.2	CI&SIV	10°C temperature margin for Junction Temperature
27.3	Transformer	IEC specified limit minus20°C
28	HVAC	-Cooling, Heating & Humidifier (as

S. No.	Parameter	Details
		required) -Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
29	PA/PIS including PSSS (CCTV)	Required
30	Passenger Surveillance	Required
31	Battery	Ni-Cd
32	Headlight type	LED
33	Coasting	10% (Run time with 10% coasting shall be the 'Run Time in All out mode plus 10%')
34	Gradient (max)	3% (Normal) 4% (Exceptional)
35	Sharpest Radius	Bogie shall be able to negotiate 300 m (in Mainline)
36	Signalling	ETCS level 2 with hybrid level 3 functionality

0.7 Signalling & Train Control System

Signalling CATC system will be ETCS Level 2 with Hybrid Level 3 functionality over LTE Communication Backbone in 700 MHz band. The spectrum for LTE Communication is 5 MHz (paired) in 700 MHz band (Band 28). Hence all references of GSM-R/TETRA/LTE-R to be replaced with LTE.

ETCS Level-2 and LTE support interoperability, which ensures interoperability of Rolling Stock across corridors and enables International Competitive Bidding for future corridor extensions. ETCS Level-2 with LTE radio is already implemented on Delhi Meerut Corridor, hence ETCS Level-2 with LTE will ensure seamless movement of trains between both corridors. The track layout of terminal stations and intermediate stations is also a key parameter for the minimum headway feasibility.

The latest available version of above technologies will be finalized at the time of tendering.

0.8 Platform Screen Doors/Gate

The Platform Screen Gate system shall provide a barrier between the track and the platform accessible to passengers. The system shall improve the safety of passengers by isolating the platforms from the track unless there is a train stop at its correct position. The PSG system shall be around 1.5 m in height at elevated stations & full height in underground stations. It shall consist of sets of doors installed along the full length of the platform.

The PSG system shall comprise Automatic Sliding Gates (ASG), Platform End Doors (PEDs), Emergency Escape Doors (EEDs) and Fixed Screens (FSs) to form a barrier along the edge of the platform adjacent to the track. Platform Gates shall correspond to the location of each of the train doors when the train has docked at its correct position. Each platform end shall be closed by a Platform End Door. The remaining portion of PSG facade shall be provided with manually openable Emergency Escape Doors and Fixed Screens.

0.9 Telecommunication System

The Telecommunication System acts as the communication backbone for Signalling systems and other Systems such as AFC, SCADA etc. and provides Telecommunication services to meet operational and administrative requirements of Namo Bharat Corridor.

The Telecommunication facilities proposed are meant for Supplementing the Signalling System for efficient train operation.

1. Exchange of managerial information
2. Crisis management during emergencies
3. Passenger information System

The proposed telecom System of the Namo Bharat corridor will cater to the following requirements:

- Continuous Digital Train Radio System LTE (For Voice, Data and Signalling Requirements)
- Backbone Data Transmission system (DTS) using Optical Fiber Cable (OFC)
- Ethernet & WAN Network.
- Station to Station dedicated communication.
- Telephone System with Telephone Exchanges, Telephones, Emergency Phone and their Recording.
- Centralized Voice Recording System (CVRS)
- Centralized Master Clock System
- Closed Circuit Television (CCTV) System
- Passenger Information & Display System (PIDS) within the station and Display from Central Control to each station, Passenger Announcement System (PAS)
- Access control and Intrusion detection system (ACIDS)
- Data Channels for Signalling, T-SCADA, Automatic Fare Collection etc.
- Network Management System
- OA/IT (Office Automation/Information Technology) system
- Telecom Supervisory Control and Data acquisition system (T-SCADA)
- Facial Recognition System (FRS)
- Cables for Telecommunication Systems

0.10 Fare Collection

The proposed AFC system will be of QR code based printed tickets / Contactless smart Card type.

It is proposed, the smart NCMC (National Common Mobility card) for implementation of AFC system in Namo Bharat. The AFC system as per the guidelines issued by Govt of India will enable seamless travel by different metros and other transport systems across the city besides retail shopping and purchases.

The AFC system will support the EMV (Europay, MasterCard, and Visa) and RuPay based open loop ticketing following the NCMC standard model for interoperability with other operators by use of non-proprietary standard so that the interface is scalable to other networks (transit operator/ retail outlets/parking/Toll etc) in Delhi (NCR). The AFC

equipment will support EMV, RuPay, QR, NFC (Near field communication) based ticketing, integration of clearing house, smart card host system of Financial.

