DETAILED PROJECT REPORT – (VOLUME I)

DETAILED PROJECT REPORT FOR SILVERLINE (SEMI HIGH SPEED RAIL) FROM THIRUVANANTHAPURAM TO KASARAGOD

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1 INTRODUCTION

Kerala is the union state located in the south western part of India and is considered the 'Gateway of South India'. Kerala is one of the most scenic and popular tourist destinations in India and is among the prime states attracting the largest number of global and domestic tourists. As per census 2011, Kerala's population is 3.4 Crores and the population density of the state is about 859 persons per square kilometres, three times the national average. Kerala is one of the densest states in the country and it recorded a decadal population growth of + 4.86%. In the human development and related indices, it occupies prime position among the Indian States.

There is a widespread realization that the economic and social life in the state of Kerala suffers due to slow speed of travel on its existing highways and railways.

With capacity augmentation of existing roads beset with problems relating to limited right of way and land acquisition, improving the rail sector in the state is the best suited solution to meet the future needs of transport in the state.

With the above objective, a joint venture agreement between Ministry of Railways, Government of India and Government of Kerala was executed on 01st September 2016 for infrastructure development of Railways in the state of Kerala and Kerala Rail Development Corporation Limited was incorporated (now popularly known as K-Rail).

Accordingly, feasibility study has been conducted between Thiruvananthapuram and Kasaragod for providing a Semi High Speed Rail Corridor with potential speed of 200 kmph (known as SilverLine) by M/s Systra and report was prepared and submitted to Government of Kerala on 20th May 2019. The Feasibility Report was approved by the Government of Kerala vide order No. G.O (MS) No.43/2019/Trans dated 26th August 2019 and submitted to Railway Board for approval. The proposal of K-Rail was examined in Ministry of Railways and competent authority has accorded In-Principle Approval (IPA) for taking up pre investment activities for the above project vide RB letter No.2019/JV cell/KRDCL/SHSRC dated 17th December 2019.

2 NEED FOR SEMI HIGH SPEED RAIL IN KERALA

The road systems in Kerala, though well connected, face severe constraints due to the urban sprawl and the haphazard ribbon development all along the routes. The existing railway network and the highways in Kerala are not amenable for faster travel due to heavy traffic density and existence of sharp curves and steep gradients due to terrain conditions. The average speed of journey by rail and road in the state is about 30% to 40% lower than that in the neighbouring states.

The vehicular density in Kerala is one among the highest in the indian states with 361 vehicles per 1000 population as of March 2018 compared with the all India average of 177. Vehicular emission and noise caused by these vehicles are severe in the cities of Kerala. Road accidents, the rate in Kerala being one of the highest in the country is the major concern for the transport planners in the state.

The increasing need for movement of people and products at the local, regional, national, and international levels has placed extreme demands on transportation systems, especially in the developing world. With all existing modes of transportation getting saturated, a transportation network developed to meet the needs of earlier age, where there was less travel and less movement of materials, is ill-suited to today's needs.

In most of the major cities in Kerala, there is no space available to expand the existing highway and rail infrastructure, and there is a strong opposition against land acquisition, environmental disturbances, etc. when such expansion is proposed. One key to solve today's such transportation problems is to develop systems that meet the needs of the markets served poorly by the existing transportation infrastructure and provide a faster more efficient, reliable, comfortable, safer, affordable, least obtrusive and sustainable transport system for intra-state passengers. **SilverLine fits snugly in just such a niche: the medium-distance travel market—too far to drive and too short to fly- ideally fit for a semi high speed line.**

The planned system will provide;

- Shorter travel time between cities, 4 hours between Thiruvananthapuram and Kasaragod instead of the present 10-12 hours.
- Adequate capacity to cater to the anticipated ridership.
- Sustainable eco-friendly and energy efficient transport system.

3 OBJECTIVE, SCOPE AND METHODOLOGY OF STUDY

3.1 Prime Objectives of SilverLine

The prime objectives of SilverLine are:-

- Providing a reliable, comfortable, safer, sustainable and affordable transportation system in Kerala State to bring guaranteed improvement to the transport sector in the State and by which to improve the economy and life of the population in the State.
- Reducing the transportation time between Cities and across the State.
- Providing a model transportation system having eco-friendliness, energy prudence and economic sense so that it becomes a model system in the whole country.

3.2 Scope of Study

The scope of the study undertaken by M/s. SYSTRA include

- Studying of all data and reports available on the development and functioning of High Speed and Semi High Speed Rail systems in India and abroad.
- Conducting field traffic study to evaluate the potential and need for the line and assess the potential.
- Conducting Topographical, Geotechnical and other studies to ascertain the ground features for fixing the route and alignment and preliminary designing structures to carry the line to arrive at the optimum, economical, least obstructive alignment and design.
- Conducting land study to assess land requirements.
- Conducting Economic Impact Assessment and Social Impact Assessment study.
- Studying & recommending on the system requires in operations, Rolling Stock, Signalling and Train Control, Ticketing and Fare Collection etc.
- Evolving a Train Operation Plan and assessing the system requirements.
- Costing the project including assessing the operation and maintenance cost.
- Finally evaluating for financial and economic viability of the project.
- Recommending an Implementation scheme including funding, execution, testing & operation.

3.3 Methodology

Methodology of the study is collection of all details by engaging experts/agencies and studying them as per scope. Each action of the project will involve specific techniques and methods which will be as per international standards acceptable to the Govt. of India and Govt. of Kerala and also to the Bi-Lateral funding agencies.

4 REVIEW OF DATA AND REPORTS

With a view to arrive at the type of high speed or semi high speed rail system suitable for the Kerala's Silver Line, a thorough review of all data and reports of similar such projects in India and abroad was carried out.

4.1 World Scenario

World over, all major/developed countries are either already running high speed trains or constructing or planning high speed rail projects. Speed of development of High Speed Rail systems is increasing day by day. Table 4-1 below shows extent of high speed lines available as on December 2014.

Table 4-1: Length of High-Speed Rail Routes and Speeds

Country	Total Network Length in Kms	Test run Speed record in Kmph	Average Speed of Fastest Scheduled Train in Kmph
Belgium	214	347	237
China	19369	394	313
France	2036	574	272
Germany	1334	406	226
Italy	923	368	178
Japan	2664	443	256
Netherlands	1200	336	140
South Korea	819	355	200
Spain	3100	404	236
Switzerland	79	280	140
Taiwan	336	315	245
Turkey	1420	303	140
United Kingdom	1377	335	219
Total	**34871**		

Source: A resource book on High Speed Rail Technology compiled by Mr Gaurav Agarwal, Director (Efficiency & Research)/Mech Engg. Ministry of Railway, Govt of India.

Table 4-2 below shows the extent of high speed lines under operation/construction. A total of 23400 kms of HSR is under construction world over currently.

Table 4-2: Length of High-Speed Lines Under Construction

Country	Length under Operation (KM)	Length under construction (km)
Austria	292	210
Belgium	209	0
China	19369.8	16280
Denmark	5	60
France	2036	757
Germany	1334	428
Italy	923	125
Japan	2664	782
Netherlands	120	0
Poland	85	322

Country	Length under Operation (KM)	Length under construction (km)
Russia	1496	0
South Korea	819	585
Spain	3100	1800
Switzerland	80	57
Taiwan	339	9
Turkey	1420	1506
UK	1377	0
USA	362	483

Source: A resource book on High Speed Rail Technology compiled by Mr Gaurav Agarwal, Director (Efficiency & Research)/Mech Engg. Ministry of Railway, Govt of India.

4.2 High Speed Rail Scenario in India

Govt. of India made a vision statement on implementation of HSR in India and the following corridors have been prioritised:

Table 4-3: Proposed High Speed Rail Corridors

Sl. No.	Corridor	Total kms	Avg. Speed (Expected)
1	Pune-Mumbai-Ahmadabad	650	250 km/h
2	Delhi-Agra-Lucknow-Varanasi-Patna	991	300 km/h
3	Howrah-Haldia	135	300 km/h
4	Hyderabad-Dornakal-Vijayawada-Chennai	679	350 km/h
5	Chennai-Bangalore-Coimbatore-Kochi-Thiruvananthapuram	850	300 km/h
6	Delhi-Chandigarh-Amritsar	591	350 km/h
7	Delhi-Jaipur-Jodhpur	530	300 km/h

Source: Executive summary of DMRC DPR for High speed rail, table 0.47 cost details

The first HSR to be implemented in the country is the Mumbai – Ahmedabad HSR of 508.17 kms length at a cost of Rs.75450 crores (initial sanctioned cost) and the project has been taken up under JICA's bilateral plan.

A number of projects are presently under consideration by Govt. of India in addition to the same already included in the Vision Statement.

- New Delhi – Kanpur – Lucknow (507 kms)
- New Delhi – Agra (199 kms)
- Ahmedabad – New Delhi (886 Kms)
- Nagpur – Mumbai (753 kms)

- New Delhi – Varanasi (865 Kms)

4.3 System parameters

The system parameters such as the Gauge, Inter- distance between the mainlines, Schedule of Dimensions , Type of Track & structures, Rolling stock, Signalling, Power Supply, Ticketing and other systems are adopted from the International high speed railways as there are no equivalent specifications or standards available in our country. Based on the above, standards as under are proposed:

- Standard Gauge (1435 mm) is the International standard gauge (though IR works on BG – 1676 mm) as IR's BG is not ready for high speeds in the range of 200 Kmph or above.
- High capacity Track & Structures for High Speed & high frequency of operation will have to be provided for.
- Advanced systems such as EMU type high speed rolling stock, 2x25KV AC traction, ETCS-2 with LTE for signalling & control etc., will be included.

5 TRAVEL DEMAND FORECAST AND FARE STRUCTURE

5.1 Approach and Methodology

The traffic and transportation surveys were conducted as a part of the study to assess the passenger movement pattern, freight movement and their travel characteristics within the study area. The data collection activities included both primary and secondary data sources such as classified traffic volume counts (TVC), origin-destination (O-D) surveys, public transport terminal surveys, tourist survey, and stated preference (SP) surveys to understand the willingness to shift to proposed SilverLine and willingness to pay for the same journey. The primary surveys such as TVC survey and OD Survey were conducted at 19 locations, public transport terminal surveys at 4 airports, railway stations and bus terminals at major towns and cities, all along the project influence area. Freight data was collected from major truck operators, freight forwarders and rail parcel service offices within Kerala and at border locations. Tourism surveys were conducted at major tourist destinations of Kerala and responses from both domestic and international tourist were recorded. In addition, significant data from secondary sources pertaining to demographic, vehicle registration, toll operator data, socio-economic characteristics, public transport system etc., was also collected as part of the data collection activity.

Potential trips are by the most probable passengers who are potential customers to use SilverLine. For this study, in case of Indian Railway's trains, only AC Class, Sleeper and Chair Car passengers travelling on express trains are considered as potential users. In case of car/ taxi and bus passengers, the trips are filtered from total traffic based on trip

length. Stated Preference survey was conducted at Airports, major bus terminals, on-board buses and major trains and different class of trains along the proposed SilverLine corridor. The regional bus, train-AC, train-Non AC and AC-bus users were interviewed to appreciate the personal characteristics, travel details, willingness to pay and shift to SilverLine and opinion on preference on 6 hypothetical transport scenarios - each scenario refers to a set or combination of Travel Cost, Time and Frequency for both SilverLine and the present mode, for an average trip length of 200 km.

5.2 Traffic and Travel Characteristics

From the analysis of field traffic survey completed, it is observed that the highest traffic flow of daily 77,639 vehicles (90,382 PCUs) was observed at Paliyekkara Toll Plaza (Ernakulam-Thrissur section). The lowest flow of daily 13,213 vehicles (12,751 PCUs) was observed at Gurupadapuri (Tirur-Thrissur section). The traffic survey indicates that 11% of the total trips are having trip length greater than 200Km. The modal share reveals that, 42% are by two-wheelers, 36% by car and 5% by bus and minibus and when freight movement is considered, the modal share is 2% by multi-axle vehicle, 2% by 2Axle trucks, 5% by LCVs and 2% by Goods Auto and remaing by other passenegr and goods vehicles. The peak hour of cumulative traffic at most of the locations were observed between 5.00 P.M and 6.00 P.M followed by 6.00 P.M to 7.00 P.M. The average peak hour factor was observed to be 6.68% and the observed average peak hour PCU is 2419.

5.3 Modal Shift

Mode wise binary logit models which give the probability of shifting from existing alternatives to SilverLine were developed using the preferences indicated by the respondents. The estimated potential trips and the % of probability of shift to SilverLine is provided in the table below for the base year 2019-20.

Table 5-1: Probability of Shift to SilverLine

Sl.No.	Class Type	Potential Trips	Prob Shift	Base Trips
1	1 AC	116	24.90%	29
2	2AC	3094	34.20%	1058
3	3AC	15535	38.80%	6028
4	SL	73230	10.30%	7543
5	AC Bus	38639	26.00%	10046
6	Non-AC Bus	49803	9.70%	4831
7	Car	158271	12.00%	18993

5.4 Estimated Daily Ridership

For all the future estimations, base year was considered as 2019-20, commissioning year as 2025-26 and horizon year as 2052-53. The traffic projection covers upto 50 year (2072-73) period. Elasticity approach (elasticity based econometric model) is used for future traffic forecasting which takes into account the elasticity of transport demand and

probable pattern of future growth of the economy (regional - India and local - Kerala). The daily ridership was estimated for four different scenarios as Pessimistic, Business-As-Usual, Realistic and Optimistic built-up based on variations in parameters such additional infrastructure developments, additional traffic generated, growth rates based on all India GDP and difference in mode-wise probability of shift from potential trips. The daily ridership was observed to be varying between approx. ~54,000 daily trips in worst scenario to ~1,14,000 trips in optimistic scenario in 2025-26.

The realistic scenario is expected to generate approx. ~79,934 daily trips in 2025-26 (including trips from airports, feeder service and TOD). The daily ridership estimate for the realistic scenario is provided in table below: -

Table 5-2: Estimated Daily Ridership – Realistic Scenario

Year	Total Daily Ridership (from Existing modes)	Total with Airport trips	Total with Airport trips and Feeder	Total with Airport trips, Feeder and TOD
2025-26	65339	71779	76667	79934
2029-30	78478	85421	91150	94672
2041-42	112315	120916	128580	132944
2052-53	134665	145018	153694	158946

Regarding connectivity with airports, Kochi airport is proposed during the commissioning year itself and for Thiruvananthapuram, it is proposed to be developed at later stages, once demand arises. The sectional loads in the stretch between Thiruvananthapuram to Kozhikode is observed to be very high.

Apart from the above, demand assessment for operating tourist trains, sleeper trains and introducing restaurant car was also conducted and observed that there is potential for operating tourist trains but on lease model and also for sleeper trains by private operator. But sleeper train requirement was observed only for weekends trips and not on daily basis. These two services on PPP model can generate additional revenue. Introduction of restaurant car in trains was found to be unviable from revenue generation perspective. However, to make the journey attractive to the SilverLine users, it is recommended to provide good quality and high-end restaurant type food through any reputed catering agency. This will also generate additional revenue in the form of Catering license fee.

RORO service if implemented through SilverLine is expected to carry daily 445 trucks in the commissioning year and 693 trucks in the horizon year. RORO is proposed to be operated during off-peak hours and night hours. But due to operational issues, the maximum trucks that can be carried by RORO is capped at 480 daily trucks.

5.5 Recommendations

To improve the ridership during the operational years, following planning and policy interventions are recommended: -

a) Multi-modal integration: All SilverLine stations are recommended to be developed on multi-modal integration concept, in which users from silver-line, road, rail and other modes can interchange modes with ease, conflict free and faster transfer.
b) SilverLine to be part of mobility network: SilverLine is not to be treated as an independent transport system and should be integrated and shall form part of larger mobility network in Kerala involving, rail line, air, road, water and NMT networks. Within the network, SilverLine to be of highest hierarchy. Comprehensive mobility plans/regional mobility plans to be prepared in all districts in line with SilverLine.
c) Provision of park and ride facilities at SilverLine stations.
d) Provision of city feeders to provide accessibility from SilverLine stations to nearby city centres – Central Business Districts (CBD) and other catchments.
e) Conducting periodic traffic surveys: traffic surveys including opinion surveys are to be conducted just before commissioning to re-establish the ridership estimates, fares and also every 3 years (minimum) during operational years.