0.11 Power Supply and Traction System

It has been proposed to adopt 25 kV AC single phase 50 Hz overhead catenary traction systems. 25 kV, pre-sagged Flexible Overhead Equipment (OHE) is proposed to be provided in the complete elevated section and tramway type OHE in depot. For 25 kV AC flexible OHE system, it is proposed to use Copper Silver (CuAg) contact wire and Copper Magnesium (CuMg) Catenary wires.

Power Demand: The total projected power demand for the various horizon years is as follows.

Table 7: Projected Power Requirement

Description	Section Name	Unit	Year			
			2030	2041	2051	2054
Traction Power requirement	Sarai Kale Khan – Panipat Sector-18	MVA	36.73	51.47	64.22	67.96
	Panipat Sector-18 – Karnal New ISBT	MVA	3.98	5.96	5.96	7.95
Auxiliary Power requirement	Sarai Kale Khan – Panipat Sector-18	MVA	14.74	15.36	16.97	19.20
	Panipat Sector-18 – Karnal New ISBT	MVA	4.46	4.46	5.02	5.57
Total Power requirement	Sarai Kale Khan – Panipat Sector-18	MVA	51.47	66.82	81.18	87.15
	Panipat Sector-18 – Karnal New ISBT	MVA	8.43	10.42	10.98	13.52
Grand Total	SKK – Panipat – Karnal Corridor	MVA	59.9	77.24	92.16	100.67
	Rounded off	MVA	60	77	92	101

Energy Requirement: The total energy requirement per year, traction as well as auxiliary, for the various horizon years, is as follows:

Table 8: Total Energy requirement in Million kWh

Purpose/Year	Section Name	2030	2041	2051	2054
Traction requirement	Sarai Kale Khan – Panipat Sector-18	168.37	240.08	297.51	312.59
	Panipat Sector-18 – Karnal New ISBT	17.37	22.58	29.96	32.57
Auxiliary requirement	Sarai Kale Khan – Panipat Sector-18	31.24	32.70	36.50	41.76
	Panipat Sector-18 – Karnal New ISBT	10.51	10.51	11.83	13.14
Total requirement	Sarai Kale Khan – Panipat Sector-18	199.61	272.68	334.01	354.35
	Panipat Sector-18 – Karnal New ISBT	27.88	33.09	41.79	45.71
Grand Total	SKK – Panipat – Karnal Corridor	227.49	305.77	375.80	400.06
Rounded off	SKK – Panipat – Karnal Corridor	227	306	376	400

Source of Power Supply

The Electric Power required for train operation and auxiliary purposes is required to be sourced from the 05 RSS planned in SKK – Panipat Sector-18 section, and 01 RSS planned in Panipat Sector-18 – Karnal new ISBT section of this corridor, which will be fed from Electric Power Supply Authorities of relevant States i.e., Delhi & Haryana.

Table 9: Proposed Locations of RSS

S. No.	Grid Substation (GSS)	Proposed Receiving Substation (RSS)	Approx. Distance of RSS from GSS
1.	220/66 kV Substation DTL, Gopalpur	Burari RSS	4 to 5 km
2.	220/132 kV Substation, Kundli, HVPNL	Kundli RSS	4 to 5 km
3.	220/132 kV Substation, Murthal, HVPNL	Murthal RSS	4 to 5 km
4.	220/132 kV Substation, Samalkha, HVPNL	Samalkha RSS	4 to 5 km

5.	220/132 kV Substation, Panipat, HVPNL	Panipat RSS	5 to 6 km
6.	132kV Substation, Madhuban, HVPNL	Madhuban RSS	5 to 6 km

For 220/132/66 kV RSS, approx. land requirement will be as follows:

- approx. 80 m X 50 m (4000 sqm) for Gas Insulated Switchgear (GIS) type substations.
- approx. 80 m X 100 m (8000 sqm) for Air Insulated Switchgear (AIS) type substations.

3.1 Ventilation and Air-Conditioning system

Ventilation System: Tunnel Ventilation Shafts & Mid Ventilation Shafts will be provided at each underground station and tunnel sections respectively. Tunnel Ventilation Nozzles will be required based on simulation study results at detailed design stage.

Air-Conditioning System: For elevated stations, VRV shall be used for air conditioning of technical and operational rooms. For the underground stations, chillers shall be used.