6 ROUTE SELECTION AND CONNECTIVITY

The aim of the team has been to design a techno-economic alignment based on the route connecting important locations finalized based on the Feasibility Report already approved by Govt. of Kerala and various discussions held with local forums, Railway and other Govt. authorities and falling at the most appropriate locations. Connectivity to all important districts and cities and activity centres will have to be ensured while keeping the prime objective of the SilverLine to provide shorter run-time between the destinations and an affordable, safer, comfortable, sustainable and greener corridor in focus. The selected route, accordingly, touches Thiruvananthapuram, Kollam, Chenganur, Kottayam, Ernakulam, Thrissur, Kozhikode, Kannur and Kasaragode along the alignment which is the most traffic demanded route in the state presently.

Options for routes were studied within the parameters specified. Coastal route via Kayankulam, Allapuzha and Kochi, though would have been marginally cheaper being a straight and level alignment, was not favoured for specific reasons like it would not serve the needy majority of the population being at the extreme edge of the state apart from being a difficult alignment passing through back waters (kayals), river mouths and being too close to coastal regulatory zones and becoming vulnerable to coastal induced corrosion. On the other hand, a hilly route on the slopes of western ghats via Pathanamthitta and Idukki would have been equally or more difficult and too costly apart from being a less popular and useful route.

The following have been the main factors which played an important role while designing the alignment.

- Difficult terrain and geology of the state

- Design the alignment connecting important locations of the project
- The dispersed urban population in the state, with even the biggest cities having less population
- Cost of the land required for the alignment and stations
- Alignment to pass through mid of the catchment of the population to the best extent

In the process of tuning and refining the alignment, main considerations are-

- It should be functional to achieve the main pupose of speed and time
- It should not affect the haibitated areas to the best extent
- It should be economical and viable

6.1 Parameters for Finalizing the Alignment:

The alignment has been prepared keeping in focus all the basic technical requirements for a SilverLine along with techno-economic considerations. To cut down land requirement as much as possible, cause less dislocation for the population in congested areas, cause least hindrance to the movement of people and vehicles on the roads, highways and streets, boats and ferries in the canals and backwaters we have adopted the following strategies;

- Bank height limited to 9 m in normal cases
- Cutting depth up to 9 m normally
- Cut & cover has been considered for depth exceeding 9 m and tunnel if the depth is more than 20 m and have adequate cover.
- Proposed formation level must be kept at least 1m above the HFL.
- Right of Way (ROW) for embankment to reduce in city centres where land is extremely costlier by installing precast short RC retainers.

In addition to above, following basic principles of the design of alignment has been adopted;

(i) Alignment has to be economical,
(ii) Easy and fast to construct,
(iii) To be built at safe level to avoid any submergence of the track during the flood,
(iv) Safe from land slide in cuttings or failure of embankment during operation,
(v) To serve the traffic potential areas based on obligatory points of the project identified, and
(vi) To serve the important Railway stations and Airports as much as possible to have the integration for transit passengers.

6.2 Economical design adopted

Based on the important locations identified along with the tentative route, to economise the cost of the project, default choice has been to keep most of the alignment in bank or cutting. Viaduct of nominal single height of about 8-15 m has been considered wherever required as per site constraints as discussed with K-Rail from time to time during various presentations of the alignment. At only unavoidable locations, the height of viaduct is relaxed to up to 20 m for over short stretches to avoid provisions of tunnels and to minimise the cost. Wherever feasible, the road locations has been crossed through RUBs to minimise the height of bank/ viaducts and depth of cuttings. Fine tuning of the alignment to minimise the heights of bank/ viaducts or depth of cuttings have been done based on detailed topographical survey plans and data available.

6.3 Safe, Economical and Durable Alignment

In the regions having unfavourable terrain and ground conditions, safety, economy and durability of the alignment has been ensured by avoiding;

- Landslide-prone areas and unstable hill slopes,
- Long span bridges, high viaducts and high embankments in locations having low bearing capacity,
- Tunnels in the collapsible/mixed rock strata,
- Heavy structures involving exorbitant cost,
- Costly Land, and
- Dense forests and wildlife.

6.4 Consideration for Economical Alignment Design followed in DPR

Alignment need to be proposed through the mid portion of any developing state which will fetch more passenger traffic from both the sides (East-West) of the corridor through feeder services by road across.

Availability of Moorum / gravel and good earth required for construction of the embankment is in abundance in mid Kerala. Eco sensitive zones are avoided in the proposed alignment. Very long and costlier bridges across large water bodies and backwaters are avoided. Religious/worship centres have been avoided to the extent possible.

Alignment has been carefully chosen to have straight at most of the locations. Only 1850m radius and flatter curves are falling in the proposed alignment in the midsection. Number of structures affected in this alignment is the bare minimum when compared with any other possible alignment. Trapping of land parcels are avoided and densely populated localities/ houses are eliminated by this selected alignment and only 9314

structures/families are to be relocated over the entire 530.6 Km stretch (out of 10349 structures identified approx.10% are retained by constructing protective RC wall).

In the midland alignment firmed up now, the interior of the districts will also have SilverLine connectivity. For the major bridges, linear waterway requirement gets reduced since neither major lake nor backwater nor rivers need to be crossed. Deeper foundations required in the coastal sandy terrain are also avoided and hence total cost of bridges gets reduced considerably (20-30 % of cost).

The proposed alignment has been discussed in various public forums, Chamber of Commerce, elected public representatives and elite professionals and their views have been obtained before finalizing the same.

7 ALIGNMENT, STATIONS AND DEPOTS

7.1 Alignment

The proposed alignment traverses through the important locations as explained here under;

- Thiruvananthapuram-Kollam: The alignment starts from Station Thiruvananthapuram (Kochuveli) and running parallel to existing Railway line till the existing Murukkumpuzha railway station, takes a divertion towards right passes through green fields and reaches Kollam Station near Kollam NH-66 bypass at about 7.0 kilometres away from the existing Kollam Railway Station.
- Kollam-Chengannur: The alignment further passes through green fields and reaches Chengannur Station near MC road at a distance of about 4.50 km from the existing Railway Station. On the way it crosses existing Kollam Madurai Highway (NH 744) and Kollam Punalur railway line and NH-183A.
- Chengannur-Kottayam: The alignment passes through green fields and reaches Kottayam Station near MC road at a distance of about 4.85 km from the existing Railway Station.
- Kottayam-Ernakulam: The alignment passes through green fields and reaches Ernakulam Station near Infopark at Kakkanad at a distance of about 7.8 km from the existing S.Railway Station. Enroute it crosses BPCL railway siding wherein RFO is proposed.
- Ernakulam-Thrissur: The alignment passes through green fields and reaches existing railway line and running parallel till near Angamali existing Railway Station to integrate with Kochi Airport. Thereafter it crosses the existing railway track and taking a diversion towards left side and passes through green fields and reaches Thrissur to integrate with Thrissur railway station on the left of the existing Railway Station at a distance of 500 m from the centre line of the existing station to SHSR station on southern side.
- Thrissur-Tirur: The alignment runs parallel to existing Railway line and crossing Guruvayur line and takes a diversion to the left side to Tirur through green fields and reaches existing railway line and running parallel for some distance reaching Tirur.

- Tirur-Kozhikode: The alignment runs parallel to existing railway line on LHS observing the Silver Line parameters and reaching Kozhikode Railway station and parallel to the existing line through a cut & cover and deep tunnel starting before the Kallayi river.
- Kozhikode-Kannur: The alignment runs parallel and adjacent to the existing track duly observing SHSR parameters and crossing the existing track and further running parallel to adjacent to existing up to Kannur station at distance of 1.40 Km from the existing Kannur station on the Kasaragod side. The alignment passes through green fields at Thalassery and Vadakara.
- Kannur-Kasaragod: The alignment traverses parallel & adjacent to S. Railway track upto Ch. 522.980 and crosses the same at this location below as cut & cover tunnel. Thereafter the alignment continues upto the end Ch. 530.6 to station and further beyond upto the depot.

7.2 Stations and Depots

Stations are proposed in such a manner they are located in the city centre or as close to them so that the city population can easily reach the stations located within a short distance. There are 11 proposed stations on the Thiruvananthapuram - Kasaragod SilverLine Corridor.

The Stations, RORO Station and Depots proposed in the SilverLine alignment are shown on the table below:-

Table 7-1: Proposed SilverLine Stations and Depots

PROPOSED STATION LOCATIONS					
Sl.No.	**Station Name**	**Chainage**	**Inter Station Distance in Km**	**Latitude (N)**	**Longitude (E)**
1	Thiruvananthapuram	0 + 000	0.000	8°30'44.94"N	76°53'50.63"E
2	Kollam	55 + 338	55.338	8°53'44.51"N	76°39'25.56"E
3	Chengannur	102 + 900	47.562	9°18'28.66"N	76°38'26.37"E
4	Kottayam	136 + 108	33.208	9°34'33.43"N	76°32'18.74"E
5	Ernakulam	195 + 329	59.221	10° 0'48.99"N	76°22'36.56"E
6	Kochi Airport	212 + 318	16.989	10° 9'21.98"N	76°22'51.02"E
7	Thrissur	259 + 117	46.779	10°30'31.32"N	76°12'19.67"E
8	Tirur	320 + 562	61.445	10°56'46.40"N	75°54'8.66"E
9	Kozhikode	357 + 868	37.306	11°14'49.70"N	75°46'46.89"E
10	Kannur	447 + 260	89.392	11°52'19.04"N	75°22'8.96"E
11	Kasaragod	530 + 615	83.332	12°29'27.51"N	74°59'13.30"E
Depot Locations					
1	Kollam	55 + 338	0.000	8°53'3.23"N	76°38'53.47"E

PROPOSED STATION LOCATIONS					
Sl.No.	**Station Name**	**Chainage**	**Inter Station Distance in Km**	**Latitude (N)**	**Longitude (E)**
2	Kasaragod	532+118	476.780	12°30'45.59"N	74°58'21.03"E
RORO Loading Points					
1	Thiruvananthapuram (Kochuveli)	0+924	-	8°31'6.24"N	76°53'29.83"E
2	Kollam	55 + 338	54.414	8°53'44.51"N	76°39'25.56"E
3	Ernakulam	194+200	138.862	10° 0'20.61"N	76°22'14.11"E
4	Thrissur	241 + 160	46.960	10°22'2.96"N	76°15'0.27"E
5	Kasargod	533+115	291.955	12°30'33.22"N	74°58'28.92"E

7.3 Aggregator Stations for Future

In order to explore the possibility of getting the ridership enhanced (by having aggregator /feeder stations where in only trains of smaller compo can be run to collect passengers from smaller towns and lead them to the adjoining major stations), a detailed traffic study was conducted at the various identified potential 27 towns.

The ridership figures forecast are not encouraging at this time to have additional feeder/ aggregator stations at the identified towns having large population. Hence it is recommended that the provision of aggregator/feeder stations can be taken up at a later date after conducting detailed studies. The alignment is provided in the figure below:-

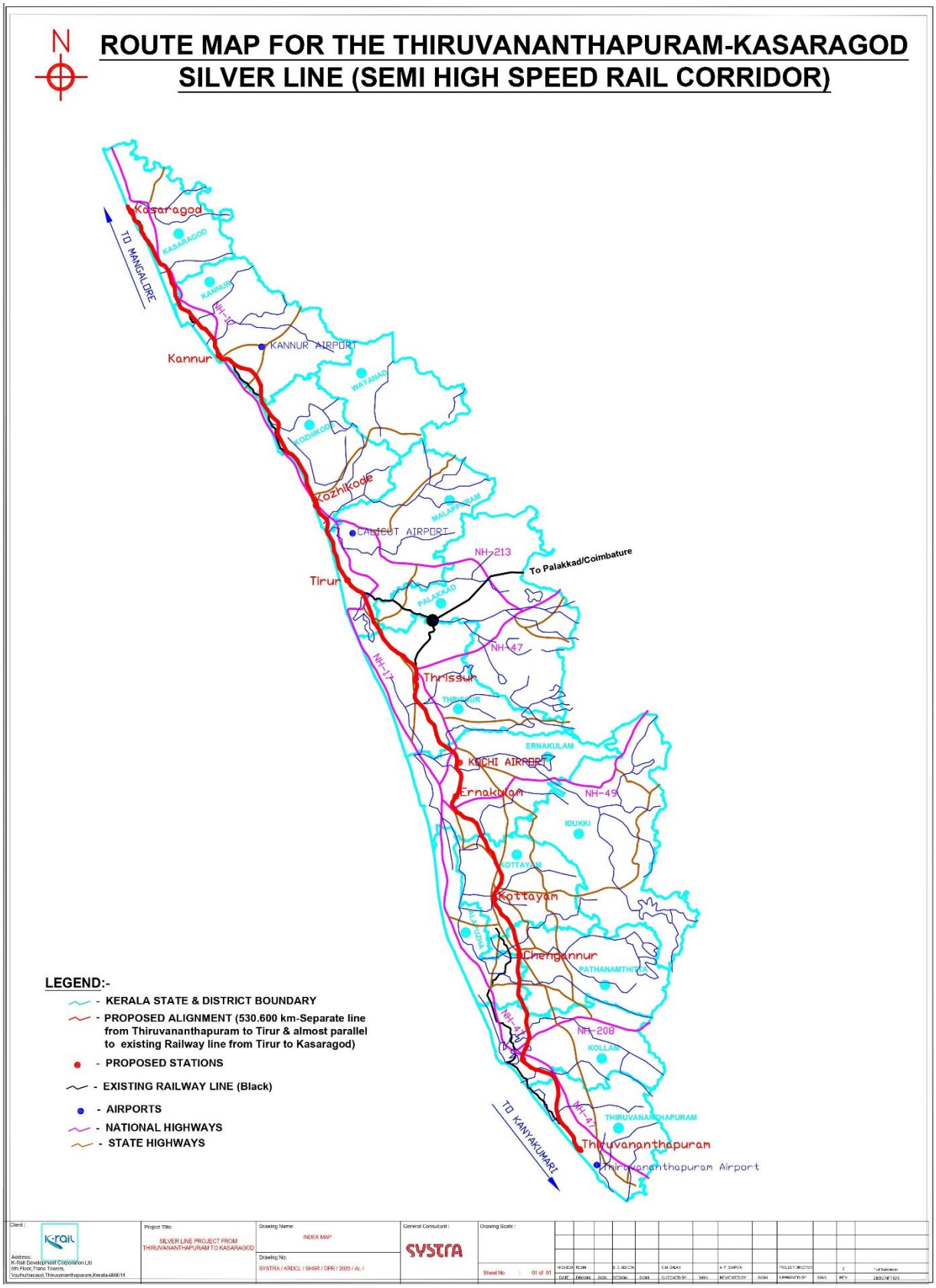

Figure 7-1: SilverLine Alignment Map

8 SURVEY AND INVESTIGATIONS CONDUCTED

The following are the surveys and investigations carried out for the SilverLine between Thiruvananthapuram and Kasaragod.

1. Geotechnical Investigation
   127 numbers of boreholes have been taken for the investigation between Thiruvananthapuram and Kasaragod at an average interval of 5km to have general idea of geology for tentative designing of the foundations for various structures like Embankments, Cuttings, Viaducts, Bridges and Tunnels for estimate purpose.
   Detailed report has been prepared and produced in the Geotechnical Investigation Chapter as an annexure to chapter 8: Civil Engineering.
   In addition, 32 borehole data collected from construction unit of Railway and K-Rail from ROB/RUB sites have also been used in the alignment design.
2. Light Detection and Ranging (LiDAR) Survey
   LiDAR Survey has been carried out between Thiruvananthapuram and Kasaragod to know the topography of the chosen alignment by conducting Aerial Lidar Survey using Aircraft.
   Detailed reports such as Digital Terrain model, Digital Elevation Model, 3D Photography Drawings and Ortho Photo pictures have been obtained and enclosed as an annexure to Chapter 8: Civil Engineering.
3. Traffic Survey.
   The data collection activities included both primary and secondary data sources such as classified traffic volume counts (TVC), origin-destination (O-D) surveys, public transport terminal surveys, tourist survey, and stated preference (SP) surveys to understand the willingness to shift to proposed Silver Line and willingness to pay for the same journey. The primary surveys such as TVC survey and OD Survey were conducted at 19 locations, public transport terminal surveys at 4 airports, railway stations and bus terminals at major towns and cities; all along the project influence area.

9 SYSTEM SELECTION

9.1 Basic Planning Parameters

The DPR for SilverLine project has been prepared adopting Standard Gauge since this project is a Standalone system, and is as per the discussions held at Railway Board. Elaborate reasoning for adopting the Standard gauge for SilverLine are discussed in the chapter 5 of Main Report (Volume II), DPR.

Basic Planning Parameters used for DPR of SilverLine are placed in tables below:-

Table 9-1: General Basic Planning Parameters

Sl. No.	Parameters	Values
1	Operating Speed for Passenger Trains	200 kmph
2	Maximum Speed for freight trains	120 kmph
3	Maximum Static Axle Load	16.0 Tonnes for Passenger Train
		22.5 Tonnes for Freight Train
4	Spacing of Tracks	4.5m
5	Width of Rolling Stock	3.4m (Maximum)
6	Gradient	
	Ruling Gradient	1 in 60 (continuous grade to be limited to 6Km)
	Limiting Gradient	1 in 50 (Restricted to ramping in tunnel approaches or extreme site constraint locations only) (continuous grade to be limited to 3Km)
	Station Yards	1 in 660 Maximum for At-grade stations (to be reviewed again before execution) 0% (Level) for Elevated stations
7	Turn-outs for Main Line	1 in 18 in Main line for all the first passenger loops and for Aggregator cum Passenger loop at Kollam connecting the Depot. 1 in 9 for other loops and sidings including RORO.
8	**Horizontal Curves**	
	Minimum Permissible Radius	1850m
	Limiting Radius for Station approaches	650m within 2km from station
9	**Vertical Curves**	
	Desirable Radius	17500m
	Limiting Radius	10000m
	Vertical curve length	60m minimum
10	Width of Formation	12.0 m

Sl. No.	Parameters	Values
11	Right of Way considered for permanent acquisition	15.00m for viaduct 25.00m for cutting 20.00m for embankments
12	Tunnel Cross-Section Area	80.0 m^2 (Width 12.75m), (Height 10.0129.50m)
13	Desirable minimum Gradient in Tunnels and Cuttings (with summit vertical curve for easy drainage)	1 in 400
14	Clearance below Viaducts	National and state highways 5.5m. For minor/ other roads 3.60 m
15	Platform Length	410 m at all stations
16	Type of Traction	2x25KV AC 50Htz
17	Type of Trains	EMU Train Set with 50% - 75% (approximately) Motoring Axle Loco Hauled Freight Trains
18	Type of Signalling	ETCS-2 with LTE

The track parameters proposed are given in table below:-

Table 9-2: Track Parameters

Sl No.	Description of Track Components	Parameters
1	Rail type–main line	60 E/UIC 1080 grade HH rails conforming to UIC 60/ 60E/EN 13674, (supplied long lengths up to 250 m - which can be shipped).
2	Rail type-Depot and non –running lines	60 E1/UIC 880 grade rails conforming to UIC 60/ 60E/EN 13674, supplied in 13 m length
3	Rail type –Check rail in curves sharper than 190m radius and check rails in Turnouts	33C1 to EN 10674 -3
4	PSC sleeper spacing required for ballasted track - Main line and test track - Depot and Non-running lines	600 ±10 mm 650 ±10 mm(600mm spacing is proposed for Uniformity for easy Maintenance by track machine)

Sl No.	Description of Track Components	Parameters
5	Ballast for ballasted track at on Main lines and test Track - Size - Cushion	 50mm, well graded 350 mm
6	Ballast for ballasted track at Depot and other Non-Running Lines - Size -Cushion.	 50mm , graded 250 mm
7	Fastening system for ballasted track	High Speed Rail-Sleeper Fastenings
8	Fastening system for ballast less track	Fastening system with 4-hole type Base plates
9	Maximum Cant	160mm
10	Maximum Cant deficiency	100 mm
11	Maximum Cant excess	100 mm
12	Rate of change of cant - Normal as per EN formula - Exceptional	 50mm/sec 60mm/sec
13	Cant gradient -Normal Exceptional case	 2.25mm/m or 1 in 444 2.50mm/m

9.2 Train Operation Plan

The SilverLine Corridor System will cover 530.6 route-kilometres and revenue service is planned to start in 2025. The full build system will provide SilverLine train service to passengers from Thiruvananthapuram to Kasaragod with 10 intermediate stops including Kollam, Ernakulam, Kozhikode and Kannur among others with a maximum operational speed of 200 kmph. The SilverLine will operate primarily passenger and RORO trains. Currently the travel time using the existing Indian Railway is 10-12 Hours. The SilverLine Train Operation will reduce the travel time from Thiruvananthapuram to Kasaragod to four hours considering two minutes dwell time at all intermediate stations.

In the proposed SilverLine Corridor, the following types of rail operations are to be performed.

a. SilverLine trains service- It will be running between the 11 SilverLine stations. The operation pattern is detailed in the subsequent sections based on the traffic demand.

b. RORO Services- To utilise the infrastructure to its full extent, 'Roll on Roll off' or piggy back train running is proposed. The loco hauled trains will carry trucks in the same corridor during the lean hours in daytime and during night-time.
c. Tourist Train Services

9.2.1 SilverLine Train Operation

Based on the forecasted traffic demand, it is proposed to run full section loop and short loops to manage the traffic demand efficiently. The normal operation hours of the SilverLine Service are from 05:00 hrs to 23:00 Hrs. There are three operation loops proposed for SilverLine corridor. RORO are to be run during daytime in off peak hours and during night after stopping the passenger services. The summary of the SilverLine train operation plan is shown below.

Table 9-3: SilverLine Operation Plan Summary

Items	2025-26	2029-30	2041-42	2052-53
Train Configuration	9 Car	9 Car	9 Car+15 Car	9 Car + 15 Car
Train Capacity	675	675	675 and 1125	675 and 1125
Traffic Volume/sectional load	18560	22760	33620	40180
Number of Trips between Thiruvananthapuram to Kasaragod (Per day per direction)	18	18	18	18
Number of Trips between Thiruvananthapuram to Kannur (Per day per direction)	20	24	36	43
Number of Trips between Thiruvananthapuram to Kozhikode (Per day per direction)	37	45	58	65
Number of Trains in peak hour per direction	3	4	6	6
Headway (minimum in the line)	20 Minutes	15 Minutes	10 Minutes	10 Minutes

The RORO trains are hauled by locomotives with a maximum operational speed of 120 kmph. After the traffic analysis, it is expected to carry approximately 450-480 trucks throughout the corridor per day. To carry 480 trucks in the corridor, there shall be 6 RORO

trips in each direction per day considering 40 wagons per RORO train. It is proposed to run 3 trips during daytime in the non-peak hours and 3 trips in the night-time in each direction.

9.2.2 Rolling Stock Requirement

The SilverLine Rolling Stock Requirement is listed below:-

Table 9-4: Rolling Stock requirement for SilverLine

Year	2025-26	2029-30	2041-42		2052-53	
Rolling Stock Configuration	9 Car	9 Car	9 Car	15 Car	9 Car	15 Car
Bare Minimum RS Required	24	28	28	7	28	11
Maintenance Reserve	3	3	3	1	3	2
Operation Reserve	2	2	2		2	
Total Rolling Stock Required	29	33	41		46	
Number of Cars	261	297	417		492	

RORO service requires 6 train sets with one train set consisting of 2 Locomotives and 40 Wagons.

9.3 Civil Engineering

9.3.1 General

9.3.1.1 Geological Conditions along the SilverLine Corridor

Kerala is endowed with a variety of soils due to the climate, topography, and vegetation characteristics. Laterite and loams form the major soil types of Kerala. The other soil types developed as a result of agro-climatic variations include riverine and coastal alluvium, black soils, and problem soils like acid saline, hydromorphic, and greyish Onattukara soil.

9.3.1.2 Geotechnical Field Investigations

GT investigations were conducted for total of 127 boreholes at an average distance of approximately 5km each and other important locations, all along the length of the proposed SilverLine corridor to have the general assessment of the type the geology along the corridor. In addition, borehole data of 32 locations available with railway construction unit and K-Rail at the proposed ROB/RUB sites were also collected for use in alignment design.

9.3.1.3 List of Proposed stations on the SilverLine project

For SilverLine project based on the traffic studies and the feasibility of the station, locations, following 11 stations are planned between Thiruvananthapuram and Kasaragod as shown in the following table. In addition, two maintenance depots are also planned as detailed below:-

Table 9-5: SilverLine Stations and Depots - Chainages

Sl.No.	Station Name	Chainage	Inter Station Distance in Km
1	Thiruvananthapuram	0 + 000	0
2	Kollam	55 + 338	55.338
3	Chengannur	102 + 900	47.562
4	Kottayam	136 + 108	33.208
5	Ernakulam	195 + 329	59.221
6	Kochi Airport	212 + 318	16.989
7	Thrissur	259 + 117	46.779
8	Tirur	320 + 562	61.445
9	Kozhikode	357 + 868	37.306
10	Kannur	447 + 260	89.392
11	Kasaragod	530 + 615	83.332
Maintenance Depots			
1	Kollam	55 + 338	
2	Kasaragod	532+118	

9.3.1.4 Classification of Stations

As per the ridership and the station loads the proposed Stations have been classified into 3 categories as Class A, B and C stations depending on the importance and other requirements of the stations as described hereunder;

CLASS "A' Stations

Seven proposed stations namely Thiruvananthapuram, Kollam, Ernakulam, Thrissur, Kozhikode, Kannur and Kasaragod Stations are categorized as Class 'A' stations. All seven stations except Kasaragod station are situated in Corporations. Kasaragod station is planned as class 'A' station being the Terminal Station.

CLASS "B' Stations

Three proposed stations namely Chengannur, Kottayam and Tirur Stations are classified as Class 'B' stations. They are all situated within the Municipalities only.

CLASS "C' Stations

Kochi International Airport Station is classified as Class 'C' station.

9.3.2 Track Structures and Components

9.3.2.1 Track Geometry

The abstract of the Track Geometry is given as under;

- Gauge: Standard Gauge: 1435mm
- Dynamic Gauge: 1507 mm
- Track centres : 4.5m
- Ruling gradient: 1 in 60
- Grade Compensation on Curves : 0.4‰ per degree of curvature
- Design Speed : 220Kmph; Operating Speed: 200 Kmph
- RORO train speed: 120 Kmph
- Minimum radius of Horizontal Curve for the Design Speed: 1850m
- Radius of Vertical curve: 17500m; Minimum : 10000
- Maximum Cant : 160mm.
- Maximum cant deficiency 100 mm.
- Maximum cant excess 100 mm.

9.3.2.2 Ballast Depots

For operation and maintenance of the SilverLine project, the Ballast depots with 1.99Ha capacity are planned at the following locations which may be reviewed during implementation stage as per requirements;

a) Kollam
b) Thrissur
c) Kozhikode (West Hill station)

9.3.2.3 Track Machine Sidings

Provision has been made in the SilverLine project for providing Track Machine Sidings at the following three locations:-

1) Kollam
2) Thrissur
3) Kannur

9.3.2.4 Track Laying

There are three prevalent methods of construction of railway tracks worldwide as below:-

1) Telescopic Method
2) Tramline Method

3) Mechanical Method

The most suitable method/(s) are to be adopted for laying of ballast-less and ballasted tracks as per site suitability and economic criteria. A suitable decision is required to be taken at the time of execution or at the time of tendering.

9.3.3 Structures

9.3.3.1 Basic Policy Followed in Design of Civil Structures

- All the structures are designed for loads of Semi High Speed trains and RORO type trains.
- No level crossings across the SilverLine is allowed.
- On rail and road crossings, only grade separators in the form of ROB, RUB, RFO (Rail Flyover) are planned.
- Possible combination of loads for the loaded train in both the tracks running simultaneously in both the direction at 4.5 m centers.
- Over the maximum possible stretches, adopt construction of embankment.
- To reduce the width of land and increase the stability, it is proposed to construct the embankments with geo-mesh and geo-grid reinforcements.
- In urban areas where land is costlier and scarce, it is proposed to construct the bank using precast self-supporting retainers, RCC and RR / retaining walls.
- For bridges, standard spans of 6.10 m, 9.15 m, 12.20 m, 18.30 m etc., are proposed for adoption.
- For viaduct, to a large extent, 25 m spans are proposed though 20 m and 30 m are also recommended, based on site requirements.
- For tunnels, a single large tunnel of approximate 80 sq. m of area to accommodate both the two tracks are planned.
- Cut & cover method is proposed where grade requirements result in very deep and unstable cuttings.
- Reduction of lifecycle cost by avoiding steel bridges and maintenance free track and structural components.
- In urban conglomeration, construct viaduct to continue with the available free paths and passages.
- Durable structures to construct in order to cater to Earthquake and other natural calamities.
- Box type structures and U type girders to have more waterway and vent way wherever required.

9.3.3.2 Track Supporting Structures

The most suitable track supporting structure for SilverLine corridor may be the elevated type when considering the topographical and hydrological nature of Kerala state. Due to prolonged rainy season and intermittent rains throughout the year, At-grade construction is likely to take more time. The time of construction in At-grade sections for formation and other allied works in cutting, cut and fill and banks likely be more. Viaduct does not require massive retaining walls, compound walls and other related works the construction of which may be affected by the rains. Viaduct does not require any underpass at regular intervals as it does not divide the land use. However, to achieve an economical solution and in order to keep the cost of project minimum, use of viaduct is limited to critical and unavoidable stretches only.

Track supporting structures can be classified into following three categories;

- At Grade : Embankment and Cutting
- Underground: Cut & cover and Tunnels
- Elevated: Viaduct and bridges

On the basis of alignment Design of the SilverLine corridor with techno-economic approach, following is the combination of the proposed length of the Tunnels, Cut & cover, Cutting, Viaduct and embankment stretches for entire 533.33 km route length from Thiruvanthapuram to the entry to the Depot at Kasargod;

Table 9-6: Proportion of Total Length for Proposed Structures

Type of structures	Length (%age of route length)
Tunnels	13.62 Km (2.55%)
Bridges	10.22 Km (1.89%)
Viaducts	57.62Km (10.81%)
Embankments	327.82Km (61.51%)
Cuttings	101.22 Km (18.96%)
Cut & cover	22.83Km (4.28%)

9.3.3.3 Typical Cross Sections

The typical cross sections of embankment and cuttings are given here under;

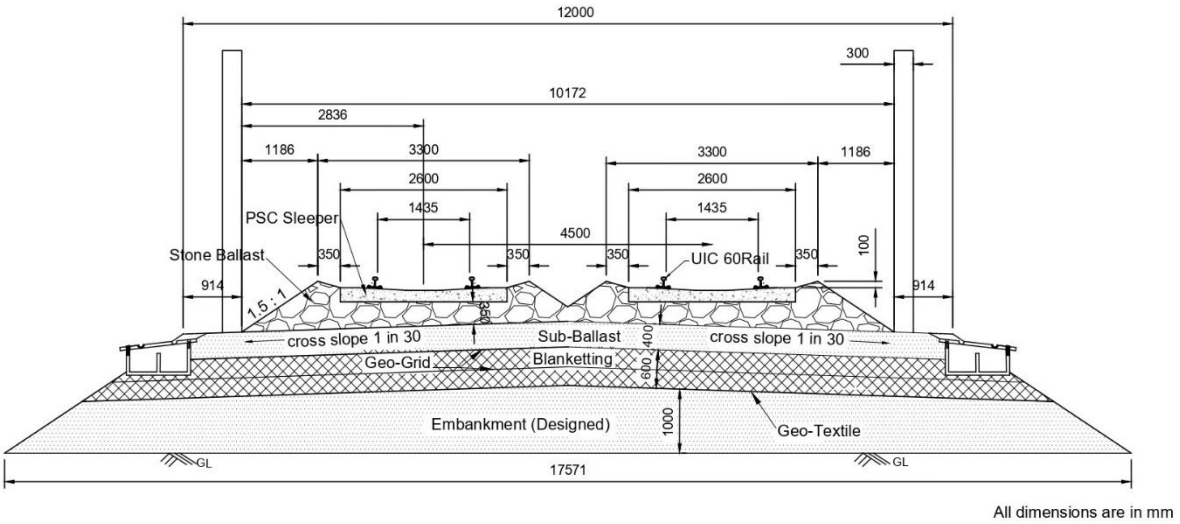

Figure 9-1: Typical Cross section of Embankment

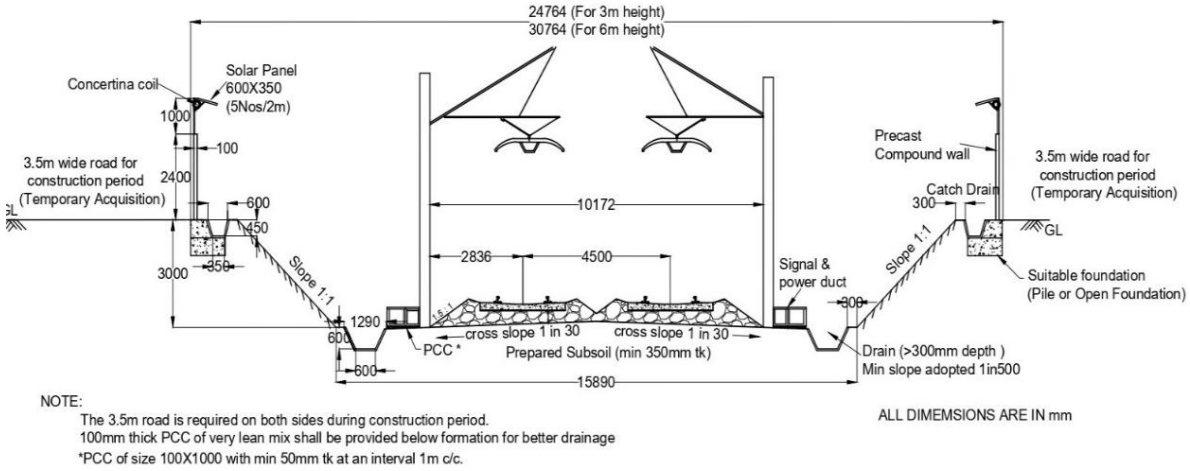

Figure 9-2: Typical Cross section of Cutting

9.3.3.4 Under Ground Structures

The main structures coming under this group are Cut & cover and Tunnel. These structures are discussed in the following paragraphs.

9.3.3.4.1 Cut & cover

The stretches with deep cuttings of more than or equal to 9m and up to 20m, cut & cover construction method is considered, with RCC box of suitable size, for the track to pass through.

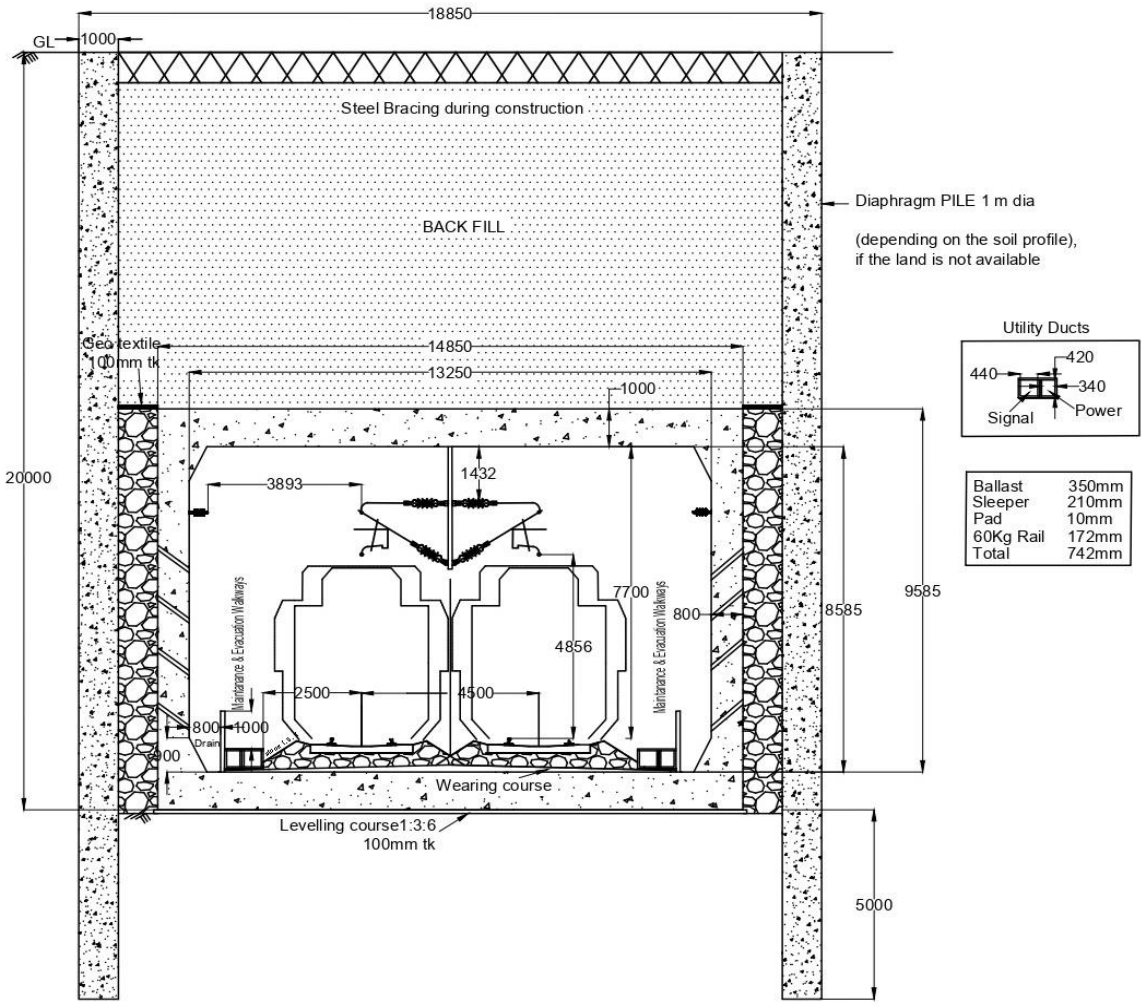

Figure 9-3: Typical section of Cut & cover structure

9.3.3.4.2 Tunnel

For SilverLine project, the tunnels have been proposed under unavoidable locations only, where the cutting is more than 20m in depth and with adequate cushion.

NATM method of tunnelling is recommended depending on the results of geological surveys on close intervals and other detailed surveys which will be carried out during actual execution. For short length of the tunnels on SilverLine corridor the best suited method is NATM, but the location where the alignment is proposed with very long length of tunnel such as in Kozhikode, TBM option can be explored due to the need of high quality construction of tunnel passing through the river and the city area. TBM is more economical when the length of the tunnel is more and in a long continuous stretch.

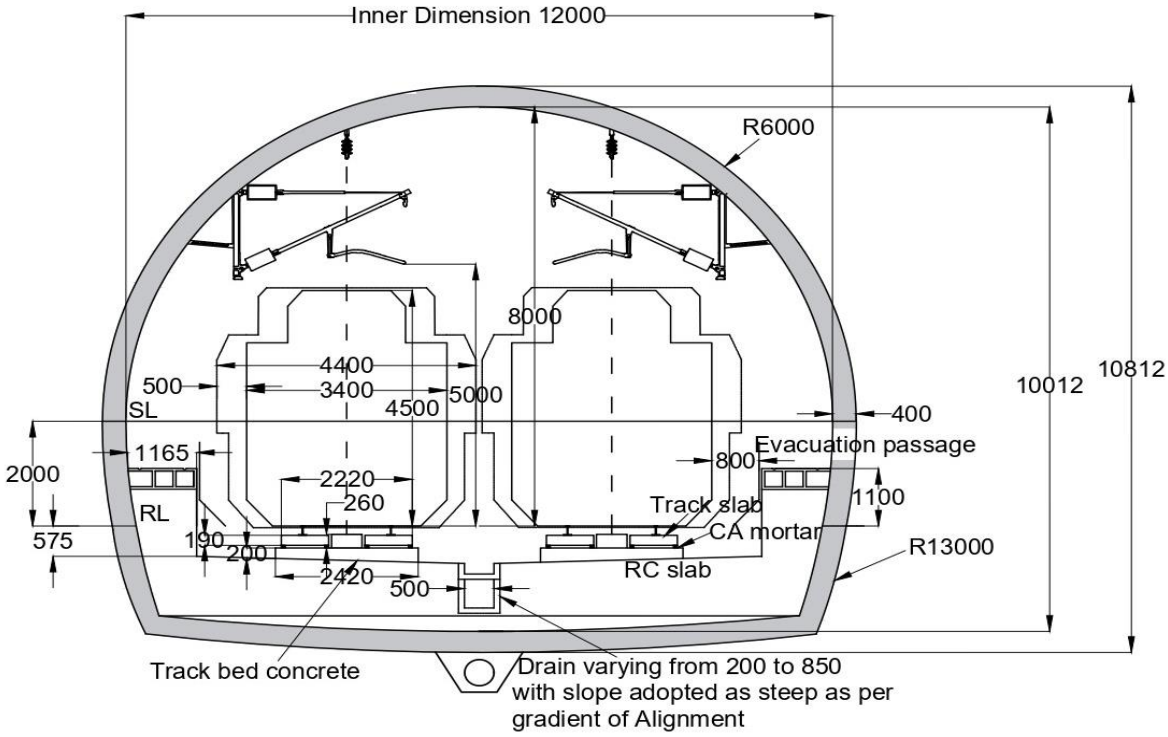

Figure 9-4: Typical Cross section of Tunnel

9.3.3.4.3 Elevated structures: Viaduct

The stretches of alignment in habitation area, low lying areas near water streams, rivers, long stretches of paddy fields and when an embankment reaches a height of 8m and more, the Viaduct has been considered to be provided suitably.

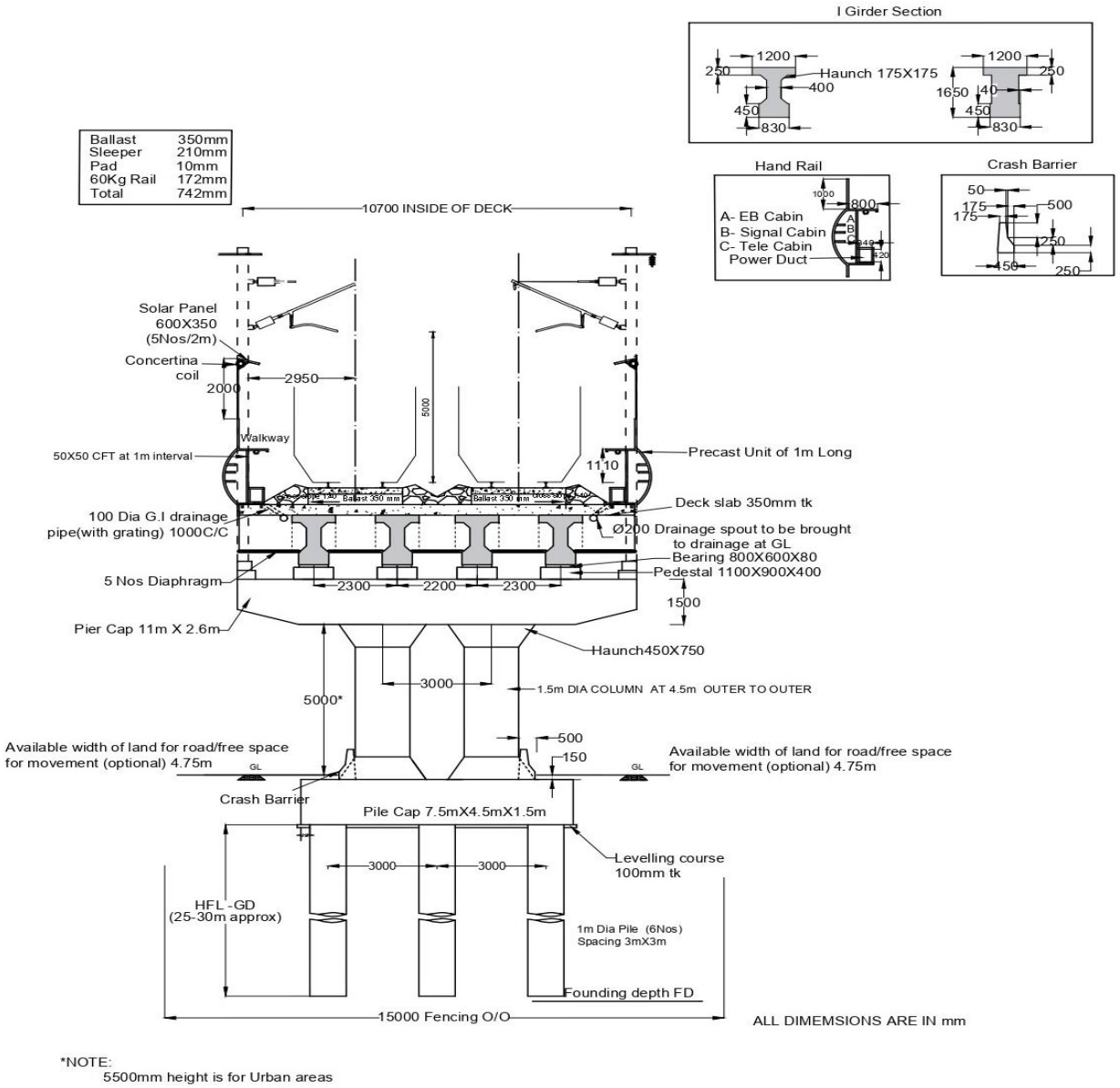

Figure 9-5: Typical cross section of Viaduct

9.3.3.5 Rail over Rail and Rail under Rail Bridges (RoR and RuR)

There are six locations where the SilverLine has to cross the existing Railway lines as detailed hereunder.

1) At Kundara Railway Station- SilverLine to cross below the existing I.Rly tracks (RuR)
2) At Ambalamugal (IOCL Siding) - RoR
3) At Angamaly Railway Station- RoR
4) Across Gurvayoor line after Thrissur- RoR
5) At Moodadi /Elathur- RoR
6) At Udma -RoR

9.4 Land Requirements and Acquisition Plan

9.4.1 Land Requirement

Land required for the alignment (Viaduct, embankment, Cutting etc.) and for stations together works out to 1383 Ha and detailed calculation is given in Chapter 15 of Volume II, Part D (Table 15-4). This includes 185 Ha of Rly land between Tirur and Kasaragod and between Kochuveli and Murukkumpuzha stations of S. Railway and the balance 1198 Ha of private land. In addition temporary land will be required for casting depots and for movements of material and machinery vehicles during construction period.

9.4.2 LA Procedures

Land acquisition involves the Govt. of Kerala acquiring the land from its owners for public purpose, subject to payment of appropriate compensation to the owners or to persons interested in the land and handing over to K-Rail for executing the SilverLine project.

The Right to Fair Compensation, Transparency in Acquisition, Rehabilitation and Resettlement Act, 2013 aims to provide fair compensation, through Rehabilitation and Resettlement of those affected, provide adequate safeguards, for their wellbeing and complete transparency in process of land acquisition.

The Right to Fair compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act,2013 Act 30 of 2013, came into force on 1st January 2014.

The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 has been enacted with the objective of ensuring just and fair compensation and rehabilitation for the affected families due to compulsory acquisition of land for public purpose.

As such, the affected families will get the award value as per the below shown tables:

1. Market value (MV) so calculated shall be multiplied by a multiplier factor as notified vide GO(P) no.646/2015/RD dated 03.12.2015. as shown below depending upon the location of land.

Table 9-7: Award value of Land for Urban Area

Sl. No.	URBAN AREA
1	Market value of land
2	Factors by which MV to be multiplied (**one)**
3	Value of assets/structure/improvements
4	Solatium 100% of (1x2)+3
5	Final Award (1 x 2)+3+4
6	Other compensation 12% additional value u/s 30(3).

Table 9-8: Award value of Land for Rural Area

Sl. No.	RURAL AREA
1	Market value of land
2	Factors by which MV to be multiplied as 1.2, 1.4, 1.6, 1.8 and 2.0
3	Value of assets/structure/improvements
4	Solatium 100% of (1x2)+3
5	Final Award (1 x 2)+3+4
6	Other compensation 12% additional value u/s 30(3).

2. Value of assets attached to land, buildings/Trees/Wells/Crops/ etc. as valued by relevant Govt. authority.
3. Solatium at 100%.
4. In addition, in each case, an amount calculated @ 12% p.a. from the date of notification of SIA to the date of award/ taking possession whichever is earlier u/s 30(3) of the Act.

As such, in order to expedite the Land Acquisition work for SilverLine Corridor from Thiruvananthapuram to Kasaragod, exclusive District level teams are to be constituted as suggested below in each district.

Table 9-9: Staff pattern of District Level Team

Sl. No.	Post	No. of Positions	Method of Appointment
1.	Tahsildar	1	On deputation from Revenue Department
2.	Deputy Tahsildar/Valuation Assistant	1	-do-
3.	Junior Superintendent	1	-do-
4.	Special Village Officer	1	-do-
5.	Village Assistant	1	-do-
6.	Surveyor Grade 1	1	-do-
7.	Draftsman	1	-do-
8.	Chainman	2	-do-
Total staff to be taken on deputation		**9**	

9.4.3 Bhoomi Rashi – A modern tool for land acquisition

For expediting the process of notification, settlement, Award etc. the software **‘’Bhoomi Rashi’’** being used by NHAI (or) similar software-based reporting and auto generation of forms may be evolved.

As a part of collection of details of land to be acquired, Kerala State Remote Sensing and Environment Centre (KSREC), a Government of Kerala organisation, is entrusted the job to collect data, field verification, verify village survey records, FMB, etc.

9.4.4 Land in 11 Districts Under Local Bodies (ULBs)

The alignment passes through 11 Districts, ie. Thiruvanthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur, and Kasaragod.

As per the alignment proposed, the total length of 530.6 km, out of which, 67%, of land falls under Panchayat area,15% in Municipal area and 18% in Corporation area.

9.5 Rolling Stock and Depot

The proposed Rolling Stock is of EMU type with distributed traction power with design speed of 220 kmph and operating speed of 200 kmph. The car body material is proposed as Aluminium because of the inheriting low weight characteristics.

9.5.1 Rolling Stock Parameters

The revenue operation of the SilverLine Corridor is planned to commence on 2025 with EMU trains having 9 Car Configuration. The configuration can be changed to 12/15 Car as per the traffic requirement arising in future. The motorisation is decided as 66% considering the acceleration and deceleration, adhesion parameters. There are two types cars in each train such as Executive car and Standard car. Executive car has 2+2 seating and Standard car has 2+3 seating. Facilities such as wheelchair area and universal toilets are specified for passengers with reduced mobility. The car body width is specified as maximum 3.4 m with length of car body as 25 m. Axle load of the Rolling Stock is limited to 16 Tonne.

9.5.2 Rolling Stock Technical Details

Rolling Stock car body should be manufactured with Aluminium based alloy. The interior floor covering shall be antiskid, firm, durable and aesthetically pleasing and it shall be easy for regular cleaning. Luggage racks and two toilets are proposed in each car. For the SilverLine Rolling Stock, Variable Voltage variable frequency (VVVF) type IGBT based propulsion system is proposed. The braking system of the EMU consists of braking control system, electric regenerative braking, pneumatic braking system electronic antiskid unit and basic braking devices, etc. Blended braking using regenerative braking and pneumatic braking is proposed for SilverLine Rolling Stock operating at 200 kmph. Each car of train is proposed to have four sliding plug type external access doors and each coach must be air-conditioned with minimum two roof mounted unit type air-

conditioning. Passenger amenities such as displays, announcement system, Wi-Fi and entertainment system are proposed in the Rolling Stock.

9.5.3 RORO Train Details

'Roll On Roll Off' service known as RORO is the rail transportation system in which trucks are loaded on the railway wagons and transport it for longer distances. The RORO trains are formed by two locomotives and 40 wagons coupled together. Two locomotives are required for hauling the train in steep gradient (1 in 60) and to maintain 120 kmph. The locomotive shall have maximum axle load of 22.5 Ton. The locomotive shall be both directions driving type. Standard gauge wagons are to be used to take the trucks on board. The maximum floor height of the wagon shall be limited to 1100 mm in order to limit the structure gauge dimensions. The wagons shall provide with flaps on end and side for loading of the trucks from both ends and sides of the wagon as per the requirement.

9.5.4 Maintenance Depots & Workshops

Depot facilities are to be provided to conduct all type of maintenance activities of the Rolling Stock. Considering different factors such as land availability, land cost and operational flexibility, the proposed SilverLine Corridor will have two depots, One at Kollam and another one at Kasaragod. The depot at Kollam will have full-fledged depot facilities to cater daily inspection, preventive maintenance, major maintenances, overhauls, corrective maintenance and other activities such as cleaning, waste disposal etc. The depot at Kasaragod will have limited facilities to cater to daily inspection and some preventive inspections, cleaning, waste disposal etc. The depot facility summary is shown below:

Table 9-10: Proposed Depot Facility Summary

Depot	Function		Inspection Classification			
	Depot	Workshop	General Inspection	Bogie Inspection	Daily and Regular inspection	Unscheduled maintenance
Kollam Depot	•	•	•	•	•	•
Kasaragod Depot	•		•	•	•	•

Machinery and Plants such as Automatic washing plant, Controlled emission centre, Water filling station, Underfloor wheel lathe etc. are provided in Depots as per the requirement. Based on the maintenance plan and the number of Rolling Stock, the following Depot service line requirement is calculated for horizon year 2052-53.

Table 9-11: Depot Service Line requirement

Depot	Inspection Bay Line (IBL)	Stabling Bay Line SHSR (SBL 400m)	Stabling Bay Line RORO (SBL-700m)	Workshop Bay Line (WBL)	Heavy Cleaning Bay Line (HBL)
Kollam Depot	5 Lines	11 Lines	2	6 Lines	1 Line
Kasaragod Depot	5 Lines	15 Lines	1	-	-

9.6 Power Supply and Traction

Un-interrupted electric power supply is essential for a Semi High Speed Rail system for running trains, Operation Control Centre, tunnel ventilation, station services (lighting, air-conditioning, firefighting and alarm system, lifts and escalators, Signaling and Telecommunications), Depot services (Inspection Shed, Workshop and Pit, wheel lathe etc.) and other maintenance infrastructure.

9.6.1 Design criteria for Power supply and Overhead Catenary systems (OCS)

As per the design parameter specified, the system is designed for running the train at a speed up to 220 kmph.The power supply and OCS system is designed to cater the speed of 250 kmph and the load requirement up to the year 2052-53.

9.6.2 Power Supply arrangement for Traction, Stations, Depot and Tunnel ventilation

An EHV supply at the voltage level of 220/110kV is to be availed from the Grid substation (GSS)/KSEBL to the various Traction Substations, distributed along the Semi High-Speed Rail corridor for train operation. In order to reduce unbalancing in the incoming supply system, it is recommended to use Scott connected transformer instead of single-phase transformer as desired by KSEBL.

A separate connection of 33kV/ 11kV is to be availed from the KSEBL to cater to the auxiliary loads of Stations and Depot.

A separate connection of 11kV/ 415V is to be availed from the KSEBL to cater the tunnel ventilation and lighting loads of SHSR

9.6.3 Power requirement

Power requirement and energy consumption for the years from 2025 to 2052, considering the traffic level projected and the train operation plan is given below:-

Table 9-12: Power demand and energy consumption

Year	Total Energy Consumption (Traction and auxiliary) in Million Unit	Power Demand (MVA)
2025-2026	279	104
2032-2033	321	119
2042-2043	427	158
2052-2053	497	184

9.6.4 Green Energy

It is planned to use 100 percentage of power from renewable sources like solar by in-house production, purchase of renewable power from third party and KSEBL to make the project as a green and Sustainable Transport System.

In SilverLine premises, the possible areas for placing the solar panels are viaducts, roof top of all the buildings (Station and Depot), compound wall of alignment and free land wherever available.

9.6.5 Feeding system adopted

The feeding system adopted for the operation of SilverLine is 2x25kV autotransformer type system.

9.6.6 Traction substations

Based on the power requirement and to achieve the desired reliability, it is decided to provide 8 numbers of Traction substations 220kV / 110kV / 2x25kV distributed along the corridor with automatic switching neutral section. This will enable to feed 2x 25 kV traction supply to the corridor with a maximum speed of 250 kmph.

Discussions were held with KSEBL authorities to determine the availability of Grid substation. Based on the discussion, the location of Grid substations is finalised.

The details of the proposed grid substations and Traction substations are given below:

Table 9-13: Proposed location of Grid substation and Traction Sub-Station

Sl. No	Location of Grid Substation	Location of Traction Substation
1	220 kV Substation ,Pothencode	Kazhakootam
2	220 kV Substation , Kundara	Kundara
3	220 kV Substation , Kottayam	Kottayam
4	110 kV Substation , Ankamali	Angamali

Sl. No	Location of Grid Substation	Location of Traction Substation
5	220 kV Substation , Kunnamkulam	Kunnamkulam
6	110 kV Substation , Chevayur	Chevayur
7	110 kV Substation , Chova	Chova
8	220 kV Substation , Ambalathara	Ambalathara

9.6.7 Types of catenary system

There are 3 types of the catenary system adopted for mainline railways and High-Speed railways

- Simple catenary system
- Simple catenary with stitch wire system (Y- stitch)
- Compound catenary system

SilverLine from Thiruvananthapuram to Kasaragod is designed to cater the speed up to 220 kmph. After detailed analysis, considering the saving in construction cost, easy maintainability, reliability and international practice for a speed potential up to 300kmph, simple catenary type OCS system is proposed for SilverLine with the speed up to 250 kmph.

The below table shows the details of the proposed system of this project:

Table 9-14: Proposed overhead equipment

Type of overhead equipment	Simple catenary
Catenary wire	120 mm^2, Cu alloy
Contact wire	150 mm^2, Cu alloy
Negative feeder	288 mm^2, Aluminium

9.6.8 SCADA and Building Management system

SCADA and Building Management system (BMS) are provided at Operation Control Centre (OCC) to monitor and control the traction and auxiliary supply and MEP services.

9.6.9 Auxiliary substation

Auxiliary substation (ASS) are to be provided at each station and depot for stepping down 33 KV/11kV supply to 415 V for auxiliary loads (lighting system, ventilation, air conditioning, fire pumps, water pumps and workshop machineries) .

9.6.10 Standby Diesel Generator (DG) sets and UPS

It is proposed to have DG sets to all stations and Depot as a backup supply in case of grid failure. The DG supply will cater the following essential services

- Essential lighting
- Firefighting system
- Lift operation
- Signalling and communication system

UPS is provided in all stations and other critical load locations to ensure uninterrupted supply to critical loads.

9.7 Signalling and Train Control System

The Signalling and Train Control system shall provide the highest security level for means of an efficient Train Control, ensuring safety in train movements. It is recommended that for Silver- Line project from Thiruvananthapuram -Kasaragod Rail Corridor be equipped with ETCS level-2 that will provide integrated, efficient, standardized, proven and off-the-shelf world-class Signalling and Traffic Control Systems.

With ETCS level 2, it is proposed to duplicate Radio Block Center (RBC), in order to provide a high level of availability to the Signalling and Train Control system. With LTE/GSM-R and RBC being fully redundant, under no circumstances the Signalling Train Control system will totally be shut down. But in case equipment of ETCS Level-2 fails and becomes unavailable, the Fallback Block system can temporarily be worked for maintenance, safety and smooth operation with the help of line side signals provided at each interlocking.

To handle increasing traffic, ensure passenger safety, and provide real-time multimedia information, a new communication system for high speed rail system is required. In the last decade, public networks have been evolving from voice-centric second-generation systems, e.g., Global System for Mobile Communications (GSM) with limited capabilities, to fourth generation (4G) broad-band systems that offer higher data rates, e.g., long-term evolution (LTE).

In order to comply with the requirements of such a high-speed rail corridor, the proven system ETCS Level -2 with LTE (Mobile Radio Communication System) is proposed to

meet requirements of Silver-Line. However, GSM-R system can be considered if the LTE (Railway) system is not matured at the time of executing this project.

Signalling and Train Control (ETCS level 2 with LTE) system of Silver-Line project in Kerala would comprise of, but not limited to, following subsystems for smoother and safer train operation:

- ETCS level-2 System with LTE
- Interlocking System (EI/CBI)
- Electric Point Machine
- Track Vacancy Detection system (Axle counter)
- Automatic Train Supervision (ATS)
- Operation Control Center (OCC) with backup OCC
- Fall-Back Block System.

9.8 Communication System

The communication system is the backbone for Signalling and Train Control system, SCADA system, Automatic Ticketing system, Safety and Security system, etc. and also provides communication service for information to passengers, Administrative management, Operation and maintenance, Emergency control etc. which are required for a high-speed rail network.

It is relevant for HSR to replace the current GSM-railway (GSM-R) technology with the next-generation railway-dedicated communication system providing improved capacity and capability. Some of the Signalling and Communication system manufacturer company has successfully completed tests to operate its range of mass transit and mainline rail control solutions with the latest Long-Term Evolution (LTE) standard for wireless data communications, commonly known as 4G. The tests were carried out with four leading suppliers with a global footprint – Ericsson, Huawei, Nokia and ZTE.

The LTE-R standard supports high speed and capacity for wireless data transmission networks and offers the ability to consolidate delivery of multi-service traffic into a single wireless network. In addition, operating rail control solutions with LTE-R will enable to enhance system stability and data encryption and security. In addition to the above, Indian railway is also going for modernisation of the signalling system with LTE in important routes. Indian Railways are processing to execute ETCS Level-2 with LTE in four different sections (Pilot projects) over Indian Railways and this work is under tendering stage now.

The Communication system for the SilverLine project in Kerala would comprise of, but not limited to, following subsystems for smoother and safer train operation:

- Long Term Evolution (LTE-Mobile Radio Communication System)
- Backbone Transmission Network (with SDH and GbEN)
- Telephone system (IP PBX exchange system)

- Centralised Digital Recording System (CDRS)
- Passenger Address System (PAS)
- Passenger Information and Display System (PIDS)
- Time Distribution System with GPS system
- Closed Circuit Television System (CCTV)
- Facility -Supervisory Control and Data Acquisition (F-SCADA)

9.9 Ticketing and Auto Fare collection System for Silver-Line

Kerala's Silver-Line project rail corridor of 530.6 km between Thiruvananthapuram to Kasaragod is planned with a design speed of 220 kmph and an operational speed of 200 kmph. The travel time will be around 4-hour. The SilverLine project is planned with 11 Nos of Station between Thiruvananthapuram and Kasaragod. SilverLine rail transit system is expected to handle a large volume of passengers. The Ticketing system shall provide world class ticketing facility to the passenger. The ticketing system shall be computerized system for effective management of the process of reservation, ticket issue and inspection with a view of improving convenience of users.

The system shall handle all functionalities of the ticketing process, management, access control, fare management, payment, financial requirements, settlement between different registered operators. The system software and hardware shall ensure, secured transaction, processing of ticket and payment using appropriate high-level security technology. The system shall ensure the ability to obtain complete and clear data backup and recovery of operation process. The Ticketing and fare collection system shall be connected on a network with a station server controlling the activities of all the local station machines. The station servers will be linked to the central computer situated in OCC through the communication backbone transmission network.

The Ticketing and fare collection system shall, as far as possible, operate using open non-proprietary, industry standards and shall be a highly reliable, scalable, secure and customer friendly facility. The system security shall include, protection against fraud, theft, falsification of data, false accounting, external threats, denial of service, eavesdropping, loss or corruption of information, masquerading (spoofing) and unauthorized access, etc.

The ticketing and fare collection system of Silver-Line Project in Kerala would comprise of, but not limited to following subsystem for providing state-of-the-art ticketing facility to the passenger:

- Central Computer System (CCS)
- Smart Card (EMV based)
- Mobile Apps/ Mobile Application
- Station Computer System (SCS)
- Ticket Office Machine (TOM)

- Ticket Vending Machine (TVM)/ Self- Service Ticketing KIOSKS
- Mobile Ticket Counter (MTC)
- Portable Processing unit (PPU)
- Automatic Gate (AG)

10 MAINTENANCE PLAN

All the assets of SilverLine project shall be maintained properly in order to provide a seamless service to public. To maintain the assets of SilverLine, an Operation and Maintenance organisation need to be set up. The maintenance of major systems may be in-house, and maintenance of minor systems may be outsourced. Maintenance of different assets will be done on a preventive and proactive maintenance principle which includes direct maintenance.

The maintenance practices for the SilverLine must follow the best international practices, suitably modified for Indian local conditions and constraints of the SilverLine. The methodology of maintenance procedures and processes will very much be dependent on the item of equipment. The strategy will depend to a large extent on the maintenance needs specified by the supplier of the equipment that is purchased and the contractual terms of the purchase – whether maintenance by the supplier will be a part of the contract, what will be the free warranty replacement period etc.

10.1 Timelines for Maintenance

The time slot for the maintenance of mainline track, OHE, S&T equipment and other equipment in mainline is allocated during the night-time. In addition to the SilverLine passenger services, RORO services are also planned to run on the same corridor. The operation time for the passenger trains are from 05:00 Hrs to 23:00 Hrs. During this period, a portion of the RORO trips are also managed in the non-peak hours.

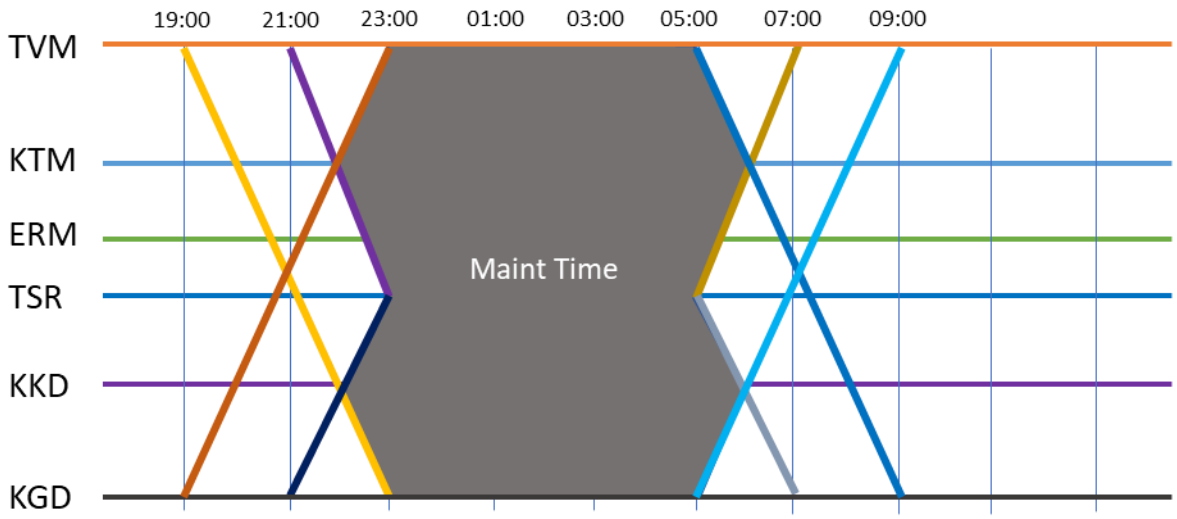

Figure 10-1: Maintenance time period

10.2 Maintenance Plan Details

Computerized Maintenance Management Systems (MMS) are now available or can be developed for the SilverLine. The organization will consist of engineers, skilled staff and managerial personnel. Some unskilled staff will also be there for manual labour intensive work. In order to optimize the manpower available and to reach the objective of an efficient maintenance, analysis of maintenance process was done, which resulted in a classification into levels according to the complexity of maintenance operations.

For track maintenance the basic approach for high speed rail system is that track should be built to such standards as to require less frequent maintenance. For track maintenance an important part will be removal of long wavelength defects in track once in 3 to 5 years depending on the rate of deterioration of track geometry in a section. Regular measurements of track geometry by Track Recording Cars, and cracks in rail by USFD Rail Testing Cars shall be the main basis for planned track maintenance activities.

A Rolling Stock and S&T maintenance workshop along with depot will be set up at Kollam to undertake maintenance of Rolling Stock as well as S&T. A sub depot at Kasaragod will also be set up, mainly for stabling trains but also for carrying out petty repairs or emergency repairs. Track and Traction Depots are provided on the mainline for better access and maintenance. Currently four track and traction depots are proposed along the corridor. All crucial safety related maintenance work must be done in house with trained staff of the SilverLine. Some non-core activities like building maintenance, electric substation maintenance, road transport, housekeeping work etc. can be outsourced to private parties.

Annual maintenance contract must be given for sophisticated sub systems like computer network, S&T equipment modules, POH of track machines and locomotives etc. The work done by the private parties must be strictly monitored by the SilverLine staff. Renewal of assets must be done after their economic life is over. The time of renewal will depend on the condition, the stated life of the asset as per the manufacturer, intensity of use etc.

The maintenance shall be carried out as per the specified maintenance documentation. The preparation of the operation and maintenance manual and catalogues is the most important activity in the whole maintenance planning. The maintenance manual is normally provided by the OEMs based on the design, RAMS requirement and manufacturer experiences and client expectations.

Special tools are considered the tools which are specific to perform the maintenance activities. The operating procedures, instructions to use and maintain these special tools and equipment shall be described in the maintenance documentation.

11 STATION PLANNING

11.1 Station Configuration

Station configuration addresses the geometry and functional needs of the station design. Station configuration issues involve the design of station entrances, the arrangement of the train platform(s), the location and relationship of the fare control area(s) to the entrance(s) and platform(s), parking facilities, work and rest areas, and the integration of ancillary and support facilities with the public functions.

11.2 Principles Followed in Designing Station and Amenities

i. Simple layout and free flow of passengers.

ii. Easy access to SHSR stations

iii. Functional orientation of amenities.

iv. Elegant and comfort in all seasons.

v. Convenience for various group of passengers.

11.3 Station Amenities

At the concourse level, all stations have ticketing facilities and entry/exit turnstiles at each of the extremities along the length to enable division into public and restricted zones. The restricted zones comprises of station operational areas such as Station Control Room, Station Master's Office, Staff Accommodation, Plant, Signalling and Operations Rooms, Heating Ventilation Air Conditioning (HVAC) handling units etc.

11.4 Paid and Unpaid Zones

The public zones are categorized into paid and unpaid zones. The unpaid zones is where riders enter the facility, use retail services like ticketing on ground level, while the paid zone in concourse and the platforms are areas where the passengers can go after purchase of tickets. The paid zone begins with entry/exit turnstiles at each of the extremities along the length. This provides access to the platform levels and other amenities.

11.5 Design of Station Building

(i) The main building will be designed to reflect the local culture and traditional art with functional orientation of all the amenities.

(ii) The platforms shall be visible from the concourse and waiting area for the convenience of passengers.

(iii) Quick transit of passengers with minimum walking distance to save time.

(iv) Free flow of passengers without cross movements and streamlined baggage handling.
(v) Area and volume required to have aesthetic architectural features are designed based on national building code of India and other Indian standards applicable.
(vi) Capacity analysis and required element identification have to be carried out in consonant with the following.

a. Overall station design – as per average and peak traffic.
b. Concourses – Based on analysis of maximum number of passengers entraining and detraining at peak operation (may vary depending on extent of transfer activity).
c. Circulation elements - The maximum throughput established for each passenger circulation element (The emergency egress requirements of the station as determined by the requirements of NFPA 130 and 101).
d. Entrance/Egress – Peak hourly load as determined by analysis (minimum of 10% of average peak daily capacity).
e. Platforms – Peak train discharge as determined by analysis (Island platform for discharging two full capacity trains simultaneously).
f. Amenities - Based on analysis of maximum number of Passengers entraining and detraining at peak operation (may vary depending on extent of transfer activity) and passenger profile.
g. Service standards – Any requirement established to clear the platform of arriving passengers within a given length of time after the train arrives for performance, operational, or other reasons.

11.6 Design of Platforms

Length of the platforms has been kept as 410m so as to have 5m extra length on both sides of the front and rear passenger car/loco of the train that departs or arrives at the particular station platform. However, over the second loop where only feeder trains may be dealt with, at a future date platform length shall be 400m and width of the platform is designed to be as under:

- Width - Island platform width to be 10.32m and one-sided platform width to be 5m.
- Direct across platforms 5m at all locations and 4m at either end.
- Height of the platform shall be 1250m from rail top table.

11.7 Means for Efficient Movement of Passengers

Strategies to facilitate the free flow of passengers shall include, but shall not be limited to the following;

- Separation of different categories of passengers.

- Design of a clear, simple, and direct passenger circulation system, minimizing turns and decision points.
- Minimizing travel distances.
- Efficient and strategic use of Vertical Circulation Elements (VCEs).
- Efficient and strategic use of electronic boards to display information about train schedules, etc.
- Minimizing crossflows and conflicting passenger movements.

11.8 Customer satisfaction, Comfort, and Convenience (3 Cs in conceptual design)

The designer shall focus on customer service including, but not limited to the following:

- Minimizing travel distance between the station entrance and the train.
- Providing assisted locomotion (i.e., elevators, escalators, moving walkways, equipment for the physically challenged, e.g., wheelchairs).
- Providing a clear and logical customer circulation system.
- Minimizing turns in the path of travel.
- Avoiding obstructions to customer movement.
- Minimizing pedestrian conflicts and crossflows.
- Providing adequate customer amenities to accommodate customer needs.
- Providing an acceptable Level of Service (minimum LOS C) to ensure a minimum degree of passenger comfort.
- Information.
- Ticketing service.
- Passenger waiting areas.
- Passenger toilet facilities (men/women/handicapped).
- Stores, shops, food stalls/restaurants.
- Providing potable water at the platforms, in addition to the station facility.
- Providing a comfortable environment with respect to acoustic, thermal, lighting and air quality.

11.9 Aggregator / Feeder Stations – For Future Consideration Only

In order to explore the possibility of getting the ridership enhanced (by having aggregator /feeder stations where in only trains of smaller compo can be run to collect passengers from smaller towns and lead them to the adjoining major stations), a detailed traffic study was conducted at the various identified potential 27 towns.

The ridership figures forecast are not encouraging at this time to have additional feeder/ aggregator stations at the identified towns having large population. Hence it is

recommended that the provision of aggregator/feeder stations can be taken up at a later date after conducting detailed studies.

11.10 Station Typologies

The SilverLine will have elevated, at-ground, as well as underground stations. The Station design and layout will follow one of the following three typologies: Typical sketches are kept at chapter 7.

- Elevated Stations at Kochuveli, Ernakulam and Thrissur
- Underground at Kozhikode.
- At-ground stations at all the other 7 Stations including at Kochi Airport.

12 TRANSIT ORIENT DEVELOPMENT AND VALUE CAPTURING

Various potential Transit-Oriented Development (TOD) sites were identified in close vicinity of station areas wherever vacant land exists. To ensure fast implementation of the proposal and optimization of earnings, the following criteria is kept in view :

- Land plots have to be in proximate to the proposed corridor.
- Land plots should be vacant and owned preferably by a single owner
- Proposed usage to be in conformity with provision of development plans of the city/Local Govt.
- Availability of adequate infrastructural support and optimum potential for commercial utilization and early high return

As sufficient Government land is not available for the Property Development, the same is proposed over the station building and on approach road sides and land requirement for property development is not projected separately

TOD in SilverLine is classified in two categories,

(1) Proximity Station Zone (PSZ): The Influence area will be 500 meters on both side of 10 nos of Main Station.
(2) Non-Proximity Station Zone (NPSZ): The Influence area will be between 500 m-1000 m on both side of 10 nos of Main Station.
(3) Non-Station Zone (NSZ): The influence area will be the identified area other than above defined zones. This will be a standalone TOD zone irrespective of distance from SHSR Stations.

Land values and property prices generally see an upside trend as large connectivity projects are implemented. Hence there is need for proper instruments such as tax/cess on property tax, development surcharge or betterment levy, etc., to capture such an upside in value. The land bank details for TOD is provided in table below and one of such models for the SilverLine influence zone has been schematically shown below and as follows:

Table 12-1: Land Bank details for TOD

S.No.	SHSR Station	Total Land (Ha)	Area of Land for Station (Ha)	Available Land for TOD (Ha)
1	Thiruvananthapuram	42.09	16.77	25.32
2	Kollam	249	53.67	195.33
3	Kottayam	256	15.51	240.49
4	Ernakulam	239	16.97	222.03
5	Thrissur	57.43	36.48	20.95
	Total	**843.52**	**139.40**	**704.12**

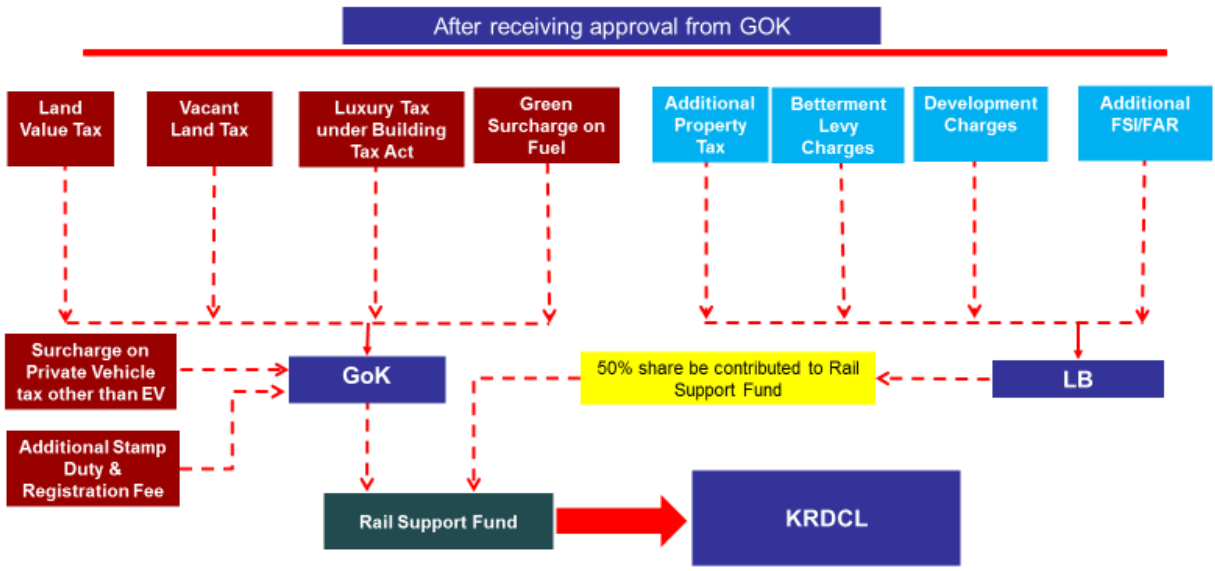

Figure 12-1: Land Value Capture Framework

13 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

An Environmental and Social Impact Assessment Study for the proposed SilverLine Project has been carried out to streamline environmental consideration in project design, mitigate the minor adverse environmental impacts and enhance the positive effects of the project to the environment and society.

13.1 Corporate Environmental Policy of K-Rail

K-Rail has adopted Corporate Environmental Policy and has developed procedures towards sustainable development. The salient features of the policy are outlined below:

- Integrated Environmental Management and Practices

- Making business decisions that aim towards environmentally friendly and sustainable development.
- Comply with all the relevant environmental and social legislation and regulatory requirements.
- Creating a low carbon operating environment to establish continual improvement of Environmental protection and Energy conservation.
- Green belt development and Biodiversity Conservation.

13.2 Applicable Policy, Legal and Administrative Frame Work

The SilverLine project may not require environmental clearance from MoEFCC as the Railway sector is exempted from the environment clearance process according to the EIA Notification, but certain permissions and no objection certificates (NOC) are required from different authorities like permission to draw water, consent to establish and operate Ready Mix plant, operation of depots, permission for tree cutting, license for storage of Fuel and other hazardous material, CRZ clearance etc.

To arrive at the ways and means of mitigating the minor effects on the environment, this EIA Study is being carried out.

13.3 Anticipated Environmental and Socio-economic Impact

Anticipated impacts due to various activities envisaged during construction and operation of SilverLine Rail Corridor have been assessed and further mitigation measures have been suggested for different environmental components, viz. air environment, noise environment, water environment, land environment, biological environment and socio-economic environment.

Analysis of various impacts reveal that the proposed construction activity for SilverLine Rail Corridor shall have only minor impact on all the components of environment, however the magnitude shall depend on the activity being carried out on any particular day. With the implementation of the suggested mitigation measures given in chapter 14 of DPR during construction and operational phase of the project, these impacts can be minimized to be much within the acceptable limits/levels. Detailed Rehabilitation and Resettlement (R&R) plan will be prepared to compensate the owners of the affected structures, trees and other agricultural land.

13.4 Environment Management Plan (EMP)

The Environment Management Plan provides guidance on how the project activities are to be planned, implemented and monitored in order to minimize and manage the environmental and social impacts. Environmental Management Plan during different stages of the project has been suggested in the chapter, which will entail only minimum damage to the environment.

13.5 Environmental Enhancement Measures (EEM)

In addition to the mitigation measures suggested to alleviate the minor negative impacts during construction and operation of the project, some of the measures for improvement of environment are proposed to be undertaken, which are Landscaping and beautification, installation of solar panels along the corridor, rooftop of all stations and depots etc.

To protect the environment, over large continuous stretch of the paddy fields under cultivation, viaduct of approx. 14 km of total length is proposed, in lieu of embankment. Further for control of noise and vibration due to running of train, protective measures are suggested for which a provision of Rs 50cr is made available.

13.6 Environment Monitoring Plan (EMoP)

An Environment Monitoring Plan has been prepared that proposes the various environment components like air, water, noise, soil and plantation and the parameters which shall be monitored for quality of each of these components. It also recommends the standards to be followed, the location, frequency and duration of the monitoring to ensure that the standards are not exceeded and also an action plan in case the standard is marginally exceeded. It also indicates the institutional responsibility for implementation and supervision, towards achieving the same.

The Railway projects may have negative impacts on few parameters of environment on a short-term basis but in the long run it will have a positive impact on the environment. The environmental and social assessment report ascertains and concludes that the SilverLine Project is unlikely to cause any significant environmental and social impacts. The SilverLine may employ ‘Industry Best Practices’ for the management of the environment and social effects of the project.

The K-Rail may arrange to take appropriate measures for protecting and enhancing the natural environment in all its planned operations as far as possible and aim to go along with compliance to all environmental legislations. The proposed development of SilverLine in Kerala will prove to be a boon for the people and economy of the Kerala State, with the above measures undertaken.

14 CAPITAL COST ESTIMATION

Detailed Capital Cost estimate for the proposed SilverLine from Thiruvananthapuram to Kasaragod has been prepared covering all the major heads of the cost as mentioned below at March 2020 price levels;

- Land acquisition and R&R
- Alignment, formation and bridges
- Station buildings
- Permanent way
- E and M works

- Depot and workshop Traction
- Signalling and telecom works
- Rolling stock
- Miscellaneous works
- PMC and design Charges
- Contingencies
- Taxes

Capital cost estimate have been prepared for the civil and System works of SilverLine corridor. The cost has been calculated as per route km for items spread over the alignment and per unit for items did not relate the route length. All items related to the alignment, whether at grade, underground or elevated construction ,permanent way, OHE signaling and telecommunication, have been estimated on cost per km basis. The cost of stations is estimated separately on Lumpsum (LS) basis. The cost of station and depots are estimated separately as per the initial design plans developed.

The cost for the stations includes cost of civil structures, architectural finishes, platforms, roofing and MEP etc. Cost of E&M works, permanent way, power supply, signalling and telecommunication, automatic fare collection, rolling stock, have been assessed separately.

Land cost has been assessed based on each segment of the land that is required.

14.1 Capital Cost

The basic cost for Semi high speed rail corridor between Thiruvananthapuram to Kasaragod at March 2020 Price levels is Rs.46,891 Crores covering all items like Civil, system, Land (excluding design, PMC charges, EIA and R&R cost, contingency and taxes) are summarized in table below:-

Table 14-1: Capital Cost Summary

Sl.No	ITEM	AMOUNT IN Cr
1	Land*	
1.1	Private land	6100.3
1.2	Government land	0
1.3	Railway land 185 Hectares	975
1.4	Cost for compensation of structure	4460
	Sub total	11535.3
1.4	Cost of R&R	1,730.00
	Sub total (1)	**13,265**
2	Alignment and Formation	
2.1	Tunnel	1566.3

Sl.No	ITEM	AMOUNT IN Cr
2.2	Cut & Cover	1893.2
2.3	Viaduct	2241.4
2.4	Embankment	3136
2.5	Cutting	703.2
	Sub total (2)	**9540.3**
2.6	Bridges **Sub Total (3)**	**624.44**
2.7.1	ROBs with Piles	1778
2.7.2	ROBs with RE wall as RC box	394.8
2.7.3	ROB in cutting	1030.4
2.7.4	RUB	788
2.7.5	Subways	383
2.7.6	ROB Modification with additional ventway for Silver line(39 Nos)	51.09
	Sub total (4)	**4425.29**
2.8	Civil Miscellaneous	
2.8.1	RORO - including parking for 40 trucks and ramp and ancillary facilities	675
2.8.2	Compound wall, RCC wall handrail 1m high, Fencing, Inspection PF& ladder for River bridge, Viaduct & River Bridge -special hand rail-walkway, Concertina coil, Signal & Power duct, or drain water pipe & Catch water drain, name boards indication boards etc.	1830
	Sub total (5)	**2505.00**
3	Stations	
3.1.1	Type A station at ground (incl lifts and escalators) - Kollam, Kannur, Kasaragod	212
3.1.2	Type A station elevated(incl lifts and escalators) – Thiruvananthapuram (Kochuveli), Ernakulam, Thrissur	280
3.1.3	Type A underground station (incl lifts and escalators) - Kozhikode	200
3.1.4	Type B station at ground (incl lifts and escalators) - Tirur, Chengannur, Kottayam	106
3.1.5	Type B station elevated (incl lifts and escalators) - NIL	0
3.1.6	Airport Stations (1)	25
3.2	OCC and administrative building	100
3.3	Auxiliary Sub-Station (ASS) and Mechanical, Electrical & Pumping (MEP) arrangements	50
	Sub total (6)	**973.00**
4	All Depots & miscellaneous	
4.1.1	Depot at Kollam including work shop and siding track and other infra, MEP and ASS	200

Sl.No	ITEM	AMOUNT IN Cr
4.1.2	Depot at Kasaragod including work shop, system and siding track and other infra, MEP and ASS	200
4.2	Machinery at Depot	170
4.2.1	Track recording car, USFD rail testing car, Rail grinding machine, Cantenary installation car etc	125
4.2.2	Accident relief Train and other equipment	175
4.2.3	Track machines & track depot including sidings	200
4.2.4	Safety & rescue and relief in tunnels and viaducts, including tunnel ventilation	135
4.2.5	Automatic River water level monitoring system, rain fall monitoring system and wind speed monitoring system	25
4.2.6	Small track machine and satellite depots	50
4.2.7	Continuous Track monitoring by Fibre technology	20
4.2.8	Provision of utilities over 530 km enroute and in Southern railway track between Tirur & Kasaragod	260
	Sub total (7)	**1560.00**
5	Permanent way	
5.1	Ballasted track for embankments, viaduct and yards, loop lines (passengers and RO-RO)(475Km * 5.6)+(120*2.77)	2992.4
5.2	Ballastless track (60 Km*9.2)	552
5.3	Points & crossings, special layouts , RORO etc	150
	Sub total (8)	**3694.40**
6	Traction and power supply incl. OHE , ASS etc	
6.1	Elevated Section/ At Grade Section	1834
6.2	Underground Section – Tunnel	16
6.3	Depot – OHE	60
6.4	RSS/ TSS (including Cabling Extra High Tension from source to RSS)	480
	Sub total (9)	**2390.00**
7	Signaling, Communication and Ticketing	
7.1	Signaling & Train Control (ETCS Level-2 with LTE) and communication system	2142.66
7.2	Ticketing & Fare collection system	88
7.3	OCC and BCC (Signalling & Communication and Ticketing System arrangement)	150
7.4	Signalling & Train Control and Communication Safety System	100
7.5	On-board equipment	38.88
7.6	Ticketing & Fare collection at Airport Station	5.5
	Sub total (10)	**2525.04**
8	Rolling Stock & including RORO	
8.1	Rolling stock (SG) – Passenger 261 cars	4175

Sl.No	ITEM	AMOUNT IN Cr
8.2	Rolling Stock – RORO (2 loco + 80 wagons)- 6 Train sets	480
	Sub total (11)	**4655.00**
9	Staff quarters and Barracks	
9.1	Staff quarters for O&M	50
9.2	Barracks, training centre, camp office..etc	50
	Sub total (12)	**100.00**
10	Others	
10.1	Shifting of Utilities	
10.1.1	Shifting of powerlines	240
10.1.2	Shifting of pipelines (KWA, Telecom..) (60 Cr for telecom)	70
10.1.3	Shifting of minor structures en-route	23.5
10.2	Multi modal Integration (e-bus etc for last mile connectivity)	95
10.3	Security	80
10.4	Noise & vibration reduction - Protection & treatment	50
	Sub total (13)	**558.50**
11	Training Equipment & Machine in training centre including Overseas training **(Sub Total (14))**	**75**
	Total for all items except land	**33626.97**
12	Land (including JDA and R&R)	13265
	TOTAL CAPITAL COST (Excluding Taxes)	**46,892.27**
13	Design Charges	672.54
14	PMC Charges	1,345.08
15	Contingency Charges	1,008.81
	Total Cost excluding Taxes – March 2020 prices	**49,918.70**
16	Central Taxes	2688.81
17	State Taxes	2446.33
	Total Project Cost at March 2020 prices	**55053.83**
18	Price Escalation	8722.76
19	IDC	164,08
	Project Completion Cost	**63940.67**

Basis and methodology followed in the cost estimating are discussed in detail in the following paragraphs.

Basis of capital cost estimation:

The capital cost of various items has been assessed based on the following principles;

- The works like Embankments, Bridges, Cut & cover, Cutting, Viaduct, Tunnels, Rolling Stock, Power Supply, Signalling, Communication, AFC, Depots, Machinery and plant (M&P) etc. have been prepared based on consultant's experience taking the reference of cost of similar items to work out the item rates.

- The rates of different items have been assessed as per rates of USSOR 2011 with 5% escalation, DSR 2018 with 5% escalation, current market prices or rates from similar works in Indian railways and metro projects in India.
- For costs of stations, Lump sum cost has been considered based on likely plinth area of the stations.
- Escalation factor @ 5% per annum has been applied to these estimated costs from other Metro and rail projects to current price level wherever required.
- Cost of M&P has been taken from Indian Railways COFMOW purchase rates and where these are not available, from rates in other Indian Railways or Metro Projects.
- Taxes and duties such a customs duties, SGST, CGST, etc., wherever applicable, have been worked out on the basis of prevailing and included in the cost estimates separately.

14.2 Methodology Adopted

Based on the individual quality of various heights/embankment in steps of 0.5m (2.0m, 2.5m, 3.0m, 3.5m, 4m, etc.) and multiplying same by the unit cost calculated for the 3 categories of constructions (namely strong ground , weak ground with stone column and weak ground with stone column using geogrid wrap), total cost of embankment is arrived.

Similarly for cutting, in increment of 1m (2.0m, 3.0m, 4m) unit cost arrived at has been used to multiply the corresponding length of cutting to arrive at the total cost of cutting.

Data separately for embankment, cutting, etc have been formulated in Excel sheets each catering to 50m stretch of alignment, in order to arrive at

(i) Stretches of embankment having height from 2.0m to 8.0m (interval of 0.5m)
(ii) Stretches of cutting from 2m to 9m (interval of 1m)
(iii) Length of viaduct in the height of 8m ,10m,15mand20m.
(iv) Length of cut & cover up to 20m depth (Strong ground and weak ground)
(v) Length of tunnels
(vi) Right Of Way (ROW) under each height /depth of embankment /cutting category.
(vii) Total length of cutting, tunnels viaduct etc.
(viii) Total length of embankment.
(ix) Quantity of Earth Work in bank cutting etc.
(x) Area of land over the 50 km separately for making formation, making the cuttings, viaduct etc. to arrive at the assessment of cost of land.

In this DPR, fairly accurate estimation of the cost involved for creation of the Civil Engg assets have been made, following the elaborate details arrived at after scrutiny of each and every 100m interval of the long 530.6 km corridor.

15 COST FOR OPERATION & MAINTENANCE

The Operation and Maintenance costs can be divided into three major parts: -

(i) Staff costs - The Operations and Maintenance staff shall consist of 3384 Inhouse employees and 1516 outsourced employees resulting in an employee requirement of 5.64 per Track KM and 6.38 employees per Route Km if main line alone is considered. For outsourced staff, it works out 2.52 per Track KM and 2.56 if main line alone is considered.

The cost of outsourced employees shall be included in the maintenance cost and only cost of in-house employee has been considered under employee costs. The average salary of an inhouse employee is estimated at RS 800,000 per annum resulting in employee cost of RS 271 crores at March 2020 levels.

Further, the escalation factor used for staff costs is 5% per annum till FY 2025- 26 and 8% from FY 2026-27.

(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables.

The maintenance expenses has been calculated at RS 1.02 Crores per km per year for the initial 10 years of operation and RS 1.31 Crores per km per year from the 11th year of operations as given below:-

Table 15-1: Maintenance expenses from 11th year of Operation

Sl. No	Sub System	Maintenance Cost Annually in the initial 10 Years (Rs. In Cr.)	Maintenance Cost Annually after 10 Years (Rs. In Cr.)	Cr/km/year in initial 10 years	Cr/km/year after10 years	Remark
1	Rolling Stock	130	282	1.02	1.31	282 Cr per year for total maintenance. Considered 45% of this cost for initial 10 years
2	S&T	152	152			0.21 Cr/km is considered
3	Traction and Power Supply					
4	Track	260	260			0.43 Cr/km is considered
5	Civil Infrastructure					
Total		542	694			

(iii) Energy costs- Energy demand for the project shall be sourced from solar power from private developer on a RESCO model and the balance power requirement shall be sourced from Kerala State Electricity Board Limited.
The solar power shall be made available at RS 3.50 per unit without any escalation for 50% of the solar power supplied directly and for the balance 50% solar power which shall be suppled through the grid which shall be sourced from interstate shall be made available at Rs 5.76 per unit of which Rs 4,76 per unit shall not be subject to any escalation and RS 1 per unit shall be subject to 5% annual escalation
Power supplied through KSEBL shall cost RS 6.50 per unit subjected to an annual escalation of 3% p.a.

16 REVENUE ASSESSMENT

The revenue from the project comprises of passenger fare box revenue, fare box revenue from RORO services and non-fare revenue and are detailed as under:

16.1 Fare Box Revenues from Passenger Traffic.

Based on the traffic Studies the most optimal fare for Passenger Fare box revenue have been calculated at 2.75 INR/km/passenger at 2019-20 level. Average Passenger trip length distribution as determined from the traffic studies is 200 km and a yearly escalation of 6% is taken on the fare rates. Accordingly, the fare box revenues is estimated as below:

Table 16-1: Fare Box Revenue

Year	Passenger Revenues (Rs in Crores)
2025-26	2,276
2032-33	4,504
2042-43	10,361
2052-53	21,827
2062-63	42,476
2072-73	81,139

16.2 Fare box revenues from Roll On Roll Off freight services

Roll On Roll Off Freight traffic is another revenue segment planned for operation during night and the lean hours. It has been estimated that RORO operations shall generate a revenue of INR 13,536 per truck for the full trip length. The per Km rate is considerd as INR 25/Km in the base year which is equalent to existing Konkan RORO rates (approximately INR 29/Km). RORO revenues have been calculated considering an average trip length of 392 kms and the revenue shall be escalated at 6% p.a. Accordingly, the fare box revenues is estimated as below:

Table 16-2: Revenue from RORO Service

Year	RORO Revenues (Rs Crores)
2025-26	237
2032-33	374
2042-43	669
2052-53	1,198
2062-63	2,146
2072-73	3,844

Non Fare Revenues

The major sources of non fare revenue are advertisement revenues from Stations & Trains, revenue from stations semi-naming rights, lease chanrges of toruist trains, catering licence fee, rentals from Kiosks, commercial development of stations and value capture financing tools like levy of additional duties and taxes.

17 PROJECT FINANCING MODEL

Various funding methods were considered and, the below financing model was found most appropriate for the implementation of the project:

Table 17-1: Proposed Financing Model

Source	Amount (Rs. in cr)	% Contribution	% Share of total Project Cost
Indian Railways - Equity	2,150	4.85%	4.89%
Indian Railways - Equity Land	975	2.20%	
GoK Equity	3,253	7.34%	5.09%
Equity from HNI/PSU/NRI	4,252	9.59%	6.65%
Loan from bilateral/multilateral agencies	33,700	76.02%	52.70%
Total Cost Excluding Land, R&R and Taxes	**44,329**	**100%**	
Ministry of Railway SD for Central taxes (100%)	3,189		4.99%
GoK SD for Land and R&R (100%)	11,837		18.51%
GOK SD for Land on JDA (Deferred Payment Scheme)	1,525		2.39%
GOK SD for State Taxes (SGST)	2,896		4.53%
Total Completion Cost before IDC	**63,777**		
IDC to be borne by GOK	**164**		0.26%
Total Completion Cost including IDC	**63,941**		100.00%

Under this funding pattern, a Special Purpose Vehicle (SPV) is to be setup under K-Rail

(a joint venture between Ministry of Railways and Government of Kerala) for the implementation of the project and for its subsequent Operation and Maintenance.

Under this arrangement, the total equity contribution shall be 24% of the total project cost excluding central taxes, State Taxes, IDC and Private and State Government Land.

To increase the private participation and considering the capital constraints of the Government, 40% of the above 24% equity capital is proposed to be raised from HNI/PSU/NRI etc., on a private placement basis. Kerala have succeeded in raising equity funds from HNI/PSU/NRI in the past for projects like Kochi International Airport Ltd (CIAL) and recently Kannur International Airport Ltd through such route. CIAL has turned into one of the most efficiently run institutions in the state with nearly 19,000 investors. Following the footsteps of CIAL, Kannur Airport was also modelled as Public Private Partnership and the Government of Kerala, owns around 33% of the company's shares.

Ministry of Railways and Government of Kerala shall contribute the remaining 60% equity in the ratio of 49:51 and run the SPV as a commercial enterprise. The railway land provided by the Ministry of Railways shall be considered as Equity contribution of MOR.

A Soft loan shall be arranged equivalent to 60% of the total project cost including land cost but excluding central taxes, State taxes, IDC. This may be possible with certain financial institutions like JICA wherein there is no restriction on the amount of the loan but may contain other restrictions on sourcing of materials.

In addition to equity, GoI will also fund by means of subordinate debt, the amount of Central taxes. Similarly GOK will fund by means of subordinate debt or grant, the state taxes and Interest during construction.

The cost of railway land amounting to approx. RS 975 crores shall be adjusted against the equity contribution by Ministry of Railways. The cost of private land, State government and R & R shall be funded through a subordinate debt from the Government of Kerala amounting to RS 11,837 Crores. The Government of Kerala shall also provide a subordinate debt for the land on Joint development amounting to RS 1,525 crores at March 2020 prices for which annuity payments shall be made to land holders on a deferred payment basis by the Government of Kerala

The contribution against completion cost is provided in the table below:-

Table 17-2: Contribution against completion cost

Agency	Completion cost (in Rs. Cr.)	Percentage
Ministry of Railway - Govt of India	6,314	10%
Govt of Kerala	18,150	28%

Agency	Completion cost (in Rs. Cr.)	Percentage
Govt of Kerala (deferred payment)	1,525	2%
Equity from HNIs/ PSU/NRI	4,251	7%
Bilateral Loan	33,700	53%
Total	**63,941**	100 %

18 FINANCIAL VIABILITY ANALYSIS

18.1 Financial Internal Rate Of Return (FIRR):

The Financial Internal Rate of Return (FIRR) has been worked out over the life cycle of the project which has been considered as 5 years construction period followed by a 50 year operations period.

On the basis of the cash flows accruing to the project considering revenues from farebox, non fare box and Value Capture Financing sources, the FIRR for the project works out to 8.49%. Further the FIRR to the equity holders of the project works out to 13.55% during this period.

18.2 Economic Internal Rate of Return (EIRR):

The economic Internal Rate of Return (EIRR) has been worked out over the life cycle of the project which has been considered as 5 years construction period followed by a 50 year operations period. For the proposed project, benefits from following were assessed:-

- Savings in Travel Time (VOT)
- Savings from vehicle operation cost (VOC)
- Savings due to reduced Environmental Pollution
- Accident cost savings
- Savings due to reduced road stress

On the basis of the benefits accruing to the society due to the implementation of the project, the EIRR for the project works out to 24.04 %.

The project has EIRR more than 14%, indicating that the benefits to the society are more than the social cost of capital of 14%.

18.3 Outcome on Economic Viability

As the project is self-sustainable as seen from the FIRR and also has an EIRR above the mandated levels, the project is economically viable and may be implemented.

Sensitivity analysis has been carried out considering the likely fluctuations in traffic earnings and expenditure.

19 PROJECT IMPLEMENTATION

The feasibility of a Public Private Partnership on a Design, Build, Operate, Finance and Transfer (BBFOT) basis has been evaluated. A Viability Gap Funding (VGF) of 20% project cost each by Government of India and Government of Kerala has been considered and found that the FIRR for a private investor will be in the range of 6.77% and hence DBFOT model under PPP is not viable.

Kerala Rail Development Corporation Ltd was established pursuant to the joint venture agreement executed between Government of Kerala and Government of India. In terms of the provisions of joint venture agreement, each project needs to be executed through a special purpose vehicle in the form of a company. Hence the project will be executed through Special Purpose Vehicle (SPV) in the form of a subsidiary company of Kerala Rail Development Corporation Limited. This SPV will execute the project and operate and maintain the system on behalf of the two Governments totally independent of Indian Railways. K-Rail will also form another SPV for the land bank development beyond the station areas by acquiring land. The two separate SPVs is necessary for value capturing but to ring fence the risk and avoid risk contamination. The surplus funds generated through the land bank development SPV can be rolled back to the project SPV by Kerala Rail Development Corporation Ltd to improve the cash flow of the Project SPV.

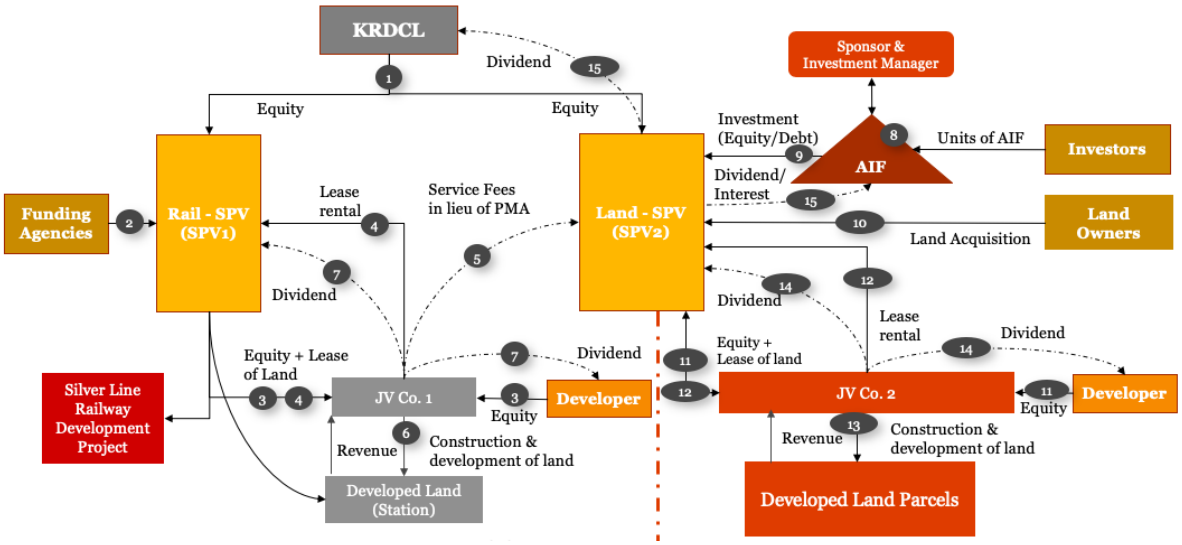

Figure 19-1: SPV Structure

The project is expected to be commissioned over a period of five years from 2020-21 to 2024-25. Based on the “in-principle” approval received from Ministry of Railways, the land acquisition process can start since the funding for the same to be borne by Government of Kerala. Physical work can start after the project is approved by Government of India

and financial closure is established. The construction and commissioning of the Silver Line can be done in one go for the entire 530.6 Kms from Thiruvananthapuram to Kasaragod, if the funds are available for the full project. Alternatively the project can be phased out with first phase between Thiruvananthapuram and Thrissur and the second phase from Thrissur to Kasaragod. It is recommended to go for the first option since the project viability and cost estimates have been worked out with a completion period of five years. Where as in the second option, the completion period will be get extended to seven years resulting in cost overrun and reduction in FIRR.

20 RECOMMENDATION AND WAY FORWARD

20.1 Conclusion

Based on elaborate study undertaken by the expert team of SYSTRA including consultation with foreign experts on the subject, Railway Board, Southern Railway, etc., the following are concluded:-

- Construction of 530.6 Km long SilverLine corridor is techno-economically feasible
- The alignment carefully chosen based on LIDAR survey, GT investigation, Traffic Surveys, etc., is the best suited one for this semi-high speed line.
- This proposal is cost effective transport solution to the state of Kerala and will bring in substantial benefits to the public by reduced pollution levels.
- Synergised development of all cities en-route, this SilverLine will result in overall accelerated development of the economy of the State.
- By integration with Airport, Metro and other transport modes, quick transit of passengers from any part of Kerala to any other part is possible.
- This SilverLine is a sustainable transport and project will provide a safe, comfortable and world-class travel experience to the citizens of our nation and tourists.

20.2 Recommendation

The 530.6 Km long SilverLine is a double line standard gauge Railway connecting Thiruvananthapuram and Kasaragod, with an operating speed of 200KMPH, eases the transport between North and South ends of the state and reduces the total travel time to less than 4 hours, compared with the present 10-12 hours.

Based on this elaborate technical study and economic analysis of this SilverLine project from Thiruvananthapuram to Kasaragod, **it is recommended to construct the Semi High Speed Rail Corridor (SilverLine) of 530.6 Km length** as a green corridor to have higher mobility, meet the traffic growth, enhance the environment and socio-economic development of the State.

In order to expedite the project and to get suggestions to make the project more fruitful, a series of meetings/discussions/presentations happened with Railways and GOK authorities. In this regard, meetings were held with Southern Railways, High Powered Committee of Government of Kerala chaired by the Honourable CM, Chamber of Commerce, etc. Detailed deliberations to make the project more feasible and viable, took place during these meetings and all the relevant suggestions have been incorporated in this Detailed Project Report.

20.2.1 Aggregator / Feeder Stations – For Future Consideration Only

In order to explore the possibility of getting the ridership enhanced (by having aggregator /feeder stations where in only trains of smaller compo can be run to collect passengers from smaller towns and lead them to the adjoining major stations), a detailed traffic study was conducted at the various identified potential 27 towns.

The ridership figures forecast are not encouraging at this time to have additional feeder/ aggregator stations at the identified towns having large population. Hence it is recommended that the provision of aggregator/feeder stations can be taken up at a later date after conducting detailed studies.

20.3 Way Forward

- Submission of the Draft DPR to KRDCL Board for approval.
- Submission of DPR to Govt of Kerala for approval.
- State Government may freeze all the developments along the corridor suggested, to avoid further construction within 30m from the centre line of the proposed alignment.
- Submission of the DPR to Southern Railway Headquarters for comments and suggestions.
- Forwarding of DPR to Ministry of Railways.
- Approval of DPR by Ministry of Railways.
- Approval by NITI Aayog.
- Approval by the extended Railway Board.
- Approval by Cabinet Committee on Economic Affairs (CCEA).
- Cabinet approval for project execution.

21 SALIENT FEATURES OF THE SILVERLINE PROJECT

1.	Railway	-	Thiruvananthapuram - Kasaragod SilverLine Corridor
2.	Route Length	-	530.6 Km
3.	Gauge	-	Standard Gauge 1435 mm
4.	Maximum Operating Speed	-	200 KMPH
5.	Stations	-	Thiruvananthapuram, Kollam, Chenganur, Kottayam, Ernakulam, Kochi Airport, Thrissur, Tirur, Kozhikode, Kannur and Kasaragod.
6.	Type of Structures	-	Tunnels - 13.62 Km (2.6%), Bridges - 10.22 Km (1.9%), Viaducts - 57.62 Km (10.8%), Embankments - 327.82 Km (61.5%), Cuttings - 101.22 Km (19.0%), Cut & cover - 22.83 Km (4.3%)
7.	Track Structure	-	Ballasted and ballast-less in combination
8.	Maintenance Depots	-	Workshop at Kollam and Inspection Depot at Kasaragod.
9.	Train type	-	EMU type
10.	Car body Width	-	3400mm(max)
11.	Seating	-	2+2(business), 3+2(standard)
12.	Passenger capacity per Train	-	675 (9 car set)
13.	Traction	-	2x25kV autotransformer type feeding system Overhead Contact System - simple catenary type
14.	Power Supply	-	Kerala State Electricity Board Ltd and supply supplemented by renewable energy supplies.
15.	Signalling and Train control	-	ETCS level 2 system
16.	Communication	-	LTE
17.	Daily Ridership	-	79,934 in 2025-26 (including Airport trips, additional trips due to introduction of city feeder, TOD) increasing to 158946 (including additonal trips) in 2052-53
18.	Train Set	-	9 cars extendable to 12/15
19.	Train operation	-	37 services in 2025 with peak headway of 20 minutes, increasing to 65 in 2052 with peak headway of 10 minutes.
20.	Cars requirement	-	261 in 2025 increasing to 492 in 2052.

21.	Fare Collection	-	Automatic Fare collection system with Centralized Computer and other supporting systems
22.	Completion time	-	5 years
23.	Capital cost (Rs) (March 2020 price)	-	49,919 Crores
24.	Cost without IDC (Rs)	-	63941 Crores
25.	Financing	-	Debt Rs.33,700 cr (52.70%) Equity-MOR-Rs.3,125 Cr (4.89%), GOK-Rs.3,253cr(7.34%), Others Rs 4,252 Cr (6.65%) GOK(land, EIA and R&R)-13,362 Cr (20.90%) Subordinated debt-GOI-Rs.3189 Cr (4.99%), GOK-Rs.2896 Cr(4.53%) and balance in IDC -Rs.164 (0.26%)
26.	Financial Internal Rate of Return	-	5.84% with 30 years concession period and 8.49% with 50 years
27.	Equity Internal Rate of Return	-	13.55% (50 years C.P)
28.	Economic Internal Rate of Return	-	24.04 % (50years C.P)

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